SUMMER PROGRAM IN SENSORY EVALUATION 2014

Vietnam, July, 25-27 , 2014

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PROCEEDINGS BOOK

FROM SENSES TO QUALITY:

WHAT CAN SENSORY EVALUATION BRING TO QUALITY CONTROL

Proceedings of the SPISE 2014 meeting

Ho Chi Minh City, Vietnam, July 25–27, 2014.

Edited by

Dominique Valentin, Sylvie Chollet, Sébastien Lê, Dzung Hoang Nguyen, & Hervé Abdi

"SPISE 2014: FROM SENSES TO QUALITY – WHAT CAN SENSORY EVALUATION BRING TO QUALITY CONTROL"

Nhiều tác giả

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FOREWORD

Spise2014: "From senses to quality: What can sensory evaluation bring to quality control," the fourth symposium on sensory evaluation in Asia, was held on July 25–27, 2014 at Ho Chi Minh-city University of Technology, Vietnam. We had the great pleasure to welcome about one hundred scientists from Vietnam, Japan, South Korea, Singapore, Thailand, Indonesia, the USA, and France. The focus of this year was on quality control.

Quality control (QC) ensures that a manufactured product or performed service adheres to a defined set of quality criteria or meets the requirements of the client or customer. For many years, QC in food companies relied mostly on chemical and microbiological analyses. Organoleptic testing was performed by the company expert who, through years of accumulated experience, was able to describe company products and set standards of quality by which raw materials should be purchased and product manufactured and marketed. More recently, the need of providing a more standardized environment for product evaluations has became apparent and a variety of scorecards were developed to serve as a basis for maintaining records and implementing a more rigorous process. These scorecards became the standards to assign quality grades to the products as, for example, in the olive oil or coffee industries, and the individual expert is now replaced by a small group of trained experts whose task is to make a consensual decision. Nowadays, more and more food companies start to integrate sensory evaluation in their QC programs and scoring ring procedures are replaced by discriminating, descriptive, and consumer acceptance procedures.

Sensory quality can be viewed from two different perspectives: the product and the consumer perspectives. The chapters in this proceeding represent these two perspectives. Product oriented chapters present some new methodological developments in sensory evaluation for quality control such as the tetrad method for difference tests as well as some applications of classical methods such as shelf-life modeling, grade classification, or sensory quality index. Consumer oriented chapters focus on different aspects of food quality such as product nutritional or environmental quality as well as individual factors affecting product perceived quality such as culture or physiological states.

All chapters are organized into three topics which we have used to organized this meeting sessions and themes:

1. Sensory evaluation in Quality Control

2. Sensory evaluation in product development

3. Fundamentals of sensory perception.

We would like to use this opportunity to express our gratitude to our two keynote speakers, Prof. Kwang-Ok Kim and Dr. Ho Huy Tuu for their great contributions. Our special thanks are due to our partners who participated in the organization of this meeting: the HCMC University of Technology, AgroSup Dijon, CSGA, AgroCampus-Ouest, and Groupe ISA Lille. We would like to thank our sponsors for their generous help: Fizz-Biosystems, Logicstream, Flavoractiv, and Bel Vietnam. We extend our special thanks to those who have helped us so much and worked so hard to make this event possible: Le Minh Tam, Phan Thuy Xuan Uyen, Nguyen Ba Thanh, Nguyen Thi Thu Ha, Nguyen Quoc Dung, Nguyen Quoc Cuong, Le Thuy Linh, Vu Thi Thanh Phuong, Ung Pham Tuong Thuy, Nguyen Quang Phong, Tran Thi Hong Cam, Vu Kien Thong, Phan Lai Minh Tam, Quach Tan Phat, Tang Nguyen Minh, Nguyen Quang Hung, and Do Mai Uyen Phuong.

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What can sensory evaluation bring to quality control?

4th International Symposium, July 25-27, VietNam

THE EFFECTS OF THE PERCEPTIONS OF FOOD (FISH) QUALITY AND RISKS ON VIETNAMESE CONSUMER SATISFACTION AND CONSUMPTION

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ABSTRACT

Purposes – This paper presents the idea that food quality management and control should be based on marketing orientation perspectives. It aims to explore the cues, reasons, criteria and sources of perceived quality and food risks, then investigates their influences on consumer satisfaction and consumption toward food (fish) in Vietnam. Finally, it recommends some directions for future research in both food marketing and Quality Control.

Methods – This presentation is based on a range of research studies using different data sets collected across provinces in Vietnam, and using different methods to analyze the data and test constructs, hypotheses and models.

Findings – First, it indicates that nutrition and taste occupy the highest ratio explaining for positive attitudes (perceived quality), while safety and negative feelings are dominated to explain negative attitudes (food risks). Consumers with more positive (negative) reasons have a higher (lower) consumption. Second, perceived quality as a multidimentionl construct is found to have a positive effect on consumer satisfaction, while negative feelings have a negative effect on satisfaction. Perceived price has no a significant influence on satisfaction but a significant positive effect on perceived quality. The results also show that there are four groups of reasons causing food risks coming from producers, sellers, consumers and products. Perceived food risk is found to have an indirect effect on consumption via consumer satisfaction, and negatively moderate the satisfaction-consumption relationship. However, the effect of perceived risks is weaker when consumer knowledge increases. Finally, ambivalence is found to have a negative direct effect on both satisfaction and health involvement. Both ambivalence and health involvement are found to moderate the satisfaction–consumption relationship in a complex mechanism.

Managerial implications – Managers and marketers should pay attention to reasons for consumer attitudes and consumption and have a multidimensional view of food quality and risk. Marketing strategies, which reduce consumer risks and educate them with relevant knowledge, may be effective strategies to increase consumption. For Quality Control, it is important that they must understand not only the established sensory standards for product quality, but also know, if possible, consumer expectations of sensory evaluations particularly at target markets pursed by a food company. Quality Control must understand all the traceable systems from raw material sourcing to finished products, and find and prevent all kind of tricks and methods that producers, processors and sellers use to avoid or even go around the specifications for the lack of the right raw material at the right time. It is important to to recruit Quality Control Inspectors who can do all this right and have the basic knowledge.

Limitation and future research – This paper focuses on only fish. Future research should expand to other foods and try to anwer the following research questions: Do the certainty or stability of perceived quality affect and/or interact with consumer satisfaction to increase consumption/loyalty? Do perceived food quality and perceived price interact to influence consumer satisfaction and consumption? Do perceived food quality and perceived risk interact to influence consumer satisfaction and consumption? What form of risk interacts with what dimension of perceived quality to influence consumer satisfaction and consumption? How can each kind of consumer knowledge help to decrease the negatitve effects of food risks? How can Quality Control and quality programs be built to solve the problems of fishing vessels, farmers, processors, marketing sectors and the consumers, and to increase the consumer's security in health and nutritional values.

Keywords: *food quality and risk, consumer satisfaction, consumption, fish, quality control, Vietnam.*

1. INTRODUCTION

Modern consumer no longer has reactive behavior towards a product but a more proactive approach, and consumer needs and the market requirements are more complex when taking into account the subjectivity in consumer's needs and desires (Alonso, Gallego *et al.*, 2005). Therefore, the paper focuses on the idea that the management of food quality and food safety or risk should based on marketing orientation perspectives. This means that through marketing/market research studies, maketers and managers can understand the cues, criteria, reasons and sources which consumers use to evaluate food quality as well as the sources of food risk and send their undersdandings to operation department to produce food products to fulfil consumers's needs to satisfy them (Klaus, Søren *et al.*, 1996).

Two approaches will be considered in the evaluation of food quality: The analysis of objective quality measured by chemical analysis, and the analysis of subjective quality measured by consumers' perceptions (Reeves and Bednar, 1994). Morgan (1985) says there is a difference in quality perception between the manufacturer and the consumer's point of view and it is the reason why it has to be analyzed from the consumer's viewpoint because they are the purchasers and the last level in the value's chain. This approach has been designated "Perceived Quality Approximation" (Garvin, 1984) highlighting that judgments on quality depend on perceptions, needs and consumer objectives.

This Perceived Quality Approximation approach is also integrated into the Total Food Quality Model that is an attempt to provide a common framework to understand how the perceptions of food quality and food safety or risks impacting on consumer attitudes and food choice (Klaus, Søren *et al.*, 1996). This model proposes two major dimensions along which we can analyse consumers' perceptions of food quality and food safety or risk: a horizontal and a vertical dimension. The horizontal dimension is a time dimension: it distinguishes the perceptions of food quality and food safety or risk before and after purchase as well as consumer satisfaction and repurchasing probabilities (Oliver, 1980). The vertical dimension deals with how consumers infer food quality and safery from a variety of signals or cues, and with how consumers find out which properties of a food product are desirable by linking them to basic motivators of human behaviour (Grunert, 2005).

Perceived quality is a multidimensional construct (Zeithaml, 1988, Reeves and Bednar, 1994, Oude Ophuis and Van Trijp, 1995, Zeithaml, Parasuraman *et al.*, 2002). In food area, previous studies also sugest that perceived food quality may include 4 dimensions: *taste quality, nutritious quality, safe quality and convenience quality* (Anderson and Anderson, 1991, Gotlieb, Grewal *et al.*, 1994, Grunert, Bredahl *et al.*, 2004). Taste quality is the food-attribute evaluations by the perceptions of tatste, texture, smell, appearance (Olsen, 2002). Nutritious quality relates to the perception of food health (Bredahl and Grunert, 1997). Safe quality is the characteristics of food safety (Anderson and Anderson, 1991). Convenience quality is reflected by easy to use, savings of time and effort (Reeves and Bednar, 1994, Olsen, 2004). Previous studies show that all four dimensions of perceived quality have influences on food satisfaction and food consumption or choice (Gempesaw, Bacon *et al.*, 1995, Steptoe, Pollard *et al.*, 1995, Bredahl and Grunert, 1997, Foxall, Leek *et al.*, 1998, Roininen, Lähteenmäki *et al.*, 1999, Leek, Maddock *et al.*, 2000, Olsen, 2002, Olsen, 2003, Chen and Li, 2007).

However, food attitudes and choice is often influenced more by the psychological interpretation of product properties than the physical properties of products themselves (Rozin and Vollmecke, 1986), and the perception of food risk is one such psychological interpretation (Yeung and Morris, 2001, Angulo and Gil, 2007). Food quality and food risks are really the two sides of a coin and related with each other (Anderson and Anderson, 1991, Yeung and Morris, 2001, Grunert, 2005). Similar to food quality, we can distinguish objective from subjective food risk. Objective food risk is a concept based on the assessment of the risk of consuming a certain food by scientists and food experts. Subjective food risk is in the mind of the consumer (Grunert, 2005). Food risk is also a multidimensional contruct that includes the components of financial, psychological, social, performance, physical and time-related risks (Stone and Grønhaug, 1993, Angulo and Gil, 2007). Financial food risk is related to losing or wasting income; Performance food risk is the status that food product does not meet the need; Physical food risk causes personal illness, injury or health issues; and Psychological food risk involves emotional pressure or social losses associated with a purchase decision (Jacob and Kaplan, 1972, Yeung and Morris, 2001, Tuu, Olsen *et al.*, 2011). Previous studies also indicate that the perceptions of food risk affect consumer food attitudes and choice in ways that are opposite with from perceptions of the other dimensions of quality we have distinguished above (Grunert, 2005).

This presentation ingregates the above different perspectives of assessing food quality and risk to understand how consumers perceive food quality and risk as well as their influences on consumer attitudes, satisfaction and consumption. Therefore, this presentation first describes the dimensions of perceived quality and the sources of food risks, then, investigates their influences on consumer attitudes, satisfaction and consumption/loyalty toward food in Vietnam. Because the two-side nature of food quality and food safety or risk, consumers who involve their health may feel ambivalent about food by its negative aspects such as risks. What are the consequences they receive depending much on their knowledge and skills of evaluating, choosing, preparing and cooking fish. Therefore, the presentation will go further by investigating the relationship between food attitudes/satisfaction and consumption with the presence of the different roles of ambivalence, involvement, consumer knowledge, perceived risks in the relationship. Finally, it recommends some managerial implications for food marketers, managers and especially for Quality Control to assure and control product quality.

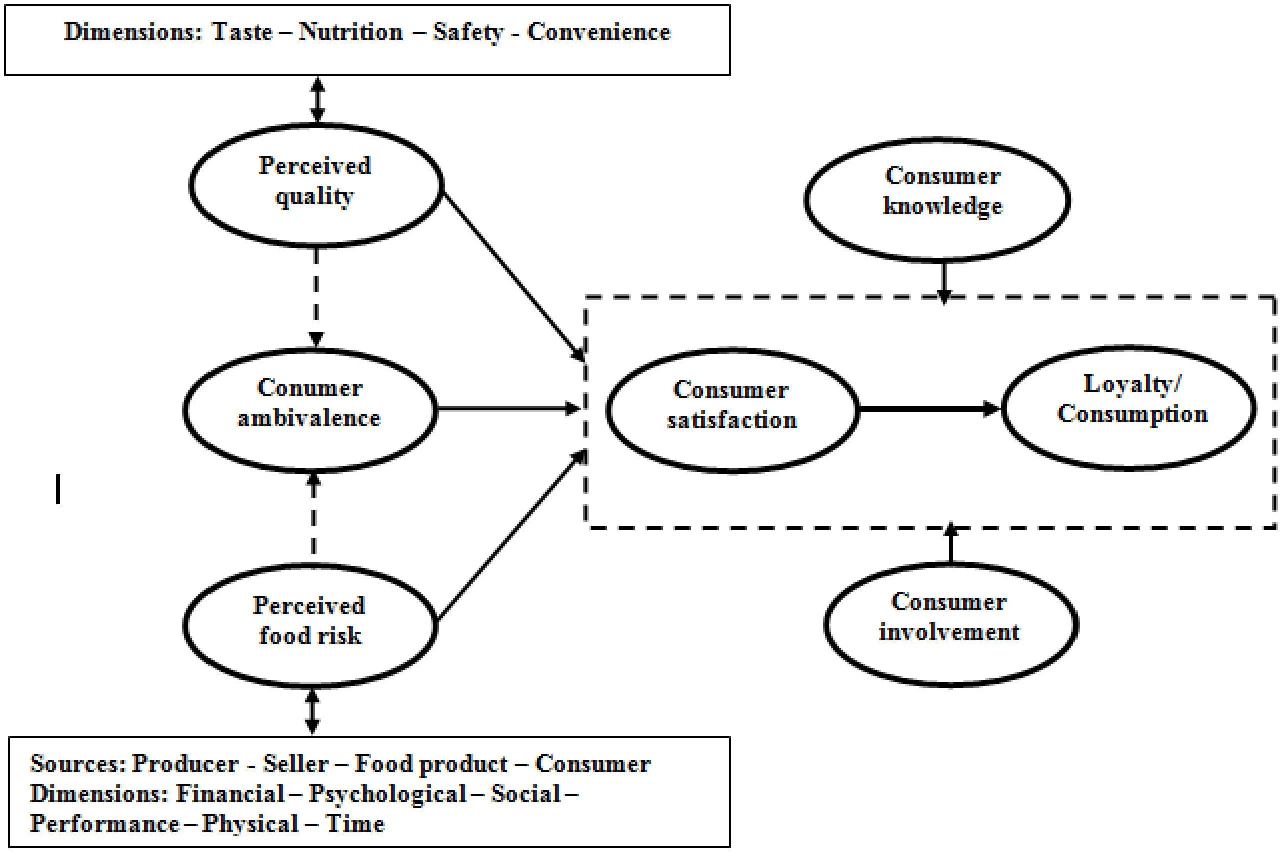

Figure 1. The general theoretical model

This paper focuses on consumer satisfaction, loyalty and the relationship between these two contructs as dependent variables. This is important because the concept of consumer satisfaction occupies a central position in marketing thought and practice and is a major outcome of marketing activity (Churchill Jr and Surprenant, 1982) (Oliver, 2009). Satisfaction is suggested to link processes culminating in purchase and consumption with post-purchase phenomena, such as loyalty (Fornell, Johnson *et al.*, 1996) (Oliver, 1999). However, satisfaction may often be "a matter of picking a low-hanging fruit" and a "trap" for marketers and managers (Reichheld, 1996) because satisfied customers are not necessarily loyal (Rowley and Dawes, 2000) and dissatisfied customers do not always defect (Day, 1984). This approach not only contributes to a deeper understanding of the nature of the satisfaction–loyalty relationship, but also highlights the role of perceived quality quality and food risk, satisfaction strength's properties (e.g., consumer knowledge, involvement, ambivalence…) as drivers and barriers of consumer satisfaction and in moving from consumer satisfaction to their loyalty toward the products. The general research model is shown in Figure 1.

2. METHODS

Among the food categories in Vietnam, fish occupies about one third in domestic consumption volume, and keeps the fisrt position in national export value. Fish is also diversified in spicies and has the most basic characteristics of a representative food type. Therefore, the paper focuses on fish, which I believe that the findings are totally generalized to other foods. This presentation is based on 6 research studies. Study 1 explores the reasons of both positive and negative evaluations of perceived quality explaining for attitudes, as well as tests their effects on consumption behavior and the attitude-behavior consistence of consumers towards fish. Study 2 investigates the role of perceived quality affecting fish consumer satisfaction. Study 3 explores the sources of risks focusing on fish products. Studies 4 and 5 focus on the relationships between attitudes/satisfaction and fish consumption with the presence of the different roles of perceived food risks and consumer knowledge in the relationship. Study 6 explores the combined role of ambivalence and consumer involvement on the relationships between satisfaction and fish consumption. Therefore, different data sets were collected across provinces in Vietnam, and different methods were used to analyze the data. Table 1 provides information related to the research designs, data sources, respondents, products and methods. The next part, I will present the findings and then following practical implications.

Table 1. Research designs, sampling details and methods

Study	Places/Products	Sample size	Collection method	Analytical methods
1	Khanhhoa Fish	361 consumers	Face-to-face, at home, questionnaire, fish	Descriptive statistics, multiple regression
2	Nhatrang Fish	250 consumers	Face-to-face, at home, questionnaire, fish	Structuaral equation modeling (SEM)
3, 4 & 5	Nhatrang Fish	20 students 100 consumers	In depth interview Face-to-face, at market, questionnaire, fish	Qualitative analysis Descriptive statistics
	Hanoi Fish	392 consumers	Face-to-face, at market, questionnaire, marine fish	SEM
6	Nhatrang, HCM city, Cantho	922 consumers	Face-to-face, at home, questionnaire, fish	SEM

Table 2. Analyzing the reasons for consumer positive attitudes (perceived quality) toward fish

Reasons for positive attitudes (perceived quality)	Frequency	%
Taste quality: good taste, attractive appearance, good texture, good smell	528	35.2
Nutritious quality: good for health, high nutrition, easy to digest, weight control	420	28.0
Convenient quality: easy to cook, many meals, available, little time to cook, diversity of recipies, different kinds of fish	182	12.1
Safety quality: natural, no chemist, no obesity, alive fish	52	3.5
Price: wide range upon kinds of fish, reasonable, relative cheap, high value for money	165	11.0
Consumer knowledge: know how to evaluate fish quality, the ways to cook, choosing fresh fish	151	10.1
Total number of reasons	1498	100.0

3. FINDINGS AND SUGGESTIONS

3.1. Analyzing the reasons for consumer attitudes toward fish products

Firstly, the paper explores the reasons of both positive and negative evaluations of perceived quality explaining for consumer attitudes, as well as tests their effects on consumption behavior and the attitude-behavior consistence of consumers towards fish products. We carry out the study based on two following perspectives:

(1) Perceived quality is a multidimensional construct including four dimensions: taste, nutrition, safety and convenience (Anderson and Anderson, 1991, Gotlieb, Grewal *et al.*, 1994, Grunert, Bredahl *et al.*, 2004).

(2) Analyzing the reasons of consumer attitudes (perceived quality, perceived risks) is based on attitude strength theory that the reason analysis helps to increase the predictive power of attitudes to behavior because consumer will have a deeper cognitive process about the attitude through the process of reason analysis (Petty and Cacioppo, 1986, Eagly and Chaiken, 1993). This means that the more reasons is given to explain consumer attitude, the stronger the attitude is. In addition, consumer is always ambivalent (i.e., is both positive and negative) in their thoughts, feelings and emotions about foods they use (Jonas, Diehl *et al.*, 1997, Olsen, Wilcox *et al.*, 2005). Therefore, while the relative amount of positive reasons keeps a role as a facilitating factor, the realative amount of negative reasons keeps a role as barrier factor of the behavior (Fishbein and Ajzen, 1975, Olsen, 2004).

Based on the above theoretical perspectives, our study indicates that nutritious quality and taste quality occupy the highest ratio explaining for positive attitudes (63.2%) (Table 2). In constrast, the food safety quality and inconvinent quality (33.2%) and negative feelings (35.3%) are dominated to account for negative attitudes (Table 3).

Table 3. Analyzing the reasons for consumer negative attitudes (perceived quality) toward fish

Reasons for negaitive attitudes (perceived quality – Food risks)	Frequency	%
Taste quality: bad taste (unsavoury), bored appearance, bad texture (soft, overripe), unattractive smell	166	11.7
Nutritious quality: fatty	94	6.6
Convenient quality: difficult to reserve, constantly observation in cooking, taking time in buying and choosing process, easy to make a wrong choice	176	12.4
Safety quality: dirty, bacteria, chemical substance, poisons, disease, allergy	296	20.8
Negative feelings: many scales, bad smell, bones	502	35.3
Price: fluctuation, unstable, difficult to compare, change depending places and times to buy	96	6.7
Consumer knowledge: lack of cooking skills, know only some kinds of fish and meals, recipies	94	6.6
Total number of reasons	1424	100.0

Table 4. Testing the effects of the amount of positive and negative reasons on fish consumption behavior and the attitude-behavior relationship

Independent variables	Unstd. Coefficients (B)		Std. Coeficients (β)	t – values	P
	Values	Std. errors			
Constant	5.86	0.14		41.1	0.00
Attitudes	0.76	0.11	0.34	6.9	0.00
Positive reasons	0.41	0.07	0.33	5.7	0.00
Negative reasons	-0.29	0.08	-0.18	-3.6	0.00
Attitudes x Positive reasons	0.14	0.05	0.15	2.9	0.00
Attitudes x Negative reasons	-0.04	0.06	-0.03	-0.7	0.49

Dependent variable: Fish consumption behavior; R^2 = 38.4 %, F = 37.9, p < 0.001.

The results also indicate that consumers with more reasons for their positive attitudes have a higher consumption behavior and a more consistence between their attitudes and behavior. By contrast, consumers with more reasons of their negative attitudes have a lower consumption behavior. However, this amount of negative reasons does not affect on the attitude-behavior relationship.

3.2. Testing the effects of perceived quality, price and negative feelings on consumer satisfaction

As presented in the first study, the aspects of perceived quality are main reasons for food/fish attitudes and consumption. Especially, as mentioned above, perceived quality is structured as a multidimensional construct with four dimentions: tatse, nutrition, safety and convenience (Anderson and Anderson, 1991, Gotlieb, Grewal *et al.*, 1994, Grunert, Bredahl *et al.*, 2004). In addition, negative feelings (negative attributes of products, such as bones, smell…) (Olsen, 2004) and perceived price (Voss, Parasuraman *et al.*, 1998) are important factors for consumer attitudes. Based on the above results, this presentation explores further the role of perceived quality, price, negative feelings impacting on consumer satisfaction. The findings indicate that perceived quality has a positive effect, while negative feelings have a negative effect on satisfaction. Perceived price has no a significant influence on satisfaction but a significant positive effect on perceived quality.

The findings suggest that managers and marketers should pay attention to the reasons for consumer attitudes or perceived quality. Positive reasons should be considered as important information to determine factors which managers can based on to build the communication strategy to consolidate consumer attitudes, while managers should try to eliminate or limit negative reasons as minimum as possible to improve product quality as well as keep favorable attitudes and remain consumption toward the fish products. Another implication for marketing the products is that managers and marketers should have a multidimensional view of food quality and need to know all aspects of product quality including even negative attributes to increase consumer satisfaction, and price strategy is not much important for marketing the products, but pricing for quality may be better.

The above disccusions and findings about perceived quality come from consumer cognitive process, which inputs are mainly based on consumer sensory evaluations and experiences about the food products. Because the main tools for the beginning of all Quality Control are the senses by smelling, seeing, feeling, tasting and even hearing, it is important that Quality Control understand not only the established sensory standards for product quality, but also know, if possible, consumer sensory expectations and evaluations particularly at target markets pursed by a food company. This knowledge has important meanings for Quality Control to give the company advices and help them to process, preserve and deliver products fulfilling the established standards as well as consumer expectations.

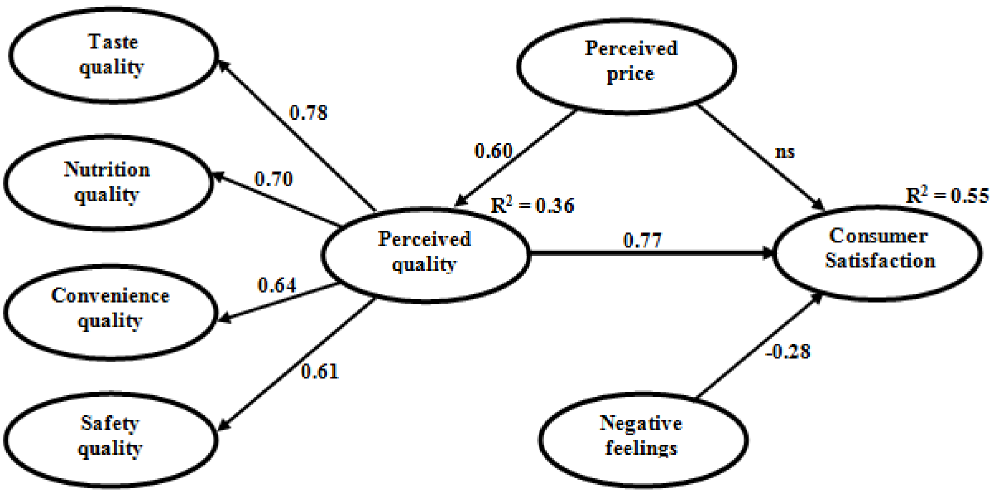

Figure 2. The structural relationships between perceived quality, negative feelings, price and satisfaction

Therefore, the sight inspection of the raw materials is important to be conducted by Quality Control. Who does not understand how a fish, a shrimp or the like must look if of good and fresh quality cannot repair this lack of raw-material quality later in the later stages of food supply chain. The raw materials must be checked by Quality Control as well as constantly control the processing for the customers or consumers demands. All five human senses are requested when it comes to Quality Control. One calls this natural Quality System of Senses a "Sensory Measure" of the food quality, and it is taught to all Control Inspectors on the Universities for Food Processing, such as in Nhatrang University in Vietnam. For example, the origin of the seafood products and the use of whatever chemicals in the farms and on the fisheríes vessels must be known and monitored also by Quality Control. It is a major criterion how the product is fitting the quality expectations of customers and/or consumers. The batches of raw materials are taken into a first sight which is relied to their freshness, also to their shape and lack of damages, to their sizing and suitability for the latter products. Then the first stages of processing are followed. Slaughtering of the fresh or alive fish, presorting and treatment of shrimp products – what chemicals are allowed, what are restricted always after the general quality farms and the quality demanded by customers or consumers.

As mentioned above, price levels may be not much important for marketing food products, but quality-based pricing for food products may be a better one. Quality Control is a part of the price of a product, so some people might think they can spare it. This risk can be quite costly nowadays because food products often travel a long way to their final markets and consumers. Quality Control can only take liability as much as human intelligence and knowledge allows them the adequate amount of fees. Quality Control cannot make the food products better, fresher or more delicious to enjoy, but it often and regular can avoid processing mistakes. Therefore, the Motto of all Quality Control is that "Better safe, than sorry!"

Table 5. Sources and reasons of food/fish risks perceived by consumers

Producers (276; 36.2%)	Sellers (246; 32.3%)	Fish products (176; 23.1%)	Consumers (64; 8.4%)
- Using poisons to catch fish - Using chemicals to preserve - Long fishing sea voyage - Lacking of tools to maintain fish quality - Unhygienic containers - Others	- Using special chemicals to refresh fish - Unhygienic fish shops - Preserving fish in a wrong way - Unhygienic tools and means to cut and slice fish - Others	- Lots of bones, scales, bad smell - High mercury content - Conminated by heavy metals, virus, bacteria, illness, toxin, pollution - Others	- Lacking of cooking skills - Not know how to evaluate fish quality - Buying new fish species - Others

3.3. Exploring the sources of food risk

Next, the paper explores the sources of food risks focusing on fish products. We carry out the study based on the following perspectives:

(1) Perceived food risks is a multidimensional construct that includes five dimensions: functional (taste, nutrition…), health (unsafety, poisonous…), time and effort (inconvenience), psychological (worried, stressful, discomfortable…) and social risks (low image, being complained…) (Jacob and Kaplan, 1972, Yeung and Yee, 2002, Tuu, Olsen *et al.*, 2011).

(2) The study is conducted in two steps. The first step is a qualitative study by personally interviewing consumers about causes or reasons that consumers think that they can cause an unsuitable meal with fish. An unsuitable meal is defined as a meal that does not taste well, wastes them time, money and effort, even harms their health. In the second step, we make a long list of causes or reasons belong to the four groups and ask consumers to choose reasons they perceive or believe that they are main reasons explaining for an unsuitable meal with fish they used to eat.

The results show that there are four groups of reasons causing food risks coming from producers, sellers, consumers themselves and chosen species of fish. The results indicate that the amount of reasons belong to the producers occuping the first ratio (36.2%), to sellers at the second rate (32.3%), then to fish products (23.1%), and to consumers with the lowest ratio (8.4%). The main reasons in the producer group include using poisons to catch fish, using chemicals to preserve, long fishing sea voyage, lacking of tools to maintain fish quality, unhygienic containers… The sellers increase food/fish risks by using special chemicals to refresh fish, unhygienic fish shops… Consumers also reveals that they sometimes make an unsuitable meal with fish because of lacking of cooking skills, do not know how to evaluate fish quality, or sometimes they decide to buy new fish species for their meals and feel dissatisfied with the decisions… Finally, consumers also say that low quality fish may have lots of bones, scales, bad smell, high mercury content, conminated by heavy metals, virus, bacteria, illness, toxin, pollution…The effects of food risk and consumer knowledge on consumer satisfaction and consumption/loyalty

This study based on:

(2) The effects of perceievd food risks on consumer food attitudes/satisfaction and behaviors are opposite with the ones of perceived quality (Yeung and Morris, 2001, Grunert, 2005).

(3) Consumer knowledge is integrated to investigate as a moderator in the relationships between perceived food risk, consumer attitudes/satisfaction and loyalty.

Furthermore, perceived risk is found to have an indirect effect on consumption through satisfaction. Perceived risk is a negative moderator in the satisfaction-consumption relationship. Consumer knowledge proves to negatively moderate the relationship between perceived food risk and satisfaction, and positively moderate the relationship between satisfaction and loyalty toward fish products.

Based on these findings, customer management based on satisfaction is not sufficient to increase consumer consumption, especially in the situations of highly perceived risk. Marketing strategies, which reduce consumers' risks, consolidate their confidence and educate them with relevant knowledge, may be effective strategies to increase consumption. Management attention should focus on reducing risks with which consumers may be faced through producing fresh or safe fish products, and communicating broadly safe signals of their products. Communication strategy should focus much more on improving knowledge and signing food safety for consumers with lower knowledge than the higher knowledge.

In addition, food quality assurance must understand the sources of risks faced by consumers. While producers and sellers need to regcognize their responsibility in fishing, farming, processing, storing and selling by safe methods, consumers need to be educated the skills and knowledge of cooking, preserving and quality evaluation. Quality Control must understand all the traceable systems from raw material sourcing through to the arrival of the products in the factory, through all processing stages until the finished products. Quality Control or Quality Control Inspectors specically should also find and prevent all kind of tricks and methods that producers, processors and sellers use to avoid or even go around the specifications for the lack of the (specified and requested) right raw material at the right time.

The biggest problem occurring in the food industry and for the Quality Control is that all kinds of chemical threats and contaminations can occur from raw material to finished product stage. These threats are natural but often also selfinflicted through lack of hygiene or treatment methods in the process conducted outside of the legal regulations. These hazards include environmental contaminations, medical treatment residues, lack of hygiene and enhancing and preserving chemicals. The first three mentioned must be avoided in every stage of the process beginning with harvesting or fishing the raw material down to the finished product. The latter must be tightly controlled as it is depending on voluntary actions and practices inside the processing factory. Quality Control must be aware of all these kinds of threats, but can often be avoided through change of hygiene and treatment regulations and habits inside the processing factor. As one is acting with a decaying situation with a lot of chemical influences taking part in the food body, the attention must be highly concentrated on avoiding all kinds of threats for the human consumption later on. The Quality Control must have the eyes and mind everywhere to see what is happening that no mistakes be made – by accident or – sometimes - even intentionally. The best and reliable Quality Control is done by Inspectors who now their job thoroughly and can follow the whole process from the raw material to the finished products. Thus, it is important to to recruit Quality Control Inspectors who can do all this right and have the basic knowledge.

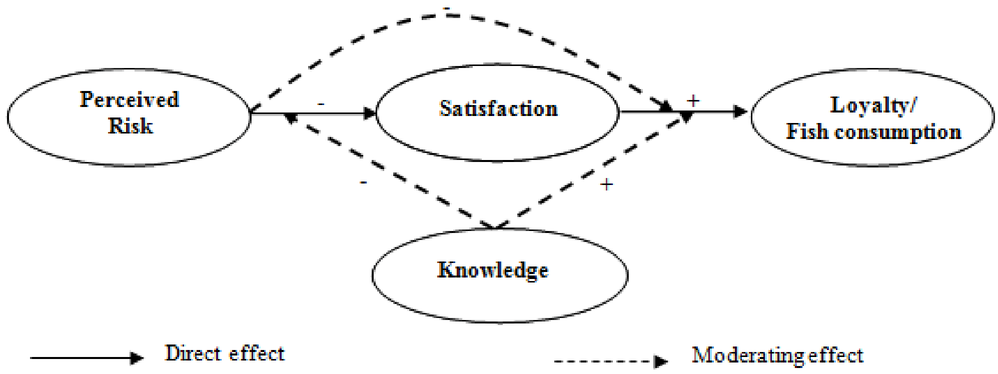

Figure 3. The effects of perceived food risk and consumer knowledge

3.4. The combined effects of ambivalence and involvement on satisfaction and consumption/loyalty

This study tests the different and combined roles of consumer involvement and ambivalence about fish products in the satisfaction–repurchase loyalty relationship.

This study is based on the following perspectives:

(1) Consumers have both positive and negative evaluations about perceived quality as well as the perceptions of food risks. Therefore, they have conflict thoughts, feelings and emotions or ambivalence about the products, which causes several negative consequences in consumer satisfaction, involvement and consumption toward the products (Olsen, Wilcox *et al.*, 2005, Costarelli and Colloca, 2007). Ambivalence also damages the satisfaction feelings which decreases the satisfaction strength (predictive power) (Conner and Sparks, 2002).

(2) Consumers involve fish products because the products are good for their health (Olsen, 2001). Involvement is integrated as a motivational factor which mediates the relationship between satisfaction and loyalty/consumption (Olsen, 2007). Involvement moderates the satisfaction-loyalty relationship because consumers' evaluations (satisfaction) based on higher involvement/importance are often stronger than ones based on lower involvement (Armitage and Conner, 2001, Chandrashekaran, Rotte *et al.*, 2007).

The results indicate that satisfaction has both positive direct and indirect effects on repurchase loyalty via involvement. Ambivalence has negative direct effects on both satisfaction and involvement, but does not directly influence repurchase loyalty. Empirical evidence also reveals that ambivalence and involvement are both moderators in the satisfaction–repurchase loyalty relationship. However, the moderating mechanisms of the two constructs in this relationship are different. While involvement moderates positively the direct effect of satisfaction on repurchase loyalty, ambivalence moderates negatively the indirect effect of satisfaction on repurchase loyalty via involvement. This result means that the indirect effect of satisfaction on repurchase loyalty through involvement is weaker under high ambivalence than low ambivalence.

These findings suggest that, for the goal of increasing repurchasing rate, food companies should focus on consolidating consumer satisfaction and involvement as well as reducing their ambivalence. First, this emphasizes rejecting the sources of ambivalent feelings (e.g., negative feelings) such as reducing perceptions of risks. These policies should go along with giving consumers an engagement about the quality guarantee, communicating positive aspects related to the products (e.g., safe, healthy, quality, stability and so on) (Povey, Wellens *et al.*, 2001), but more importantly keeping these actions consistently. Specifically, ambivalent consumers would be targets for persuasive messages to increase the value of their positive beliefs and/or decrease their negative beliefs regarding buying or using a particular product, brand or service, while long-term efforts are needed for consumers with only negative beliefs, first creating ambivalent attitudes and then converting them to positive ones at a later point (Olsen, Wilcox *et al.*, 2005). Second, this research indicates that marketers could improve their marketing knowledge not only by knowing the degree to which repurchase behavior is driven by individual satisfaction, but also by understanding the psychological structure and process of how satisfaction is related to repurchase behavior, especially the role of food involvement as a motivational and moderating factor (Olsen, 2007) as well as the barrier nature of ambivalence.

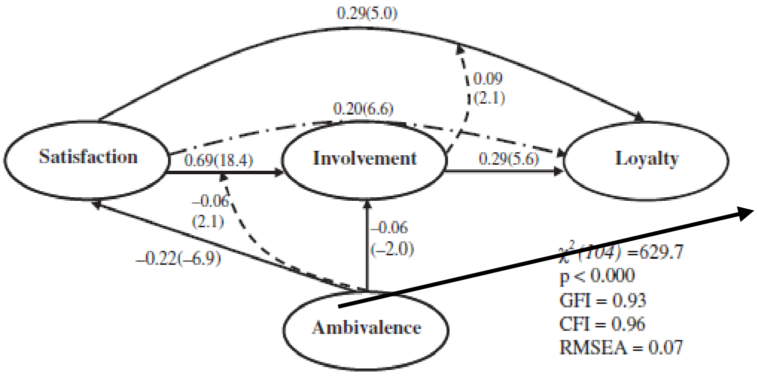

Figure 4. The effects of involvement and ambivalence

4. DISCUSSIONS AND FUTURE RESEARCH

4.1. Discussions

As a summary, based on the perspectives of perceived quality and food risks in broader theories of Perceived Quality Approximation, Total Food Quality Model and Attitude Strength, this paper investigates and reports the different sources and dimensions of perceived quality and perceived food risks affecting consumer satisfaction and consumption in food/fish consumption context in Vietnam. This presentation illustrated different reasons for and the sources of perceived quality and food risks and their effects on consumer satisfaction and consumption. It has also proven that both perceived quality and perceived food risk are multidimensional constructs and affect consumer satisfaction and consumption in different ways. Finally, both consumer ambivalence and health involvement have been proven to affect consumer satisfaction and consumption in a complex mechanism.

In a developing country such as Vietnam, consumers are faced with a low and unreliable quality of food/fish supplied by the local markets. Thus, the number of victims due to food poisoning has been considerable in recent years. Even though perceived quality and risk is important constructs in marketing (Campbell and Goodstein, 2001, Olsen, 2002), only a few studies investigate how they affect and interact with satisfaction in influencing consumers' repurchase loyalty or consumption (e.g. Grewal, Iyer *et al.* (2007); Tsiros and Heilman (2005)). Furthermore, consumer knowledge are suggested as important factors to understand perceived risk, understand how consumers manage to reduce risks (Dowling and Staelin, 1994, Mitchell, 1999) as well as to increase consumer satisfaction (Cordell, 1997, Pieniak, Verbeke *et al.*, 2007) and consumer consumtion/loyalty (Bell, Auh *et al.*, 2005, Chiou and Droge, 2006). Thus, the role of consumer knowledge and its interaction with perceived risk on satisfaction, consumption/loyalty and on the satisfaction–loyalty relationship is also important understandings. For the parallel presence of both positive ans negative aspects of food quality and risk, consumers who involve their health may feel ambivalent about food, and its consequences depends much on consumer knowledge and skills in evaluating, choosing, preparing and cooking fish. Thus, health involvement and ambivalence are integrated in the model as factors which may impact on consumer satisfaction, loyalty and the relationship between these two contructs. Generally, this paper has made an effort to generate a integated model that draws a comprehensive picture to understand consumer perceived food quality and risk as well as relevant psychological factors influencing consumer attitudes, satisfaction and consumption/loyalty at least in the context of Vietnamese food/fish consumption. From the findings, this paper calls for managers' attention on consumer perceived quality, food risks and their reasons and sources to research, design, process and control food product quality and risks to fulfill consumer satisfaction and increase consumer consumption/loyalty.

5. FUTURE RESEARCH

The findings and implications of each study and the integrated conceptual model presented in this paper must be viewed in light of its limitations. This paper will discuss these limitations and suggest directions for future research.

Perceived food quality has so far been discussed and investigated on the basis of cumulative mean evaluations consumers perceived at the time of investigating. However, those evaluations might change time by time or uncertain. The certainty or uncertainty of food quality and its levels may cause different consequences on consumer feelings, emotions and behaviors. Thus, a key question for managers and researchers is as follows:

Research question 1: Do the certainty or stability of perceived food quality affect and/or interact with consumer satisfaction to increase consumption/loyalty? Food quality as perceived by consumers is often uncertain, which may generate consumers' unconfident evaluations. This may damage consumer satisfaction feelings during consumption and decrease the consumption of the product. Therefore, food quality assurance or control or keeping food quality constantly at least fulfilling established standards or consumer expectations may be important to consolidate consumer satisfaction and increase the consumption. Because different dimensions of food quality are perceived by consumers and the acceptance of assuring and controlling all these dimensions may cost much money, the price of food products may be an issue for both processors and consumers at least for domestic markets. So far, perceived quality and price have been discussed independently, however whether perceived food quality and price can get together and interact with each other to influence consumer satisfaction and consumption is an undercovered issue. Thus, the next question is:

Research question 2: Do perceived food quality and perceived price interact to influence consumer satisfaction and consumption? Although many researchers have agreed that perceived price is an important determinant of consumers behaviors, little empirical research has investigated the influence of perceived price on consumer behaviors in the food industry. Some researchers imply that perceived price may moderate the relationship between perceived quality, consumer satisfaction and consumption (Zeithaml, 1988, Caruana, Money *et al.*, 2000). Specifically, when consumers perceive the price to be reasonable, their satisfaction with food quality will increase, and may enhance the effect of food quality on consumer satisfaction. The addition of the interaction between perceived food quality of service and perceived price may contribute to explaining better consumer satisfaction and consumption toward the food products. In addition, food quality and safety or risk has discussed thorough in the paper as two sides of a coin. Although they have been discussed so far as independent constructs rather than related to each other, consumers can not have a good meals if they perceive the food as a risky choice, and thus they may stop eating it temporarily if they perceive that risk higher than a certain threshold. It means that food quality and risk may interact to influence consumer satisfaction and consumption. However, we only have a little knowledge about how perceived food quality and perceived risk interact to influence consumer behaviors in the literature. Thus, the next question is:

Research question 3: Do perceived food quality and perceived risk interact to influence consumer satisfaction and consumption? A few studies explore the moderator role of perceived risk in the link between product evaluations and choice (Campbell and Goodstein, 2001, Gürhan-Canli and Batra, 2004). Because perceived food risk often relates to losses and future uncertainty consequences (Dowling and Staelin, 1994) as well as damaging perceived benefits (Saba and Messina, 2003), it is reasonable to anticipate that when consumers perceive high levels of perceived food risk, their expectations and evaluations of food quality are formed with less stability, which implies that the predictive strength of perceived quality on consumer satisfaction and consumption decreases when perceived risk increases. This knowledge is important for both food marketing in building risk-reducing strategy and Quality Control in convincing food processors conducting the established standards of food quality. We have discussed the interaction between perceived quality and perceived risk as overall constructs. However, different forms of risk as well as different dimensions of perceived food quality exist in the literature (Anderson and Anderson, 1991, Gotlieb, Grewal *et al.*, 1994, Grunert, Bredahl *et al.*, 2004, McCarthy and Henson, 2005). Therefore, the next question is that:

Research question 4: What form of risk interacts with what dimension of perceived quality to influence consumer satisfaction and consumption? As discussed in the Introduction, perceived food quality includes the following dimensions: taste, nutrition, safety and convenience, while perceived food risk includes the aspects of performance, health, psychological, social, time and effort and financial risks. Therefore, the possiblility for the interaction of each aspect of food risk and perceivd food quality may be different. On the basic of their nature and concepts, it could be expected there are the interation pairs as follows: performance risk – taste quality; nutritious quality – health risk; safety quality – health risk; safety quality – psychological risk; safety quality – social risk; convenience quality – time and effort risk and the like. The exploration of each interaction pair may give significant understandings to call for managerial attention in building marketing messages to confirm product quality dimensions and in realizing the necessity of building the system of risk control for the products. When perceived risk exceeds individual tolerance levels, consumers often manage to reduce the negative effect of risk by such methods as obtaining additional information (Mitchell, 1999), or careful evaluations of alternatives and product trials (Dowling and Staelin, 1994, Cho and Lee, 2006). It has for a long time been suggested that increasing consumers' knowledge is an important strategy to reduce perceived risk because more information or experiences result in a learning process that leads consumers to perceive less risk (Roselius, 1971). The findings show that consumer overall knowledge can help to decrease the negative effects of perceived food risk on consumer satisfaction and consumption. However, different facets of knowledge exist in the literature (Alba and Hutchinson, 1987) and the different dimensions of knowledge (e.g., such as declarative, procedural, schematic knowledge or knowledge about product class and so on) have been shown to have unequal effects on different outcome variables (Park, Mothersbaugh *et al.*, 1994, Cordell, 1997). Thus, the next question is as follows:

Research question 5: How can each kind of consumer knowledge help to decrease the negatitve effects of food risks? In relation to food risks and their sources, it is possible to argue that if consumers have knowedge of how to evaluate fresh food quality, they can avoid the risk of health, financial and performance risks; or if they have good skills of preparing and cooking, the performance, financial and psychological or even social risks may decrease; and so on. A study that investigates the role of each kind of knowledge in reducing food risks may be important because it could provide useful information for marketers in designing communication program to educate consumers with the relevant knowledge.

However, food quality and safety are credence attributes, which are not easily assessed by consumers (Andersen & Philipsen, 1998). Consumers may not detect the presence or absence of this attribute even after purchase and use (Angulo and Gil, 2007). Therefore, besides educating consumers with relavent knowledge, other efforts need to be generated to convince consumers trusting in food quality and safety. Food trust is considered as a value which dominate consumers' attitude toward food or food improvement. Food quality improvement is a desire consumers considers while consuming food. When they trust in food or food improvement, they will have a positive attitude toward this food. Therefore, the role of Quality Control should be enhanced and quality programs should be built to solve the problems of fishing vessels, farmers, processors, marketing sectors and the consumers, and to increase the consumer's security in health and nutritional values. It may be that the consumer's concerns are not taken directly into consideration by the quality programs, but processors, retailers or the civil servants should represent their interests through marketing strategies. A consequence of these policies is the increase of quality control and market transparency. However, while ethical issues in business is popular nowadys, such quality programs and the increase of Quality Control are always big challenges for Vietnamese food industry.

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REFERENCES

Alba, J. W. and J. W. Hutchinson (1987). "Dimensions of consumer expertise." Journal of consumer research: 411-454.

Alonso, M. A. S., P. A. M. Gallego and J.-P. L. Mangin (2005). "Testing a model of perceived food quality determinants." Journal of International Food & Agribusiness Marketing **17**(1): 9-33.

Anderson, J. G. and J. L. Anderson (1991). "Seafood quality: issues for consumer researchers." Journal of Consumer Affairs **25**(1): 144-163.

Angulo, A. M. and J. M. Gil (2007). "Risk perception and consumer willingness to pay for certified beef in Spain." Food Quality and Preference **18**(8): 1106-1117.

Armitage, C. J. and M. Conner (2001). "Efficacy of the theory of planned behaviour: A meta-analytic review." British journal of social psychology **40**(4): 471-499.

Bell, S. J., S. Auh and K. Smalley (2005). "Customer relationship dynamics: service quality and customer loyalty in the context of varying levels of customer expertise and switching costs." Journal of the Academy of Marketing Science **33**(2): 169-183.

Bredahl, L. and K. G. Grunert (1997). Determinants of the consumption of fish and shellfish in Denmark: an application of the theory of planned behavior. International Seafood Conference: Seafood from producer to consumer, integrated approach to quality.

Campbell, M. C. and R. C. Goodstein (2001). "The moderating effect of perceived risk on consumers' evaluations of product incongruity: Preference for the norm." Journal of consumer research **28**(3): 439-449.

Caruana, A., A. H. Money and P. R. Berthon (2000). "Service quality and satisfaction–the moderating role of value." European Journal of marketing **34**(11/12): 1338-1353.

Chandrashekaran, M., K. Rotte, S. S. Tax and R. Grewal (2007). "Satisfaction strength and customer loyalty." Journal of Marketing Research **44**(1): 153-163.

Chen, M.-F. and H.-L. Li (2007). "The consumer's attitude toward genetically modified foods in Taiwan." Food Quality and Preference **18**(4): 662-674.

Chiou, J.-S. and C. Droge (2006). "Service quality, trust, specific asset investment, and expertise: direct and indirect effects in a satisfaction-loyalty framework." Journal of the Academy of Marketing Science **34**(4): 613-627.

Cho, J. and J. Lee (2006). "An integrated model of risk and risk-reducing strategies." Journal of Business Research **59**(1): 112-120.

Churchill Jr, G. A. and C. Surprenant (1982). "An investigation into the determinants of customer satisfaction." Journal of Marketing Research: 491-504.

Conner, M. and P. Sparks (2002). "Ambivalence and attitudes." European review of social psychology **12**(1): 37-70.

Cordell, V. V. (1997). "Consumer knowledge measures as predictors in product evaluation." Psychology & Marketing **14**(3): 241-260.

Costarelli, S. and P. Colloca (2007). "The moderation of ambivalence on attitude–intention relations as mediated by attitude importance." European Journal of Social Psychology **37**(5): 923-933.

Day, R. L. (1984). "Modeling choices among alternative responses to dissatisfaction." Advances in consumer research **11**(1): 496-499.

Dowling, G. R. and R. Staelin (1994). "A model of perceived risk and intended risk-handling activity." Journal of consumer research: 119-134.

Eagly, A. H. and S. Chaiken (1993). The psychology of attitudes, Harcourt Brace Jovanovich College Publishers.

Fishbein, M. and I. Ajzen (1975). Belief, attitude, intention and behavior: An introduction to theory and research.

Fornell, C., M. D. Johnson, E. W. Anderson, J. Cha and B. E. Bryant (1996). "The American customer satisfaction index: nature, purpose, and findings." The journal of marketing: 7-18.

Foxall, G., S. Leek and S. Maddock (1998). "Cognitive Antecedents of Consumers» Willingness to Purchase Fish Rich in Polyunsaturated Fatty Acids (PUFA)." Appetite **31**(3): 391-402.

Garvin, D. A. (1984). "What does "product quality" really mean." Sloan management review **1**.

Gempesaw, C. M., R. Bacon, C. R. Wessells and A. Manalo (1995). "Consumer perceptions of aquaculture products." American Journal of Agricultural Economics **77**(5): 1306-1312.

Gotlieb, J. B., D. Grewal and S. W. Brown (1994). "Consumer satisfaction and perceived quality: complementary or divergent constructs?" Journal of applied psychology **79**(6): 875.

Grewal, D., G. R. Iyer, J. Gotlieb and M. Levy (2007). "Developing a deeper understanding of post-purchase perceived risk and behavioral intentions in a service setting." Journal of the Academy of Marketing Science **35**(2): 250-258.

Grunert, K. G. (2005). "Food quality and safety: consumer perception and demand." European Review of Agricultural Economics **32**(3): 369-391.

Grunert, K. G., L. Bredahl and K. Brunsø (2004). "Consumer perception of meat quality and implications for product development in the meat sector—a review." Meat science **66**(2): 259-272.

Gürhan-Canli, Z. and R. Batra (2004). "When corporate image affects product evaluations: the moderating role of perceived risk." Journal of Marketing Research **41**(2): 197-205.

Jacob, J. and L. B. Kaplan (1972). The Components of Perceived Risk. SV - Proceedings of the Third Annual Conference of the Association for Consumer Research.

Jonas, K., M. Diehl and P. Brömer (1997). "Effects of attitudinal ambivalence on information processing and attitude-intention consistency." Journal of Experimental Social Psychology **33**(2): 190-210.

