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TASTE AND TRY BEFORE YOU FRY:
FROM PRODUCT FORMULATION TO CONSUMER EXPERIENCE

PROCEEDINGS BOOK

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SUMMER PROGRAM IN SENSORY EVALUATION

Taste and Try before You Fry:

From Product Formulation to Consumer Experience

Edited by

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FOREWORD

Spise2016: "Taste and Try before you Fry: From product formulation to consumer experience," the fifth symposium on sensory evaluation in Asia, was held on July 29–31, 2016 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, Mexico, and France. The focus of this year was on product formulation. This topic is particularly timely because there is widespread agreement in the food and beverage sector that competitiveness in food markets depends upon the development of new and well differentiated products that are adapted to the different and specific preferences of consumers or consumer segments. To do so, the formulation of successful products needs to carefully integrate the physical and sensory properties of raw and processed materials as well as their—sometimes complex—interactions.

Product formulation 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 (part I) present some applications of design of experiments and sensory evaluation for product development. Consumer oriented chapters (part II) focus on different food choice determinants including product nutritional or environmental quality and individual factors such as culture or familiarity.

We would like to use this opportunity to express our gratitude to our keynote speakers, Dr. Paula Valera and Dr. Olivier Wathelet and to our invited speakers, Dr. Hajime Nagai, Pr. Hervé Abdi, and Dr. Youngkyung Kim. Our special thanks are due to our partners who participated to the organization of this meeting: the HCMC University of Technology, AgroSup Dijon, "Université de Bourgogne Franche-Comté", CSGA, AgroCampus-Ouest, ISA, and "Université Catholique de Lille."

We extend our special thanks to those who have helped us so much and worked so hard to make this event possible: Tran Que Khanh, Cao Hoang Bao Tran, Nguyen Quang Phong, Vu Thi Thanh Phuong, Nguyen Thi Minh, Tran Thi Hong Cam, Nguyen Ba Thanh, Nguyen Thi Thu Ha, Phan Thuy Xuan Uyen.

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REDUCING SALT IN INSTANT RICE PORRIDGE

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ABSTRACT

In recent years, consuming high amount of sodium has been considered as one of the main reasons leading to chronic diseases such as cardiovascular disease, renal failure, and stomach cancer. Hence, reducing and replacing sodium in daily products, particularly in instant products, will contribute to the prevention of these diseases. The aim of the present study was to evaluate consumer preferences for salt, to find the best ratio of salt replacers, and to propose strategies to effectively reduce sodium without negatively affecting the sensory properties of instant rice porridge. The study included two experiments, a consumer acceptance test and an optimization experiment, which were undertaken at the Faculty of Agro-Industry, Chiang Mai University, Thailand.

In the first experience, a total of 60 volunteer panelists assessed the taste acceptability of four instant rice porridges: W1 (traditional), W2 (30 % salt reduced), W3 (30% salt reduced and 25% KCl replaced), W4 (30% salt reduced and 25% KCl combine Glycine replaced) by using a nine-point hedonic scale and a Just About Right (JAR) scale. The second experiment aimed to optimize the concentration of potassium chloride. We tested ratios of 25%, 40%, 50% of KCl replacing. The statistical analyses indicated that the sensory attributes of the regular salt porridge (W1) and the reduced salt porridge (W2) were significantly different ($p < 0.05$), however, no difference between product W1 and W3 were observed ($p > 0.05$). In addition, the results of the second experience showed a significant difference between the three treatments ($p < 0.05$). The product in which 25% of NaCl was replaced by KCl was accepted by most panelists. Finally, Potassium Chloride is the best solution to replace sodium chloride with a substitution ratio of 25%.

Keywords: *reducing salt, potassium chloride, sodium chloride, glycine, instant rice porridge.*

1. INTRODUCTION

Common salt or sodium salt (NaCl) is an ingredient used in various kind of products since ancient time till nowadays. Sodium is found naturally in a variety of foods, including milk and cream (approximately 50 mg of sodium per 100 g), eggs (approximately 80 mg/100 g) and is used in much higher quantities in manufactured foods such as bread (approximately 250 mg/100 g), processed meats like bacon (approximately 1,500 mg/100 g), snack foods such as pretzels, cheese puffs and popcorn (approximately 1,500 mg/100 g), as well as in condiments such as soy sauce (approximately 7,000 mg/100 g), and bouillon or stock cubes (approximately 20,000 mg/100 g) (WHO, 2013). Salt is considered in medical textbooks as the major reason leading to severe diseases like cardiovascular diseases (CVD), high blood pressure, renal failure (Midgely, 1996; Kilcast & Angus, 2007; Kilcast & Ridder, 2007). Consuming high amount of sodium (> 2300mg/day) can have detrimental effects on health (Consensus Action on Salt and Health, 2009) and so salt reduction in food products is a critical issue (Ruusunen & Puolanne, 2005; Desmond, 2006).

There are different ways to reduce sodium in food such as: reducing salt gradually, adding taste enhancer, or using finer salt. One popular method is to replace salt by other ingredients (CTAC, 2009). This was applied in our study: We reduced sodium and replaced the remaining sodium by potassium and glycine.

Until now, potassium chloride is the most common substitute of salt in food (Renqvist, 1919; McBurney & Lucas, 1966; Dzendolet & Meiselman, 1967; Frank & Michelsen, 1970; Murphy *et al.*, 1981; Klaauw & Smith, 1995; Rosett *et al.*, 1995, David Kilcast & Fiona Angus, 2003). Potassium chloride can

bring salty taste like sodium salt, however using potassium chloride brings some off-tastes like bitterness, metallic taste and aftertaste. Previous work investigated a combination of potassium chloride and glycine (Gou *et al.*, 1996) in fermented sausages and dry cured loins. Results indicated that glycine decreases the perception of salt and tart tastes (Gou *et al.*, 1996; Gelabert *et al.*, 2003). More recent work uses them successfully in other food products (Gelabert *et al.*, 2003; CTAC, 2009).

In our study, we reduced sodium in instant rice porridge, a popular food in Thailand, Vietnam, and Asian countries. This study aims to evaluate consumer preferences for salt as well as to optimize the methods and strategies to effectively reduce sodium without negatively affecting consumer acceptability. The end goal of this work is to develop and produce healthy food products which fulfill the demand of consumers.

2. EXPERIMENT 1: SELECTION REDUCED-SODIUM FORMULAS IN INSTANT RICE PORRIDGE SAMPLE PRODUCT

2.1. Objective

This first experiment was set to suggest the best solution to reduce sodium ingredients in instant rice porridge.

2.2. Material and methods

2.2.1. Material

The instant porridge rice formula included dried rice, dried pork, shallot, sodium chloride, monosodium glutamate, etc. All samples were prepared and mixed at the laboratory following the procedure used for commercial instant rice porridge (rice, pepper, sugar, sodium, etc).

This procedure provided four kinds of instant rice porridge coded as W1, W2, W3 and W4. W1 is the control sample (traditional commercial product), W2 was obtained by reducing 30% of sodium, W3 by reducing 30% of sodium and replacing 25% of the remaining sodium by Potassium Chloride (KCl), and W4 by reducing 30% of sodium and replacing 25% of the remaining sodium by a combination of KCl and Glycine.

2.2.2. Participants

The consumer panel comprised 60 volunteer panelists (aged between 18 to 40 years) who were staff and students at the Faculty of Agro-Industry, Chiang Mai University, Thailand. All participants were untrained.

2.2.3. Methods

All samples were prepared and mixed at laboratory with the main ingredients is the same as the commercial instant rice porridge (rice, pepper, sugar, sodium, etc.).

This procedure provided four kinds of instant rice porridge were coded as W1, W2, W3 and W4. We compared four formulas W1, W2, W3, and W4. In which W1 is the control sample (traditional product, commercial product), W2 is the product which was reduced 30% sodium in total, W3 was reduced 30% sodium in total and 25% Potassium Chloride (KCl) replaced, in formulas W4, we reduced 30% sodium in total and 25% KCl combine Glycine replaced.

2.3. Sensory evaluation

Each panelist was served with about 47 grams of each sample in a small clear plastic cup with 60 mm diameter which was labeled with a random code. The panelists were asked to evaluate each sample based on overall and saltiness liking using a nine-point hedonic scale (1 = Dislike extremely; 5 = Neither like or dislike and 9 = Like extremely) (Peryam & Girardot, 1952; Peryam & Pilgrim, 1957) and a Just About Right scale (1 = No salty enough; 5 = Too salty). Water was provided for mouth rinsing between samples.

2.4. Physicochemical properties

All the samples of instant rice porridges were investigated for physicochemical properties including moisture content (MC), water activity (a_w). The color parameter L* (lightness), a* (red-green axis), and b* (yellow-blue axis) were determined by using Tristimulus Minolta Chroma meter (Konica Minolta Corp, model CR-400).

2.5. Statistical analysis

All sensory, physical and chemical data were analyzed using one-way analyses of variance (ANOVA) (SPSS software model 16.0) and by Duncan's multiple range test (DMRT). A significant level of $\alpha = 0.05$ was used throughout the study.

2.6. Results and discussion

The average liking scores obtained for the four kinds of instant rice porridge are shown Table 1. A significant difference in saltiness and overall liking

was observed between the traditional product (W1) and the reduced sodium salt instant rice porridge products (W2, W3, W4).

Table 1. Liking score of four instant rice porridge. Means in same row with different letters are significantly different ($p \leq 0.05$).

Parameters	W1	W2	W3	W4	*p*
Saltiness	6.9±1.2a	6.0±1.5b	6.6±1.4a	6.0±1.5b	0.001
Overall	7.1±1.0a	6.2±1.4b	6.7±1.4a	6.6±1.3ab	0.005

Both ANOVAs showed significant effects of saltiness liking and overall liking ($F = 5.52$, $p < 0.001$ for saltiness; $F = 4.37$, $p < 0.005$ for overall linking).

The sensory acceptability scores for saltiness liking of W1 and W2 were significantly different ($p < 0.001$) thus revealing a difference in perceived saltiness between these samples. However, there was no significant difference in saltiness liking between W1 and W3. These two samples have similar perceived saltiness. Therefore, potassium chloride could be used to substitute the sodium salt in instant rice porridge.

Table 2 shows the Just About Right scale results. W1 was most familiar to consumers and the saltiness of this sample was just about right for 70% of panelists. In contrast the saltiness of the three other samples should be increased.

Table 3 shows the physicochemical properties of all samples. There was no significant difference ($p > 0.05$) in all samples about color parameter: Potassium chloride and glycine did not affect the color of the samples.

The moisture content of the instant rice porridges increased significantly from W1 (6.53 ± 0.1), to W3 (7.38 ± 0.11) and W4 (6.83 ± 0.08) but decreased slightly for W2 (6.42 ± 0.09). The amount of salt in the products affected their moisture content. Potassium chloride had the highest effect.

The water activity of the four instant rice porridges was significantly different ($F = 16.46$, $p < 0.001$). The water activity of W3 was the highest whilst that of W2 was the lowest. This may be due to the fact that the water activity depends on the amount of sodium salt and potassium chloride in the products.

3. EXPERIMENT 2: OPTIMIZATION OF THE AMOUNT OF POTASSIUM CHLORIDE (KCL) TO REPLACE SODIUM CHLORIDE (NACL) IN INSTANT RICE PORRIDGE

3.1. Objective

The second experiment was set to optimize the proportion of potassium chloride (KCl) to replace sodium salt (NaCl) in Instant Rice Porridge.

3.2. Material and methods

Based on the results of experiment 1 we selected sample W3 (in which KCL was used to replace 25% of sodium) as a basis for experiment 2. Three kinds of instant rice porridge with different concentration of KCL were used: 25% KCl, 40% KCl and 50% KCl. All steps in experiment 2 were performed like in experiment 1.

Both ANOVAs showed significant effects of saltiness liking and overall liking ($F = 3.57$, $p < 0.05$ for saltiness; $F = 3.05$, $p < 0.05$ for overall linking).

Table 2. Result of Just About Right Scale about saltiness. The net effect can be calculated: minus of total increase scores and total decrease scores.

Types of instant rice porridge	Decrease it very much (%)	Decrease it slightly (%)	Just About Right (%)	Increase it slightly (%)	Increase it very much (%)	Net effect
W1	1.7	8.3	70	20	0	-
W2	0	10	28.33	36.67	25	51.67
W3	0	6.67	56.67	31.66	5	29.99
W4	0	8.33	0.01	43.33	18.33	53.33

Table 3. Physicochemical properties of four kinds samples of instant rice porridge. NS: no significant difference.

Parameter	W1	W2	W3	W4	*p*
L	81.21±2.5	76.65±1.5	78.77±1.7	77.67±2.6	NS
a*	-0.66±0.31	-0.95±0.28	-0.74±0.09	-0.9±0.2	NS
b*	13.26±0.62	12.05±0.3	12.65±0.29	12.7±0.6	NS
Water activity (a_w)	0.49±0.02	0.45±0.01	0.54±0.02	0.47±0.01	0.001
Moisture content (%)	6.53±0.1	6.42±0.09	7.38±0.11	6.83±0.08	0.000

Table 4. Liking score of instant rice porridge. Means in same row with different letters are significantly different ($p \leq 0.05$).

Parameters	25% KCL	40% KCL	50% KCL	*p*
Saltiness liking	6.5±1.2[a]	6.1±1.4[ab]	6.0±0.1[b]	0.05
Overall liking	6.7±1.3[a]	6.4±1.3[ab]	6.1±1.2[b]	0.03

Table 5. Result of Just About Right Scale about saltiness. The net effect is calculated as the total of increased scores minus the total of decreased scores

Types of instant rice porridge	Decrease it very much	Decrease it slightly	Just About Right	Increase it slightly	Increase it very much	Net effect
25% KCL	0	5.00	68.33	21.67	5.00	21.67
40%KCL	0	6.67	60.00	30.00	5.00	23.33
50%KCL	0	1.60	48.33	36.67	13.33	48.4

The explanation is that potassium chloride does not increase sufficiently the saltiness of product; this is a reason why panelists feel that the products are tasteless when they taste the samples with 40% KCl and 50% KCl. Another reason is that consumers had the habit of using products with high sodium salt content. Therefore, the samples with 40% KCl and 50% KCl were not preferred by consumers.

Table 5 shows the JAR scale results. The sample with 25% KCl was most accepted by consumers and the saltiness of this sample on JAR scale was more than 68%. It means that when we increased the amount of KCl in the sample, the proportion of not salty enough response was increased.

4. CONCLUSION

No significant difference between traditional instant rice porridge and reduced sodium salt in instant rice porridge products was observed. Potassium chloride has been proposed as a good substitute for NaCl. A salt proportion between NaCl:KCl (75:25) has potential to develop sodium reduced products. With other salt proportions of NaCl:KCl (60:40, 50:50) instant rice porridge was perceived as not salty enough and was not preferred by consumers. Despite the popularly of using glycine in some kinds of food, in this experiment, replacing sodium by glycine was not accepted by most consumers. This study has strength but also some limitations. We recommend that one approach to reducing salt in the food system would be the development of salt substitutes with the same sensory properties as salt but without sodium.

REFERENCES

Consensus Action on Salt and Health (2009) Salt and Health. Retrieved from http://www.actiononsalt.org.uk.

CTAC (2009). Reformulation of products to reduce sodium: Salt Reduction guide for the Food Industry. Retrieved from http://www.worldactiononsalt. com/docs/world/78296.pdf.

Kilcast, D. & Angus, F. (2007). Reducing Salt in Foods, Woodhead Publishing/CRCpress, Boca Raton, USA, pp. 77-98.

Kilcast, D. & Ridder, D. (2007). Sensory issues in reducing salt in food products. In D. Kilcast & F. Angus (Eds.) Reducing Salt in Foods, Woodhead Publishing/CRCpress, Boca Raton, USA. pp. 201-220.

Dzendolet, E. & Meiselman, H. L. (1967). Gustatory quality changes as a function of solution concentration. *Perception & Psychophysics*, 2, 29-33.

Desmond, E. (2006). Reducing salt: A challenge for the meat industry. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/22062728

Frank, R. L. & Michelsen, O. (1970). Sodium-potassium chloride mixtures as table salt. Third Symposium on Salt, 2, 135-139.

Gelabert, J., Gou, P., Guerrero, L., & Arnau, J. (2003). Effect of sodium chloride replacement on some characteristics of fermented sausages. *Meat Science*, 65, 833-839.

Gou, P., Guerrero, L., Gelabert, J, & Arnau, J. (1996). Potassium chloride, potassium lactate and glycine as sodium chloride substitutes in fermented sausages and in dry-cured pork loin. *Meat Science*, 42, 37-48.

Klaauw, N. J. & Smith, D. V. (1995). Taste quality profiles for fifteen organic and inorganic salts. *Physiology & Behavior*, 58, 295-306.

Mcburney, D. H. & Lucas, J. A. (1966). Gustatory cross adaptation between salts. *Psychonomic Science, 4, 301-302.*

Midgely, J. P. (1996) Effect of reduced dietary sodium on blood pressure: a meta-analysis of randomized controlled trials. Journal of the American Medical Association 1996. Retrieved from: http://www .ncbi.nlm.nih.gov/sites/entrez.

Murphy, C., Cardello, A. V., & Brand, J. G. (1981). Tastes of fifteen halide salts following water and NaCl: Anion and cation effects. *Physiology & Behavior*, 26, 1083-1095.

Renqvist, Y. (1919). Uber den Geschmack. Skandinavisches Archiv fuÈr Physiologie, 38, 97-201.

Rosett, T. R., Wu, Z., Schmidt, S. J., Ennis, D. M. & Klein, B. P. (1995). KCl, CaCl2, Na+, and salt taste of gum systems. *Journal of Food Science*, 60, 849-867.

Ruusenen, M. & Puolanne, E. (2005). Reducing sodium intake from meat products. *Meat Science*. 70, 531-541.

Peryam, D. R. & Girardot, N. F. (1952). Advanced taste test method. *Food Engineering*, 24, 58-61.

Peryam D. R. & Pilgrim F. J. (1957). Hedonic scale method of measuring food preference. *Food Technology*, 11, 9–14.

World Health Organization (WHO). Jan 31, 2013. WHO issues new guidance on dietary salt and potassium. Retrieved from http://www.who.int/mediacentre/news/notes/2013/salt_potassium_20130131/en/

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POTENTIAL FOR APPLE CIDER PRODUCTION FROM APPLE CULTIVARS GROWN IN ESTONIA AND FINLAND ACCORDING TO SENSORY AND CHEMICAL PROPERTIES

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ABSTRACT

The objective of this study was to evaluate cider production potential of selected apple cultivars based on their sensory and chemical properties. Twenty-four apple cultivars originating from Estonia and Finland were analyzed. Descriptive sensory analysis and chemical analysis of sugars, malic acid and tannins contents were used to evaluate cider production potential. The sensory attributes that differentiated the cultivars were sweet aroma, overall flavor intensity, sweet, sour, astringent, bitter, and fruity flavor. The results showed flavor clusters of the cultivars. Chemical analysis showed that due to high malic acid content, all analyzed cultivars were classified as "sharp" or "bittersharp". Therefore there may be a need for malolactic cider fermentation in this region when using local cultivars. Data from sensory analysis combined with results from chemical analysis were used to identify those cultivars with the greatest potential for cider production. Five cultivars (Antei, Chestnut, Kulikovskoje, Melba and Talvikaneli) were selected as potential cultivars for cider production. This paper proposes that the ideal cider apples were region-specific. Parameters and recommendations for Northern part of Eastern Europe region "Ideal cider apple" were presented.

Keywords: *apples, cider, sensory analysis.*

1. INTRODUCTION

Apples are one of the most common and well known fruits in the world. According to the Food and Agriculture Organization (FAO), the production of apples has shown constant growth during the last decade. The annual production of apples in year 2011 reached over 75 million tons (FAO, 2014). Although production is increasing, the dominating countries in production remain the same. This means that in many countries local apple cultivars have to compete with cultivars imported mainly from China, USA, India, Turkey, and Poland (FAO, 2014). This is also the case in Northern Europe. Therefore many orchard owners have problems marketing their local products. Apple cider production is a possibility for apple growers to add value to their products and also market their products without having to compete with imported cultivars. Also, as texture is an important driver of consumer acceptance for fresh apples (Seppä *et al.* 2012) and texture changes during storage, cider production can help growers overcome problems associated with storage after harvest.

Cider is generally regarded as a beverage made from apples. In North-America, the term "cider" generally refers to cloudy unpasteurized apple juice and the term "hard cider" is used for a fermented product. In Europe, however, the term "cider" refers to the fermented product, an alcoholic beverage with an alcohol content between 1.2%-8.5% v/v (Lea & Piggott, 2003). The United Kingdom has the largest market of cider and perry – 940 million liters in 2010. This is 55% of the total world market of cider and perry. The United Kingdom is followed by South Africa (13%), France (6%), Spain (5%) and Germany

(5%) (Mitchell, 2012). In this study the term "cider" refers to a fermented alcoholic beverage.

The classical Barker's Classification of Cider Apples (Lea & Piggott, 2003) has been used to cluster apple cultivars according to their chemical properties. This classification is based on two chemical parameters, malic acid content and tannins content. According to this classification all cultivars are divided into four groups: sharp, bittersharp, bittersweet, and sweet (Lea & Piggott, 2003).

Descriptive sensory analysis is referred to as one of the most comprehensive, flexible and useful methods to provide an objective description of sensory perception, in both qualitative and quantitative terms (Murray, Delahunty, & Baxter, 2001). A major strength of descriptive analysis is its ability to allow relationships between descriptive sensory and instrumental or consumer preference measurements to be determined (Murray, Delahunty, & Baxter, 2001). For biological samples, such as apples, variability exists within each cultivar and even within each fruit. Descriptive sensory analysis has been found suitable for objective measurement of fruit quality (Seppä *et al.* 2012; Bavay *et al.* 2013). High variability is usually overcome with sufficient replicates (Seppä *et al.* 2012); however, detailed instructions for the assessment, use of an extensive lexicon and experienced panel members are likewise important factors. Also, as this research is mainly focused on finding potential raw materials for natural apple cider production, variability of apples within a batch is overcome by using a preparation of combined juices from apples in the batch.

Recent studies about apple and apple juice sensory characteristics have mainly focused on sensory parameters that can be used in horticultural or marketing, and also for public if simplified (Seppä *et al.* 2012; Aprea *et al.* 2012; Seppä, 2014). But it would be also necessary to examine the suitability of different local apple cultivars for different products, *e.g.* jams, juices, cider etc. in order to increase usage of local raw material, revitalize the countryside and create new rural jobs (Lento, Pirttijärvi & Hasu, 2010). A closer look at the chemical composition of the raw materials in comparison with the end products could also contribute new perspective to usage of variety of local cultivars. Studies focused on apple cider have concentrated on the different: ripening stages (Braga *et al.* 2013), yeast types (Blanco-Gomis *et al.* 2009; Valles *et al.* 2005; Valles *et al.* 2008), fermentation conditions (Herrero, Garcia, & Diaz, 2006; Kelkar & Dolan, 2012) and apple cultivars (Braga *et al.* 2013; Abrodo *et al.* 2010; Wilson *et al.* 2003). However, recent studies have been using well known cultivars (*e.g.*, Fuji, Golden, Lisgala, Crispin, McIntosh) for cider production. In this study, apple cultivars from other geographic regions that are not so well known have been studied. The aim of this study was to determine which apple cultivars in Estonia and Finland show the greatest potential for cider production, based on sensory and chemical properties of apple juice. It is important to highlight that in this study the decision about the potential for cider production was made only by evaluation of chemical and sensory properties of apple juice. Even though it is well known that during fermentation remarkable changes happen to apple juice flavor (Lean & Piggott, 2003; Lento, Pirttijärvi & Hasu, 2010; Braga *et al.* 2013; Valles *et al.* 2005; Herrero, Garcia & Diaz, 2006; Abrodo *et al.* 2010), the traditions for cider production in the region under investigation are too young. Hence, the preselection of suitable cultivar is often made by apple cider producer by sensory analysis of apple juice. Sometimes information about the total amount of sugars and acids is included if possible. The cultivars included in the study were selected according to interest of two orchards providing the samples. No preselection was made according to any criteria before the study.

2. MATERIALS AND METHODS

2.1. Samples

A total of 24 apple cultivars were analyzed in this study, 14 were harvested from Estonia and 10 from Finland (Table 1). Dessert and processing cultivars, as well as summer, autumn and winter cultivars were included in the study. One cultivar was represented from both countries ("Tobias.E" – sample from Estonia; "Tobias.F" – sample from Finland).

The apples were harvested in 2011 during September and October. Samples of at least 3 kg of each cultivar were brought to the laboratory when the apples had reached commercial ripeness. Estimation of ripeness was made using the iodine starch test in a laboratory setting (Travers *et al.* 2012).

2.2. Sample Preparation

All of the apples were washed with tap water and dried of excess surface water before pressing the apple for juice. Apples with remarkable quality defects (rotting, molding etc.) were excluded, but no selection was made according to appearance of the apple, *e.g.* size, color, etc.

The apple juice was prepared with a Vita Pro-Active JE810 Juice Extractor (Kenwood, Havant, United Kingdom). At least 1.5 L of apple juice of each cultivar was prepared. The juice was then drained using a test sieve (250 µm, 200mm x 50 mm, Retsch Test Sieve ISO-3310-1, Nettetal, Germany). The drained apple juices were poured into glass bottles (0.5 L or 1 L) and frozen (-40 °C) until sensory and chemical analysis would be conducted. The storage time of frozen samples was two to three months depending of the testing schedule.

2.3. Panelists

Eight trained panelists (female, age 26-43, from Competence Centre of Food and Fermentation Technologies, Tallinn, Estonia) participated in the study. The panelists had descriptive testing experience with a variety of foods such as apple juice, strawberry jam, bread, and fish products. All the assessors participated in 8 hours of orientation (four, 2-hour sessions) before the evaluation of the representative samples.

2.4. Vocabulary development

During the training sessions, the panelists identified the parameters considered essential for sensory assessment of apple juice. The assessors listed all the sensory parameters they deemed necessary to describe the appearance, aroma, and flavor of the apple juice samples. The panel leader had previously prepared a list of parameters used in scientific publications about apple and apple juice sensory analysis (Seppä *et al.* 2012; Bavay *et al.* 2013; Aprea *et al.* 2012; Corollaro *et al.* 2013; Karlsen *et al.* 1999; Mehinagic *et al.* 2004; Quere *et al.* 2006) to identify the most appropriate terminology for those parameters highlighted by the panel.

Table 1. Origin and classification of apple cultivars included in the study. E – Private apple orchard in Valgjärve, Estonia; F – MTT Piikkiö, Finland

Cultivar	Origin of the samples	Cultivar type	Dessert and/or processing cultivar
Åkero hassel	E	Winter	Dessert apple
Antei	E	Winter	Dessert apple
Auksis	E	Autumn/winter	Dessert apple
Chestnut	F	Autumn	Dessert apple
Juuso	E	Winter	Dessert apple
Jättimelba	F	Autumn	Dessert apple
Konsta	F	Winter	Processing apple
Krista	E	Autumn	Dessert apple
Kuldrenett	E	Autumn	Dessert apple
Kulikovskoje	E	Winter	Dessert apple
Linnan omena	F	Autumn/winter	Processing apple
Lobo	E	Winter	Dessert apple
Melba	E	Autumn	Dessert apple
Orlovski sinap	E	Winter	Processing apple
Paide taliõun	E	Winter	Dessert apple
Punainen atlas	F	Winter	Processing apple
Sügisdessert	E	Autumn	Dessert apple
Talvikaneli	F	Winter	Dessert/processing apple
Talvikki	F	Winter	Dessert/processing apple
Tobias	E/F	Winter	Dessert apple
White transparent	E	Summer	Dessert apple
Valtti	F	Winter	Dessert apple
Yltöisten sitruuna	F	Autumn	Processing apple

Table 2. The attribute list for apple juice with attributes, definitions and references.