Klaus, G. G., B. Søren, B. Lone, S. Elin and A. N. Niels (1996). A survey of Danish consumers' purchase of seafood, Aarthus School of Business. **MAPP–report**.

Leek, S., S. Maddock and G. Foxall (2000). "Situational determinants of fish consumption." British food journal **102**(1): 18-39.

McCarthy, M. and S. Henson (2005). "Perceived risk and risk reduction strategies in the choice of beef by Irish consumers." Food Quality and Preference **16**(5): 435-445.

Mitchell, V.-W. (1999). "Consumer perceived risk: conceptualisations and models." European Journal of marketing **33**(1/2): 163-195.

Morgan, L. A. (1985). "The importance of quality." Perceived quality: 61-64.

Oliver, R. L. (1980). "A cognitive model of the antecedents and consequences of satisfaction decisions." Journal of Marketing Research: 460-469.

Olsen, S. (2001). "Consumer involvement in seafood as family meals in Norway: an application of the expectancy-value approach." Appetite **36**(2): 173-186.

Olsen, S. O. (2002). "Comparative evaluation and the relationship between quality, satisfaction, and repurchase loyalty." Journal of the Academy of Marketing Science **30**(3): 240-249.

Olsen, S. O. (2003). "Understanding the relationship between age and seafood consumption: the mediating role of attitude, health involvement and convenience." Food Quality and Preference **14**(3): 199-209.

Olsen, S. O. (2004). "Antecedents of seafood consumption behavior: an overview." Journal of Aquatic Food Product Technology **13**(3): 79-91.

Olsen, S. O. (2007). "Repurchase loyalty: the role of involvement and satisfaction." Psychology & Marketing **24**(4): 315-341.

Olsen, S. O., J. Wilcox and U. Olsson (2005). "Consequences of ambivalence on satisfaction and loyalty." Psychology & Marketing **22**(3): 247-269.

Oude Ophuis, P. A. and H. Van Trijp (1995). "Perceived quality: a market driven and consumer oriented approach." Food Quality and Preference **6**(3): 177-183.

Park, C. W., D. L. Mothersbaugh and L. Feick (1994). "Consumer knowledge assessment." Journal of consumer research: 71-82.

Petty, R. E. and J. T. Cacioppo (1986). "Communication and persuasion: Central and peripheral routes to attitude change."

Pieniak, Z., W. Verbeke, I. Vermeir, K. Bruns∅ and S. O. Olsen (2007). "Consumer interest in fish information and labelling: exploratory insights." Journal of International Food & Agribusiness Marketing **19**(2-3): 117-141.

Povey, R., B. Wellens and M. Conner (2001). "Attitudes towards following meat, vegetarian and vegan diets: an examination of the role of ambivalence." Appetite **37**(1): 15-26.

Reeves, C. A. and D. A. Bednar (1994). "Defining quality: alternatives and implications." Academy of management Review **19**(3): 419-445.

Reichheld, F. F. (1996). "The Loyalty Effect, Harvard Business School Press." Boston, MA.

Roininen, K., L. Lähteenmäki and H. Tuorila (1999). "Quantification of consumer attitudes to health and hedonic characteristics of foods." Appetite **33**(1): 71-88.

Roselius, T. (1971). "Consumer rankings of risk reduction methods." The journal of marketing: 56-61.

Rowley, J. and J. Dawes (2000). "Disloyalty: a closer look at non-loyals." Journal of Consumer Marketing **17**(6): 538-547.

Rozin, P. and T. A. Vollmecke (1986). "Food likes and dislikes." Annual review of nutrition **6**(1): 433-456.

Saba, A. and F. Messina (2003). "Attitudes towards organic foods and risk/benefit perception associated with pesticides." Food Quality and Preference **14**(8): 637-645.

Steptoe, A., T. M. Pollard and J. Wardle (1995). "Development of a measure of the motives underlying the selection of food: the food choice questionnaire." Appetite **25**(3): 267-284.

Stone, R. N. and K. Grønhaug (1993). "Perceived risk: further considerations for the marketing discipline." European Journal of marketing **27**(3): 39-50.

Tsiros, M. and C. M. Heilman (2005). "The effect of expiration dates and perceived risk on purchasing behavior in grocery store perishable categories." Journal of Marketing **69**(2): 114-129.

Tuu, H. H., S. O. Olsen and P. T. T. Linh (2011). "The moderator effects of perceived risk, objective knowledge and certainty in the satisfaction-loyalty relationship." Journal of Consumer Marketing **28**(5): 363-375.

Voss, G. B., A. Parasuraman and D. Grewal (1998). "The roles of price, performance, and expectations in determining satisfaction in service exchanges." The journal of marketing: 46-61.

Yeung, R. M. and J. Morris (2001). "Consumer perception of food risk in chicken meat." Nutrition & Food Science **31**(6): 270-279.

Yeung, R. M. and W. M. Yee (2002). "Multi-dimensional analysis of consumer-perceived risk in chicken meat." Nutrition & Food Science **32**(6): 219-226.

Zeithaml, V. A. (1988). "Consumer perceptions of price, quality, and value: a means-end model and synthesis of evidence." The journal of marketing: 2-22.

Zeithaml, V. A., A. Parasuraman and A. Malhotra (2002). "Service quality delivery through web sites: a critical review of extant knowledge." Journal of the Academy of Marketing Science **30**(4): 362-375.

FURTHER READINGS

Cong, L.C., Olsen, S.O. & Tuu, H.H. (2013). The roles of ambivalence, preference conflict and family identity: A study of food choice among Vietnamese consumers. Food Quality and Preference, 28, 92-100.

Honkanen, P., Olsen, S.O., Bass, V. & Tuu, H.H. (2012). Reflective and impulsive influences on unhealthy snacking. The moderating effects of food related self-control. Appetite, 58, 616-622.

Ho, H. T. & Olsen, S.O. (2010). Ambivalence and involvement in the satisfaction-repurchase loyalty Eelationship. Australasian Marketing Journal, 18, 151-158.

Ho, H. T., Olsen, S.O. & Tran, T. P. L.. (2011). The moderator effects of perceived risk, objective knowledge and certainty in the satisfaction–loyalty relationship. Journal of Consumer Marketing, 28 (5), 363-375.

Ho, H. H. & Olsen, S.O. (2012). Certainty, risk and knowledge in the satisfaction-purchase intention relationship in a new product experiment. Asia Pacific Journal of Marketing and Logistics, 24(1), 78-101.

Ho, H. T., Olsen, S.O., Tran, D.T. & Nguyen, T. K. A.. (2008). The role of norms in explaining attitudes, intention and consumption of a common food (fish) in Vietnam. Appetite, 51, 546-551.

Ho, H. T., Nguyen, T. M. H & Le, N. H. (2009). Các nhân tố ảnh hưởng đến sự hài lòng: Cấu trúc đa chiều của chất lượng thủy sản cảm nhận. Tạp chí Khoa học Công nghệ Thủy sản, Trường Đại học Nha Trang, 03, 208-215.

Ho, H. T. (2011). Phân tích thái độ của người tiêu dùng đối với sản phẩm cá. Tạp chí Khoa học và Công nghệ Thủy sản, Trường Đại học Nha Trang, 2, 11-18.

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ACCELERATED VS. REAL TIME MODELING FOR SHELF LIFE: AN EXAMPLE WITH FORTIFIED BLENDED FOODS

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ABSTRACT

This study used sensory descriptive properties as the primary criteria to investigate the validity of using Accelerated Shelf Life Testing (ASLT) to determine shelf life of four extruded fortified blended foods (FBFs) compared to a real time model. The real-time environment was set at 300C and 65% relative humidity, based on the weather in Tanzania, the expected location of product use. The ASLT environment was at 50⁰C and 70% relative humidity based on a Q factor of 4, which was equivalent to a one-week ASLT equals one-month real time. The samples were evaluated for aroma and flavor by a highly trained descriptive panel for 3 time points in each shelf life model. Among the eighteen attributes tested, rancid and painty were the main sensory criteria to determine the shelf life of the products.

The ASLT shelf life predictive model was consistent with the real time shelf life for three of the samples. However, it failed to predict the real time shelf life of the fourth similar sample. This affirms the essential use of real time modeling in shelf life study for a new product, even when an accelerated model has been developed for other similar products in the same category. ASLT testing can still be used, but only for early guidance or after validation.

Keywords: shelf life, sensory descriptive, accelerated, real time

1. INTRODUCTION

Shelf life is defined as “the period of time during which the food product will remain safe; be certain to retain desired sensory, chemical, physical, microbiological and functional characteristics; and comply with any label declaration of nutritional data when stored under the recommended conditions” (Science and Technology, 1993). For many foods, the microbiological characteristics are often the determining factors for its shelf life; no sensory data are needed (Harry and Hildegarde, 2010). Yet for many other foods, the changes in sensory characteristics occur largely before any risk to consumers’ health is reached, especially foods that do not tend to suffer from microbiological changes such as baked goods, flour and so on (Harry and Hildegarde, 2010). The shelf lives of such foods become limited by changes in their sensory characteristics (Hough, Garitta et al., 2006). Therefore, sensory shelf-life estimation of foods has recently become increasingly important and resulted in a need for development and applications of new methodologies (Giménez, Ares et al., 2012). Giménez, Ares et al. (2012) also reported that the numbers of articles included in Scopus database including the words shelf-life and food in their title, abstract or keywords has increased 3 times from 2002 to 2011.

Accurate estimation of shelf life is crucial for both manufacturers and consumers, given that consumers’ demands for safe and high quality foods has rapidly increased. Giménez, Ares et al. (2012) reviewed current methodological approaches from designs to different sensory testing approaches to modeling and data analysis. Those authors confirmed that sensory descriptive analysis using trained panels was one of the popular approaches for sensory shelf life estimation. Muñoz, Civille et al. (1992) demonstrated an example of a descriptive evaluation of potato chips and the range of sensory specifications. Lareo, Ares et al. (2009) used this methodology for estimating the shelf life of lettuce based on visual appearance. Jacobo-Velázquez and Hernández-Brenes (2011) applied it to shelf life of avocado paste. Sensory shelf life also can be determined based on one key attribute. The intensity of rancid flavor was used in Nattress, Ziegler et al. (2004) to estimate the sensory shelf life of dark chocolate containing hazelnut paste while oxidized flavor was the key attribute to determine shelf life of whole milk in Nielsen, Stapelfeldt et al. (1997).

Another challenge with shelf life testing is to develop experimental designs that minimize cost and reduce time while still be reliable and valid (Robertson, 2009). Many food products are expected to have shelf lives of several months or perhaps years, making real time shelf life testing not practical for food companies where decisions need to be made in a timely fashion. Therefore, accelerated shelf life testing (ASLT) often is preferred in industry as it satisfies the requirement of time and thus, reduces cost. In ASLT, the food products are subjected to controlled environments in which one or more of the extrinsic factors such as temperature, humidity, gas atmosphere or light are set at a higher-than-normal level. In such environments, the food is expected to deteriorate more quickly, reaching the stage of failure in a shorter-than-normal time. However, according to Robertson (2009), ASLT is not very well accepted in the food industry, partly because of a lack of basic data on the effect of extrinsic factors on the deteriorative rate. Often, to set up an ASLT, a company has to determine an accelerating factor either from experience or a rule-of-thumb or from data of previous similar products. Thus, the deteriorating factor has an uncertainty degree cannot be accounted for in the shelf life estimation (Hough, Garitta et al., 2006). This method also assumes that the new product design has the same acceleration factor (Nelson, 2009). Consequently, ASLT has the possibility of resulting in an inaccurate shelf life.

This study aimed to investigate the validity of using ASLT to estimate the sensory shelf life of extruded fortified blended foods (FBFs) in comparison to using real time shelf life testing. Sensory attributes were used as the key factors to determine the shelf life of the products in both shelf life models.

2. MATERIALS AND METHODS

2.1. Samples

Four extruded fortified blended foods (FBFs) used as porridges were evaluated, including whole sorghum soy blend (WSSB), whole sorghum soy blend with oil (WSSB+oil), decorticated sorghum soy blend (DSSB) and decorticated sorghum soy blend with oil (DSSB+oil). These four samples consisted of a base formulation made of either whole (for WSSB and WSSB+oil) or decorticated (for DSSB and DSSB+oil) sorghum flour (67.27%), defatted soy flour (21.13%), and whey protein concentrate (30%). Then vegetable oil (5.5%) was added to the premixed formulation before extrusion to create the two samples with oil. The premix was then extruded at high energy of 450 rpm with 20% process moisture. Extruded products were dried at 1040C and then cooled at room temperature on a cooling belt. The extruded products were then milled and sieved through a 900 μm sieve before micronutrient fortification. WSSB and DSSB were fortified with 3% mineral, 0.1%vitamin, and 5.5% oil while WSSB+oil and DSSB+oil were fortified with only mineral (3%) and vitamin (0.1%).

2.2. Shelf life testing design

Two shelf life models were used in this study. The real time model was set up at 300C and 65% relative humidity. These set points were based on the tropical weather of Tanzania, the expected location of product use. The accelerated environment was at 500C and 70% relative humidity. These parameters were based on the Q10 factor (Robertson, 2010). The Q10 value is a temperature quotient that reflects the change in reaction rate for every 100C rise in temperature. Mathematically: Q10 = $\frac{k_{T+10}}{k_T}$. Q10 is also found as the ratio between the shelf life at temperature T (0C) to the shelf life at temperature T+10 (0C) or: Q10 = $\frac{\theta_{S(T)}}{\theta_{S(T+10)}}$. If the temperature difference is Δ (Δ = T2 – T1) rather than 100C, the following equation is used: (Q10)Δ/10 = $\frac{\theta_{S(T1)}}{\theta_{S(T2)}}$ (Robertson, 2009). Therefore, with the assumption that the deteriorative factor Q10 was 2, the temperature difference Δ = 50 – 30 = 20 (0C), the accelerated time intervals corresponding to the real time intervals were shown in table 1.

Table 1. Shelf life time interval (weeks) for the corresponding accelerated and real time models

Testing time point	ASLT (weeks) 50°C, 70% RH	Real time (weeks) 30°C, 65% RH
0	0	0
1	6	24
2	9	36

2.3. Descriptive Analysis

All four FBFs were subjected to both shelf life testing models. At each testing time point, sensory descriptive analysis was conducted to evaluate the flavors and aromas of all samples using a descriptive panel of the Sensory Analysis Center at Kansas State University. This panel consisted of six highly trained panelists who have experienced more than 1000 hours of sensory testing, including grain products.

The samples used in the descriptive analysis testing were porridges made from the fortified flours. The porridge was prepared to 20% solid content by adding 50 g flour (either WSSB, WSSB+oil, DSSB, or DSSB+oil) to 230 ml of boiling water, bringing back to a boil and cooking for 2 minutes while continuously stirring with a wooden spoon. Sample was cooked to a final weight of 250 g by checking the weight at 2 minute and every 10 sec after, if needed. This procedure allowed maintaining the desired solid-water ratio without any need of adding water back. Sample was then placed in a 400 ml beaker to cool down to the serving temperature of 30-350C. Approximately 30 g of porridge was then served in a 120 ml Styrofoam cup labeled with a three digit code. The porridge samples were individually evaluated for 18 flavor and aroma attributes on a 15-point scale (0 = none to 15 = extremely high) with 0.5 increments using a randomized complete block design. Each sample was evaluated in duplicate in two sessions. The panelists used deionized water, carrots and unsalted crackers to cleanse their palate between samples.

3. DATA ANALYSIS

Intensity scores on the 15-point scale were averaged over 6 panelists and 2 replicates to result in an average panel score for each attribute per each sample in both shelf life models. Only the data of the key attributes were presented in this paper.

4. RESULTS AND DISCUSSIONS

During the orientation session of 2 hours, the sensory panel developed 7 aromas and 11 flavor attributes to describe the porridge samples. The aromas included grain, musty, cardboard, toasted, brown, rancid, and painty. The flavor consisted of overall flavor, sorghum, soy, starch, toasted, brown, cardboard, musty, rancid, painty and astringent. Among those attributes, rancid and painty were chosen to be the key attributes to determine the shelf life of the products. The acceptable range of these two attributes was set from 0 to 5 on the 15-point scale. Any sample that scored higher than 5 was considered a failure. Table 2 and table 3 show the average panel scores (with standard deviation) for rancid and painty aroma and flavor of all samples in the real time shelf life model. Based on the predetermined criteria of the acceptable range of these two attributes, WSSB + oil, DSSB + oil and DSSB had shelf life of somewhere before 36 weeks or 9 months. Only WSSB was still acceptable after 9 months of storage.

Table 2. Average panel scores for rancid and painty AROMA for the products in the Real time model: time 0 – no storage; time 1 – 24 weeks, time 2 – 36 weeks. Standard deviations are shown in parentheses.

Sample	Rancid Aroma			Painty Aroma		
	Time 0	Time 1	Time 2	Time 0	Time 1	Time 2
WSSB + oil	0.58 (1.08)	1.58 (2.22)	7.96 (0.33)	0.13 (0.45)	0.71 (1.17)	4.21 (0.33)
WSSB	0.46 (0.83)	0.92 (1.48)	2.25 (0.78)	0.00 (0.00)	0.46 (0.68)	0.88 (1.17)
DSSB + oil	0.50 (0.76)	0.92 (1.57)	6.00 (1.33)	0.00 (0.00)	0.25 (0.58)	3.42 (0.59)
DSSB	0.50 (0.08)	0.33 (0.61)	11.04 (2.94)	0.00 (0.00)	0.00 (0.00)	9.92 (3.87)

The results from the ASLT model (Tables 4 and 5) supported the conclusion drawn from the real time model for WSSB+oil, DSSB+oil and WSSB, but not for DSSB. The ASLT data showed that DSSB had rancid and painty aroma and flavor in the acceptable range at the testing time of 9 weeks, which was assumingly equivalent to a 36 weeks or 9 months in the real time model. In addition, the intensities of these attributes were far below the acceptable threshold, which implied that DSSB's shelf life could be longer than 9 months. This disagreed with the result from the real time model.

The ASLT model in this study was set up based on the assumption that all four FBFs flours had the same deteriorate factor, which was Q10 = 2. Yet the result showed that DSSB seemed to have a different deteriorate factor from the other three. As DSSB was completely rancid at 9 months (36 weeks) in the real time model but not yet at 9 weeks in the ASLT model, the Q10 factor of this sample should be smaller than 2, which would result in a longer storage time in the ASLT environment to approach the deteriorate process in real time. This result made sense given the nature of DSSB, which was made from decorticated sorghum flour and did not have oil added before extrusion. The extrusion process, due to its high energy, was expected to affect the fat content in the flour, causing it to rancid. Therefore, WSSB+oil and DSSB+oil, because of the higher amount of oil before extrusion, would go rancid faster than DSSB. In addition, the real time model in this study was, in fact, a controlled environment in an environmental chamber with temperature kept at 350C and humidity always around 65%. Therefore, this real time model can be seen as an ideal given the fact that real weather is not always this stable. Even with this ideal set up, the accelerated model still failed to predict the shelf life of one sample. Thus, if the real time shelf life testing had been conducted at the real location, under the influence of other factors from the weather during the year, the shelf life obtained from this model could be quite different from what was obtained from the accelerated model.

Table 3. Average panel scores for rancid and painty FLAVOR for the products in the Real time model: time 0 – no storage; time 1 – 24 weeks, time 2 – 36 weeks. Standard deviations are shown in parentheses.

Sample	Rancid Flavor			Painty Flavor		
	Time 0	Time 1	Time 2	Time 0	Time 1	Time 2
WSSB + oil	0.88 (0.97)	2.00 (2.18)	9.04 (0.75)	0.08 (0.28)	1.00 (1.49)	7.67 (0.61)
WSSB	0.54 (0.81)	1.29 (1.65)	4.08 (1.36)	0.00 (0.00)	0.42 (0.76)	1.33 (1.21)
DSSB + oil	0.75 (0.89)	1.17 (1.64)	8.71 (1.40)	0.00 (0.00)	0.33 (0.61)	6.83 (2.42)
DSSB	0.54 (0.54)	0.54 (0.89)	12.00 (2.46)	0.08 (0.28)	0.13 (0.43)	10.79 (3.71)

Table 4. Average panel scores for rancid and painty aroma for the products in ASLT model: time 0 – no storage; time 1 – 6 weeks, time 2 – 9 weeks. Standard deviations are shown in parentheses.

Sample	Rancid Aroma			Painty Aroma		
	Time 0	Time 1	Time 2	Time 0	Time 1	Time 2
WSSB + oil	0.58 (1.08)	0.79 (1.07)	9.29 (0.54)	0.13 (0.45)	0.00 (0.00)	5.29 (1.01)
WSSB	0.46 (0.83)	1.79 (1.38)	0.67 (1.61)	0.00 (0.00)	0.13 (0.43)	0.42 (0.99)
DSSB + oil	0.50 (0.76)	1.50 (1.58)	8.38 (1.77)	0.00 (0.00)	0.29 (0.68)	5.13 (1.28)
DSSB	0.50 (0.08)	0.54 (1.01)	0.58 (1.50)	0.00 (0.00)	0.00 (0.00)	0.50 (1.33)

Table 5. Average panel scores for rancid and painty flavor for the products in ASLT model: time 0 – no storage; time 1 – 6 weeks, time 2 – 9 weeks. Standard deviations are shown in parentheses.

Sample	Rancid Flavor			Painty Flavor		
	Time 0	Time 1	Time 2	Time 0	Time 1	Time 2
WSSB + oil	0.88 (0.97)	2.42 (1.25)	9.25 (1.25)	0.08 (0.28)	0.92 (0.97)	5.38 (0.91)
WSSB	0.54 (0.81)	3.42 (1.04)	1.88 (2.65)	0.00 (0.00)	0.79 (0.86)	0.50 (1.00)
DSSB + oil	0.75 (0.89)	2.58 (1.80)	9.50 (1.02)	0.00 (0.00)	1.29 (1.23)	5.79 (1.15)
DSSB	0.54 (0.54)	2.08 (1.25)	1.25 (2.29)	0.08 (0.28)	0.75 (0.98)	0.50 (1.06)

In this case, if ASLT with a Q10 factor of 2 had only been conducted with WSSB+oil, DSSB+oil, or WSSB a "valid" accelerated shelf life model might be a logical conclusion. However, using such an ASLT model for DSSB would have predicted a much longer shelf life than actually was found in real life testing. Therefore, ASLT must be used with caution and it is always necessary to validate the ASLT results with real time shelf life testing.

5. CONCLUSIONS

This study applied sensory descriptive analysis for estimation of sensory shelf life of several samples of fortified blended foods, which could be used in food aid programs in Tanzania and other countries. The study demonstrated the essential use of real time shelf life testing for a new product, even when an accelerated model has been developed for other similar products in the same category. ASLT testing should be used for early guidance, but the results must be validated using real time testing.

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REFERENCES

Giménez, A., F. Ares and G. Ares (2012). "Sensory shelf-life estimation: A review of current methodological approaches." Food research international **49**(1): 311-325.

Harry, T. L. and H. Hildegarde (2010). Sensory Evaluation of Food: Principles and Practices, Springer, New York.

Hough, G., L. Garitta and G. Gómez (2006). "Sensory shelf-life predictions by survival analysis accelerated storage models." Food Quality and Preference **17**(6): 468-473.

Jacobo-Velázquez, D. and C. Hernández-Brenes (2011). "Sensory Shelf-Life Limiting Factor of High Hydrostatic Pressure Processed Avocado Paste." Journal of food science **76**(6): S388-S395.

Lareo, C., G. Ares, L. Ferrando, P. Lema, A. GAMbaro and M. Soubes (2009). "Influence of temperature on shelf life of butterhead lettuce leaves under passive modified atmosphere packaging." Journal of Food Quality **32**(2): 240-261.

Muñoz, A. M., G. V. Civille and B. T. Carr (1992). Comprehensive descriptive method. Sensory Evaluation in Quality Control, Springer: 52-107.

Nattress, L., G. Ziegler, R. Hollender and D. Peterson (2004). "Influence of hazelnut paste on the sensory properties and shelf-life of dark chocolate." Journal of sensory studies **19**(2): 133-148.

Nelson, W. B. (2009). Accelerated testing: statistical models, test plans, and data analysis, John Wiley & Sons.

Nielsen, B. R., H. Stapelfeldt and L. H. Skibsted (1997). "Early prediction of the shelf-life of medium-heat whole milk powders using stepwise multiple regression and principal component analysis." International Dairy Journal **7**(5): 341-348.

Robertson, G. L. (2009). Food packaging and shelf life. Food Packaging and Shelf Life: A Practical Guide, CRC Press: 1-16.

Science, I. o. F. and Technology (1993). Shelf Life of Foods: Guidelines for Its Determination and Prediction, Institute of Food Science & Technology (UK).

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APPLICATION OF QUALITY INDEX METHOD FOR FRESHNESS OF CHILLED STORED FARMED COBIA (*RACHYCENTRON CANADUM*) PORTION

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ABSTRACT

Quality index method (QIM), a method for sensory evaluation of raw fish materials, gives scores close to zero for very fresh fish and higher scores as the fish deteriorates. A QIM scheme has been developed for each fish species and/or product. The objective of this study was to apply a QIM scheme developed for chilled-stored farmed cobia *(Rachycentron canadum)* portions in the product freshness evaluation. The product quality was also assessed by other sensory methods such as quantitative descriptive analysis (QDA) and Torry scheme, by chemical methods (total volatile base nitrogen/TVB-N determination), and by microbiological methods for comparison. Cobia portions were packed in expanded polystyrene trays with 2-3 portions per tray and stored at 0-2 °C up to 2 weeks. Each sensory session included fish from 2-3 batches of different storage time. Samples were taken for the analyses every 1-3 days. Day 0 was the harvest day. It was found that the QIM score (quality index QI) linearly increased with time and reached ¾ of the maximal scale (21) after 8 days of storage at 0-2 °C, which was the product shelf life determined by QDA. Partial least square regression (PLS-R) on QIM data also showed that QI could be used to predict the shelf life of the fish with the precision of 1.5 days if three portions from each batch were evaluated per time. Torry score linearly decreased with time and approached a score above 7 after 8 days. TVB-N did not change significantly at the beginning, but dramatically rose from day 10 and surpassed 30 mg/100 g, the proposed acceptable level for human consumption of this product, after 11 days. At day 10, total viable counts (TVC) reached 2.8 x 10^6 CFU/g, indicating that the fish should be stored for less than 10 days. In conclusion, the studied QIM scheme appears to be a good tool for evaluating the freshness and estimating the shelf-life of the product.

Keywords: QIM, cobia, sensory

1. INTRODUCTION

Quality index method (QIM), a method for sensory evaluation of raw fish materials, was originally developed by the Tasmanian Food Research Unit in Australia (Bremner, 1985) and has been further developed by European fisheries research institutions. QIM gives scores close to zero for very fresh fish and higher scores as the fish deteriorates (Martinsdóttir, Sveinsdóttir *et al.*, 2001). The method is considered unique and reliable as QIM scheme has been developed for each QIM fish species and/or product.

Freshness of fish can be determined as a quality state of the product, described by a variety of definite properties of the fish which can be assessed by various indicators with different methods such as sensory, chemical, microbial and physical ones (Olafsdottir, Martinsdóttir *et al.*, 1997, Bremner and Sakaguchi, 2000).

A freshness estimate can be obtained by defining criteria related to changes in sensory attributes such as appearance, color, odor, flavor and texture, measured and quantified by sensory and/or other methods (Olafsdottir, Martinsdóttir *et al.*, 1997, Ólafsdóttir, 2005).

Newly harvested fish is very "fresh" with certain sensory, physical, chemical, biochemical and microbiological characteristics, and these properties change with storage time and storage conditions (such as temperature). In other words, fish become less fresh during storage.

The objective of this study was to apply a QIM scheme developed for chilled-stored farmed cobia *(Rachycentron canadum)* portions in the product freshness evaluation and estimate the shelf life of the fish.

2. MATERIALS AND METHODS

2.1. Materials

Cobia farmed in Vin Pearl Island, Nha Trang Bay, Vietnam, weighing 7.5-8.5 kg/individual, was harvested and transported live to a collector in the main land in the afternoon. At the collector, fish was chilled and stored with crushed ice in thermally isolated boxes overnight. In the next morning, fish was headed, gutted and cut into portions of about 2 cm thick, put with alternative crushed ice layers into expanded polystyrene (EPS) boxes, and transported to the laboratories (labs) which were 5 minutes of motor driving. At the labs, fish was washed and put into EPS trays (2-3 portions/tray) and cover with thin polyethylene film. The trays were put into a climatic chamber with gel mats of 500 g below and above each tray and stored at 0-2 °C up to 2 weeks; gel mats were checked and replaced if necessary every 2-3 days. Storage temperature was monitored and recorded by temperature loggers 3M TL30. Experiments were carried out with 5 fish of different storage times from 2-5 days, giving fish portions of 5 batches accordingly. Day 0 was the harvest day. Fish portions from the first two batches were used for pre-observation and sensory panel training, as well as to form the QIM scheme. Fish portions from the last three batches were used for freshness and shelf life determination, validating the QIM scheme.

2.2. Sensory evaluation

Seven panelists, staff of the University and familiar with QIM, were selected and trained in accordance with ISO 8586: 2012 in three sessions of 2-3 h each.

The QIM scheme for chill-stored cobia (*Rachycentron canadum*) portions consisted of nine attributes (skin odor, skin brightness, skin muscus, slice odor, slice muscus, slice white muscle color, slice red muscle color, slice blood, and slice texture) of 1-3 demerit scores with a total quality index of 21.

The sensory evaluation of cobia portions was carried out with three portions from each batch, each session included fish from 2-3 different batches. The portions were coded with random 3-digit numbers, placed in a random order and evaluated individually.

Sensory evaluation of cooked samples using QDA (Stone and Sidel, 1985) was carried out in parallel as a control method and to determine the maximum storage time of the fish (Sveinsdottir, Hyldig *et al.*, 2003). Torry scheme for fat fish (Shewan, Macintosh *et al.*, 1953, Martinsdóttir, Sveinsdóttir *et al.*, 2001) was also used for comparison. At each session of 1.0-1.5 h, panelists evaluated four samples from two different storage times (i.e. using duplicated samples).

Each sample for sensory analysis was coded with a random 3-digit number.

2.3. Chemical analysis

TVB-N was analyzed according to EC 2074/2005.

2.4. Microbiological analysis

TVC was analyzed according to NMKL86, 2006.

2.5. Data analysis

Microsoft Excel 2003 was used to calculate means and standard deviations for all multiple measurements and to generate graphs. PLS modelling of QIM data (samples x QIM attributes x storage day) of farmed cobia portions stored at 0-2°C was carried out with the software Unscrambler X 10.2 (CAMO A/S, Norway) using mean center data, weight 1/SDev (standard deviation), full cross validation, algorithm Non-Linear Iterative Partial Least Squares (NIPALS), predicted against measured values (i.e. storage time from harvest), in order to evaluate the possibility of QIM to predict the fish storage time.

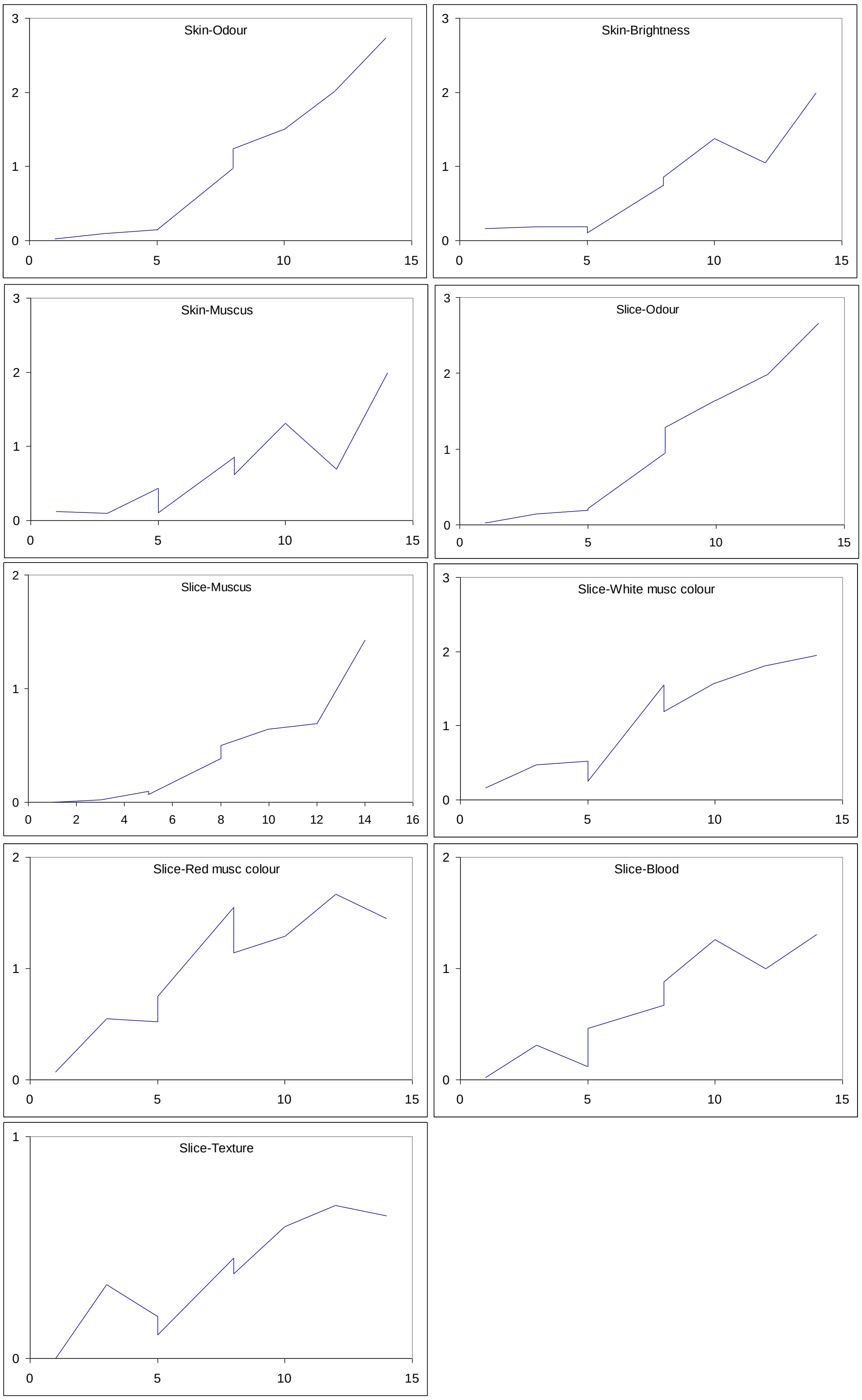

Figure 1. Average scores (N = 3) of each quality attribute assessed with QIM scheme for cobia portions against storage days at 0-2 °C. X-axis is storage time (days) and Y-axis is score of each attribute

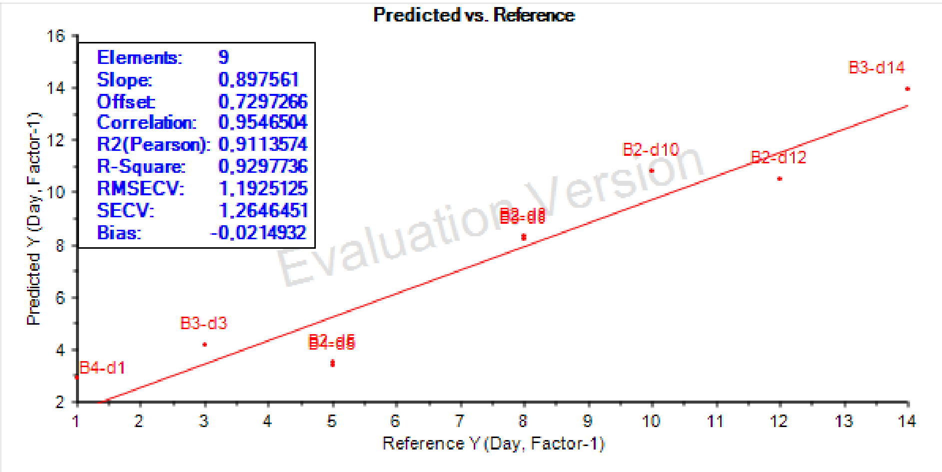

Figure 2. PLS modelling of QIM data of cobia portions stored at 0-2 °C using full cross validation: predicted against measured Y values, that is storage time from harvest. "b" stands for batch number and "d" for storage days

3. RESULTS AND DISCUSSION

The sensory results in Figure 1 showed a general trend that the intensity of all the attributes increased with storage time. The changes with time were most evident for those attributes such as skin odor and slice odor, which normally hinted the earliest sign of spoilage for fish raw materials. The results were in good agreement with the findings for other species, such as squid (Mai, 2013b). Other attributes such as slice white muscle color, slice red muscle color also showed clear changes with time.

The Quality Index (QI) formed a linear relationship with storage time (Figure 3): QI = 1.24*day - 2.1354 (R^2 = 0.9481). This is in accordance with the findings from other studies that the QI is linearly correlated with storage time (Sveinsdottir, Hyldig *et al.*, 2003, Cyprian, Sveinsdóttir *et al.*, 2008, Mai, Martinsdóttir *et al.*, 2009, Sykes, Oliveira *et al.*, 2009, Mai, 2012, Mai, 2013a).

PLS-R results (Figure 2) gave a standard error of cross validation (SECV) of 1.26. As QI was the sum of nine attributes, the measurement error may be assumed to be normally distributed and the prediction can be considered as t-distributed. Therefore, SECV x t (df = 8) = 1.26 x 2.306 = 2.906 could be regarded as a 95% confidence interval. So it can be assumed that the QI (if 3 portions of fish from the same lot were assessed) could be used to predict storage time with the precision of ± 1.5 days. The prediction precision of QIM was similar to those of other fish species such as (*Salvelinus alpinus*): ± 1,3 days (using 5 samples/batch/evaluation) (Cyprian, Sveinsdóttir *et al.*, 2008), *Sepia officinalis*: ± 1 ngày (using 5 cuttlefish/batch/evaluation) (Sykes, Oliveira *et al.*, 2009), fillets of *Pangasius hypophthalmus*: ± 1,67 days (using 3 fillets/batch/evaluation) (Mai, 2012), *Todarodes pacificus*: ± 1,05 days (using 7 squid/batch/evaluation) (Mai, 2013a).

The QDA results indicated that the maximum storage time was eight days, when rancid odor reached a score higher than 20 (Mai, 2013b).

QI linearly increased with time while Torry score linearly decreased during storage. Normally, at the end of shelf-life determined by QDA, QI reaches about 75% of the maximal total QI (i.e., 21 in this study) (Sykes, Oliveira *et al.*, 2009) and Torry score for fat fish species reaches a value of 5.5 (Martinsdóttir, Sveinsdóttir *et al.*, 2001). This was true for QIM, but not for Torry results in this study where at the end of shelf-life the Torry score remained as high as above 7 (at day 8) (Figure 3), revealing the advantage of QIM schemes developed for individual species and products over Torry ones developed just for lean or fat species in general.

TVB-N did not change significantly at the beginning of storage, but sharply increased after day 10 and surpassed 30 mg/100 g after 11 days of storage (Figure 4). This finding was in a good agreement with other studies that TVB-N level only clearly went up at the end of the storage when sign of spoilage became evident (Ólafsdóttir, 2005, Mai, Gudjónsdóttir *et al.*, 2011). In the study of Mai, Gudjónsdóttir *et al.* (2011), TVB-N in cod loin surpassed 35 mg/100 g, which is the acceptable level of TVB-N in EU (95/149/EC), after 10 days of storage at 0.5 °C. In Vietnam, the authorized levels of TVB-N are not the same for all the fish species, e.g. 30 mg/100 g for squid (TCVN 8335:2010) and 25 mg/100 g for *Pangasius* (TCVN 8338:2010), which could be explained by the species characterization. Based on the results of this study, TVB-N authorized level for cobia might be 30 mg/100 g, which is in accordance with sensory and TVC results.

TVC slowly increased at the beginning of the storage and showed a sharp rise from day 8, reaching 2.8x10^6 CFU/g at day 10 (Figure 5), which surpassed the acceptable level of 10^6 CFU/g. This means the shelf-life of cobia portions at 0-2 °C was less than 10 days.

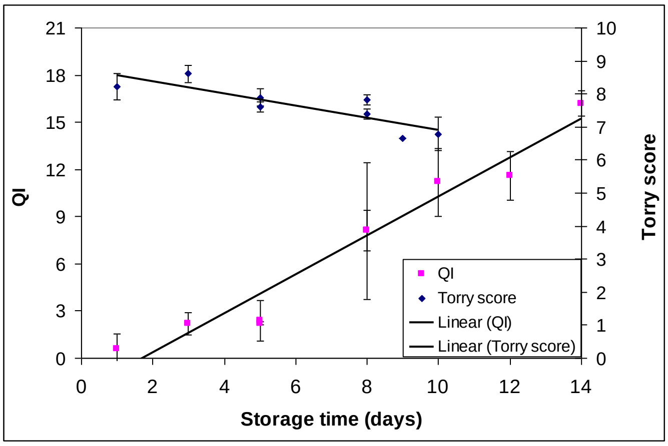

Figure 3. QI and Torry scores for cobia portions stored at 0-2 °C as a function of storage days

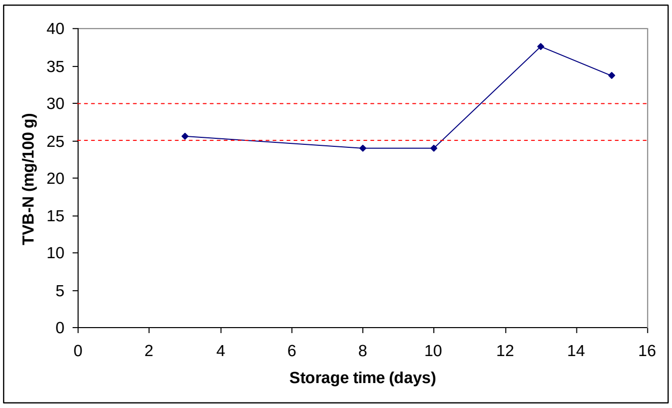

Figure 4. TVB-N changes during the storage of cobia portions at 0-2 °C

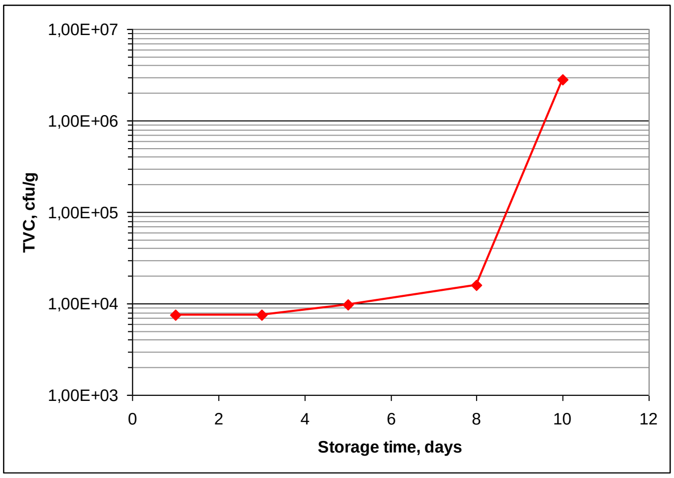

Figure 5. TVC changes during the storage of cobia portions at 0-2 °C

In summary, based on QDA, Torry, TVB-N and TVC analyses, it could be conclude that the shelf-life of cobia portions at 0-2 °C was eight days. This shelf-life was similar to those of other fish species such as eight days in ice for Atlantic herring (Mai et al., 2007) and cod fillet (Bonilla et al., 2007); eight days at 2 ± 2 °C for European cuttlefish (*Sepia officinalis, L.*) (Sykes, Oliveira *et al.*, 2009); but was shorter compared to 13-15 days at 1 °C for farmed tilapia (*Oreochromis niloticus*) (Odoli, 2009), 18 days in ice at 0-1 °C for *Lates calcarifer* fillet (Tran and Tran, 2011). The difference in shelf-life is due to certain factors such as biological variety of the species, handling methods, storage conditions, etc.

4. CONCLUSION

The QIM scheme for chilled-stored cobia portions could be used to predict the shelf-life of the fish stored at low temperatures with the precision of 1.5 days when three portions per batch were evaluated.

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REFERENCES

Bremner, A. (1985). A convenient easy to use system for estimating the quality of chilled seafood. Proceedings of the fish processing conference, New Zealand.

Bremner, H. A. and M. Sakaguchi (2000). "A critical look at whether 'freshness' can be determined." Journal of Aquatic Food Product Technology 9(3): 5-25.

Cyprian, O. O., K. Sveinsdóttir, H. Magnússon and E. Martinsdóttir (2008). "Application of quality index method (QIM) scheme and effects of short-time temperature abuse in shelf life study of fresh water arctic char (Salvelinus alpinus)." Journal of Aquatic Food Product Technology 17(3): 303-321.

Mai, N. T., E. Martinsdóttir, K. Sveinsdóttir, G. Olafsdóttir and S. Arason (2009). "Application of quality index method, texture measurements and electronic nose to assess the freshness of Atlantic herring (Clupea harengus) stored in ice." World Academy of Science, Engineering and Technology (WASET) 57: 371-377.

Mai, N. T. T. (2012). Development of A Quality Index Scheme for Sensory Evaluation of Chill-Stored Pangasius hypophthalmus Fillets. Traditional resources: Scientific approaches towards quality foods. , School of Food Science and Nutrition Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia.

Mai, N. T. T., M. Gudjónsdóttir, H. L. Lauzon, K. Sveinsdóttir, E. Martinsdóttir, H. Audorff, W. Reichstein, D. Haarer, S. G. Bogason and S. Arason (2011). "Continuous quality and shelf life monitoring of retail-packed fresh cod loins in comparison with conventional methods." Food Control 22(6): 1000-1007.

Mai, T. T. N. (2013a). Developing a quality index scheme for chilled Japanese flying squid (Todarodes pacificus). 5th Cold Chain Management CCM Workshop, University Bonn, Bonn, Germany.

Mai, T. T. N. (2013b). "Development of sensory attributes for farmed cobia (Rachycentron canadum) used in quantitative descriptive analysis (QDA)." Journal of Fisheries Science and Technology (Vietnam): 27-32.

Martinsdóttir, E., K. Sveinsdóttir, J. Luten, R. Schelvis-Smit and G. Hyldig (2001). Sensory evaluation of fish freshness, QIM.

Ólafsdóttir, G. (2005). Volatile compounds as quality indicators in chilled fish: evaluation of microbial metabolites by an electronic nose. Faculty of Science, University of Iceland and Icelandic Fisheries Laboratories, Reykjavík, Iceland.

Olafsdottir, G., E. Martinsdóttir, J. Oehlenschläger, P. Dalgaard, B. Jensen, I. Undeland, I. Mackie, G. Henehan, J. Nielsen and H. Nilsen (1997). "Methods to evaluate fish freshness in research and industry." Trends in Food Science & Technology 8(8): 258-265.

Shewan, J., R. G. Macintosh, C. Tucker and A. Ehrenberg (1953). "The development of a numerical scoring system for the sensory assessment of the spoilage of wet white fish stored in ice." Journal of the Science of Food and Agriculture 4(6): 283-298.

Stone, H. and J. Sidel (1985). Sensory evaluation practices, Academic Press, New York.

Sveinsdottir, K., G. Hyldig, E. Martinsdottir, B. Jørgensen and K. Kristbergsson (2003). "Quality Index Method (QIM) scheme developed for farmed Atlantic salmon (*Salmo salar*)." Food Quality and Preference 14(3): 237-245.

Sykes, A. V., A. R. Oliveira, P. M. Domingues, C. M. Cardoso, J. P. Andrade and M. L. Nunes (2009). "Assessment of European cuttlefish (*Sepia officinalis*, L.) nutritional value and freshness under ice storage using a developed Quality Index Method (QIM) and biochemical methods." LWT-Food science and technology 42(1): 424-432.

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SUSTAINABILITY LABELS: A KEY COMPONENT OF FOOD QUALITY? IMPACT OF FOOD-PROCESSING INFORMATION ON THE APPRECIATION OF BREAD.

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ABSTRACT

The environmental problem is causing growing concerns and the food industry is sometimes perceived as one of the main contributors to environmental degradation. But, at the same time, the rapidly growing world's population requires increased food production. In addition, the industry is becoming more environmentally conscious and so food companies are looking for new processes, called "clean processes," to reduce energy use, water consumption, CO_2 emission and waste generation, as well as decreasing production cost.

In parallel, consumers in a purchase situation are exposed to various types of information such as brand, price, packaging, product origin, nutritional values, etc., often mentioned by claims or labels. The question that naturally arises is: Is it necessary to communicate with consumers about the notion of clean food-processing? And if so, would this information modify their product quality perception?

The aim of this study was to explore the influence of communication about food-processing environmental impact on the global liking of food products for French consumers and to investigate the link with their knowledge about sustainability and behavior. To address this issue, a consumer test with two different industrial breads in two conditions (one blind and one with a food-processing labelling) was carried out with 209 consumers. At the end of the test, participants were administrated a questionnaire to assess their general knowledge and behaviors related to sustainability. Results show that the most preferred product in blind condition was perceived as better when presented with a clean process label, and was not affected by an energy-consuming process label. Conversely, the least liked product was not affected by a clean process label but was depreciated by a negative one.

These results suggest that the quality perceived by the consumer can be impacted by a labelling with information about sustainably.

Keywords: sustainability, clean food-processing, hedonic test.

1. INTRODUCTION

In 2002 the United Nations World Summit on Sustainable Development in Johannesburg declared that "fundamental changes in the way societies produce and consume are indispensable for achieving global sustainable development. All countries should promote sustainable consumption and production patterns." Food production and consumption are mainly concerned by these recommendations. Indeed the food industry is a large user of key resources: water, raw material, and energy. At the same time, the demand for food is growing because of the rapid growth of the world's population and the increasing affluence of emerging economies such as China and India. From an industrial point of view, the challenge for factories is to continue to achieve economic success whilst saving energy, limiting the environmental footprint of industrial processes, and reducing the wastes produced during the transformation process. From a consumer point of view, changes in consumption behavior imply that consumers have the necessary information available to help them to make more sustainable food choices. There is an increasing public awareness of the environmental impact of food consumption. Even if food price and consumer income are still playing a key role in influencing the purchasing decisions of food consumers, the sustainable manner by which the food products has been manufactured is becoming a food quality attribute, in the same way as safety, health, nutrition, taste, or convenience (Torjusen, Lieblein *et al.*, 2001). According to a survey by the European Commission in 2012, 84% of European citizens said that the product's impact on the environment is "very important" or "rather important" when making purchasing decisions. This puts the environment in the third place among product attributes that consumers say influence their purchasing decisions, after quality (97%) and price (87%). In addition, more than three-quarters of respondents were willing to pay more for environmentally-friendly products if they were confident that the products are truly environmentally-friendly (77%).

Aware of all these issues, public authorities are urging food companies to develop sustainable strategies and to communicate about it to the consumers. This is why environmental labelling is the target of increasing scientific and general public studies dealing with the best ways to set up this new sustainable communication tool. The dual purpose of this action is to include an environmental component in consumer purchasing choices and to provide the entire food production and distribution chain with new indicators to promote and intensify their efforts to produce more sustainably. The problem is that consumers (48% of the European citizens) are confused by the stream of incomparable and diverse environmental information and only just over half of them generally trust producers' claims about the environmental performance of their products (Commission, 2013). In this context and to tackle the problem of fragmentation in the provision of environmental information, the European Commission has introduced the Single Market for Green Products initiative in April 2013. The initiative advises companies to adopt the Product Environmental Footprint (PEF) in order to provide consumers with reliable information that can be compared with information provided by other companies. These methods are based on Life Cycle Assessment (LCA), a tool that strives to identify the environmental impacts of a product over its entire life, from the extraction of raw materials to the end of life of the product.