Attribute	Definition	Reference
Odor		
Overall odor intensity	Overall apple juice odor intensity	Hipp children's apple purée = 5.0
Freshness	Fresh and green odor notes	Fresh peeled cucumber = 10.0
Fruity	Odor notes of different fruits (except apples)	Rainbow canned fruit purée = 10.0
Sweet	Sweet odor notes	Rainbow canned fruit purée = 11.0
Sour	Sour odor notes	Rainbow canned fruit purée = 6.0
Fermented	Odor notes that refer to fermentation	Diluted apple vinegar (1:200) = 6.0
Artificial	Odors that are not natural to apples	Kalev apple candy "draakon" = 14.0
Earthy, moldy	Dirt, mustiness, damp, dry-rotten leaves	Fresh peeled beet = 10.0
Flavor		
Overall taste intensity	Overall apple juice taste intensity	Hipp children's apple purée = 5.0
Sweet	The fundamental taste factor associated with a sucrose solution	2% sucrose solution = 2.0 4% sucrose solution = 4.0 6% sucrose solution = 6.0
Sour	A fundamental taste factor of which citric acid in water is typical	0.025% citric acid solution = 2.5 0.05% citric acid solution = 3.5 0.08% citric acid solution = 5.0 0.1% citric acid solution = 7.0
Astringent	The dry puckering mouthfeel associated with an alum solution	0.02% alum solution = 1.0 0.05% alum solution = 2.5 0.1% alum solution = 5.0
Bitter	The fundamental taste factor of which caffeine or quinine is typical	0.01% caffeine solution = 2.0 0.02% caffeine solution = 3.5
Metallic	The impression of slightly oxidized metal, such as iron, copper and silver spoons	0.025 % iron(ii)sulfate solution = 2.5
Fermented	Taste notes that refer to fermentation	Diluted apple vinegar (1:200) = 10.0
Fruity	Taste notes of different fruits (except apples)	Rainbow canned fruit purée = 13.0
Earthy, moldy	Dirt, mustiness, damp, dry-rotten leaves	Fresh peeled beet = 10.0
Artificial	Taste that is not natural to apples	Kalev apple candy "draakon" = 14.0

The final list of attributes was a combination of those identified by the panelists and the attributes found in the literature search. The attribute list (Table 2) used for sensory analysis consisted of eight aroma attributes: overall aroma intensity, freshness, fruity, sweet, sour, fermented, artificial, earthy; and 10 flavor/taste attributes: overall flavor intensity, sweet, sour, astringent, bitter, metallic, fermented, fruity, earthy, and artificial.

Various descriptive references were provided for the panelists. Some references were proposed by the panelists based on previous work and experience, whereas other references were added to the list by the panel leader according to literature overview. The most appropriate references were selected by panel consensus for each sensory parameter. Two reference selection sessions were held in order to produce references appropriate for all sensory parameters used in the lexicon. The intensities of the references were also agreed upon during these sessions.

2.5. Sample Evaluation Procedure

The samples were served at room temperature (22 ± 2 °C) to enhance the perceptible flavors in the apple juices. The presentation order of the samples was randomized and 3-5 samples were presented monadically during each session. The samples were coded with three-digit random numbers with each replicate having different codes during evaluation. The samples were evaluated in triplicate.

Sensory analysis was conducted in a laboratory equipped with individual booths and computers according to ISO 8589:1988. Data was collected using Microsoft Excel program, assessors inserted attribute intensities for each coded sample directly into their data collection file. All samples were presented in lidded cups in 40 ml portions. A descriptive scale of 0-15 with 0.5 increments was used to measure intensity, where 0 represented "none" and 15 indicated "extremely high." Each panelist assigned intensities to the individual attributes present in the sample. References were

available for assessors during every evaluation session. Crackers and water were provided for palate cleansing.

2.5.1. Sugar profile and malic acid

Individual sugars and malic acid levels were measured in triplicate using a HPLC (Alliance; Waters Corp., Milford, MA, USA) equipped with Bio-Rad HPX-87H column, temperature 35 °C. The samples of apple juice were diluted 1:25 (v/v) with Ultra Pure water (MilliQ) and then filtered with 0.2 µm membrane (Whatman Spartan 13, Dassel, Germany) before injection. The sample injection volume was 10 µL and sample temperature was 8 °C. The elution condition included an isocratic gradient and a flow rate of 0.6 mL/min; 0.005 M H_2SO_4 solution was used as mobile phase. The Refractive index (RI-)detector (model 2414; Waters Corp., Milford, MA, USA) and the ultraviolet (UV-)detector (Dual λ absorbance detector; model 2487; Waters Corp., Milford, MA, USA) was used consecutively. Detection of the samples was established by comparison of retention times of the standards of reference. The quantification was calculated for calibration curves of glucose, fructose, sucrose and malic acid monitored at column temperature. These chromatographic conditions result in co-elution of fructose and malic acid. The correct quantification of both compounds was established by means of using two consecutively connected detectors. The wavelength 210 nm was used for UV-detector. Concentrations of the co-eluting compounds mentioned above were calculated according to the following equation:

$$S^{UV} = \frac{MAL}{K_{mal}^{UV}} + \frac{FRU}{K_{fru}^{UV}} \quad (1)$$

$$S^{RI} = \frac{MAL}{K_{mal}^{RI}} + \frac{FRU}{K_{fru}^{RI}} \quad (2)$$

where S^{UV} and S^{RI} are the co-eluting compounds' peak areas in sample according to the UV- and RI-detector, respectively; MAL shows malic acid concentration as mg/ml; FRU indicates fructose concentration as mg/ml; K_{mal}^{UV} is peak area of malic acid standard measured with UV-detector; K_{fru}^{UV} is peak area of fructose standard measured with UV-detector; K_{mal}^{RI} is peak area of malic acid standard measured with RI-detector; and K_{fru}^{RI} shows peak area of fructose standard measured with RI-detector.

In addition, as all other disaccharides co-elute with sucrose under the chosen chromatographic conditions, the results are presented as total disaccharides, although it is well known that sucrose is the dominant disaccharide in apple juice (USDA, 2014).

2.5.2. Determination of total phenolics

The Folin-Ciocalteau method (Waterhouse, 2002) was used for measurement of total phenolic content. A total of 20 µL of sample, standard solution (gallic acid) or MilliQ water was pipetted into a plastic cuvette to analyze the sample, make a calibration curve, or to make a blank, respectively. A total of 1.58 ml of MilliQ water was added, followed by 100 µL of Folin-Ciocalteau reagent. The sample was mixed by pipetting and incubated for 6 minutes. Lastly, 300 µL of 20 % sodium carbonate solution was added to the sample and it was mixed again and incubated at room temperature for 2 hours. After incubation, the sample absorbance was measured at 765 nm. The absorbance of gallic acid was measured at concentrations 50, 100, 125, 200 and 250 mg/L. The calibration curve was made according to the measured results. The absorbance of the apple juice sample was monitored in the calibration area, and additional dilutions were made, if necessary. All the measurements were done in triplicates. The results of the method are expressed as gallic acid equivalent (GAE). To use total phenolic content in the cider apple classification, the GAE values were converted to percentage values of tannins.

2.6. Data Analysis

All collected results were analyzed with XLSTAT version 2013.4.03 (Addinsoft, Paris, France). Analysis of Variance (ANOVA) and Principal Components Analysis (PCA) were used to analyze results of sensory and chemical analysis. PCA was conducted on sensory analysis data and data from chemical analysis was added as supplementary data. Attributes that did not differentiate the samples ($p > 0.05$) according to ANOVA analysis (Tukey's HSD test) were excluded from the PCA analysis. Agglomerative Hierarchical Clustering (AHC) was used to find sample clusters.

3. RESULTS AND DISCUSSION

3.1. Sensory Analysis – Apple Juices Aroma and Flavor

Four aroma attributes showed statistically significant differences ($p < 0.05$) among analyzed samples: fermented, earthy, artificial, and sweet

(Table 3). Attributes fermented, earthy, and artificial were scored low (< 0.75 on a scale from 0 to 15) for most samples. These parameters can be understood as off-aromas for fresh apples and apple juice, indicating that there were few off-aromas among the cultivars. As a result, we can see that the only important aroma attribute differentiating the cultivars was sweet. The cultivar with the sweetest aroma was Sügisdessert. Cultivars with the lowest sweet aroma ratings were: Auksis, Paide Taliõun, Konsta, Linnan omena, Punainen Atlas, Tobias.F and Yltöisten Sitruuna. Though it is well known that there is no sweet aroma per se, the taste properties of an odor can be affected by a history of co-occurrence with a sweet taste (Stevenson, Prescott & Boakes, 1995). In the case of apples, we probably learn early in the childhood that sweet tasting apples have a specific odor which we associate with sweet odor (Seppä, 2014). Odor of apple juice will change considerably after fermentation into cider; whether the odor quality of apple juice has an impact on the apple cider's odor characteristics, should be determined through further cider production research.

Eight flavor attributes showed statistically significant differences among analyzed samples: overall flavor intensity, sweet, sour, astringent, bitter, fermented, fruity, and earthy (Table 4). A total of four flavor attributes were scored low (metallic, fermented, artificial, and earthy) and were excluded from Principal Component Analysis. As these flavor attributes refer to off-flavors, we can conclude that there was no significant sign of off-flavors.

Table 3. Average aroma intensities of analysed apple juices. Values are expressed as means; means with a different letter within a column are significantly different at $p < 0.05$ level.

Cultivar	Overall aroma intensity	Freshness	Fruity	Sweet	Sour	Fermented	Artificial	Earthy
Åkero hassel.e	7.9*	3.2	1.5	5.6 AB	5.8	0.4 AB	0.2 B	0.2 AB
Antei.e	6.5	3.2	3.5	6.9 AB	4.4	0.2 AB	0.3 B	0.6 AB
Auksis.e	6.9	2.6	1.6	4.8 B	5.5	0.2 B	0.2 B	0.8 AB
Chestnut.f	6.1	2.5	1.8	6.4 AB	5.1	1.0 AB	0.4 B	0.8 AB
Juuso.e	8.4	3.3	2.5	7.0 AB	6.6	0.1 B	0.5 B	0.3 AB
Jättimelba.f	8.4	3.4	2.0	5.6 AB	7.6	1.3 AB	0.3 B	0.5 AB
Konsta.f	7.6	3.7	1.0	4.8 B	6.6	0.5 AB	0.3 B	0.8 AB
Krista.e	6.9	3.1	1.6	5.2 AB	5.9	0.3 AB	0.2 B	0.2 AB
Kuldrenett.e	7.6	3.5	2.0	5.8 AB	6.4	0.9 AB	0.2 B	0.1 B
Kulikovskoje.e	8.1	3.6	2.3	6.1 AB	6.7	0.2 B	0.2 B	0.4 AB
Linnan omena.f	6.0	2.8	2.3	4.8 B	4.7	0.4 AB	0.7 B	0.3 AB
Lobo.e	7.5	3.2	1.6	5.0 AB	6.0	0.3 AB	0.3 B	0.2 AB
Melba.e	8.3	3.6	1.8	5.7 AB	6.8	0.5 AB	0.1 B	0.3 AB
Orlovski sinap.e	8.3	3.7	1.4	5.8 AB	6.7	0.5 AB	0.2 B	0.1 B
Paide taliõun.e	6.6	3.2	1.5	4.8 B	5.5	0.2 AB	0.1 B	0.4 AB
Punainen atlas.f	6.8	1.9	1.3	4.7 B	5.8	1.1 AB	0.3 B	0.7 AB
Sügisdessert.e	8.6	4.2	3.1	7.3 A	6.5	0.3 AB	1.0 B	0.3 AB
Talvikaneli.f	8.0	3.3	2.2	5.4 AB	6.3	1.4 A	0.1 B	0.3 AB
Talvikki.f	7.3	3.0	1.5	5.1 AB	6.2	0.2 B	0.1 B	0.3 AB
Tobias.e	8.3	2.3	1.4	5.3 AB	6.5	0.6 AB	0.7 B	1.1 A
Tobias.f	6.6	2.3	1.2	4.2 B	5.5	0.2 AB	0.7 B	0.7 AB
White transparent.e	7.9	3.3	1.1	5.9 AB	6.8	1.0 AB	0.4 B	1.1 AB
Valtti.f	8.3	3.6	2.5	7.3 AB	6.0	0.5 AB	2.4 A	0.2 AB
Yltöisten sitruuna.f	5.8	2.4	1.4	3.8 B	3.4	0.5 AB	0.5 B	0.3 AB

Table 4. Average flavor intensities of analysed apple juices. Values are expressed as means; means with a different letter within a column are significantly different at $p < 0.05$ level.

Cultivar	Overall flavor intensity	Sweet	Sour	Astringent	Bitter	Fruity	Fermented	Earthy	Metallic	Artificial
Åkero hassel.e	9.0* ABCDE	3.6 ABCD	3.9 D	1.9 B	0.9 BCDE	1.4 AB	0.1 C	0.0 B	0.2	0.2
Antei.e	9.5 ABCD	3.9 ABC	4.1 D	2.7 AB	0.7 CDE	4.4 A	0.2 BC	0.1 B	0.3	0.2
Auksis.e	7.9 BCDE	3.9 ABC	3.2 D	1.8 B	0.9 CDE	2.4 AB	0.0 C	0.9 AB	0.2	0.1
Chestnut.f	8.8 ABCDE	4.3 AB	3.7 D	2.0 B	1.3 ABCDE	2.4 AB	0.3 BC	0.1 B	0.1	0.6
Juuso.e	11.2 A	3.7 ABC	4.1 D	1.9 B	0.8 CDE	2.6 AB	0.2 C	0.0 B	0.0	0.7
Jättimelba.f	10.3 ABC	2.9 BCDEF	5.6 BCD	4.0 AB	1.8 ABCD	1.1 B	0.4 B	1.0 AB	0.3	0.0
Konsta.f	9.9 ABCD	2.1 EFGH	7.5 AB	3.4 AB	1.5 ABCDE	1.0 B	1.0 ABC	0.5 AB	0.7	0.1
Krista.e	8.6 ABCDE	2.8 CDEF	4.8 CD	2.8 AB	1.0 BCDE	1.5 AB	0.4 BC	0.2 B	0.2	0.0
Kuldrenett.e	9.4 ABCD	4.5 A	4.3 D	1.7 B	0.7 DE	2.7 AB	0.3 BC	0.0 B	0.2	0.2
Kulikovskoje.e	10.2 ABC	3.7 ABC	4.7 CD	2.9 AB	1.1 BCDE	1.9 AB	0.1 C	0.1 B	0.1	0.1
Linnan omena.f	9.8 ABCD	2.3 EFGH	8.4 A	4.9 A	2.0 AB	1.5 AB	0.1 C	0.0 B	0.2	0.3
Lobo.e	7.5 CDE	2.2 EFGH	4.4 CD	2.8 AB	1.3 ABCDE	1.3 B	0.3 BC	0.4 B	0.2	0.6
Melba.e	8.9 ABCDE	4.0 AB	3.7 D	1.4 B	0.6 E	2.4 AB	0.2 C	0.2 B	0.3	0.2
Orlovski sinap.e	10.7 A	4.1 AB	3.9 D	1.8 B	0.7 DE	1.7 AB	0.0 C	0.2 B	0.1	0.2
Paide taliõun.e	10.4 AB	3.2 BCDE	4.3 CD	2.3 B	1.0 BCDE	1.7 AB	0.3 BC	0.3 B	0.3	0.0
Punainen atlas.f	11.4 A	1.2 H	9.0 A	4.7 A	2.1 AB	0.6 B	1.2 AB	0.5 AB	0.5	0.0
Sügisdessert.e	6.6 E	2.5 DEFG	3.5 D	2.3 B	1.5 ABCD	0.8 B	0.5 BC	0.8 AB	0.3	0.4
Talvikaneli.f	9.3 ABCDE	3.3 BCDE	3.7 D	3.3 AB	1.1 BCDE	2.1 AB	0.9 ABC	0.4 AB	0.3	0.4
Talvikki.f	10.3 ABC	1.5 GH	6.0 BCD	3.9 AB	1.5 ABCDE	0.9 B	0.5 BC	0.4 B	0.4	0.3
Tobias.e	6.9 DE	3.2 BCDE	2.6 D	1.3 B	0.9 BCDE	1.7 AB	0.4 BC	0.7 AB	0.4	0.6
Tobias.f	7.6 BCDE	3.9 ABC	2.4 D	1.5 B	0.7 DE	2.9 AB	0.0 C	0.3 B	0.0	0.9
White transparent.e	6.0 E	2.1 EFGH	4.3 D	4.1 AB	2.6 A	0.3 B	1.6 A	1.6 A	0.4	0.2
Valtti.f	9.6 ABCD	1.7 FGH	6.8 ABC	3.6 AB	1.9 ABC	0.8 B	1.0 ABC	0.1 B	0.4	0.3
Yltöisten sitruuna.f	6.1 E	1.9 EFGH	6.2 ABCD	4.4 AB	1.6 ABCD	0.3 B	0.9 ABC	0.1 B	0.1	0.0

3.2. Principal Component Analysis (PCA) and Agglomerative Hierarchical Clustering (AHC)

According to the Principal Components Analysis (PCA) of flavor characteristics, the first two PCs explained 87.6 % of the variation among samples (Figure 1). PC1 was positively loaded with sweet and fruity flavor attributes and negatively loaded with the attributes bitter, astringent and sour. PC2 showed positive loading for the overall flavor intensity attribute. PC3 was responsible for less than 10 % of the variation and was not included in following discussion of results. These results showed that the key attributes for flavor are sweet and fruity versus bitter, astringent and sour.

According to the flavor characteristics there were three clusters identified among the samples (Figure 1). These clusters can be associated with certain sensory parameters. The first cluster consisted of 13 cultivars and was characterized mainly by the attributes sweet and fruity. The second cluster consisted of six cultivars and was characterized mainly by attributes sour, astringent and bitter. The third cluster consisted of five cultivars and was characterized by attributes astringent and bitter. Sour, astringent and bitter have been negatively linked with consumer acceptance, although sensory perceptions astringent and sometimes sour can be expected in certain levels in some foods, for example, wines and cider (Lea & Piggott, 2003; Koppel *et al.* 2014). A recent study on pomegranate juice acceptance showed that understanding what kind of products are accepted better across the consumer segments, may be more appropriate than looking for individual products accepted more readily in certain countries (Koppel *et al.* 2014). Based on this theory, segments of apple cider consumers should be investigated further to identify their flavor preferences. There will likely be new cider styles devised to suit new markets – for instance in Asia and North-America (Seppä *et al.* 2012). This means that classifying raw materials will not only be important in terms of deciding on best cultivars for traditional cider production, but it will also give valuable information for identifying types of ciders that can be produced to satisfy new markets.

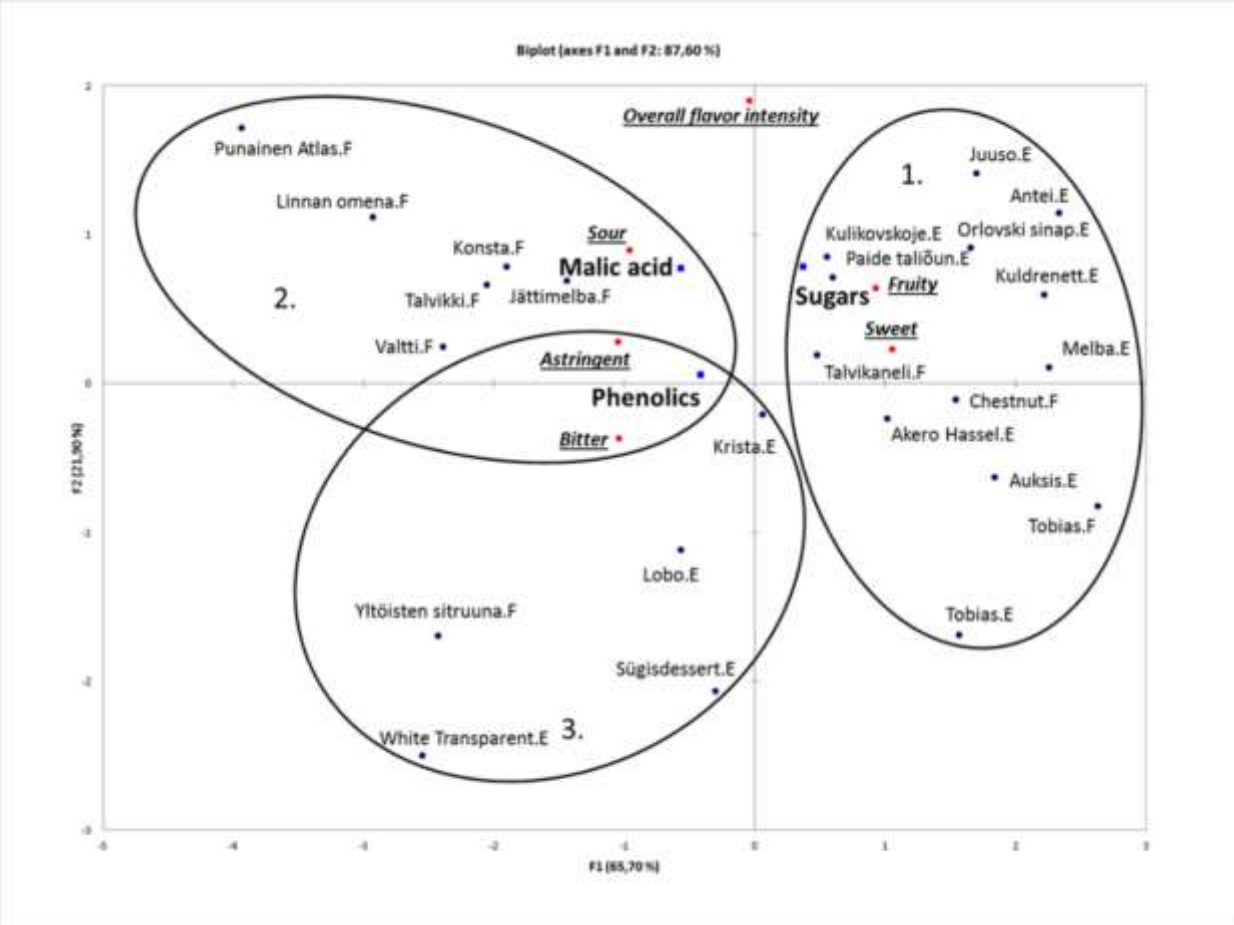

Figure 1. Principal components analysis biplot of apple cultivars sensory properties, malic acid, sugars, and phenolics content. E – estonian cultivar, f- finnish cultivar. The ovals indicate clusters based on agglomerative hierarchical clustering.

3.3. **Instrumental analysis**

The results of instrumental analysis (Table 5) were used to classify analyzed apple cultivars in different classes according to the classical Barker's Classification of Cider Apples (Table 6). The results showed that all analyzed apple cultivars belong to two out of the four possible groups: classes "sharp" and "bittersharp." There were no "sweet" or "bittersweet" apples, due to the fact that the malic acid content of all the analyzed cultivars was higher than 0.45 %. This showed that apples grown in the northern part of Eastern Europe have relatively high malic acid content and are therefore perceived as more sour. This is an important fact for cider producers, because relatively high malic acid content leads to a need for malolactic fermentation, malic acid conversion to lactic acid is usually accomplished by *Oenococcus oeni* (Gao, Rupasinghe & Pitts, 2013).

Table 5. Results of instrumental analysis. Sum of fructose, glucose and disaccharides. SD – standard deviation. Means with a different letter within a column are significantly different at $p < 0.05$ level.

Cultivar	Fructose, % Mean ±sd	Disaccharides, % Mean ±sd	Glucose, % Mean ±sd	Total sugar*, %	Malic acid, % Mean ±sd	Tannins, % Mean ±sd
Åkero hassel.e	6.80 ±0.03 d	3.34 ±0.01 g	1.68 ±0.01 b,c	11.82	0.87 ±0.03 i	0.06 ±0.01 j,k
Antei.e	7.13 ±0.00 c	4.33 ±0.00 b	1.62 ±0.00 c	13.07	1.09 ±0.00 f	0.33 ±0.01 e
Auksis.e	4.91 ±0.01 l	1.07 ±0.00 s	1.16 ±0.00 g,h,i,j	7.14	0.48 ±0.01 m	0.12 ±0.01 i,j
Chestnut.f	10.04 ±0.05 a	2.24 ±0.01 m	2.53 ±0.01 a	14.81	0.90 ±0.01 i	0.35 ±0.03 e
Juuso.e	5.81 ±0.02 h,i	4.10 ±0.01 d	1.05 ±0.00 j,k	10.96	0.99 ±0.01 h	0.08 ±0.02 i,j,k
Jättimelba.f	8.12 ±0.09 b	1.85 ±0.06 q	1.57 ±0.05 c,d	11.54	1.04 ±0.00 g,h	0.66 ±0.01 c
Konsta.f	5.08 ±0.02 l	2.79 ±0.01 j	1.24 ±0.01 f,g,h,i	9.11	1.22 ±0.01 c	0.15 ±0.00 h,i
Krista.e	5.98 ±0.01 f,g,h	0.64 ±0.02u	1.45 ±0.01 d,e	8.07	0.91 ±0.03 i	0.24 ±0.00 f
Kuldrenett.e	6.00 ±0.03 f,g,h	2.17 ±0.02 n,o	0.55 ±0.01 m	8.72	0.68 ±0.00 j	0.04 ±0.00 k
Kulikovskoje.e	6.88 ±0.04 d	2.86 ±0.02 i	1.12 ±0.01 i,j	10.86	0.88 ±0.00 i	0.21 ±0.04 f,g,h
Linnan omena.f	7.23 ±0.00 c	2.37 ±0.00 l	1.79 ±0.00 b	11.38	1.36 ±0.00 b	0.81 ±0.02 b
Lobo.e	5.02 ±0.01 l	1.32 ±0.00 r	1.36 ±0.00 e,f	7.71	0.54 ±0.01 k,l	0.04 ±0.00 k
Melba.e	6.57 ±0.09 e	3.76 ±0.03 e	1.33 ±0.00 e,f	11.66	1.05 ±0.03 f,g	0.70 ±0.08 c
Orlovski sinap.e	5.99 ±0.25 f,g,h	3.68 ±0.08 f	1.40 ±0.22 f,g,h	11.06	1.16 ±0.01 d,e	0.09 ±0.03 i,j,k
Paide taliõun.e	4.54 ±0.01 m	5.21 ±0.01 a	0.83 ±0.01 l	10.58	1.09 ±0.00 f	0.03 ±0.01 k
Punainen atlas.f	5.53 ±0.00 j,k	2.58 ±0.00 k	1.13 ±0.00 i,j	9.24	1.35 ±0.00 b	0.26 ±0.02 f
Sügisdessert.e	6.45 ±0.03 e	1.91 ±0.01 q	1.34 ±0.00 e,f	9.70	0.55 ±0.04 k	0.12 ±0.02 i,j
Talvikaneli.f	6.92 ±0.00 d	4.22 ±0.00 c	1.14 ±0.00 h,i,j	12.27	0.86 ±0.00 i	0.57 ±0.02 d
Talvikki.f	5.89 ±0.01 g,h	2.25 ±0.00 m	1.37 ±0.00 e,f	9.51	1.20 ±0.00 c,d	0.54 ±0.04 d
Tobias.e	6.08 ±0.01 f	3.26 ±0.00 h	0.91 ±0.00 k,l	10.25	0.53 ±0.01 k,l	0.06 ±0.02 j,k
Tobias.f	6.51 ±0.01 e	2.23 ±0.01 m,n	0.96 ±0.01 k,l	9.70	0.50 ±0.01 l,m	0.24 ±0.01 f
White transparent.e	5.69 ±0.02 i,j	0.76 ±0.00 t	1.29 ±0.00 f,g	7.74	0.56 ±0.03 k	0.16 ±0.01 g,h,i
Valtti.f	6.02 ±0.02 f,g	2.06 ±0.01 p	1.62 ±0.01 c	9.69	1.15 ±0.00 e	0.23 ±0.01 f,g
Yltöisten sitruuna.f	5.47 ±0.02 k	2.11 ±0.00 o,p	0.95 ±0.00 k,l	8.54	2.06 ±0.01 a	1.13 ±0.02 a

The "Ideal cider apple" should also have malic acid content of approximately 0.4 %, but the range of malic acid content for cider apples is usually 0.1-1.0 % (Lea & Piggott, 2003). All of the analyzed samples had high malic acid content, higher than the "Ideal cider apple". Almost half of the analyzed cultivars (n = 11) even exceeded the given usual cider apple malic acid content (Lea & Piggott, 2003).

The classical Barker's Classification of Cider Apples that was used for analyzed cultivars showed clustering of the cultivars between two countries where the samples originated. Most of the cultivars from Estonia were classified as "sharp," and most of the cultivars from Finland were classified as "bittersharp." Generally, this showed that apples grown in Finland had relatively higher tannin content than apples grown in Estonia. The limit of tannins content between the classes of "sharp" and "bittersharp" is 0.2 %. This was also well confirmed by the cultivar that was presented from both countries: Tobias. Tobias that originated from Estonia (sample Tobias.E) was classified as "sharp", but Tobias from Finland (sample Topias.F) was classified as "bittersharp". A latitudinal distance between MTT Piikkiö, Findland (60°23' N) and private apple orchard in Valgjärve, Estonia (58°8') is 120 km. Yang et al. (2013) showed in his study the effects of latitude on phenolic compounds in currant

cultivars and highlighted similar findings that the total content of phenolic compounds was 10-19 % higher in the north than in the south with a latitudinal distance of 690 km (Yang et al. 2013). The northern climate – long days with cool night temperatures – have mainly a positive impact on the biosynthesis of different phenolic compounds such as flavonoids (Jaakola & Hohtola, 2010).

Table 6. Classification of the analysed cultivars according to the classical Barker's Classification of Cider Apples. E – Estonia, F – Finland.

Sharp (11)	Bittersharp (13)
Åkero hassel.e	Antei.e
Auksis.e	Chestnut.f
Juuso.e	Jättimelba.f
Konsta.f	Krista.e
Kuldrenett.e	Kulikovskoje.e
Lobo.e	Linnan omena.f
Orlovski sinap.e	Melba.e
Paide taliõun.e	Punainen atlas.f
Sügisdessert.e	Talvikaneli.f
Tobias.e	Talvikki.f
White transparent.e	Tobias.f
	Valtti.f
	Yltöisten sitruuna.f

The results showed that all the analyzed samples had relatively low sugar content. The highest sugar content was 14.81 % for cultivar Chestnut followed by cultivars Antei and Talvikaneli, 13.07 % and 12.27 %, respectively. The "Ideal cider apple" should have a relatively high sugar content of around 15 % (Lea & Piggott, 2003). Results from chemical analysis showed that analyzed cultivars grown in Estonia and Finland had remarkably lower sugar content. This means that addition of sugar may be necessary during cider production for analyzed cultivars. The legislation of addition of fermentable sugar depends on the country. There are certain legislations for countries with a long history of cider production and for those with the biggest cider production such as UK, Spain, France and Germany (Lea & Piggott, 2003), but this legislation currently does not exist in the countries where the cultivars were grown for this study.

3.4. Recommendation for potential cultivars for cider production

The results of this study set the stage to initiate a database of sensory and chemical properties of apple cultivars in the northern part of Eastern Europe. This study needs to be repeated to collect data about variations between different harvesting years that are dependent of weather conditions. Also, samples have to be collected from different areas, because the climate of a specific region may have an impact on fruit properties. For final conclusions and descriptions of different cultivars, the described methods of this study can be used by researchers in different geographic locations and these results could be gathered in one final database. Furthermore, this topic needs to be studied further to validate the findings from this study by fermenting these proposed suitable cider apples into cider.

The best cultivars for traditional apple cider production can be found from the first cluster. The taste parameter sweet mainly shows that the amount of sugars is high or that the ratio of sugars:acids is relatively high. In this cluster, there might be some cultivars with low sugar content that are perceived as sweet because of low malic acid content, therefore, analysis of total sugar content is necessary for final selection to make sure there is sufficient amount of those sugars needed for ethanol production. If the sour taste dominates in apple juice, after fermentation of sugars during production, sourness will be perceived even more strongly; therefore, those cultivars can be classified as too sour for cider production.

The results of this study showed that parameters for the "Ideal cider apple" are region-specific. The "Ideal cider apple" for the northern part of Eastern Europe can be identified mainly on the basis of malic acid, sugars and tannins. Malic acid content is usually high, in a range 0.5-1.5%, so there is clear need for malolactic fermentation. Malic acid is important, because during malolactic fermentation different volatile compounds are formed that enrich the quality of final product (Moreno-Arribas, Gomez-Cordoves & Martin-Alvarez, 2008).

In optimal fermentation, most of the sugar is converted to ethanol, with only a small percentage converted to other byproducts (Lea & Piggott, 2003). Although alcohol content of cider varies, traditional ciders usually have alcohol content > 4 %Vol (Lea & Piggott, 2003). This indicates that cider apples should have a sugar content > 10 %. Results of this study showed that in the northern part of Eastern Europe, the sugar content of apples is relatively low; therefore certain limits for this parameter would be useful to establish potential of the cultivar for cider production.

High tannins content is recommended for body and mouthfeel in the end product (Lea & Piggott, 2003). Therefore, if sensory and chemical analyses are used together and selected cultivar astringency is not the dominant flavor, there should not be an

upper limit for tannins content. Lower limit for tannins could be the same as recommendations for the "Ideal cider apple" indicated above at 0.2 % content.

According to the present study, recommendations for the "Ideal cider apple" for the northern part of Eastern Europe would be to have a sugar content > 10 %, tannins > 0.2 % and malic acid content in range 0.5 – 1.5 %.

4. CONCLUSION

Twenty-four apple cultivars from Northern Europe (14 from Estonia and 10 from Finland) were selected for sensory and instrumental analysis. The present study sought to find those cultivars with the highest potential for natural apple cider production. Descriptive sensory analysis for apple juice was conducted to assess all selected cultivars. The instrumental analysis included chemical analysis such as sugar profile, malic acid content, and total phenolic content. The present study showed that descriptive sensory analysis is a useful tool for pre-selection of the apple cultivars, but chemical analysis should guide the final selection of cultivars suitable for cider production. The "Ideal cider apple" parameters turned out to be region-specific, therefore chemical content of the "Ideal cider apple" of the northern part of Eastern Europe was proposed. According to the results, five cultivars were selected with the highest potential for cider production: Antei, Chestnut, Kulikovskoje, Melba and Talvikaneli. This selection needs to be confirmed with following cider production studies to understand if the methods used in the apple juice analysis will give us sufficient amounts of information to make selection of cultivars with potential for apple cider with highest quality.

REFERENCES

Abrodo, P.A., Llorente, D.D., Corujedo, S.J., Fuente, E.D., Alvarez, M.D.G. & Gomis, D.B. (2010) Characterisation of Asturian cider apples on the basis of their aromatic profile by high-speed gas chromatography and solid-phase microextraction. Food Chemistry 121, 1312-1318.

Aprea, E., Corollaro, M.L., Betta, E., Endrizzi, I., Demattè, M.L., Biasioli, F. & Gasperi, F. (2012) Sensory and instrumental profiling of 18 apple cultivars to investigate the relation between perceived quality and odour and flavor. Food Research International 49, 677-686.

Bavay, C., Symoneaux, R., Maître, I., Kuznetsova, A., Brockhoff, P.B. & Mehinagic, E. (2013) Importance of fruit variability in the assessment of apple quality by sensory evaluation. Postharvest Biology and Technology 77, 67-74.

Blanco-Gomis, D., Mangas-Alonso, J.J., Junco-corujedo, S. & Gutiérrez-Álvarez, M.D. (2009) Characterisation of sparkling cider by the yeast type used in taking foam on the basis of polypeptide content and foam characteristics. Food Chemistry 115, 375-379.

Braga, C.M., Zielinski, A.A.F., Silva, K.M., Souza, F.K.F., Pietrowski, G.A.M., Couto, M., Granato, D., Wosiacki, G. & Nogueira, A. (2013) Classification of juices and fermented beverages made from unripe, ripe and senescent apples based on the aromatic profile using chemometrics. Food Chemistry 141, 967-974.

Corollaro, M.L., Endrizzi, I., Bertolini, A., Aprea, E., Demattè, M.L., Costa, F., Biasioli, F. & Gasperi, F. (2013) Sensory profiling of apple: Methodological aspects, cultivar characterisation and postharvest changes. Postharvest Biology and Technology 77, 111-120.

Gao, J., Rupasinghe, H.P.V. & Pitts, N.L. (2013) Characterisation of malolactic conversion by Oenococcus oeni to reduce the acidity of apple juice. International Journal of Food Science and Technology 48, 1018-1027.

Herrero, M., García, L.A. & Díaz, M. (2006) Volatile Compounds in Cider: Inoculation Time and Fermentation Temperature Effects. Journal of Institute of Brewing 112(3), 210-214.

ISO (1988) Sensory analysis – General guidance for the design of test rooms. ISO

8589:1988, ISO Geneva; Switzerland.

Jaakola, L. & Hohtola, A. (2010) Effect of latitude on flavonoid biosynthesis in plants. Plant Cell Environment 33, 1239-1247.

Karlsen, A.M., Aaby, K., Sivertsen, H., Baardseth, P. & Ellekjær, M.R. (1999) Instrumental and sensory analysis of fresh Norwegian and imported apples. Food Quality and Preference 10, 305-314.

Kelkar, S. & Dolan, K. (2012) Modeling the effects of initial nitrogen content and temperature on fermentation kinetics of hard cider. Journal of Food Engineering 109, 588-596.

Koppel, K., Chambers IV, E., Vázquez-Araújo, L., Timberg, L., Carbonell-Barrachina, Á. A. & Suwonsichon, S. (2014) Cross-country comparison of pomegranate juice acceptance in

Estonia, Spain, Thailand, and United States. Food Quality and Preference 31, 116-123.

Lea, A.G.H. & Piggott, J.R. (2003) Cidermaking, in Fermented beverage production (Lea, A.G.H. and Drilleu, J.F.) 2nd ed, pp 59-88, Kluwer Academic/Plenum Publishers, New York.

Lento, S., Pirttijärvi, T. & Hasu, M. (2010) Effect of raw materials (currants and apples) on the processability and quality of Finnish country fruit wines. Final report. Ministry of agriculture and forestry doc. no. 4535/504/2006.

Mehinagic, E., Royer, G., Symoneaux, R., Bertrand, D. & Jourjon, F. (2004) Prediction of the sensory quality of apples by physical measurements. Postharvest Biology and Technology 34, 257-269.

Mitchell, P. (2012) Presentation of 2012 Northwest Cider & Perry Seminar. The Cider & Perry Academy. Northwest Agriculture Business Academy.

Moreno-Arribas, M.V., Gómez-Cordovés, C. & Martín-Álvarez, P.J. (2008) Evolution of red wine anthocyanins during malolactic fermentation postfermentative treatments and ageing with lees. Food Chemistry 109, 149-158.

Murray, J.M., Delahunty, C.M. & Baxter, I.A. (2001) Descriptive sensory analysis: past, present and future. Food Research International 34, 461-471.

Organization of the United Nations, FAOSTAT database (FAOSTAT, 2014). http://faostat.fao.org/.

Quéré, J.M.L., Husson, F., Renard, C.M.G.C. & Primault, J. (2006) French cider characterization by sensory, technological and chemical composition. Lwt - Food Science and Technology 39, 1033-1044.

Seppä, L., Railio, J., Mononen, R., Tahvonen, R. & Tuorila, H. (2012) From profiles to practice: Communicating the sensory characteristics of apples to the wider audience through simplified descriptive profiles. Food Science and Technology 47, 46-55.

Seppä, L. (2014) Domestic apple cultivars: sensory descriptions and consumer responses. EKT-Series 1633. University of Helsinki, Department of Food and Environmental Sciences. 90 pp.

Stevenson, R.J., Prescott, J, & Boakes, R.A. (1995) The acquisition of taste properties by odors. Learning and Motivation 26, 433-455.

Travers, I., Jacquet, A., Brisset, A. & Maite, C. (2002) Relationship between the enzymatic determination of starch and the starch iodine index in two varieties of cider apple. Journal of Science of Food and Agriculture 82, 983-989.

United States Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. USDA National Nutrient Database for Standard Reference, Release 27. Version: August 2014. http://www.ars.usda.gov/ba/bhnrc/ ndl.

Valles, B.S., Bedriñana, R.P., Tascón, N.F., Garcia, A.G & Madrera, R.R. (2005) Analytical differentiation of cider inoculated with yeast (*Saccharomyces cerevisiae*) isolated from Asturian (Spain) apple juice. Lwt - Food Science and Technology 38, 455-461.

Valles, B.S., Bedriñana, R.P., Queipo, A.L. & Alonso, J.J.M. (2008) Screening of cider yeasts for sparkling cider production (Champenoise method). Food Microbiology 25, 690-697.

Waterhouse, A.L. (2002) Determination of total phenolics. Current Protocols in Food Analytical Chemistry I1.1.1-I1.1.8.

Wilson, S.M., Maguer, M., Duitschaever, C.L., Buteau, C. & Allen, O.B. (2003) Effect of processing treatments on the characteristics of juices and still ciders from Ontario-grown apples. Journal of Science of Food and Agriculture 83, 215-224.

Yang, B., Zheng, J., Laaksonen, O., Tahvonen, R. & Kallio, H. (2013) Effects of Latitude and Weather Conditions on Phenolic Compounds in Currant (*Ribes* spp.) Cultivars. Journal of Agricultural Food Chemistry 61, 3517-3532.

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THE RELATIONSHIP BETWEEN VOLATILE COMPOUNDS AND AROMA QUALITY OF ORTHODOX BLACK TEA (*CAMELLIA SINENSIS*)

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ABSTRACT

Relationships between the sensory aroma and the volatile composition of O4 black tea grades produced from Vietnam were studied. A consumer preference test was carried out by 80 consumers to evaluate the aroma liking of these samples. Aroma concentrate was prepared by HS-SPME method and analyzed using GC/MS. PLSR was used to determine the relationship between preference scores and peak area percentage data of 46 detected volatile compounds. Among these compounds, 18 identified compounds were showed to contribute significantly to the aroma liking of Orthodox (OTD) black teas. On the basis of these 18 compounds, a PLSR model was constructed to predict the aroma liking of Vietnam OTD black tea. The result showed that the determination of volatile composition by HS-SPME and GC/MS combined with sensory evaluation and multivariate data analysis could be a useful tool for aroma liking prediction of Vietnam OTD black tea.

Keywords: *aroma compounds, Vietnam OTD black tea,*

1. INTRODUCTION

Black tea is a fermented tea that is consumed around the world due to the promotion of the health benefits of tea consumption (Senthil Kumar, Murugesan, Kottur, & Gyamfi, 2013). Usually, the quality of black tea is determined by human sensory evaluation based on "shape, colour, aroma and taste". (Okinda Owuor, Obanda, Nyirenda, Mphangwe, Wright, & Apostolides, 2006). Among these characteristics, aroma and taste are essential criteria in the evaluation of sensory acceptability and in the commercial description of tea (Kumar, Murugesan, Kottur, & Gyamfi, 2013). Therefore, a tea quality grade and its market price are commonly decided on aroma and taste.

The quantification of black tea quality is a difficult task because of the presence of innumerable compounds and their diverse contribution to black tea quality. In the Orthodox Black Tea quality process, sorting is the final step which is used for separating the different sized tea particles into even sized particles. With regard to the sorting process, there is no standard which 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)]. (Kumar, Murugesan, Kottur, & Gyamfi, 2013). In black tea, volatile flavour compounds (VFC) are present in very low quantities about 0.01% to 0.02% of the total dry weight, but have a high impact on the flavour of the products due to their low threshold value (Yang, Baldermann, & Watanabe, 2013). These VFCs can be divided into two groups. The Group I compounds are obtained by lipid breakdown, which imparts an undesirable grassy odour. However, the Group II compounds, which impart a sweet flavour aroma to black tea, are mainly derived from terpenoids, carotenoids and amino acids. The flavour of the tea depends on the

ratio of the sum of VFC Group II to that of VFC Group I, which is the flavour index or volatile flavour compounds (VFC) index (Ravichandran, 2002).

Sensory or instrumental approaches are usually used for aroma analysis. Highly reliable and consistent sensory evaluation methods have been developed for aroma descriptions. However, these sensory methods are sometimes expensive to implement as well as time consuming when used properly, and cannot be implemented "on-line" or "in-line" for immediate feedback (Chambers & Koppel, 2013). Instrumental methods for studying aroma have also been developed to provide feedback about the individual volatile compounds associated with aroma. Those methods take many forms, but all are based on separation or extraction, identification, and qualification or /and quantification of volatiles compounds either in headspace or in the actual product matrix. Instrumental methods can be implemented to run continually in order to provide immediate or near immediate information about products in a short time and in a consistent and cost-effective manner (Chambers & Koppel, 2013; Considine & Frankish, 2014; d'Acampora Zellner, Dugo, Dugo, & Mondello, 2008). Instruments could be used instead of tasters in the following scenarios: (a) a correlation between a sensory characteristic and an instrumental measurement has been established, (b) the sensory test is laborious and may damage 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 & Koppel, 2013). Therefore, it is necessary to find a suitable technique to describe the instrumental and sensory quality correlation. In many previous studied, partial least squares regression (PLSR) was used to regress compound data of food material against evaluation scores of taster (Lin, Dai, Guo, Xu, & Wang, 2012; Olafsdottir, Chanie, Westad, Jonsdottir, Thalmann, Bazzo, *et al.*, 2005; Rosenfeld & Nes, 2000). Partial least square regression (PLSR) aims at finding the components from independent *X*-variables (or volatile profiles) that are relevant to dependent *Y*-variables (or aroma liking scores) and predicting the liking scores from a set of volatile profile. (Hibbert, 2009; Kirsanov, Mednova, Vietoris, Kilmartin & Legin, 2012; Toscas, Shaw & Beilken, 1999).

For the case of Vietnam's black tea products, there is no report about the correlation between volatile constituents of OTD black tea grades and the aroma liking of OTD black tea beverage except one previous study using a different extraction method (Hoang, Tham, Vu, Nguyen & Nguyen, 2014). In addition, little information about the correlation between volatile profiling and quality ranking or grade of OTD black tea is available. This study presents results in which the aroma liking of difference grade OTD black teas can be predicted by volatile profiling using HS-SPME method and gas chromatography mass spectrometry and sensory analysis.

2. MATERIALS AND METHODS

2.1. Materials

A total of four different grades of OTD black tea samples (F, OP, P, BPS) were obtained from a factory at PhuTho, Vietnam. All tea samples were collected in 2014, kept in polymer bags (200 g/bag) and stored in a dark room at ambient temperature before analysis.

2.2. Volatile compounds analysis

2.2.1. Sample Preparations

One gram of black tea samples were infused in a 10-ml glass septum vial with distilled water (5 ml) heated on a heater apparatus for 10 min. After the equilibration, commercially available SPME fibre (Supelco, Bellefonte PA, USA) coated with 65 µm polydimethylsiloxane/divinylbezene (PDMS/DVB) was rapidly inserted into the headspace of the vial. The absorption step was kept at 90°C for 30 min. The PDMS/DVB fiber was preconditioned for five min in the injection port of the GC at 220°C before each analysis. Sample analyses were carried out in duplicates (Lin, Dai, Guo, Xu & Wang, 2012).

2.2.2. 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 three min and then increased to 190°C at a rate of 5°C min-1 and held at 190°C for one min, and then increased to 240°C at a rate 20oC min-1, held at this temperature for three 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, Pan, Xu, Luo & Wang, 2013). Volatile compounds were identified by electron impact mass spectrum and similarly match index. Flavour indices were calculated for each compound expressed as the ratio of group II to group I VFCs.

2.3. Consumer test

A liquor of tea was prepared for the consumer test following the ISO 3103-1980 standard (TCVN5086-90-(ISO3103-1980), 1990).

The consumer preference test was conducted with 80 consumers to assess the aroma quality of four OTD black tea grades. Vietnamese black tea consumers of age between 18 and 45 years were recruited from Hanoi (Vietnam). Consumers indicated their degree of liking of the aroma of the tea samples on a 9-cm unstructured line scale with "dislike extremely" on the left end and "like extremely" on the right end of line (Hoang, Tham, Vu, Nguyen & Nguyen, 2014).

2.4. Statistical analysis

PLS regression was performed by XLSTAT (version 2013).

3. RESULTS AND DISCUSSION

3.1. Volatile compounds

In black tea, volatile flavour components constitute about 0.02% of total dry weight, unlike most aromatic foods, which contain higher percentages of volatile constituents (Pripdeevech & Wongpornchai, 2013). The HP-SPME was employed to extract volatile components in order to characterize black tea grade flavour. GC-MS profile of extracted flavour shows the presence of a wide range of compounds including terpenoids, alcohols, acids, aldehydes, ketones, ester, and long-chain hydrocarbons.

The VFC profile of tea obtained by HP-SPME was dominated by terpenoids (Table 1). Phytol, an acyclic diterpene alcohol, constituted the highest amount (2.56% - 44.00%), followed by hexahydro-farnesylacetone (1.35%-20.2%), farnesyl acetone (1.93% - 4.33%) and β-ionone (5.12% - 11.07%), α-ionone (~1.5%). Among non-terpenoids, ester compounds like methyl palmitate (1.67% - 9.19%), methyl linoleate (1.46-2.25%) were present in a relatively high amount. Other compounds like aldehydes (hexanal, pentanal, *etc.*), alcohols (3-hexen-1-ol, benzyl alcohol, *etc.*) were detected in somewhat lower amounts (Table 1).

The number of compounds detected ranged from 31 in grade 4 to 45 in grade 1. In general, high-quality tea (grades 1-2) had more volatiles than low-quality (grades 3-4). In other words, there was a decreasing trend in number of volatiles detected as grades lower. The results also showed that the total number of terpene compounds in high-grades tends to be higher than those of low-grade quality, while the number of aldehydes and alcohols compounds in high-grades was lower than those of low-grade quality. The flavour Index, defined as the ratio of group II to group I VFCs, is the best flavor quality indicator of teas, and it decreased from high-grade to low-grade quality. Although the selection of the "best" grade is a subjective matter, the combination of several classes of volatile compounds is responsible for the distinctive and unique flavour of different grades of OTD black tea.

3.2. PLS regression

Based on the volatile profile which was prepared by HS-SPME method and analyzed by GC/MS and preference scores of 04 black tea grades, the results of PLSR analysis indicated positive and negative correlations between volatile compounds and specific sensory attributes. The regression coefficients of the 46 volatile compounds are listed in Table 2. Eleven compounds have both weight vectors that are negatively correlated with sensory attributes (aroma quality) included 3-methyl-butanal, (E)-2-pentenal, 2-methyl-2-pentenal, (Z)-2-penten-1-ol, (Z)-3-hexen-1-ol, methyl palmitate, methyl oleate, farnesyl acetaldehyde, α-ionone and three unknown compounds, while the others are negatively or positively correlated (Table 2).

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Table1. Volatile compounds detected in Orthodox Black tea by HP-SPME/GC-MS

No	Volatile compounds	Peak area ratio, %			
		OP	P	BPS	F
comp1	3-methyl-butanal	0.17	0.23	0.48	0.49
comp2	*(E)*-2-pentenal	0.28	0.29	0.58	0.94
comp3	2-methyl-2-pentenal	0.11	0.21	0.27	0.18
comp4	*(Z)*-2-penten-1-ol	0.30	0.30	0.70	0.90
comp5	hexanal	0.90	0.98	0.20	0.90
comp6	*(Z)*-3-hexen-1-ol	0.00	0.20	0.32	0.40
comp7	*(E)*-2-hexenal	0.14	0.33	0.19	0.90
comp8	benzeneacetaldehyde	0.10	0.65	0.05	0.20
comp9	1-hexanol	1.10	0.90	0.80	0.85
comp10	linalool oxide-*trans*	0.40	0.50	0.60	0.40
comp11	β-linalool	0.93	0.80	0.36	5.81
comp12	1,2-dimethoxy-bezen	0.12	0.10	0.17	0.00
comp13	β-cyclocitral	0.61	0.24	0.15	0.93
comp14	*cis*-geraniol	0.18	0.12	0.12	0.35
comp15	unknown	0.08	0.13	0.30	0.37
comp16	keto-Isophorone	0.08	0.07	0.11	0.72
comp17	α-ionol	0.18	0.15	0.19	0.74
comp18	β-damascenone	0.46	0.57	0.39	0.40
comp19	ethyl caprylate	0.11	0.36	0.00	0.00
comp20	α-ionone	1.02	0.86	1.19	1.33
comp21	β-ionone	11.07	6.77	6.33	5.12
comp22	unknown	1.13	5.63	1.05	6.68
comp23	α-farnesene	0.20	0.00	0.00	3.89
comp24	U-muurolene	0.25	0.27	0.00	0.00
comp25	nerodidol	0.52	1.02	0.00	1.90
comp26	hexadecane	0.54	0.67	0.81	0.53
comp27	unknown	1.89	0.57	0.52	0.00
comp28	unknown	1.19	4.61	1.53	8.80
comp29	heptadecane	0.89	0.58	0.37	0.00
comp30	unknown	0.15	0.00	0.00	0.00
comp31	alkane	0.94	1.11	0.97	4.50
comp32	unknow	1.30	1.46	0.62	6.81
comp33	farnesyl acetaldehyde	0.40	1.20	1.47	0.65
comp34	hexahydrofarnesylacetone	8.37	11.18	20.20	1.35
comp35	unknown	0.65	0.86	0.88	0.55
comp36	unknown	0.00	0.92	0.99	1.71
comp37	farnesyl acetone	1.93	2.24	4.33	0.00
comp38	methyl palmitate	5.91	8.00	9.12	9.19
comp39	unknown	0.10	0.00	1.17	0.00
comp40	unknown	0.20	1.17	0.00	1.09
comp41	methyl oleate	0.75	1.10	1.13	1.28
comp42	methyl linoleate	2.25	2.01	2.25	1.46
comp43	phytol	44.00	35.15	31.61	20.24
comp44	unknown	1.07	0.99	2.70	0.00
comp45	unknown	0.33	0.31	0.00	0.00
comp46	unknown	1.17	0.34	0.77	0.00
Terpenes alkan		***61.3***	***47.9***	***44.9***	***40.7***
Aldehydes		***2.1***	***2.7***	***3.24***	***4.26***
Alcohols		***1.4***	***1.4***	***1.8***	***2.2***
Esters		***9.02***	***11.47***	***12.5***	***11.93***
Ketones		***8.91***	***11.82***	***20.7***	***2.47***
Others		***11.3***	***20.9***	***12.9***	***31.0***
Total % composition		***94.02***	***96.15***	***95.99***	***92.56***

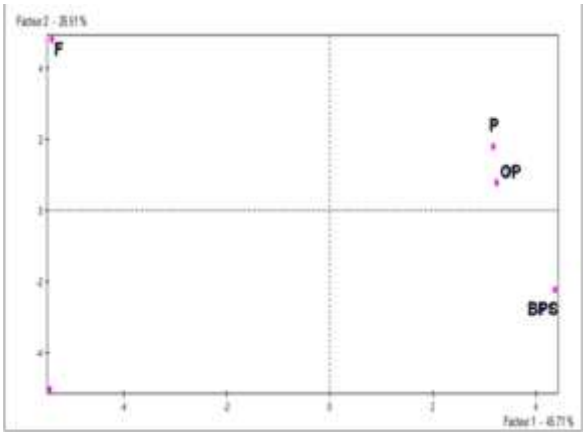

Figure 1: PCA score plots of OTD black tea samples (HP-SPME): PC1: 45,7%; PC2: 26,5%

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3.3. PLS regression

Based on the volatile profile which was prepared by HS-SPME method and analyzed by GC/MS and preference scores of 04 black tea grades, the results of PLSR analysis indicated positive and negative correlations between volatile compounds and specific sensory attributes. The regression coefficients of the 46 volatile compounds are listed in Table 2. Eleven compounds have both weight vectors that are negatively correlated with sensory attributes (aroma quality) included 3-methyl-butanal, (E)-2-pentenal, 2-methyl-2-pentenal, (Z)-2-penten-1-ol, (Z)-3-hexen-1-ol, methyl palmitate, methyl oleate, farnesyl acetaldehyde, α-ionone and three unknown compounds, while the others are negatively or positively correlated (Table 2).

Among them, phytol (0.201), heptadecane (0.202), β-ionone (0.173), methyl linoleate (0.171) and U-muurolene (0.169) showed strong positive correlation with aroma liking scores, whereas, 3-methyl-butanal (-0.179), (E)-2-pentenal (-0.199) and (Z)-3-hexen-1-ol (0.192) showed strong negative correlation with aroma liking scores. β-farnesene was determined to have a fruity odour. (E)-2-pentenal has been characterized as aroma-active compounds contributing to pungent, green, apple, tomato odour in black teas. β-ionone has also been determined to have tea leaves and woody odour in teas. Fresh, fruity green odour were given by 3-methyl-butanal (Pripdeevech & Wongpornchai, 2013).

The result of the consumer preference test showed that OP grade was the preferred grade followed by P and BPS grades. The least preferred is F grade (Table 3). The result showed that some volatile compounds were disliked by consumer, especially 3-methyl-butanal, (E)-2-pentenal, (Z)-2-penten-1-ol, 2-methyl-2-pentenal.

When the calibration model was considered, a good correlation between volatile profiles and sensory liking scores could be achieved as observed from a good determination coefficient (R^2) of 0.998. The root mean square error of estimation (RMSE), an error rate of predictability of calibration model, was found at 0.023. The RMSE values counted for less than 5%, indicating a reliable calibration model. The low RMSE values of this model suggested that volatile profiles obtained from HS-SPME along with GC/MS provided sufficient information to predict the sensory liking scores. The high correlation of the PLS regression model suggested that the complexity of sensory perception could be related directly to the volatile profiles by means of multivariate analysis.

Variable importance in the projection (VIP) is a parameter of PLS analysis that shows the importance of a variable in a PLS model (Zhang, Huang & Yu, 2008). Large VIP values, more than 1, are the most relevant for explaining the liking scores of OTD black teas. Compounds with VIP values greater than 1.0 are presented in Table 4. It was found that key compounds contributing to the quality predictive model included various volatile compounds.

After eliminating the VIP with values less than 1.0, a simplified model of OTD black tea products was obtained (Equa.1).