In this context, the scientific community is examining the different angles of sustainable consumption and tries to understand the results of the public surveys on food consumer's perception of sustainability labelling. The two most studied sustainability labels are Fair Trade and organic ones, using a very large range of products, *e.g.* coffee (De Pelsmacker, Driesen *et al.*, 2005, Loureiro and Lotade, 2005), yogurts (Laureati, Jabes *et al.*, 2013, Lee, Shimizu *et al.*, 2013), chocolate (Didier and Lucie, 2008), cheese (Napolitano, Braghieri *et al.*, 2010a), meat (Gil, Gracia *et al.*, 2000, Napolitano, Braghieri *et al.*, 2010b), bread (Kihlberg, Johansson *et al.*, 2005), eggs (Gil, Gracia *et al.*, 2000, Zander and Hamm, 2010), pineapple (Poelman, Mojet *et al.*, 2008) or beer (Caporale and Monteleone, 2004). A part of this literature focuses on food consumers' understanding of sustainability concept and/or labels (Hoogland, de Boer *et al.*, 2007, Schleenbecker and Hamm, 2013, Sirieix, Delanchy *et al.*, 2013, Zepeda, Sirieix *et al.*, 2013, Ginon, Ares *et al.*, 2014, Grunert, Hieke *et al.*, 2014, Hartikainen, Roininen *et al.*, 2014, Pomarici and Vecchio, 2014). In summary, these studies suggest that, for most people, sustainability is quite an abstract notion that refers more to the environmental dimension than to the ethical dimension. There are large differences the information provided by sustainability labels, some being better self-explanatory than others (Carbon footprint and Animal welfare). Moreover, familiarity with these labels seems to be important for the consumers' confidence but is not necessarily correlated with a better understanding of the meaning of the label. A lot of studies focused on willingness to pay for sustainability labelled food products (*e.g.*, De Pelsmacker, Driesen *et al.* (2005); Kimura, Wada *et al.* (2010); Loureiro and Lotade (2005); Napolitano, Braghieri *et al.* (2010a); Napolitano, Braghieri *et al.* (2010b); Gil, Gracia *et al.* (2000); Lee, Shimizu *et al.* (2013); Pomarici and Vecchio (2014); Didier and Lucie (2008); Zander and Hamm (2010)). Despite the variety of studied labels and products, the general trend from the results is that consumers are willing to pay more for products presented with a sustainability label. However, this global effect depends on several parameters, especially the label by itself (Loureiro and Lotade, 2005, Didier and

Lucie, 2008, Pomarici and Vecchio, 2014), the product and the consumers' attitudes towards sustainable issues (Gil, Gracia *et al.*, 2000). Conversely, fewer studies deal with this issue of perception of sustainability food labels by introducing a tasting phase in their experimental design in order to evaluate the effect of sustainability information or label on consumers' liking (Johansson, Haglund *et al.*, 1999, Caporale and Monteleone, 2004, Kihlberg, Johansson *et al.*, 2005, Grankvist and Biel, 2007, Poelman, Mojet *et al.*, 2008, Napolitano, Braghieri *et al.*, 2010a, Napolitano, Braghieri *et al.*, 2010b, Laureati, Jabes *et al.*, 2013, Lee, Shimizu *et al.*, 2013). Conclusions are globally the same as for willingness to pay: whatever the product (e.g., yogurt, pineapple, bread, tomatoes), a sustainability label enhanced the liking of the product. Most of the time, liking is measured in three conditions—blind, expected and informed—and the results are interpreted in terms of confirmation or disconfirmation of the hedonic expectation (Anderson, 1973, Deliza and MacFie, 1996). As for the willingness to pay for sustainability labelled food products, the results can also vary according to consumers' sensitivity to sustainable issues. For example, Laureati, Jabes *et al.* (2013) found that non-sustainable consumers had a better appreciation of non-organic yogurts compared to organic yogurts whereas sustainable consumers evaluated organic and conventional yogurts in the same way.

Today, environmental efforts made by the food industry do not concern anymore only organic or Fair Trade productions but each of the different sub-processes that use resources and produce unwanted outputs. Many food industries opt for more green technologies to produce their products such as the use of enzymes as biological catalysts, microwave, radio-frequency heating or high pressure processing instead of thermal treatments for microbiological control or else elimination of drying operation that is very energy-consuming (Boye and Arcand, 2013). Either because they are forced to by legislations or as a direct result of the own initiatives, an increasing number of food industrials evaluate their activities in order to report, improve and market their environmental efforts. In this context, one can ask if it is valuable for food companies to communicate to consumers about their use of green food manufacturing processes and if this kind of information would modify the quality perception of the food products by consumers as it is the case for organic or Fair Trade information. To address these issues, a hedonic test on sandwich breads was carried out in two conditions (blind and with a food-processing label). So we tested whether informing the consumers about the positive or negative environmental impact of the food manufacturing technology used to produce the sandwich breads they tasted could modify their liking degree of the products. The same consumers were also administrated a questionnaire devised to explore their general knowledge and behaviors related to sustainability, with the aim to explore whether these factors could influence the hedonic ratings.

2. MATERIALS AND METHODS

2.1. Assessors

Two hundred and nine (129 females and 80 males) participants aged between 18 and 76 years (M = 41.1; SD = 14.6) were recruited among a database of consumers living in Lille (France) and its suburbs. No specific recruitment criterion was used.

2.2. Products

Two commercial industrial breads were used as experimental samples (Regular American Sandwich, Harrys and Regular Special Sandwich, McEnnedy, Lidl). Products were purchased in a local supermarket and for a given brand all samples were chosen from the same batch and across the two brands the difference in shelf-life was no more than four days. Bread samples were stored and served at room temperature. For the tasting phase, bread slices were divided into four squares and one sample corresponded to a quarter of slice.

2.3. Procedure

2.3.1. Hedonic test

Assessors took part individually in the test in a single session lasting around 20 min. The test was conducted in the sensory laboratory of the ISA Group (Lille, France) designed according to ISO guidelines (ISO, 1988). Data were collected using a form built with Google Drive 2014 (Google Inc., Mountain View, United States).

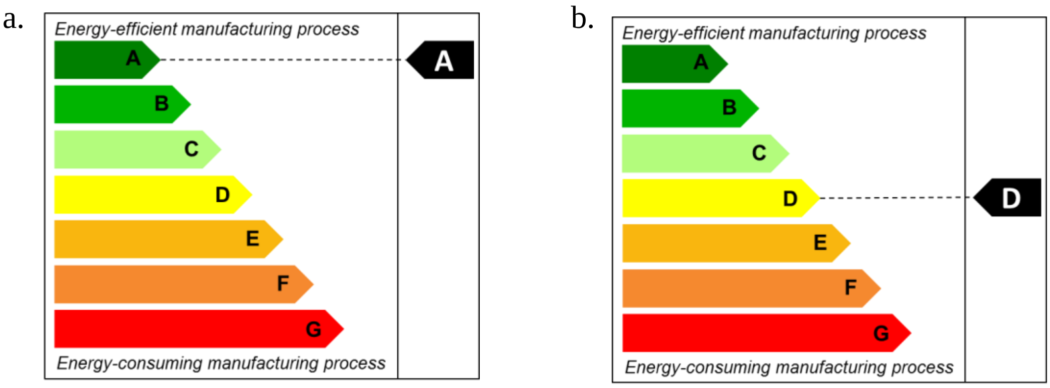

Figure 1. Positive (a.) and negative (b.) food-processing label

The two toast breads were first evaluated under blind condition and then under informed condition. Assessors were first asked to rate the liking degree of the two products under blind condition (*i.e.,* without any information about the product) using an unstructured scale ranging from 0 (I don't like it at all) to 10 (I like it a lot). Then, using the same scale, the assessors were asked to rate their liking degree of the two products, presented two times each: one time with a "positive" food-processing label (Figure 1a.) and one time with a "negative" food-processing label (Figure 1b.). The labels were shown on a screen, with the following sentence: "Below is the environmental classification of the manufacturing process of sliced bread #123. This classification represents energy and water consumption, and CO_2 emissions." The assessors were not informed that there were only two products they tasted several times.

The presentation order of the samples was balanced among the assessors for the blind condition on the one side and for the informed condition on the other side according to a Latin Square. Mineral water was available for assessors to rinse between samples.

2.3.2. Questionnaire

At the end of the tasting phase, assessors were administered a questionnaire designed to evaluate their behavior and their general knowledge about sustainability. The questionnaire was inspired from other surveys searching for the same objectives (Laureati, Jabes *et al.*, 2013, Grunert, Hieke *et al.*, 2014, Hartikainen, Roininen *et al.*, 2014) and designed to be answered in no more than 10 minutes. The structure of the questionnaire could be divided in 5 different parts (a through e) as follows: a) demographic questions, b) consumption habits of toast bread, c) criteria of food choice, d) declarative sustainable behavior and e) knowledge about sustainability. Each section is detailed below.

a) For the demographic characteristics consumers were presented six closed questions asking about gender, age, occupation, number of people in their household and number of children.

b) For consumption habits, the questions were: Do you personally eat sliced bread? If so, how often do you eat sliced bread?, How often do you buy sliced sided bread for your household? At what time of the day do you eat sliced bread? [possible answers: at breakfast, alongside my meals (except breakfast), as a snack, as a nibble for aperitif, as a sandwich, as a toastie or croque-monsieur].

c) To evaluate the importance of different criteria for food choice, the assessors were asked to give the degree of importance of 20 attributes (see Table 2) when shopping for groceries, by choosing between *not at all important*, *slightly important*, *important* and *very important* for each of them.

d) For declarative sustainable behavior, the assessors answered the following question: "Over the 3 last months, how often have you performed the following actions?" For 19 different actions (see Table 3), they chose the frequency among *Never*, *Rarely*, *Sometimes*, *Often* and *Always*.

e) To explore assessors' general knowledge about sustainability, assessors answered 10 multiple-choice questions choosing to cover all the aspects of this notion.

3. RESULTS

3.1. Global panel: hedonic test

Data from the hedonic test were first analyzed for the whole panel (209 assessors, Figure 2) using a three-factor analysis of variance (ANOVA) on the hedonic ratings to evaluate the effect of assessor, product (*Harrys* vs. *Lidl*), label (*without* vs. *positive* vs. *negative*) and the two-way interaction product × label. These three factors were entered in the model as within-subject variables.

This analysis revealed significant effects for all the factors and for the interaction (Table 1). The Harrys product (M = 6.48 ± 2.03) is globally more appreciated than the Lidl product and products with the positive label (M = 6.21 ± 2.17) obtained better marks than products with the negative label (M = 5.81 ± 2.18) or without any label (M = 5.62 ± 2.23). Because the interaction product × label was significant, two two-factor ANOVAs were carried out with assessor and label (*without* vs. *positive* vs. *negative*) as factors and the hedonic ratings as dependent variable for Harrys and for Lidl respectively. Both ANOVAs showed significant effects of the label factor [$F(2,416) = 35.56$, $p<.0001$ for Harrys; $F(2,416) = 3.64$, $p < .0001$ for Lidl]. Harrys bread with the positive label (M = 7.02 ± 1.77) was more appreciated than when presented with the negative label (M = 6.60 ± 1.93), which was itself more appreciated than when presented without any label (M = 5.81 ± 2.18). For the Lidl bread, there was no difference of appreciation between the positive label (M = 5.43 ± 2.27) and the presentation without any label (M = 5.39 ± 2.23) but both obtained better marks than the negative label (M = 5.02 ± 2.12).

Table 1. Results of the three-way ANOVA

Factor	F (df factor/df error)	p
Assessor	3.19 (208/1040)	< .0001
Product	141.18 (1/1040)	< .0001
Label	11.76 (1/1040)	< .0001
Interaction product×label	16.21 (2/2040)	< .0001

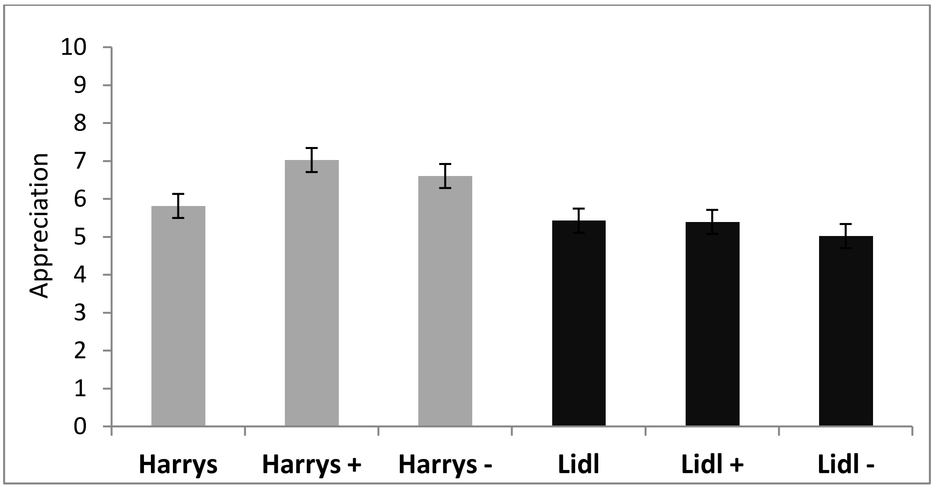

Figure 2. Mean hedonic ratings and error standard for the 209 assessors for Harrys and Lidl products when presented without any label, with the positive label (+) and with the negative label (-).

3.2. Global panel: questionnaire

3.2.1. Self-reported food choice criteria

The mean score of the assessors to the question "When shopping for groceries, which criterion are important to you?" (with 0 = "Not at all important", 1 = "Slightly important", 2 = "Important" and 3 = "Very important") are given in Table 2. The results revealed that taste is the most important purchase criterion with 99% of the respondents declaring that this item is important or very important. Then come quality (97.1%), food safety (88.5%) and price (88.0%). Sustainability items are less important, the first one—methods of raising animals— coming at the 11th place out of 20 items with 64.% of the respondents considering it as important or very important. Then come country of origin (62%), ability to recycle the packaging (57%), environmental (59%) and ethical (58%) impacts which are not major factors in consumers' purchasing decision, as well as organic status of the food products which is the second to last criterion with only 44% of the assessors declaring that it is important or very important.

3.3. Declarative sustainable behavior

The mean scores of the consumers to the question "Over the 3 last months, how often have you perform the following actions?" (with 0 = "Never," 1 = "Rarely," 2 = "Sometimes," 3 = "Often," and 4 = “Always”) are reported in Table 3. As shown, “Recycling waste” is the most regular sustainable action with 94% of the respondents declaring that they often or always recycle their waste. The next two actions regularly performed by the consumers are buying seasonal products and switching off appliances with standby (respectively 78% and 71% of the respondents declared to have performed these two actions often and always over the last three months). We can observe that the four non-sustainable actions (NS in Table 3) are among the less performed ones. Only 10% of the respondents declared buying often or always exotic food over the last three months and less than 30% of them have taken a bath, used a clothes dryer or left the TV on standby.

Table 2. Self-reported food choice criteria. (N = 209)

“When shopping for groceries, which criteria are important to you? Indicate the degree of importance on the scale below.”
0 = “Not at all important” and 3 = “Very important”.

Criterion	Mean	Std. Deviation
Taste	2.76	0.49
Quality	2.64	0.57
Best before / use by date	2.38	0.76
Food safety	2.31	0.71
Price	2.31	0.74
Health and nutritional benefits	2.20	0.72
Ingredients list	2.02	0.80
Nutritional values	1.93	0.82
Ease	1.91	0.67
Quantity/size of products	1.88	0.78
Methods of raising animals	1.80	0.93
Familiar product	1.77	0.79
Country of origin	1.73	0.91
Ability to recycle the packaging	1.69	0.93
Brand	1.69	0.86
Environmental impact	1.67	0.87
Ethical impact	1.61	0.81
Allergy information	1.59	1.07
Organic status	1.35	0.95
Cooking instructions	1.33	0.90

3.4. Sustainability knowledge

Concerning the sustainability knowledge of the respondents, Table 4 shows that scores vary from 28% to 90% of correct answers, indicating a quite large variability in the questions’ difficulty. This variability is interesting for categorizing respondents according to their knowledge of the sustainability notions.

Table 3. Self-reported sustainable behavior (N=209)

Actions	Mean	Std. deviation
Recycling waste (S)	3.65	0.73
Buying seasonal products (S)	2.97	0.77
Switching off appliances with standby (S)	2.93	1.05
Civering the pot when boiling water (S)	2.80	1.37
Using the paper on both sides (S)	2.78	1.09
Buying local food (S)	2.53	0.87
Using public transportation (S)	2.52	1.29
Taking back your unused or expired pharmaceuticals to a pharmacy (S)	2.38	1.53
Giving or reselling unused objects which still work (S)	2.33	1.12
Avoiding GMO food (S)	1.95	1.43
Buying eco-refills (S)	1.85	1.16
Eating organic food (S)	1.67	1.06
Buying exotic food (NS)	1.65	0.76
Avoiding preservatives in food (S)	1.56	1.18
Leaving the TV on standby (NS)	1.50	1.44
Buying Fair Trade products (S)	1.48	1.01
Using a clothes dryer (NS)	1.47	1.42
Refuse junk mail and advertising circulars (S)	1.43	1.58
Taking a bath (NS)	1.33	1.28

“Over the 3 last months, how often have you performed the following actions?”
0 = “Never”, 4 = “Always”; S = sustainable action, NS = non-sustainable action

A Pearson’s correlation coefficient calculated between the assessors’ age and the sustainability knowledge score (r = –0.218, p = .002) indicates that younger consumers have more knowledge about sustainability than older consumers. No correlation between assessors’ sex and sustainability knowledge was found.

3.5. Relation between food choice criteria, sustainable behavior and sustainability knowledge

In order to find whether a relation existed between the three measures of sustainability sensitivity of the questionnaire (food choice criteria, sustainable behavior and sustainability knowledge), we first computed a new score for the food choice criteria parameter and for the sustainable behavior. For the food choice criteria, we considered only the six sustainable food choice criteria, namely *country of origin*, *methods of raising animals*, *ability to recycle the packaging*, *environmental impact*, *ethical impact* and *organic status*, and for each assessor we computed the mean score over these six criteria. So, the higher the food choice score, the more the assessor has a sustainable behavior regarding this point. For sustainable behavior, we re-calculated the mean score over the 19 proposed actions for each assessor by inversing the score of the four non-sustainable actions (buying exotic food, taking a bath, leave the TV on standby, using a clothes dryer). So here again, the higher the behavior score, the more sustainable the assessor reported to be. No transformation was made for the knowledge score which conveys the knowledge level of the assessors. The higher this score, the more the assessor knows about sustainability. Then Pearson's correlation coefficients were computed between these three new scores two by two. The food choice score and the one concerning the sustainable behavior are highly correlated ($r = .702$, $p < .0001$) a pattern meaning that assessors who declared that sustainable food choice criteria are important for them also self-reported regularly perform sustainable actions. On the contrary, there is no correlation between the knowledge score and neither the food choice score ($r = .014$, $p > .05$) nor the behavior score ($r = .059$, $p > .05$).

Table 4. Percentages of correct answers to the 10 sustainability knowledge questions (N=209)

Questions	Correct answers (%)
Is petrol a renewable energy?	90.0%
According to you, Fair Trade is mostly relevant to which type of product?	83.7%
What did the countries who signed the Kyoto protocol agreed to do?	83.3%
Deforestation contributes to climate change because…	77.5%
When recycled, plastic containers and transparent bottled can be turned into…	72.7%
What are the 3 pillars of sustainability?	62.7%
Which product requires 33 000 liters of water for its manufacture?	59.3%
How many wind turbines are needed to reach the power of a small nuclear power station?	49.3%
How many humans suffer of malnutrition around the world?	34.0%
What proportion of house refuse is made of packaging?	28.2%

Besides, Pearson's correlation coefficients calculated between the assessors' age on one hand and the self-reported food choice criteria score ($r = .311$, $p < .0001$), and sustainable behavior score ($r = .234$, $p = .001$) on the other hand, showed that older consumers are more sensitive to sustainability than younger consumers, with a larger importance of sustainable food choice criteria and more sustainable actions. Moreover, women report having more sustainable actions than the men [$F(1,197) = 19.93$, $p < .0001$].

3.6. Assessors' segmentation according to the global sustainable behavior

Because food choice scores and sustainable behavior score were correlated, we fused in a unique score now called *global sustainable behavior* (GSB), considering that the food criterion reported by the assessors conveyed their behavior in a purchasing situation. The GBS score was calculated as the mean of the food choice and the behavior scores, both rescaled to a maximum of 10, for each assessor. Then we categorized the assessors into three subgroups according to their GSB, using the same method as Laureati, Jabes *et al.* (2013). The assessors with a GSB score within the 25th percentile of the distribution ($Q_1 = 4.46/10$) were defined as "non-sustainable" (54 assessors), the ones with a GSB score over the 75th percentile ($Q_3 = 6.89$) were defined as "sustainable" (55 assessors) whereas the rest of the assessors were defined as "uncertain" (100 assessors). Then the hedonic ratings of sandwich breads were computed for each group (Figure 3) with a four-factor ANOVA considering *assessors* (nested within GSB level), *GSB level* (non-sustainable, uncertain and sustainable), *product* (Harrys and Lidl), *label* (without, positive and negative) and the two two-way interactions *product × GSB level* and *label × GSB level* as factors and hedonic scores as dependent variable.

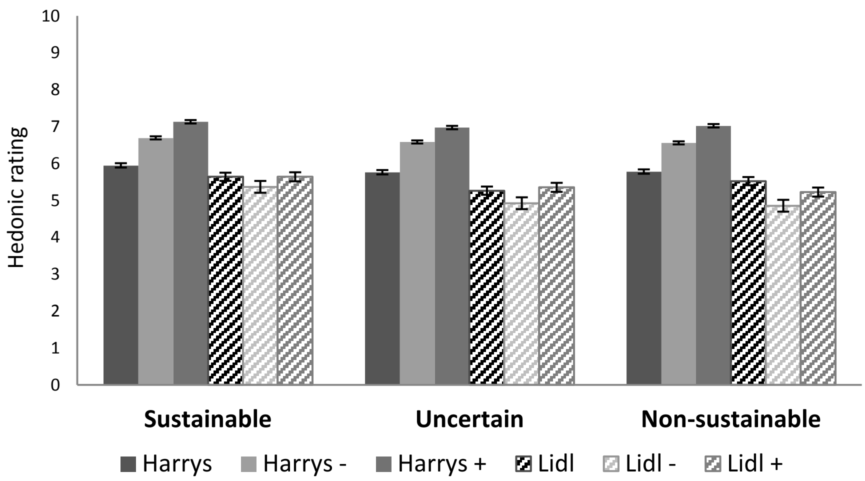

Figure 3. Mean hedonic ratings and standard errors of the sustainable, uncertain and non-sustainable groups of consumers for Harrys and Lidl products when presented without any label, with the positive label (+) and with the negative label (-).

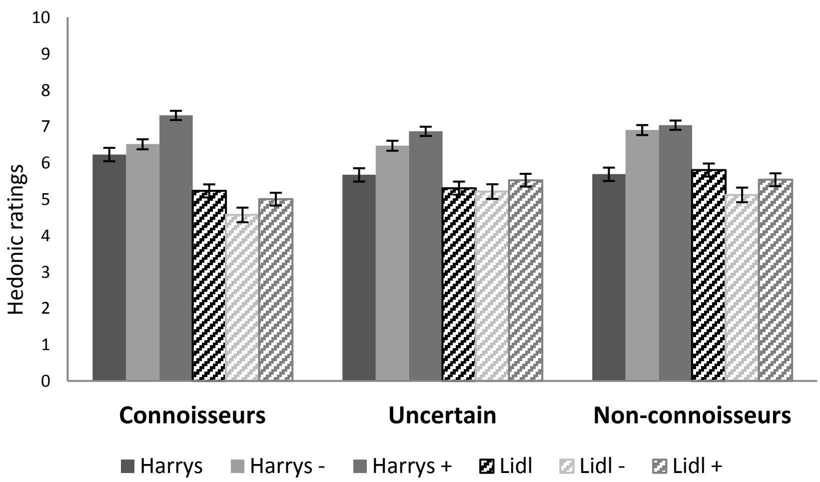

Figure 4. Mean hedonic ratings and standard errors of the connoisseurs, uncertain and non-connoisseurs groups of consumers for Harrys and Lidl products when presented without any label, with the positive label (+) and with the negative label (–).

ANOVA results showed a significant effect of the product [$F(1,1038) = 276.33$, $p = .0018$] and of the label factors [$F(2,1038) = 9.92$, $p = .0001$] but no interaction are significant, confirming the observations of the Figure 3 and indicating that the GSB level has no effect on the hedonic appreciation of sandwich breads.

3.7. Assessors' segmentation according to the sustainability knowledge level

Assessors were then grouped in three groups according to their sustainability knowledge score according to the same method as for the GSB score. The assessors with a sustainability knowledge score within the 25th percentile of the distribution (Q_1 = 5/10) were defined as "non-connoisseur" (60 assessors), the ones with a score over the 75th percentile (Q_3 = 8/10) were defined as "connoisseurs" (53 assessors) whereas the rest of the assessors were defined as "uncertain" (96 assessors). The hedonic ratings of sandwich breads for each consumers' group are shown Figure 4. To study the influence of the sustainability knowledge level on the appreciations, we carried out a four-factor ANOVA considering *assessors* (nested within sustainability knowledge level), *sustainability knowledge level* (non-connoisseurs, uncertain and connoisseurs), *product* (Harrys and Lidl), *label* (without, positive and negative) and the two two-way interactions *product × sustainability knowledge level* and *label × sustainability knowledge level* as factors and hedonic scores as dependent variable.

The results showed a significant effect of interaction *product × sustainability knowledge level* [$F(1,1038) = 16.08$, $p = .0075$]. Whatever the label, the connoisseurs globally appreciated the Harrys bread (M = 6.68) more than the uncertain (M = 6.33) and non-connoisseur consumers (M = 6.53) and conversely, they appreciated less the Lidl bread (M = 4.93) than the two other consumers' groups (M = 5.34 for uncertain and M = 5.48 for non-connoisseurs). The *label × sustainability knowledge level* interaction was no significant, indicating that the level of sustainability knowledge do not influence the way the consumers perceived the label.

4. DISCUSSION

The aim of the present study was to evaluate the influence of information on the environmental impact of the food manufacturing process on the appreciation of a convenience food (*i.e.,* sandwich bread). This kind of approach has been already used to study consumers' perception of different sustainability labels, especially organic and Fair Trade labels (*e.g.*, Laureati, Jabes *et al.* (2013); Loureiro and Lotade (2005); Napolitano, Braghieri *et al.* (2010a); Napolitano, Braghieri *et al.* (2010b); Poelman, Mojet *et al.* (2008)). In an International and European context of sustainable development, public authorities as well as consumers are increasingly demanding for clear communication on the environmental impacts of the food products. Then the kinds of information to communicate as well as the way to do it are important issues for food industrials. The food manufacturing process is an important step in the production of a food item and is more and more progressing by introducing green technologies which help reducing the needed resources and the unwanted waste. However, this production step is unknown by the food consumers, so studying the impact a communication on environmental impact of the food processing on the appreciation of consumers has a great interest for industrials, as well as for consumers and public authorities.

The first important result is that taste remains an important factor for consumers liking of sandwich bread. Even when presented with a negative environmental information (negative label), the Harrys bread is not less appreciated than when presented in blind condition (without any information). This effect was already found by other authors (Torjusen, Lieblein *et al.*, 2001, Kihlberg, Johansson *et al.*, 2005, Didier and Lucie, 2008) and is supported by the results of the question on the food choice criteria when shopping for groceries. Taste stands out as the most important criterion for the consumers, at the quite same level as quality. However, when presented with a positive label, the Harrys bread sees its hedonic mark improved compared to the blind condition, and conversely, the hedonic score of the Lidl bread presented with a negative label is lower than in blind condition. These results indicate that the information about environmental impact of the food-processing influences consumers' liking, either by improving it when the product is perceived as good or by decreasing it when the product is perceived as less good. This is not completely in accordance with previous results on tomatoes, showing that the best liked tomatoes maintained their hedonic scores while the least liked tomatoes scored higher for liking when declared to be ecologically grown (Johansson, Haglund *et al.*, 1999).

When studying the hedonic scores by groups of assessors, no difference of liking appears between the groups, that the categorization was made according to their sustainability knowledge level or to their global sustainable behavior. This result is not in the same way as previous studies which observed an influence of the engagement in environmentally friendly activities on the perception of sustainability-labelled food products (Gil, Gracia *et al.*, 2000, Kihlberg, Johansson *et al.*, 2005, Lee, Shimizu *et al.*, 2013, Grunert, Hieke *et al.*, 2014, Pomarici and Vecchio, 2014). Laureati, Jabes *et al.* (2013) showed that sustainable consumers have a higher expectation towards organic yogurts than non-sustainable assessors. Gil, Gracia *et al.* (2000) found that only likely (*i.e.* concerned with natural food consumption, life equilibrium and health care) and actual organic food consumers showed positive attitudes towards organic foods and were willing to pay a premium for them. Also Kihlberg, Johansson *et al.* (2005) observed that consumers reporting the highest frequency of buying organic food showed the highest enhancement of liking when informed that the tasted sample had organic origin. Similar effects were found by Schuldt and Hannahan (2013) who observed that participants low in environmental concern perceive organic products as having inferior taste quality. Our results could be due to our questionnaire which does not allow discriminating sufficiently between the sustainable behavior and sustainability knowledge of our consumers. However, other works (*e.g.,* Laureati, Jabes *et al.* (2013); Schuldt and Hannahan (2013)) have observed difference between consumers' perception of sustainability labeling food products with the same kind of questionnaire. Another believable explanation is linked to the nature of the environmental information itself. The way foods are processed to transform raw materials into value-added foods and ingredients is unknown to the consumers. So it is likely that the assessors did not understand to what notion the food-processing label referred to, especially as no information concerning food process is communicated to the food consumers at the moment. Moreover, although French consumers are familiar with the energy label which is affixed to household appliance since 1995, this logo is not used for food products, conversely to Fair Trade, organic, Rainforest Alliance logos or various carbon index schemes.

Finally, the answers to the questionnaire highlight results in agreement with the literature, especially the fact that recycling waste is the most cited sustainable actions, as previously found by Laureati, Jabes *et al.* (2013) and Gil, Gracia *et al.* (2000). Also we found that respondents' sustainability knowledge is not linked to their reported sustainable behavior. This is not because consumers have theoretical knowledge on sustainability notions that they act in a sustainable manner in the everyday life. This result has been already found by others authors (Bulkeley, 2000, Barr, 2003). Redman and Redman (2014) refined that declarative knowledge alone do not predict increased participation in sustainable behaviors while procedural and social knowledge are good predictors of sustainable food behaviors. Moreover, we found that older consumers declared to be more engaged in sustainable actions, as previously reviewed by Wiernick, Wiernik, Ones *et al.* (2013) who indicated that older individuals appear to be more likely to engage with nature, avoid environmental harm, and conserve raw materials and natural resources. Gender is another socio-demographic variable that influences sustainable behavior as we found that women declared more environmental behavior than male, as previously showed by Awan and Abbasi (2013) or Zelezny, Chua *et al.* (2000), but conversely to Tan and Lau (2009).

To conclude, the present experiment corroborates previous studies showing that sustainability labels are not major criteria in consumers' food choice. From a marketing point of view, a green label could be an attractive feature for consumers but only if the food item shows a good sensory quality originally. Moreover, the application of these sustainability labels on the food products will certainly require to be accompanied by a communication campaign to explain the label signification and origin to the consumers, as some environmental impacts of the products (*e.g.* food manufacturing process impacts) are more difficult to comprehend than others.

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REFERENCES

Anderson, R. E. (1973). "Consumer dissatisfaction: the effect of disconfirmed expectancy on perceived product performance." Journal of marketing research: 38-44.

Awan, U. and A. S. Abbasi (2013). "Environmental Sustainability through Determinism the Level of Environmental Awareness, Knowledge and Behavior among Business Graduates." Research Journal of Environmental and Earth Sciences 5(9): 505-515.

Barr, S. (2003). "Strategies for sustainability: citizens and responsible environmental behaviour." Area 35(3): 227-240.

Boye, J. I. and Y. Arcand (2013). "Current trends in green technologies in food production and processing." Food Engineering Reviews 5(1): 1-17.

Bulkeley, H. (2000). "Common knowledge? Public understanding of climate change in Newcastle, Australia." Public understanding of Science 9(3): 313-334.

Caporale, G. and E. Monteleone (2004). "Influence of information about manufacturing process on beer acceptability." Food Quality and Preference 15(3): 271-278.

Commission, E. (2013). "Attitudes of Europeans towards building the Single Market for Green Products." Flash Eurobarometer 367.

De Pelsmacker, P., L. Driesen and G. Rayp (2005). "Do consumers care about ethics? Willingness to pay for fair-trade coffee." Journal of consumer affairs 39(2): 363-385.

Deliza, R. and H. J. MacFie (1996). "The generation of sensory expectation by external cues and its effect on sensory perception and hedonic ratings: a review." Journal of Sensory Studies 11(2): 103-128.

Didier, T. and S. Lucie (2008). "Measuring consumer's willingness to pay for organic and Fair Trade products." International Journal of Consumer Studies 32(5): 479-490.

Gil, J. M., A. Gracia and M. Sanchez (2000). "Market segmentation and willingness to pay for organic products in Spain." The International Food and Agribusiness Management Review 3(2): 207-226.

Ginon, E., G. Ares, L. H. E. d. S. Laboissière, J. Brouard, S. Issanchou and R. Deliza (2014). "Logos indicating environmental sustainability in wine production: An exploratory study on how do Burgundy wine consumers perceive them." Food Research International 62: 837-845.

Grankvist, G. and A. Biel (2007). "The impact of environmental information on professional purchasers' choice of products." Business Strategy and the Environment 16(6): 421-429.

Grunert, K. G., S. Hieke and J. Wills (2014). "Sustainability labels on food products: Consumer motivation, understanding and use." Food Policy 44: 177-189.

Hartikainen, H., T. Roininen, J.-M. Katajajuuri and H. Pulkkinen (2014). "Finnish consumer perceptions of carbon footprints and carbon labelling of food products." Journal of Cleaner Production 73: 285-293.

Hoogland, C. T., J. de Boer and J. J. Boersema (2007). "Food and sustainability: Do consumers recognize, understand and value on-package information on production standards?" Appetite 49(1): 47-57.

ISO, I. (1988). "8589 Sensory analysis: general guidance for the design of test rooms." Ente Nazionale Italiano di Unificazione. Italy.

Johansson, L., Å. Haglund, L. Berglund, P. Lea and E. Risvik (1999). "Preference for tomatoes, affected by sensory attributes and information about growth conditions." Food Quality and Preference 10(4): 289-298.

Kihlberg, I., L. Johansson, Ø. Langsrud and E. Risvik (2005). "Effects of information on liking of bread." Food Quality and Preference 16(1): 25-35.

Kimura, A., Y. Wada, A. Kamada, T. Masuda, M. Okamoto, S.-i. Goto, D. Tsuzuki, D. Cai, T. Oka and I. Dan (2010). "Interactive effects of carbon footprint information and its accessibility on value and subjective qualities of food products." Appetite 55(2): 271-278.

Laureati, M., D. Jabes, V. Russo and E. Pagliarini (2013). "Sustainability and organic production: how information influences consumer's expectation and preference for yogurt." Food Quality and Preference 30(1): 1-8.

Lee, W.-c. J., M. Shimizu, K. M. Kniffin and B. Wansink (2013). "You taste what you see: Do organic labels bias taste perceptions?" Food Quality and Preference 29(1): 33-39.

Loureiro, M. L. and J. Lotade (2005). "Do fair trade and eco-labels in coffee wake up the consumer conscience?" Ecological Economics 53(1): 129-138.

Napolitano, F., A. Braghieri, E. Piasentier, S. Favotto, S. Naspetti and R. Zanoli (2010a). "Cheese liking and consumer willingness to pay as affected by information about organic production." Journal of dairy research 77(03): 280-286.

Napolitano, F., A. Braghieri, E. Piasentier, S. Favotto, S. Naspetti and R. Zanoli (2010b). "Effect of information about organic production on beef liking and consumer willingness to pay." Food Quality and Preference 21(2): 207-212.

Poelman, A., J. Mojet, D. Lyon and S. Sefa-Dedeh (2008). "The influence of information about organic production and fair trade on preferences for and perception of pineapple." Food Quality and Preference 19(1): 114-121.

Pomarici, E. and R. Vecchio (2014). "Millennial generation attitudes to sustainable wine: an exploratory study on Italian consumers." Journal of Cleaner Production 66: 537-545.

Redman, E. and A. Redman (2014). "Transforming sustainable food and waste behaviors by realigning domains of knowledge in our education system." Journal of Cleaner Production 64: 147-157.

Schleenbecker, R. and U. Hamm (2013). "Consumers' perception of organic product characteristics. A review." Appetite 71: 420-429.

Schuldt, J. P. and M. Hannahan (2013). "When good deeds leave a bad taste. Negative inferences from ethical food claims." Appetite 62: 76-83.

Sirieix, L., M. Delanchy, H. Remaud, L. Zepeda and P. Gurviez (2013). "Consumers' perceptions of individual and combined sustainable food labels: a UK pilot investigation." International Journal of Consumer Studies 37(2): 143-151.

Tan, B.-C. and T.-C. Lau (2009). "Examining sustainable consumption patterns of young consumers: is there a cause for concern." The Journal of International Social Research 2(9): 465-472.

Torjusen, H., G. Lieblein, M. Wandel and C. A. Francis (2001). "Food system orientation and quality perception among consumers and producers of organic food in Hedmark County, Norway." Food Quality and Preference 12(3): 207-216.

Wiernik, B. M., D. S. Ones and S. Dilchert (2013). "Age and environmental sustainability: a meta-analysis." Journal of Managerial Psychology 28(7/8): 7-7.

Zander, K. and U. Hamm (2010). "Consumer preferences for additional ethical attributes of organic food." Food Quality and Preference 21(5): 495-503.

Zelezny, L. C., P. P. Chua and C. Aldrich (2000). "New ways of thinking about environmentalism: Elaborating on gender differences in environmentalism." Journal of Social issues 56(3): 443-457.

Zepeda, L., L. Sirieix, A. Pizarro, F. Corderre and F. Rodier (2013). "A conceptual framework for analyzing consumers' food label preferences: An exploratory study of sustainability labels in France, Quebec, Spain and the US." International Journal of Consumer Studies 37(6): 605-616.

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EFFECT OF SENSORY ATTRIBUTE ON DRINKING YOGURT IN VIEWING OF THAI CONSUMER

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ABSTRACT

The objective of this research was to study how physicochemical and sensory qualities of drinking yogurt affected Thai consumer preference. Due to the limitation of serving sample for sensory evaluation, four brands of commercial drinking yogurt (brand A-D) were selected to be investigated. Two of these yogurts were the highest and the lowest market share brand in Thailand. It was found that the four drinking yogurts had a pH in the range of 3.67–3.93, total soluble solid (TSS) 17–20 °B, and %. acidity 0.53–0.61. The L* values of all samples were in the range 72.30–77.39, a* 0.75–7.81 and b* 13.69–20.02. The viscosity of all samples was thixotropic and had a viscosity at shear rate 63 s^{-1} in the range of 2.4–6.2 mPa.s. Brand C had the lowest pH and viscosity but was highest in % acidity, TSS, and b* value. Sensory evaluation of all samples was done by using a nine point hedonic scale with 150 teenage Thai consumers. Analysis of variance (ANOVA) and correlation analysis were used to analyze sensory data. The ANOVA indicated that brand C and D had significantly ($p < .05$) higher overall liking score than the others. From correlation analysis, it was found that the sourness, sweetness, flavor, viscosity were the main sensory attributes that affected overall liking. Viscosity strongly correlated with overall liking. Flavor strongly correlated with sweetness, sourness, and overall liking. Sweetness strongly correlated with flavor, sourness, and overall liking. Sourness strongly correlated with flavor, sweetness, and overall liking. Liking scores of brand C and D were significantly ($p < .05$) higher than the others for all attributes which affected the overall liking score. Based on this limited set of four samples, Thai teenager consumers appear to prefer products with low viscosity, high sourness, and high sweetness.

Keywords: *Drinking yogurt, sensory quality, physicochemical quality, correlation Analysis,*

1. INTRODUCTION

In recent years, health, convenience, and private labels have become key drivers of the world's fastest growing food and beverage categories. Consumers want food that is inherently healthy, yet easy to prepare and consume (Gonzalez, Adhikari *et al.*, 2011). Drinking yogurt, categorized as stirred yogurt with a low viscosity, is a growing area of interest based on its convenience, portability, and ability to deliver all of the health and nutritional benefits of stirred or set yogurt (Eder, 2003, Thompson, Lopetcharat *et al.*, 2007). It is among the most common dairy products consumed around the world, and its sensory attributes have a large effect on consumer acceptability (Saint-Eve, Lévy *et al.*, 2006). Drinking yogurt is a healthy drink that has been popular with consumers, because it has bioactive components inherent. Some drinking yogurt can also be specifically enhanced to reduce the risk of disease, such as drinking yogurt fortified with probiotics/prebiotics to maintain the health of the colon.

Of course, manufacturers want to produce products that consumers will buy. To survive the intense competition from other manufacturers, products must meet consumers' desires and needs. A consumer's food choice is a complex phenomenon affected by many factors. One way to approach these factors is to divide them into three main groups as Shepherd (1989) has done. The first group includes such product-related factors as physical and chemical properties, sensory quality (aroma, taste, texture) and product packaging. The second group includes consumer-related factors such as age, gender, education, and psychological factors, while the third group is environment-related, and includes economic, cultural, social factors, etc. All these factors influence consumers' food choices to a different degree depending on the product (Jaeger, 2006).

Sensory analysis is needed for manufacturers to know what sensory attributes affect the acceptance and judgment in product selecting. Among these sensory attributes, the overall liking is essential and determines the repeated consumption and purchase of the product (Lim, 2011). So, the objective of this research was to study how physicochemical and sensory qualities of four brands of commercial drinking yogurt (brand A-D, two of them had the highest and lowest market share) effected on Thai teenager consumer preference.

2. MATERIALS AND METHODS

2.1. Materials

Four brands of commercial drinking yogurt, brand A, B, C and D were selected from local merchants. Due to the limitation of serving sample for sensory evaluation, four brands of commercial drinking yogurt (brand A-D) were selected. All of them were different in color, odor, flavor, sourness, sweetness, and viscosity. One brand had the highest, and another had the lowest market share.

2.2. Physicochemical properties

The drinking yogurts were investigated for physicochemical properties including pH, Total Soluble Solid (TSS: °brix), and acidity (%lactic acid, AOAC 2005). The color parameters L* (lightness), a*(red–green axis) and b* (yellow–blue axis) were determined by using a colorimeter (Gardner). A standard ceramic white was used as a blank. The viscosity was determined by using a Rheometer (Physica, model MCR 300), with cylindrical probe (DG 26.7) at a controlled temperature of 25 ± 1°C. The flow behavior was measured by the Power Law model ($\sigma = K\gamma^n$), where σ shows shear stress (Pa), γ is shear rate (s^{-1}), and K and n are a consistency factor ($Pa.s^n$) and the flow behavior index, respectively. Viscosity values in the upward viscosity/shear rate curves at a shear rate of 63 s^{-1} were taken as the apparent viscosity. All determinations were repeated at least three times independently.

2.3. Sensory evaluation

Sensory evaluation of all samples was performed using a nine point hedonic rating scale (1-dislike extremely; 9-like extremely) with 150 Thai teenagers. The samples were codified and served to the judges in plastic cups (50 mL), at 4 ± 1°C. Water and cream crackers (Ping Pong Brand, Malaysia) were provided for mouth rinsing between samples.

2.4. Statistical analysis

Data of physicochemical properties were analyzed by one-way analysis of variance (ANOVA), and LSD test (analyses were performed with SPSS 11.0). The sensory data were analyzed by ANOVA and correlation analysis in order to identify the sensory attributes that influence the Thai teenager consumer preference (analyses were performed with XLSTAT, version 2006).

3. RESULTS AND DISCUSSION

3.1. Physicochemical properties

Physicochemical properties of four brands of commercial drinking yogurt are shown in Table 1. The pH of the four brands were in a range of 3.67 – 3.93. The pH of brand A was the highest and brand C was the lowest, a result that agrees with the results of acidity values. The percent acidity (which represents the amount of lactic acid in the product) measurements of the four brands were in the range of 0.657–0.761. Percent acidity of brand A was the highest and brand C was the lowest. The TSS values of the four brands were in a range of 17.07- 20.07 °brix. The TSS value of brand C was the highest and brand A was the lowest.

Table 1. Physicochemical properties of the four brands commercial drinking yogurt

Sample Brand	pH	Acidity **(%)**	Total Soluble Solid (°brix)
A	3.93±0.01^c	0.534±0.002^a	17.07±0.12^a
B	3.76±0.03^b	0.548±0.004^b	18.87±0.12^c
C	3.67±0.05^a	0.618±0.006^c	20.07±0.12^d
D	3.87±0.02^c	0.554±0.009^{ab}	18.00±0.00^b

^{a,b,c,d} *Means in the same column with different superscript were significantly difference (p≤0.05).*

Table 2 shows the apparent viscosity at a shear rate of 63 s^{-1} and the rheological parameters from the Power Law model (K and n values) of the four brands. The apparent viscosity (shear rate = 63 s^{-1}) values of the four brands were in the range of 2.41–6.23 *mPa.s*. The apparent viscosity of brand B was the highest and brand C was the lowest, and the *k* values were in the range of 2.88–9.57 *mPa.sn*. The *n* values of the four brands were in the range of 0.898–0.969 and so all were less than one. All brands showed non-Newtonian behavior, with shear-thinning ($n < 1$) characteristics and the thixotropic behavior. These results are in agreement with the results reported by Penna, Sivieri *et al.* (2001) and Oliveira, Sodini *et al.* (2002) who found that lactic beverages and lactic beverages supplemented oligofructose had thixotropic behavior.

The color of four brands are shown in Table 3. The L^* values were in a range of 72.30-79.85. The L^* value of brand B was the highest and brand D was the lowest. The a^* values were in a range of 0.75–7.81. The a^* value of brand D was the highest and brand B was the lowest. Brand B had red hues and was very low when compared with the others. The b^* values were in a range of 13.69–20.02. The b^* values of brand C was the highest and brand B was the lowest. Brand C and D were darker than brand A and B. Brand A and B had yellow hues. Brand C had yellow-orange hues and brand D had orange-red hues.

Table 2. Viscosity and the rheological parameters from the Power Law model of the four brands commercial drinking yogurt

Sample Brand	Apparent viscosity at a 63 s^{-1} [mPa·s]	k (mPa.s^n)	n
A	6.23 ± 0.01^c	9.57 ± 0.05^d	0.898 ± 0.001^a
B	6.04 ± 0.03^c	6.94 ± 0.04^c	0.969 ± 0.0002^c
C	2.41 ± 0.04^a	2.88 ± 0.00^a	0.958 ± 0.004^b
D	5.00 ± 0.14^b	5.70 ± 0.17^b	0.967 ± 0.002^c

[a,b,c,d] *Means in the same column with different superscript were significantly difference (p≤0.05).*

Table 3. Color (L*, a*, b*) of the four brands commercial drinking yogurt

Sample Brand	L*	a*	b*
A	77.39 ± 0.02^c	2.64 ± 0.02^b	17.22 ± 0.03^b
B	79.85 ± 0.01^d	0.75 ± 0.02^a	13.69 ± 0.01^a
C	73.64 ± 0.07^b	4.49 ± 0.06^c	20.02 ± 0.04^d
D	72.30 ± 0.02^a	7.81 ± 0.02^d	18.58 ± 0.02^c

[a,b,c,d] *Means in the same column with different superscript were significantly difference (p≤0.05).*

3.2. Sensory evaluation

Average liking scores of the four brands of commercial drinking yogurt for various attributes are shown in Table 4. The liking score of flavor, sweetness, sourness, and overall preference of brands C and D were not significantly different ($p > .05$) and were significantly higher than brands A and B. These results agree with previous research of Barnes, Harper *et al.* (1991b) and Harper, Barnes *et al.* (1991) who noted that the overall liking of yogurt is strongly correlated with the intensity of sweetness. On the basis of this previous research, Barnes, Harper *et al.* (1991a) suggested that yogurt should have sweet over sour, to obtain a higher overall preference. From Table 1, brands C and D showed higher TTS and percent acidity but lower viscosity than brands A and B. It maybe concluded that consumers prefer drinking yogurt, which had sweetness and sourness in high intensity and low viscosity.

Table 5 shows the correlation matrix obtained from sensory evaluation of the four brands commercial drinking yogurt. The overall preference attribute is strongly correlated with viscosity, flavor, sweetness, and sourness. The viscosity attribute correlated with flavor, sweetness and sourness and strongly correlated with the overall preference score. The flavor attribute correlated with viscosity and strongly correlated with sweetness, sourness and overall preference. The sweetness attribute correlated with viscosity and strongly correlated with flavor, sourness and overall preference. The sourness attribute correlated with viscosity attribute and strongly correlated with flavor, sweetness and overall preference. These results confirm previous work of Olugbuyiro (2011) who noted that flavor attribute correlated with taste and odor of yogurt, which significantly influenced consumer acceptance.

4. CONCLUSIONS

From sensory evaluation of the four brands commercial drinking yogurt (brand A-D), it was found that viscosity, flavor, sweetness, and sourness all affected Thai consumer preference. Based on this limited set of four samples, Thai teenager consumers appear to prefer products with low viscosity, high sourness and high sweetness.

Table 4. Liking score of the four brands commercial drinking yogurt

Attributes	Sample Brand			
	A	B	C	D
Viscosity	5.87±1.76[b]	5.33±1.62[a]	5.96±1.55[b]	5.78±1.63[b]
Color	6.49±1.57[c]	4.80±1.99[b]	6.05±1.82[c]	3.86±1.88[a]
Odor	5.35±2.01[ab]	5.14±1.78[a]	5.28±1.78[ab]	6.11±1.70[c]
Flavor	4.49±2.11[a]	4.17±1.89[a]	6.17±1.83[b]	5.97±1.85[b]
Sweetness	5.26±1.84[a]	4.89±1.62[a]	6.02±1.56[b]	5.95±1.59[b]
Sourness	5.29±1.91[a]	4.89±1.70[a]	6.36±1.59[b]	5.92±1.57[b]
Overall preference	5.35±1.92[b]	4.68±1.71[a]	6.52±1.58[c]	6.14±1.63[c]

[a,b,c,d] Means in the same row with different superscript were significantly difference (p≤0.05).

Table 5. Correlation matrix of the four brands commercial drinking yogurt

Variables	Viscosity	Color	Odor	Flavor	Sweetness	Sourness	Overall preference
Viscosity	1*	.465	.283	.673*	.766*	.786*	.826*
Color	.465	1*	-.666	-.195	-.121	.041	.025
Odor	.283	-.666	1*	.552	.586	.389	.470
Flavor	.673*	-.195	.552	1*	.988*	.972*	.971*
Sweetness	.766*	-.121	.586	.988*	1*	.974*	.988*
Sourness	.786*	.041	.389	0.972*	0.974*	1*	.993*
Overall preference	.826*	.025	.470	.971*	.988*	.993*	1*

** Values are significantly different from the others (p≤0.05).*

REFERENCES

Barnes, D. L., S. J. Harper, F. W. Bodyfelt and M. R. McDaniel (1991a). "Correlation of descriptive and consumer panel flavor ratings for commercial prestirred strawberry and lemon yogurts." Journal of dairy science 74(7): 2089-2099.

Barnes, D. L., S. J. Harper, F. W. Bodyfelt and M. R. McDaniel (1991b). "Prediction of consumer acceptability of yogurt by sensory and analytical measures of sweetness and sourness." Journal of dairy science 74(11): 3746-3754.

Eder, R. (2003). "Drinkable yogurt beats the bagel. " Drug Store News 25: 42.

Gonzalez, N. J., K. Adhikari and M. F. Sancho-Madriz (2011). "Sensory characteristics of peach-flavored yogurt drinks containing prebiotics and synbiotics." LWT-Food Science and Technology 44(1): 158-163.

Harper, S. J., D. L. Barnes, F. W. Bodyfelt and M. R. McDaniel (1991). "Sensory ratings of commercial plain yogurts by consumer and descriptive panels." Journal of dairy science 74(9): 2927-2935.

Jaeger, S. R. (2006). "Non-sensory factors in sensory science research." Food Quality and Preference 17(1): 132-144.

Lim, J. (2011). "Hedonic scaling: A review of methods and theory." Food Quality and Preference 22(8): 733-747.

Oliveira, M., I. Sodini, R. Remeuf, J. Tissier and G. Corrieu (2002). "Manufacture of fermented lactic beverages containing probiotic cultures." Journal of food science 67(6): 2336-2341.

Olugbuyiro, J. A. (2011). "Physico-chemical and sensory evaluation of market yoghurt in Nigeria." Pakistan Journal of Nutrition 10(10): 914-918.

Penna, A., K. Sivieri and M. Oliveira (2001). "Relation between quality and rheological properties of lactic beverages." Journal of Food Engineering 49(1): 7-13.

Saint-Eve, A., C. Lévy, N. Martin and I. Souchon (2006). "Influence of proteins on the perception of flavored stirred yogurts." Journal of dairy science 89(3): 922-933.

Shepherd, R. (1989). "Factors influencing food preferences and choice." Handbook of the psychophysiology of human eating: 3-24.