Table 2. Correlation matrix of the variables (Correlation matrix of W)

No	Volatile compounds	w*1	w*2
comp1	3-methyl-butanal	-0.179	-0.174
comp2	(E)-2-pentenal	-0.199	-0.064
comp3	2-methyl-2-pentenal	-0.071	-0.215
comp4	(Z)-2-penten-1-ol	-0.192	-0.119
comp5	hexanal	0.025	0.271
comp6	(Z)-3-hexen-1-ol	-0.189	-0.118
comp7	(E)-2-hexenal	-0.180	0.076
comp8	benzeneacetaldehyde	0.030	0.142
comp9	1-hexanol	0.146	0.171
comp10	trans -linalool oxide	0.012	-0.228
comp11	β-linalool	-0.170	0.086
comp12	1,2-dimethoxy-bezen	0.136	-0.162
comp13	β-cyclocitral	-0.100	0.147
comp14	cis-geraniol	-0.152	0.094
comp15	unknown	-0.194	-0.133
comp16	keto-Isophorone	-0.183	0.048
comp17	α-ionol	-0.181	0.051
comp18	β-damascenone	0.114	0.162
comp19	ethyl caprylate	0.109	0.145
comp20	α-ionone	0.168	0.107
comp21	β-ionone	0.173	0.090
comp22	unknown	-0.122	0.142
comp23	α-farnesene	-0.175	0.068
comp24	U-muurolene	0.169	0.181
comp25	nerodidol	-0.128	0.172
comp26	hexadecane	0.018	-0.229
comp27	unknown	0.177	0.072
comp28	unknown	-0.165	0.104
comp29	heptadecane	0.202	0.072
comp30	unknown	0.138	0.104
comp31	alkane	-0.180	0.066
comp32	unknow	-0.169	0.094
comp33	farnesyl acetaldehyde	-0.017	-0.194
comp34	hexahydrofarnesylacetone	0.078	-0.214
comp35	unknown	0.082	-0.144
comp36	unknown	-0.192	-0.047
comp37	farnesyl acetone	0.090	-0.208
comp38	methyl palmitate	-0.171	-0.147
comp39	unknown	-0.007	-0.269
comp40	unknown	-0.081	0.176
comp41	methyl oleate	-0.181	-0.075
comp42	methyl linoleate	0.171	-0.099
comp43	phytol	0.201	0.049
comp44	unknown	0.070	-0.231
comp45	unknown	0.174	0.181
comp46	unknown	0.164	-0.050

w_1*-firt X-weight vector
w_2*-second X-weight vector

Table 3. Aroma liking scores of black tea samples

OTD	OP	P	BPS	F
Scores	7.2[a]	6.8[a]	6.4[b]	5.6[c]
SD	0.95	1.21	1.22	1.04

Y= 0.043 × comp29 + 0.042 × comp43 - 0.042 × comp2 - 0.043 × comp4 - 0.042 × comp6 + 0.035 × comp16 + 0.034 × comp17 - 0.039 × comp41 - 0.033 × comp7 - 0.042 × comp1 - 0.033 × comp23 + 0.038 × comp21 + 0.031 × comp42 - 0.039 × comp38 + 0.031 × comp11 + 0.040 × comp24 + 0.037 × comp20 + 0.027 × comp14.

The equation of the model showed that 18 identified volatile compounds could affect significantly the aroma sensory liking scores of OTD black teas. Among these compounds, 10 contributed to an increase and eight to a decrease in liking scores of OTD black tea. This result could be used as a reference for developing a good aroma Vietnam OTD black tea.

Table 4. Key compounds contributing to the predictive model using volatile profiles obtained from GC/MS. VIP: variable important in the projection

No	Volatile compounds	VIP	Standardized coefficients
comp29	heptadecane	1.368	0.043
comp43	phytol	1.366	0.042
comp2	*(E)*-2-pentenal	1.347	-0.042
comp4	*(Z)*-2-penten-1-ol	1.303	-0.043
comp6	(Z)-3-hexen-1-ol	1.280	-0.042
comp16	α-ionol	1.242	0.035
comp17	keto-isophorone	1.226	0.034
comp41	methyl oleate	1.225	-0.039
comp7	*(E)*-2-hexenal	1.222	-0.033
comp1	3-methyl-butanal	1.216	-0.042
comp23	α-farnesene	1.189	-0.033
comp21	β-ionone	1.171	0.038
comp42	methyl linoleate	1.159	0.031
comp38	methyl palmitate	1.157	-0.039
comp11	β-linalool	1.154	0.031
comp24	U-muurolene	1.147	0.040
comp20	α-ionone	1.140	0.037
comp14	*cis*-geraniol	1.031	0.027

4. CONCLUSION

Eighteen compounds were determined to contribute significantly to the perceived aroma liking of black teas, especially heptadecane, phytol, *(E)*-2-pentenal, *(Z)*-2-penten-1-ol, (Z)-3-hexen-1-ol, and α-ionol. On the basis of these 18 volatile compounds, a PLS regression model (determination coefficient of 0.998 and root mean square error of 0.023) was constructed to predict the aroma quality of Vietnam OTD black tea.

From the result obtained in this study, the volatile combination by HS-SPME along with GC/MS in the profiling with sensory and multivariate data analysis could be a useful tool for aroma quality prediction of Vietnam OTD black tea. To the best of our knowledge, this is the first report using HS-SPME and GC-MS coupled with sensory analysis techniques in aroma quality prediction of Vietnam OTD black tea. Further investigation is needed in order to study all seven scales of quality of OTD black teas to improve the prediction model.

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REFERENCES

Chambers, E., & Koppel, K. (2013). Associations of Volatile Compounds with Sensory Aroma and Flavor: The Complex Nature of Flavor. *Molecules, 18*, 4887-4905.

Considine, J. A., & Frankish, E. (2014). Chapter 2 - Flavors and Aromas in Foods and Beverages. In J. A. Considine & E. Frankish (Eds.), *A Complete Guide to Quality in Small-Scale Wine Making*, (pp. 11-21). San Diego: Academic Press.

d'Acampora Zellner, B., Dugo, P., Dugo, G., & Mondello, L. (2008). Gas chromatography–olfactometry in food flavour analysis. *Journal of Chromatography A, 1186*, 123-143.

Hibbert, D. B. (2009). 4.12 - Chemometric Analysis of Sensory Data. In S. D. Brown, R. Tauler & B. Walczak (Eds.), *Comprehensive Chemometrics*, (pp. 377-424). Oxford: Elsevier.

Hoang, Q. T., Tham, B. H. P., Vu, H. S., Nguyen, D. T., & Nguyen, T. M. T. (2014). Sensory aroma and related volatile flavor compound profiles of different black tea grades (camellia sinensis) produced in northern Vietnam. In S. C. Dominique Valentin, Sébastien Lê, Dzung Hoang Nguyen, & Hervé Abdi (Ed.), *SPISE 2014: From senses to quality-What can sensory evaluation bring to quality control*, (pp. 113-119). VietNam: VNU-HCM Publishing.

Kirsanov, D., Mednova, O., Vietoris, V., Kilmartin, P. A., & Legin, A. (2012). Towards reliable estimation of an "electronic tongue" predictive ability from PLS regression models in wine analysis. *Talanta, 90*, 109-116.

Lin, J., Dai, Y., Guo, Y.-n., Xu, H.-r., & Wang, X.-c. (2012). Volatile profile analysis and quality prediction of Longjing tea (Camellia sinensis) by HS-SPME/GC-MS. *Journal of Zhejiang University. Science. B, 13*, 972-980.

Lin, J., Dai, Y., Guo, Y. N., Xu, H. R., & Wang, X. C. (2012). Volatile profile analysis and quality prediction of Longjing tea (Camellia sinensis) by HS-SPME/GC-MS. *J Zhejiang Univ Sci B, 13*, 972-980.

Lin, J., Zhang, P., Pan, Z., Xu, H., Luo, Y., & Wang, X. (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*, 259-265.

Okinda Owuor, P., Obanda, M., Nyirenda, H. E., Mphangwe, N. I. K., Wright, L. P., & Apostolides, Z. (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*, 644-653.

Olafsdottir, G., Chanie, E., Westad, F., Jonsdottir, R., Thalmann, C. R., Bazzo, S., Labreche, S., Marcq, P., Lundby, F., & Haugen, J. E. (2005). Prediction of Microbial and Sensory Quality of Cold Smoked Atlantic Salmon (Salmo salar) by Electronic Nose. *Journal of Food Science, 70*, S563-S574.

Pripdeevech, P., & Wongpornchai, S. (2013). Chapter 26 - Odor and Flavor Volatiles of Different Types of Tea. In V. R. Preedy (Ed.), *Tea in Health and Disease Prevention*, (pp. 307-322): Academic Press.

Ravichandran, R. (2002). Carotenoid composition, distribution and degradation to flavour volatiles during black tea manufacture and the effect of carotenoid supplementation on tea quality and aroma. *Food Chemistry, 78*, 23-28.

Rawat, R., Gulati, A., Kiran Babu, G. D., Acharya, R., Kaul, V. K., & Singh, B. (2007). Characterization of volatile components of Kangra orthodox black tea by gas chromatography-mass spectrometry. *Food Chemistry, 105*, 229-235.

Rosenfeld, H. J., & Nes, A. (2000). Prediction of sensory quality of strawberry jam by means of sensory quality attributes of fresh fruits. *Journal of the Science of Food and Agriculture, 80*, 1895-1902.

Senthil Kumar, R. S., Murugesan, S., Kottur, G., & Gyamfi, D. (2013). Chapter 4 - Black Tea: The Plants, Processing/Manufacturing and Production. In *Tea in Health and Disease Prevention*, (pp. 41-57): Academic Press.

TCVN5086-90-(ISO3103-1980). (1990). Tea-Preparation of liquor for use in sensory tests).

Toscas, P. J., Shaw, F. D., & Beilken, S. L. (1999). Partial least squares (PLS) regression for the analysis of instrument measurements and sensory meat quality data. *Meat Science, 52*, 173-178.

Yang, Z., Baldermann, S., & Watanabe, N. (2013). Recent studies of the volatile compounds in tea. *Food Research International, 53*, 585-599.

Zhang, Q., Huang, J., & Yu, G. (2008). Prediction of soot–water partition coefficients for selected persistent organic pollutants from theoretical molecular descriptors. *Progress in Natural Science, 18*, 867-872

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USING SENSORY EVALUATION TO FIGHT MALNUTRITION IN MADAGASCAR: FORMULATION OF A SNACK RICH IN ESSENTIAL NUTRIENTS

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ABSTRACT

The aim of this study was to formulate a snack which consumption would contribute to fight against essential nutrients deficiencies in Malagasy children. We identified the principal characteristics that would make a food adopted by the Malagasy population, using focus groups and questionnaires. Based on households' food beliefs and practices, specifications were defined to formulate products associating cassava roots and MO leaf powder that would be accepted by the consumers. Four cassava based snacks were proposed, which varied in MO and sucrose quantities. Hedonic and choice tests were performed with children, which showed that children preferred the sweet product with high MO quantity. The contribution of this snack to recommended dietary intakes were calculated. This strategy is a promising approach to help introducing "new" local and healthy food in households' food repertory.

Keywords: *malnutrition, focus group, questionnaire, formulation, consumer test*

1. INTRODUCTION

Foods that we choose to eat are strong determinants of our health status during our entire lifetime. Inappropriate food practices are generally the reason of inadequate nutrient intakes and necessitate a shift towards healthier consumption patterns. But it is difficult to change completely one's food behavior. A solution is to propose new foods containing a higher nutritional density. Formulation of healthy new food can either come from a demand from the consumers, or be proposed to them in order to change their intakes towards a more nutritious/balanced diet. In this situation, consumers' behavior towards new foods is difficult to predict. In spite of having good nutritional properties, unappreciated products or products not belonging to consumer's food repertory would not be chosen, even by consumers concerned by health. To avoid the rejection of healthier formulated products, consumers' habits and food choice criteria should be taken into account before starting the formulation process.

Food-choice driving parameters were shown to be multiple. They include sensory attributes, post-ingestive sensations and attitudes toward the food, that are linked to various factors, as for instance healthiness, availability and price of the food, but also social environment and psychological factors involving the consumer (Shepherd & Raats, 1996). Most of the time, the respective contribution of all these criteria is unknown. A current drawback of products formulated to improve nutritional intakes is that these products fail to take into account social aspects of eating and the reasons behind peoples' food choices, such as habits, preferences, affordability, circumstance, culture and social norms.

Dietary practices and perceived barriers to healthy eating are regularly studied in developed countries before the formulation process of a new food. But in developing countries, the reasons behind peoples' food choices are not really considered when

proposing products to fight against chronic malnutrition. Undernourishment occurs when a person is not able to acquire enough food to meet the daily minimum dietary energy requirements (FAO). It can lead to various consequences: being underweight for one's age, too short for one's age (stunted), and deficient in vitamins and minerals (micronutrient malnutrition). Moreover, undernourishment reduces resistance to infection, and synergy of malnutrition and infection is the principal cause of morbidity and mortality in developing countries. Malnutrition in developing countries is often thought to result exclusively from scarcity of food, and food choices opportunities are considered inexistent. It is true that food scarcity is the major cause of malnutrition. But sometimes, along with scarcity of food, inadequate food choices worsen the nutritional status of populations. To fight against malnutrition, micronutrient supplements are generally the practical short-term solution, but other strategies could be used to improve nutritional intakes.

Our objective was to formulate a food made of local nutrient resources, which consumption would contribute to fight against essential nutrients deficiencies in children from a developing country, after having identified the principal characteristics that would make a food adopted by children and their parents. Madagascar was a good candidate to lead this study: despite a lot of local natural resources, fifty-three percent of households in rural Madagascar have an insufficient consumption of nutritious foods to maintain an active and healthy life (WFP & UNICEF, 2011). The Malagasy diet does not respect the recommended nutritional balance. The proportion of carbohydrates is extremely high (77% to 79% of the energy supply), while protein and fat consumption is low: about 45g of protein and 20 g of fat per capita per day, while theoretical needs are 56 g of proteins and 77 g of fat (FAO, 2005). Rice is the most consumed staple food in Madagascar. During the lean season (the period between the two rice harvests), the replacement of rice by other staple foods, particularly cassava, frequently worsen the nutritional intakes of the poor Malagasy households.

A solution to improve the diet of children in developing countries would be to focus, not on specific nutrients, but on specific types of food (Semba & Bloem, 2008). To this end, commonly consumed staple foods could be combined with affordable local plants. Protein and essential nutrients rich plants grow in Madagascar, like *Moringa oleifera* (MO), a leaf vegetable containing EAA, PUFA and micronutrients. MO is frequently consumed in other countries but not integrated to Malagasy food repertory. To evaluate whether MO could contribute to fight against essential nutrients deficiencies in Malagasy children, we used a two-step approach:

First, the principal characteristics that would make a food adopted by the Malagasy population were identified, using focus groups and questionnaires.

Secondly, we used the information collected in the survey to develop food products which preparation and consumption corresponded to existing practices. This product acceptance by children was checked by hedonic tests.

2. PART I: STUDY OF FOOD HABITS, ATTITUDES AND BELIEFS OF LOW INCOME HOUSEHOLDS, BY FOCUS GROUPS AND QUESTIONNAIRES

2.1. Material and methods

The study took place in urban and rural areas of two regions of Madagascar. Analamanga is located in the central part of Madagascar and is characterized by a heterogeneous population. Its principal city is Antananarivo, the capital of Madagascar. Diana, the second region, is located in the northern coastal area and is mostly populated by two ethnic populations. Its principal city is Antsiranana.

A combination of focus groups and questionnaires was used to investigate the food practices and belief structures of Malagasy parents of school age children.

2.1.1. Focus group

Seventy-two parents (six to eight participants per group) of children enrolled in public primary school of Analamanga and Diana regions were recruited to participate in the discussions. The recruitment was carried out among low income parents. The age range of the participants was between 19 and 62 years old. Housewives were largely represented in the Focus Groups. Only a few of the participants had been educated beyond primary school. For more details about participants, see Ramaroson Rakotosamimanana *et al.* (2014).

Nine focus groups were held. Each focus group lasted from 75 to 90 minutes. The discussions were

conducted by a moderator in participants' native language (the official Malagasy language for Analamanga and the north dialect for Diana). To access the parents' food practices we first asked them a question on their habits (what are the foods that you frequently consume?) Then, to access their food beliefs structures, we used an association task in which participants were prompted with a stimulus word (nutrition) and were asked to indicate all the words that came to their minds (What comes to your mind when I say nutrition?). Participants were then invited to discuss about the properties they attributed to different staple foods and *Moringa oleifera* leaves.

The audio-recorded discussions of all the focus groups were fully transcribed on the days after discussion. The moderator and the assistants independently analyzed each transcription using the notes taken by the assistants to supplement the tape recordings. The results were then compared and adjusted after consensus had been reached

2.1.2. Questionnaire

The belief structures and food practices that emerged from the focus groups were then validated using a close-ended questionnaire with a larger population.

The questionnaire was administered to 1000 parents (797 women and 206 men) of school age children from different social classes using a face-to-face interview-assisted technique in urban Analamanga (UA), rural Analamanga (RA), urban Diana (UD) and rural Diana (RD). The interviewees' characteristics can be found in Ramaroson Rakotosamimanana *et al.* (2014). The final questionnaire included 31 main questions (29 close-ended, two open-ended questions) as well as 11 socio demographic questions. Survey data were first analyzed by compiling the frequency count for each question in each interviewing area.

2.2. Results and discussion

2.2.1. What is a nutritive food for the respondents?

When asked about their understanding of the word "nutrition", participants in focus groups mainly cited the words "clean", "balanced", satiating", "nutritious", "well cooked", "tasty" and "expensive". The questionnaire showed that among these characteristics the most frequently cited were nutritious (55 to 80% of citation, depending on the area) and clean (46 to 86%), followed by "balanced" (41 to 69%). The high citation frequency of the word "nutritious" shows that the consumption of a sufficient nutrient quantity is a concern for the respondents. The understanding of "balanced" meals by the respondents can be understood as meals providing a variety in nutrients or a different meal each day, or even different recipes using the same ingredients, as showed by a verbatim of a focus group participant: "*I can buy for example vegetables every day, but I modify my way of cooking them*". About a third of the respondents to the questionnaire also cited "well cooked" foods when asked about nutrition. This has to be considered along with "clean" food. These words show the concern of respondents about microbiological quality of food, probably due to the high frequency of food contamination in Madagascar, that have serious health consequences. Finally, the words "Tasty" and "Satiating" were barely cited (between 11 and 42%).

These results show that respondents are informed about nutritional matters. They could be interested in products that help to improve nutritional intakes. Due to their high concern for microbiological risks, they would probably reject raw or not thoroughly cooked products.

2.2.2. Replacement of rice during the lean period

Participants in focus groups indicated that their diet consists mainly of rice: they consume rice up to 3 times a day. 99% of survey respondents eat rice every day, or even two or three times a day for some of them (68% and 27% of respondents). This large consumption of rice certainly explains that in Madagascar, rice provides 53% of energy consumption and 50% of protein consumed (Juliano, 1993). This high consumption of rice is certainly inherited from the Asian food culture, as the first inhabitants of Madagascar, the Austro-Melanesian, were from Asia (Randriamandimby, 1981; Serva, 2012). During the lean season, when rice is not affordable, poor Malagasy households replace it with different carbohydrate foods such as maize, plantain, cassava roots, or pasta. In Analamanga region, pasta and corn are the staple foods most frequently chosen to replace rice. In rural areas, sweet potato, cassava, taro, corn and plantain banana are frequently chosen to replace rice. In urban area of Diana, none of these staple food was cited more than others.

The selection criteria for each of these foods that emerged from the focus groups were price, availability, nutritional properties and "taste". The questionnaire showed that the importance of these

criteria depend on both the food and the geographic area of the respondents. Nutrient content as criteria of choice of staple foods was opposed to availability in the four areas and to price in three areas (Figure 1). The nutrient content was cited as a reason for choosing pasta to replace rice in the four areas. Availability and price were mostly cited by those who choose cassava, sweet potato and breadfruit. Among those three staple, cassava was the most frequently elicited to replace rice.

Cassava is indeed one of the most consumed staple food after rice in Madagascar: between 251 and 430 g per capita (Montagnac, Davis, & Tanumihardjo, 2009). It is recognized to be a "shock absorber" food for less advantaged households, during the lean period (Dostie, Haggblade, & Randriamamonjy, 2002). Cassava roots are most frequently consumed by poor households than richer households. In our study, 41% of households with a monthly income below US$ 22 stated replacing rice with manioc roots, against only 17% of households with a monthly income of over US$ 220. It is also mostly consumed in rural areas, probably because people grow it, as revealed during the focus groups: "*Cassava root are expensive in the market, so we grow cassava in our field*". It is striking that in our study cassava is at the same time the food the most chosen for availability and price, the less selected for its nutrient content and not particularly cited for its taste (Figure 1). Moreover, respondents describe cassava roots as inducing stomachache and teeth bleeding, and to have a decalcifying effect (Figure 2). They also consider cassava roots as not providing much micronutrients and not a good way of diversifying meals. The only positive characteristic attributed to cassava roots is their satiating properties. Among the cheap and available staple foods that can replace rice during the lean season, cassava is the most consumed, despite its poverty in nutrients well known by consumers. For this reason, we decided to focus on cassava products for the rest of the study.

It would probably be useless to encourage poor Malagasy households to replace cassava roots by other foods for nutritional reasons: they are fully aware of the low nutritional interest and the anti-nutritional properties of cassava roots but still, they go on eating cassava. A more promising solution would be to propose other ways of consuming cassava to overcome the lack of nutrients. As availability appears to be an important criterion of choice, followed by price, the proposed recipes should be based on available and cheap ingredients.

2.2.3. Food practices concerning cassava roots

To go further, we needed to investigate the food practices and habits of respondents concerning cassava roots. Figure 3 shows the ingredients most often associated with cassava by respondents. The most frequently added ingredient is sugar. This food practice is not in favor of a balanced diet, because cassava is itself almost exclusively composed of carbohydrates.

Ingredients that could compensate the poor nutritional value of cassava are rarely associated to it (peanut and leaf vegetables, for example). These results show that despite relatively good nutritional representations, poor Malagasy people have food practices that do not favor dietary balance. To formulate a well-accepted healthier food, these habits should be taken into account. A recipe associating sweet cassava and a nutritive ingredient could be a good option.

2.2.4. Representations and food practices concerning Moringa oleifera leaves

We decided to associate to cassava roots a nutritive and affordable local plant, *Moringa oleifera* (MO). MO is a wild plant which leaves are rich in vitamins, amino-acids, ω3 fatty acids and iron (Thurber & Fahey, 2009). This plant grows well in the Madagascar climate. It was introduced in the northern coastal areas of Madagascar, at the beginning of the twentieth century (Foidl, 2001). It did not spread to the central regions of the country until recently, when the National Office for Nutrition heightened awareness in the population about its nutritional benefits (ONN, 2008). MO is widely eaten and highly valued in other countries like India, where numerous recipes contain MO leaves. Yet, the consumption of these leaves is rather low in Madagascar.

Focus groups revealed that mixing cassava roots and MO leaves is not a current practice in the studied areas. Respondents eventually consider eating cassava roots and MO leaves in the same meal but prepared separately, in distinct recipes.

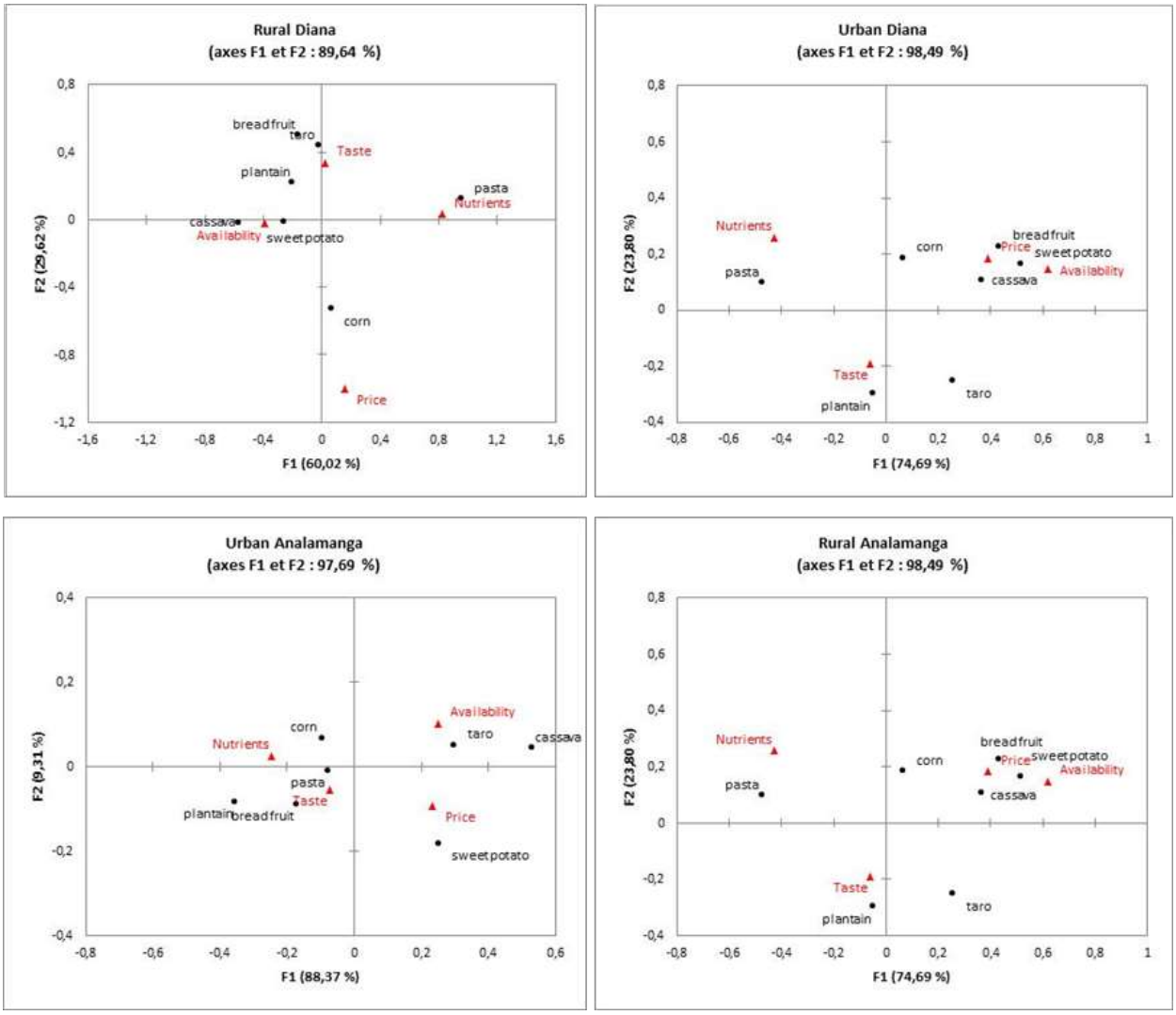

Figure 1. Correspondence analyses showing the reasons of choice of different staple foods to replace rice during the lean season in the four studied areas.

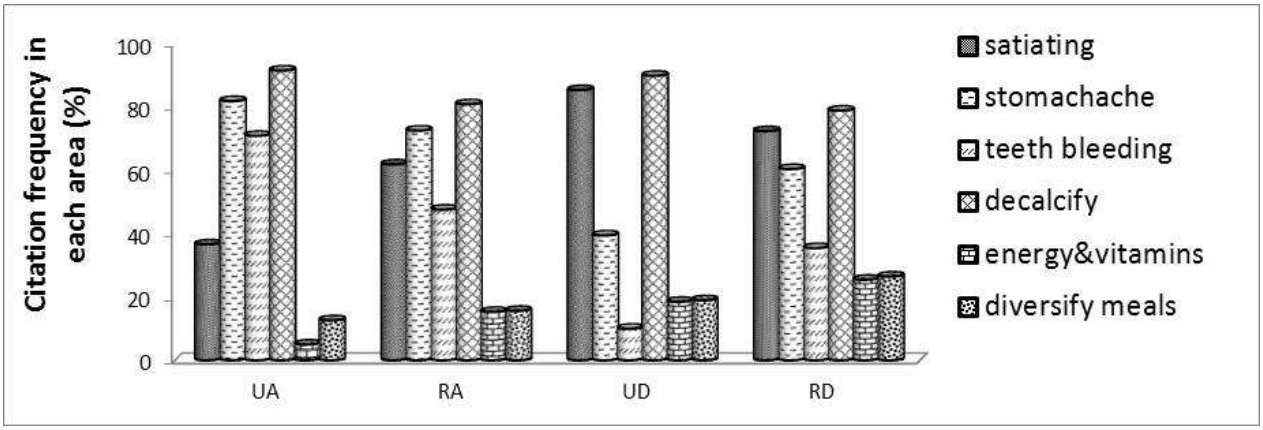

Figure 2. Principal characteristics of cassava roots related to nutrition and health, according to parents of Malagasy school age children, in the four studied areas (AU: Analamanga, urban, AR: Analamanga, rural, DU: Diana, urban and DR: Diana rural).

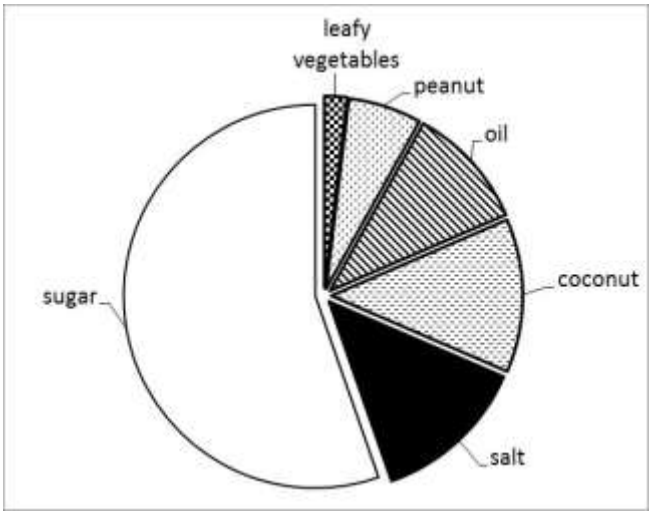

Figure 3. Ingredients frequently consumed with cassava roots (sum of the answers of the respondents of the four areas).

The survey revealed that 18% and 30% of respondents from UA and RA respectively were not familiar with MO leaves, while almost all respondents from Diana were (Figure 4a). In each area, those who had already heard about MO were asked about its characteristics. In the four areas, at least 60% of those who had heard about MO knew that it brings nutrients and at least 40% cited its curative properties.

A proportion of 98.5% and 100% of respondents from RD and UD had already eaten MO, versus only 40% and 29% in Analamanga urban (UA) and rural (RA) respectively (Figure 4b). Those who had already eaten MO were asked about the ingredients they frequently consume with MO (Figure 5).

MO leaves are mostly eaten salty, particularly in Diana (Figure 5). In Analamanga households, respondents also reported eating them with oil. In Diana, about a quarter of households eat MO with other leafy vegetables. MO leaves are seldom eaten with coconut, sugar and peanut.

During the focus groups, respondents from Diana, who know MO well, underlined its strong odor as a limiting factor to its consumption. This strong odor could origin from the way MO is usually consumed. So it would be interesting to propose another way of consuming it.

Based on the results of the focus groups and questionnaire, it was decided to formulate sweet products associating boiled cassava and MO, first to increase the palatability of these products for children, who are known to like sweet products, and secondly to correspond to the way cassava is generally eaten while introducing a new way to consume MO.

Such a product could be a good way for new MO consumers to learn its aroma and make them like it. It was showed that consumers exposed to a novel food product experience flavor–flavor learning and flavor–nutrient conditioning (Prescott, 2012; Yeomans, Leitch, Gould, & Mobini, 2008). Indeed, while the initial exposure to a new aroma may or may not provoke a strong sensory liking of disliking, the emotions to taste are innate (Steiner, Glaser, Hawilo, & Berridge, 2001). Sweetness has a strong hedonic valence, and repeated pairing of a novel aroma that was initially neutral with a liked sweet taste produces a transfer of perceptual properties, leading to a change in the hedonic character of the aroma. Associations between the flavor and post-ingestive consequences are also learned. They lead to a greater liking and desire-to-eat products whose flavor was paired with a high energy density product during a previous exposure (Brunstrom & Mitchell, 2007). A synergy between flavor–flavor learning and flavor–nutrient conditioning was also suggested, leading to an important liking of flavors previously associated to sweet food with high energy density. Considering these data, a snack associating cassava and MO leaves and having a sweet taste could induce a liking of MO leave flavor, which in turn could lead to an increased consumption.

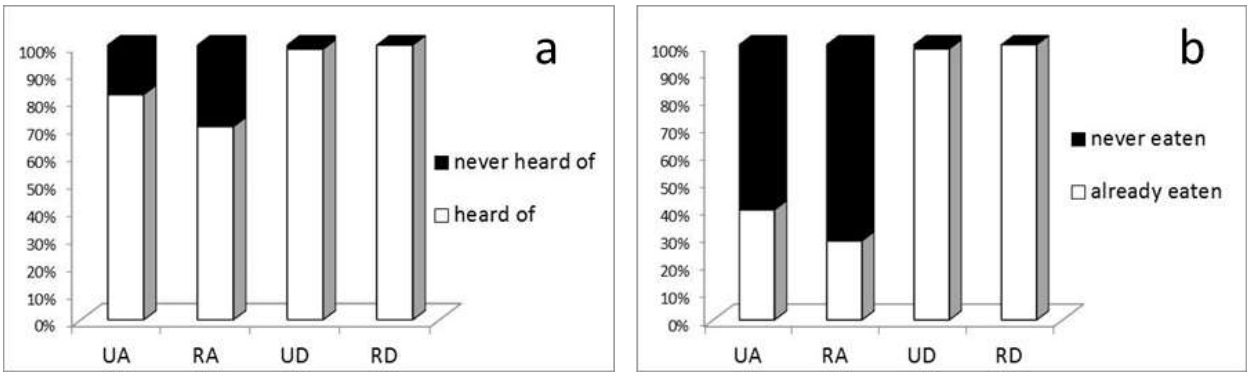

Figure 4. Proportion of respondents who had already heard of (a) and eaten (b) *Moringa oleifera* leaves

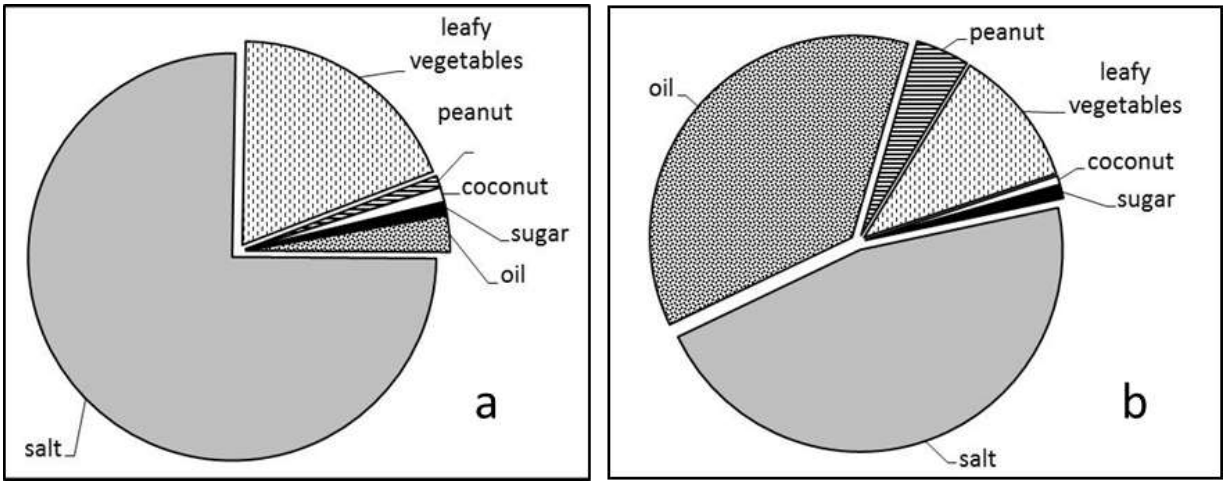

Figure 5: Ingredients frequently consumed with cassava roots a: in Analamanga (sum of the answers of RA and UA, n = 163) and b: in Diana (sum of the answers of RD and UD, n = 397).

3. PART II: FORMULATION OF A SNACK AND STUDY OF ITS SENSORY ACCEPTABILITY

3.1. Materials and methods

3.1.1. Products

Three products, made with cassava roots, MO leave powder and sugar in different proportions (Table 1) were formulated (for more details about the formulation process, see Rakotosamimanana *et al.* (2015)). Fresh cassava roots were purchased at the local market. They were grated and mixed with the other ingredients. MO leaves were from Antananarivo. They were sun-dried for 48-96 h, following a standard practice in Madagascar, then ground to powder.

Table 1: Ingredients in the three formulations (in percentages w/w). MO: *Moringa oleifera* leaf powder. C: Cassava

	C roots	*MO*	Sugar
C - MO [C1]	99.4	0.6	0
C - MO [C1] - sugar	89.4	0.6	10
C - MO [C2] - sugar	88.8	1.2	10

The mixture was cooked for 45 min in a steam cooker. The mixture was cooled to room temperature and samples of about 25 g were distributed in 25 mL glasses. The tests took place less than three hours after cooking the samples.

3.1.2. Assessors and localization

A total of 424 children between the ages of six and 13 participated in the hedonic tests (67 girls and 52 boys in AU, 62 girls and 38 boys in AR, 54 girls and 47 boys in DU, and 60 girls and 42 boys in DR). Sessions were conducted in four public schools located in four neighborhoods.

3.2. Procedure of hedonic tests

Each child participated in one session and tasted the four samples which were presented in a sequential monadic design according to a Williams Latin square. They were asked to score their overall liking on a seven-point pictorial scale. At the end of the test, children chose one of the products as a reward for their participation in the test.

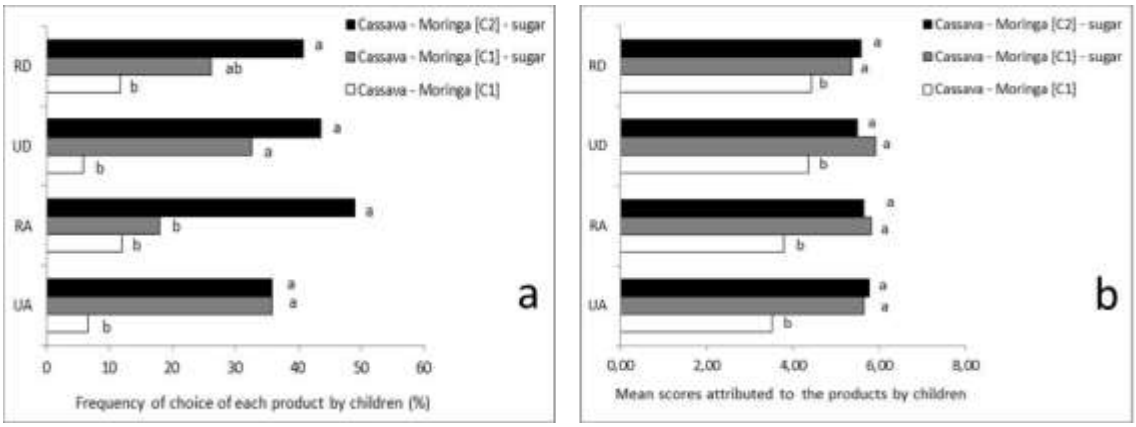

Figure 6 a) Scores given to the tested products during acceptance tests, in the four areas. A score of 1 corresponds to a product extremely disliked and a score of 7 to a product extremely liked. b) Products chosen by children as a reward (%) in the four areas. In each area, means with the same letter are not significantly different.

To ensure they did not choose on the basis of the quantity remaining in each sample, they were given takeaway samples especially prepared, and not the samples used for the test. The test was performed in the native language of each location during snack time before lunch. Children had not eaten for at least two hours before the test.

3.3. Data analysis

Hedonic scores from the four panels were submitted to a two-way ANOVA with the following mixed model: Score = assessor area + product + product × area + *error*. Whenever a significant effect of product was found a NeumaneKeuls (SNK) multiple comparison test was performed to reveal significant differences among the four products. XLStat 2013 (Addinsoft, Paris) was used for data analysis.

Choice data were analyzed by recording the number of children who chose each product as a gift at the end of the test in each area. A χ^2 test was performed to check for area effects. Whenever a significant difference was found, the Marascuilo procedure was used to explain the difference.

4. RESULTS AND DISCUSSION

Results in Figure 6 clearly show that in all areas sugar allowed to enhance the liking of the products containing cassava roots and MO leaves. Both liking test and choice test show that sweet products were well accepted, regardless of the quantity of MO they contained. In urban areas no difference was observed in sample choice between the two MO concentrations in the sweet samples which were chosen much more often than the unsweetened one. In rural areas children a clearer preference appears for the samples with the highest concentration of MO, especially for RA.

A snack of 250 g containing 1.2% of MO provides at least 9% of recommended dietary allowance (RDA) for essential amino acids (up to 27% for Trp) for a child of 15 kg, and respectively 19%, 7%, 4.5%, of RDA for alpha-linolenic acid (ALA), calcium and magnesium. This product would be an improved alternative to the sweet cassava that Malagasy are used to consume during the lean period.

5. CONCLUSION

In this study, food representations and habits of poor Malagasy households were considered to formulate a healthier food which consumption could replace the staple foods consumed during the lean season.

Our suggestion was to propose a food containing cassava and MO leaves. Sweet products formulation was well accepted by children and could be suggested to parents as a snack which both satiates and provides their children with more essential aminoacids and ALA than the foods containing cassava only. A score of 1 corresponds to a product extremely disliked and a score of 7 to a product extremely liked. b) Products chosen by children as a reward (%) in the four areas. In each area, means with the same letter are not significantly different.

ACKNOWLEDGMENTS

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Abbreviations: PUFA: Poly-Unsaturated Fatty Acids; EAA: Essential Amino Acids; Trp: Tryptophan

REFERENCES

Brunstrom, J. M., & Mitchell, G. L. (2007). Flavor-nutrient learning in restrained and unrestrained eaters. *Physiology & Behavior*, 90, 133-141.

Dostie, B., Haggblade, S., & Randriamamonjy, J. (2002). Seasonal poverty in Madagascar: Magnitude and solutions. *Food Policy*, 27, 493-518.

FAO. (2005). Madagascar, Plan d'action national pour la sécurité alimentaire. In: Département de la coopération technique. FAO.

Foidl, N., Makkar, H.P.S., & Becker, K. (2001). The potential of Moringa oleifera for agricultural and industrial uses. In *What development potential for Moringa products*. Dar Es Salaam.

Juliano, B. O. (1993). *Rice in human nutrition.* (Vol. 26): FAO & IRRI.

Montagnac, J. A., Davis, C. R., & Tanumihardjo, S. A. (2009). Nutritional value of cassava for use as a staple food and recent advances for improvement. *Comprehensive Reviews in Food Science and Food Safety, 8*, 181-194.

ONN. (2008). Ananambo: la plante "miraculeuse". *Hetsoro Ainga Vao, 9*, 25-34.

Prescott, J. (2012). Chemosensory learning and flavour: perception, preference and intake. *Physiology & Behavior*, 107, 553-559.

Ramaroson Rakotosamimanana, V., Arvisenet, G., & Valentin, D. (2014). Studying the nutritional beliefs and food practices of Malagasy school children parents. A contribution to the understanding of malnutrition in Madagascar. *Appetite, 81*, 67-75.

Ramaroson Rakotosamimanana, V., Valentin, D., & Arvisenet, G. (2015). How to use local resources to fight malnutrition in Madagascar? A study combining a survey and a consumer test. *Appetite,* 95, 533-543.

Randriamandimby, B.-J. (1981). Convergences culturelles à Madagascar. *Hiratra, 3*, 133-151.

Semba, R. D., & Bloem, M. W. (2008). *Nutrition and health in developing countries* (Second Edition). NJ, USA: Humana Press.

Serva, M. (2012). The settlement of Madagascar: What dialects and languages can tell us. *PloS ONE,* 7, 1-6.

Shepherd, R., & Raats, M. M. (1996). Attitudes and beliefs in food habits. In H. L. Meiselman & H. J. H. MacFie (Eds.), *Food choice, acceptance and consumption*. Grande Bretagne: Blackie Academic & Professional, pp. 346-362.

Steiner, J. E., Glaser, D., Hawilo, M. E., & Berridge, K. C. (2001). Comparative expression of hedonic impact: affective reactions to taste by human infants and other primates. *Neuroscience & Biobehavioral Reviews,* 25, 53-74.

Thurber, M. D., & Fahey, J. W. (2009). Adoption of Moringa oleifera to combat under-nutrition viewed through the lens of the "Diffusion of innovations" theory. *Ecol Food Nutr,* 48, 212-225.

WFP & UNICEF. (2011). Rural Madagascar Comprehensive Food and Nutrition Security and Vulnerability Analysis..

Yeomans, M. R., Leitch, M., Gould, N. J., & Mobini, S. (2008). Differential hedonic, sensory and behavioral changes associated with flavor–nutrient and flavor–flavor learning. *Physiology & Behavior,* 93, 798-806.

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FROM SENSORY EVALUATION TO FOOD PRODUCT DEVELOPMENT: HOW TO FIT A NEW VEGETAL FERMENTED PRODUCT TO THE CONSUMER TASTE

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ABSTRACT

We present a series of studies showing the role of sensory evaluation in the optimization of new vegetal fermented products. The first series of studies showed that French consumers did not accept fermented products with vegetal protein ratio over 10%. Moreover, positive information on vegetal protein benefits did not lead to an increase in liking scores. So, a second series of studies was carried out in order to optimize the raw material and processes used to prepare the products and improve their organoleptic properties. In a first step, the vegetal proteins were purified permitting to obtain firmer products with less off flavors. In a second step, the effect of four factors (T °C, pea concentration, heat process, heat fermentation) with two variation levels each was evaluated following a design of experiment methodology. The volatile and peptide profiles, acidity and firmness of the products were evaluated in order to select the optimal process and starter culture. A combination of Check-All-That-Applied (CATA) and consumer tests was then used to evaluate consumer appreciation.

Keywords: *CATA, consumer test, QDA, vegetal protein, fermentation*

1. INTRODUCTION

Due to the worldwide population increase, the production of proteins for feeding people and the quality of these proteins to satisfy the needs of humanity could become major issues in the future decades. Indeed, it is currently acknowledged that a global change towards a diet consisting mainly of vegetal products would have positive impacts both on the environment and public health (Esnouf, Russel, & Bricas, 2013). The development of new foods optimizing protein intake from vegetal origin seems to be a promising solution. Many problems have been identified following the incorporation of vegetal proteins in our food. The limiting factor in achieving more consumption of vegetal protein is the difficulty of changing dietary habits (Rozin, 1996). Products derived from vegetal raw materials are rich in off-flavors (*e.g.* vegetal taste, chalky) and are characterized by a high astringency and bitterness (Torres-Penaranda, Reitmeier, Wilson, Fehr, & Narvel, 1998). The vegetal off-flavors are developed by lipoxygenase, which essentially produces aldehydes, ketones and alcohols (Schindler *et al.*, 2012). These off-flavors generally result in a refusal of consumers whether they are familiar with vegetal protein products or not (Tu, Husson, Sutan, Ha, & Valentin, 2012; Tu, Valentin, Husson, & Dacremont, 2010). Fermentation by microorganisms appears to be a suitable solution to tackle those drawbacks. Lactic acid fermentation could help to reduce or mask vegetal off-flavors (Schindler *et al.*, 2012) but other barriers, related to the fermentation, could limit the acceptability of plant-based fermented foods. Substitution of cow milk by vegetal protein, for example, leads to a more fragile coagulum and so to a lesser degree of firmness or "hardness" (Lee & Marshall, 1979; Lu, Schmitt, & Chen, 2010). Also, lactic fermentation could cause the formation of bitter peptides (Lemieux & Simard, 1992).

The aim at this study is to fit a new vegetal fermented product to the consumer taste. First, a consumer test was used to check the acceptability of fermented pea-milk product. The effect of adding

sugar as well as positive health and environmental messages on the acceptability was investigated. Then, the capacity of ten starter cultures was tested using rheological measures and quantitative descriptive analysis (QDA) to improve the sensory and physico-chemical characteristics of a series of fermented pea-milk products. Finally, one starter culture was selected to ferment six mixtures of cow-pea milks, and the obtained products assessed by Check-All-That-Apply method and a consumer test.

2. CONSUMER FEEDBACK ON NEW FERMENTED PEA-MILK PRODUCT

2.1. Preparation of samples

Using skim milk powder purchased from Régilait (Saint-Martin-Belle-Roche, France) and pea protein isolate Nutralys® S85F supplied by Roquette (Lestrem, France), cow and pea milks were prepared at the same protein concentration (4.5 g/L). Lactose, calcium and citrate levels were also balanced in the two milks. Before the incubation with starter culture for homemade yogurt production (*Streptococcus thermophilus* and *Lactobacillus bulgaricus*) obtained from Alsa (Rueil-Malmaison, France), the cow milk was heated in a water bath at 90 °C for 10 minutes, and the pea milk was autoclaved at 110 °C for 10 minutes. When the two milks temperature returned to about 42 °C, they were mixed according to the needed concentrations, inoculated and then incubated at 42 °C for 4-6 hours. Six fermented products with different pea protein concentrations (0, 10, 20, 30, 40 and 100%) were prepared and stored for 24 hours at 4 °C.

2.2. Sensory test

A panel of French consumers has evaluated the six fermented products. This panel consisted of 75 participants recruited during a public scientific event ("Nuit des chercheurs") in the University of Burgundy. The consumers tested the samples under red light in a classroom with enough separation between the tables to avoid any communication between the participants during the test. For each panelist, about 10 g of each sample were served in a white plastic cup coded with a random three-digit number. The six samples were presented at the same time. Bottled water was provided to cleanse the palate. Panelists had to rate overall liking as well as, appearance, odor, taste and texture acceptability on hedonic scales going from 1 (I do not like at all) to 7 (I like very much), with 4 being anchored as neither like or dislike.

2.3. Results and discussion

A Student Newman-keuls mean comparison test showed that the presence of pea protein even in the lowest concentration (10%) reduced the overall acceptability of yogurts (Table 1). The average liking score move from the neutral zone for fermented cow milk (0%) to the negative one for the products that contained pea protein. The overall liking decreases as a linear function of increase in pea concentration.

Figure 1 shows the average liking scores obtained for visual appearance, taste, odor and texture. The products with higher concentration were less appreciated for all the characteristics. Taste followed by odor seems to be the most problematic dimension of the products as negative average score can be observed starting with 10% for taste and 20% for odor. Appearance and texture remain in the neutral area up to 40% and 30% respectively.

2.4. Conclusion

Sensory test results suggest that replacing animal by vegetal protein will not directly lead to an acceptable product but that further optimizations taking the product in its integrality are needed.

3. ADDING SWEETENERS & THE EFFECT OF HEALTH AND ENVIRONMENTAL INFORMATION ON THE APPRECIATION OF THESE NEW PRODUCTS

3.1. Experimental design

A set of 25 fermented pea-milk products was obtained using a design of experiment with four factors (pea, sucrose, FOS, and cream) and three levels of variation.

Eight semi-trained panelists assessed the 25 products on a list of descriptors obtained from previous studies on an unstructured scale. They also rated the quality of the products on a 5-point quality scale. Four products with a medium quality were then selected to evaluate the effect of information on consumers' acceptability judgment.

Table 1. Mean scores of overall acceptability as a function of pea concentration - Means with different superscript letters are significantly different (Student Newman-Keuls test, $p < 0.0001$). 7-point scale (1: I do not like at all – 7: I like very much)

0%	10%	20%	30%	40%	100%
4.51[a]	3.65[b]	2.68[c]	2.32[c,d]	2.11[d,e]	**1.80**[e]

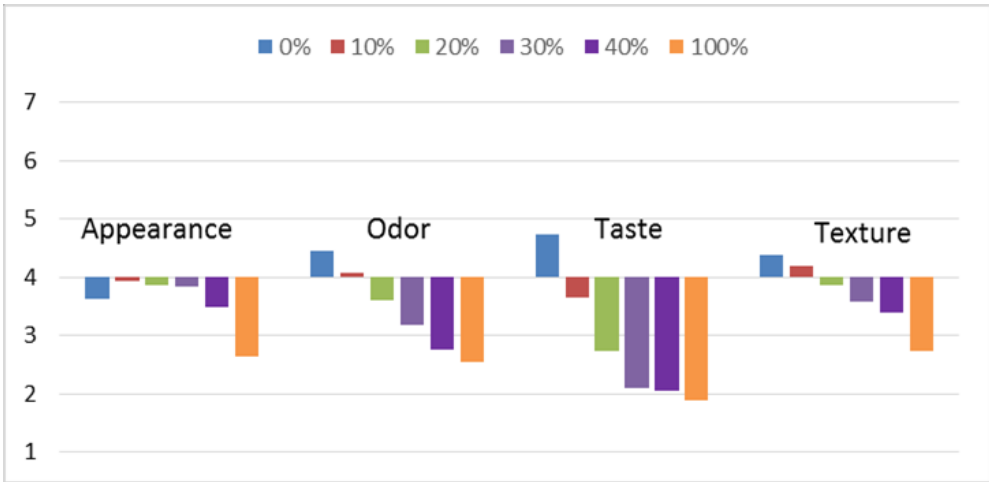

Figure 1. Means of liking scores for visual appearance, taste, odor and texture assessed on hedonic scales ranging from 1 (I do not like at all) to 7 (I like very much), 4 (neither like nor dislike).

3.2. Preparation of samples

Two "cow and pea" milks were prepared and fermented as previously mentioned with two concentrations (20 and 40%) of pea protein. Two sucrose levels (6 and 9 g/100 mL) were added after the fermentation to each gel. The products were stored at 4 °C for one day before the sensory session.

3.3. Sensory test

Fifty-eight consumers aged from 18 to 72 years participated in the sensory test (25.9% males and 74.1% females). All participants consume yogurt at least once a week. The test was conducted in two sessions in the same classroom in AgroSup Dijon. The test was carried out under white light. In the first session, the panel assessed the four products on a hedonic scale from 1 (I do not like at all) to 9 (I like very much). The samples were served in a white plastic cup, coded with a random three-digit number, but without any labels or another information. In the second session, the same samples were presented in a sequential monadic design according to a Williams Latin square, but in labeled cup this time. These labels included health or environmental information and pea protein concentration. The panelists were divided into two groups (29 in each of them) to randomize the selected messages as described in Table 2. All participants received and scored two samples with environmental messages and two samples with health messages.

3.4. Results and discussion

Globally, without information, yogurts containing 20% pea milk are more appreciated by participants than those containing 40% pea as the vegetal character is less marked (Figure 2). However, only yogurts containing 20% pea milk and 9 g/100 mL sucrose obtained a positive score (*i.e.* above 5).

A three-way ANOVA with participant as random factor and information and pea concentration as fixed factors showed no main effect of the presence of a message on the liking score. However, an interaction between information and pea concentration was observed: A significant effect of information was observed only in the health message condition for the product with 20% of pea protein and 9 g/100 mL of sucrose. However, this effect was in the opposite direction than the expected one: the health message decreased the liking of the fermented product. This might be due to the inconsistency between the message and the high concentration in sugar.

3.5. Conclusion

The presence of sucrose has improved the acceptability of products with 20% pea protein but not the acceptability of products with 40% pea that remains in the negative zone. On the other hand, neither the environmental nor the health messages had a positive impact on the acceptability of the products.

This result could be due to the fact that the sweet taste is in contradiction with the health message delivered with these products suggesting that adding sugar is probably not the best solution to improve the acceptability of plant-based fermented products. Another possibility is to increase consumers' acceptability by screening lactic acid bacteria with specific characteristics.

Table 2. The selected products with the messages used for each group of panelists

Sample	1st group of panelists	2nd group of panelists
S.15 - 40% pea - 6 g/100 mL sucrose	Respect the environment	Low in cholesterol
S.21 - 40% pea - 9 g/100 mL sucrose	Source of vitamins and minerals	Ecological yogurt: locally produced
S.18 - 20% pea - 6 g/100 mL sucrose	Ecological yogurt: locally produced	Source of vitamins and minerals
S.23 - 20% pea - 9 g/100 mL sucrose	Low in cholesterol	Respect the environment

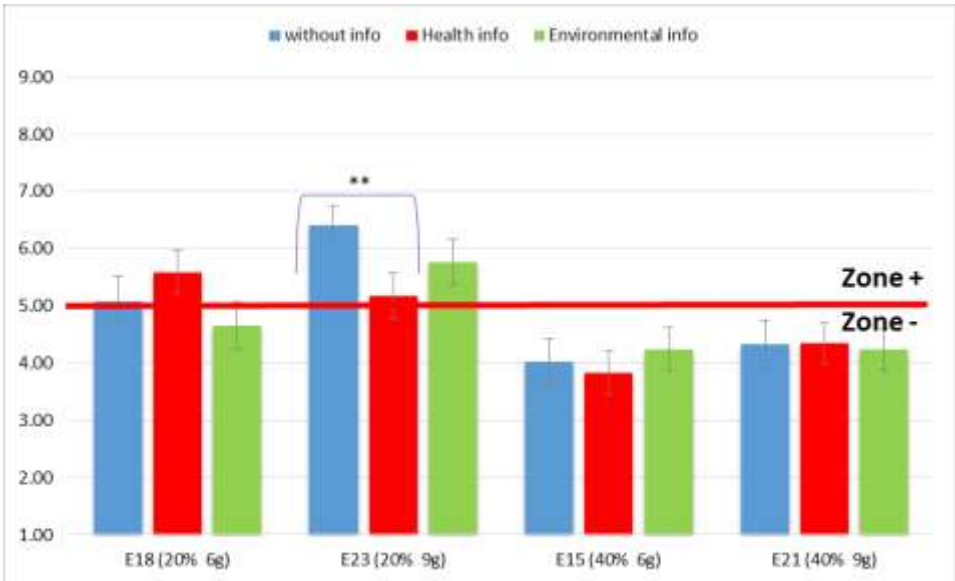

Figure 2. Comparison of means overall acceptability score for the four tested products, with and without health or environmental information - ** $p < 0.01$

4. SCREENING OF DIFFERENT STARTER CULTURES FROM LACTIC ACID BACTERIA

4.1. Preparation of samples

The two "cow and pea milks" were prepared and fermented as previously mentioned. Five concentrations of pea protein in cow milk (0, 10, 20, 30 and 40%) were prepared, inoculated with ten starter cultures (Table 3) "10^7 CFU/mL of each lactic acid bacteria" from our laboratory collection, incubated for 24 h at 37 °C and stored at 4 °C till the next tests.