Thompson, J., K. Lopetcharat and M. Drake (2007). "Preferences for commercial strawberry drinkable yogurts among African American, Caucasian, and Hispanic consumers in the United States." Journal of dairy science 90(11): 4974-4987.

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SUMMER PROGRAM IN SENSORY EVALUATION 2014

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SENSORY EVALUATION AS A TOOL IN ASSESSING THE QUALITY OF NEW FERMENTED PRODUCTS

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ABSTRACT

Ten starter cultures of lactic acid bacteria were used to ferment five mixtures of milk and pea protein (0%, 10%, 20%, 30%, and 40% of pea) to select the cocktail of starters that could lead to products similar to traditional yogurt. Product quality evaluation was performed by comparing the sensory profiles of 49 formulated products with the profile of a milk fermented by commercial lactic ferments. The sensory profiles were analyzed with three-way ANOVAs and a principal component analysis (PCA). Substitution of cow milk protein with 40% of pea proteins reduce starter cultures effects and decrease product quality. In contrast, up to 30% of pea protein, starter cultures show positive and negative effects. For example, products fermented by *Streptococcus thermophilus* + *Lactobacillus acidophilus* with 30% pea protein have positive characteristics like creamy and smooth, but *Lactobacillus delbrueckii* subsp. *Bulgaricus* + *Lactobacillus rhamnosus* caused bad quality and negative characters like bitter and astringent even with 100% cow milk.

Keywords: Sensory profile, new fermented product, quality evaluation, pea protein

1. INTRODUCTION

The increase in global demand of animal proteins in recent years may become a major issue in a close future. In order to initiate the reduction in the use of animal proteins in European diet, it might be interesting to combine dairy proteins with vegetable proteins in products already known by consumers. Tu, Husson *et al.* (2012) have shown that consumers can accept dairy-like products combining cow milk and soybean proteins if the ratio of soybean protein does not excess 50%. However, soybean might not be the best substitution protein because consumers tend to have negative attitudes towards this source of protein (Wansink and Chan, 2001, Tu, Husson *et al.*, 2012). For example, Zare, Boye *et al.* (2011) have suggested lentil flour as an alternative protein substitution. They showed that supplementation with 1-3% of lentil flour did not affect much sensory properties and overall acceptance compared to traditional yogurt. However, this rate of substitution is not high enough to initiate a change in food habits towards an animal/vegetal balanced diet.

In this paper, we propose pea protein as a good substitute for cow milk protein in dairy products, because of its balanced amino acid profile, low level of allergy, functional properties and availability at an affordable price. Pea could be a better substitute for milk protein than soybean because of its high digestibility level, the absence of phytoestrogens and its environmentally friendly and local agriculture. Although pea protein has positive characteristics and has been used in sports foods and in meat based products, its use is almost absent in fermented products due to its intense flavor and odor.

The objective of this research was to determine the combination of starter culture and pea concentration that will give a dairy product close to traditional yogurt. A standard descriptive analysis approach was used to compare the sensory profiles of fermented products obtained by fermenting five ratios of cow/pea milks with 10 starters with that of a cow milk yogurt fermented with a commercial milk ferment.

2. MATERIALS AND METHODS

2.1. Products

Figure 1 illustrates the yogurt preparation. Starting from skim milk powder purchased from Régilait (Saint-Martin-Belle-Roche, France) and pea protein isolate Nutralys® S85F supplied by Roquette (Lestrem, France), two different milks were prepared with the same concentration of protein (45 g/L), lactose, calcium and citrate. Different mixtures of the two milks were prepared with five concentrations of pea milk (0%, 10%, 20%, 30% and 40%). These five mixtures were inoculated with 10 different starter cultures and incubated at 37°C for 24 hours to obtain 50 fermented products (see Table 1). The products were prepared in jars, stirred for 30 seconds and placed in sealed plastic cups coded with three digit numbers. Samples were stored at 4°C and kept at room temperature (22°C) to equilibrate, one hour before serving. Panelists evaluated the products in standard sensory booths under green light to hides color variance in the products.

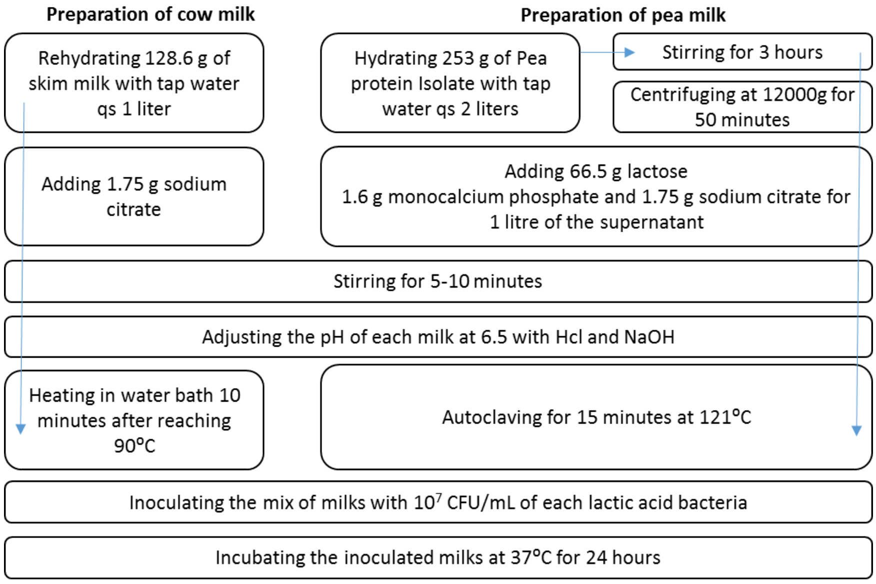

Figure 1. Yogurt preparation

Table 1. List of products

	Pea Concentration (%)					Starter culture
A	A00	A10	A20	A30	A40	Alsa (Streptococcus thermophilus + Lactobacillus delbrueckii subsp. Bulgaricus)
B	B00	B10	B20	B30	B40	Streptococcus thermophilus + Lactobacillus delbrueckii subsp. bulgaricus
C	C00	C10	C20	C30	C40	Streptococcus thermophilus + Lactobacillus helveticus
D	D00	D10	D20	D30	D40	Streptococcus thermophilus + Lactobacillus rhamnosus
E	E00	E10	E20	E30	E40	Lactobacillus delbrueckii subsp. Bulgaricus + Lactobacillus helveticus
F	F00	F10	F20	F30	F40	Streptococcus thermophilus + Lactobacillus acidophilus
G	G00	G10	G20	G30	G40	Lactobacillus delbrueckii subsp. Bulgaricus + Lactobacillus fermentum
H	H00	H10	H20	H30	H40	Streptococcus thermophilus + Lactobacillus casei subsp. casei
I	I00	I10	I20	I30	I40	Lactobacillus delbrueckii subsp. Bulgaricus + Lactobacillus rhamnosus
J	J00	J10	J20	J30	J40	Lactobacillus rhamnosus

2.2. Panels

The panel was composed of 10 women between the ages of 22 to 50 years. All panelists were recruited amongst the students and staff of AgroSup Dijon, France. They attended 10 one-hour training sessions, one per week one session for selection, two sessions for vocabulary generation, four sessions for training and three sessions for panel performance evaluation). After that, the trained panelists evaluated in duplicate the 50 products (two one-hour sessions each week for 4 weeks).

2.3. Procedure

2.3.1. Selection

One selection session was carried out for testing the panelists' ability to detect tastes (i.e., bitter, acid) and odors (i.e., butter, herbs, peas, and earth) on pea "yogurt" as well as their verbal fluency and ability to describe products. The 12 panelists with the highest detection performance, verbal fluency and ability to describe a product were selected. Among those 12 panelists, two abandoned the panel due to availability problem.

2.3.2. Generation of attributes

Attribute generation was conducted in two sessions. In the first session, panelists were asked to describe with their own words five samples selected among the 50 possible products so as to span as much as possible the product sensory space. Generated attributes were compiled to form a preliminary list. In the second session, panelists were presented five new products which they had not been exposed to before, and were asked to rate every attributes on a 6-point intensity scale (from 0 to 5) using the preliminary list of attributes. Panelists were free to add attributes to the list if necessary. A reduction of the list of attributes was then performed following the ISO (1994) norm.

2.3.3. Training procedure

During training, panelists agreed upon definitions, references and procedures for each attribute and were trained to rank different water and yogurt solutions containing substances that give the required attributes (e.g. acid lactic for the acid attribute or caffeine for the bitter attribute). Finally, 10 new products were presented in duplicate to determine whether the panel was homogeneous, discriminant and repeatable.

2.3.4. Final profiling

The final profiling consisted of eight one-hour sessions (two sessions a week). Fifty products were evaluated in duplicate on a structured interval scale going from 1 (low) to 10 (high).

2.4. Data analysis

2.4.1. Panel performance

A three-way ANOVA was carried out for each attribute with the following model:

$$Score = assessor + product + assessor\ x\ product + session + product\ x\ session.$$

Both assessor and product were considered as fixed factors. When a significant product × assessor interaction was found, a principal component analysis (PCA) was performed to evaluate the consensus between panelists. Data were statistically analyzed using SPAD version 7.4.

2.4.2. Product description

Table 2. List of descriptors and references generated by the panel to describe yogurts

Descriptor French	Descriptor English	Attribute classification	References
	Texture		
Astringent	Astringent	-	Oak tannins
Fluide	Fluid	-	Whole milk (Carrefour)
Lisse	Smooth	+	Faisselle (Carrefour)
Crémeux	Creamy	+	Fresh cream 30% fat (Carrefour)
	Taste		
Sucré	Sweet	+	Lactose
Amer	Bitter	-	Caffeine - Burdock (2010)
Acide	Acid	-	Lactic acid - Contis, Ho *et al.* (1998)
	Aroma		
Vinaigre	Vinegar	-	Acetic acid - Burdock (2010)
Terre	Earth	-	Beet juice
Végétale	Vegetable	-	cis-3-Hexen-1-ol - Burdock (2010)
Fumé	Smoked	-	Barbecue sauce (Carrefour)
Laitage	Dairy	+	Cow milk (Carrefour)
Pois	Pea	-	Pea flour

Intensity scores obtained for each attribute were averaged across repetition and submitted to three-way ANOVAs with assessor, starter culture and pea concentration as within subject factors. Assessor was considered as a random factor and both starter culture and pea concentration as fixed factors.

Attributes with a significant effect of either starter culture or pea concentration were then submitted to a normalized principal component analysis (PCA) and a hierarchical cluster analysis (HCA). ANOVA were performed using SAA 9.3, and PCA and HCA with SPAD 7.4.

3. RESULTS AND DISCUSSION

3.1. Attributes generated by the panels

To describe the products, the panelists used 13 attributes including four of texture (astringent, fluid, smooth, creamy) three of taste (sweet, bitter, acid) and six of aroma (vinegar, earth, vegetable, smoked, dairy, pea). The 13 attributes were classified as positive or negative attributes based both on the literature (Tu, Valentin *et al.*, 2010) and on a preliminary study (Table 2).

3.2. Panel performance

The product effect was significant for all the attributes at the 5% level. Therefore, the panelists were able to discriminate between the 50 products. The repetition effect was significant at the 5% level for six descriptors (fluid, creamy, smooth, astringent, bitter, and acid). This repetition effect can however be due in part to differences in the products rather than in the panelists. A significant interaction assessor x product was found for all attributes. However, the PCA performed on each descriptor with assessors as variables, showed a good consensus between assessors except for the attribute bitter.

3.3. Product description and comparison with the standard

3.3.1. ANOVA: product description

Table 3. Results of three-way ANOVA

	Starter culture		Pea concentration		Starter culture & pea	
	F Value	Pr > *F*	*F* Value	Pr > *F*	*F* Value	Pr > *F*
Odor vinegar	5.54	<.0001	2.92	.0343	1.73	.0076
Odor earth	2.57	.0121	8.66	<.0001	1.73	.0074
Odor vegetable	5.32	<.0001	2.41	.0675	1.42	.0615
Texture fluid	3.61	.0008	26.70	<.0001	8.89	<.0001
texture creamy	7.96	<.0001	10.12	<.0001	5.49	<.0001
texture smooth	10.49	<.0001	2.72	.0446	9.31	<.0001
sensation astringent	4.73	<.0001	1.05	.3950	1.50	.0387
Taste sweet	7.48	<.0001	1.16	.3443	2.77	<.0001
Taste bitter	3.21	.0023	2.66	.0485	1.50	.0386
Taste acid	29.14	<.0001	4.42	.0052	4.39	<.0001
Aroma smoked	1.20	.3041	24.31	<.0001	1.56	.0249
Aroma dairy	2.88	.0055	17.28	<.0001	1.17	.2377
Aroma pea	6.03	<.0001	36.17	<.0001	1.68	.0113

The three-way ANOVA (Table 3) showed a significant effect of starter cultures for all descriptors except smocked. Globally, we found Alsa, *Lactobacillus delbrueckii* subsp. *Bulgaricus* + *Lactobacillus fermentum*, *Streptococcus thermophilus* + *Lactobacillus rhamnosus* and *Lactobacillus rhamnosus* to have higher intensity for positive descriptors such as creamy, dairy and sweet, and lower intensity for negative descriptors such as vegetable, earth and vinegar. On the other hand, starter cultures of *Lactobacillus delbrueckii* subsp. *Bulgaricus* + *Lactobacillus helveticus*, *Lactobacillus delbrueckii* subsp. *Bulgaricus* + *Lactobacillus rhamnosus* and *Streptococcus thermophilus* + *Lactobacillus helveticus* have higher intensity for negative descriptors such as acid and astringent but rather low intensity for pea and earth. Starter cultures, which lead to the highest intensity in negative descriptors such as pea or vegetal like Alsa, *Streptococcus thermophilus* + *Lactobacillus rhamnosus* and *Lactobacillus rhamnosus* have also high positive effect leading to descriptors as smooth and creamy.

A significant effect of pea concentration was also found for eight descriptors (vinegar, earth, fluid, creamy, acid, smoked, dairy, and pea). Among those descriptors, as expected, the intensity of negative descriptors pea, earth, fluid, vinegar, and smoked increased with pea concentration, whereas the intensity of positive descriptors creamy, acid and dairy decreased with pea concentration.

Beside the main effects, significant interactions between starter culture and pea concentration were found for all descriptors except dairy and vegetable. An effect of pea concentration was observed for five negative descriptors (earth, smoked, pea, acid, and fluid) as well as for two positive descriptors (smooth and creamy) for most starter cultures. For the other descriptors (vinegar, bitter, sweet, and astringent), we observed a pea concentration effect for only a small number of starter cultures thus indicating that only a small number of starter cultures are able to counterbalanced the negative effect of pea proteins

3.3.2. PCA and HCA: comparison with the standard

Figures 2a and b represents the first two PCA dimensions that, together, explain 61% of the total variance. The first dimension, that explains 36% of the total variance, opposes the negative aroma attributes pea, earth, and smoked as well as the negative texture attribute fluid to the positive aroma attribute dairy. It represents a gradient in pea concentration going from 0% to 40%. Negative attributes are mostly associated with the 40% pea concentration yogurts and the positive one to 0% pea concentration yogurts. The second dimension, that explains 26% of variance, opposes the positive attributes: sweet and creamy to the negative attributes: vinegar, astringent, acid, and bitter. It opposes starter cultures yielding negative attributes such as *Lactobacillus delbrueckii* subsp. *Bulgaricus* + *Lactobacillus helveticus* and *Lactobacillus delbrueckii* subsp. *Bulgaricus* + *Lactobacillus rhamnosus* to starter cultures yielding positive attributes as Alsa (*Streptococcus thermophilus* + *Lactobacillus delbrueckii* subsp. *Bulgaricus*) and *Streptococcus thermophilus* + *Lactobacillus acidophilus* independently of pea concentration.

Figure 2b shows that with smaller concentrations of pea protein, an effect of starter cultures is observed. Some starter cultures seem to attenuate the negative effect of pea proteins whereas some others seem to exhaust it. For example, with 10% of pea protein, Alsa (*Streptococcus thermophilus* + *Lactobacillus delbrueckii* subsp. *Bulgaricus*) gave dairy and creamy characteristics whereas other ones like *Streptococcus thermophilus* + *Lactobacillus helveticus* and *Lactobacillus delbrueckii* subsp. *Bulgaricus* + *Lactobacillus helveticus* gave bitter, astringent and acid characteristics. The comparison between all formulated yogurts and the standard, situated in the bottom right corner, showed that one starter culture *Streptococcus thermophilus* + *Lactobacillus casei* subsp. *casei* gave rise to yogurts with up to 40% of pea protein. On the other hand, two starter cultures *Streptococcus thermophilus* + *Lactobacillus acidophilus* and *Streptococcus thermophilus* + *Lactobacillus delbrueckii* subsp. *bulgaricus* gave rise to yogurts with up to 30% of pea protein with sweet, smooth and creamy attributes close to those of a yogurt made with commercial starter culture and 100% of cow milk.

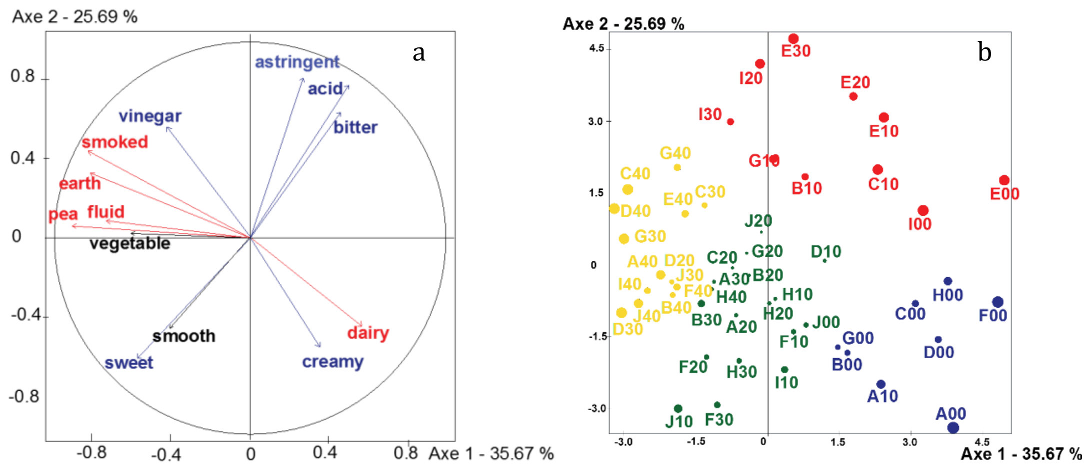

Figure 2. First two dimensions of the principal component analysis performed on the attribute by product matrix a) correlation circle, b) projections of the yogurts. Colors represent product groups yielded by the hierarchical cluster analysis.

The HCA performed on the first two PCA dimensions showed that the 50 products could be divided into four classes (Table 4). The first class includes eight products, seven of them without pea protein. It has been described with positive attributes close to the attributes of traditional yogurts usually consumed by the panel Tu, Valentin *et al.* (2010). Moreover, products fermented by traditional starter culture *Streptococcus thermophilus* + *Lactobacillus delbrueckii* subsp. *Bulgaricus* have good evaluation (neither acid nor astringent). The second class includes 10 products; two of them have been described with negative descriptors as bitter, astringent and acid despite the absence of pea protein. This may be caused in "I" starter culture by the high ability of acidification of *Lactobacillus rhamnosus* that could decrease sensory characteristics (Milesi, Vinderola *et al.*, 2009) or by the high esterase activities of the two strains in "E" starter culture *Lactobacillus delbrueckii* subsp. *Bulgaricus* + *Lactobacillus helveticus* (El Soda, EL WAHAB et al., 1986). The third group includes promising products, which were not associated with negative characteristics such as astringent, acid or bitter and have received high scores for positive descriptors like sweet, smooth and creamy. The metabolic activity of some microorganisms such as *Lactobacillus acidophilus* (Jafarei and Ebrahimi, 2011), and *Lactobacillus casei* (Marilley, Ampuero *et al.*, 2004), results in production of flavor, and aroma that cause good organoleptic properties. These organoleptic properties could be cumulated to those of traditional strains used in fermented products (*Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *Bulgaricus*), when they were used together as starter cultures. The main quality caveat of this group of products is the presence of pea-derived aromas (pea, vegetal, and earth) which might be reduced using aromatization processes. The fourth class includes products with 40% of pea protein, which are characterized by high intensity of pea aromas. With this level of pea protein, no starter culture was able to decrease the negative characteristics of pea protein.

Table 4. Four yogurt classes yielded by the hierarchical cluster analysis performed on the projection of the yogurts on the first two dimensions of the principal component analysis.

Class 1		Class 2		Class 3		Class 4	
A00 A10 B00 C00 D00 F00 G00 H00		B10 C10 E00 E10 E20 E30 G10 I00 I20 I30		A20 A30 B20 B30 C20 D10 F10 F20 F30 G20 H10 H20 H30 H40 I10 J00 J10		A40 B40 C30 C40 D20 D30 D40 E40 F40 G30 G40 I40 J30 J40	
+	-	+	-	+	-	+	-
Dairy Creamy	Vegetable Vinegar Fluid Earth Pea Smoked	Acid Astringent Bitter	Pea Creamy Smooth Sweet	Sweet Smooth Creamy	Astringent Acid Bitter	Earth Pea Smoked Vegetable Fluid Sweet Vinegar	Dairy Acid Creamy

The plus and minus sign indicate the positive and negative descriptor that are more significantly present in the class than in the whole set of products (t-test, p = .05)

4. CONCLUSION

Products with 40% pea protein were associated with all negative descriptors and no positive effect of starter cultures on sensory profile was observed. Therefore, 40% of pea protein leads to bad-quality products. In addition to that, some starter cultures caused bad-quality products even with 0% of pea protein. While products with "good" quality compared with the control product, could be obtained with some starter cultures with 30% pea protein. Taken together with additional results related to physico-chemical properties the current results will enable us to select the starter cultures and highest pea protein concentration possible that give products with the closest quality to the traditional yoghurt.

REFERENCES

Burdock, G. A. (2010). Fenaroli's handbook of flavor ingredients, CRC press.

Contis, E. T., C.-T. Ho, C. Mussinan, T. Parliment, F. Shahidi and A. Spanier (1998). Food Flavors: Formation, Analysis and Packaging Influences: Formation, Analysis and Packaging Influences, Elsevier.

El Soda, M., H. A. EL WAHAB, N. EZZAT, M. Desmazeaud and A. Ismail (1986). "The esterolytic and lipolytic activities of the Lactobacilli. II. Detection of the esterase system of Lactobacillus helveticus, Lactobacillus bulgaricus. Lactobacillus lactis and Lactobacillus acidophilus." Le Lait 66(4): 431-443.

ISO (1994). Sensory analysis - Identification and selection of descriptors for establishing a sensory profile by a multidimentional approach. 11035:1994. .

Jafarei, P. and M. T. Ebrahimi (2011). "Lactobacillus acidophilus cell structure and application." African Journal of Microbiology Research 5(24): 4033-4042.

Marilley, L., S. Ampuero, T. Zesiger and M. G. Casey (2004). "Screening of aroma-producing lactic acid bacteria with an electronic nose." International dairy journal 14(10): 849-856.

Milesi, M. M., G. Vinderola, N. Sabbag, C. A. Meinardi and E. Hynes (2009). "Influence on cheese proteolysis and sensory characteristics of non-starter lactobacilli strains with probiotic potential." Food Research International 42(8): 1186-1196.

Tu, V. P., F. Husson, A. Sutan, D. T. Ha and D. Valentin (2012). "For me the taste of soy is not a barrier to its consumption. And how about you?" Appetite 58(3): 914-921.

Tu, V. P., D. Valentin, F. Husson and C. Dacremont (2010). "Cultural differences in food description and preference: Contrasting Vietnamese and French panellists on soy yogurts." Food quality and preference 21(6): 602-610.

Wansink, B. and N. Chan (2001). "Relation of soy consumption to nutritional knowledge." Journal of Medicinal Food 4(3): 145-150.

Zare, F., J. Boye, V. Orsat, C. Champagne and B. Simpson (2011). "Microbial, physical and sensory properties of yogurt supplemented with lentil flour." Food Research International 44(8): 2482-2488..

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SENSORY QUALITY INDICES AND CONSUMER ACCEPTABILITY OF FUNCTIONAL SOFT DRINK FROM THAI BERRIES (*ANTIDESMA THWAITESANUM* MUELL ARQ.) DURING STORAGE CONDITIONS

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ABSTRACT

The objective of this study was to determine the sensory quality indices of soft drink using the Check All That Apply (CATA) techniques to evaluate the effect of storage on this product. A soft drink product was prepared from Thai berries and stored at 5, 25, 35 and 45°C, respectively, for 0, 4, 8, and 12 weeks using reversed storage design. Consumers (n = 50) were asked to rate the acceptability of eight soft-drink products on a 9-point hedonic score, check all the attributes which were provided to describe the product characteristics using a CATA procedure, and evaluate product acceptance using yes/no scale. Consumer acceptance test revealed that the acceptance decreased with increased storage time at all temperatures. Moreover, products stored at 25, 35 and 45°C for 12, 8, and 4 weeks had 52, 48, and 62%, respectively, unacceptance rate which, in addition, increased with storage time. The quality indices for unacceptable products were dark-brown color followed by coagulate, turbidity, decreased sweetness, increased sourness, and increased astringency. This approach is useful for determining sensory quality indices for acceptable products and could be used to predict sensory shelf life.

Keywords: sensory quality indices, unacceptable product, Thai berries

1. INTRODUCTION

Sensory descriptive analysis has been extensively used to characterize sensory properties of products. It helps with business decision and guides product developers to make products that match consumer desire, and can be linked to consumer data to understand sensory drivers of product acceptability (Gacula Jr, 1997, Stone and Sidel, 2004, Moussaoui and Varela, 2010). There are various ways to perform traditional and non-traditional sensory descriptive method. Several non-traditional sensory descriptive methods have been developed in the last ten years. Non-traditional techniques take different approaches (Varela and Ares, 2012) are less time consuming and more flexible, and can be used with semi-trained assessors or even untrained consumers. In addition these methods provide sensory maps very close to those from a traditional descriptive analysis with highly trained panels.

Check All That Apply (CATA), a non-traditional sensory descriptive method was first introduced by Coombs (1964) and applied in sensory evaluation to understand consumer's perception to optimize products (Adams, Williams *et al.*, 2007, Lancaster and Foley, 2007, Valentin, Chollet *et al.* (2012)). The CATA procedure can be applied to develop different new food products (such as, e.g., salty snack, chocolate milk dessert, vanilla ice cream, strawberry cultivars, orange-flavored powdered drink, and wine, see: Adams, Williams *et al.* (2007); Ares, Barreiro *et al.* (2010); Dooley, Lee *et al.* (2010); Lado, Vicente *et al.* (2010); Ares, Varela *et al.* (2011); Popper, Abdi *et al.* (2011) cited in Valentin, Chollet *et al.* (2012)). The CATA procedure can be performed with consumers, who select the set of answer words to describe the sensory quality of the products to be evaluated. The descriptors can be provided by a trained panel or generated by consumers (Dooley, Lee *et al.*, 2010). The CATA attributes are also often obtained from the answers of open-ended questions (Ares, Giménez *et al.*, 2010). In the CATA procedure, assessors are asked to evaluate different kinds of products and are provided with a list of attributes to describe these products, assessors are asked to check for each product all the attributes that are considered relevant for this product. Assessors are given unlimited time to perform this task.

Thai berry fruit, *Antidesma thwaitesianum*, (Mao fruits) is a native berry fruit found in the northeastern local region of Thailand. Several varieties are grown in Sakon Nakhon, Nakhon Pranom, Kalasin, and Mukdahan provinces and are classified in the family *Stilaginaceae*, genus *Antidesma*. There are more than 18 varieties of Thai *Antidesma* (Hoffmann, 2006) and they are of high nutritive value. Mao fruits change from red to dark purple color when fully ripe, resulting in increased anthocyanins and phenolic contents. In addition, these berries are rich in calcium, iron, zinc, vitamins B and E, and amino acids. Currently, Mao fruits are widely used to make various products, such as jam, jelly, juice, juice concentrate, and red wine. Fruit maturity is important to the overall quality of fruit and their derived products (Butkhup and Samappito, 2011). Mature Mao fruits are essential for their health beneficial effects and for quality of fruit for industrial processing of foods and beverages. Mao fruits can be used as ingredients in various soft-drink products.

Shelf life estimation of food products is essential to consumers and food industrials. Consumers want food companies to be innovative and provide fresh, safe, and high quality products. The shelf life of most food products is limited by changes in their sensory characteristics (Hough, 2010). Therefore, to predict shelf life, food companies should rely on accurate shelf life estimation approaches to meet consumers' needs for safe products that also have acceptable sensory qualities. Currently there is no published literature addressing the problem of how to determine the sensory descriptors for shelf life estimation methodology using the CATA techniques with soft drinks made from Thai berry fruits. Therefore, the objectives of this study were to identify sensory attributes for differentiation and determine the sensory quality indices of soft-drink product under storage conditions using the CATA procedure.

2. MATERIAL AND METHODS

2.1. Functional soft drinks preparation

Thai berry fruits (*Antidesma Thwaitesanum Muell Arq.*) were harvested at the ripening stage from Sakon Nakhon province (Thailand) and were visually sorted for defective and damaged fruits. Subsequently, these fruits were squeezed through a muslin cloth. Gac fruits were supplied from Khon Kaen University's plantation. Gac fruits were cut, their seeds were removed, and the aril was extracted. Fructose syrup was supplied from Mitr Phol Ltd., Thailand. The functional soft drinks products were prepared from the berry juice, gac aril, fructose syrup, and water. All ingredients were mixed for 5 min and heated at 85^{o}C for 15 min. After heating, juice was filled in glass bottle and sealed with cap. Finally, the bottles were cooled in ice bath. Next, products were stored with different storage temperatures (5, 25, 35, and 45^{o}C) and times (0, 4, 8, and 12 weeks) using reversed storage design. The stored products were visually sorted and then the deteriorated products were removed as cut off point. This procedure provided eight products that were coded as T5W0, T25W4, T25W8, T25W12, T35W4, T35W8, T45W4, and T45W8, with were stored at 5^{o}C for 0 week, 25^{o}C for 4 weeks, 25^{o}C for 8 weeks, 25^{o}C for 12 weeks, 35^{o}C for 4 weeks, 35^{o}C for 8 weeks, 45^{o}C for 4 weeks, and 45^{o}C for 8 weeks, respectively, before used.

2.2. Develop sensory descriptors of functional soft drink products

The sensory descriptors of soft drink products were generated by a small group of consumers (N = 10, 5 females, 5 males, in the 19–60 years of age group)— recruited from the Faculty of Technology, Khon Kaen University, Khon Kaen province, Thailand—who regularly consumed soft drink products. Before proceeding to the evaluation, these consumers received a brief introduction about how to generate sensory descriptors. All eight samples Thai berry juices products (prepared from different storage temperatures and storage times) were presented with the soft drink product kept at 5^{o}C for 0 week as control sample. Thirty ml of the soft drink were served in white plastic cups coded with 3 digits. Consumers were instructed to describe the sensory attributes of the products. They were asked to look at, small, and taste the products, and to describe the products sensory properties using their own words. Each assessor evaluated eight samples and compared them with the control sample. Next, the sensory descriptors were then pulled and a consensus was developed such that the descriptors that were kept for the CATA procedure were used by all 10 assessors.

2.3. Consumer acceptance test

For fifty regular soft drink consumers (aged between 17 to 60 years) were recruited at Khon Kaen University, Thailand. Thirty ml of the soft drink were served in white plastic cups coded with 3 digits. Each consumer was presented with eight soft drink products and was asked to evaluate products for five sensory attributes, including purple-red color, berry fruits odor, sweetness, sourness, and overall liking using a 9-point hedonic scale (1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely) (Peryam and Pilgrim, 1957). Consumer also rated overall acceptance of products using a binary (yes/no) scale. After tasting each sample, consumers were instructed to take an unsalted cracker and drink water. The first-order carry-over effect was balanced in the experimental design.

2.4. Check all that apply (CATA) method

The CATA procedure was performed as described by Ares, Varela *et al.* (2011). The soft drink samples were presented in a monadic and balanced form for each consumer. Thirty ml of the soft drink were served in white plastic cups coded with 3 digits. Each consumer was presented with eight coded soft drink products and one product sample stored at 5^0C for 0 week as the control sample. The consumer was asked to check all the attributes that applied to describe the sample. The terms used in the CATA questionnaire were obtained as described above.

2.5. Statistical analysis

Analysis of variance (ANOVA) was performed to determine if overall difference existed among the eight soft drink products in term of acceptability of each sensory attribute and overall liking. The Duncan's New Multiple Range Test (DMRT) was performed to locate the differences among the eight soft drink products. Test were considered significant if they reached the $p < .05$ significance level. Additionally for the CATA analysis we create a product by variable data matrix in which we counted for each product the number of consumers who checked the corresponding attribute. Correspondence analysis (CA) on the frequency matrix was then performed to obtain a sensory map. The analysis was performed by using the R program (Team, 2012). Additionally a principal component analysis (PCA) was performed on a correlation matrix obtained from the means of the samples. Hierarchical cluster analysis (HCA) was also performed to find group of samples with similar sensory characteristics (Moussaoui & Varela, 2010).

3. RESULTS AND DISCUSSION

3.1. Sensory descriptor development results

Thirty descriptors were generated in sensory descriptor development procedure, seventeen of these descriptors were chosen by at least 50% of the consumers (see Table 1). Ten descriptors were used by all 10 assessors: dark-brown color, coagulate, turbidity, fermented odor, alcoholic odor, decreased sweetness, increased sourness, and increased astringency, respectively. The ten descriptors were used for the CATA procedure.

Table 1. The sensory descriptors used in the descriptor sensory quality of eight soft drink products and their frequency (%) of choice by the assessors (N = 10)

Descriptors	Frequency (%) 1/
Dark-brown color	100.0
Coagulate	100.0
Turbidity	100.0
Fermented odor	100.0
Alcoholic odor	100.0
Decreased sweetness 2/	100.0
Increased sourness 2/	100.0
Increased astringency 2/	100.0
Clarity	62.5
Increased viscosity	62.5
Brown color	50.0
Red color	50.0
Viscosity	50.0
Sour odor	50.0
Sourness	50.0
Sweetness	50.0
After taste of sourness	50.0

1/ Frequency (%) of usage calculated from 10 assessors response.
2/ "Increased" and "decreased" mean that the intensity increased or decreased when compared the control sample (product stored at 5^0C for 0 week).

3.2. Consumer acceptability demographic information

The 50 consumers participating in this study were 40% males and 60% females. The majority of the participating consumers (60.5%) were 17–30 years of age, 20.8 % of participants were 31-40 years of age, and 18.7% of the participant were 41-60 years of age.

3.3. Consumer acceptability

The results of the ANOVA indicate that the sensory acceptability scores of purple-red color, berry fruits odor, sweetness, sourness, and overall liking were significantly different among eight soft drink products (Table 2). All the mean acceptability score tended to decrease with increased storage temperature and time. The mean acceptability score of purple-red color and overall liking for the product stored at 45°C for 8 weeks (T45W8) was lower than for the product stored at 5°C for 0 weeks (T5W0) and showed a 53.78 % decrease (score of purple-red color; 7.40 vs. 3.42) and 27.76% decrease (score of overall liking, 7.06 vs. 5.10), respectively. Moreover, the product stored at 25°C for 8 and 12 weeks, 35 °C for 4 and 8 weeks, and 45 °C for 4 and 8 weeks had an overall liking score of lower than 6.00.

Results of overall unacceptance products indicated that product store at 25°C for 12 weeks (T25W8), 35°C for 8 weeks (T35W8), and 45°C for 4 and 8 weeks (T45W4 and T45W8) had 52%, 48%, 62%, and 80% unacceptance, respectively. The product T25W12, T45W4 and T45W8 have higher than 50% unacceptance and based on the criteria to cut off point product more than 50% unacceptance, thus the sensory product descriptors were considered as sensory quality indices.

Table 2. Mean consumer scores for sensory acceptability and overall product acceptance (%) of soft drink products with different storage times and temperatures

Product 1/	Attribute score Acceptability 2/					Overall acceptance(%) 3/	
	Purple-red color	Fruits odor	Sweetness	Sourness	Overall liking	Positive (Yes)	Negative (No)
T5W0	7.40±0.95 a	6.68±1.30 a	6.42±1.68 a	6.54±1.64 a	7.06±1.22 a	80	20
T25W4	6.96±0.87 b	6.14±1.26 b	6.56±1.30 a	6.26±1.29 a	6.46±1.28 b	76	24
T25W8	6.60±1.05 bc	5.94±1.25 b	5.94±1.35 b	6.06±1.50 ab	5.98±1.33 c	66	34
T25W12	6.54±0.99 c	5.90±1.33 b	5.14±1.70 c	5.08±1.84 d	5.26±1.47 e	48	52
T35W4	6.24±1.38 cd	5.92±1.07 b	5.48±1.42 bc	5.74±1.42 bc	5.76±1.25 d	66	34
T35W8	6.04±1.32 d	5.88±1.04 b	5.60±1.37 bc	5.72±1.18 bc	5.70±1.11 d	52	48
T45W4	5.20±1.62 e	5.50±1.34 c	5.32±1.43 c	5.52±1.46 cd	5.50±1.31 de	38	62
T45W8	3.42±1.77 f	4.98±1.47 d	5.58±1.61 bc	5.76±1.41 bc	5.10±1.34 e	20	80

1/ Product T5W0, T25W4, T25W8, T25W12, T35W4, T35W8, T45W4, and T45W8, respectively, contained difference storage temperatures and times at 25 ºC/ 4 weeks, 25 ºC/ 8 weeks, 25 ºC/ 12 weeks, 35 ºC/ 4 weeks, 35 ºC/ 8 weeks, 45 ºC/ 4 weeks, and 45 ºC/ 8 weeks.

2/ Mean ± standard deviation from 50 responses and based on a 9-point hedonic. Mean values in the same column not followed by the letter are significantly different (p < .05).

3/ Based on the binomial (yes/no) scale from 50 response

Table 3. Unacceptable sensory attributes of soft drink product stored at difference temperatures and time and their frequency (%) of usage by consumers (*N* = 50)

Unacceptable attributes	Product 1/							
	T5W0	T25W4	T25W8	T25W12	T35W4	T35W8	T45W4	T45W8
Dark-brown color (a1)	6	10	16	18	30	32	42	92
Coagulate (a2)	6	12	14	20	10	12	16	20
Turbidity (a3)	6	8	12	18	8	18	10	20
Fermented odor (a4)	0	4	6	10	4	12	6	12
Alcoholic odor (a5)	0	0	2	2	8	10	4	6
Decreased sweetness (a6)	6	18	18	24	20	22	14	24
Increased sourness (a7)	8	12	16	32	20	22	18	24
Increased astringency (a8)	12	14	14	20	20	30	26	28
Non descriptor detection (a9)	34	34	34	18	20	20	22	4

1/ Product T5W0, T25W4, T25W8, T25W12, T35W4, T35W8, T45W4, and T45W8 contained different storage temperatures and times at 25 ºC/ 4 weeks, 25 ºC/ 8 weeks, 25 ºC/ 12 weeks, 35 ºC/ 4 weeks, 35 ºC/ 8 weeks, 45 ºC/ 4 weeks, and 45 ºC/ 8 weeks , respectively.

3.4. Check All That Apply (CATA) results

The CATA procedure was used to derive sensory descriptor corresponding to unacceptable attributes of soft drink products stored at difference temperatures and time. The 10 descriptors that were used by all 10 assessors in the sensory development phase were: dark-brown color, coagulate, turbidity, fermented odor, alcoholic odor, decreased sweetness, increased sourness, and increased astringency, respectively. All these terms were used for CATA procedure. As compared with the same storage temperature, the results (see Table 3) indicate that the frequency of usage by consumer for all unacceptable sensory attributes increased with storage time of soft drink products while no detection descriptor trended to decrease with longer storage time. A large majority of 92% of the panelists used dark-brown color as the most frequent term for product T45W8. The frequency of usage by consumer for dark-brown color, coagulate, turbidity, decreased sweetness, increased sourness, and increased astringency of products at 25°C, 35°C and 45°C stored more than 8 weeks was higher than for product stored less than 8 weeks. Meanwhile the smallest frequency of usage by consumer was reported for fermented odor and alcoholic odor were found in those products.

3.5. Multiple factor analysis of CATA data results

Product clusters obtained from Hierarchical Cluster Analysis of the CATA on factor map (Fig.1) were used to visualize and find groups of samples with similar sensory characteristics. The results indicated that there were two groups of products. Group 1 consisted of product T5W0, T25W4, and T25W8 that were closely positioned. The others samples were T25W12, T35W4, T35W8, T45W4, and T45W8.

A PCA biplot (Fig. 2) was used to visualize the matrix obtained from Multiple Factor Analysis (MFA) of the CATA data. It revealed a relationship between CATA descriptors and products with the first two principal components accounted for 86.35% of total variances explained (Dim 1, 68.94% and Dim 2, 17.41%). Product T5W0, T25W4, and T25W8 were closely positioned closely to the non detection descriptor (a9) and farther from another group of products. Products T25W12, T35W4, T35W8, T45W4, and T45W8 were closely positioned and closely the descriptors consisting of dark-brown color (a1), coagulate (a2), turbidity (a3), fermented odor (a4), alcoholic odor (a5), decreased sweetness (a6), increased sourness (a7), and increased astringency (a8).

Results from overall product acceptance (Table 2) indicated that products T25W12, T45W4 and T45W8 have more negative overall acceptance than 50%. These results agree with the results of the CATA procedure (Table 3) that indicate a high proportion of unacceptable sensory attribute (Fig.1). Overall these results indicate that the important attributes for predicting product shelf life from consumers' sensory descriptions are: dark-brown color followed by coagulate, turbidity, decreased sweetness, increased sourness and increased astringency.

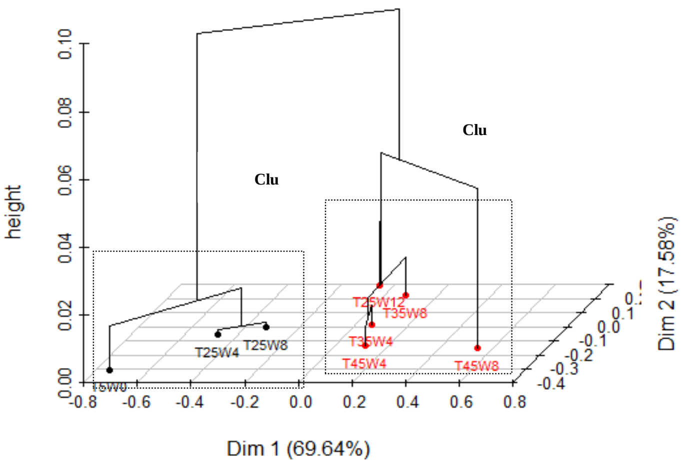

Figure 1. Two products clusters obtained from Hierarchical Cluster Analysis of CATA on factor map

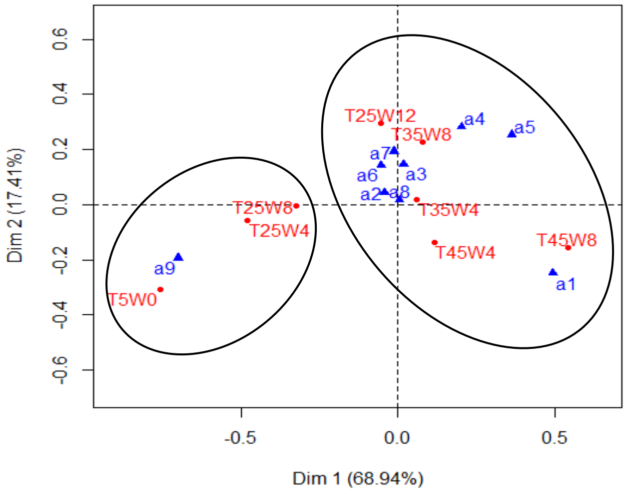

Figure 2. The product positioning map with 2 products clusters and the terms used to describe the samples in the first two dimensions of PCA of data from CATA method.

Symbol : (▲) a1-a9 for attributes ; and (•) for products codes, the details reference are in Table 2 footnote and listed in Table 3.

4. CONCLUSION

This study used a combination of sensory acceptability, overall product acceptance and sensory descriptors from CATA procedure to determine the sensory quality indices of soft drink products as a function of storage conditions. Results indicated that eight sensory descriptors of soft drink products were unanimously chosen by the assessors. These descriptors for unacceptable products: were dark-brown color followed by coagulate, turbidity, decreased sweetness, increased sourness and increased astringency. This approach is useful for determining sensory quality indices for acceptable product and could be used to predict sensory shelf life on consumer's perception.

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REFERENCES

Adams, J., A. Williams, B. Lancaster and M. Foley (2007). Advantages and uses of check-all-that-apply response compared to traditional scaling of attributes for salty snacks. 7th Pangborn sensory science symposium.

Ares, G., C. Barreiro, R. Deliza, A. Gimenez and A. Gambaro (2010). "Application of a check-all-that-apply question to the development of chocolate milk desserts." Journal of Sensory Studies 25(s1): 67-86.

Ares, G., A. Giménez, C. Barreiro and A. Gámbaro (2010). "Use of an open-ended question to identify drivers of liking of milk desserts. Comparison with preference mapping techniques." Food Quality and Preference 21(3): 286-294.

Ares, G., P. Varela, G. Rado and A. Giménez (2011). "Are consumer profiling techniques equivalent for some product categories? The case of orange-flavoured powdered drinks." International Journal of Food Science & Technology 46(8): 1600-1608.

Butkhup, L. and S. Samappito (2011). "Changes in physico-chemical properties, polyphenol compounds and antiradical activity during development and ripening of Maoluang (Antidesma bunius L. Spreng) fruits." Journal of Fruit and Ornamental Plant Research 19(1): 85-99.

Coombs, C. H. (1964). "A theory of data."

Dooley, L., Y.-s. Lee and J.-F. Meullenet (2010). "The application of check-all-that-apply (CATA) consumer profiling to preference mapping of vanilla ice cream and its comparison to classical external preference mapping." Food Quality and Preference 21(4): 394-401.

Gacula Jr, M. (1997). "Descriptive sensory analysis methods." Descriptive Sensory Analysis In Practice: 5-15.

Hoffmann, P. (2006). Antidesma in Malaysia and Thailand. Royal Botanic Gardens, Flora Malesiana. 292 pp.

Hough, G. (2010). Sensory shelf life estimation of food products, CRC Press.

Lado, J., E. Vicente, A. Manzzioni and G. Ares (2010). "Application of a check-all-that-apply question for the evaluation of strawberry cultivars from a breeding program." Journal of the Science of Food and Agriculture 90(13): 2268-2275.

Lancaster, B. and M. Foley (2007). Determining statistical significance for choose-all that-apply question responses. 7th Pangborn sensory science symposium.

Moussaoui, K. A. and P. Varela (2010). "Exploring consumer product profiling techniques and their linkage to a quantitative descriptive analysis." Food Quality and Preference 21(8): 1088-1099.

Peryam, D. R. and F. J. Pilgrim (1957). "Hedonic scale method of measuring food preferences." Food technology.

Popper, R., H. Abdi, A. Williams and B. J. Kroll (2011). Multi-block Hellinger analysis for creating perceptual maps from check-all-that-apply questions. 9th Pangborn sensory science symposium.

Stone, H. and J. Sidel (2004). Quantitative descriptive analysis (The QDA Method), sensory evaluation practices, Elsevier Academic Press, San Diego, CA. pp-215-235.

Team, R. C. (2012). R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria, 2012, ISBN 3-900051-07-0.

Valentin, D., S. Chollet, M. Lelievre and H. Abdi (2012). "Quick and dirty but still pretty good: A review of new descriptive methods in food science." International Journal of Food Science & Technology 47(8): 1563-1578.

Varela, P. and G. Ares (2012). "Sensory profiling, the blurred line between sensory and consumer science. A review of novel methods for product characterization." Food Research International 48(2): 893-908.

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ROLE OF SENSORY EVALUATION IN QUALITY CONTROL: A TEXTUAL POINT OF VIEW

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ABSTRACT

This bibliographic study attempts to reveal the role of sensory evaluation in the research domain of quality control. Sixteen scientific articles were collected in 10 years by using the key words "*sensory quality control*" on the Google Scholars search engine. A text-based approach based on word co-occurrence analysis via a correspondence analysis was use to evaluate the similarities among articles. This analysis highlighted the evolution trends of sensory evaluation within the flield of quality control in the last 10 years.

A total of 8087 distinct words was extracted from the corpus formed by the 16 articles. After lemmatization (i.e., grouping of the inflected forms of a word) a dictionary of 5631 terms was obtained. The frequencies of occurrence of these terms in each of the 16 articles were compiled into a term x article matrix. The size of this matrix was eventually reduced by keeping only the 412 terms, with frequencies superior or equal to 20 before being submitted to a correspondence analysis.

The first two CA dimensions separate the articles into three groups with different lexical profiles. Each group corresponds to a different period with different sensory key issues. Articles in the first group were written in the year 2002 and focused on the establishment of a standard program of sensory evaluation and training in company, together with the instrumental analyses, aimed at assuring product quality. The second group of article dated from 2007 and 2010 focused on food quality certification, requiring a method of panel performance evaluation. And the third group of articles written in 2011 focused on parameters which could contribute to differentiate products according to the quality grade as well as on the modelization of quality.

Keywords: sensory evaluation, quality control, text mining, correspondence analysis.

1. INTRODUCTION

"*Sensory*" is one of the three important aspects of product quality, in addition to "*chemo-physical*" and "*microbial*" aspects. However, the use of sensory evaluation in quality programs is not yet well established and many variations exist in different food industries. Such variations originate from the diversity in the way sensory evaluation is implemented in the quality program (e.g., separate vs. integrate sensory evaluation on an available quality management system) as well as in the purpose of the implementation (e.g., stabilize product quality vs. diverse products to meet consumer needs).

The main objective of this study is to identify key issues and trends of sensory evaluation in quality control. A textual analysis of scientific articles published in the field of sensory quality control in the last 10 years was carried out.

2. MATERIAL AND METHODS

2.1. Selection of articles

Sixteen scientific articles were found using "*sensory quality control*" as key words in Google Scholar[1]. The small number of articles can be

[1] *Google Scholar is a freely accessible web search engine that indexes the full text of scholarly literature across an array of publishing formats and disciplines.*

explained by the publication period that was restricted to the last 10 years. Some important features of the articles are presented in Table 1.

Table 1. Titles and publication years of the scientific articles in the result list of Google Scholar by using key words "*sensory quality control*".

Title	Year	Code	Title	Year	Code
Decision trees in selection of featured determined food quality (Dębska and Guzowska-Świder, 2011)	2011	P1	Sensory quality control for food certification: A case study on wine (Etaio, Albisu *et al.*, 2010)	2010	P11
Analysis of sensory data of different food products by ANOVA (Kuti, Hegyi *et al.*, 2004)	2004	P2	Descriptive sensory analysis: past, present and future (Murray, Delahunty *et al.*, 2001)	2001	P12
Examining the case of green coffee to illustrate the limitations of grading systems/expert tasters in sensory evaluation for quality control (Feria-Morales, 2002)	2002	P3	Sensory quality control for food certification: A case study on wine. Panel training and qualification, method validation and monitoring (Etaio, Albisu *et al.*, 2010)	2010	P13
A consumer-focused QC/sensory program in the food industry (Pecore and Kellen, 2002)	2002	P4	A comparison of sensory methods in quality control (Costell, 2002)	2002	P15
Expanding the sensitivity of conventional analytical techniques in quality control using sensory technology (Desrochers, Keane *et al.*, 2002)	2002	P5	Dimensions of sensory quality: a critique (Lawless, 1995)	1995	P16
Advances in sensory evaluation for quality control (Muñoz, 2002)	2002	P6	Sensory Analysis in Quality Control: The Gin as an Example (Aumatell, 2011)	2011	P17
Food quality certification: An approach for the development of accredited sensory evaluation methods (Elortondo, Ojeda *et al.*, 2007)	2007	P7	The Sensory Quality System: a global quality control solution (King, Gillette *et al.*, 2002)	2002	P18
A method for the analysis and control of sensory properties during processing–– application to the dry sausage process (Curt, Trystram *et al.*, 2004)	2004	P10	Sensory evaluation in quality control: an overview, new developments and future opportunities (Muñoz, 2002)	2002	P19

Figure 1. Illustration of the word cloud constituted from the 412 most frequent distinct words.

2.2. Pre-treatment of the articles

The set of articles having pdf extension by default was initially transformed into text files. These articles were imported as a collection of text documents. A total of 8087 distinct words were extracted from this corpus and 5631 terms retrieved from these distinct words after lemmatization (i.e., grouping of the inflected forms of a word). The frequencies of occurrence of these terms in each of the 16 articles were compiled into a term x article matrix. The size of this matrix was eventually reduced by keeping only the 412 terms, with frequencies superior or equal to 20.