4.2. Instrumental analysis

Changes in pH values during fermentation were determined every two hours at room temperature by means of a calibrated pH electrode and a pH-vision 6071 microcomputer (JENCO Electronics LTD, Shanghai, China). Titratable acidity was determined according to the Dornic degree (D°) method which quantifies the lactic acid present in dairy products (Robinson & Wilbey, 1998). The syneresis "degree of whey separation" was determined according to a siphon method (Amatayakul, Sherkat, & Shah, 2006). Rheological characteristics (i.e. firmness, consistency, cohesiveness and viscosity/consistency index) were evaluated by Texture Analyzer TA.HD plus (Stable Micro Systems, Godalming, England) with Exponent software version 6,1,7,0. This measurement was performed by means of a single compression test, using a 5 Kg-load cell with a return distance of 85 mm, a test speed of 1.00 mm/sec, a trigger force of 0.010 N and 9 mm as distance of penetration. The probe used was a cylindrical probe of 10 mm diameter. From the curve, the focus was on one value representing "Firmness": maximum force value.

4.3. Quantitative descriptive analysis (QDA)

Ten training sessions were conducted with 12 panelists selected for their ability to detect tastes and odors in fermented pea milk as well as their verbal fluency. Two sessions were carried out to generate a preliminary list of attributes based on five samples selected from the set of 50 experimental

products. This list was then reduced, based on the ISO 11035:1994 norm (ISO, 1994), to obtain the final list of descriptors. The next four sessions were dedicated to training. Panelists agreed upon definitions, references and procedures for each attribute and were trained to rank different water and yogurt solutions containing substances that conferred the required attributes. In the last three sessions, ten new products were presented in duplicate to determine whether the panel was homogeneous, discriminating and repeatable. Panelists had to rate the intensity of all attributes for each product on a structured interval scale ranging from 1 (low) to 10 (high). After training, ten panelists evaluated the 50 products in duplicate.

4.4. Results and discussion

ANOVA showed that starter cultures, pea concentration and the interaction between them had significant effects on rheological parameters ($p < 0.05$). The results concerning firmness after 14 days of storage at 4 °C are presented in Figure 3. For all starter cultures, the presence of pea milk induced a decrease in firmness. The highest decrease in firmness was observed with the H starter culture in yogurts without pea milk and in those with 40% pea milk at 14 days of storage.

The sensory profiles of the 49 formulated products were compared with the profile of cow milk fermented with a commercial starter (Alsa). The lexicon included three odors (vinegar, earth, vegetal), three aromas (smoked, dairy, pea), three tastes (in mouth: bitter, acid, and sweet), and two mouth feeling (creamy, astringency) attributes. Vinegar, earth, vegetal, astringency, bitter, acid, smoked and pea were regarded as negative descriptors for the overall smell and taste of the fermented product, whereas creamy, sweet and dairy were regarded as positive descriptors. A three-way repeated measurement ANOVA with panelists as a random factor and pea concentrations and starters as fixed factors showed a significant effect of bacteria starters for all descriptors except smoked.

Table 3. List of products. Capital letters label the bacteria cocktail used; numbers indicate pea protein concentration (g /100 g total protein)

Products					Starter Culture
A00	A10	A20	A30	A40	Alsa (*Streptococcus thermophilus* + *Lactobacillus delbrueckii* subsp. *bulgaricus)*
B00	B10	B20	B30	B40	*Streptococcus thermophilus* + *Lactobacillus delbrueckii* subsp. *bulgaricus*
C00	C10	C20	C30	C40	*Streptococcus thermophilus* + *Lactobacillus helveticus*
D00	D10	D20	D30	D40	*Streptococcus thermophilus* + *Lactobacillus rhamnosus*
E00	E10	E20	E30	E40	*Lactobacillus delbrueckii* subsp. *bulgaricus* + *Lactobacillus helveticus*
F00	F10	F20	F30	F40	*Streptococcus thermophilus* + *Lactobacillus acidophilus*
G00	G10	G20	G30	G40	*Lactobacillus delbrueckii* subsp. *bulgaricus* + *Lactobacillus fermentum*
H00	H10	H20	H30	H40	*Streptococcus thermophilus* + *Lactobacillus casei* subsp. *casei*
I00	I10	I20	I30	I40	*Lactobacillus delbrueckii* subsp. *bulgaricus* + *Lactobacillus rhamnosus*
J00	J10	J20	J30	J40	*Lactobacillus rhamnosus*

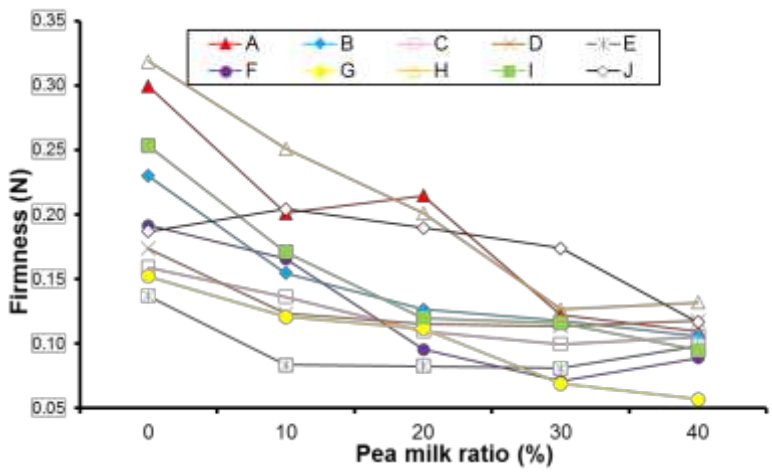

Figure 3. The firmness of products after 14 days of storage at 4 °C, according to the starter culture and the pea protein concentration (g/100 g total protein).

A significant effect of pea concentration was also found for eight descriptors (vinegar, earth, fluid, creamy, acid, smoked, dairy and pea). Among these descriptors, as expected, the intensity of the negative descriptors pea, earth, fluid, vinegar, and smoked increased with pea concentration, whereas the intensity of the positive descriptors creamy and dairy decreased with pea concentration. In addition to these main effects, significant interactions between starter culture and pea concentration were found for all descriptors except dairy and vegetal. An effect of pea concentration was observed for five negative descriptors (earth, smoked, pea, acid and fluid) as well as for one positive descriptor (creamy) for most starter cultures. As for the other descriptors (vinegar, bitter, sweet and astringent), we observed a pea concentration effect in only a small number of starter cultures. A principal component analysis (PCA) was performed on the average intensity of all descriptors. Fig 4 represents the first two PCA dimensions that explain 61.36 % of the total variance. The products up to 30% of pea protein fermented with starters A, B, F and H have positive attribute (sweet) without negative descriptors (astringency, acid, and bitter).

4.5. Conclusion

The partial substitution of milk protein with pea protein did not enhance the physico-chemical characteristics of the dairy gels studied. In order to improve the firmness of these fermented products, a study on the procedure of preparation that may favor the interactions between pea and milk proteins must be performed. Whatever the strain, the intensity of five negative descriptors increased with the pea protein ratio. In these conditions, the products composed of more than 20 g pea protein/100 g total protein were far removed from the sensory profile of conventional yogurts. Considering the sensory characteristics, four starter cultures (A, B, F and H) seem promising for the production of fermented product "yogurt type" with pea proteins. The starters A & B are the same cocktail of bacteria, so the starter A was selected along with F and H for further optimization of milk heat treatments, temperature of fermentation and pea protein state.

5. OPTIMIZING PROCEDURES AND RAW MATERIAL

5.1. Experimental design

Four factors with two variation levels for each were studied using a two-level experimental design. Dairy-vegetal gels were made by changing two different levels of pea protein substitution ratio in cow milk (20% and 40%), milk heat treatment (90 °C and 110 °C), blend of pea proteins in milk (before or after heat treatment) and incubation temperature (37 °C or 42 °C).

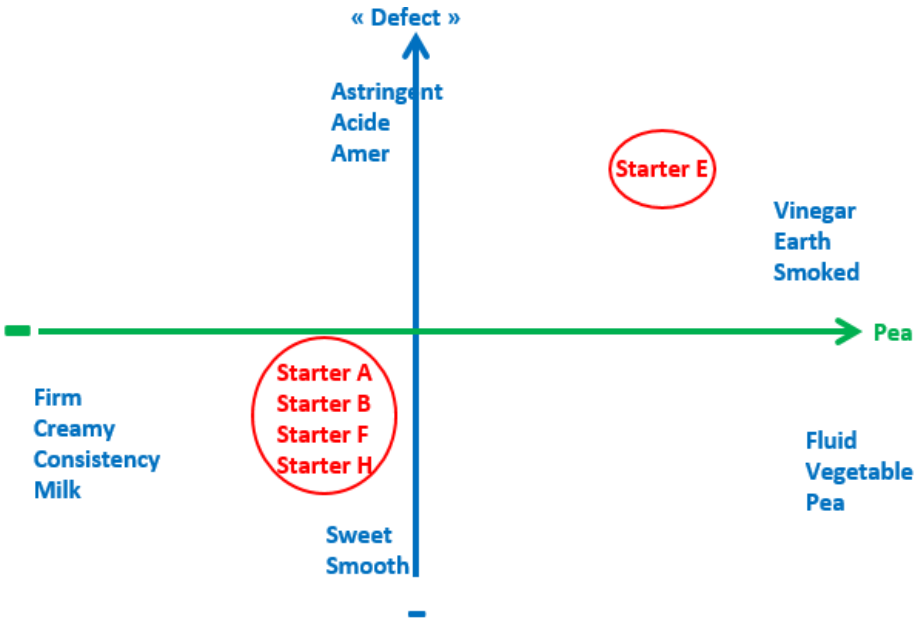

Figure 4. Illustration of the result of principal component analysis performed on all the attributes by product matrix. - (Yousseef et al., Lubbers, Husson, & Valentin, 2014)

5.2. Preparation of samples

First, using skim milk powder purchased from Régilait (Saint-Martin-Belle-Roche, France) and pea protein isolate Nutralys® S85F supplied by Roquette (Lestrem, France), cow and pea milks were prepared at the same protein concentration (4.5 g/L). Lactose, calcium and citrate levels were also balanced in the two milks. A total of 21 products were formulated. Sixteen products were formulated following the design of experiment. An additional center point sample was also formulated using intermediate conditions (30% pea protein, heat treatment 100 °C, half quantity mixed before heating and the rest after heating, incubation at 39.5 °C). For further comparisons, four other samples were prepared: 100% cow milk heated at 90°C, incubated at 37 °C or 42 °C and 100% pea milk heated at 90 °C, incubated at 37 °C or 42 °C. Two grams of lyophilized lactic acid bacteria for homemade yogurt production were added directly to one liter of milk (two milks mixture in our case) according to product instructions. Different inoculated mixtures were sampled in plastic flasks (40 mL in 45 mL flasks) and incubated for 24 h, either at 37 °C or 42 °C. The samples were stored for 24 h before doing any analysis.

Second, pea milk from suspension of globular pea protein extracted in our laboratory according to Nguyen *et al.*, (2014), was obtained by diluting the obtained suspension to the needed concentration (45 g/L). Then this pea milk fermented with Alsa for 24 h at 37 °C and compared to pea milk from industrial isolate fermented in the same conditions.

5.3. Instrumental analysis

The acidity (measured with pH meter), Dornic degree, syneresis and texture (measured with TA.XT2i Texture Analyzer) were evaluated for all the resulting products. The amounts of two aroma compounds: hexanal and 1-hexanol, markers of pea flavor, were determined using SPME-GC-MS in the gels of fermented laboratory and industrial isolates.

5.4. Results and discussion

Regarding Dornic degree (Figure 5A), the greatest changes were observed when the fermentation temperature changed from 37 °C to 42 °C. The fermentation at 42 °C has significantly increased the amount of the produced lactic acid that is probably due to growth, survival and activity optimal for the used starter culture at 42 °C. The other factors affecting the value of Dornic degree according to their importance are as follow: the pea concentration in milk, the heat treatment conditions and finally the moment of mixing the two milks (Figure 5A).

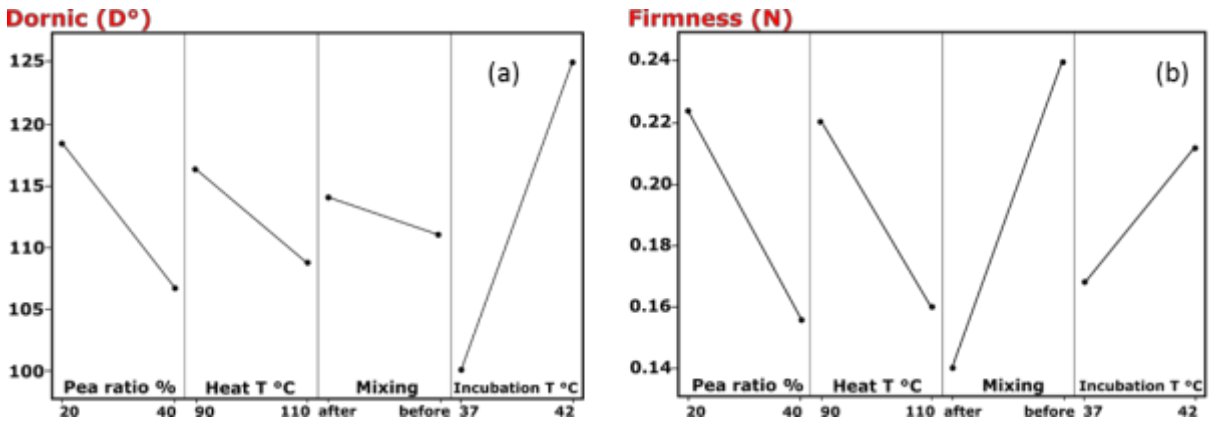

Figure 5. Main effect for (a) Dornic degree and (b) firmness obtained from the experimental design.

Table 4. Industrial and laboratory protein isolates fermented with a starter culture of yogurt (Alsa). Values of firmness, syneresis, hexanal and 1-hexanol - Different letters in one column are significantly different.

	Firmness (N)	Syneresis (%)	Hexanal (peak air)	1-Hexanol (peak air)
S85 F Isolate	0.32±0.01[a]	0.75±1.40[a]	3.88E+06 ± 0.28E+06[a]	2.71E+07±0.21E+07[a]
Laboratory Isolate	0.10±0.01[b]	1.60±0.50[b]	2.24E+06 ± 0.14E+06[b]	1.68E+07±0.08E+07[b]

The four technological studied factors induced a significant effect on the firmness of the gels (α = 5%). Mixing the two milks before heat treatment increased the firmness of gels to the highest level; that could be due to the formation of a primary interaction between the vegetal and animal proteins before fermentation. The next three factors affecting the firmness in order of importance were as follow: the pea amount, the heating temperature and the incubation temperature (Figure 5B).

Laboratory isolate of pea globulin fermented with traditional yogurt bacteria resulted in gels with firmness value about three times higher than that of the fermented industrial isolate. Also, using laboratory isolate reduced the amounts of syneresis, hexanal and 1-hexanol as showed in Table 4.

5.5. Conclusion

Using a simple optimization, the most favorable conditions were to mix cow and pea milks before heating at 90 °C, as these conditions yielded products with Dornic degrees between the values obtained for cow milk fermented at 37 °C and 42 °C, and maximized the firmness value. The following studies were carried out using laboratory isolate of pea protein under these two favorable conditions.

6. UNDERSTANDING THE DIFFERENCE AMONG THE STARTER CULTURES AND CHOOSING THE BEST STARTER

6.1. Preparation of samples

Globular pea proteins extracted in our laboratory were diluted to obtain the needed protein concentration (45 g/L). Then, lactose, calcium and citrate were added to the suspension and stirred for 10 minutes. Pea milk was heated in a water bath at 90 °C for 10 minutes. Finally, pea milk was inoculated with three selected starter cultures and incubated for 24 h at 37 °C. The fermented products were stored at 4 °C.

6.2. Instrumental analysis

Aroma compounds (off-flavors and yogurt aroma) were measured by SPME-GC-MS, peptide profiles were determined by RP-HPLC-UV. The tyrosine index (bitterness) and firmness of pea milk fermented by the four bacterial cocktails were measured after 7 and 14 days of storage at 4 °C.

6.3. Results and discussion

A PCA was performed on all variables. Figure 6a and b represent the first two PCA dimensions (76.36 % of total variance). Starter cultures "E and H" resulted in products with the highest values of the index of tyrosine and the highest amount of peptides, suggesting the most potentially bitter products. The starter "A" gave the firmest product, but its ability to reduce the amount of hexanal (off-flavor) is the lowest among the four cocktails. The starter "F" gave the nearest product to traditional yogurt "fermented cow milk", with the higher content of 3-hydroxy-2-butanone (yogurt aroma).

6.4. Conclusion

The cocktail F (*S. thermophilus* + *Lb. acidophilus*) was selected for its ability to increase the firmness of the gel formed as well as its "yogurt type" flavor, and to reduce off-flavors and bitter peptides. To validate these results, a sensory test was realized.

7. CHECK-ALL-THAT-APPLY (CATA) AND LIKING RATING OF DIFFERENT MIXTURES PEA/COW MILKS FERMENTED WITH THE SELECTED STARTER CULTURE

7.1. Preparation of samples

Cow milk from skim milk powder Régilait® and pea milk from laboratory pea globulin isolate were mixed to obtain six concentrations of pea milk in cow milk (0%, 20%, 40%, 60%, 80% and 100%). These mixtures were heated at 90 °C for 10 mins, then inoculated with the selected starter F (*S. thermophilus* + *Lb. acidophilus*) and incubated at 37 °C for 10-12h to obtain products with pH= 4.6±0.1. The products were stored at 4 °C for one day before the CATA and liking tests.

7.2. CATA and liking procedures

Sixty consumers aged from 18 to 59 years participated in the sensory test (53,33% males and 46.66% females). Six samples of fermented cow and/or pea milk were assessed. Ten grams of each sample were served to the panelists in closed plastic cups labeled with three-digit random numbers. Samples were presented monadically following a Williams Latin square. Mineral water was used for rinsing between samples. Participants were asked to test each sample and to score their overall liking using a 9-point scale going from (1) “dislike very

much" to (9) "like very much." After rating their overall liking, participants completed a CATA question with 21 terms related to sensory characteristics of yogurts and vegetal protein (Table 5). The attributes were selected based on previous studies (Ares & Jaeger, 2014; Yousseef, Lubbers, Husson, & Valentin, 2014). After completing the CATA question, consumers were asked to check all the terms they considered appropriate to describe their ideal vegetal yogurt. The order of terms was randomized between participants but the same order was kept for each panelist.

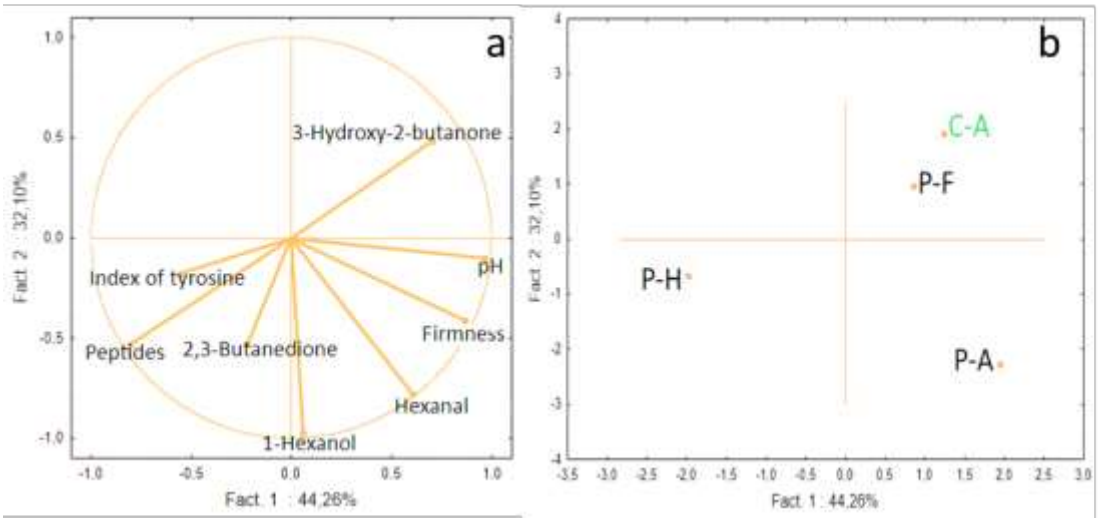

Figure 6. First two dimensions of the principal component analysis performed on all the results A) correlation circle, B) projections of the fermented products. Where C-A: Cow milk fermented by the starter A, P-A: Pea milk fermented by the starter A, P-F: Pea milk fermented by the starter F. P-H: Pea milk fermented by the starter H.

7.3. Results and discussion

An analysis of variance (ANOVA) performed on liking scores, considering consumer and sample as fixed source of variation, showed that as expected pea concentration has a significant effect on the acceptability of the products (Table 5).

Table 5. Mean scores of liking as a function of pea concentration - Two products with different letters are significantly different (Student Newman-Keuls test, $p < 0.0001$).

Sample	0%	20%	40%	60%	80%	100%
Score	6.17^{a}	4.81^{b}	$4.15^{b,c}$	$3.64^{c,d}$	$3.26^{c,d}$	2.90^{d}

Figure 7 shows that most consumers scored the 0 and 20 % products in the positive zone of the scale, and the 60% to 100% products in the negative one. In contrast, a disagreement is observed for the product with 40% pea protein. Some consumers assessed it positively, and others assessed it negatively. Based on this result, we divided the panelists into two groups (G+ and G-) to analyze the CATA data. G+ are the consumers who appreciate the product with 40 % pea protein (liking score above or equal to 5) and G- are the consumers who gave a liking score below 5).

We then analyze the CATA result by counting the number of consumers in each group that used each word to describe each product (Table 6). A correspondence analysis (CA) was finally performed, for each group. Consumer overall liking scores and ideal product evaluation were projected as supplementary data (Ares, Deliza, Barreiro, Giménez, & Gámbaro, 2010).

For the group G+ (Figure 8A), the first CA two dimensions represent 81.56% of the variance. The first dimension is correlated with liking. It opposed the terms: smoked, astringency, aftertaste, thick, viscous, vegetal and chalk, to the terms: smooth, creamy and taste of yogurt. On the other hand, the second dimension was positively correlated to consistency and negatively to liquid. Liking scores were positively correlated to the term taste of yogurt and 'delicious', and negatively correlated to the terms: smoked, earth, vinegar. The products are well spread out along the first dimension with the product 0% pea being acid and yogurt taste, the product 20 and 40% creamy taste homogeneous, sweet and more liquid that the 0% pea and the other pea products. The products above 40% pea are associated with negative descriptors. The ideal product project in between the 0% and 20, 40% products.

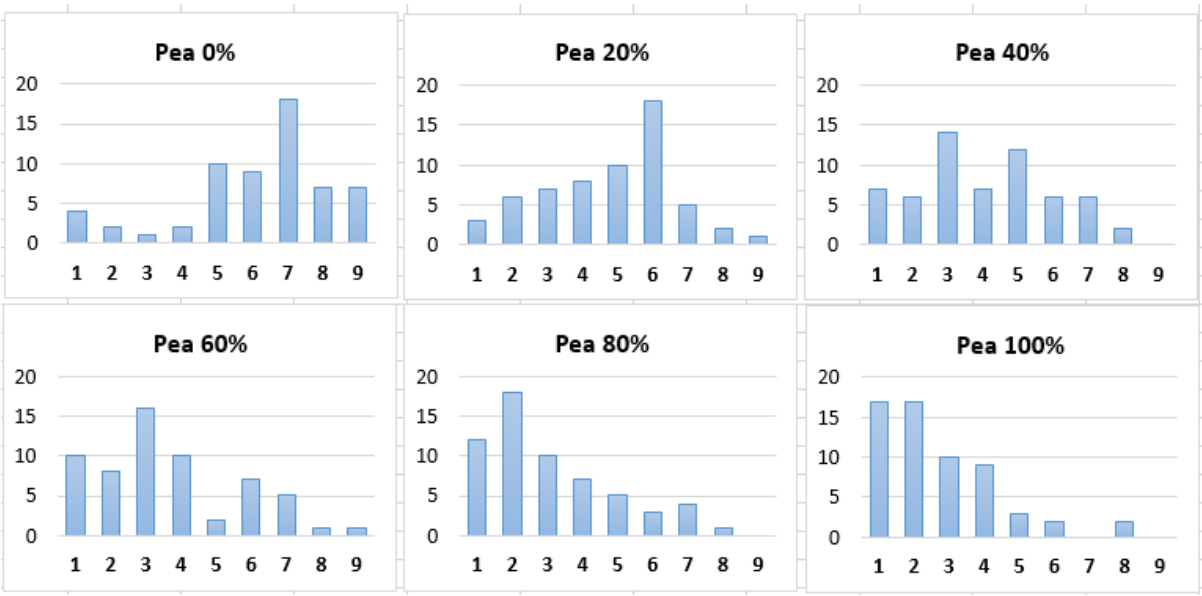

Figure 7. Frequency of consumers liking scores measured on a scale going from (1) "dislike very much" to (9) "like very much".

Table 6. CATA test: Frequency of occurrence each term as a function of pea concentration for the group of participants would appreciate the product with 40% pea (G+) and the group who did not appreciate it (G-)

	Group G+							Group G-						
Product	0%	20%	40%	60%	80%	100%	Ideal	0%	20%	40%	60%	80%	100%	Ideal
Astringent	2	2	4	4	7	5	0	0	3	9	6	7	6	0
Vinegar	1	1	0	1	1	3	0	2	0	1	2	2	1	0
Sour	14	3	3	5	1	2	8	16	5	4	7	4	6	9
Earth	0	2	4	6	8	10	2	1	5	14	15	10	16	0
Vegetal	2	10	11	14	15	16	10	1	8	12	13	14	17	13
Smoked	0	1	3	1	5	4	0	1	5	6	3	7	3	0
Chalk	0	2	4	3	6	5	0	3	8	9	8	7	6	0
Bitter	4	2	3	2	4	5	0	3	1	10	5	8	9	0
Sweet	5	6	3	1	3	3	14	3	3	0	2	1	2	20
Creamy	12	8	8	6	4	4	11	16	7	4	5	4	5	20
Taste of cream	6	7	6	4	4	1	8	5	5	4	1	2	2	2
Taste of yogurt	21	14	13	6	0	1	19	27	16	6	7	4	3	28
Aftertaste	4	7	7	11	16	14	2	4	11	20	19	21	20	2
Liquid	1	7	4	3	1	0	4	1	7	0	2	2	1	2
Smooth	10	8	6	4	4	3	12	16	11	2	9	7	4	17
Viscous	2	4	0	1	2	4	3	0	4	6	2	5	4	2
Firm	10	5	10	7	6	5	8	13	7	5	8	8	11	11
Consistency	9	7	7	8	8	6	12	13	5	7	9	4	5	16
Thick	5	6	7	4	6	7	5	9	4	4	10	11	8	4
Heterogeneous	1	4	6	6	4	6	0	4	9	14	7	8	8	1
Homogeneous	12	12	9	7	9	4	22	17	9	6	9	10	10	25

For the group G- (Figure 8B), the first two dimensions of the CA represent 86.83% of the variance of the experimental data. The distribution of descriptors for this group is almost like this of the G+. However, the distribution of products is different among the two groups. The product without pea protein (0%), describe as yogurt taste, creamy and acid, is the closest to the ideal product for the panelists in this group. This product is very different from all other products which are associated with negative terms. As for G+ the 20% pea product is described as more liquid creamy taste and somewhat sweet. However, it is quite far from the ideal product.

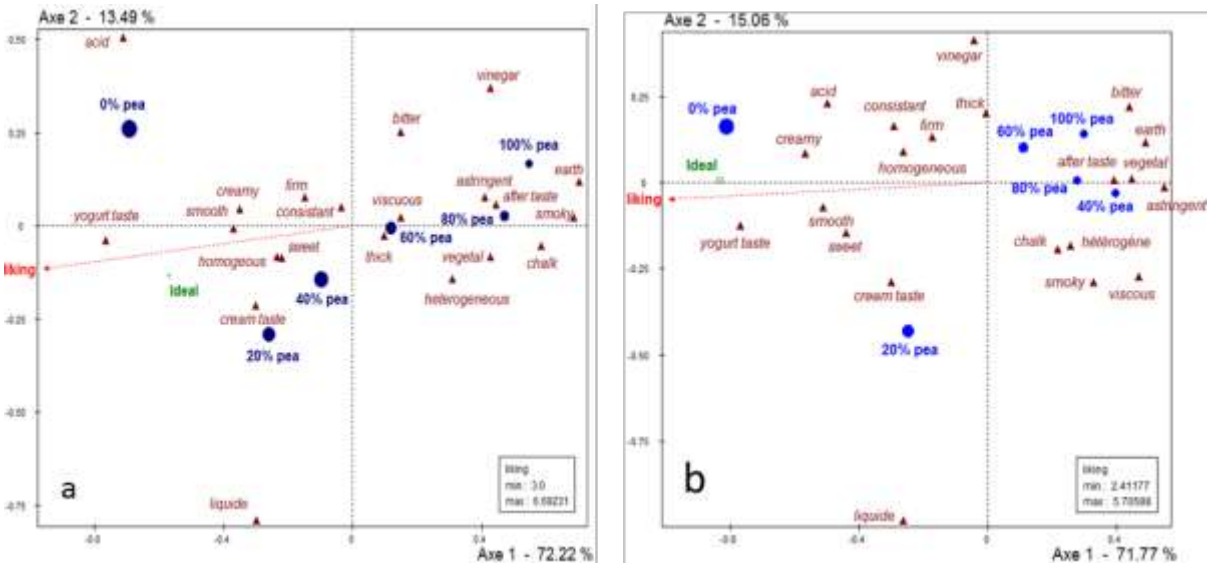

Figure 8. First two dimensions of the Correspondence Analysis carried out on the CATA frequency table analysis for (a) group G+ and (b) group G-. Liking and ideal product were projected as supplementary data. The size of the dots representing the six fermented products is proportional to their average liking scores.

8. CONCLUSION

From the first sensory tests, it was clear that it will not be easy to convince consumers to buy fermented pea-milk product. This was caused mainly by the intense effect of pea protein off-flavors on the preference of consumers as well as the lack of motivation to eat this type of products. So, different solutions have been tested to solve these problems. Encouraging consumers to accept this type of food by transmitting positive messages about vegetal protein was not effective probably because of the presence of vegetal driven off-flavors. Different starter cultures were tested to select one starter that could yield an "acceptable" product with the highest possible concentration of pea protein in cow milk. From the physico-chemical point of view, the starter culture *St. thermophilus* + *Lb. acidophilus* was able to give a fermented pea product close to traditional yogurt. From the sensory point of view, this starter with 20% of pea protein gave a product accepted by most of consumers. The product with 40% of pea protein was assessed positively by some panelists and negatively by others.

REFERENCES

Amatayakul, T., Sherkat, F., & Shah, N. P. (2006). Syneresis in set yogurt as affected by EPS starter cultures and levels of solids. *International Journal of Dairy Technology*, *59*, 216–221.

Ares, G., Deliza, R., Barreiro, C., Giménez, A., & Gámbaro, A. (2010). Comparison of two sensory profiling techniques based on consumer perception. *Food Quality and Preference*, *21*, 417–426.

Ares, G., & Jaeger, S. (2014). Check-all-that-apply (CATA) questions with consumers in practice. Experimental considerations and impact on outcome. *Rapid Sensory Profiling Techniques: Applications in New Product Development and Consumer Research*, pp. 227–245.

Esnouf, C., Russel, M., & Bricas, N. (2013). *Food system sustainability: insights from duALIne*. Cambridge University Press.

ISO. 11035. (1994). Sensory analysis: identification and selection of descriptors for establishing a sensory profile by a multidimensional approach. International Organization for Standardization.

Lee, Y. H., & Marshall, R. T. (1979). Rennet curd from milk plus soy protein mixtures. *Journal of Dairy Science*, 62, 1051-1057.

Lemieux, L., & Simard, R. E. (1992). Bitter flavour in dairy products. II. A review of bitter peptides from caseins: their formation, isolation and identification, structure masking and inhibition. *Le Lait*, 72, 335–385.

Lu, X., Schmitt, D., & Chen, S. (2010). Effect of sesame protein isolate in partial replacement of milk protein on the rheological, textural and microstructural characteristics of fresh cheese. *International Journal of Food Science & Technology*, *45*, 1368–1377.

Nguyen, T. D., Lafarge, C., Murat, C., Mession, J.-L., Cayot, N., & Saurel, R. (2014). Partition of volatile compounds in pea globulin–maltodextrin aqueous two-phase system. *Food Chemistry*, *164*, 406–412.

Robinson, R. K., & Wilbey, R. A. (1998). Tests for acidity and chemical analysis in process control. In *Cheesemaking Practice*. Springer, pp. 81–97.

Rozin, P. (1996). The socio-cultural context of eating and food choice. In *Food choice, acceptance and consumption*. Springer, pp. 83–104.

Schindler, S., Zelena, K., Krings, U., Bez, J., Eisner, P., & Berger, R. G. (2012). Improvement of the aroma of Pea (Pisum sativum) protein extracts by lactic acid fermentation. *Food Biotechnology*, 26, 58–74.

Torres-Penaranda, A. V, Reitmeier, C. A., Wilson, L. A., Fehr, W. R., & Narvel, J. M. (1998). Sensory Characteristics of Soymilk and Tofu Made from Lipoxygenase-Free and Normal Soybeans. *Journal of Food Science*, *63*, 1084–1087.

Tu, V. P., Husson, F., Sutan, A., Ha, D. T., & Valentin, D. (2012). For me the taste of soy is not a barrier to its consumption. And how about you? *Appetite*, *58*, 914–21.

Tu, V. P., Valentin, D., Husson, F., & Dacremont, C. (2010). Cultural differences in food description and preference: Contrasting Vietnamese and French panellists on soy yogurts. *Food Quality and Preference*, 21, 602–610.

Yousseef, M., Lafarge, C., Valentin, D., Lubbers, S., & Husson, F. (2016). Fermentation of cow milk and/or pea milk mixtures by different starter cultures: physico-chemical and sensorial properties. *LWT - Food Science and Technology*.

Yousseef, M., Lubbers, S., Husson, F., & Valentin, D. (2014). Sensory evaluation as a tool in assessing the quality of new fermented products. *From senses to quality: what can sensory evaluation bring to quality control*, 42.

PART 2 – CONSUMER ORIENTED PERSPECTIVE

SUMMER PROGRAM IN SENSORY EVALUATION
SPISE 2016
Taste and Try before you Fry
From product formulation to consumer experience
5th International Symposium, July 29-31, VietNam

HOW TO MEASURE THE DRINKING EXPERIENCE OF BEER TO DRIVE NEW PRODUCT DEVELOPMENT

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ABSTRACT

Consumers interact with products using three mental systems: affects, senses, and cognition. These systems give rise to "consumer experience". Two studies were conducted to measure the experience of drinking craft and industrial beers. The first study consisted in an online survey with 75 consumers whose goal was to select phrases related to each system. A set of 18 phrases was selected to perform the second study in which consumers had to drink industrial beers, rate liking and select phrases that best described their experience of drinking in a CATA list. CATA phrases were related to the affective, sensory or cognitive systems. Beers were rated similar in liking, however, significant differences were observed for the CATA phrases. Cognitive phrases were more frequently checked for craft beers while sensory and affective phrases were more frequently checked for industrial beers.

Keywords: *drinking experience, consumer experience, beer.*

1. INTRODUCTION

Consumers do not buy randomly, every product that is consumed and every service that is used corresponds to multiple needs. Consumers are therefore in the constant quest to find solutions to fulfil their needs. According to Darpy (2012) they are not interested in what the products are, but in what the products can do for them. They do not buy the characteristics of the products, but the benefits that they can obtain by their consumption or use, whether these benefits are functional, symbolic or experiential. According to Lipovetsky & Serroy (2013) what defines contemporary hyper-consumption is an aesthetic approach of production. This aesthetic approach makes an echo in the food and beverage consumption with sophisticated bottles, beautiful packages, special presentations, hyper-realism and product individualization. Food design, for example, is now a well-known branch of industrial design, not only present at innovation fairs (*e.g.* Sial Paris), but also in the academy (*e.g.* Scuola Politecnica di Design) and industry (*e.g.* Enivrance). It is transforming the way people see, use and taste a food product to make it a unique food product experience.

Today the food and beverage product developers need to make products that are not only functional but that also trigger a unique experience. This experience includes its perception, the identification process it triggers, the cognitive associations and memories it activates, the feelings and emotions it elicits, and the evaluative judgements it brings about (Schifferstein & Cleiren, 2005). In the beverage domain, alcoholic beverages have been studied for their capacity to evoke positive or negative emotions, to modify mood (Desmet, 2008) as well as for their cultural relevance (Simonnet-Toussaint 2006; Do, Patris, & Valentin 2009), their functional benefits (Guinard *et al.*, 1998), and economic impact (Euromonitor, 2014). Alcoholic beverages are not just "beverages" and as such they constitute a good model to study consumers' product experience.

The aim of this research was to understand the experience of drinking beer by assessing the impact of different dimensions used in the interaction with the product: affects, senses and cognition. Two studies were performed for this purpose. The objective of the first study was to define a set of phrases that can be used to relate affects, senses and cognition while drinking beer in a Check-All-That-Apply (CATA) question. The objective of the second study was to measure the drinking experience of beers in a real consumption context using the final CATA phrases issued from study 1.

2. STUDY 1 – CATA SELECTION PHRASES

2.1. Material and methods

2.1.1. Material

A list of 45 phrases were derived from two previous studies: a) a consumer ethnography (Gómez-Corona *et al.*, 2016) whose goal was to understand the habits, attitudes and motivations towards beer consumption in Mexico, and b) a contextual focus group aiming at examining the variables involved in the beer drinking experience. This list included 15 sensory, 15 cognitive, and 15 affective phrases (Table 1).

2.1.2. Participants

Eighty consumers took part of the study. Participants were recruited with the support of an online consumer panel company (www.cint.com). They were recruited based on their age (25-45 years), gender, beer consumption (at least once a month), and were born and lived in Mexico City.

2.1.3. Procedure

The internet questionnaire consisted of basic demographic information (age, gender, and beer consumption), and the key questions were appropriateness of the phrase to describe a beer (Q1. "How appropriate is this phrase to describe a beer" in a five-point scale from 1-not at all to 5-very much), and categorization of the phrase into affective, cognitive or sensory dimensions (Q2. "Do you think this phrase describe the way you feel about the product" – affective dimension; "the way you think when consuming the product" – cognitive dimension, or "the way you perceive it threw your senses" – sensory dimension).

2.2. Data analysis

The scale used for the appropriateness question was analyzed using a 3-way ANOVA, fixed model: dimension + phrase + gender + phrase×gender. When significant differences were found at $\alpha = 0.05$, a multiple comparison Tukey post hoc test was performed. The phrases were then plotted in an interval plot, using one plot for each dimension (sensory, affective and cognitive) to identify visually the phrases that were rated below the mean for the appropriateness variable. Afterwards, the sensory, affective or cognitive categorization data were transformed into frequencies for each phrase and 2×2 tables were built and analyzed using a paired comparison Fisher's exact test. Significant differences were identified at $\alpha = 0.05$. For each dimension the phrases with an appropriateness score above the dimension mean score and a frequency to describe the dimension significantly higher than the frequency to describe the other dimensions (*e.g.* a phrase for the sensory dimension was selected for being above the mean score of appropriateness and higher in the frequency for describing sensory attributes). At the end of the analysis 18 phrases (six per dimensions) were selected for the CATA list of study 2.

2.3. Results

Results from the appropriateness analysis show that the mean scores are similar across dimensions, no significant difference was found. The mean score for sensory phrases (Figure 1) was 4.1, followed by 3.8 for the affective phrases and 3.7 for the cognitive phrases. No significant gender effect was found, meaning that men and women rated in a similar way the appropriateness of the phrases for each dimension.

For the sensory dimension significant differences were observed across phrases ($p < 0.000$), with four phrases significantly higher than the average (S10, S13, S31, S34). No gender effect was found. For the affective dimension, there were also significant differences across the phrases ($p < 0.000$) with eight phrases above the mean score (A8, A11, A20, A26, A32, A35, and A41). Finally, for the cognitive dimension significant differences were observed across phrases ($p < 0.004$). The phrases that were significantly lower than the others were C39 and C45.

Table 1. Phrases used in study 1, divided in sensory, affective and cognitive dimensions.

Sensory	Affective	Cognitive
1. I will take the time to enjoy the beer, smell and taste it	2. Find something unexpected in the beer surprises me	3. I like to read the label of this beer
4. I enjoy this beer will all my senses	5. I fill calmed when I drink this beer	6. I would like to ask and know more about this beer
7. The cold temperature makes me enjoy this beer	8. When I drink this beer I feel that I am in my relaxation moment	9. The more information I have of the beer, the more I enjoy it
10. I found this beer refreshing	11. Drinking this beer takes out my stress	12. I would like to know who produces this beer
13. The most important thing of this beer is the flavor	14. This beer puts me in a sensitive mood	15. I want to know more about this beer
16. I enjoy the sensation on my mouth of this beer	17. When I drink this beer I get excited	18. It could be interesting to know who is the person that makes this beer
19. I enjoy the texture of this beer	20. To take this beer relaxes me, calm me	21. This is a beer to put attention to
22. I enjoy the bitterness of this beer	23. To drink this beer relaxes me	24. Drink this beer leaves me with a sensation of thinking what does it taste like
25. I enjoy the aroma of this beer	26. Drink this beer can help in those moments of tension	27. This beer triggers me more interest
28. To drink this beer is a complete sensory experience	29. I'm in love of this beer	30. This beer triggers me more curiosity
31. The experience of this beer comes from the flavour	32. I feel happy when I drink this beer	33. I found ludic and entertaining to drink this beer
34. Its worthy to take some time to enjoy the beer	35. To drink this beer is like a big pleasant sensation	36. Drinking this beer is physically stimulating
37. I would like to take this beer in a cup to enjoy it more	38. I feel great drinking this beer	39. This is a beer for thought
40. I like beers that are balanced between flavour, aroma and body	41. I would like to share this beer with someone	42. I like to know the style of beer I'm drinking
43. I preferred to drink this style of beer in a special glass, to have a better experience	44. I feel a connection with this beer	45. I want to take a picture of the beer to put it in my beer's list

The analysis of the sensory, affective and cognitive categorization data indicates that almost all phrases were categorized in their correct dimension. For the sensory dimension (Table 2) the Fisher exact test showed that two phrases were attributed a similar number of times to the emotional, sensory and cognitive category (phrase S1 and S16). For the affective dimension, only one phrase was attributed as often to the affective and cognitive dimension (A2). And finally for the cognitive dimension all phrases were attributed by the majority of participants to the cognitive dimension. Only the phrases that were rated above the appropriateness mean score and selected to represent better each dimension were used in the final CATA study. Table 3 shows the final list of six phrases per dimension.

2.4. Conclusion

The results of study one show that consumers are capable of identifying phrases that are both considered as appropriate to rate beers and significantly attributed to a sensory, cognitive or affective dimension. The results also show a high agreement between men and women in the phrases appropriateness judgments. Overall this method was suited to select a set of six phrases per dimension in order to be used in the following study to measure the experience of drinking beer.

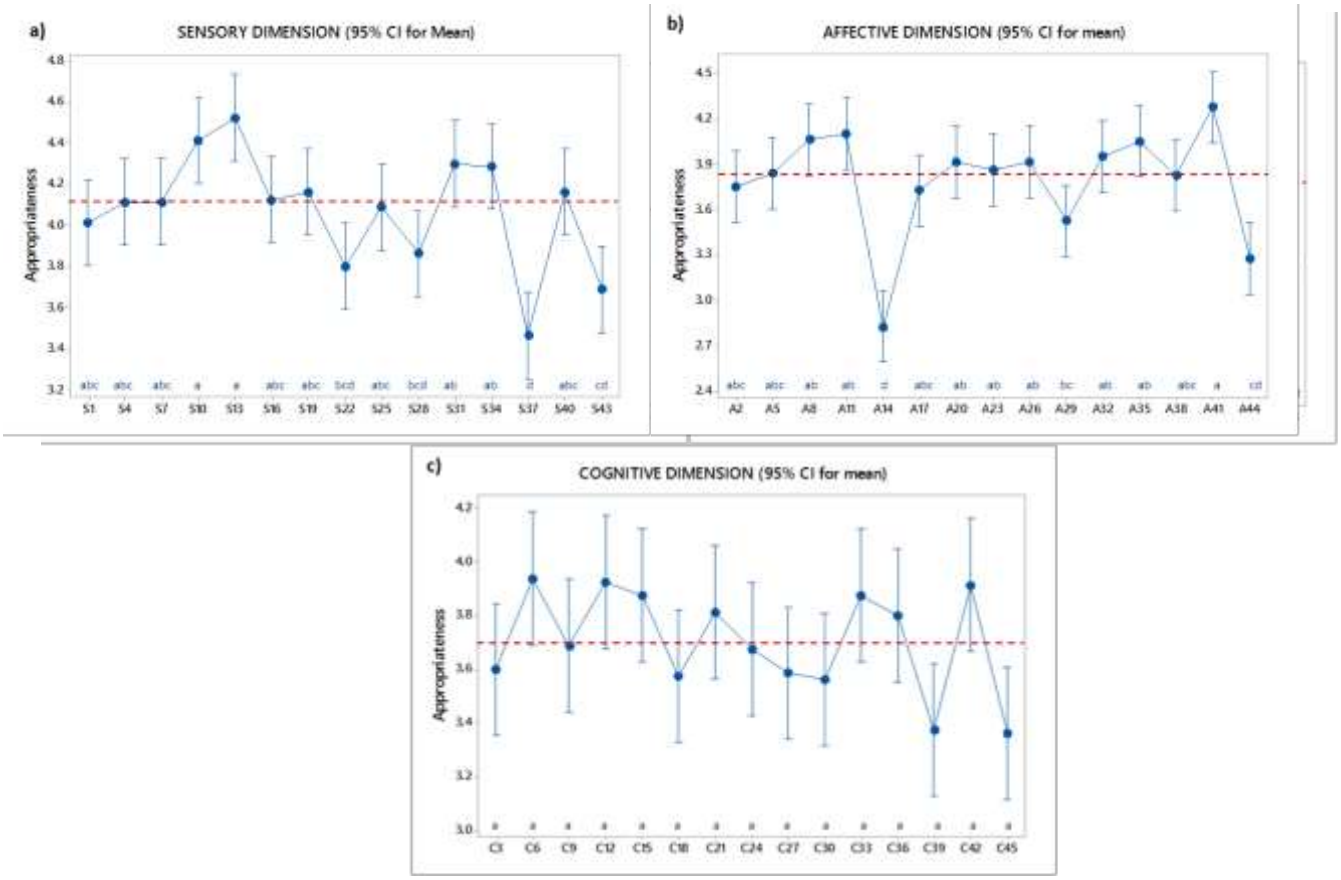

Figure 1. Mean score of phrases appropriateness to describe beers for: a) sensory dimension, b) affective dimension, and c) cognitive dimension. The dotted red line indicates the mean score of all the phrases. Sentences with the same letters were not significantly different (Tukey post hoc test, α = 0.05).

3. STUDY 2 – DRINKING EXPERIENCE IN REAL CONTEXT

3.1. Material and methods

A quantitative study was done in a contextual ambient (restaurant) in which beers is usually consumed. A set of four beers (Figure 2) were selected based on a previous study (Gómez-Corona et al 2016) in which industrial beers are commonly divided by consumers as being blond or dark beers.

3.1.1. Participants

Two hundred consumers were recruited in Mexico City at a central location. An intercept sampling procedure was used at affluence points; the interviewers stopped any possible consumer and invited them to participate in the study. The inclusion criteria were: gender (50% men and 50% women), age (20-49 years), and consuming beer at least once a month. Participants who passed the inclusion criteria were invited to take part in the study in a room conditioned for consumer tests. The location in which the study was made is a restaurant-bar in Mexico City which serves beers as part of their regular beverages.

3.1.2. Procedure

Participants evaluated only one beer (out of four) as a pure monadic evaluation. The beers were randomly assigned to the participants, but balanced across genders. At the end of the interviews a total of 50 interviews were completed for each of the four beers. The test was divided in a non-tasting and a tasting step.

In the non-tasting step, the participants had to rate their expected liking on a nine-point hedonic scale and rate their beer experience using a CATA question from the phrases selected from study 1 (Table 3).

Table 2. Sensory, affective and cognitive phrases selected for the final study. Numbers in bold indicate values above the mean frequency.

Phrases	Affective	Cognitive	Sensory	P value
Sensory				
S1. I will take the time to enjoy the beer, smell and taste it	35a%	31.2a%	33.8a%	>0.5
S4. I enjoy this beer will all my senses	42.5a%	23.8b%	33.8ab%	0.018
S7. The cold temperature makes me enjoy this beer	27.5a%	27.5a%	45b%	0.032
S10. I found this beer refreshing	25a%	33.8ab%	41.2b%	0.043
S13. The most important thing of this beer is the flavour	26.2a%	30ab%	43.8b%	0.031
S16. I enjoy the sensation on my mouth of this beer	28.7a%	32.5a%	38.8a%	>0.5
S19. I enjoy the texture of this beer	23.8a%	32.5ab%	43.8b%	0.012
S22. I enjoy the bitterness of this beer	20a%	32.5ab%	47.5b%	0.000
S25. I enjoy the aroma of this beer	28.7a%	25a%	46.2b%	0.003
S28. To drink this beer is a complete sensory experience	25a%	25a%	50b%	0.002
S31. The experience of this beer comes from the flavour	27.5a%	21.2a%	51.2b%	0.003
S34. Its worthy to take some time to enjoy the beer	33.8a%	17.5b%	48.8a%	0.007
S37. I would like to take this beer in a cup to enjoy it more	20a%	23.8a%	56.2b%	0.000
S40. I like beers that are balanced between flavour, aroma and body	18.8a%	31.2b%	50b%	0.000
S43. I preferred to drink this style of beer in a special glass, to have a better experience	25a%	27.5a%	47.5b%	0.005
Affective				
A2. Find something unexpected in the beer surprises me	40a%	33.8ab%	26.2b%	0.032
A5. I fill calmed when I drink this beer	56.2a%	30b%	13.8c%	0.001
A8. When I drink this beer I feel that I am in my relaxation moment	53.8a%	26.2b%	20b%	0.001
A11. Drinking this beer takes out my stress	50a%	25b%	25b%	0.002
A14. This beer puts me in a sensitive mood	57.5a%	23.8b%	18.8b%	0.000
A17. When I drink this beer I get excited	71.2a%	20b%	8.8c%	0.000
A20. To take this beer relaxes me, calm me	58.8a%	25b%	16.2c%	0.000
A23. To drink this beer relaxes me	62.5a%	23.8b%	13.8b%	0.000
A26. Drink this beer can help in those moments of tension	58.8a%	30b%	11.2c%	0.000
A29. I'm in love of this beer	60a%	27.5b%	12.5c%	0.000
A32. I feel happy when I drink this beer	50a%	30b%	20b%	0.000
A35. To drink this beer is like a big pleasant sensation	66.2a%	22.5b%	11.2b%	0.000
A38. I feel great drinking this beer	60a%	26.2b%	13.8c%	0.000
A41. I would like to share this beer with someone	58.80%	22.50%	18.80%	0.000
A44. I feel a connection with this beer	62.5a%	23.8b%	13.8b%	0.000
Cognitive				
C3. I like to read the label of this beer	13.8a%	71.2b%	15a%	0.000
C6. I would like to ask and know more about this beer	16.2a%	63.7b%	20a%	0.000
C9. The more information I have of the beer, the more I enjoy it	18.8a%	70b%	11.2a%	0.000
C12. I would like to know who produces this beer	10a%	81.2b%	8.8a%	0.000
C15. I want to know more about this beer	17.5a%	70b%	12.5a%	0.000
C18. It could be interesting to know who is the person that makes this beer	20a%	70b%	10a%	0.000
C21. This is a beer to put attention to	15a%	65b%	20a%	0.000
C24. Drink this beer leaves me with a sensation of thinking what does it taste like	22.5a%	58.8b%	18.8a%	0.000
C27. This beer triggers me more interest	17.5a%	65b%	17.5a%	0.000
C30. This beer triggers me more curiosity	22.5a%	70b%	7.5c%	0.000
C33. I found ludic and entertaining to drink this beer	13.8a%	76.2b%	10a%	0.000
C36. Drinking this beer is physically stimulating	15a%	70b%	15a%	0.000
C39. This is a beer for thought	15a%	76.2b%	8.8a%	0.000
C42. I like to know the style of beer I'm drinking	7.5a%	86.2b%	6.2a%	0.000
C45. I want to take a picture of the beer to put it in my beer's list	15a%	75b%	10a%	0.000

Group 1 Blond-industrial		Corona Industrial American lager 4.6% Alc. Vol. Mexico 355 mL 0.7 €		Pacífico Industrial American lager 4.8% Alc. Vol. Mexico 325 mL 0.7 €
Group 2 Dark-industrial		Victoria Industrial Vienna lager 4% Alc. Vol. Mexico 355 mL 0.6 €		Bohemia Obscura Industrial Vienna lager 5.5% Alc. Vol. Mexico 355 mL 0.9 €

Figure 2. Image and basic information of the set of beers used in the study: commercial name (*e.g.* Corona), type (*e.g.* industrial), style (*e.g.* American lager), percent of alcohol volume (*e.g.* 4.6%), country of origin (*e.g.* Mexico), milliliters in the bottle (*e.g.* 355 mL), and local price (Mexico City, 2016) in euros.

Table 3. Set of phrases used in the CATA question separated by sensory, affective and cognitive dimension.

Sensory dimension	Affective dimension	Cognitive dimension
The most important thing of this beer is the flavour	I would like to share this beer with someone close to me	I like to know the style of the beer that I am drinking
The experience of this beer comes from its flavour	Drink this beer is like a big sensation of pleasure	I would like to know who produces this beer
Its worthy to take some time to enjoy this beer	Drink this beer relaxes me, calm me	I found ludic and enter- taining to drink this beer
I like beers like this, that are balanced between flavour, aroma and body	Drink this beer can help in those moments of tension	This is a beer for thought
What makes me enjoy this beer is its cold temperature	This beer changes my mood	I would like to take a picture of this beer to remember it
I enjoy the aroma of the beer	I feel great drinking this beer	I like to read the label of this beer

In the tasting condition, participants were given a glass and a beer opener. They were instructed to open the beer and drink it (directly from the bottle or in the glass, as they wished). They were asked to take their time to drink the beer as they usually drink it and to rate their overall liking on a 9-point hedonic scale and their experience when drinking the beer with the same CATA question as in the non-tasting step. Once they finished, they were asked to call the interviewer which checked that the questionnaire was completed. Participants were thanked for their participation but they were not paid.

3.2. Data analysis

The questions with a scale for the non-tasting and the tasting condition were analyzed using a one-way ANOVA to explore the differences across products and variables. A two-way ANOVA was also used to see the differences across gender and age. Whenever a p value smaller than 0.05 was obtained, a Tukey multiple comparison test was performed. All analyses were performed on Minitab software (version 16.1.0, Minitab Inc., State College, USA). The CATA frequency data were analyzed with a Z-test for proportion.

3.3. Results

3.3.1. Liking results

The ANOVA showed no significant difference between beers in expected liking in both the non tasting and the tasting conditions. In the non-tasting condition, the liking scores were 7.2 for Pacífico, 7.1 for Bohemia Oscura, 7.0 for Victoria and 6.7 for Corona. In the tasting condition, the liking scores were 7.5 for Pacífico, 7.4 for Bohemia Oscura, 7.3 for Victoria and 7.1 for Corona.

Table 4. Contingency table of the frequencies for each dimension and beer. Letters indicate the significant differences across beers using a Z-test for proportions.