2.3. Textual analysis

Figure 1 is a visual representation of the frequency of occurrence of the terms collected from the 16 articles. The size of the words in the cloud represent their frequencies of occurrence in the text (i.e. the larger the size, the higher the frequency, and vice versa). The most frequent words, such as "*sensory, quality, product*" reflect the themes common to all the articles. This frequent words correspond to the general topic of the corpus (e.g., "*sensory, quality, product*") as well as to specific implementation methods (e.g., "*evaluation, standardization, description, program, training*") or refer to the objects of interest (e.g., "*attribute, difference, reference, defect, panelist, consumer, expert*").

The low frequency words reflect the specificity of some articles. Those words with low frequency may present research trend.

2.4. Correspondence Analysis

Correspondence Analysis (CA) is a statistical analysis method adapted to the analysis of a contingency table, (e.g., in this case the 16 articles as the rows and 412 words as columns (Husson, Lê *et al.*, 2009, Greenacre, 2010). When applied to a lexicographics study, CA shows the relationship between two sets articles and words. Projecting the publication years as supplementary individuals can show the research topic changes over time.

Statistical analysis was performed using R version 3.0.2. The package "tm" was used to carry out text processing (Feinerer, 2008), "wordcloud" to perform text graphic (Fellows, Fellows *et al.*, 2013), and "FactoMineR" to perform CA (Husson, Josse *et al.*, 2013).

3. RESULTS AND DISCUSSION

3.1. Sensory evaluation in quality control: Key issues

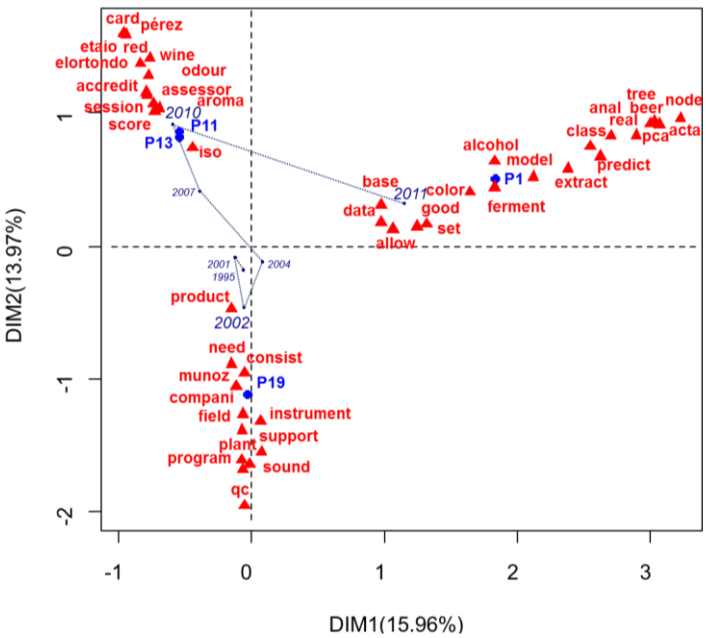

Figure 2. First plane of CA results for 16 scientific articles.

Figure 2 shows the CA results. In this figure, only the articles and terms with a major contribution to the construction of the first two dimensions are represented. The first dimension distinguishes two groups of articles: the paper P1 on the right and two papers P11 and P13 on the left.. Various types of products mentioned in these studies, such as "*beer*" for P1 and "*red wine*" for P11 and P13 contribute to Dimension 1. The specific terms related to P1, such as "*node, tree, class, PCA, model, predict*" describe the exclusive approach of product sensory quality assessment. The main objective of P1 was to investigate the parameters contributing to the classification of beer quality. These parameters accounted for the chemical as well as sensory properties of the product and the property-selecting procedure could point out the important attributes to classify the product quality.

On the other hand, P11 and P13 are characterized by the terms "*card, accredit, assessor, session, score, iso,*" displaying the sensory quality evaluation method based on selecting and training the internal panel. These articles described the evaluation criteria in a permanent way of monitoring the panel performance, assessor re-qualification and the quality controls.

The second dimension is characterized by the terms "*qc, program, plant, instrument, company*" specific of P19. This article made an overview of the history and development of quality control (QC) and sensory evaluation, and raised new developments and future potentials in this domain.

3.2. Trends of sensory evaluation in quality control

In addition to the above results, the development trend of quality control and the role of sensory evaluation in this area can be observed by projecting the years of publication of the articles on the first plane (Figure 2). The differences in the published research results are marked in the years of 2002, 2010, and 2011. In 2002 there were 7 articles on the importance of quality control and sensory evaluation programs within compagnies. This period was characterized by the integration of sensory evaluation panel in the product plant as well as in the research centers. Standardized program of training in sensory evaluation were established to insure the stability of product quality.The year 2007 was characterized by the introduction of sensory evaluation in food quality certification, requiring the development of training procedure and expert performance evaluation. The year 2011 was characterized by the development of statistical models used to predict food grades..

4. CONCLUSION

This study applied text mining as a tool for the rapid identification of key issues and trends in the development of sensory evaluation in quality control. In addition to the display of the specific and highly frequent terms of the articles, this technique also visualizes the correlation between the articles and the terms, highlighting the issues and trends of sensory evaluation.

REFERENCES

Aumatell, M. R. (2011). "Sensory Analysis in Quality Control: The Gin as an Example."

Curt, C., G. Trystram, H. Nogueira-Terrones and J. Hossenlopp (2004). "A method for the analysis and control of sensory properties during processing––application to the dry sausage process." Food control **15**(5): 341-349.

Dębska, B. and B. Guzowska-Świder (2011). "Decision trees in selection of featured determined food quality." Analytica chimica acta **705**(1): 261-271.

Desrochers, R., P. Keane, S. Ellis and K. Dowell (2002). "Expanding the sensitivity of conventional analytical techniques in quality control using sensory technology." Food quality and Preference **13**(6): 397-407.

Elortondo, F., M. Ojeda, M. Albisu, J. Salmerón, I. Etayo and M. Molina (2007). "Food quality certification: An approach for the development of accredited sensory evaluation methods." Food quality and Preference **18**(2): 425-439.

Etaio, I., M. Albisu, M. Ojeda, P. Gil, J. Salmerón and F. Elortondo (2010a). "Sensory quality control for food certification: A case study on wine. Method development." Food control **21**(4): 533-541.

Etaio, I., M. Albisu, M. Ojeda, P. Gil, J. Salmerón and F. Pérez Elortondo (2010b). "Sensory quality control for food certification: A case study on wine. Panel training and qualification, method validation and monitoring." Food control **21**(4): 542-548.

Feinerer, I. (2008). "An introduction to text mining in R." R News **8**(2): 19-22.

Fellows, I., M. I. Fellows and L. Rcpp (2013). "Package 'wordcloud'."

Feria-Morales, A. M. (2002). "Examining the case of green coffee to illustrate the limitations of grading systems/expert tasters in sensory evaluation for quality control." Food quality and Preference **13**(6): 355-367.

Greenacre, M. (2010). Correspondence analysis in practice, CRC Press.

Husson, F., J. Josse, S. Le and J. Mazet (2013). FactoMineR: Multivariate Exploratory Data Analysis and Data Mining with R, R package version 1.24.

Husson, F., S. Lê and J. Pagès (2009). Analyse de données avec R, Presses universitaires de Rennes.

King, S., M. Gillette, D. Titman, J. Adams and M. Ridgely (2002). "The sensory quality system: a global quality control solution." Food quality and Preference **13**(6): 385-395.

Kuti, T., A. Hegyi and S. Kemény (2004). "Analysis of sensory data of different food products by ANOVA." Chemometrics and intelligent laboratory Systems **72**(2): 253-257.

Lawless, H. (1995). "Dimensions of sensory quality: a critique." Food quality and Preference **6**(3): 191-199.

Muñoz, A. M. (2002a). "Advances in sensory evaluation for quality control." Food quality and Preference **13**(6): 327-328.

Muñoz, A. M. (2002b). "Sensory evaluation in quality control: an overview, new developments and future opportunities." Food quality and Preference **13**(6): 329-339.

Murray, J., C. Delahunty and I. Baxter (2001). "Descriptive sensory analysis: past, present and future." Food research international **34**(6): 461-471.

Pecore, S. and L. Kellen (2002). "A consumer-focused QC/sensory program in the food industry." Food quality and Preference **13**(6): 369-374.

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PART 2 - SENSORY EVALUATION IN PRODUCT DEVELOPMENT

Jirukkakul, N., SPISE Proceedings 4 (2014), 63-65

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From Senses To Quality
What can sensory evaluation bring to quality control?

4th International Symposium, July 25-27, VietNam

POTENTIAL USE OF PUMPKIN FLOUR INSTEAD OF WHEAT STARCH IN A NOODLE PRODUCT

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ABSTRACT

Recently, Thai pumpkin, containing high fiber and carotenoids, has not been widely used in an industrial scale due to the short shelf-life after cutting. However, drying pumpkin and transform it to flour could increase its shelf-life and allow its use as substitution to other flours. Therefore, pumpkin flour was prepared to be an ingredient to increase dietary of noodle. In this experiment, wheat flour was substituted by pumpkin flour for 10, 20, and 30% in the noodle recipe. All data were analyzed using ANOVA. The proximate analysis revealed that noodles with pumpkin powder had higher fiber content than the control. For this pilot project the sensory evaluation was performed using 30 panelists. The results showed noodle substituted with pumpkin powder at 30% had the highest acceptance score, perhaps because its color was similar to alkaline noodle. In addition, it had a sweet taste. The tensile strength and elongation of noodle were analyzed by texture analyzer. The results revealed that tensile strength of sample with pumpkin powder was higher but the elongation was lower, when compared with the control. Based on the results, pumpkin could be prepared in a dried powder form for convenient use and it may be appropriate for substitution in noodles.

Keywords: Pumpkin flour, Noodle

1. INTRODUCTION

Pumpkin (*Cucurbita Cucurbitaceae*) is a plant which originally grews America and then spread throughout the world. Pumpkins are generally cheap and have been processed to a variety of foods such as spicy soup, dessert, soup, snack, cake and pie. The pumpkin flesh has normally a yellow color and it consists of protein, fat, fiber, and carbohydrate about 1.63, 0.2, 0.88, and 10.1% (wet basis). In addition, the residue providing vitamin A is reported to be 2,220 iu and the total energy is approximately 48.7 kcal energy (Agriculture, 2013). Yellow noodle was invented by Chinese and wildly accepted around the world. The yellow appearance is due to egg and colorant in the recipe, which consists of wheat flour, egg, salt and base solution or colorant (Encyclopedia, 2013). Substitution of the wheat flour by pumpkin flour would be a way to increase fiber in the noodle as well as to reduce the production cost. Therefore, the substitution of wheat flour with pumpkin flour in yellow noodle was investigated.

2. OBJECTIVES

The aim of this research was to evaluate the effect of wheat flour substitution by pumpkin flour on the chemical composition, physical properties and consumer preference of the yellow noodle.

3. MATERIALS AND METHODS

3.1. 3.1 Pumpkin flour preparation

The fresh pumpkin was selected and cut to open it. The skin, seed, and string were removed. The pumpkin flesh was washed and sliced into thin pieces (5 mm thickness) using a sharp knife before drying in the oven at 60°C for 24 h. The dried pumpkin was ground to flour using a hammer mill.

3.2. Noodle preparation

The noodle recipe was prepared according to the details in Table 1. The wheat flour and pumpkin flour were mixed and sieved together. The egg and salt were mixed together and water was added into the mixture. The ingredients were kneaded 10-15 min then hold on at room temperature about 30 min. The dough was pressed to a thin sheet and cut into lines by cutting machine. During pressing and cut processing, the wheat flour was strewed to prevent stickiness.

Table 1. Formulation of noodle production

Tr	Wheat flour (g)	Pumpkin flour (g)	Water (ml)	egg	Salt (g)
1	500	-	200	2	5
2	450	50	200	2	5
3	400	100	200	2	5
4	350	150	200	2	5

3.3. Sensory evaluations

The obtained noodle was served with soup to 30 trained panelists. A 9-point hedonic scale was used to evaluate panelists liking. A score of 1 represents dislike extremely and a score of 9 represents like extremely. The panelists were required to evaluate the quality attributes including appearance, color, flavor, texture, taste, and overall acceptability toward the tested samples.

3.4. Proximate analysis

Moisture content, protein, fat, ash, fiber and carbohydrate of noodle were analyzed according to the method described by AOAC (2000).

3.5. Color

The color of noodle was evaluated by chroma meter. The L*, a*, b* values were recorded.

3.6. Tension and elongation test

The texture analyzer was used to perform the tensile test. The noodle was wrapped with 2 probes which had a starting length of 5 cm and a separation rate of 2 mm/s. The tension force, the maximum force to tear the noodle, was recorded. The elongation parameter is equal to the final length of noodle before shearing.

4. RESULTS

4.1. Sensory evaluations

The consumer preference data are shown in Table 2. The noodles substituted with different levels of pumpkin flour were accepted differently ($P<0.05$). In addition, the noodle sample with 30% pumpkin flour substitution was the most accepted. In previous work on steamed stuff bun, pumpkin flour replaced wheat flour at only 10% (Suphavititpattana, 2000). The results in this study were different from Normai, Akarabanditsakul *et al.* (2013), who indicated that the noodle with 20% pumpkin flour was the most accepted. The difference in results may come from different drying temperatures. Our pumpkin flour was dried at 60 C, while that of Normai et al was at 70^{o}C. This suggests that the reduction of drying temperature could increase the substitution level of pumpkin flour in the noodle. Therefore, noodle with 30% pumpkin flour was selected for proximate analysis and physical properties.

4.2. Proximate analysis

The pumpkin flour had 15.26% (db) protein, 4.77% (db) fat, 14.26% (db) fiber, 5.91% (db) ash and 59.81% (db) carbohydrate. The substitution of pumpkin flour thus wouldcaused a high carbohydrate and fiber content in the noodle but low protein content (Table 3). The fat content in noodle with pumpkin flour were higher than in the control noodle. These results were in agreement with the results from Teingtrong, Malai *et al.* (2013). The low fat content of pumpkin flour provided the benefit for the human health.

4.3. Color

The pumpkin flour showed lightness, redness and yellowness values of 70.31, 13.44 and 51.81, respectively. The noodle with 30% pumpkin flour had the lowest L value but the highest b value (Table 3). This was due to the carotene content in the pumpkin (J.R, 1999).

4.4. Tension and elongation

The fresh noodle tension could not be measured because it was very soft. However, the boiled noodle was stickier. The boiled noodle with 30% pumpkin flour had similar tension but lower elongation value than the control noodle (Table 3). This suggests that the pumpkin flour substitution affected the structure of the noodle.

Table 2. Sensory evaluation of the noodle substituted with different levels of pumpkin flour

Samples	Control	Noodle with Pumpkin flour 30%	Noodle with Pumpkin flour 20%	Noodle with Pumpkin flour 10%
Color	3.54	7.53	6.43	4.78
Odor	1.49	5.73	5.12	4.99
Salty	6.34	5.48	6.17	3.71
Sticky	6.64	4.33	4.61	3.22
Softy	5.17	4.20	5.16	4.33
Flavor	6.43	6.88	5.23	5.78
Overall	3.57	6.97	5.95	3.58

Table 3. Proximate analysis, color and mechanical properties of noodle substituted with 30% pumpkin flour

Samples	Control	Noodle with 30% pumpkin flour
Protein (%db)	23.20[a]	13.23[b]
Fat (%db)	3.78[b]	9.37[a]
Fiber (%)	21.56[b]	25.88[a]
Ash (%db)	2.95[b]	3.64[a]
Carbohydrate (%db)	48.51[a]	47.88[a]
L	61.32[a]	52.00[b]
a	3.72[b]	11.93[a]
b	18.29[b]	52.08[a]
TS (N)*	0.21[a]	0.29[a]
E (%)*	69.68[a]	27.12[b]

**boiled noodle*

[a, b] *Different letters indicate statistical difference ($p \leq 0.05$).*

5. CONCLUSION

The noodle with 30% pumpkin flour was the most accepted by the panelists, which is due to the color, flavor, and odor attributes . Substitution of wheat flour by pumpkin flour resulted in an increase of fat, fiber and ash content as well as the yellowness and redness. However, a reduction in protein content, lightness, and elongation was found. Therefore, pumpkin flour could be use to substitute the wheat flour in noodle recipe, providing a convenient way for utilization of pumpkin in food industry.

REFERENCES

Agriculture, D. o. (2013). Pumpkin, Thailand Ministry of Agriculture and Cooperatives.

AOAC (2000). Association of Official Agricultural Chemists. The United States Department of Agriculture.

Encyclopedia, W. T. F. (2013). "Noodle." from http://th.wikipedia.org, 3/3/2013.

J.R, L. (1999). "Spaghetti elaboration from pumpkin flour and its physic-chemical properties."

Normai, Y., et al. (2013). Dried pumpkin noodle, King Mongkut's Institute of Technology Ladkrabang. Thailand

Suphavititpattana, P. (2000). Effect of pumpkin flour on quality of Salapao flour. Faculty of Agricultural Technology, Pibulsongkram Rajabhat University. Thailand. Thesis of Food Science and Technology.

Teingtrong, T., et al. (2013). Noodle Supported with Vitamin A, Naresuan Uniersity. Thailand. Clinic Technology.

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PREFERENCE MAPPING FROM THE COMBINATION OF CUSTOMER LINKING AND QUANTITATIVE DESCRIPTIVE ANALYSIS ON SENSORY QUALITY OF SOYMILK PRODUCTS

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ABSTRACT

The scope of this study was to compare the sensory attributes and the customer liking of experimental soymilk processed with germinated soybean (G soymilk) to four commercial soymilk products from four beverage companies in South Vietnam (A, B, C, D soymilk). Quantitative descriptive analysis (QDA) was used to describe the key attributes of five bottled soymilk products. Principal component analysis (PCA) identified two main principal components that accounted for 72.5% of the variance in the sensory attribute data. G soymilk was located in similar position as B soymilk in the principal component plot. Beside, a total of 200 consumers rated the overall liking for these products using a 9–point hedonic scale. Preference mapping of these products was performed based on the combination of quantitative descriptive analysis and customer liking. The contour plot from preference map showed that A and C soymilk got 60 – 80% of satisfied assessors and G soymilk, B and D soymilk 40–60%.

Keywords: soymilk, germination, principal component analysis, quantitative descriptive analysis, preference mapping

1. INTRODUCTION

Amongst the many soy products, soymilk is one of the most popular traditional beverages in Asian countries (Shun-Tang, Ono *et al.*, 1997) including China, Japan, Korea, Singapore, Thailand and Vietnam. Soymilk, the water extract of soybeans, is typically produced by grinding the soaked soybeans with water (Jiang, Cai *et al.*, 2013) and was consumed as a nutritious and economical protein food (Matsuura, Obata *et al.*, 1989). Consumers in western countries consumed soymilk mainly as an important substitute of cow milk due to lactose intolerance or allergic reaction to cow's milk, and as a low cost source of good quality protein and energy (Kwok and Niranjan, 1995, Rosenthal, Deliza *et al.*, 2003). In recent decades, strong relationships between soy food consumption and health–promoting effects have been evidenced and the most recent innovations are focusing on producing "functional soymilk". Functional soymilk can be considered as soymilk that contains extra bioactive components and may help to enhance health or lower risk of diseases (Jiang, Cai *et al.*, 2013).

The germination process is the leading way to improve the nutritional value of soybeans, so as to increase its use. The benefits of germination include the increasing of vitamin C, riboflavin and calcium contents (Kaushik, Satya *et al.*, 2010); improvement of protein digestibility (Martinez, Martinez *et al.*, 2011); hydrolysis of flatulent–causing oligosaccharides; reducing levels of trypsin inhibitors, lectin, phytic acid and lipoxygenase activity, which lead to undesirable beany flavor (Sattar and Akhtar, 1990, Paucar-Menacho, Berhow *et al.*, 2010) and the enrichment of phenolics, isoflavone aglycones and saponin glycosides (Paucar-Menacho, Berhow *et al.*, 2010, Martinez, Martinez *et al.*, 2011) which possess biological activity. Thus, germination can be a very potent and efficient step for producing functional soymilk (Jiang, Cai *et al.*, 2013). Currently, there are no data comparing the sensory quality and the acceptability of commercial soymilk and soymilk processed from germinated soybean.

The sensory quality is what consumers perceive directly and is the ultimate measure of product quality (Drake, 2007). The analysis is made possible through employment of basic techniques such as descriptive sensory analysis, consumer test and preference mapping (Mongi, Bernadette *et al.*, 2013). Descriptive analysis is a sensory methodology that provides quantitative descriptions of all the sensory attributes of a food or product, based on perceptions of a group of qualified assessors while consumer test is a method used to assess whether the consumers like the product, prefer it over another product or find the product acceptable based on its sensory characteristics (Harry and Hildegarde, 2010). Preference mapping is a commonly used tool in understanding the descriptive sensory attributes that drive consumer preferences (Schlich, 1995, Næs and Risvik, 1996, Murray and Delahunty, 2000). Two main types of preference mapping are applied in sensory science: internal preference mapping and external preference mapping. Internal preference mapping uses only consumer data to determine consumer preference patterns, whereas external preference mapping relates consumer preference data to descriptive sensory information and/or instrumental data (Lawlor and Delahunty, 2000). These techniques can guide product optimization and development (Næs and Risvik, 1996). Both internal and external preference mapping techniques have been implemented in a number of studies with a variety of products (Hough and Sánchez, 1998, Yackinous, Wee *et al.*, 1999, Richardson-Harman, Stevens *et al.*, 2000, Young, Drake *et al.*, 2004).

This study was carried out to evaluate the sensory profiles, consumer liking and external preference mapping of five bottled soymilk samples. They included one sample processed from germinated soybean and four commercial products from different beverage companies in South Vietnam.

2. MATERIALS AND METHODS

2.1. Materials

2.1.1. Preparation of soymilk from germinated soybean

Soybeans (Glycine max L., MTD 760 variety) were supplied from Department of Agricultural Genetic, College of Agricultural and Applied Biology, Cantho University.

Soybeans were cleaned and rinsed three times with cleaned water before being soaked for 12 hours at room temperature with a water to dry bean ratio of 10:1, v/w. The soaked beans were drained, rinsed and placed in a semi-automatic germination machine (Green–life 611, made in Vietnam), which watered the seeds every four hours with cleaned water (ambient temperature) automatically, the time for watering was two minutes, and water was changed every 12 h manually. The germination process was carried out at ambient temperature (28–30°C) for 36 hours.

Briefly, to make soymilk, the germinated soybeans were drained, rinsed and ground with hot water (water/dry bean = 9:1, v/w) (Jiang, Cai *et al.*, 2013) by the crushing machine, the slurry was filtered through a mesh screen to obtain soymilk. Soymilk was then heated, homogenized and bottled before sterilization.

2.1.2. Commercial soymilks

Five bottled soymilk samples were collected from Can Tho Beverage Corporation company (Cantho city), Tan Hiep Phat Beverage Group (HCM city), Tribeco company (HCM city) and Nam Hai Soymilk 111 company (Cantho city). These samples were randomly named A, B, C and D soymilk in the text.

2.2. 2.2 Methods

2.2.1. Quantitative descriptive analysis (QDA)

A descriptive sensory profiling for soymilk was developed according to the list of attributes described by Torres-Penaranda and Reitmeier (2001) with slight modification. The trained sensory panel included 12 assessors, comprising six males and six females. In a pre-testing session the assessors were trained in developing sensory descriptors and the definition of the sensory attributes. An unstructured line scale was used for rating attribute intensity. The left side of the scale corresponded to the lowest intensity of each attribute (value 0) and the right side corresponded to the highest intensity (value 10). Descriptive analysis was carried out for five bottled soymilk samples kept at 12–15°C. The samples coded with 3-digit random numbers were served to each panelist. Water was served alongside samples for rinsing mouth before evaluating other samples during the test.

2.2.2. Consumer tests

The test was carried out in the Department of Food Technology Laboratory. Test subjects were recruited from students and staff at Cantho University and local residents through personal referral or by posting flyers on campus and the intranet. The subjects were screened based on criteria such as no health problems (i.e., soybean allergy or digestive problems), previous experience, and no aversion regarding consumption of soymilk. A total of 200 panelists participated in the study using a 9 point hedonic scale (where 1 = dislike extremely and 9 = like extremely) as described by Harry and Hildegarde (2010). The samples were kept at 12–15°C for testing, they were coded with 3-digit random number and served to the panelists in a randomized order. The judges were instructed to rate their overall liking or disliking by checking the appropriate number in the hedonic scale. Sample evaluation was conducted under the same conditions as for the sensory descriptive test.

2.2.3. Statistical data analysis

The data were analyzed by using Portable Statgraphics Centurion 15.2.11.0 for one–way analysis of variance to determine the significant differences between the factor means at ($p<0.05$). Principal component analysis (PCA) and preference mapping were performed using the R package 2.15.

3. RESULTS AND DISCUSSIONS

3.1. Principal component analysis of descriptive sensory data

Figure 1 shows bi–plot with the first two principal components from principal component analysis (PCA) on average sensory attributes. The results show principal component (PC) 1 accounted for 46.4% of the systematic variation in the data while principal component (PC) 2 accounted for 26.1%. The soymilk samples were separated. The G soymilk was located near the B soymilk on the graph. These two samples correlated positively with descriptive attributes viscous, mouth-coating, legume flavor and beany aroma while the A, C and D soymilks correlated positively with whiteness, vanilla flavor and sugar sweetness along PC 1. The results indicate that the variation between samples was explained by the attributes whiteness, vanilla flavor and sugar sweetness on one side and other attributes on the other side along PC 1.

The correlation between PC 1 and 2 and the original attribute measurements are shown in Table 1. Loadings with an absolute value greater than 0.519 with squared cosines of the variables > 80% (shown in bold type) represent a strong influence. PC1 is entirely related to the oxidized flavor, viscous, vanilla flavor and mouth-coating. PC2 is entirely related to the white and yellow color.

Table 1. Squared cosines of the attribute variables from principal component analysis

Attributes	F1	F2
Sugar sweetness	0,179	0,364
Legume sweetness	0,265	0,005
Bitterness	0,799	0,003
Sourness	0,519	0,012
Metallic	0,383	0,508
Starchy aroma	0,079	0,520
Beany aroma	0,364	0,000
Vanilla flavor	0,874	0,053
Oxidized flavor	0,976	0,019
Cooked flavor	0,108	0,421
Mouth-coating	0,856	0,019
Viscous	0,910	0,083
Whiteness	0,149	0,827
Yellowness	0,040	0,813

3.2. Consumer test

The average hedonic scores from 200 consumers for the five soymilk samples are showed in Table 2 along with LSD test results.

Table 2. The hedonic scores of soymilks

Samples	Mean scores
A soymilk	$7.0^{a} \pm 1.41$
C soymilk	$6.9^{ab} \pm 1.52$
G soymilk	$6.7^{bc} \pm 1.47$
D soymilk	$6.7^{bc} \pm 1.51$
B soymilk	$6.6^{c} \pm 1.51$

Means (± SD) within each column followed by different letters are significantly different according to Fisher's protected least significant difference test ($p \leq 0.05$). For each sample, panelists scored their liking using the nine-point hedonic scale (1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, and 9 = like extremely)

Table 2 showed that there was a difference in the customer liking of soymilk products. The liking score of the G soymilk (6.7) is not significantly different from the liking scores of C, D and B soymilks, but it is significantly lower than the A soymilk liking score (*P* ≤ *0.05*). This result is partially consistent with previous result at 3.1 section. The fact that G soymilk liking score is not significantly different from the B soymilk liking score can be explained by the fact that these samples are located at the same position on the biplot from Figure 1, meaning they have the same sensory attribute scores.

3.3. Preference mapping

The preference mapping of the soymilks performed from the combination of analysis of product sensory quality attributes and consumer liking showed that consumers can be clustered into seven groups (Figure 2).

The Figure 2 showed that the preference from consumers in group 2 was different with preference from other groups (from the PC1 and PC2). Over half of the consumer groups tend to prefer the A and C soymilks, so these products get highest preference scores (60–80%). The G soymilk gets the same preference from the customers as B and D soymilk products (40–60%). This result is consistent with the statistical results in Table 2 and the results from the analysis of the product sensory quality attributes. In addition, because of the slight difference in the preference of customer groups, the SD values from the hedonic mean scores are rather high (Table 2). All samples could not get the maximum satisfaction from the customers (80–100%) because they are stored in bottle, so their sensory quality could not be as good as the paper boxed soymilk products.

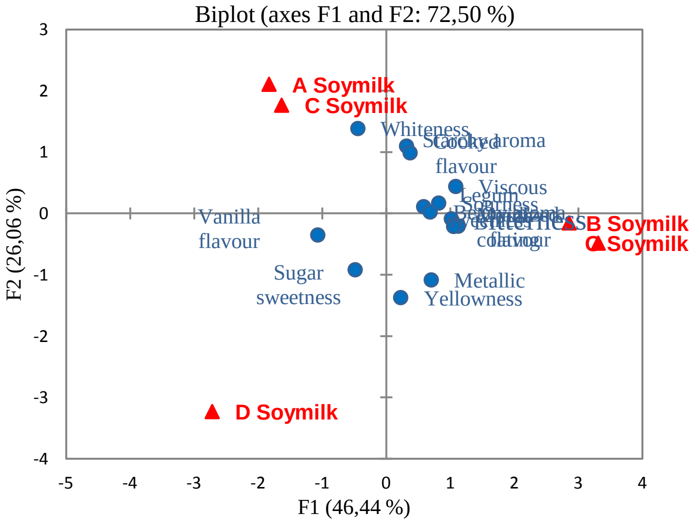

Figure 1. Bi-plot from PCA of descriptive sensory data for soymilks

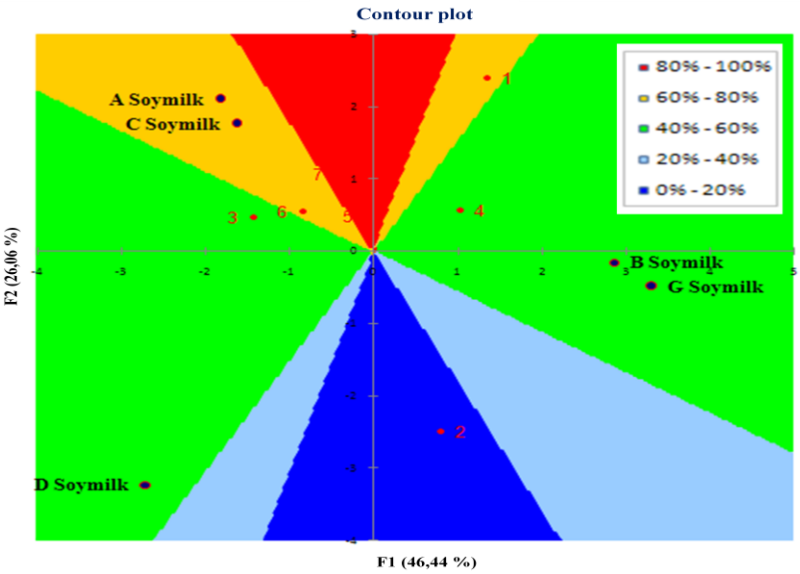

Figure 2. The preference mapping of the soymilks

4. CONCLUSION

In conclusion, QDA and preference mapping can contribute to strategic product positioning for development and marketing of new products, including soymilk product processed from germinated soybean. The sensory quality and the customer liking of the experimental germinated soybean milk product are equivalent to that of commercial soymilk products.

REFERENCES

Drake, M. (2007). "Invited review: Sensory analysis of dairy foods." Journal of dairy science 90(11): 4925-4937.

Harry, T. L. and H. Hildegarde (2010). Sensory Evaluation of Food: Principles and Practices, Springer, New York.

Hough, G. and R. Sánchez (1998). "Descriptive analysis and external preference mapping of powdered chocolate milk." Food quality and preference 9(4): 197-204.

Jiang, S., W. Cai and B. Xu (2013). "Food Quality Improvement of Soymilk Made from Short-Time Germinated Soybeans." Foods 2(2): 198-212.

Kaushik, G., S. Satya and S. N. Naik (2010). "Effect of domestic processing techniques on the nutritional quality of the soybean." Mediterranean Journal of Nutrition and Metabolism 3(1): 39-46.

Kwok, K. C. and K. Niranjan (1995). "Review: effect of thermal processing on soymilk." International journal of food science & technology 30(3): 263-295.

Lawlor, J. B. and C. M. Delahunty (2000). "The sensory profile and consumer preference for ten speciality cheeses." International Journal of Dairy Technology 53(1): 28-36.

Martinez, A. P. C., P. C. C. Martinez, M. C. Souza and S. G. C. Brazaca (2011). "Chemical change in soybean grains with germination." Food Science and Technology (Campinas) 31(1): 23-30.

Matsuura, M., A. Obata and D. Fukushima (1989). "Objectionable flavor of soymilk developed during the soaking of soybeans and its control." Journal of Food Science 54(3): 602-605.

Mongi, R. J., N. Bernadette, B. Chove and T. Wicklund (2013). "Descriptive Sensory Analysis, Consumer Liking and Preference Mapping for Solar Dried Mangocv Dodo." Food Science and Quality Management 16: 16-23.

Murray, J. and C. Delahunty (2000). "Mapping consumer preference for the sensory and packaging attributes of Cheddar cheese." Food quality and preference 11(5): 419-435.

Næs, T. and E. Risvik (1996). Preference mapping for product optimization. Multivariate analysis of data in sensory science, Elsevier. 16: 71-80.

Paucar-Menacho, L. M., M. A. Berhow, J. M. G. Mandarino, Y. K. Chang and E. G. d. Mejia (2010). "Effect of time and temperature on bioactive compounds in germinated Brazilian soybean cultivar BRS 258." Food research international 43(7): 1856-1865.

Richardson-Harman, N. J., R. Stevens, S. Walker, J. Gamble, M. Miller, M. Wong and A. McPherson (2000). "Mapping consumer perceptions of creaminess and liking for liquid dairy products." Food quality and preference 11(3): 239-246.

Rosenthal, A., R. Deliza, L. Cabral, L. C. Cabral, C. A. Farias and A. M. Domingues (2003). "Effect of enzymatic treatment and filtration on sensory characteristics and physical stability of soymilk." Food Control 14(3): 187-192.

Sattar, A. and M. Akhtar (1990). "Irradiation and germination effects on phytate, protein and amino acids of soybean." Plant Foods for Human Nutrition 40(3): 185-194.

Schlich, P. (1995). "Preference mapping: relating consumer preferences to sensory or instrumental measurements." Colloques de l'INRA (France).

Shun-Tang, G., T. Ono and M. Mikami (1997). "Interaction between protein and lipid in soybean milk at elevated temperature." Journal of Agricultural and Food Chemistry 45(12): 4601-4605.

Torres-Penaranda, A. and C. Reitmeier (2001). "Sensory descriptive analysis of soymilk." Journal of Food Science 66(2): 352-356.

Yackinous, C., C. Wee and J.-X. Guinard (1999). "Internal preference mapping of hedonic ratings for Ranch salad dressings varying in fat and garlic flavor." Food quality and preference 10(4): 401-409.

Young, N. D., M. Drake, K. Lopetcharat and M. R. McDaniel (2004). "Preference mapping of Cheddar cheese with varying maturity levels." Journal of dairy science 87(1): 11-19.

SUMMER PROGRAM IN SENSORY EVALUATION 2014

From Senses To Quality

What can sensory evaluation bring to quality control?

4th International Symposium, July 25-27, VietNam

CROSS-CULTURAL DIFFERENCES IN CONSUMER QUALITY PERCEPTION OF RICE

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ABSTRACT

Most aspects of food product quality perception are culture-bound. We present a cross-cultural study aiming at understanding how consumers from four countries (French, Japanese, Korean and Thai) perceive, describe and appreciate rice and rice quality. Marked differences were found in participants' motivation to consume rice: sensory and commodity in France; sensory and health in Japan; nutrition and commodity in Thailand; and nutrition, health and safety in Korea. For the description of rice qualities, despite a few cultural differences, especially between Korean and Thai descriptions of white and brown rice samples, similar sensory profiles were obtained in the four countries. In all countries germinated rice samples were less appreciated than the other samples. A preference mapping combining descriptive and liking data showed that, contrary to what we expected, preference of Japanese consumers were closer to that of French consumers than to that of other Asian consumers. This study suggests that cultural differences in food product quality perception might be more driven by motivation than by perception and that geographical proximity is not a good predictor of quality perception.

Key words: *cross cultural study, rice, quality, perception, motivation, preference*

1. INTRODUCTION

Consumers' demand for foods that are healthier, safer, more palatable and more environmentally or animal friendly is increasing (Gao, Schroeder *et al.*, 2010, Horská, Ürgeová *et al.*, 2011). Consumers want quality and value, however, these terms have slippery meanings that are hard to pin down. The ISO 8402-1986 standard defines quality as "*the totality of features and characteristics of a product or service that bears its ability to satisfy stated or implied needs*". Manufacturers define it as a measure of excellence or a state of being free from defects, deficiencies, and significant variations, brought about by the strict and consistent adherence to the measurable and verifiable standards to achieve the uniformity of output that satisfies the specific customer or user requirements. Quality is thus considered synonymous with innate excellence and cannot be analyzed, but only recognized through experience (Oude Ophuis and Van Trijp, 1995). The formation of quality judgments entails a subject-object interaction, since the quality judgment is formed by an individual with respect to a certain product. Perceived-quality judgments emerge in contextual setting and, therefore, cannot be located "inside" the consumer as a completely subjective concept or "outside" the consumer as a subject-free objective concept (Thompson, Locander *et al.*, 1989). As such, quality judgments are culture-bound.

According to Wansink, Sonka *et al.* (2002) all cultures do not have the same perception of food. "*Some cultures view food exclusively as providing nutrition (utilitarian perception), whereas other have a greater appreciation for the complexity of* *preparation and for the process of savouring food (hedonic perception)" (p. 354).* For example, according to these authors, Vietnam is considered as a culture where a utilitarian perception of food is dominant. Food consumption has become focused on providing nutritional and health benefits as a result of food shortages and civil strife. As a consequence, Vietnamese people view food primarily as a functional instrument that provides value by being a means to an end. In this context food quality might relate mostly to the nutritional value of the food. On the other hand, Japanese culture is considered as a hedonic culture that views food as experiential and affective. In this culture, food is appreciated for its own sake, with less regard for its practical characteristics. In this context food quality might relate mostly to sensory appeal of the food.

Food quality judgments are strongly related to sociocultural factors, thus, to understand quality judgments we need to understand cultural factors. Cultures are not characterized only by specific cuisines and dishes but also by specific attitudes toward foods and toward the role of foods in daily life. Cultures and individuals vary in the importance they attribute to food in their lives, the ritual and moral significance of food, and the role of food as a social vehicle. Among different food categories, starchy foods are interesting to study not only because of their importance in our diet but also because of the beliefs they generate in different cultures. Consumers have mixed beliefs on these foods. For example, Lloyd, Paisley *et al.* (1993) observed that for 40% of consumers increasing the intake of starchy food was favorable for weight control, whereas about the same percentage thought the opposite. Rice, along with wheat and corn, is one of the three most important grains in the world to be used today as a starch source. Especially in Asia, rice is crucial for food security since rice provides on average more than 28% of the daily calorie intake against 1.65% in Europe. Beyond the calorie intake, brown rice and even value-added rice such as germinated brown rice (GBR) have gained a great deal of attention, especially in Asian countries as a result of growing health consciousness (Sakamoto, Hayashi *et al.*, 2007, Moongngarm and Saetung, 2010, Roy, Nei *et al.*, 2010, Cha, Han *et al.*, 2012).

The general objective of the work presented here was to better understand cultural differences in the motivation of rice consumption and the determinants of choice of rice and rice cooking methods with regard to the different values attached to nutrition, taste and convenience across cultures. The end goal of this work was to provide insights to develop new rice cooking processes to enhance nutritional and organoleptic qualities to international consumers. The first step towards this goal was to understand consumers' expectations and perception of rice and rice cooking processes. We hypothesized that these expectations and perceptions would be influenced by consumers' cultural background. To verify this hypothesis, we conducted a series of cross-cultural studies in four countries that have contrasted and shared cultures. To represent Eastern culture, we included three Asian countries: Korea (Seoul), Japanese (Tsukuba and Tokyo) and Thai (Bangkok). These selected Asian countries shared a rice-based culture; however, they differ substantially in terms of geographic, social and economic factors, especially Thailand, a South-east Asian country and Korea and Japan, North-East Asian countries. To represent Western culture, we selected France (Dijon). France is one of the larger consumers of rice in the EU with Spain and Italia. The second step was to evaluate the effect of cultural differences in expectation and motivation on rice perceived sensory characteristics. We hypothesized that different expectations and motivations might lead consumers to focus their attention on different characteristics of the rice and thus lead to differences in terms of description and appreciation of rice qualities. We first developed a "universal" tool to describe the organoleptic characteristics of rice across cultures. A modified optimized descriptive profile (ODP) was then used based on this lexicon to describe white, brown and germinated rice samples in the four countries. In parallel a consumer test was conducted to evaluate the appreciation of the same products by consumers from the same countries.

2. EXPECTATIONS AND PERCEPTION OF RICE AND RICE COOKING PROCESSES

2.1. Material and Methods

Participants. A total of 80 participants from four countries – Korea (Seoul), Japan (Tokyo and

Tsukuba), Thailand (Bangkok), and France (Dijon) – participated in this study. Inclusion criteria were that the participants were the primary person responsible for food preparation in the household, spoke the native language, were aged between 20 and 70 years, cooked rice at least once per week and were willing to receive two researchers in their kitchen and talk about their way of cooking rice. As an incentive, participants were offered a payment going from $10 in Thailand to $50 in Japan. The payment was based on the economic standard of the country. The majority of participants were females (75 women; five men); reflective of data showing that women prepare meal more frequently than men especially in Asia. The males who participated in our study were all French.

Procedure. Participants were interviewed individually at home. They were first asked to cook rice in their usual way. The cooking step was videotaped (Figure 1). At the end of this step, participants were interviewed through a semi-structured individual face-to-face interview including a free association task (Son, Do *et al.*, 2014), a matching task (Son, Do *et al.*, 2013) and questions linked to their rice-cooking behaviors, as well as their perception of other rice-cooking methods, and rice and other cereals and beans usage. The ways they stock rice was also observed by taking pictures of their cupboards. The interviews were conducted in native language. The interviews lasted from 1h30 to 2h and were audio-taped.

Data analysis. Videotapes were analyzed independently by two researchers. The analyses focused on three main aspects: 1) the ingredients that participants used and those they have in their cupboard, 2) the cooking devices they generally use and 3) the cooking steps they used the day of cooking. In addition, the audio recordings were transcribed and verbatim transcripts were analyzed by two researchers to help understanding the observed behaviors. The association and matching tasks were analyzed by comparing respectfully the frequencies of words and matches obtained in each culture (see Son, Do *et al.* (2013) and Son, Do *et al.* (2014) for further details).

2.2. Results and discussion

Figure 1, 2 and 3 illustrates the cooking methods and ingredients used in the four countries. In France, participants cooked rice mostly in standard pots, whereas participants from the three Asian countries used mostly electronic rice cookers. Differences in the type of electronic rice cookers were observed among the three Asian countries. In Thailand, participants used electronic rice cookers with simple functions, such as cook and warm. In Korea and Japan, most participants used high-technology multi-function rice cookers. All Korean participants used pressure cookers, but only half of them used induction-heating (IH) system. In Japan, most participants used IH system, but only half of them used pressure.

Figure 1. Illustration of cooking methods in the four countries.

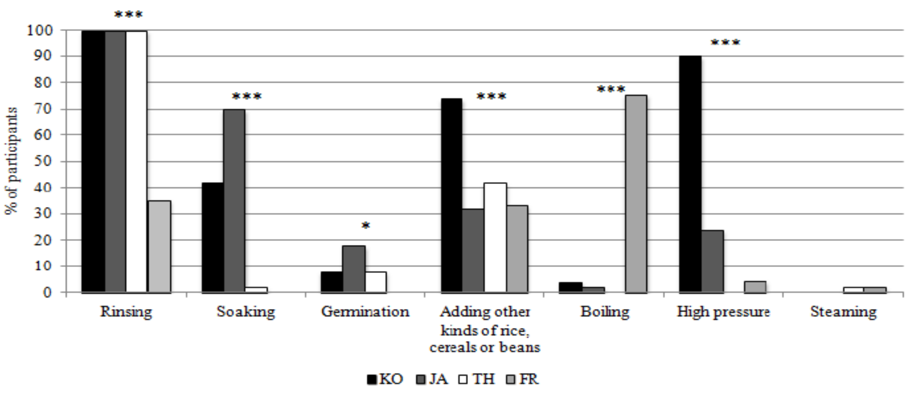

Figure 2. Frequency of participants using the seven different rice cooking processes.

****, p<0.001; *, p<0.05, khi2 test*

Figure 3. Illustration of ingredients used in the four countries

In the four countries the most frequently used ingredient was white rice. However, the variety of rice was different: Long-grain rice was used in France, Jasmine rice in Thailand, and Japonica rice in Korea and Japan. Many Korean participants added cereals and beans into the white rice and even some of them used brown rice instead of white rice and they explained their motivation to use these ingredients with nutritional-related issues. This behavior appeared also in Thailand in a lesser extent but not in Japan and France.

When asked what came to their mind when prompted with the words rice or good rice, French participants tended to associate "rice" more frequently with concepts such as foreign countries, culture, travel and exoticism. Participants in Asian countries tended to associate rice more frequently with concepts such as agricultural products, necessary goods, and emotions. Framed into the triadic approach of consumption, these results indicate that symbolic motivation is more important for French participants and utilitarian and experiential motivations are more important for Asian participants in rice consumption. Association to "good rice" showed that health was more considered by Korean and Thai participants and cooking process was more considered by French and Japanese participants. Sensory aspects, type of rice, and cleanliness were considered as important criteria for good rice in all four countries, which can be the criteria for better taste, nutrition, and safety.

2.3. Conclusion

Our findings showed that cultural environment has an impact on rice consumption motivations and perceived quality. Habitual behavior in rice-cooking process is strongly associated with beliefs' on cooking quality of rice which were acquired from long experience in each culture. In addition, there was a tendency to account for one's pattern of behavior by moving in circles from positive beliefs to habits and back to positive beliefs again.

3. DESCRIPTION AND APPRECIATION OF RICE QUALITIES

3.1. Material and Methods

Participants. The descriptive panels were composed of eight women in each country (aged 26±2 in Korea and 29±5 in France) who consume rice at least once a week and had prior experience in sensory profiling techniques but not of cooked rice. The consumer panels were composed of 100 women in each country.

Products. Six cooked rice samples obtained by crossing three types of rice (white, brown and germinated brown rice from the chu-cheong variety) and two cooking methods (called Korean and French cooking) were utilized. The details of cooking conditions are described in Table 1.

Descriptive test procedure. A modified version of the Optimized Descriptive Profile (ODP, de Cássia dos Santos Navarro da Silva, Minim *et al.* (2012)) was used. A "universal lexicon" was first developed (Son, Pecourt *et al.*, 2012). The lexicon included 22 descriptors illustrated by a set of definitions and references as illustrated figure 4.

Panelists were first familiarized with the lexicon and the set of reference during two sessions. Then eight evaluation sessions were conducted. Panelists were asked to indicate the intensity of the attribute for each sample on an unstructured 10cm line scale. They received all rice samples at the same time along with the references illustrating the weak and strong end of each scale.

Consumer test procedure. Panelists were asked to taste the rice samples and to indicate their liking on a 9-point scale going from dislike extremely to like extremely.

Data analysis. For the descriptive test the sensory scores obtained for each attribute in each country were averaged across repetitions and submitted to a multiple factor analysis (MFA). For the consumer test the liking scores were submitted to a two-way analysis of variance with country as a between subject factor and rice samples as a within subject factor. Pairwise comparisons with a SNK test were computed to evaluate the difference in liking between products in each country.

Table 1. Rice samples

	Cooking condition		Details		
Code	Rice type	Cooking type	Rice :Water(g)	Pre-cooking in the water bath*	Cooking appliance/ cooking Program
WF	White	French	572:905	Soak during 30 minutes at 60°C	Seb 8 en 1 electric rice cooker /Rapid cooking without smimering
WK	White	Korean	600 :700	-	Cuckoo electric pressure rice cooker /White rice menu (1)
BF	Brown	French	572 : 905	Soak during 60 minutes at 60°C	Seb 8 en 1 electric rice cooker /Rapid cooking with simmering
BK	Brown	Korean	600 : 800	-	Cuckoo electric pressure rice cooker /Brown rice menu (4)
GF	Germinated brown	French	572 : 905	Soak during 16 hours with lactic bacteria at 30°C	Seb 8 en 1 electric rice cooker /Rapid cooking with simmering
GK	Germinated brown	Korean	600 : 800	Soak during 16 hours with lactic bacteria at 30°C	Cuckoo electric pressure rice cooker /Brown rice menu (4)

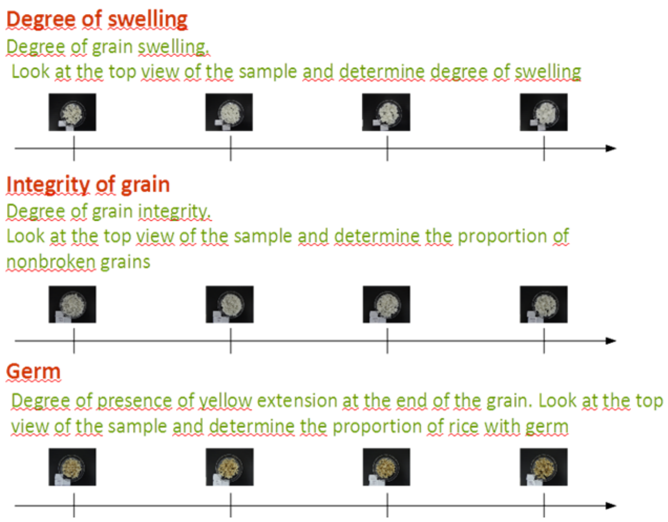

Figure 4. Illustration of universal lexicon used for rice description

3.2. Results and discussion

Descriptive test. The first three MFA components explain 96% of the total variance (Figure 5). For all panels, the first dimension opposes white rice to brown rice, the second dimension opposes the two cooking methods and the third one opposes brown rice to germinated rice.

All panels described the rice samples similarly. White rice samples were characterized with high glossiness, swelling, integrity of grain, rice cake odor, adhesiveness, cohesiveness of mass, and watery. Brown rice and germinated brown rice samples were characterized with high color, germ, sourness, astringency, bitterness, rice bran odor, roasted barley odor, firmness, chewiness, skin toughness and residual. Germination strengthen the sourness, corn odor and acidic odor characteristics of the brown rice and the French cooking method (with more water and no high pressure) lowered the color and glossiness characteristics and strengthen the easy to separate characteristics of brown rice. Korean panelists were more sensitive to the difference between brown rice either due to the cooking method or to the germination process than other panelists.

Consumer test. The ANOVA showed a significant effect of country with higher scores given by the Thai panel compare to the three other panels, F() = , p < as well as a product effect with the germinated rice being less appreciated than the other rice samples, F() = , p < and an interaction effect, F() = , p <. Figure 6 shows that French and Japanese panels tended to have similar liking patterns which differed from the Thai and Korean pattern.

An internal preference mapping (figure 7) showed that the attributes the less valued by consumers in the four countries are the attributes describing the germinated samples: acid, astringent and bitter taste, acid and corn smell, firmness, chewiness, skin toughness as well as the excessive adhesion and cohesion of the mass. In contrast the attributes the most appreciated by consumers are the attributes describing the white rice sample with the FR cooking method (i.e. with more water and no high pressure) and the brown rice samples. Among those attributes odor attributes vary by country: rice bran and rice cake odor in Thailand and Japan, roasted barley in France and Japan whereas texture and appearance tend to be the same in all countries: integrity of the rice grain, swelling of the grains and glossiness.

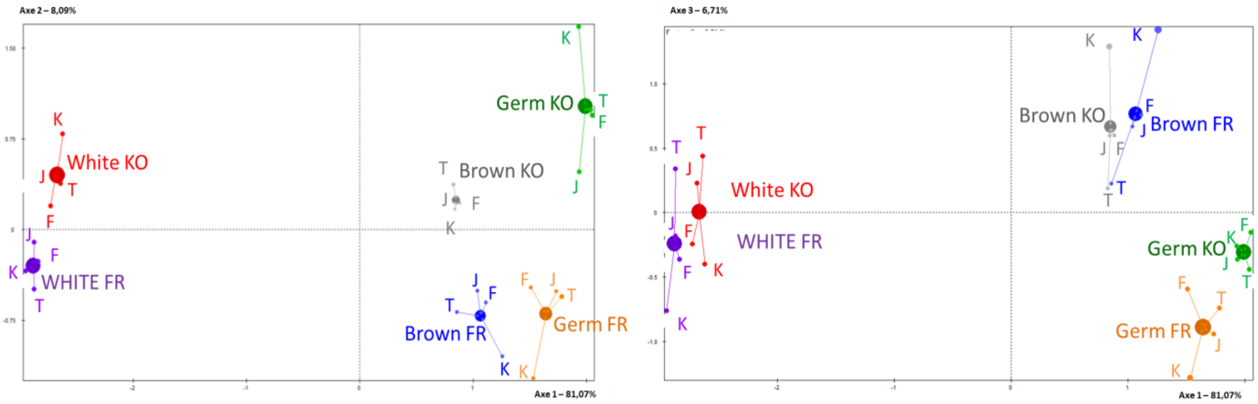

Figure 5. Projection of the products on the first three dimensions of the MFA carried out on the descriptive data collected in the four countries

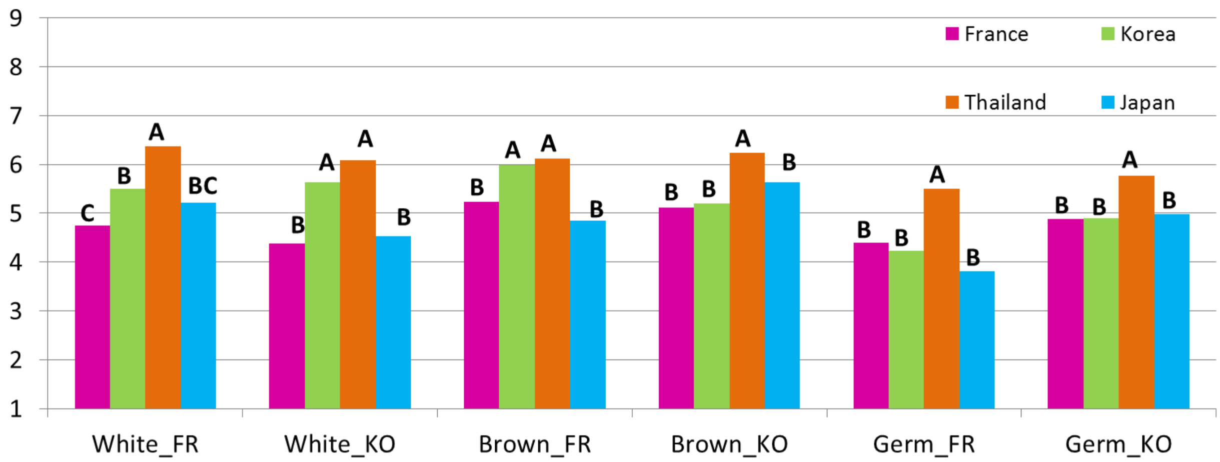

Figure 6. Average liking scores of the four panels. The letters represent the results of the SKN pair comparison test. Two samples with the same letter were not significantly different.

3.3. Conclusion

Although all panels described globally the rice samples similarly, some differences appear in the preference pattern. These differences may be attributed to different sensitivity of the panelists to some characteristic of the samples due to different food habit and familiarity with the products as well as to difference in expectation due to different representations. Finally, contrary to what we expected, preferences of Japanese consumers were closer to that of French consumers than to that of other Asian consumers which suggests that geographical proximity is not a good predictor of preferences and quality perception.

4. GENERAL CONCLUSION

Our results indicate the importance of understanding cultural differences in the development of a new rice cooking process for consumers across the world to satisfy quality demands underlying rice consumption in each country. For example, nutritional benefits can be emphasized when targeting Korean consumers and to a lesser degree Thai consumers. Convenience might be a more important factor to highlight for Thai consumers. For Japanese consumers, sensory qualities should be fulfilled fundamentally. Finally, to targeting French consumers, symbolic meaning of rice consumption such as voyage and exotic concepts can be used as a useful marketing strategy.

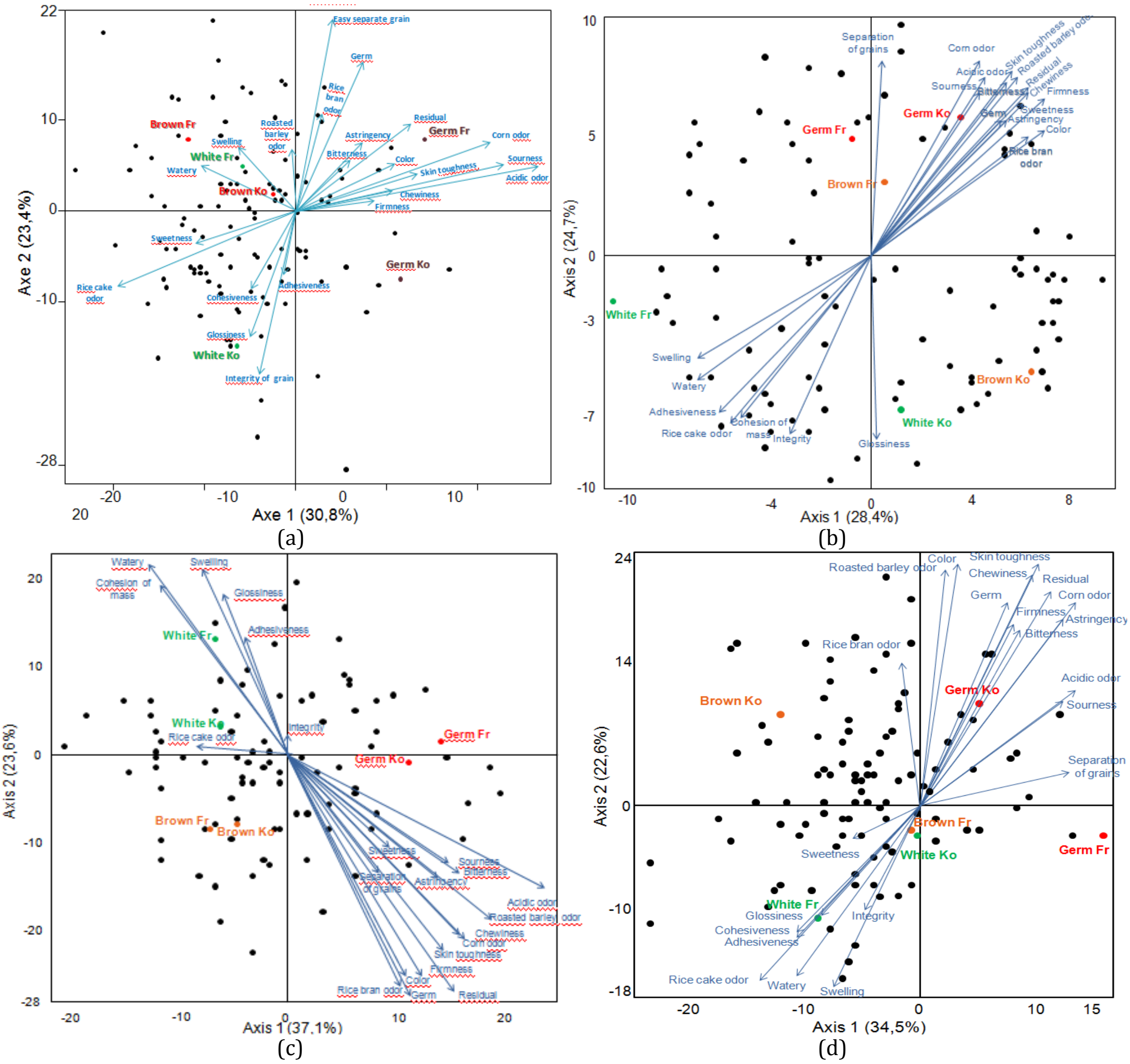

Figure 7. Illustration of the preference mapping realized in the four countries: a) South Korea, b) Thailland, c) Japan, and d) France)

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REFERENCES

Cha, H.-M., G. Han and H.-J. Chung (2012). "A study on the trend analysis regarding the rice consumption of Korean adults using Korean National Health and Nutrition Examination Survey data from 1998, 2001 and 2005." Nutrition research and practice 6(3): 254-262.

de Cássia dos Santos Navarro da Silva, R., V. P. R. Minim, A. A. Simiqueli, L. E. da Silva Moraes, A. I. Gomide and L. A. Minim (2012). "Optimized descriptive profile: a rapid methodology for sensory description." Food quality and Preference 24(1): 190-200.

Gao, Z., T. C. Schroeder and X. Yu (2010). "Consumer willingness to pay for cue attribute: the value beyond its own." Journal of International Food & Agribusiness Marketing 22(1-2): 108-124.

Horská, E., J. Ürgeová and R. Prokeinova (2011). "Consumers' food choice and quality perception: Comparative analysis of selected Central European countries." Agric. Econ.–Czech 57: 493-499.

Lloyd, H., C. Paisley and D. Mela (1993). "Changing to a low fat diet: attitudes and beliefs of UK consumers." European Journal of Clinical Nutrition 47(5): 361-373.

Moongngarm, A. and N. Saetung (2010). "Comparison of chemical compositions and bioactive compounds of germinated rough rice and brown rice." Food Chemistry 122(3): 782-788.

Oude Ophuis, P. A. and H. Van Trijp (1995). "Perceived quality: a market driven and consumer oriented approach." Food quality and Preference 6(3): 177-183.

Roy, P., D. Nei, T. Orikasa, H. Okadome, M. Thammawong, N. Nakamura and T. Shiina (2010). "Cooking properties of different forms of rice cooked with an automatic induction heating system rice cooker " Asian Journal of Food and Agro-Industry 3(4): 373-388.

Sakamoto, S., T. Hayashi, K. Hayashi, F. Murai, M. Hori, K. Kimoto and K. Murakami (2007). "Pre-germinated brown rice could enhance maternal mental health and immunity during lactation." European journal of nutrition 46(7): 391-396.

Son, J.-S., V. B. Do, K.-O. Kim, M. S. Cho, T. Suwonsichon and D. Valentin (2013). "Consumers' attitude towards rice cooking processes in Korea, Japan, Thailand and France." Food quality and Preference 29(1): 65-75.

Son, J.-S., V. B. Do, K.-O. Kim, M. S. Cho, T. Suwonsichon and D. Valentin (2014). "Understanding the effect of culture on food representations using word associations: The case of “rice” and “good rice”." Food quality and Preference 31: 38-48.

Son, J. S., A. Pecourt, F. Hayagawa, K. Suzuki, T. Suwansichon, K.-O. Kim and D. Valentin (2012). How can we communicate sensory characteristics of food in different languages and cultures? The case study of cooked rice. SPISE, Vietnam.

Thompson, C. J., W. B. Locander and H. R. Pollio (1989). "Putting consumer experience back into consumer research: the philosophy and method of existential-phenomenology." Journal of consumer research: 133-146.

Wansink, B., S. T. Sonka and M. M. Cheney (2002). "A cultural hedonic framework for increasing the consumption of unfamiliar foods: soy acceptance in Russia and Colombia." Review of Agricultural Economics 24(2): 353-365.

PART 3 - FUNDAMENTALS OF SENSORY PERCEPTION

SUMMER PROGRAM IN SENSORY EVALUATION 2014

From Senses To Quality
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4th International Symposium, July 25-27, VietNam

POWER COMPARSION OF TRIANGLE AND TETRAD TESTS APPLIED TO HIGH ETHANOL BEVERAGES

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ABSTRACT

The power of a sensory discrimination test is the capacity of that test to reliably detect differences between products. Consideration of power is important because this helps researchers to choose which discriminative tests to apply in some specific cases. In this study we used ethanol based beverages to compare the power of the Triangle and Tetrad tests with respect to their correct response probabilities with various effect sizes (δ).

The discrimination tests, Triangle and Tetrad, were performed by a same panel (N = 30) on samples made from a basic alcoholic beverage made with 50% v/v alcohol and the same beverage with added citric acid. Different panels evaluated different citric acid concentrations which were tailored to get effect sizes (δ) from 1.5 to 3. A logistic regression model was applied to predict correct response probability from two variables: citric acid concentrations and type of protocol.

For 5 experimental sessions, we had 35%, 85%, 85%, 35%, 65% confidence that the Triangle test returned greater numbers of correct responses than the Tetrad test when we added 4.394, 6.214, 8.789, 12.430, 17.578 g/l citric acid, respectively. Multivariate logistic regression analysis showed that acid citric concentration was a significant factor affecting correct response probability (p =.009). Logistic regression analysis indicated that there was a 70% chance for the Triangle's power to be higher than Tetrad's power. Moreover, no interaction between stimulus's concentration and type of protocol was found.

These findings suggest that the Triangle test can be used as a suitable testing methodology for alcoholic beverages with made with 50% v/v alcohol.

Keywords: *power, Triangle test, Tetrad test, logistic regression, alcohol*

1. INTRODUCTION

Power analysis can evaluate the efficiency of a discrimination test. The more powerful a discrimination test, the less likely it is to lead to a Type II error. In foods and consumer products industries, making a Type II error could lead to miss a positive significant change in formula modification or in processing, or fail to detect a negative sensation which could lead to consumers rejecting purchase or consuming products. It is therefore critical to choose a discrimination test which minimizes Type II error (i.e., that is higher in power). In fact, the power of a discrimination test is considered as the most important issue to be considered when choosing methods (Bi and Ennis, 2001).

There is a large body of work evaluating discrimination testing methods by comparing their power. For example, Masuoka, Hatjopoulos *et al.* (1995) compared two pairs of tests on performed with beers and concluded that the 3-AFC test was more powerful than the Triangle test but could find differences in power between the specified Tetrad or the non-specified Tetrad. In a study with basic yogurt, the Triangle test was found to be less powerful than the Same-Different test by Rousseau, Meyer *et al.* (1998). In a more comprehensive study, Bi (2008); Bi and Ennis (2001) ranked discrimination tests in order of increasing statistical power as follow: duo-trio, triangle, A-Not A, 2-AFC, 3-AFC. In general, specified tests are more powerful than unspecified tests (Van Hout, Hautus *et al.*, 2011). This suggests that specified tests are preferable to unspecified tests when statistical power is concerned but are, in fact, less applied in food evaluation practice because food is considered a complex and multi-dimensional system (Meilgaard, Carr *et al.*, 2006). Replicating samples (Bruun Brockhoff and Schlich, 1998; Ishii, O'Mahony *et al.*, 2014), adding a "no choice" option (Angulo and O'Mahony, 2005), increasing the sample size (Meilgaard, Carr *et al.*, 2006), comparing the sensitivity of various testing methodologies (Ennis, 2012; Garcia, Ennis *et al.*, 2012) were all proposed to enhance the power of these unspecified tests.

Several notable papers have focused on the power comparison between tetrad and other methods. For example, Ennis and Jesionka (2011) calculated the power as a function of sample size at different *d'* to compare the power of Tetrad, Triangle, Duo-trio, and 2-AFC. In a study with apple juice, Garcia, Ennis *et al.,* (2012) and Ennis (2012) concluded that the power of the Tetrad test was still higher than the power of the Triangle test even though the effect size of Tetrad was smaller. However, Garcia, Ennis *et al.* (2012) - after investigating effects of different types of salsa on the power of the Tetrad test - recommended that one should not switch from the Triangle to the Tetrad test for salsa. These different conclusions could be explained by sensory fatigue, adaptation, and memory effect. As a case in point, for apple juice and orange juice product categories, Ishii, O'Mahony *et al.* (2014) reported that the Tetrad test could have higher power than the Triangle test for small effect sizes and for some resampling conditions. In the work reported by Garcia, Ennis *et al.* (2013), the specified Tetrad test revealed a larger difference between the stimuli than the 2-AFC test in case of large sample size. Although the above researchers concluded that the Tetrad test has maximal power, investigation of the power of the Tetrad test on various food categories is still limited, especially in sensory fatigue-caused foods. Moreover, comparison between the Tetrad's and Triangle's power at different effect sizes has not been given proper consideration.

The aim of this research is to investigate the power of unspecified Tetrad test at different *d'* values when applied to a Vietnamese spirit product which has the highest level of alcohol (50% v/v). Spirit products can easily cause sensory fatigue (Garcia, Ennis *et al.*, 2012). As a consequence, evaluating this type of products could increase the variance of perceptual distribution and this in turn would decrease *d'*. We first examine whether or not the decrease of *d'* when tasting the fourth sample of a tetrad protocol is large enough to lose the power advantage of the Tetrad method. The association between the power of Tetrad or Triangle tests and effect size is also investigated.

2. MATERIALS AND METHODS

2.1. Stimuli

The stimuli for the experiment consisted of a basic spirit (Bau Da, 50%v/v alcohol, Tam Huong company Inc., Binh Dinh province, Vietnam) and the same spirit with added commercial citric acid (Hoa Nam Inc., HCMC., Vietnam) at different concentrations. The first stimulus will be referred to as Sample A, and the series with citric acid as samples Bx.

Preliminary testing using successive additions was conducted to estimate approximately the citric acid concentrations that would insure that the Triangle test would get from medium to high proportion of distinguishers (i.e., P_d > 25%) or that the proportion of correct responses would be larger than 50% (ISO). According to the results of the preliminary testing, 4.394 g/l was chosen as the lowest concentration of samples Bx to obtain 50% correct answers corresponding to a *d'* = 1.47. The next concentrations were determined by multiplying the lowest concentration and square roof of 2 until *d'* reached the maximum possible value of interest (i.e., *d'* = 3) (Ennis, 2012).

Spirit bottles were chilled until their temperature was below 5^{0}C before being mixed into the homogenous sample. This sample was divided into two parts: one for sample A and the other for samples B. Citric acid was added into the Bx samples to get the expected concentrations. Both sample A and samples B were stirred until citric acid in samples B was dissolved completely. The desired samples were poured in plastic bottles and kept in cold water (approx. 1-5^{0}C).

Before starting an experimental session, 10ml samples were dispensed in plastic-lidded cups and kept in fridge for at least 5 minutes to ensure that all samples had the same temperature (approx. 8-10^{0}C). When panelists evaluated samples, the temperature of the samples was about 12-15^{0}C.

2.2. Subjects

One hundred fifty participants from HCM-City University of Technology and Industrial University of HCM-city participated in this study. They were 18 to 35 years old, willing to consume alcohol, not suffering from periodontal disease and not be allergic to any of the ingredients in the product. This information was collected by questionnaires before conducting the experiment.

2.3. Testing Procedure

For each concentration of citric acid added, each of 30 panelists was performed only one time with both Tetrad test and Triangle test in an experimental session. Half the panel (15) started with the Tetrad test, while the other half started with the Triangle test. Each of the six possible presentation orders of both the Triangle and Tetrad tests was presented 5 times.

The panelists were explained the instructions, rinsed their mouth three times with distilled water, tasted the samples from left to right, swallowed the whole 10 mL of each sample, and finally gave their answer upon tasting the last sample. For the Triangle test, the instructions were to select the odd sample which was different from the others (ASTM, E1885 - 04(2011)). For the Tetrad test, panelists were asked to divide the four samples into two groups of two based on similarity (Masuoka, Hatjopoulos *et al.*, 1995). Before continuing the second test, panelists had a 10 minute rest to reduce the effect of sensory-fatigue. The testing time for the each test lasted approximately 10 minutes on average and 30 minutes for the complete experiment. The same procedure was repeated with another panelists for other citric acid concentrations.

2.4. Statistical Analysis

Chi square test was used to compare correct response proportions.

Models developed by regression analysis allow us to observe simultaneously the influence of both protocols and degrees of difference on the correct response probability (Hosmer Jr and Lemeshow, 2004). Therefore regression analysis was used in our study to give a more accurate picture of the power relationship between protocols and degrees of difference.

A multivariate logistic regression analysis was carried out to test the association between independent variables and correct response probabilities with and without interaction. The independent variables tested in the model were citric acid concentrations (4.394 g/l, 6.214 g/l, 8.789 g/l, 12.43 g/l and 17.578 g/l) and types of protocols (Triangle test and Tetrad test).

The statistical software R (version 3.1.0) was used for all statistical analyses. All reported *p*-values were two-tailed, and *p*-values < .05 were considered statistically significant.

3. RESULTS

Results of five experimental sessions are summarized in table 1. The Chi-square test was used to compare correct response proportions. In all concentrations tested, *p*-values greater than .05 indicated that there was no significant difference between Triangle's and Tetrad's P_c.

Table 1. The correct response proportion (P_c) and variance values for each protocol, and *P*-values of Chi-square test to compare correct response proportions for each stimuli's concentration.

Citric concentration (g/l)	Protocol	N	Correct answer	P_c	Var	*P*-value
4.394	Triangle	30	15	0.500	0.008	0.7961
	Tetrad	30	16	0.533	0.008	
6.214	Triangle	30	22	0.733	0.007	0.1760
	Tetrad	30	17	0.567	0.008	
8.789	Triangle	30	20	0.667	0.007	0.1904
	Tetrad	30	15	0.500	0.008	
12.430	Triangle	30	22	0.733	0.007	0.7656
	Tetrad	30	23	0.767	0.006	
17.578	Triangle	30	23	0.767	0.006	0.5593
	Tetrad	30	21	0.700	0.007	

Table 2. The ratios of the tetrad's correct response proportion to the triangle's and the confidence levels that ratio is greater than 1 for each stimuli's concentration.

Citric concentration (g/l)	Protocol	P_c	Var	$\frac{P_{c.triangle}}{P_{c.tetrad}}$	Confidence that P_c ratio is greater than 1
4.394	Triangle	0.500	0.008	0.94	35%
	Tetrad	0.533	0.008		
6.214	Triangle	0.733	0.007	1.29	85%
	Tetrad	0.567	0.008		
8.789	Triangle	0.667	0.007	1.33	85%
	Tetrad	0.500	0.008		
12.430	Triangle	0.733	0.007	0.96	35%
	Tetrad	0.767	0.006		
17.578	Triangle	0.767	0.006	1.10	65%
	Tetrad	0.700	0.007		

Table 3. The ratios of the tetrad's correct response proportion to the triangle's and the confidence levels that ratio is greater than 1 for each stimuli's concentration.

Citric concentration (g/l)	Protocol	d'	Var	$\frac{d'_{\text{tetrad}}}{d'_{\text{triangle}}}$	Confidence that d' ratio is lower than 2/3	Increase in perceptual noise
4.394	Triangle	1.4660	0.4788	0.776	35%	28.79%
	Tetrad	1.1383	0.3119			
6.214	Triangle	2.6962	0.4815	0.464	85%	115.51%
	Tetrad	1.2511	0.3037			
8.789	Triangle	2.3214	0.4604	0.440	85%	127.14%
	Tetrad	1.0220	0.3247			
12.430	Triangle	2.6962	0.4815	0.725	35%	37.88%
	Tetrad	1.9554	0.3094			
17.578	Triangle	2.9028	0.4984	0.587	65%	70.25%
	Tetrad	1.7050	0.2986			

Similar to the ratio comparison approach (Ennis and Ennis, 2011), the ratio of $P_{c.triangle}/P_{c.tetrad}$ can be estimated and compared to 1. The confidence levels of the ratios which were greater than 1 were shown in table 2. We have at least 35% confidence that the Triangle test returned greater numbers of correct responses than the Tetrad test in case of 4.394 g/l and 12.430 g/l citric acid added, while the confidence level is 85% in case of 6.214 g/l and 8.789 g/l citric acid added; 65% in case of 17.578 g/l citric acid added.

Table 3 provides the *d'* values and their variances estimated. The *d'* ratios of two protocols and the increase in perceptual noise when we switched from the Triangle test to the Tetrad test are also shown. There is a consistent drop in the *d'* values when switching from the Triangle test to the Tetrad test. At 6.214 g/l, 8.789 g/l concentrations, the chance of $d'_{tetrad}/d'_{triangle}$ being lower than 2/3 is 85%; the other cases are lower than 85%.

Logistic regression was used to determine which variables related to correct response probabilities and also to estimate the magnitude of the overall effect of the explanatory variables on the outcome of our study. Table 4 shows the coefficients and involving statistics in the logistic regression models.

In Model 1, predictive variables are acid concentration, protocol, and interaction between concentration and protocol; while acid concentration and protocol are in Model 2.

In logistic regression analysis, the first important concept is β coefficient (the slope value). Value β represents the amount of change of the dependent variable when the independent variable changes by one unit. In the two considered models, protocols were treated as categorical variables, and triangle test and tetrad test were coded as 1 and 0. Thus, the β coefficient showed expressed the Triangle's test.

In model 1, the interaction between citric acid concentrations and testing protocols was not found significantly (p-value = .495). Thus, Model 2 was used for obtaining the regression equation.

In Model 2, the β coefficient of acid concentration variable was positive. This positive value indicates that the proportion of correct responses increased when the citric acid concentration increased. Table 5 provides the β coefficients and their confidence intervals. The 95% confidence interval of β ranges from –0.181 to 0.780 and this range includes zero. Therefore the types of protocols did not significantly influence the probability of correct response. However, in the 70% confidence interval, the smallest value of β was

0.045 and this value would correspond to the case in which the power of the Triangle test power was larger than the power of the Tetrad (see Figure 1).

Table 4. The results of the model with, and without interaction

	Independent Variables	β - coefficients	Standard errors	*P*-value* (>|z|)	*P*-value** (> ChiSq)
Model 1	Acid concentration	0.07	0.037	0.058	0.417
	Protocol	0.306	0.565	0.588	
	Concentration:Protocol	0	0.054	0.989	
Model 2	Acid concentration	0.07	0.027	0.009	0.432
	Protocol	0.299	0.245	0.222	

P-value: is our measure of statistical significance and will tell us whether it is likely that we would have found a relationship of this size in the sample if there was no relationship in the population.*

*P-value**: used for evaluation the goodness of fit of used model. When P-value is higher than 0.05 which suggests that our model fits the data.*

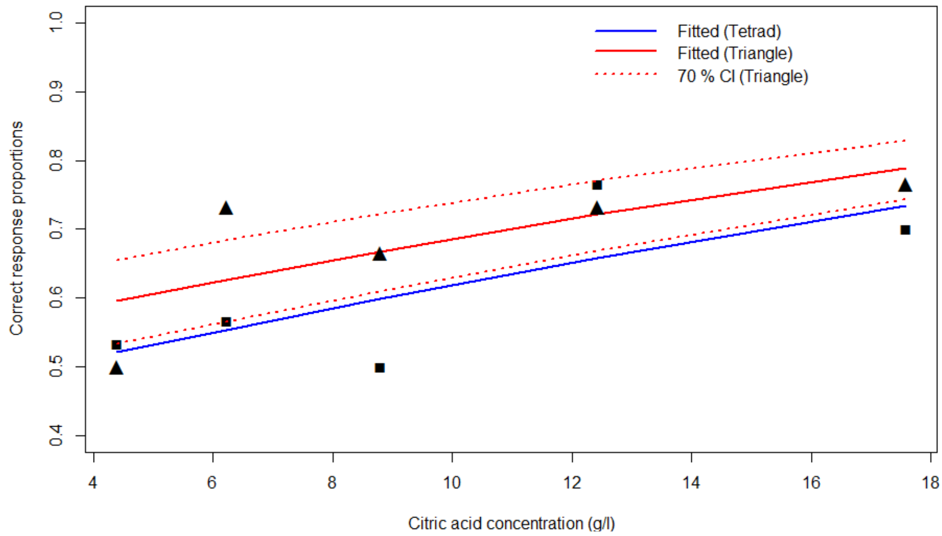

Figure 1. Confidence intervals of β coefficient for Tetrad test and Triangle test.

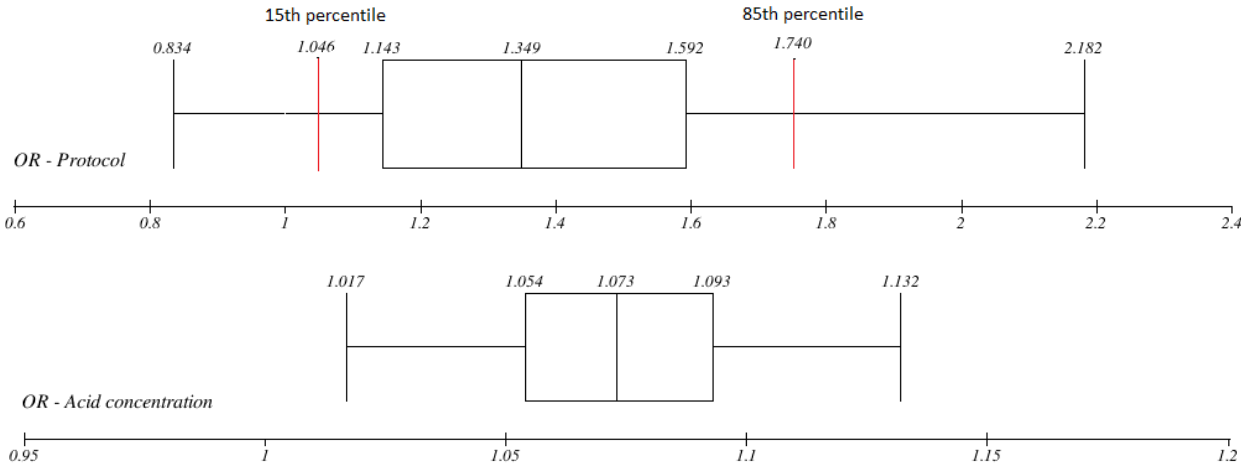

Figure 2. OR values of acid concentration and protocol variables

Table 5. Confidence intervals of the β coefficient in Model 2.

	Mean	95% CI		70%CI	
		Lower	Upper	Lower	Upper
Acid concentration	0.071	0.017	0.124	0.043	0.099
Protocol	0.299	–0.181	0.780	0.045	0.554

Another important concept is the odds ratio (OR) which estimates the change in the odds of membership in the target group for a one unit increase in the predictor. It is computed by using the regression coefficient of the predictor as the exponent (Hosmer Jr and Lemeshow, 2004).

With a 95% confidence interval, the OR values of the acid concentration variable are significantly greater than 1 while the same conclusion drawn from protocol variable can be also be reached with 70% interval confidence (Figure 2).

4. DISCUSSION

In this research, the powers of the Triangle and Tetrad test were compared through P_c values. According to the results shown in table 1, the differences of P_c values of two protocols were not significant. However, when calculating the confidence levels of P_c ratios, we found a 85% chance that $P_{c.triangle}$ was higher than the Tetrad test's in case of 6.214 g/l and 8.789 g/l citric acid concentrations.

Analyzing *d'* showed that all *d'* values decreased when presenting one more sample in the Tetrad test. The decrease in *d'* values was explained by the increase of perceptual variance even when the average difference in perceptual intensities between the spirit variants was the same in both tests (Ennis, 2012; Garcia, Ennis *et al.*, 2012). This conclusion is not only drawn from the Tetrad and triangle tests, but can also be drawn from other discrimination tests (Rousseau and O'Mahony, 1997; Dessirier and O'Mahony, 1998; Lau, O'mahony *et al.*, 2004). These researches which considered the discrimination tests with the same psychological underlying but difference in the number of samples pointed out that when memory is an important factor, the effect size *d'* of protocols with fewer samples is greater than the effect size obtained with more samples.

As noticed by Garcia, Ennis *et al.* (2012), a 50% noise increase corresponds to a 2/3 *d'* ratio and this value is considered as the critical point to identify a notable decrease of power between the Tetrad and the Triangle test. When we analyzed confidence levels with *d'* values lower than 2/3, we still reached the same conclusion as when using P_c ratios analysis. Although the increase in perceptual noise was quite large (over 100%), we could not conclude that the power of the Triangle was higher than the power of the Tetrad test at the 95% confidence level. Along the same line, when we conducted the experiment with small size, we observed that the power of the Triangle test was not higher than the power of the Tetrad test at any concentration investigated. Using logistic regression analysis is probably a solution for reduction of undesired effect of small sample size.

By logistic regressive analysis, the results showed that there was no interaction between citric acid concentrations and testing protocols. The association between triangle's correct response probability and tetrad's was therefore not influenced by the effect size *d'.*

By analyzing β coefficient and OR values, we could not conclude that the Triangle test was more powerful than the Tetrad test at 95% confidence interval. However, there is still a 70% chance that the Triangle's power could be greater than the tetrad's power. Thus, applying the triangle protocol to this high alcohol spirit would have a 70% chance to commit fewer Type II errors than the Tetrad test.

The degradation of tetrad test in this study could not support the conclusions drawn from the research on apple juice products of Garcia, Ennis *et al.* (2012). It is obvious that the samples used in these two studies are different in terms of causing sensory fatigue. In this research, the Vietnamese spirit product with highest content of alcohol (50% v/v) was intentionally chosen to investigate power when presenting the fourth sample. Although all *d'* values decreased when presenting one more sample, the magnitude of *d'* decrease would likely be larger if samples caused sensory fatigue, for examples drinks with high alcohol level as in this research. At 50% v/v alcohol content, *d'* is reduced enough to diminish power and increase the risk of a Type II error.

This results is supported by the research of Ennis (2012) who used salsa products that had the highest spiced levels. Both alcohol drinks and salsa are food products causing sensory fatigue. This suggests that sensory properties of food products must be taken into account when comparing Triangle and Tetrad tests with the intent of reducing Type II error. With this in mind, a Tetrad procedure is not recommended in case of 50% v/v alcohol drinks.

It is also possible that there was some influence of alcohol on memory of the panelists but we could evaluate this possible effect because we did not include measurement of its possible effects. However, it might be of interest to study this issue. Moreover, further studies are needed to employ other beverages with alcohol content lower than 50%v/v to have a guideline for sensory-field practitioners who are considering a switching from the Triangle test to the Tetrad test.

5. CONCLUSION

In this paper, we compared the power of the Tetrad and Triangle tests at different effect sizes. Specifically, when applying both discrimination tests to high alcohol spirit, the chance of the Tetrad test to be more powerful than the Triangle test was low. This suggests to apply the Triangle test to high alcohol-type products even if the two tests have equal power.

It is possible that our results reflect sensory fatigue caused by high-alcohol level products. The evaluation of the fourth sample in tetrad protocol increased the variance of perceptual distribution that led to decrease *d'* enough to lose its power advantage. This conclusion do not depend on effect size *d'*.

The Triangle test is therefore recommended as a standard protocol in cases that discrimination of high-alcohol products is desired.

REFERENCES

Angulo, O. and M. O'Mahony (2005). "The paired preference test and the 'No Preference'option: was Odesky correct?" Food Quality and Preference 16(5): 425-434.

ASTM (E1885 - 04(2011)). ASTM E1885 - 04(2011) Standard Test Method for Sensory Analysis - Triangle Test ASTM International: 8.

Bi, J. (2008). Sensory discrimination tests and measurements: Statistical principles, procedures and tables, John Wiley & Sons.

Bi, J. and D. M. Ennis (2001). "The Power Of The " A" -" Not A" Method." Journal of Sensory Studies 16(4): 343-359.

Bruun Brockhoff, P. and P. Schlich (1998). "Handling replications in discrimination tests." Food Quality and Preference 9(5): 303-312.

Dessirier, J.-M. and M. O'Mahony (1998). "Comparison of d′ values for the 2-AFC (paired comparison) and 3-AFC discrimination methods: Thurstonian models, sequential sensitivity analysis and power." Food Quality and Preference 10(1): 51-58.

Ennis, J. M. (2012). "Guiding the switch from triangle testing to tetrad testing." Journal of Sensory Studies 27(4): 223-231.

Ennis, J. M. and D. M. Ennis (2011). "Confidence bounds for multiplicative comparisons." Communications in Statistics-Theory and Methods 40(17): 3049-3054.

Ennis, J. M. and V. Jesionka (2011). "The power of sensory discrimination methods revisited." Journal of Sensory Studies 26(5): 371-382.

Garcia, K., J. M. Ennis and W. Prinyawiwatkul (2012). "A Large-Scale Experimental Comparison Of The Tetrad And Triangle Tests In Children." Journal of Sensory Studies 27(4): 217-222.

Garcia, K., J. M. Ennis and W. Prinyawiwatkul (2013). "Reconsidering the specified Tetrad test." Journal of Sensory Studies 28(6): 445-449.

Hosmer Jr, D. W. and S. Lemeshow (2004). Applied logistic regression, John Wiley & Sons.

Ishii, R., M. O'Mahony and B. Rousseau (2014). "Triangle and tetrad protocols: Small sensory differences, resampling and consumer relevance." Food Quality and Preference 31: 49-55.

ISO, B. 4120: 2004. Sensory analysis-Methodology-Triangle test.

Lau, S., M. O'mahony and B. Rousseau (2004). "Are three-sample tasks less sensitive than two-sample tasks? Memory effects in the testing of taste discrimination." Perception & psychophysics 66(3): 464-474.

Masuoka, S., D. Hatjopoulos and M. O'Mahony (1995). "Beer bitterness detection: Testing Thurstonian and sequential sensitivity analysis models for triad and tetrad methods." Journal of Sensory Studies 10(3): 295-306.

Meilgaard, M. C., B. T. Carr and G. V. Civille (2006). Sensory evaluation techniques, CRC press.

Rousseau, B., A. Meyer and M. O'Mahony (1998). "Power And Sensitivity Of The Same-Different Test: Comparison With Triangle And Duo-Trio Methods." Journal of Sensory Studies 13(2): 149-173.

Rousseau, B. and M. O'Mahony (1997). "Sensory Difference Tests: Thurstonian And SSA Predictions For Vanilla Flavored Yogurts." Journal of Sensory Studies 12(2): 127-146.

Van Hout, D., M. J. Hautus and H.-S. Lee (2011). "Investigation Of Test Performance Over Repeated Sessions Using Signal Detection Theory: Comparison Of Three Nonattribute-Specified Difference Tests 2-Afcr, A-Not A And 2-Afc." Journal of Sensory Studies 26(5): 311-321.

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EFFECT OF FREEZING POMEGRANATE JUICE TO SORBET ON FLAVOR

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ABSTRACT

Pomegranate popularity has prompted many studies examining processing methods (i.e. filtration, drying), effects of processing (i.e. color, antioxidant activity), and sensory attributes of pomegranate juices. The objective of this study was to examine if different processing methods have an effect on pomegranate juice flavor and how flavor changes when juice is frozen (in sorbet). Arils from fresh Wonderful pomegranates were used in preparation of frozen juice, pasteurized frozen juice, and reconstituted juice from dried arils; each juice was subsequently used in sorbet preparation. The juices and sorbets were evaluated by a trained sensory panel using a modified consensus flavor profile method. The results showed that the different processing methods demonstrate an accumulation of small changes in a large number of attributes for juice and sorbet. Fruit flavors (i.e. cherry and grape), sweet sour, and bitter tastes, and astringency were present in all samples; however some aromatic characteristics were lost in sorbet preparation.

Keywords: pomegranate juice, pomegranate sorbet, freezing, flavor

1. INTRODUCTION

Pomegranates, originally native to the Middle East to Northern India, have grown in popularity, particularly due to their breadth of health benefits. Improvements to cardiovascular health, cancer and diabetic benefits, as well as cosmetic properties have been recurrently investigated (Viuda-Martos, Fernández-López *et al.*, 2010, Johanningsmeier and Harris, 2011, Rymon, 2011). Accompanying the increase in popularity, pomegranate flavor has also been explored. Koppel and Chambers IV (2010) developed a lexicon to characterize pomegranate juices. Based on the large variety of juices used to create the lexicon, many pomegranate juices can be characterized as having sour, sweet, musty/earthy, fruity aromatics with varying degrees of astringent mouthfeel. Astringency may be decreased by clarification which removes a large degree of phenolic compounds (Alper, Bahçeci *et al.*, 2005). Other studies have used descriptive analysis to compare commercial juices to fresh juice (Vázquez-Araújo, Koppel *et al.*, 2011), pomegranate juice and wine (Andreu-Sevilla, Mena *et al.*, 2013, Wasila, Li *et al.*, 2013), pomegranate juice blends (Vázquez-Araújo, Chambers IV *et al.*, 2011, Lawless, Threlfall *et al.*, 2013), and pomegranate juices containing albedo and carpellar membranes homogenate (Vázquez-Araújo, Chambers IV *et al.*, 2011).

Pomegranates are a seasonal fruit that can be processed by cold storage, drying, or various methods of concentration to reduce water available for microbial activity (Yousefi, Emam-Djomeh *et al.*, 2012). Thermal and non-thermal pasteurization methods can be employed to ensure safety (Lozano, 2006). Several studies have examined the results processing has on color (Alper, Bahçeci *et al.*, 2005, Turfan, Türkyılmaz *et al.*, 2011) and phenolic content (Alper, Bahçeci *et al.*, 2005, Fischer, Dettmann *et al.*, 2011, Turfan, Türkyılmaz *et al.*, 2011, Alighourchi *et al*, 2008) but very few have considered the effect on flavor.

Pomegranate juice uses have been more frequently investigated and with these new suggested uses the number of pomegranate products has grown (Rymon, 2011). In the frozen dessert category, fruit juices and purees are used in the preparation of sorbets. There currently is no standard of identity for sorbet, however it may be considered an upscale water ice frozen while whipping. Commonly ingredients include fruit juice/puree, water, sugar, and stabilizer (Marshall, Goff *et al.*, 2003). Little research has been performed to understand the changes the fruit ingredient flavor undergoes upon freezing. Ledeker, Chambers *et al.* (2012) explored how sensory characteristics differ in mango puree and mango sorbet (with puree used as the main ingredient). Only the main sensory characteristics of mango puree were present in sorbet, including sweetness and fruity characteristics.

Understanding pomegranate flavor changes during processing as well as flavor differences when used as an ingredient in sorbet may help in future ingredient selection. If dissimilarities across processing methods are present in frozen products, ingredient selection may be based on juice properties. Conversely, if dissimilarities are masked, flavor properties of juice may be ignored. The objective of this study was to understand flavors in juice from different processing methods including freezing, batch pasteurization, and rehydration of ground, dried arils and how the flavors of these juices change when frozen (in sorbet).

2. MATERIALS & METHODS

Fresh pomegranates of the Wonderful cultivar grown in the United States were acquired from Youngstown Grape Distributors (Reedley, CA, USA). The pomegranates were washed and arils were separated from the albedo and carpellar membranes to be juiced or dried. Juice was prepared using a Hamilton Beach Health Smart Juice Extractor 67800 (Hamilton Beach/Proctor Silex Inc., South Pines, NC, USA). Half of the juice produced was frozen fresh. The remaining half was batch pasteurized using a Pastomaster 60 RTX (Carpigiani, Bologna, Italy) at 63°C for 30 minutes prior to freezing. Arils for drying were placed in single layers onto trays of an Excalibur 3926T Food Dehydrator (Excalibur Products, Sacramento, CA, USA). Each batch was dried at 57°C for 10 hours. Dried arils were frozen until test preparation.

Frozen juice samples were allowed to thaw in the refrigerator overnight prior to juice evaluation or sorbet preparation. Dried frozen arils were ground using a Black and Decker Smart Grind CBG5 (Applica Consumer Products, Inc, Miami Lakes, FL, USA). The resulting powder was rehydrated with purified water at a respective ratio of 0.21:0.79. After resting for 10 minutes the solids were separated from the juice with a sieve.

Pomegranate sorbet mix was prepared in 2.5 kg batches using the following ratio: 60.95% pomegranate juice, 20.68% water, 14.91% sucrose, 3.37% dextrose, and 0.08% Dairyblend 101-B FF (TIC Gums, White Marsh, MD, USA). The mix was aged in the refrigerator for a minimum of 10 hours prior to freezing. After aging each batch of sorbet mix was frozen using a Carpigiani LB 302 RTX batch freezer (Carpigiani, Bologna, Italy). Upon removal, the sorbet was placed into a chilled pan and transferred to Standex BCF93558-0DX6 blast freezer (Standex, Salem, NH, USA) at -26±1°C to harden for 3 hours. Sorbet was stored overnight in a freezer at -18±1°C.

Six highly trained panelists with over 1000 hours testing experience from the Sensory Analysis Center, Kansas State University (Manhattan, KS, USA) participated in this study. The panelists had previous experience with a variety of products including pomegranates. The panelists received supplementary orientation and training on pomegranate juices and sorbets.

Samples were evaluated in 1.5 hour sessions, 2 samples per session. Each sample was assigned a three-digit code and serving order was randomized. Descriptive attributes, references, and reference materials (Table 1) were adapted from Koppel and Chambers IV (2010). Evaluation was performed using a modified flavor profile method previously used by Koppel and Chambers IV (2010), Talavera-Bianchi and Chambers (2008), Talavera-Bianchi *et al.* (2010). Each panelist evaluated the sample provided individually using an intensity scale from 0-15, with half point increments, for each attribute. Then the group discussed and assigned attribute intensities for each sample based on reference intensities. For juice evaluation, each panelist received a 96ml cup containing 30ml of sample juice at ambient room temperature (21±1°C). For sorbet evaluation, sorbets were removed from the storage freezer and allowed to temper for 2 hours in a Mondial Group SRL J7 display case (Mondial Group SRL, San Giorgio Monferrato, Italy) at -12±1°C. Each panelist received a 118ml Styrofoam bowl containing 30ml scoop of sample sorbet.

Panelists were provided with purified water, unsalted crackers, and mozzarella cheese for palate cleansing when evaluating juice. Purified warm water and unsalted crackers were used for palate cleansing when evaluating sorbet.

3. RESULTS & DISCUSSION

Juice samples were evaluated for 27 attributes. All attributes were evaluated in the weak intensity range (<5.0). The juice samples demonstrated an accumulation of small differences across processed products (Table 2). Compared to the fresh frozen juice, pasteurized and reconstituted juices had slightly lower cherry flavor and astringency. Alper, Bahçeci *et al.* (2005) indicated that clarification of juice should reduce astringency; however heating processes used for these samples also indicated a slight level of astringency reduction. Products treated with heat (via pasteurization or dehydration) were found to be more intense in fruity-dark, musty/ earthy, brown sweet, and molasses flavors. The reconstituted product demonstrated the most frequent differences including the presence of brown spice and fermented flavors and loss of beet, green-viney, and honey characteristics. Although the reconstituted juice exhibited these differences, it still retained characteristics of commercial juices found by Koppel and Chambers IV (2010) such as sour, bitter, grape, and woody.

Sorbet samples were evaluated for a total of 22 attributes. The attribute "fruity" used for juice evaluation was replaced with "overall fruity" in the sorbet evaluation. This change was made to include fruits that were previously excluded such as cranberries and grapes as well as to cover some fruity characteristics that were not prevalent enough to be described alone. The fruity-dark definition and reference was modified to include figs in place of cranberries to best describe the flavor present in sorbet.

The sorbet created from the fresh frozen juice had the highest intensity of cranberry, carrot, sweet overall, and candy-like flavors along with the highest sweet taste and astringent mouthfeel among the sorbets. Sorbet prepared with batch pasteurized juice was heightened in berry flavor and reduced in beet flavor and sweet taste. Compared to sorbet prepared with fresh frozen or pasteurized juice, sorbet prepared with reconstituted juice had the least cranberry and candy-like flavors. In comparison to the pasteurized sample the fruity-dark, musty/earthy, and woody flavors were higher in the reconstituted juice sorbet.

Table 1. Juice and sorbet descriptive sensory analysis attributes, definitions, and reference materials.

Attribute	Definition	Reference Materials
Overall Fruity[2]	An aromatic blend of a variety of fruits, excluding citrus, may include apples, pears, cranberries, berries, cherries, and grapes.	Old Orchard Berry Blend = 9.0
Apple[1]	A sweet, light, fruity, somewhat floral aromatic commonly associated with apple juice and apples	Gerber Applesauce = 6.0
Berry	The sweet, sour, sometimes dark aromatics associated with a variety of berries such as blackberries, cherries, currants, raspberries etc, excluding cranberries.	Blackwell Red Currant Jelly = 8.5
Cranberry	The sweet, fruity, slightly sour and sharp aromatics commonly associated with cranberries.	Old Orchard's Frozen Cranberry diluted (1:1) = 3.5
		[1]Ocean Spray Dried cranberries = 9.0
Cherry	The sour, fruity, slightly bitter aromatics commonly associated with cherries.	RW Knudsen Cherry Juice diluted (1:2) = 4.0
Grape	The sweet, brown, fruity, musty aromatics commonly associated with grapes.	Welch's Concord Grape Juice diluted (1:1) = 5.0
		[1]Welch's White Grape Juice diluted (1:1) = 5.0
Floral	Sweet, light, slightly perfumey impression associated with flowers.	Welch's White Grape Juice diluted (1:1) = 5.0
Fruity[1]	An aromatic blend of a variety of fruits, excluding citrus, cranberry and concord grape. May include apples, pears, white grapes etc.	Welch's white grape juice diluted (1:1) = 5.0
Carrot	The aromatics commonly associated with canned, cooked carrots.	Del Monte Sliced Canned Carrots= 7.0
Beet	The damp, musty/earthy, slightly sweet aromatics commonly associated with beets	Diluted Kroger Canned Beet juice (1:2) = 4.0

Brown Spice[1]	Aromatics associated with a range of brown spices such as cinnamon, nutmeg, cloves and allspice.	McCormick Spices, mixed=7.5 (a)
Fermented[1]	The aromatics associated with ripe/ overripe fruit; can be somewhat sweet, sour, browned, musty, and fruity.	Regina Cooking Wine = 10.0 (a)
Fruity-Dark[1]	The sweet, brown honey/caramel-like aromatics commonly associated with dark fruits such as raisins and prunes that have been cooked.	Mixture of Sun Maid Raisins, Prunes, Ocean Spray Cranberries and water: juice = 5.0
Fruity-Dark[2]	The sweet, brown honey/caramel-like aromatics commonly associated with dark fruits such as raisins, figs, and prunes that have been cooked.	Mixture of Sun Maid Raisins, Prunes, Mission Figs and water: juice = 5.0
Green-Viney[1]	A green aromatic associated with green vegetables and newly cut vines and stems; characterized by increased bitter and musty/earthy character.	Campbell's Tomato Juice = 2.0
Musty/Earthy	Humus-like aromatics that may or may not include damp soil, decaying vegetation, or cellar-like characteristics.	Raw potatoes = 3.0 (a) Diluted Kroger Canned Beet Juice (1:2) = 7.0 (a)
Brown Sweet	A rich full-bodied brown sweet aromatics.	C&H Golden Brown Sugar dilution = 5.0
Honey	Sweet, light brown, slightly spicy aromatics associated with honey.	Busy Bee Honey dilution = 6.5
Molasses[1]	Dark, caramelized top notes that are slightly sharp and characteristic of molasses.	Grandmas Molasses = 6.5
Sweet, Overall	The perception of the combination of sweet taste, sweet aromatics, caramelized, brown sugar, honey, and maple	3% C&H Golden Brown Sugar solution = 4.0 [2]6% C&H Golden Brown Sugar solution = 9.0
Sweet	The fundamental taste factor associated with a sucrose solution	[1]2% Sucrose Solution = 2.0 4% Sucrose Solution = 4.0 [2]6% Sucrose Solution = 6.0 [2]8% Sucrose Solution = 8.0 [2]10% Sucrose Solution = 10.0
Woody	The aromatics associated with dry freshly cut wood	Forster Craft Stick = 7.5 (a)
Salt[1]	Fundamental taste factor of which sodium chloride is typical	0.20% NaCl Solution = 2.5 0.25% NaCl Solution = 3.5
Sour	A fundamental taste factor of which citric acid in water is typical	0.025% Citric Acid Solution = 2.5 0.050% Citric Acid Solution = 3.5 0.080% Citric Acid Solution = 5.0
Bitter	The fundamental taste factor of which caffeine or quinine is typical.	0.010% Caffeine Solution = 2.0 0.020% Caffeine Solution = 3.5 0.035% Caffeine Solution = 5.0
Metallic[1]	The impression of slightly oxidized metal, such as iron, copper and silver spoons.	0.10% Potassium Chloride Solution = 1.5 0.2% Potassium Chloride solution = 4.0
Astringent	The dry puckering mouthfeel associated with an alum solution.	0.05 % Alum Solution = 2.5 0.1 % Alum Solution = 5.0
Toothetch	A sensation of abrasion and drying of the surface of the teeth	Welch's Concord Grape Juice diluted (1:1) = 5.0
Chalky Mouthfeel	A dry, powdery sensation. Can be on mouth and /or teeth	1% Cornstarch solution = 3.0
Stale[2]	The aromatics associated with wet cardboard that is characterized by a lack of freshness.	2" cardboard square in 1/2 c water = 7.5 (a)
Candy like[2]	A sweet non-natural aromatic usually found in candy products.	Cotton Candy Jelly Belly = 7.5

[1]Attribute or reference material used only for juice samples
[2]Attribute or reference material used only for sorbet samples

Converting the juice into sorbet resulted in a loss of 8 (apple, fruity, brown spice, fermented, green-viney, molasses, salty, and metallic) and a gain of 3 attributes (overall fruity, stale, and candy like). The new overall fruity attribute received higher scores than the fruity, likely due to its encompassment of a larger number of fruit flavors. Sweetness increased in the sorbet when compared to the juice samples while astringency declined. This may be due to the increased sugar level resultant from the sorbet formulation. Ledeker, Chambers *et al.* (2012) attributed a similar result in astringency reduction in mango sorbet to increased sugar content. Interestingly few attributes that were present in both juice and sorbet declined in intensity. Some attribute intensities increased such as grape, beet, and musty/earthy in the fresh frozen and reconstituted sorbet samples. The added sweetness may be attributed to the enhancement of these flavor characteristics. The appearance of candy like flavor in all sorbet samples and stale flavor in the pasteurized sorbet sample may be attributed to the added sugar and stabilizer respectively.

Table 2. Juice and sorbet attribute intensities

	FF (J)	P (J)	R (J)	FF (S)	P (S)	R (S)
Overall Fruity	--	--	--	6.5	7.0	6.5
Apple	2.0	0.0	1.5	--	--	--
Berry	2.5	3.0	3.0	3.0	5.0	3.5
Cranberry	3.5	3.5	3.0	3.5	3.0	2.5
Cherry	3.0	1.5	2.0	2.5	2.5	2.0
Grape	2.0	3.0	2.0	3.0	2.5	3.0
Floral	2.5	3.0	3.0	3.5	3.5	3.0
Fruity	4.0	4.0	3.5	--	--	--
Carrot	1.5	2.0	2.0	2.0	0.0	1.5
Beet	2.0	2.5	0.0	3.0	2.0	3.0
Brown Spice	0.0	0.0	1.5	--	--	--
Fermented	0.0	0.0	1.5	--	--	--
Fruity-Dark	2.0	3.0	3.5	2.5	2.0	3.0
Green-Viney	2.0	1.5	0.0	--	--	--
Musty/Earthy	0.0	2.0	1.5	2.5	2.0	3.0
Brown Sweet	2.0	3.0	3.0	3.0	2.5	2.5
Honey	2.0	1.5	0.0	1.5	1.5	2.0
Molasses	0.0	2.0	2.0	--	--	--
Sweet, Overall	4.0	4.0	4.5	8.5	8.0	7.5
Sweet	2.5	3.0	3.0	7.0	6.0	6.5
Woody	2.5	2.0	2.5	3.0	2.5	3.5
Salty	2.5	1.5	2.5	--	--	--
Sour	3.5	3.5	3.5	3.0	3.5	3.0
Bitter	3.5	3.5	3.5	3.5	3.5	3.0
Metallic	2.0	2.5	1.5	--	--	--
Astringent	5.0	4.0	4.0	3.5	2.5	3.0
Toothetch	2.5	2.0	2.0	2.0	2.5	1.5
Chalky Mouthfeel	2.0	2.0	2.5	2.0	2.0	2.5
Stale	--	--	--	0.0	2.5	0.0
Candy like	--	--	--	3.5	2.5	1.5
FF(J) = Fresh Frozen Pomegranate Juice						
P(J) = Pasteurized Pomegranate Juice						
R(J) = Reconstituted Pomegranate Juice						
FF(S) = Sorbet from Fresh Frozen Pomegranate Juice						
P(J) = Sorbet from Pasteurized Pomegranate Juice						
R(J) = Sorbet from Reconstituted Pomegranate Juice						

The effect of freezing from juice to sorbet demonstrated flavor differences through descriptive analysis. Although the samples were not tested by consumers, some of the differences definitely were large enough to be noticed by consumers. Future evaluation should consider testing juice and sorbet samples with consumers to better understand if the flavor differences are important to untrained panelists and impact acceptance. If so, ingredient choices become more limited. During orientation sessions panelists also noted that textural differences across gelato samples were apparent, but those were not studied in this test. Future studies should additionally consider examining texture in addition to flavor changes during freezing to gain a more complete understanding of the influence of processing.

4. CONCLUSION

Processing pomegranate juices in ways such as pasteurization and reconstituting dried arils alters flavor by accumulating small changes in a large number of attributes as compared to fresh frozen juice. When using these juices as the major component of sorbet preparation, many attributes are lost during the freezing process. Along with increased sweetness, some flavor attributes may be enhanced. These small differences should not be ignored as combined together they can impart noticeable differences. When determining what pomegranate juice to use in sorbet it is suggested to consider the flavor changes that may occur upon freezing. Further research to understand if consumers can detect differences as a result of freezing should be considered when choosing ingredients.

REFERENCES

Alper, N., K. S. Bahçeci and J. Acar (2005). "Influence of processing and pasteurization on color values and total phenolic compounds of pomegranate juice." Journal of food processing and preservation 29(5-6): 357-368.

Andreu-Sevilla, A. J., P. Mena, N. Martí, C. García Viguera and Á. A. Carbonell-Barrachina (2013). "Volatile composition and descriptive sensory analysis of pomegranate juice and wine." Food Research International 54(1): 246-254.

Fischer, U. A., J. S. Dettmann, R. Carle and D. R. Kammerer (2011). "Impact of processing and storage on the phenolic profiles and contents of pomegranate (Punica granatum L.) juices." European Food Research and Technology 233(5): 797-816.

Johanningsmeier, S. D. and G. K. Harris (2011). "Pomegranate as a functional food and nutraceutical source." Annual review of food science and technology 2: 181-201.

Koppel, K. and E. Chambers IV (2010). "Development and application of a lexicon to describe the flavor of pomegranate juice." Journal of Sensory Studies 25(6): 819-837.

Lawless, L. J., R. T. Threlfall, J. F. Meullenet and L. R. Howard (2013). "Applying a mixture design for consumer optimization of black cherry, concord grape and pomegranate juice blends." Journal of Sensory Studies 28(2): 102-112.

Ledeker, C. N., D. H. Chambers, I. Chambers and K. Adhikari (2012). "Changes in the sensory characteristics of mango cultivars during the production of mango purée and sorbet." Journal of food science 77(10): S348-S355.

Lozano, J. E. (2006). Fruit manufacturing: scientific basis, engineering properties, and deteriorative reactions of technological importance, Springer.

Marshall, R. T., H. D. Goff and R. W. Hartel (2003). Ice cream, Springer.

Rymon, D. (2011). "Mapping features of the global pomegranate market." Acta Hort 890: 599-602.

Turfan, Ö., M. Türkyılmaz, O. Yemiş and M. Özkan (2011). "Anthocyanin and colour changes during processing of pomegranate (*Punica granatum* L., cv. Hicaznar) juice from sacs and whole fruit." Food Chemistry 129(4): 1644-1651.

Vázquez-Araújo, L., E. Chambers IV, K. Adhikari and A. Carbonell-Barrachina (2011). "Physico-chemical and sensory properties of pomegranate juices with pomegranate albedo and carpellar membranes homogenate." LWT-Food Science and Technology 44(10): 2119-2125.

Vázquez-Araújo, L., K. Koppel, E. Chambers Iv, K. Adhikari and A. Carbonell-Barrachina (2011). "Instrumental and sensory aroma profile of pomegranate juices from the USA: differences between fresh and commercial juice." Flavour and fragrance journal 26(2): 129-138.

Viuda-Martos, M., J. Fernández-López and J. Pérez-Álvarez (2010). "Pomegranate and its many functional components as related to human health: a review." Comprehensive Reviews in Food Science and Food Safety 9(6): 635-654.

Wasila, H., X. Li, L. Liu, I. Ahmad and S. Ahmad (2013). "Peel Effects on Phenolic Composition, Antioxidant Activity, and Making of Pomegranate Juice and Wine." Journal of food science 78(8): C1166-C1172.

Yousefi, S., Z. Emam-Djomeh, S. M. A. Mousavi and G. R. Askari (2012). "Comparing the effects of microwave and conventional heating methods on the evaporation rate and quality attributes of pomegranate (Punica granatum L.) juice concentrate." Food and Bioprocess Technology 5(4): 1328-1339.

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CONSUMER ACCEPTIBILITY OF PARTIAL SUBSTITUTION OF WHEAT FLOUR WITH THE GLUTINOUS PUFFED RICE, KHAO MA, FLOUR ON MUFFIN

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ABSTRACT

The objective of this study was to develop the optimum formula and to investigate consumer acceptability of partial substitution of wheat flour (WF) with khao mao flour (KMF) on muffin. Four ratios of KMF and WF (30:70,40:60,50:50,60:40) were investigated. Results showed that the optimal composite flour ratio was 40:60. Consumer acceptability of this developed product using a 9-point hedonic scale and a Just About Right (JAR) procedure was performed by 100 consumers. The result indicated that consumers slightly liked color, khao mao (KM) flavor, and sweet. Softness, overall texture and overall liking were moderately correlated with hedonic scores. The result of JAR and opportunity analysis of this developed product indicated that it should be decreased in color and KM flavor. A large majority of consumers (98%) accepted this product and 96% of them decided to buy it. Relationships between overall liking and liking scores of sensory attributes were analyzed with correlation and multiple linear regression. Results showed that color and KM flavor were associated with overall liking ($p \leq .05$).

Keywords: consumer acceptability, khao mao, muffin

1. INTRODUCTION

Glutinous rice (*Oryza sativa* L.) is widely grown in the northern and northeastern regions of Thailand. Processing glutinous rice into other products depends upon the objectives of producers and the demands of consumera. Khao mao (KM) is a kind of processed glutinous rice and is a traditional glutinous rice product in some Southeast Asian countries such as Thailand, Laos, and Vietnam. Consumers usually eat KM with sugar, salt, and shredded coconut. To produce KM the grains are harvested 15–20 days after grain formation (dough stage of the rice life-cycle). It is processed by soaking the grains in water, roasting, and pounding in a manually operated or motorized mortar. Each varieties of glutinous rice could be produced KM with different texture and taste (Yambunjong, Sriroth *et al.*, 1999). The protein content of KM is higher than white rice (Voraputhaporn and Wongsamun, 2003). It has green color and unique aroma (Bunnak and Chaosap, 2006). Voraputhaporn, Ngamsuk *et al.* (2008) successfully developed breakfast cereal from dried KM. The product was accepted by consumers and ranked with moderately liked on 9-point hedonic scales.

Many studies have been performed on the substitution of wheat flour (WF) with rice, glutinous rice, and germinated rice flour on bakery products but there is no report about using khao mao flour (KMF) as a WF substitute. Therefore, the aims of this study were to develop an optimum formula for substituting KMF for WF and to investigate the acceptability and purchase intent of muffins made with partial substitution of WF with KMF.

2. MATERIALS AND METHODS

2.1. Materials

Khao mao from glutinous rice (*Oryza sativa* L. cv. RD6) was used to produce flour that was used to produce muffins. Ingredients for prepared muffin formulations were: wheat flour (Royal Fan® cake flour; UFM Food Center Co., Ltd. Bangkok, Thailand), refined sugar (Mitr Phol®; Mitr Phol Sugar Corp., Ltd, Bangkok, Thailand), fresh eggs (CP®; Charoen Pokphand Foods PCL, Nakhon-nayok, Thailand), evaporated milk (Carnation®; Nestle [Thai] Ltd, Patumthanee, Thailand), salted butter (Orchid®; Thai Milk Industry Co., Ltd, Ayutthaya, Thailand), rice bran oil (King®; Thai Edible Oil Co., Ltd. Bangkok, Thailand), green tea powder (Oriental®, Bangkok, Thailand), baking powder (Imperial®; KCG Corporation, Co., Ltd, Bangkok, Thailand), salt (Prung Thip®; Pure Salt Industry Co., Ltd, Nakhonratsima, Thailand).

2.1.1. Khao mao flour preparation

Khao mao flour (KMF) production was adapted from the process described by Chueamchaitrakun, Chompreeda *et al.* (2011) as follows: Khao mao was washed with tap water and dried at 55°C for 4 hours using a tray dryer (Model HA 200, K.S.L. Engineering Co., Ltd., Bangkok, Thailand), finely ground using turbo mill (Sahachon Co., Ltd, Chonburi, Thailand) and sieved through a 100-mesh sieve to produce uniform-size KMF. The KMF was packed in polyethylene bags and kept at 30°C for used in muffin preparation.

2.1.2. Muffin preparation

Four muffin formulations were prepared with KMF: WF at 30:70, 40:60, 50:50 and 60:40 ratios. The ingredients of four muffin formulations are shown in Table 1. The muffin preparation was adapted from Yungbhumphuttha (2007) as follows: The egg, sugar, salt, and evaporated milk were poured into a mixing bowl and mixed until sugar and salt were dispersed (3 min) at speed 6 using a Kitchen-Aid mixer (Model 5K5SS, St. Loseph, Michigan, USA). The baking powder, green tea powder, WF, and KMF were then added to a butter and mix for 7 min at speed 6. The melted salted butter and rice bran oil were added and mixed for 3 min at speed 2. Batter was rested for 30 min, then poured batter into paper cake cases (30 cm × 20 cm × 15 cm) and baked at 200°C for 25 min using convection oven (Model DH4B-B, LinkRich, Saint-Petersburg, Russia) After the muffin had been cooled on a rack for 1 h in order to avoid moisture condensing on their undersurface, They were packed in double zipper storage bags (Kitchen Neat®, Thantawan Industry PCL, Nakornpathom, Thailand) and kept at room temperature (30°C) for further analysis.

2.2. Sensory evaluation

Four muffins prepared with KMF: WF at 30:70, 40:60, 50:50 and 60:40 ratios were tested on a laboratory scale by 50 target consumers recruited among the students and staff of the department of Product Development, Faculty of Agro-Industry, Kasetsart University. Criteria for recruitment were that participants were: (1) between 15 to 45 years of age, (2) consumed muffin at least once a week, and (3) available for testing. Testing was carried out in sensory laboratory with individual booths under white light. All samples were coded by three-digit random numbers and served at room temperature in a random order. Each participant received four samples monadically in a single session. Participants were required to rinse their palate with water between each sample. Participants evaluated each sample on a 9-point hedonic scale (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, and 1 = dislike extremely). Participants scored each sample for crumb color, KM flavor, sweet, softness, overall texture, and overall liking.

Table 1. Formulation of partial substitution of wheat flour (WF) with khao mao flour (KMF) on muffin

Ingredients (%)	KMF:WF 30:70	40:60	50:50	60:40
WF	17.00	14.57	12.15	9.72
KMF	7.29	9.72	12.15	14.57
Sugar	20.23	20.23	20.23	20.23
Egg	16.99	16.99	16.99	16.99
Milk	16.19	16.19	16.19	16.19
Butter	9.71	9.71	9.71	9.71
Rice bran oil	8.09	8.09	8.09	8.09
Green tea power	3.03	3.03	3.03	3.03
Baking powder	1.20	1.2	1.2	1.2
Salt	0.27	0.27	0.27	0.27

2.3. Consumer acceptability

Consumer acceptability of muffins prepared with KMF: WF of 40:60 was evaluated by 100 participants (68 females and 32 males; age 15 to 45) at the cafeteria of Kasetsart University. Participants were asked to score the crumb color, KM flavor, sweet, softness, overall texture, and overall liking, on a 9-point hedonic scale. They also scored the Just-About-Right (JAR) of crumb color, KM flavor, sweet, and softness using a 3-point scale (1 = not enough, 2 = just about right, and 3 = too much). Product acceptability and purchasing decision were evaluated using a binary (yes/no) scale. Sample were tested for microbial safety before evaluate consumer acceptability.

2.4. Data analysis

Data were analyzed by analysis of variance (ANOVA) using SPSS 12.0 (SPSS Inc., Chicago, USA) and by Duncan's multiple range test (DMRT). Pearson correlation and multiple linear regressions (MLR) were performed to identify liking scores of sensory attributes influencing overall liking score. The criteria for statistically significant differences was set at $p < .05$. The JAR data were analyzed using penalty analysis (ASTM 2009) and the opportunity analysis was analyzed by following the method described in Prinyawiwatkul (2010) and shown in Equations (1) and (2)

$$\text{Opportunity} = \frac{D}{C+D} \times 100 \qquad (1)$$

$$\text{Risk} = \frac{B}{A+B} \times 100 \qquad (2)$$

Where: A = Number of product likers but attribute dislikers; B = Number of product and attribute likers; C = Number of product dislikers but attribute likers; D = Number of product and attribute dislikers

To dichotomize the liking scales, the break-point on 9-point hedonic scale may fall close to 6 (dislikers = 1–5 and likers = 6–9)

3. RESULTS AND DISCUSSION

3.1. Sensory evaluation

The mean liking scores of four muffins prepared with KMF: WF at 30:70, 40:60, 50:50 and 60:40 ratios are shown in Table 2. The crumb color liking scores decreased when the amount of KMF flour increased. All samples had no significant difference liking scores of KM flavor and sweetness. The liking scores of softness tended to decrease when the levels of replacement of KMF was increased, a result probably due to sticky texture (this is a well known as a disadvantage of the rice flour products, see, e.g., Johnson (1990)).

Table 2. Mean liking score of partial substitution of wheat flour (WF) with khao mao flour (KMF) on muffin (n = 50)

Attributes	KMF:WF			
	30:70	40:60	50:50	60:40
Crumb color	7.0±1.2^a	6.2±1.2^b	5.0±1.4^c	4.8±1.4^c
KM flavor ^{ns}	6.2±1.4	5.9±1.1	5.8±1.4	5.6±1.3
Sweet ^{ns}	6.6±0.8	6.7±1.2	6.2±1.6	6.3±1.3
Softness	6.7±1.1^a	6.5±1.5^a	5.5±1.6^b	5.3±1.7^b
Overall texture	6.4±1.3^a	6.4±1.1^a	5.5±1.5^b	5.3±1.7^b
Overall liking	6.7±0.9^a	6.3±0.9^a	5.5±1.3^b	5.6±1.4^b

^{ns} mean within the same row with difference letters are not significantly different (p > .05)

$^{a-c}$ means within the same row with difference letter are significantly different (p $\leq$ .05)

Muffin samples prepared with KMF: WF at 30:70 and 40:60 ratios showed no significant differences. Therefore, KMF: WF ratio of 40:60 was selected to test consumer acceptability of KMF formulation.

3.2. Consumer acceptability, overall product acceptance and purchase intent

The liking scores of muffins prepared with KMF: WF of 40:60 for six attributes were showed in Table 3. The result indicated that consumers slightly liked crumb color (6.1), KM flavor (6.5), and sweetness (6.6). Softness, overall texture, and overall liking were moderately liked (7.2, 7.1, and 7.4, respectively). Results of product acceptance and purchase intent are also given in Table 3. The majority of target consumers (98%) accepted muffins prepared with KMF: WF at 40:60. After knowing information about the developed muffins, 96% of consumers indicated that they would buy this product if it were available in the market.

Table 3. Mean liking score ± standard deviation for sensory acceptability, positive product acceptance and purchase intent of muffins prepared with khao mao flour (KMF): wheat flour (WF) of 40:60 (n=100)

Attributes	KMF:WF (40:60)
Liking scores*	
Crumb color	6.1±0.9
KM flavor	6.5±0.9
Sweet	6.6±0.8
Softness	7.2±0.8
Overall texture	7.1±0.7
Overall liking	7.4±1.0
Positive (yes) overall Acceptance (%) †	98
Positive (yes) purchase Intention (%) †	96

** Mean ± standard deviation based on a 9-point hedonic*

† Based on the binomial (yes/no) scale

Table 4. Percentage of consumer, mean drop and total penalty for liking score of each JAR category of muffins prepared with khao mao flour (KMF): wheat flour (WF) of 40:60

Attributes	JAR		Total penalty§
	Not enough	Too much	
Crumb color	-	29*(-1.96)†	0.57
KM flavor	-	28(-1.14)	0.32
Sweet	-	-	-
Softness	-	-	-

** Indicates the percentage of consumers who found each product to be "Too much" for crumb color and KM flavor JAR.*
† The number in the parentheses is the mean drop calculated as (Mean liking score for the non-JAR consumer response – mean liking score for the JAR consumer response)
§ Total penalty = Mean drop × percentage of non-JAR consumer responses. A total penalty > .05 is high and > .25 is noteworthy (Cadot et al, 2010).
(-) Indicates less than 20% of consumers' selected corresponding JAR category.

Pearson correlation computation and MLR analyses were performed on overall liking and liking scores of other attributes. Results showed that liking scores of crumb color and KM flavor were important qualities for consumer acceptance. The MLR equation was $Y = 0.102X_1 + 0.290X_2 + 5.503$ (Y was overall liking, X_1 was liking scores of crumb color and X_2 was liking scores of KM flavor). The multiple correlation coefficient (R^2) was equal to .825.

3.3. Analysis of diagnostic JAR attributes by the penalty analysis.

Table 4 shows the calculated mean drop values and the total penalty for muffins prepared with KMF: WF at 40:60. The mean drop values are used to gain an understanding of the product attributes needed to be adjusted. According to ASTM (2009); the mean drop values of crumb color and KM flavor were –1.96 and 1.14, respectively. These values indicate that crumb color was a concerning attribute while KM flavor was a slightly concerning attribute. The developed muffin will need to reduce crumb color and KM flavor. The result of the penalty analysis agreed with the MLR analysis which indicated that the overall liking score was influenced by liking scores of crumb color and KM flavor.

3.4. Opportunity analysis.

According to penalty analysis, crumb color and KM flavor needed to be adjusted. Therefore, percentage of opportunity and risk of crumb color and KM flavor were calculated by their 9-point hedonic data. The results are showed in Figure 1. Crumb color was lower risk and higher opportunity than KM flavor. It indicated that the adjustment of KM flavor much more risky than crumb color.

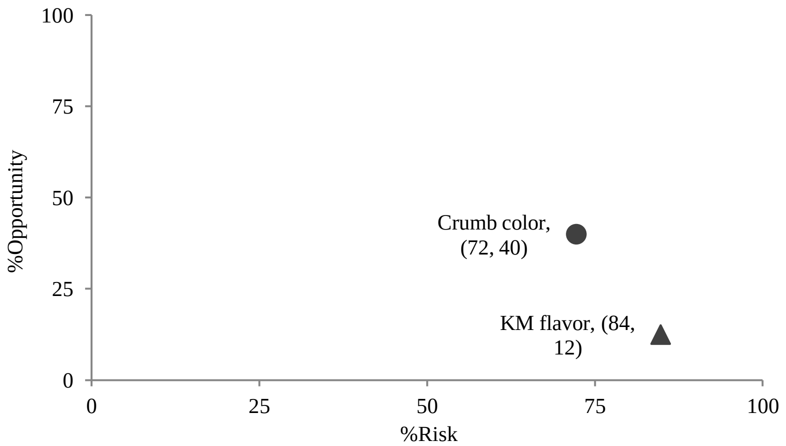

Figure 1. Opportunity analysis. Opportunity of product rejection and risk of product accept for crumb color, flavor and khao mao (KM) flavor.

4. CONCLUSION

This study indicated that the optimal composite flour of KMF: WF ratio was 40:60. KMF can be used as a wheat substitution in muffin. A large proportion (98%) of consumers accepted this new developed muffin. However, further product improvement is needed. Qualities of crumb color and KM flavor are required to suitable adjustment.

REFERENCES

Bunnak, J. and C. Chaosap (2006). "Study of nutrition value of khao-mao and khao-mao processing for added value."

Chueamchaitrakun, P., P. Chompreeda, V. Haruthaithanasan, T. Suwonsichon, S. Kasemsamran and W. Prinyawiwatkul (2011). "Sensory descriptive and texture profile analyses of butter cakes made from composite rice flours." International Journal of Food Science & Technology 46(11): 2358-2365.

Johnson, F. (1990). "Characteristics of muffins containing various levels of waxy rice flour." Cereal Chem 67(2): 114-118.

Prinyawiwatkul, W. (2010). "Analysis of JAR data." In Application of Sensory Techniques in Product Development: 1-72.

Voraputhaporn, W., T. Ngamsuk, S. Natiwara and T. Pitirit (2008). Production and development of breakfast cereal products from Yong Puffed Rice. Khon Kean Thailand, Khon Kean University.

Voraputhaporn, W. and C. Wongsamun (2003). The production development of roasted rice and some of its products from the Northest Heritage. Khon Kean Thailand, Khon Kean University.

Yambunjong, P., K. Sriroth and U. Karnjanapakornchai (1999). Effects of rice varieties and harvesting time on rice flake products. Tropical Agriculture, Kasetsart University. Degree of Master: 158.

Yungbhumphuttha, K. (2007). "Electronic distance learning tv; muffin." Retrieved July 15, 2013, from http://edltv.vec.go.th/index.php?option=com_edl&task=course&view=lesson&lid=1154&pid=1153&idx=0&Itemid=19.

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COMPARISON OF CONSUMER PREFERENCES OF DOG FOOD PRODUCTS BETWEEN THAILAND AND SINGAPORE USING CHOICE BASED CONJOINT ANALYSIS

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ABSTRACT

This research investigated the difference in consumer perception of dog food products between Thais and Singaporeans using Choice-Based Conjoint Analysis (CBC). The empirical analysis used consumer-level questionnaires to elicit the information (n= 184 for Thai consumers and n = 141 for Singaporean consumers) with regards to four attributes (packaging format, price, brand quality and nutrition) with three predefined elements (For Thai consumers : packaging format: canned, pouch, dry; price: 85 Baht, 135 Baht, 165 Baht per kg; brand quality: unbranded, commercial, premium ; nutrition : fulfilled, silky fur and skin condition, dog's preference; For Singaporean consumer : packaging format: canned, pouch, dry; price : < S$5, S$5-$7, > S$7 per kg; brand quality: supermarket, premium, holistic; nutrition: general, specific, dog's preference). The results of conditional logistic regression suggested that "premium", "dry", "silky fur and skin condition" were important elements for Thai consumers, while "dry", "holistic brand" and "specific nutrition" were important elements for Singaporean consumers. The "price" attribute did not contribute significantly to consumer preferences in both countries. In addition, CBC showed an overestimation in values of elements of dog food products. This may have resulted from respondents having focus on their preferred elements and ignored other elements. It was also found that the "dry" and "holistic" elements were the main dominating attributes for Singaporean and Thai consumers respectively. The comparison of the CBC results between both countries has helped to identify the potential profile of dog food products.

Keywords: Choice-Based Conjoint Analysis, Preference measurement, Dog food, Cross Cultural Study

1. INTRODUCTION

The consumption of dog food in Thailand and Singapore has been continually growing recently. Nowadays dogs have become one important member of family and consumers believe that the food feeding their dogs should be as good as the food they consume themselves (Canada, 2010, International, 2012). These trends led to the development of premium brands that contain added ingredients and formulations following the trends for human food (Koppel, 2014). Dog food products that contain functional ingredients become more prominent as their labels claimed that these products have better quality and are healthier for digestion, immune system and joint health. These ingredient patterns are also found in the human nutrition market (Canada, 2010). In order to be successful products in market, the pet food companies need to focus on product innovation and product development oriented to consumer preferences. However, the evaluation of preferences of dog food product is still challenging since dogs lack the linguistic capabilities to express themselves and their owners have to determine dog food acceptability before serving it (Koppel, 2014). This phenomenon results in an increasing demand for faster and more efficient approaches in product development in pet food manufactures.

In recent years, many studies have used Choice-Based Conjoint Analysis (CBC) to measure consumer preference toward food products (Kallas, Lambarraa *et al.*, 2011, Phaosathienpan and Tengpongsathon, 2012). CBC is a method used to determine how consumer value different product concepts in term of utility value. The utility value, obtained from weighting the importance of attributes and elements in product profiles, allows product developers to identify products with high potential. As cultural differences might occur it is interesting to study the influences of dog food characteristics toward the owner preference on consumers from different cultures.

Therefore, the objective of this research was to investigate the difference in consumer preference on dog pet food products between Thais and Singaporeans by using CBC method. Understanding the relevant attribute that drive consumers liking will help product developers to identify high potential concepts of dog food product that is most preferred in both countries.

2. CHOICE-BASED CONJOINT ANALYSIS (CBC)

Choice-Based Conjoint analysis, also called Choice Experiment (CE), is one of the most frequently used methods in the exploration of consumer preference by means of questionnaire. The CBC is based on the presentation of product concepts made of different attributes and elements to the respondent. The respondent is then asked to choose the most preferred product concept in each choice set. This method can be applied to evaluate consumers' preference of "complex goods" that comprise several attributes and elements. The CBC method was created for overcoming several critical assumptions inherent to the traditional Conjoint Analysis (CA) that could lead to incorrect predictions (Kallas, Lambarraa *et al.*, 2011). CBC has gain popularity because it is more realistic and easier for the respondents than CA. In CBC consumers have to choose the preferred product among alternatives which is similar to what consumers actually do at the market place. Finally, CBC estimates the preferences in term of utility values by using Conditional Logit model (Kallas, Lambarraa *et al.*, 2011).

2.1. The structure of choice set in CBC

The CBC questionnaire includes several question sets or "choice set". Each choice set is formed by two or more product concepts or "alternative choice" that is constructed from product attributes and their levels or elements (Haaijer and Wedel, 2003). Practically, CBC offers a bundle of choice set which have two or more "alternative choices" to the respondents. Respondents are asked to choose only one alternative (the one they most prefer) in each choice set. An example of choice set is shown in Table 1.

Table 1. An example of a choice set in CBC

Attributes	Alternative "A"	Alternative "B"	Alternative "C"
Packaging format	Canned	Pouch	
Price per Kg.	135 baht	85 baht	Neither alternative "A"
Brand Quality	Commercial Quality	Premium Quality	nor "B I preferred
Nutrition	Fulfilled nutrition	Dog's preference	
	☐A	☐B	☐C

If you were in the market to buy dog food product, which one would you choose?

In addition, a "no-choice" alternative is often added to each choice set to avoid to force the respondent to choose a product concept when there are not any preferred alternatives in the choice set (Haaijer and Wedel, 2003). However, it should be noted that respondents may choose "no-choice" because the element they expected is not included in the alternative in the choice set. Alternatively, respondents may choose the "no-choice" in order to avoid the difficult alternative choice (Haaijer and Wedel, 2003).

2.2. The methodology of CBC

The CBC methodology is based on Lancaster's Theory of Value which stated that utilities for products or services can be decomposed into separable utilities for their attributes (Kallas, Lambarraa *et al.*, 2011) and on the Random Utility Theory where the utility value is divided into two components: systematic and random (Aizaki and Nishimura, 2008). The systematic component is the utility value that is measurable from the empirical study and the random component or "error term" is the utility value that is unobservable from the empirical study. These two components allow us to determine the utility value where respondent choose the alternative that has the higher level of utility in choice set (Ryan and Gerard, 2003). From Lancaster's Theory of value, the utility function of individual *n* for alternative *i* is presented in Equation 1 below:

$$U_{in} = V_{in}(Z_i) + \varepsilon_{in} \quad (1)$$

where U_{in} represents the utility value provided by alternative *i* for individual *n*, V_{in} is the systematic component or measurable component of utility, Zi is a vector of attributes of the alternative such as "format", "price", "quality-brand" and "nutrition". ε_{in} is the random error term or unobservable factors (Ryan and Gerard, 2003, Kallas, Lambarraa *et al.*, 2011). From the Random Utility Theory, the probability that individual *n* choose the alternative *i* denoted by Pr(i |C_n) rather than the alternative *j* or utility of alternative *i* (U_{in}) is greater than utility of alternative j (U_{in}) is represented in Equation 2 and can be transformed into Equation 3 as shown below:

$$Pr(i|C_n) = Pr[U_{in}>U_{jn}] = Pr[V_{in} + \varepsilon_{in} > V_{jn} + \varepsilon_{jn}] \quad (2)$$

$$Pr(i|C_n) = Pr[V_{in} - V_{jn} > \varepsilon_{jn} - \varepsilon_{in}] \quad (3)$$

The probabilities that individual *n* will choose alternative *i* Pr(i |C_n) equal to the probability that (V_{in} - V_{jn}) is greater than (ε_{jn} - ε_{in}) even though the random components are unobservable (Kallas, Lambarraa *et al.*, 2011). The Conditional Logistic (CL) model is commonly used to determine the utility function from the choice-based data (Ryan and Gerard, 2003, Kallas, Lambarraa *et al.*, 2011) According to the CL model, the functional form of the systematic utility function is given by the following linear utility function (Ryan and Gerard, 2003).

$$V_{in} = ASC + \sum_{k}^{k} \beta_k X_k \quad (4)$$

where V_{in} is the systematic utility of alternative *i* for individual *n*, ASC is the alternative specific constant, $\sum\beta_k X_k$ is the summation of all the coefficients of attribute X_k and i = 1,…, I represents the number of alternatives. It can be assumed that the coefficient values provide the relative importance of attributes or elements in consumer choice (Colombo, Angus *et al.*, 2009). Finally, the utility function in the basic Condition Logistic model for dog food attributes is given by Equation 5

In CL model, the product attributes can be nominal, ordinal or even quantitative scales of measurement (Meißner and Decker, 2009). The ASC variable in the CL model is an alternative specific constant for dog food model. The coefficient values of elements are denoted as βi_s. For the CL model with a categorical dependent variable, the goodness of fit can be accessed through rho-square or pseudo R^2 following Macfadden's R^2 estimation method (Novotorova, 2007).

$$\text{Utility value} = \beta_{CAN}(CAN) + \beta_{POU}(POU) + \beta_{DRY}(DRY) + \beta_{PRI}(PRI) + \beta_{UNB}(UNB) + \beta_{COM}(COM) + \beta_{PRE}(PRE) + \beta_{FUL}(FUL) + \beta_{SIL}(SIL) + \beta_{DOG}(DOG) + ASC \quad (5)$$

3. THE EMPIRICAL ANALYSIS

3.1. creening and selecting attributes

In the empirical application of CBC, the first step is to identify and screen attributes and elements. Since there are different dog food products available between Thailand and Singapore, we selected the attributes and elements for each group of consumers separately. For Thai consumers, a first set of attributes and elements was obtained from the literature. After discussion with target consumers (n=30), the final set of attributes and elements was established (Phaosathienpan and Tengpongsathon, 2012, Phaosathienpan, 2014). For Singaporean consumers the attributes were obtained from focus group discussions (n= 25). Predefined set of attributes and elements for both countries were identified (Figure 1 and 2.)

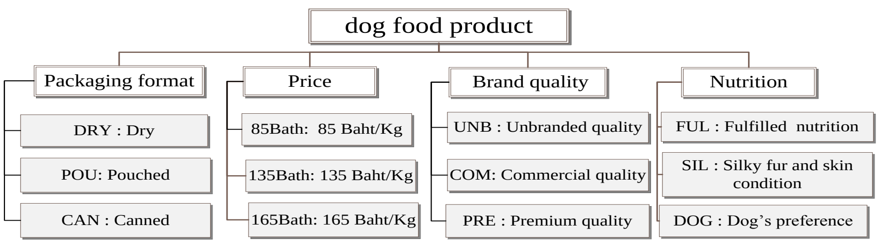


Figure 1. The attributes and elements for Thai consumers

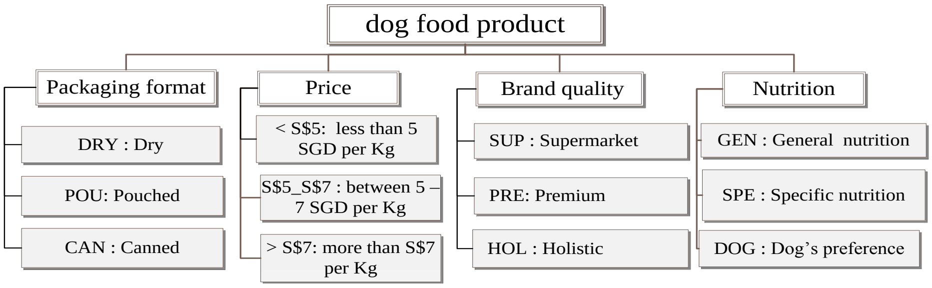


Figure 2. The attributes and elements for Singaporean consumers

In this study, the empirical analysis used consumer-level questionnaires to elicit the information, regarding to four attributes (packaging format, price, brand quality and nutrition) with three levels of each predefined element (For Thai consumers, packaging format: canned, pouch, dry; price: 85 Baht, 135 Baht, 165 Baht per kg; brand quality: unbranded, commercial, premium; nutrition : fulfilled, silky fur and skin condition, dog's preference for nutrition; for Singaporean consumers : packaging format: canned, pouch, dry for format; price : < S$5, S$5-$7, > S$7 per kg; brand quality: supermarket, premium, holistic for brand quality; general, specific, dog's preference for nutrition).

3.2. Creating the questionnaire

The questionnaires were created by using the final set of attributes and elements as guided by the study of Aizaki and Nishimura (2008). The choice sets presented to respondents were created using an experimental design with respect to four attributes containing three elements. The number of choice set presented to each target group created by full factorial design was equal to 3^4 = 81 choice sets. In order to avoid an overload effect for respondents, we used fractional factorial design to reduce the number of choice sets by the "optFederov function" of the Algdesign package (Wheeler and Wheeler, 2008) with R program (Team, 2012). At final, the total set of choice sets presented to each respondent was nine. The consumer had to choose the most preferred alternative in each choice set ("Alternative A", "Alternative B" and "no-choice").

3.3. Data collection and data analysis

Dog owners who live in Thailand (Bangkok area) and Singapore were chosen to fill the CBC questionnaire. There were 184 and 141 respondents in Thailand and Singapore respectively.

After all respondents had selected one of three alternatives in the nine choice sets, the Conditional logit model (CL) was used to estimate the utility values of dog food products from Thai and Singaporean consumers. Data analysis was performed by using the survival package (Therneau, 2013) in R program version 2.13.0 to achieve the conditional logit model. In order to be able to compare the results between Thai and Singaporean consumers, we considered the attributes and elements of dog food that explain the utility function, regardless of interaction effect between attributes.

4. RESULTS AND DISCUSSION

4.1. Thai consumers

Table 2 shows the results of CBC for Thai consumers (n = 184) derived from the CL model. According to the likelihood ratio test (p = 0.000), we can reject the null hypothesis "all coefficients were equal to zero" at 99.99% confidential level. Moreover, the goodness of fit can be accessed through rho-square. For Thai consumers, the rho-square was equal to 0.2721. As McFadden (1972) noted, any rho-square greater than 0.2 indicates model sufficiency (Novotorova, 2007).

Dry dog food was the most preferred element, followed by "canned" and "pouch". For the "price" elements, the coefficient values were 0.10692, 0.07555, -0.18247 for 85 Baht per Kg, 135 Baht per Kg and 165 Baht per Kg which were close to zero. It can be assumed that price element did not have a major effect on the utility value (p-value < 0.05). For brand quality, the most preferred element was "Premium" element. In addition, for nutrition elements, the most preferred elements was "Silky fur and skin condition", followed by "fulfilled nutrition" and "dog's preference" subsequently.

Thus, the utility function for Thais consumer could be presented in the linear regression model given by:

$$\text{Utility value}_{\text{Thais}} = -0.45049\ (\text{CAN}) - 0.51199\ (\text{POU}) + 0.96248\ (\text{DRY}) + 0.10692\ (85\text{Bht}) + 0.07555\ (135\text{Bht}) - 0.18247\ (165\text{Bht}) - 1.62644\ (\text{UNB}) - 0.50783\ (\text{COM}) + 2.13427\ (\text{PRE}) + 0.17649\ (\text{FUL}) + 0.89681\ (\text{SIL}) - 1.07330\ (\text{DOG}) + 2.18019$$

Table 2. Results of the choice-based conjoint analysis for Thais consumers.

Variables	Coefficient	Standard Error	*p*-value
ASC	2.18019	0.15586	0.00000 ***
Canned	-0.45049	0.15436	0.00352
Pouch	-0.51199	0.10880	0.00000 ***
Dry [a]	0.96248	0.00000	NA
85 Baht per Kg	0.10692	0.08282	0.19673
135 Baht per Kg	0.07555	0.10951	0.49029
165 Baht per Kg	-0.18247	0.00000	NA
Unbranded	-1.62644	0.11722	0.00000 **
Commercial	-0.50783	0.13051	0.00000 **
Premium [a]	2.13427	0.00000	NA
Fulfilled	0.17649	0.15717	0.26148
Silky fur and skin condition	0.89681	0.09242	0.00000 **
Dog's preference [a]	-1.07330	0.00000	NA
Summary statistics			
No. of observations	184		
Likelihood ratio test = 957.6 on 9 df, *p*-value = 0.000			
rho-squared (RHO2)[c]	0.2721		
Adjust rho-square (AdjRHO2)	0.2647		

[a] *Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.5 '.' 0.1 '' 1*
[b] *Based element of attributes : coefficient of the base elements (β0) were calculated as (β1 + β2) x (-1) following the effect coding procedure.*
[c] *The rho-squared (RHO2) also called Mcfadden's R^2 or pseudo R squares*
[NA] *variances and p-values can be obtained by re-estimating the model by changing the based element.*

Table 3. Results of the choice-based conjoint analysis for Singaporean consumers.

Variables	Coefficient	Standard Error	*p*-Value	
ASC	1.68561	0.18050	0.00000	***[a]
Canned	-1.11531	0.13889	0.00000	***
Pouch (wet food)	-2.04144	0.13421	0.00000	***
Dry [b]	3.15675	0.00000	NA	
< S$5 per kg	-0.28302	0.14250	0.04700	*
S$5-7 per kg	0.27676	0.14121	0.05000	
> S$7 per kg [b]	0.00626	0.00000	NA	
Supermarket	-1.40132	0.12348	0.00000	***
Premium	-0.15897	0.12558	0.20600	
Holistic [b]	1.56029	0.00000	NA	
General nutrition	0.09709	0.15313	0.52600	
Specific nutrition	0.24698	0.19134	0.19700	
Dog's preference [b]	-0.34407	0.00000	NA	
Summary statistics				
No. of observations	141			
Rho-squared [c]	0.1464			
Adjust rho-square (RHO)	0.1371			
Likelihood ratio test = 408.3 on 9 df, *p*-value = 0.000				

[a] *Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.5 '.' 0.1 '' 1*
[b] *Based element of attributes : coefficient of the base elements (β0) were calculated as : (β1 + β2) x (-1) following the effect coding procedure.*
[c] *The rho-squared (RHO2) also called Mcfadden's R^2 or pseudo R squares.*
[NA] *variances and p-values can be obtained by re-estimating the model by changing the based element.*

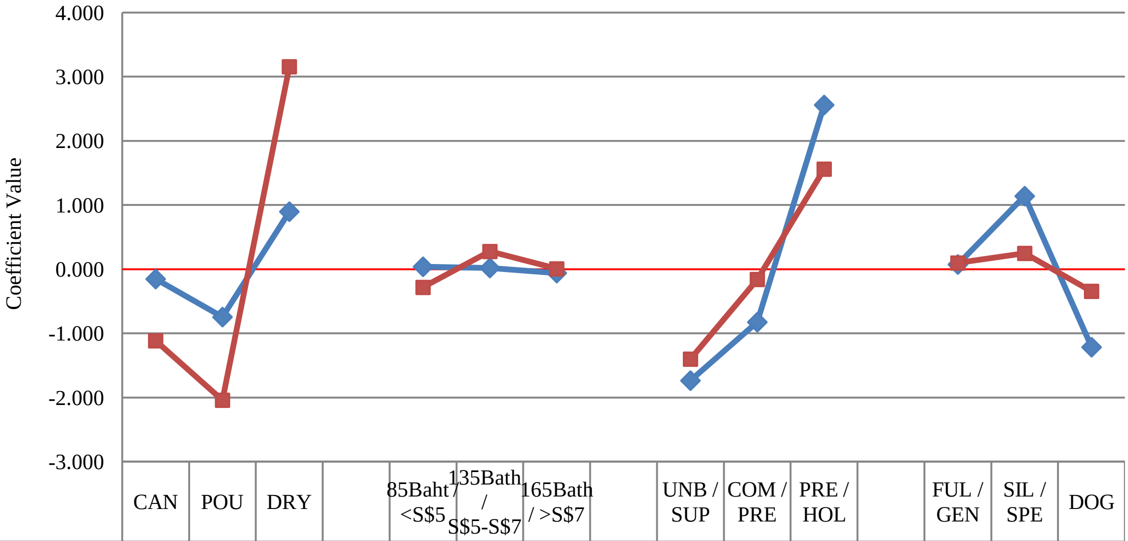
From the utility function, it is assumed that consumers will choose the product concept with higher utility value. Positive coefficients contributing to high utility value were associated with the element "premium", "dry", "silky fur and skin condition" and negative coefficients contributing to low utility value with the elements "unbranded", "dog's preference", "pouch", "commercial" and "canned" . The results suggested that the product profile which contained elements of "premium", "dry" and "silky fur and skin condition" have high potential of success and preference by Thai consumers.

4.2. Singaporean consumers

The results from CL model for Singaporean consumers are shown in Table 3. The likelihood ratio test suggested that the null hypothesis was rejected at 99.99% confidential level. The rho-square showed that the goodness of fit was equal to 0.1464 which was less than 0.2. However, the rho-square is still an acceptable range for the CL model (Kallas, Lambarraa *et al.*, 2011)

Considering elements within each attribute, "dry" was the most appreciated, followed by "canned" and "pouch". For the price attribute, the highest price, "> S$7", did not contribute to the utility value. The most preferred element was "S$5-S$7" and the least preferred element was "<S$5". For brand quality, "holistic brand" was the most preferred, compared to "premium" and "supermarket". For nutrition,"general" was the most preferred element followed by "specific" and "dog's preference". The utility function of dog food product for Singaporean is shown below:

$$\text{Utility value}_{\text{Thais}} = -1.11531(CAN) - 2.04144(POU) + 3.15675(DRY) - 0.28302(<S\$5) + 0.27676(S\$5\_S\$7) - 0.00626(>S\$7) - 1.40132(SUP) - 0.15897(PRE) + 1.56029(HOL) + 0.09709(GEN) + 0.24689(SPE) - 0.34407(DOG) + 1.68561$$



	CAN	POU	DRY		85Baht / <S$5	135Bath / S$5-S$7	165Bath / >S$7		UNB / SUP	COM / PRE	PRE / HOL		FUL / GEN	SIL / SPE	DOG
Thais	-0.153	-0.745	0.898		0.039	0.020	-0.059		-1.736	-0.825	2.561		0.075	1.140	-1.215
Singaporean	-1.115	-2.041	3.157		-0.283	0.277	0.006		-1.401	-0.159	1.560		0.097	0.247	-0.344

Figure 3. Comparison of consumer preference between Thai and Singaporeans

** NB: All codes are denoted as elements as previously defined in Figure 1 and 2. (CAN = canned, POU = pouch, DRY = dry; 85Baht = 85 Baht per Kg, 125 Baht = 125 Baht per Kg, 165Baht = 165 Baht per Kg; <S$5 = less than 5 SGD, S$5 – S$7 = between 5 to 7 SGD, >S$7 = more than 7 SGD; UBN = unbranded brand quality, COM = commercial brand quality, PRE = premium quality, SUP = supermarket brand quality, HOL = holistic brand quality; FUL = fulfilled nutrition, SIL = silky fur and skin condition, DOG = dog's preference, GEN = general nutrition, SPE = specific nutrition)*

From the utility function, positive coefficients contributing to high utility value were associated with the element "dry", "holistic", "S$5-S$7", "specific nutrition" and negative coefficients contributing to low utility value with the elements "pouch", "supermarket", "canned", "dog's preference", "<S$5", "premium". These results suggested that the product with the higher potential for Singaporean consumers was the product profile which contained the elements "dry", "holistic", "S$5-S$7" and "specific" elements.

4.3. Comparison between Thai and Singaporean consumers.

To compare the consumer preference between Thais and Singaporean, we considered the coefficient values of each element presented in Figure 3. Some similarities can be observed from both groups. Regarding packaging format, both Thai and Singaporean consumers showed the same appreciation of “dry” element rather than “canned” and “pouch”. This could be due to the wide availability and convenience of dry foods from consumer who follow an urban life style (Naksuwan, 2006, International, 2013).

For the brand quality attribute, Thai and Singaporean consumers showed higher preference scores when dog food product contained higher brand quality element. The highest brand quality element for Thai consumers was “premium”, while for Singaporean consumers it was “holistic”. Canada (2010) had reported that dog owners considered that the food they feed their dogs should be as good as what they consume themselves.

For the nutritional attribute, it was found that both countries preferred dog food to have specific functional properties. Thai and Singapore consumers gave higher preference scores to dog foods that contain the “silky fur and skin” element and “specific” element respectively, compared to “fulfilled”, “general” and “dog’s preference” which received lower preference scores. It should be noted that the “price” attribute did not contribute significantly to consumer preferences in both countries.

In addition, it was found that the “dry” and “premium” or “holistic” elements were the main dominating attributes for Thai and Singaporean consumers. The results from CBC showed an overestimation in “premium” element for Thai and “holistic” element for Singaporean consumers. This may have resulted from respondent giving increasing weight to their preferences and ignoring other elements.

5. CONCLUSION

We focused on assessing the difference in perception of dog food product between Thais and Singaporean consumers by using CBC method. The CBC method allows product developers to identify relevant attributes and elements that influenced consumer’s preference on dog food. It was found that dry dog food and high brand quality were the main dominating attributes for both countries. Functional properties that provide health and wellness impacted also the preference. Finally, the price attribute did not contribute significantly to respondent preferences.

This study demonstrates that the CBC method is an interesting and practical method to be applied in food science for measuring the preference of dog food products which are not directly consumed by human. The CBC seems to be realistic and friendly to consumers by asking to choose the most preferred product among the alternative products within choice sets. This simulates what the consumer does at the marketplace. However, the CBC does not allow determining the preference score at individual level. Future studies should focus on the effects of individual characteristics such as gender, number of dogs and purpose for having a dog, in order to better understand different perceptions of consumers.

REFERENCES

Aizaki, H. and K. Nishimura (2008). "Design and analysis of choice experiments using R: a brief introduction." Agricultural Information Research 17(2): 86-94.

Canada, A. a. A.-F. (2010, 3 Dec. 2013). "Global pet food trends." from http://www.gov.mb.ca/agriculture/statistics/food/global_pet_food_en.pdf

Colombo, S., A. Angus, J. Morris, D. J. Parsons, M. Brawn, K. Stacey and N. Hanley (2009). "A comparison of citizen and “expert” preferences using an attribute-based approach to choice." Ecological Economics 68(11): 2834-2841.

Haaijer, R. and M. Wedel (2003). Conjoint choice experiments: General characteristics and alternative model specifications. Conjoint Measurement, Springer: 371-412.

International, E. (2012). "Pet humanization continues to drive the global pet care market." Retrieved 2 Apr., 2014, from http://blog.euromonitor.com/2012/08/pet-humanization-continues-to-drive-the-global-pet-care-market.html.

International, E. (2013). "Country report: dog food in Thailand ". Retrieved 1Apr., 2014, from http://www.euromonitor.com /dog-food-in-thailand/report.

Kallas, Z., F. Lambarraa and J. M. Gil (2011). "A stated preference analysis comparing the analytical hierarchy process versus choice experiments." Food quality and preference 22(2): 181-192.

Koppel, K. (2014). "Sensory analysis of pet foods." Journal of the Science of Food and Agriculture.

McFadden, D. (1972). Conditional logit analysis of qualitative choice behavior.

Meißner, M. and R. Decker (2009). An empirical comparison of CBC and AHP for measuring consumer preferences. International Symposium of Analytical Hierarchy Process.

Naksuwan, K. (2006). Marketing factors attesting dog ready food buying decision in Bangkok metropolis, Department of management, Rajamangala University of Technology Thanyaburi, Patumtani Thailand.

Novotorova, N. (2007). A Conjoint Analysis of Consumer Preferences for Product Attributes: The Case of Illinois Apples, University of Illinois at Urbana-Champaign.

Phaosathienpan, S. (2014). Comparision of Choice-Based Conjoint Analysis and Analytical Hierarchy Process in consumer preference of dog food. Faculty of Agro-Industry, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand: . MsD thesis.

Phaosathienpan, S. and K. Tengpongsathon (2012). Application of Choice-Based Conjoint Analysis for consumer preference on dog's pet food product in Thailand. SPISE 2012 Integrating sensory evaluation to product development, An Asian perspective, University of technology, Ho Chi Minh City.

Ryan, M. and K. Gerard (2003). "Using discrete choice experiments to value health care programmes: current practice and future research reflections." Applied health economics and health policy 2(1): 55-64.

Team, R. C. (2012). R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria, 2012, ISBN 3-900051-07-0.

Therneau, T. (2013). A package for survival analysis in S. R package version 2.37-4.

Wheeler, B. and M. B. Wheeler (2008). The AlgDesign Package.

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EFFECTS OF MIRACLE FRUIT JUICE ON THE CHANGES IN BASIC TASTES RECOGNITION THRESHOLD AND THE SENSORY QUALITY OF ORANGE JUICE

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ABSTRACT

Miracle fruit (*Synsepalum dulcificum*) contains a taste modifying protein, namely miraculin. Its effect consists in a temporary replacement of sour and bitter taste with sweet taste. Despite previous psychophysical investigations, very little is known about the effect of this fruit on taste interaction from the product. In this study, the changes induced by miracle fruit juice on the recognition threshold of four basic tastes were investigated. In addition, the effect of miracle fruit juice on the sensory quality of orange juice was evaluated. The recognition threshold of sweet taste decreased significantly after using 1ml miracle fruit juice. In contrast, the recognition threshold of sour and bitter taste increased after using 1.5ml this juice and the recognition threshold of salty taste was not effected by using miracle fruit juice in range of 1–2ml. The addition of 10% miracle fruit juice enhanced the sensory quality of the orange juice.

Keywords: Miracle fruit, recognition threshold, basic tastes, acceptability, orange juice

1. INTRODUCTION

Miracle tree (*Richadella dulcifica*), a native shrub in tropical West Africa, was first discovered in 1725 by Reynaud Dés Marchais, a French explorer. In 1852, W.F. Daniell described in details the unusual property of the ripe fruit. It can modify sour and bitter taste into sweet taste. He classified this tree as Synsepalum dulcificum, a member of Sapotaceae family and named it “miracle tree” (Tran, Vu *et al.*, 2010). In Vietnam, miracle tree was imported about seven years ago and was cultivated throughout the country (Dan tri news–paper, 15/02/2013).

The active component of Richadella dulcifica that modifies sourness and bitterness to sweetness, designated as miraculin, was first reported in 1968 (Kurihara and Beidler, 1968). Miraculin contents can reach up to 10% of the total soluble protein of miracle fruits (Sun, Cui *et al.*, 2006). It is a homodimeric glycosylated protein composed of 191 amino acid residues (Brouwer, Glaser *et al.*, 1983, Theerasilp, Hitotsuya *et al.*, 1989). The purified miraculin contains as much as 13.9% of sugars, which consists of glucosamine, mannose, galactose, xylose and fucose in a molar ratio of 3.03:3.00:0.69:0.96:2.12 (Theerasilp and Kurihara, 1988). Miraculin is not sweet by itself, but modifies sourness into sweetness (Al Bachchu, Jin *et al.*, 2011). When a few granules of freeze-dried extract of miraculin dissolve on the tongue for a few minutes, one can appreciate a pleasant sweet sensation when sour substances (i.e., lemon, vinegar) are tasted (Capitanio, Lucci *et al.*, 2011). When chewing miracle fruit, miraculin binds directly to the region of the human sweet taste receptor molecule on the outside of the cell and the interaction between miraculin and the human sweet taste receptor is extremely strong. It subsequently acts as an agonist every time a sour solution is tasted. The taste-modifying activity of miraculin can maintain over one hour (Misaka, 2013). Thus, this effect can last for hours until the taste buds become normal (Hirai, Sato *et al.*, 2010).

Bartoshuk, Gentile *et al.* (1974) suggested that the reduction of sourness by miracle fruit is the result of mixture suppression: the sourness would be reduced by the added sweetness. When miracle fruit was added to citric acid, sourness was suppressed and sweetness emerged, in a comparable way as adding sugar to citric acid makes it taste sweet. The effect of sourness reduction after miraculin would depend on the action of induced sweetness rather than on an intrinsic suppression of sourness due to miraculin itself (Dzendolet, 1969).

Foods are complex gustatory matrices, whose sensory attributes can be understood by studying in the laboratory how single tastants combines perceptually with each other in controlled mixtures (Capitanio, Lucci *et al.*, 2011). Although the perception of isolated tastants can be explained, less is known in this respect about interactions among tastants. When evaluating sensory quality of foods, many phenomena such as adaptation, fatigue, compensation, contrast take place on gustation causing the changes in the taste reception ability (Ngo, 1989). However, these effects have not been investigated on miracle fruit and miraculin. In this study, we assessed the impact of miracle fruit juice on the recognition threshold of individual basic taste and on the taste perception of orange juice.

2. MATERIALS AND METHODS

2.1. Products

Ripe miracle fruits were bought from a farm at Long Ho, Vinh Long and orange juice products (Berri Orange Juice, a trade from Australia) were collected from local supermarket (Coop Mart, Cantho city).

Miracle fruits were harvested in the early morning. Uniform, intact ripe fruits with the same size were collected and washed several times with tap water. Peel and seed were separated by a sharp knife and the pulp pressed to obtain the juice. Fruit juice was filtered through a sterile sieve to obtain a homogeneous preparation of juice for experiments.

2.2. Experiment 1: Effect of miracle fruit juice on the recognition threshold for four basic tastes

2.2.1. Panelists

The number of panelists was 20 (10 male and 10 female), they were students of College of Agriculture and Applied Biology, Cantho University. All of them were required to fulfill the following criteria: be in good health condition, without psychological effects of stress in the day of test; without smoking and drinking any beverage including coffee, tea or refreshments or chewing gum for at least two hours before the tests (Fox, 1985).

2.2.2. Sample preparation

Miracle fruit juice solution: Four concentration levels of 0, 10, 15 and 20% of miracle fruit juice were prepared.

For this test, sucrose (sweetness), sodium chloride (salty), citric acid (sourness) and caffeine (bitterness) solutions were used. Each taste gradient consisted of:

- 23 solutions for sucrose, from 0 to 22 g/l (in 1g/l increments);
- 23 solutions for sodium chloride, from 0 to 2.2 g/l (in 0.1g/l increments);
- 12 solutions for citric acid, from 0 to 1.1 g/l (in 0.1g/l increments) and 13 solutions for caffeine (HiMedia Laboratories Pvt. Ltd), from 0 to 1.2 g/l (in 0.1g/l increments)

2.2.3. Procedure

A recognition threshold test was used. Firstly, each volunteer tasted 10ml miracle fruit juice solution. After five minutes, he/she was asked to taste and determine the taste of the sample solution, ordered in progressively higher concentration starting from pure water as blank. The test continued until the volunteer clearly identified the taste of the solution. The concentration of that solution is the recognition threshold of volunteer. Each time, volunteer was tested only for one basic taste and only one concentration of miracle fruit juice solution.

Recognition thresholds were evaluated before and after tasting miracle fruit juice solution with the concentration of 10; 15 and 20% (1; 1.5 and 2ml in 10ml solution).

2.3. Experiment 2: Effect of miracle fruit juice on the sensory quality of orange juice

2.3.1. Sample preparation

Miracle fruit juice was added to the orange juice (stored at 20^{o}C at least one day before testing) to the ratio of 0, 10, 15 and 20% (v/v). The samples coded with 3-digit random numbers were served to each panelist.

2.3.2. Panelists

Sensory quality of product was judged by ten trained panelists who attended three training courses to evaluate orange juice attributes two weeks before joining the panel.

2.3.3. Procedure

Experiments were carried out by descriptive analysis (DA) method with two main categories: flavor and taste. Each time, panelist only judged one orange juice sample. The flavor and taste attributes of orange juice consist of: orange flavor, strange flavor, peel flavor, sweetness, sourness, bitterness, strange taste. Attributes were quantified with an intensity scale from 0 to 5. In addition, the samples were rated "accept" or "un-accept" by panelists.

2.4. Statistical analysis

Data analysis was processed by hypothesis testing for mean (t–test) and logistic regression analysis by STATGRAPHICS Centurion XVI.I. The graphs were plotted using Microsoft Excel 2007 and STATGRAPHICS Centurion XVI.I.

3. RESULTS AND DISCUSSIONS

3.1. Effects of miracle fruit juice concentration on the changes of recognition thresholds for four basic tastes

The recognition thresholds for four basic tastes from 20 volunteers are presented on Figure 1. In addition, the changes on recognition threshold for the four basic tastes with and without trying miracle fruit juice are shown in Figure 2.

Figure 1 shows that in normal status of the volunteers (without trying miracle fruit juice), the recognition threshold for salty, sweet, sour and bitter tastes corresponded to 1.59g/l NaCl; 14g sucrose/l; 0.38g/l citric acid and 0.43g/l caffeine. These results were not much different from the results from previous studies that were 1.6g/l NaCl for the salty, 16g/l sucrose for the sweetness, 0.44g/l citric acid for the sourness and 0.33g caffeine for the bitter taste (Ngo, 1989).

As shown in Figure 1, it is important to note that the changes in recognition threshold after trying miracle fruit juice are not the same for the four basic tastes. The concentration of miracle fruit juice in range of 1–2ml/10ml solution (10–20%) seems to have no effect on the recognition threshold for salty taste. Tasting 1.5ml/10ml solution (15%) of miracle fruit juice increases the recognition threshold of sour and bitter tastes. Besides, tasting the 1.0ml/10ml solution (10%) of miracle fruit juice results in a decrease in recognition threshold for sweet taste.

As predicted, miraculin in miracle fruit juice had an effect on the perception of sourness, bitterness and sweetness in the cases of the sour and bitter tastes. Figure 2 shows clearly how the recognition threshold of sourness, sweetness and bitterness changed. No effect was observed in the case of the salty taste with the concentration of miracle fruit juice in range of 1–2 ml/10 ml (10– 20%) tasting solution.

After tasting 15% miracle fruit juice solution, the changes in recognition threshold for sour and bitter tastes are significantly higher than 0 ($p < 0.05$). This means the recognition threshold increases significantly at this level of miracle fruit juice for sour and bitter tastes. Besides, the change in recognition threshold for sweet taste is significantly lower than 0 ($p < 0.05$) after tasting the 10% miracle fruit juice solution, that means recognition threshold for sweetness decreases significantly with 10% miracle fruit juice solution.

These results can be explained by miraculin from miracle fruit juice. They confirm the effectiveness of miraculin on the perception of a sour solution (Bartoshuk, Gentile *et al.*, 1974) and the property of miraculin of temporarily modifying gustatory perception. The effectiveness of miraculin on the acidic pH of saliva might have been the explanation for a suppressive reduction in bitterness reported with caffeine (Capitanio, Lucci *et al.*, 2011). In addition, according to the functional scheme for the sweet inducing mechanism of miraculin by Kurihara and Beidler (1969), miraculin is bound to membrane of taste cells near the sweet receptor site. The receptor membrane undergoes a structural change in the presence of protons (H+), causing the sugar part of the miraculin molecule to bind to the sweet receptor site in the membrane, thereby evoking a strong sensation of sweetness (Misaka, 2013). The sweetness of some taste-modifying proteins appears in fact to strongly depend on pH (Nakajima, Asakura *et al.*, 2006) and it has been hypothesized that miraculin could also be considered a pH-dependent sweetener in this respect. In other words, the basis of the sweetness-inducing behavior under acidic conditions is the pH-dependent conformational changes of the receptor membrane that detect the sweet sensation (Kurihara and Beidler, 1969).

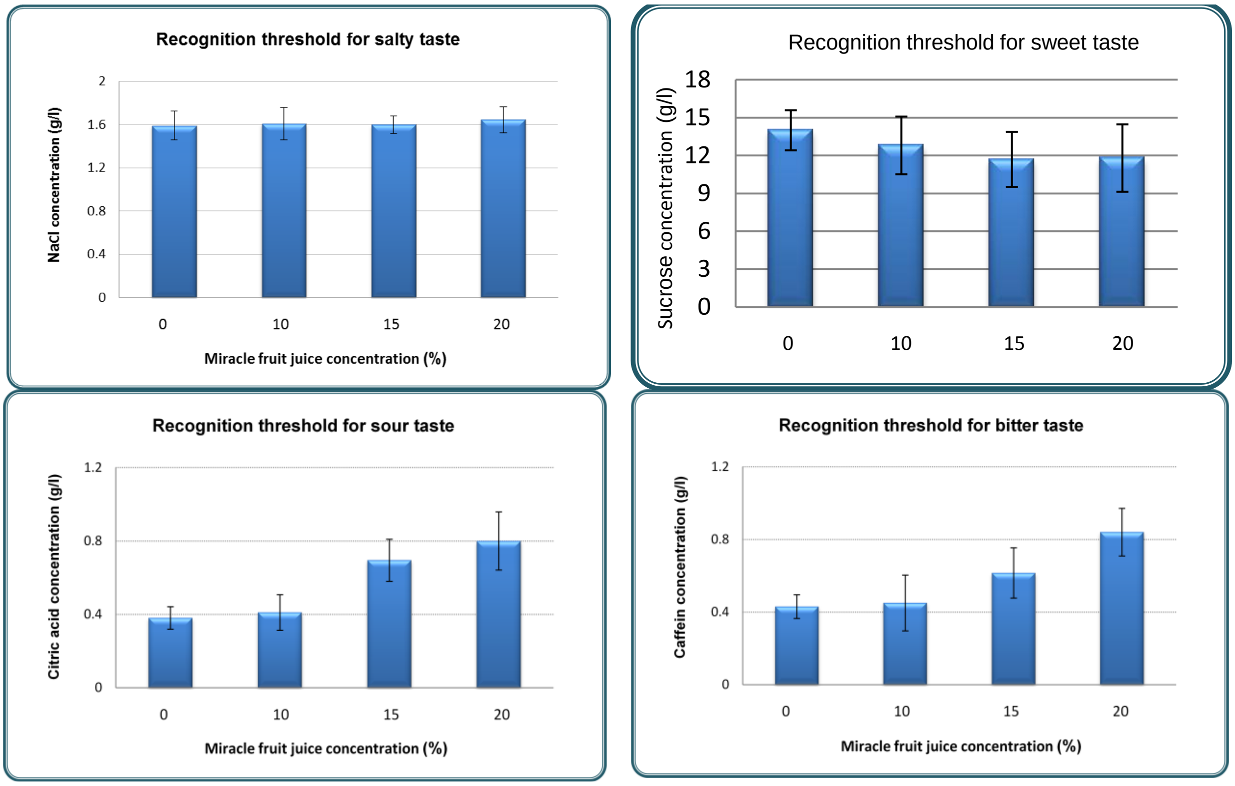

Figure 1. Recognition thresholds (means ± SD) for four basic tastes from 20 volunteers

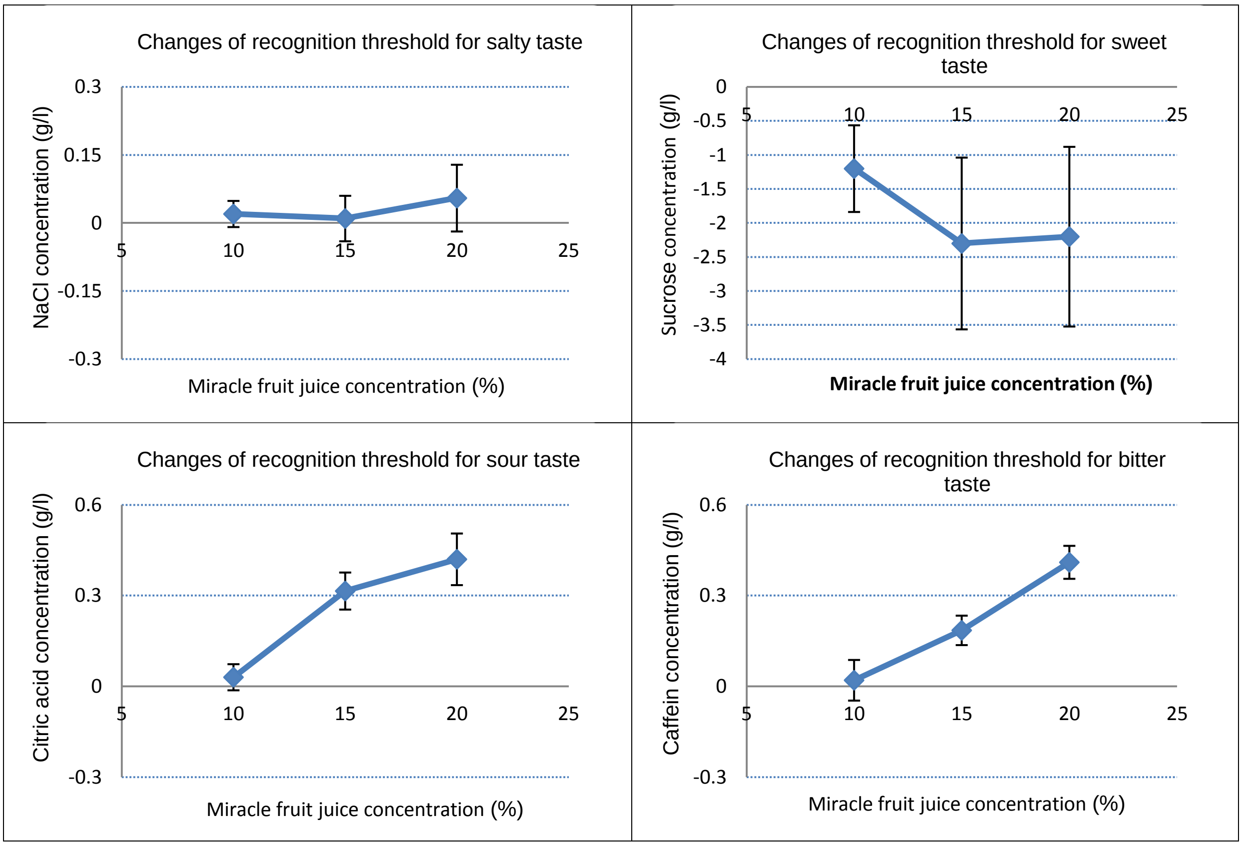

Figure 2. Changes on recognition threshold (means±95% confident limits) for the four basic tastes

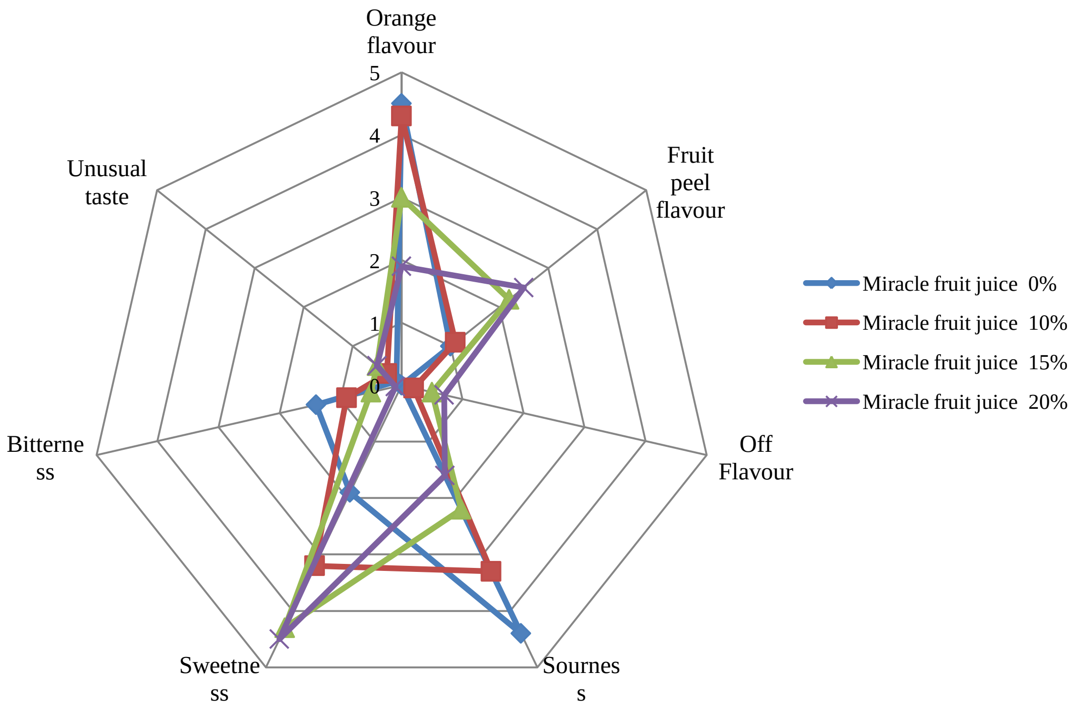

Figure 3. Sensory profiles of orange juices

3.2. Effects of miracle fruit juice on the sensory quality of orange juice

Miracle fruit juice affects mainly the taste and flavor of orange juice, so the selected sensory attributes belongs to taste and flavor properties. They include: orange flavor, fruit peel flavor, off–flavor, sweetness, sourness, bitterness and unusual taste. To create a visual profile or "fingerprint" of product attributes, spider plots (Figure 3) were created by plotting average intensity values on each scale, and then joining the points (Stone and Sidel, 1998). In addition, a preliminary result of the product acceptability was expressed on Figure 4.

Figure 3 illustrates that "orange flavor", "sweetness" and "sourness" were the product's most prominent characteristics. As also shown in Figure 3, miracle fruit juice decreases the sourness and the bitterness and increases the sweetness of the products leading to product sensory quality improvement. Unfortunately, adding high levels of miracle fruit juice results in the orange flavor declining. This result might be due to the effect of other ingredients from miracle fruit juice that are not miraculin.

A regression model, expressed by the following equation can be used to estimate the product acceptability (Figure 4):

Acceptability = $e(\eta)/(1+e(\eta))$, where $\eta = 0{,}442566 + 0{,}535221 \times x - 0{,}0291617 \times x^2$

where x: miracle fruit juice ratio (%)

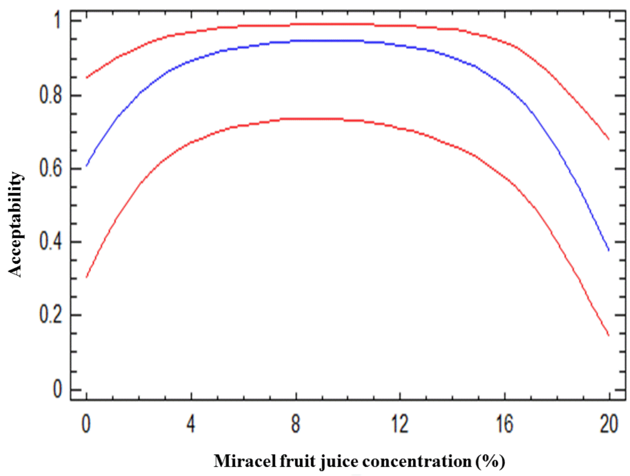

Figure 4. Acceptability of the orange juices

Applying the miracle fruit juice with low level (10%) increases the product acceptability due to the moderate changes in sweet, sour and bitter tastes. But, with higher levels of miracle fruit juice the product acceptability decreases. This last observation results from a decrease in orange flavor. This preliminary result is in agreement with the results from DA. Addition of 10% miracle fruit juice into orange juice improves significantly the acceptability of the product (getting about 90%). To verify this result, a further investigation should be carried out with a larger number of consumers.

4. CONCLUSION

Overall, our result confirms that miracle fruit juice (containing miraculin) can act as “sweet effect” on sour and bitter tastants (by stimulation to produce a sweet perception), but has no effect on salty tastant. The observations demonstrate that with an addition of 10% miracle fruit juice into orange juice the sensory quality and the acceptability of the product are significantly improved.

REFERENCES

Al Bachchu, M. A., S.-B. Jin, J.-W. Park, K.-H. Boo, H.-J. Sun, Y.-W. Kim, H.-Y. Lee, K.-Z. Riu and J.-H. Kim (2011). "Functional expression of miraculin, a taste-modifying protein, in Transgenic Miyagawa Wase Satsuma mandarin (Citrus unshiu Marc.)." Journal of the Korean Society for Applied Biological Chemistry 54(1): 24-29.

Bartoshuk, L. M., R. L. Gentile, H. R. Moskowitz and H. L. Meiselman (1974). "Sweet taste induced by miracle fruit (*Synsepalum dulcificum*)." Physiology & behavior 12(3): 449-456.

Brouwer, J., D. Glaser, C. H. af Segerstad, G. Hellekant, Y. Ninomiya and H. Van der Wel (1983). "The sweetness-inducing effect of miraculin; behavioural and neurophysiological experiments in the rhesus monkey Macaca mulatta." The Journal of physiology 337(1): 221-240.

Capitanio, A., G. Lucci and L. Tommasi (2011). "Mixing taste illusions: the effect of miraculin on binary and trinary mixtures." Journal of Sensory Studies 26(1): 54-61.

Dzendolet, E. (1969). "Theory for the mechanism of action of “miracle fruit”." Perception & Psychophysics 6(3): 187-188.

Fox, P. C. (1985). "Xerostomia." Evaluation of a symptom with increasing significance. JAm Dent Assoc 110: 519-525.

Hirai, T., M. Sato, K. Toyooka, H.-J. Sun, M. Yano and H. Ezura (2010). "Miraculin, a taste-modifying protein is secreted into intercellular spaces in plant cells." Journal of plant physiology 167(3): 209-215.

Kurihara, K. and L. M. Beidler (1968). "Taste-modifying protein from miracle fruit." Science 161(3847): 1241-1243.

Kurihara, K. and L. M. Beidler (1969). "Mechanism of the action of taste-modifying protein." Nature 222: 1176-1179.

Misaka, T. (2013). Molecular mechanisms of the action of miraculin, a taste-modifying protein. Seminars in cell & developmental biology, Elsevier.

Nakajima, K.-i., T. Asakura, H. Oike, Y. Morita, A. Shimizu-Ibuka, T. Misaka, H. Sorimachi, S. Arai and K. Abe (2006). "Neoculin, a taste-modifying protein, is recognized by human sweet taste receptor." Neuroreport 17(12): 1241-1244.

Ngo, T. H. T. (1989). Kiểm Nghiệm Thực Phẩm Bằng Phương Pháp Cảm Quan. Nhà xuất bản Khoa Học và Kỹ thuật., Nhà xuất bản Khoa Học và Kỹ thuật.

Stone, H. and J. L. Sidel (1998). "Quantitative descriptive analysis: developments, applications and the future." Food technology (USA).

Sun, H.-J., M.-l. Cui, B. Ma and H. Ezura (2006). "Functional expression of the taste-modifying protein, miraculin, in transgenic lettuce." FEBS letters 580(2): 620-626.

Theerasilp, S., H. Hitotsuya, S. Nakajo, K. Nakaya, Y. Nakamura and Y. Kurihara (1989). "Complete amino acid sequence and structure characterization of the taste-modifying protein, miraculin." Journal of Biological Chemistry 264(12): 6655-6659.

Theerasilp, S. and Y. Kurihara (1988). "Complete purification and characterization of the taste-modifying protein, miraculin, from miracle fruit." Journal of Biological Chemistry 263(23): 11536-11539.

Tran, D. T., V. D. Vu and K. S. Ngo (2010). "Bước đầu trồng thử nghiệm và tách chiết hoạt chất miraculin trong quả cây Thần kỳ (Synsepalum dulcificum Daniell)." Tạp chí Phát triển Khoa học và Công nghệ 13(1): 48-53.

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SENSORY AROMA AND RELATED VOLATILE FLAVOR COMPOUND PROFILES OF DIFFERENT BLACK TEA GRADES (*CAMELLIA SINENSIS*) PRODUCED IN NORTHERN VIETNAM

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ABSTRACT

Relationships between the sensory aroma and the volatile composition of four black tea grades were determined. A consumer preference test on aroma was carried out by 60 consumers to assess the aroma quality of OTD black tea grades. The aroma concentrate was prepared by Brewed Extraction Method and analyzed using gas chromatography coupled with mass spectrometry. Partial Least Squares regression was used to determine the relationship between preference scores and peak area percentage data of sixty-four identified volatile compounds. Among these compounds, thirty five compounds were determined to contribute significantly to the perceived aroma quality of black teas, especially α-ionone, ethyl caprylate, 3-hydroxy-β –damascone, β-ionone, 2(4H)-benzofuranone, n-nonaldehyde, and β-farnesene, γ-ionol acetate, hexanal, benzeneacetaldehyde, and coniferyl alcohol. On the basis of these 35 compounds, a model (determination coefficient of .985 and cross-validated correlation coefficient of .943) was constructed to predict the aroma quality of OTD black tea. From the result obtained in this study, the volatile profiling by GC/MS in the combination with sensory and multivariate data analysis should be a promising tool for aroma quality prediction of black tea.

Keywords. Black teas, sensory evaluation, aroma compounds,

1. INTRODUCTION

Black tea is a fermented tea that is consumed round the world (Senthil Kumar, Murugesan *et al.*, 2013). Normally, the major quality attributes of black teas are appearance, colour, aroma, and taste (Okinda Owuor, Obanda *et al.*, 2006). Among these characteristics, aroma is an essential criterion in the evaluation of sensory scores and on the commercial description of tea (Senthil Kumar, Murugesan *et al.*, 2013). Therefore, a tea quality grade and its market price are commonly decided based on aroma and taste. Quantification of black tea quality is a difficult task because of the presence of innumerable compounds and their diverse contribution to black tea quality. Moreover, black tea quality is linked to the climate of the growing area and to the manufacturer's specification (Obanda, Okinda Owuor *et al.*, 2001, Liang, Lu *et al.*, 2003). There are two types of black tea included CTC and OTD. In the Orthodox Black Tea process, sorting is the final step for separating the different sized tea particles into even sized portions. With regard to the sorting process, there is no standard that stipulates the particle size range for each grade of tea, therefore, the traditional grade names are no more than an indication of leaf size. Orthodox black tea is usually graded on one of seven scales of quality [high-quality tea (OP - FBOP – P) and low-quality tea (P - BPS - F and/or D)]. The highest grades are referred to as "orange pekoe" and the lowest as "fannings" or "dust." Whole leaf teas are produced with little or no alteration of tea leaves and therefore, are widely considered the most valuable, whereas broken leaves are commonly sold as medium and/or low grade loose teas. Fannings and dusts usually have a darker colour, lack of sweetness, and lighter flavour when brewed. The low-quality groups of teas are marketed after being blended with high quality group categories according to demand (Senthil Kumar, Murugesan *et al.*, 2013).

Aroma analysis usually takes one of two forms, sensory or instrumental. Sensory descriptive methods used for testing have been developed that are highly reliable and consistent and obviously identify the human perception of aroma or/and flavour. Sensory analysis is the preferred method for evaluation of flavour (d'Acampora Zellner, Dugo *et al.*, 2008, Considine and Frankish, 2014). However, sensory methods are sometimes expensive to implement, time consuming when used properly, and cannot be implemented "on-line" for immediate feedback (Chambers and Koppel, 2013). Instrumental methods for examining aroma have also been developed that can provide feedback about the individual volatile compounds associated with aroma. These methods take many forms, but all are based on separation, identification, and quantification of volatiles compounds either in headspace or in the actual product matrix. These methods are particularly good at finding "errant compounds" that may result in aroma changes, and when validated, some instrumental methods can be implemented to run continually in order to provide immediate or near immediate information about products (d'Acampora Zellner, Dugo *et al.*, 2008, Chambers and Koppel, 2013, Considine and Frankish, 2014). Therefore, the development of methods that can partially replace the panel during routine work, achieving objective measurement in a short time and in a consistent and cost-effective manner is of great importance for the black tea industry. Machines could be used instead of human judges in the following scenarios: (a) a correlation between a sensory characteristic and an instrumental measurement has been established, (b) there is a possibility that the sensory test is laborious and may damage the panelists' health, and (c) the testing does not result in critical product-related decisions. The latter indicates that even if there is a proven relationship, sensory testing cannot completely be replaced by machines (Chambers and Koppel, 2013). PLS regression aims at finding the components from independent *X*-variables (or volatile profiles) that are relevant to dependent *Y*-variables (or aroma quality rankings) and predicting the quality rankings from a set of volatile profiles. Therefore, PLS is a suitable technique to describe the instrumental and sensory quality correlation (Toscas, Shaw *et al.*, 1999, Hibbert, 2009, Kirsanov, Mednova *et al.*, 2012).

In a food product development or processing control, instrumental measurements can be coupled with sensory analysis techniques to try and determine the exact volatile(s) responsible for some flavor sensations. This approach may prove helpful if certain aromatics in the product need to be enhanced or removed or there is a need to create further understanding of process-related aromatics (Chambers and Koppel, 2013). For the case of Vietnam's black tea products, there is no report about the volatile constituents of OTD black tea and their correlation with the final aroma quality of OTD black tea beverage. In addition, only a little information about the volatile profiling correlating to quality ranking or grade of OTD black tea has been available. In this study we evaluate if the final aroma quality of OTD black tea can be predicted by volatile profiling using gas chromatography mass spectrometry and sensory analysis. The volatile compounds of OTD black tea grades which has already introduced in other paper by the same authors was used for multivariate analysis (Tuan, 2013).

2. MATERIALS AND METHODS

2.1. Materials

A total of 4 different grades of OTD black tea samples (F, OP, P, BPS) were obtained from a factory at PhuTho, Vietnam. All tea samples were kept in polymer bags (200 g/bag) and stored in the dark at room temperature before analysis.

2.2. Volatile compounds analysis

Brewed Extraction Method: Twenty grams of black tea sample were brewed in 140 ml of deionized boiling water for 10 min. After filtration, the filtrate was saturated with sodium chloride and was extracted by using 100 ml of dichloromethane. The extract was dried over anhydrous sodium sulfate for 1h. After sodium sulfate was filtrated out, the solvent was removed carefully by using an evaporative concentrator. The extraction was carried out in duplicate for each sample (Kawakami, Ganguly *et al.*, 1995).

GC-MS analysis: The Thermo trace GC Ultra gas chromatograph coupled with the DSQ II mass spectrometer was used to perform the aroma analysis. An HP-5 capillary column (30 m × 0.25 mm × 0.25 μm) was equipped, with purified helium as the carrier gas, at a constant flow rate of 1 ml min-1. The oven temperature was held at 50 °C for 3 min and then increased to 190°C at a rate of 5°C min^{-1} and held at 190°C for 1 min, and then increased to 240°C at a rate 20°C min^{-1}, held at this temp for 3 min. Ion source temperature was at 200°C and spectra was produced in the electron impact (EI) mode at 70eV. The mass spectrometer was operated in the full scan, and the peak area was determined by Xcalibur software (Thermo Technologies) (Lin, Zhang *et al.*, 2013). Volatile compounds were identified by retention time, electron impact mass spectrum and similarly match index.

2.3. Consumer test

Preparation of a liquor of tea for use in consumer tests (TCVN5086-90, 1990)

Apparatus: a pot of white porcelain or glazed earthenware, with its edge partly serrated and provided with a lid, the skirt of which fits loosely inside the pot. Bowl, of white porcelain or glazed earthenware.

Test portion: Weigh, to an accuracy of ± 2 %, a mass of tea corresponding to 2 g of tea per 100 ml of liquor (i.e. 5,6 ± 0,1 g of tea for the large pot) and transfer it to the pot.

Preparation of liquor: Fill the pot containing the tea with freshly boiling water and put on the lid. Allow the tea to brew for 6 min, and then, holding the lid in place so that the infused leaf is held back, pour the liquid through the serrations into the bowl. Remove and invert the lid, transfer the infused leaf to it and place the inverted lid on the empty pot to allow the infused leaf to be inspected.

Consumer test

A consumer preference test was conducted with 60 consumers to assess the aroma quality of 04 OTD black tea grades. Consumers were recruited from Hanoi, Vietnam. Eligibility criteria included were consumption of black teas, no affiliation with a market research Company and age between 18 and 65 year. Consumers indicated their degree of liking of the products on the horizontal lines with “dislike extremely” on the left end and “like extremely” on the right end of line.

2.4. Statistical analysis

The chromatographic data were unit variance transformed before partial least square (PLS) regression analysis. PLS regression was performed by XLSTAT (Version 2013.4.06).

3. RESULTS AND DISCUSSION

Based on the volatile profiles which were analyzed by GC/MS and preference scores of 04 black tea grades (Tuan, 2013), the results of PLSR analysis identified positive and negative correlations between volatile compounds and specific sensory attributes. Among sixty-four volatile compounds, 39 compounds for which regression models with moderate to high validation coefficients were developed as listed in Table 1. In these compounds, 24 were positively correlated and the others were negatively correlated with sensory attributes (aroma quality). Among them, α-ionone (0.244), ethyl caprylate (0.239), 3-hydroxy-β–damascone (0.238), β-ionone (0.231), 2(4H)-benzofuranone (0.226), n-nonaldehyde (0.212), and β-farnesene (0.672) showed strong positive correlation with aroma scores, whereas, γ-ionol acetate (-0.212), hexanal (-0.144), benzeneacetaldehyde (-0.168), alkane (-0.163), and coniferyl alcohol (-0.155) showed strong negative correlation with aroma scores (Fig 2 and 3). β-farnesene was determined to have fruity odor. Nonanal has been characterized as aroma-active compounds contributing to floral or fruity odors in black teas such as Longjing tea. β-ionone has also been determined to have tea leaves and woody odor in teas. Deep and mild odor were given by 2(4H)-benzofuranone (Pripdeevech and Wongpornchai, 2013).

A consumer preference test was conducted with 60 consumers to assess the aroma quality of 04 OTD black tea grades, consumers were recruited from Hanoi (Vietnam); results showed that P grade was the most preferable, followed by BPS and OP grades, and the least preferable was F grade (p<.05, see Figure 1). As mentioned in standard for black teas, OP grades was graded as a higher quality product than BPS grades. The result showed that volatile compounds was disliked by consumer included 1-hexanol, coniferyl alcohol, β-linalool, γ-ionol acetate, 7,8-dihydro-3,4 dihydro -α-ionol, (Z)-

3-hexen-1-ol, hexanal, benzeneacetaldehyde, alkane, 4-hydroxy-β-ionone.

When considering the calibration sets, a good correlation between volatile profiles and sensory quality ranking could be achieved as observed from a good determination coefficient (R^2) of .985. The error rate of predictability of calibration model could be expressed from a term of root mean square error of estimation (RMSE), which was found equal to .021. These errors counted for less than 5%, indicating a reliable calibration model. The good correlation of the reliable calibration model suggested that the complexity of sensory perception could be related directly to the volatile profiles by means of multivariate analysis. The low RMSE values of this model suggested that volatile profiles obtained from instrument methods provided sufficient correlation information to the sensory quality ranking.

Furthermore, compounds with high relevance for explaining dependent *Y*-variables were also identified from variable importance in the projection values (VIP). Large VIP values, more than 1, are the most relevant for explaining the quality rankings of black tea and the compounds with VIP values greater than 0.8 were presented in Table 2. It was found that key compounds contributing in creating the quality predictive model were composed of various aroma compounds.

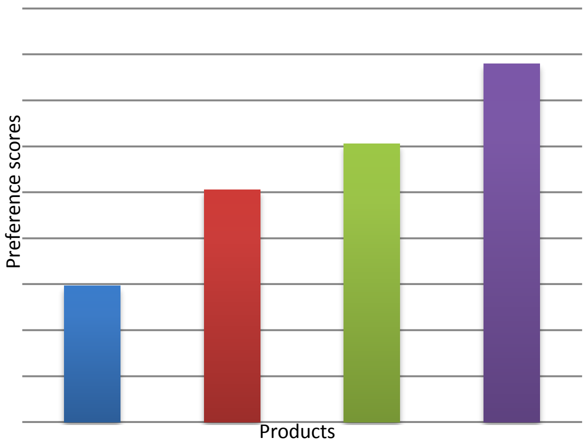

Figure 1. Preference scores and products

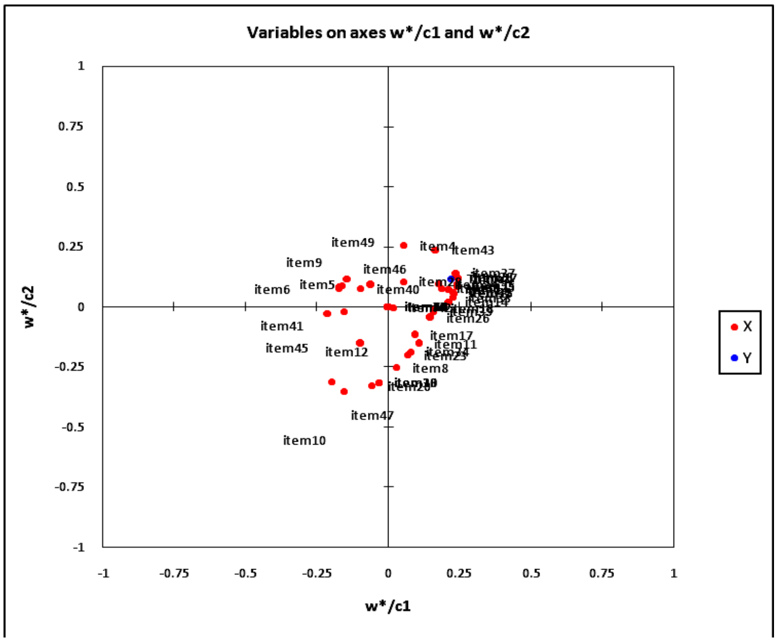

Figure 2. Consumer preference (*Y*) and volatile compounds (*X*) of Black tea grade

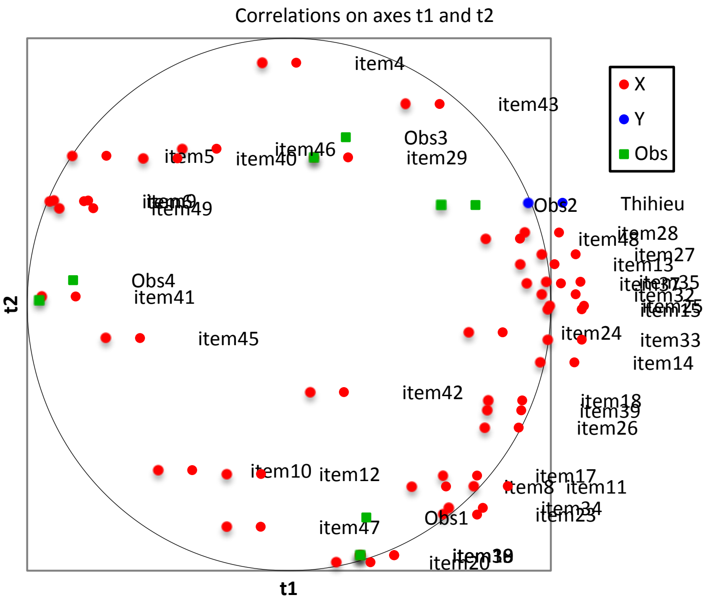

Figure 3. The correlations map on t_1 and t_2 of products (obs), volatile compounds (X) and consumer preference (Y)

Table 1. Correlation matrix of the variables (Correlation matrix of W)

Item	Variables	w*1	w*2	Item	Variables	w*1	w*2
1	3-methyl-butanal	0.000	0.000	33	phenol, p-propoxy	0.225	0.039
2	(E)-2-pentenal	0.000	0.000	34	nerodidol	0.076	-0.187
3	2-methyl-2-pentenal	0.000	0.000	35	imidazole, 1-methyl-5-nitro	0.239	0.089
4	(Z)-2-penten-1-ol	0.053	0.254	36	hexadecane	0.000	0.000
5	hexanal	-0.144	0.117	37	3-hydroxy-β -damascone	0.238	0.141
6	(Z)-3-hexen-1-ol	-0.175	0.074	38	unknown	-0.035	-0.316
7	(E)-2-hexenal	0.000	0.000	39	2-undecen-4-ol	0.158	-0.020
8	caproic acid	0.027	-0.253	40	4-hydroxy-□-ionone	-0.098	0.074
9	benzeneacetaldehyde	-0.168	0.084	41	γ-ionol acetate	-0.212	-0.028
10	1-hexanol	-0.200	-0.312	42	unknown	0.016	-0.004
11	linalool oxide-trans	0.107	-0.154	43	unknown	0.166	0.237
12	β-linalool	-0.096	-0.154	44	heptadecane	0.000	0.000
13	n-nonaldehyde	0.212	0.073	45	7,8-dihydro-3,4 dihydro -□-ionol	-0.157	-0.022
14	benzyl alcohol	0.213	0.020	46	unknown	-0.061	0.090
15	succinimide, N-ethyl	0.230	0.056	47	coniferyl alcohol	-0.155	-0.352
16	1,2-dimethoxy-bezen	0.000	0.000	48	loliolide	0.185	0.077
17	linalool oxide(pyranoid)	0.092	-0.118	49	alkane	-0.163	0.087
18	safranal	0.163	-0.005	50	unknow	0.000	0.000
19	β-cyclocitral	-0.035	-0.316	51	farnesyl acetaldehyde	0.000	0.000
20	cis-geraniol	-0.058	-0.329	52	hexahydrofarnesylacetone	0.000	0.000
21	unknown	0.000	0.000	53	unknown	0.000	0.000
22	keto-Isophorone	0.000	0.000	54	unknown	0.000	0.000
23	α-ionol	0.068	-0.201	55	farnesyl acetone	0.000	0.000
24	β-damascenone	0.176	0.095	56	methyl palmitate	0.000	0.000
25	ethyl caprylate	0.239	0.083	57	unknown	0.000	0.000
26	T-neoclovene	0.147	-0.046	58	unknown	0.000	0.000
27	α-ionone	0.244	0.120	59	methyl oleate	0.000	0.000
28	β-ionone	0.231	0.125	60	methyl linoleate	0.000	0.000
29	unknown	0.052	0.105	61	phytol	0.000	0.000
30	α-farnesene	-0.035	-0.316	62	unknown	0.000	0.000
31	U-muurolene	0.000	0.000	63	unknown	0.000	0.000
32	2(4H)-benzofuranone	0.226	0.061	64	unknown	0.000	0.000

After eliminating the VIP, with values < .8, a simplified model of favorable products was obtained (see, Eq.1):

$Y = 0.041\text{item}4 - 0.018\text{item}5 - 0.03\text{item}6 - 0.023\text{item}8 - 0.027\text{item}9 - 0.08\text{item}10 + 0.005\text{item}11 - 0.039\text{item}12 + 0.055\text{item}13 + 0.049\text{item}14 + 0.057\text{item}15 + 0.006\text{item}17 + 0.035\text{item}18 - 0.044\text{item}19 - 0.051\text{item}20 - 0.008\text{item}23 + 0.049\text{item}24 + 0.062\text{item}25 + 0.027\text{item}26 + 0.067\text{item}27 + 0.065\text{item}28 - 0.044\text{item}30 + 0.056\text{item}32 + 0.054\text{item}33 - 0.005\text{item}34 + 0.062\text{item}35 + 0.068\text{item}37 - 0.044\text{item}38 + 0.032\text{item}39 - 0.05\text{item}41 + 0.064\text{item}43 - 0.037\text{item}45 - 0.075\text{item}47 + 0.049\text{item}48 - 0.026\text{item}49$ (Eq.1).

The Equation of the model of favorable products showed that thirty-five volatile compounds could significantly affect the sensory quality ranking of black teas. From these, nineteen compounds increase the aroma quality of black tea while sixteen compounds decrease the aroma quality of black tea. This result could be used as scientific evidence for the engineers and managers at black tea factories to operate the tea processing and decide how to get a better aroma product by changing or controlling the technology parameters to increase or decrease some volatile compounds.

4. CONCLUSION

Thirty five compounds were determined to contribute significantly to the perceived aroma quality of black teas, especially α-ionone, ethyl caprylate, 3-hydroxy-β –damascone, β-ionone, 2(4H)-benzofuranone, n-nonaldehyde, and β-farnesene, γ-ionol acetate, hexanal, benzeneacetaldehyde, and coniferyl alcohol (determination coefficient of .985 and cross-validated correlation coefficient of .943). On the basis of these 35 compounds, a model (determination coefficient of 0.985 and cross-validated correlation coefficient of 0.943) was constructed to predict the aroma quality of OTD black tea. From the results obtained in this study, the volatile profiling by GC/MS in the combination with sensory and multivariate data analysis should be a promising tool for aroma quality prediction of black tea. To the best of our knowledge, this is the first report using GC-MS coupled with sensory analysis techniques in aroma quality prediction of OTD black tea. Further investigation is needed in order to carry out study to all seven scales of quality of OTD black teas to improve the prediction model.

Table 2. Key compounds contributing to the construction of predictive model using volatile profiles obtained from GC/MS

Items	Variable	VIP
item27	α-ionone	1.805
item25	ethyl caprylate	1.769
item37	3-hydroxy-β -damascone	1.766
item35	imidazole, 1-methyl-5-nitro	1.763
item28	β-ionone	1.715
item15	succinimide, N-ethyl	1.697
item32	2(4H)-benzofuranone	1.671
item33	phenol, p-propoxy	1.662
item10	1-hexanol	1.659
item14	benzyl alcohol	1.580
item13	n-nonaldehyde	1.568
item41	γ-ionol acetate	1.568
item47	coniferyl alcohol	1.473
item48	loliolide	1.368
item6	(Z)-3-hexen-1-ol	1.351
item43	unknown	1.349
item9	benzeneacetaldehyde	1.314
item24	β-damascenone	1.305
item49	alkane	1.280
item18	safranal	1.216
item39	2-undecen-4-ol	1.184
item5	hexanal	1.175
item45	7,8-dihydro-3,4 dihydro -a-ionol	1.162
item26	T-neoclovene	1.127
item20	cis-geraniol	1.045
item11	linalool oxide-trans	0.979
item19	β-cyclocitral	0.971
item30	α-farnesene	0.971
item38	unknown	0.971
item34	nerodidol	0.863
item23	α-ionol	0.848
item8	caproic acid	0.828
item4	(Z)-2-penten-1-ol	0.827
item17	linalool oxide(pyranoid)	0.818
item12	β-linalool	0.806

REFERENCES

Chambers, E. and K. Koppel (2013). "Associations of volatile compounds with sensory aroma and flavor: The complex nature of flavor." Molecules 18(5): 4887-4905.

Considine, J. A. and E. Frankish (2014). Chapter 2 - Flavors and Aromas in Foods and Beverages. A Complete Guide to Quality in Small-Scale Wine Making. J. A. Considine and E. Frankish. San Diego, Academic Press: 11-21.

d'Acampora Zellner, B., P. Dugo, G. Dugo and L. Mondello (2008). "Gas chromatography–olfactometry in food flavour analysis." Journal of Chromatography A 1186(1): 123-143.

Hibbert, B. (2009). "Chemometric analysis of sensory data." Comprehensive Chemometrics. Chemical and biochemical data analysis. Amsterdam: Elsevier. p: 377-324.

Kawakami, M., S. N. Ganguly, J. Banerjee and A. Kobayashi (1995). "Aroma composition of oolong tea and black tea by brewed extraction method and characterizing compounds of Darjeeling tea aroma." Journal of Agricultural and Food Chemistry 43(1): 200-207.

Kirsanov, D., O. Mednova, V. Vietoris, P. A. Kilmartin and A. Legin (2012). "Towards reliable estimation of an “electronic tongue” predictive ability from PLS regression models in wine analysis." Talanta 90: 109-116.

Liang, Y., J. Lu, L. Zhang, S. Wu and Y. Wu (2003). "Estimation of black tea quality by analysis of chemical composition and colour difference of tea infusions." Food chemistry 80(2): 283-290.

Lin, J., P. Zhang, Z. Pan, H. Xu, Y. Luo and X. Wang (2013). "Discrimination of oolong tea (*Camellia sinensis*) varieties based on feature extraction and selection from aromatic profiles analysed by HS-SPME/GC–MS." Food chemistry 141(1): 259-265.

Obanda, M., P. Okinda Owuor and R. Mang'oka (2001). "Changes in the chemical and sensory quality parameters of black tea due to variations of fermentation time and temperature." Food chemistry 75(4): 395-404.

Okinda Owuor, P., M. Obanda, H. E. Nyirenda, N. I. Mphangwe, L. P. Wright and Z. Apostolides (2006). "The relationship between some chemical parameters and sensory evaluations for plain black tea (*Camellia sinensis*) produced in Kenya and comparison with similar teas from Malawi and South Africa." Food chemistry 97(4): 644-653.

Pripdeevech, P. and S. Wongpornchai (2013). Chapter 26 - Odor and Flavor Volatiles of Different Types of Tea. Tea in Health and Disease Prevention. V. R. Preedy, Academic Press: 307-322.

Senthil Kumar, R. S., S. Murugesan, G. Kottur and D. Gyamfi (2013). Chapter 4 - Black Tea: The Plants, Processing/Manufacturing and Production. Tea in Health and Disease Prevention. V. R. Preedy, Academic Press: 41-57.

TCVN5086-90 (1990). Tea-Preparation of liquor for use in sensory tests.

Toscas, P., F. Shaw and S. Beilken (1999). "Partial least squares (PLS) regression for the analysis of instrument measurements and sensory meat quality data." Meat science 52(2): 173-178.

Tuan, H. Q. (2013). "Characterization of volatile components of orthodox black tea grades (*Camellia sinensis*) by gas chromatography-mass spectrometry." Tap Chi Khoa Hoc va Cong Nghe 51: 6.

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