	Corona	Pacífico	Victoria	Bohemia Oscura
Non tasting				
Sensory	101 a	115 ab	**129 b**	111 ab
Affective	**100 a**	74 b	83 ab	61 b
Cognitive	54 a	37 ab	29 b	47 a
Tasting				
Sensory	101 a	**137 b**	**128 b**	**135 b**
Affective	**92 a**	**88 a**	**96 a**	67 b
Cognitive	48 a	29 b	38 ab	18 b

3.3.2. CATA (dimensions) results

The CATA phrases were separated by dimension: sensory, affective and cognitive. The results show a higher frequency of sensory dimension in both the non-tasting and tasting conditions. In the non-tasting condition, the beers Victoria and Bohemia Oscura had significantly more phrases selected for the sensory dimensions. The affective dimension was dominant for Corona and Victoria. The cognitive dimension was also higher in Corona and Bohemia Oscura. In the tasting condition, all the beers expect Corona had a higher frequency of phrases selected. For the affective dimension no difference was observed except for Bohemia Oscura which had significantly lower frequencies. And finally in the cognitive dimension for the tasting condition a low frequency was observed for all beers.

4. DISCUSSION

Based on the results, our study helps to identify the experience of drinking beer and is capable of measuring the influence of affects, senses and cognition in the interaction with the product, both in a non-tasting and tasting condition. In this framework, the study help address the gap in the product experience research by showing two important things.

The first one is that expected and overall liking variables can be less discriminant than we think. Products with similar liking were associated to different variables such as sensory, affective and cognitive. And second, these variables can explain the way we interact with products and more specifically the experience of drinking beer. Purchases do not come stamped as "experiences" or "possessions". Instead, it is the set of psychological processes that tend to be invoked by experiences and material goods that determine how much satisfaction they provide (Gilovich, Kumar, & Jampol, 2015).

The idea of having a sensory, affective or cognitive experience is not new. In a previous research with a set of 12 material and food products, Gentile, Spiller, & Noci (2007) used a factor analysis to group the dimensions of the experiential consumption. The underlining dimensions were considered as: sensorial, emotional, cognitive, pragmatic, lifestyle and relational. The results of the factor analysis showed that each product loaded on both pure components (that is, factors that can be related to a single experiential component) and "mixed components" (that is, factors whose variables belong to different experiential components). Mixed components can be considered as a cue for the hypothesized existence of interrelations between components, which in turn stand for complex experiences. Complex experiences emerge as a specific case in which the components are so intimately intermingled that consumers are unable to draw any separation between them. In agreement with Gentile, Spiller & Noci (2007) we found that the beer drinking experience can be described both in terms of pure components and mixed components.

5. CONCLUSION

Our study helped addresses the gap in the experience research. We propose that drinking experience can be better understood by taking into consideration three dimensions: sensory, affective and cognitive. One variable or a mix of them can be

more salient during the product interaction, and therefore we can differentiate the products based on these salient dimensions. The results show that while acceptability may be similar between products, the sensory, cognitive or affective experience can be different. Therefore, products with similar liking can be designed to have a salient dimension, according to the benefits in which we want to position a product in the market.

The methodology proposed was helpful to obtain the phrases for the CATA question (in study 1) and CATA question was also a useful way to explore the salient dimension before and during product consumption. Different types of analysis can be performed with the frequency data such as multivariate techniques like correspondence analysis or multiple factor analysis for contingency tables. These types of analysis can be very useful to take into consideration all of the phrases used in the study to access the experience of drinking beer.

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REFERENCES

Darpy, D. (2012). *Comportements du consommateur*. Paris: DUNOD.

Desmet, P. (2008), Product emotion. In: N. J. Schifferstein & P. Hekkert (Eds.) *Product Experience*, UK: Elsevier, pp. 1-8.

Do, V. B., Patris, B., Valentin, D. (2009). Opinions on wine in a new consumer country: A comparative study of Vietnam and France. Journal of Wine Research, 29 , 227-245.

Euromonitor International. (2014). Beer in Mexico. Retrieved from Euromonitor Passport database. London: Euromonitor International.

Gentile, C., Spiller, N., & Noci, G. (2007). How to Sustain the Customer Experience: An Overview of Experience Components that Co-create Value with the Customer. *European Management Journal*, 25: 395-410.

Gilovich, T., Kumar, A., Jampol, L. (2015). A wonderful life: experiential consumption and the pursuit of happiness. *Journal of Consumer Psychology*, 25, 152-165.

Gómez-Corona, C., Escalona-Buendía, H. B., García, M., Chollet, S., & Valentin, D. (2016). Craft vs. industrial: Habits, attitudes and motivations towards beer consumption in Mexico. *Appetite*, 96, 358-367.

Guinard, J.X., Uotani, B., & Schlich, P. (2001). Internal and external mapping of preferences for commercial lager beers: comparison of hedonic ratings by consumers blind versus with knowledge of brand and price. *Food Quality and Preference*, 243-255.

Lipovetsky, G. & Serroy, J. (2013). *La estetización del mundo. Vivir en la época del capitalismo artístico*. Barcelona: ANAGRAMA.

Schifferstein, H.N.J. & Cleiren, M. (2005). Capturing Product Experiences: A split-modality approach. *Acta Psychologica*, 118, 293-318.

Simonnet-Toussaint, C. (2006). Le vin sur le divan. Des répresentations sociales aux représentations intimes. Bordeaux: Féret.

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DEVELOPING SUSTAINABLE FOOD: THE ROLE OF CONSUMER LIKING IN OPTIMIZATION OF PEA YOGURT

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ABSTRACT

In the development of new food consumers' acceptability is a critical factor. This study aimed at evaluating the possibility to introduce pea proteins as new fermented food. For this purpose, mixtures of cow and pea milks with different ratios of pea (0, 10, 20, 30, 40 and 100%) were fermented with French commercial yogurt-ferment. Consumer acceptability in two European countries: France (Western Europe) and Bulgaria (Southeastern Europe) was investigated. 60 Bulgarian and 70 French panelists were asked to rate: overall acceptability, appearance, odor, taste and texture on a hedonic scales going from 1 (I do not like at all) to 7 (I like very much). The ANOVA showed a highly significant effect of products and countries for all acceptability scores. Globally, the Bulgarian consumers gave higher average scores than the French consumers. The mean comparison test showed that the presence of pea protein even in the lowest concentration (10%) reduced the overall acceptability of yogurts in both countries. These results suggest that replacing animal by vegetal protein will not directly lead to an acceptable product.

Keywords: *consumer test, cross-cultural study, vegetal protein, mixed-protein yoghurt*

1. INTRODUCTION

As a response to the increasing demand for animal protein and the consequences of this issue, it might be interesting to increase the consumption of plant proteins in European diet. To start changing consumer behaviors, the strategy of introducing plant protein as a part of traditional foodstuffs seems promising (Boland *et al.*, 2013). Despite the negative organoleptic properties inherent to plant ingredients, it was shown that consumers can accept dairy-plant products (cow milk and soybean proteins) with a ratio of soybean protein to 50% (Tu, Husson, Sutan, Ha, & Valentin, 2012). However, soybean might not be the most suitable plant protein source because of its associated allergy and phytoestrogens issues (Cederroth, Auger, Zimmermann, Eustache, & Nef, 2010; Eastham, 1989). Pea (*Pisum sativum*) may be a better substituent because of its high-quality amino acid profile (Schneider & Lacampagne, 2000), its good functional properties (Bora, Brekke, & Powers, 1994), its lower allergic effect (Jaffuel, Demoly, & Bousquet, 2001), and its lower phytoestrogen content (Mazur, 1998). Pea protein, like other plant proteins, has some off-flavors (Murat, Gourrat, Jerosch, & Cayot, 2012), but sensory characteristics are not the only factor that affects food choice and preference. Non-sensory factors including food familiarity, health claims, price and mood have an influence on food choice (Prescott, Young, O'Neill, Yau, & Stevens, 2002). James (2004) showed that consumers' cultural background could affect these sensory and non-sensory factors.

In last years, many cross-cultural consumer studies have compared variations between cultures

in food preference. These studies were usually carried out to assess how product familiarity influence consumers' perception, by comparing the liking of food known and accepted in one culture with another culture which is not familiarized to this food (Kim, Jombart, Valentin, & Kim, 2013; Pagès, Bertrand, Ali, Husson, & Lê, 2007). Because they are omnivore, humans naturally tend to be interested in new food but they are cautious about trying it because of a phenomenon called food neophobia (Pliner & Hobden, 1992). Repeated and wide exposure to new food could reduce this phenomenon by increasing consumers' familiarity. One possible way to introduce pea protein to consumers could be dairy products such as yogurt. Yogurt, one of the most popular food for a long time all around the world, is made of cow milk fermented by two specific lactic acid bacteria (*Lactobacillus bulgaricus* and *Streptococcus thermophilus*).

The goal of this study is to know whether it would be possible to introduce pea proteins as fermented new food to European consumers. We investigated how cow-pea fermented milk could be perceived in France (Western Europe) and Bulgaria (Southeastern Europe). While these two countries have a strong tradition of consuming yogurts and have soy yogurt in their markets, the studied product "itself" is not familiar to the French and Bulgarian consumers. However « boza » a cereal-based fermented beverage is popular in Bulgaria. No such plant-based products exist in the French food tradition.

2. MATERIALS AND METHODS

2.1. Preparation of samples

Using skim milk powder purchased from Régilait (Saint-Martin-Belle-Roche, France) and pea protein isolate Nutralys® S85F supplied by Roquette (Lestrem, France), cow and pea milks were prepared at the same protein concentration (4.5 g/L). Lactose, calcium and citrate levels were also balanced in the two milks. Before the incubation with starter culture for homemade yogurt production (*Streptococcus thermophilus* and *Lactobacillus bulgaricus*) obtained from Alsa (Rueil-Malmaison, France), the cow milk was heated in a water bath at 90 °C for 10 minutes, and the pea milk was autoclaved at 110 °C for 10 minutes. When the milks temperature returned to about 42 °C, the two milks were mixed according to the needed concentrations, inoculated and then incubated at 42 °C for 4-6 hours. Six fermented products with different concentrations of pea protein (0, 10, 20, 30, 40 and 100%) were prepared, stored for 24 hours at 4 °C (Table 1).

Table 1. Gel samples used in the sensory test.

Gel sample (Name)	Milk protein concentration (g/100 g protein total)	Pea protein concentration (g/100 g protein total)
0%	100	**0**
10%	90	**10**
20%	80	**20**
30%	70	**30**
40%	60	**40**
100%	0	**100**

2.2. Sensory test

2.2.1. Consumers

A Bulgarian and a French panel of consumers have evaluated the six fermented products. The Bulgarian panel consisted of 60 students and staff members from the University of Plovdiv (73.33% female – 33.33% <30 years and 66.67% >30 years). The French panel consisted of 70 participants recruited during a public scientific event ("Nuit des chercheurs") in the University of Burgundy (64.52% female – 55.88% <30 years and 44.12% >30 years).

2.2.2. Evaluation procedure

In both countries, the panel tested the samples in a classroom with enough separation between the tables to avoid any communication between the participants during the test. In France, the test was carried out under red light. For both panels, about 10 g of each sample were served in a white plastic cup that was coded with a random three-digit number. The six samples were presented at the same time. Bottled water was provided to cleanse the palate. Panelists had to rate overall, appearance, odor, taste and texture acceptability on a hedonic scales going from 1 (I do not like at all) to 7 (I like very much), with 4 being anchored as neither like or dislike. The questionnaires were written in the native language of each country.

2.2.3. Statistical analysis

Three-way ANOVAs were carried out (Dell Statistica version 12) for each acceptability rating with consumer as a random factor, country a fixed between-subject factor and product a fixed within-subject factor. When a significant product effect was observed a student Newman-keuls pairwise comparison test was carried out. For all panelists, a

principal component analysis (PCA) on the overall acceptability scores followed by a hierarchical ascending classification (HAC) was performed (SPAD version 8) to identify classes of consumers who were homogeneous in their preference for yogurts. Finally, a multiple factor analysis (MFA) was performed on all the assessed attributes in order to compare the French and Bulgarian panels.

3. RESULTS

3.1. Overall acceptability

The ANOVA on the overall acceptability scores from both panels showed a highly significant country effect ($p < 0.0001$) indicating that the two consumer groups evaluated the products differently. On the average, the Bulgarian consumers gave higher scores than the French group as shown Figure 1. This result should, however, be interpreted with caution as it can be due either to a higher preference or to a difference in using the scale as was previously shown in cross-cultural studies (Prescott *et al.*, 2002). No significant product × country interaction effect was observed indicating that the two panels scored the fermented products in the same manner.

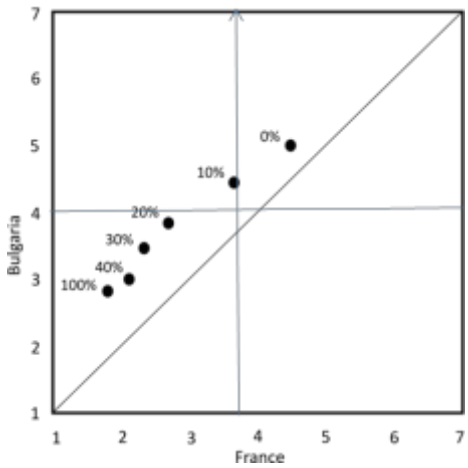

Figure 1. Comparison of overall acceptability mean score for all tested products.

A highly significant effect of product ($p < 0.0001$) was also observed. The mean comparison test (Table 2) showed that the presence of pea protein even in the lowest concentration (10%) reduced the overall acceptability of yogurts. The overall liking decreases with the increase of pea concentration with a first plateau for 20 and 30% pea protein products and a second one for 40 and 100% pea protein products. We can also note that the average liking score move from the neutral zone for the 0 and 10% concentration to the negative one for the 20% and above concentration.

Figure 2 represents the PCA performed on individual overall acceptability scores of all the panelists (French and Bulgarian). The first two PCA dimensions explain 60.52% of the total variance. The first PCA dimension explains 43.96% and is correlated to all products substituted with pea protein (from 10% to 100%) while the second dimension (16.56% of variance) is correlated with the yogurt without pea protein. Most consumers accepted the fermented cow milk but not the yogurt containing pea protein. The third and fourth dimensions (23% of the total variance) explained the difference among the samples depending on pea protein substitution level (data not shown).

The HCA performed on the first four PCA dimensions showed three classes of consumers. Figure 3a shows the distribution of French and Bulgarian consumers in each class and Figure 3b the average liking scores of each class. The first class represents 29.23% of the total number of consumers, 60.53% of consumers in this class are from the Bulgarian panel. The consumers in this class appreciated all the products including the product with 100% pea protein. The second class represents 43.85% of consumers. The proportion of French and Bulgarian panelists in this class are almost equal. The products up to 10% pea protein are in the positive zone and the others in the negative zone. Furthermore, the largest discrepancy between 100% milk yogurt and 100% pea protein occurs in this class. The third class represents 26.92% of all panelists, about 75% of this class are French participants. The consumers in this class scored all the products in the negative zone even the yogurt without pea protein.

Table 2. Mean scores of overall acceptability on a 7-point scale (1: I do not like at all – 7: I like very much) as a function of pea concentration. Means with different superscript letters are significantly different (Newman-Keuls test, $p < 0.05$)

0%	10%	20%	30%	40%	**100%**
4.76[a]	4.05[b]	3.28[c]	2.94[c]	2.57[d]	**2.36**[d]

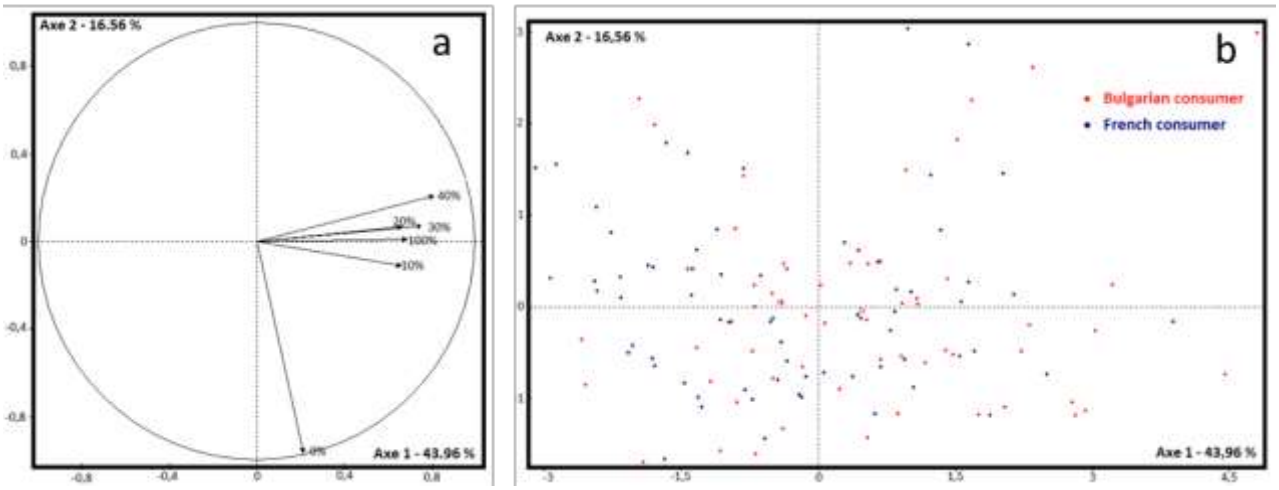

Figure 2. First two dimensions of the principal component analysis (PCA) performed on the overall acceptability: a) correlation circle, b) projections of the panelists. The Bulgarian consumers are represented in red and the French ones in blue.

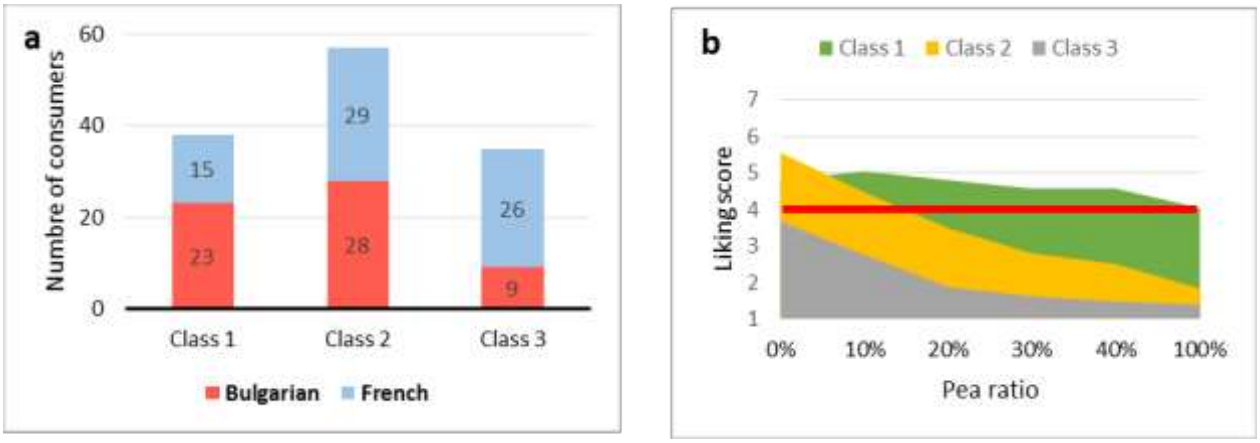

Figure 3. Classes of consumers yielded by the HCA performed on the first fourth dimension of the liking score PCA: a) Distribution of French and Bulgarian consumers in terms of Class; b) the three classes of consumers in terms of liking score.

3.2. Visual appearance, taste, odor and texture

The ANOVA showed the same patterns as for the overall acceptability (Figure 5). Globally, the products with higher pea protein concentration were less appreciated for all the attributes. Again, for all attributes, the Bulgarian consumers gave higher scores than the French consumers. Moreover, they generally scored the attributes in the neutral zone for the products that contain till 20% pea protein, unlike French consumers who assessed all the products containing pea protein (even with just 10% pea) in the negative zone.

The MFA performed on the overall acceptability, appearance, odor, taste and texture scores for the French and Bulgarian panelists is presented in Figure 5. The first dimension (89% of variance) is correlated with all scales. As expected, the factors that affected the overall acceptability of products in ascending order are: the taste, the odor, the texture and finally the appearance (Figure 4a). In other words, for both panels, taste was the most correlated with overall acceptability and appearance the least. The two panels gave the lowest scores to the product with 100% pea protein, possibly because the participants were expecting the fermented milk product to taste like a conventional yogurt (Tu, Valentin, Husson, & Dacremont, 2010). Although the mean overall acceptability for all the products is highly correlated for the two panels (RV coefficient ≈ 0.98), Figure 4b shows the presence of some differences among the two panels in the assessment of the products from 0% to 40% pea protein. This is due mainly to differences in the assessment of appearance and odor among the French and Bulgarian panels.

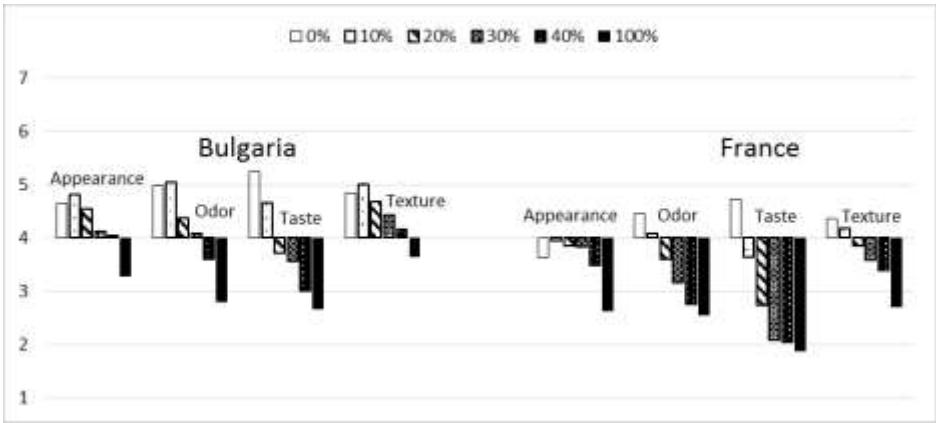

Figure 5. Mean liking scores for visual appearance, taste, odor and texture assessed on hedonic scales ranging from 1 (I do not like at all) to 7 (I like very much), 4 (neither like nor dislike).

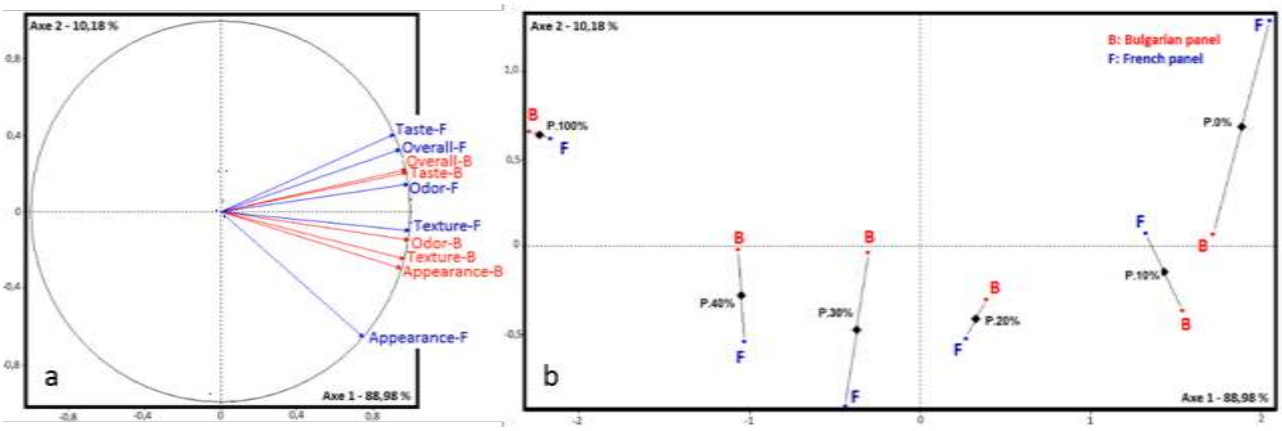

Figure 4. First two dimensions of the multiple factor analysis (MFA) performed on all the assessed attributes: a) correlation circle (the name of the variables is followed by F for the French panel and by B for the Bulgarian panel and b) coordinates of all the products. Lines are drawn between the Bulgarian panel (B) and the French (F) for the corresponding projected products.

4. CONCLUSION

As consumers' acceptability is the factor the most important in order to commercialize new food. The first step in developing new food must be the investigation of the acceptability to understand the need of improvements. In this work, the consumers showed clearly that the insertion of plant protein in the European diet need more efforts as the presence of small quantity of pea protein in fermented milk has reduced the acceptability. With just 10% of pea protein, all French consumers and 20% of Bulgarian consumers scored the product in the negative zone. Globally, Bulgarian and French consumers scored the fermented products similarly even though the liking mean scores were higher for Bulgarian. Significant differences between French and Bulgarian were observed for the appearance and odor assessment with French consumers criticizing considerably the appearance and the odor of these products. In the light of these results, more attention must be given not only to the taste but also to the odor and the appearance of these fermented products.

REFERENCES

Boland, M. J., Rae, A. N., Vereijken, J. M., Meuwissen, M. P. M., Fischer, A. R. H., van Boekel, M. A. J. S., & Hendriks, W. H. (2013). The future supply of animal-derived protein for human consumption. *Trends in Food Science and Technology*.

Bora, P. S., Brekke, C. J., & Powers, J. R. (1994). Heat Induced Gelation of Pea (Pisum sativum) Mixed Globulins, Vicilin and Legumin. *Journal of Food Science*, 59, 594–596.

Cederroth, C. R., Auger, J., Zimmermann, C., Eustache, F., & Nef, S. (2010). Soy, phyto-oestrogens and male reproductive function: a review. *International Journal of Andrology*, 33, 304–316.

Eastham, E. J. (1989). Soy protein allergy. *Carnation Nutrition Education Series (USA)*.

Jaffuel, D., Demoly, P., & Bousquet, J. (2001). Les allergies alimentaires. *Revue Française D'allergologie et D'immunologie Clinique*, *41*, 169–186.

James, D. (2004). Factors influencing food choices, dietary intake, and nutrition-related attitudes among African Americans: Application of a culturally sensitive model. *Ethnicity & Health*, 9, 349–367.

Kim, Y.-K., Jombart, L., Valentin, D., & Kim, K.-O. (2013). A cross-cultural study using Napping®: Do Korean and French consumers perceive various green tea products differently? *Food Research International*, 53, 534–542.

Mazur, W. (1998). 11 Phytoestrogen content in foods. *Baillière's Clinical Endocrinology and Metabolism*, 12, 729–742.

Murat, C., Gourrat, K., Jerosch, H., & Cayot, N. (2012). Analytical comparison and sensory representativity of SAFE, SPME, and Purge and Trap extracts of volatile compounds from pea flour. *Food Chemistry*, 135, 913–920.

Pagès, J., Bertrand, C., Ali, R., Husson, F., & Lê, S. (2007). Sensory analysis comparison of eight biscuits by French and Pakistani panels. *Journal of Sensory Studies*, 22, 665–686.

Pliner, P., & Hobden, K. (1992). Development of a scale to measure the trait of food neophobia in humans. *Appetite*, 19, 105–120.

Prescott, J., Young, O., O'Neill, L., Yau, N. J. ., & Stevens, R. (2002). Motives for food choice: A comparison of consumers from Japan, Taiwan, Malaysia and New Zealand. *Food Quality and Preference*, 13, 489–495.

Schneider, A., & Lacampagne, J. P. (2000). Peas: A European production of protein-rich materials for feed and food. *Industrial Proteins*, 8, 3–6.

Tu, V. P., Husson, F., Sutan, A., Ha, D. T., & Valentin, D. (2012). For me the taste of soy is not a barrier to its consumption. And how about you? *Appetite*, 58, 914–21.

Tu, V. P., Valentin, D., Husson, F., & Dacremont, C. (2010). Cultural differences in food description and preference: Contrasting Vietnamese and French panellists on soy yogurts. *Food Quality and Preference*, 21, 602–610.

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MOTIVATION OF EVERYDAY FOOD CHOICES: DIFFERENCES BETWEEN AMERICAN AND TURKISH RESPONDENTS

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ABSTRACT

Online survey questionnaires using the same protocol were conducted in both the U.S. and Turkey to investigate the difference in motivations of food choices between the two food cultures. The participants (198 American, 141 Turkish) reported all the food/beverage items they consumed for the latest eating occasion and the motivations associated with those items. Liking was found to be the most important driving factor for food consumption, almost regardless of eating occasion, food group and culture. U.S. participants reported six different eating occasions per day, i.e. breakfast, mid-morning snack, lunch, mid-afternoon snack, dinner and late-night snack. A mid-morning snack was not included in the eating pattern of Turkish respondents. Turkish's choices for breakfast and dinner were influenced by Traditional Eating while the same motivation was not considered important for breakfast by U.S. respondents. Sweets were consumed as "indulgent' foods for U.S. respondents but were eaten based on a 'socializing' meaning for Turkish counterparts. The findings revealed how eating patterns and motivations vary depending on culture.

Keywords: *culture, eating motivation, U.S., Turkey*

1. INTRODUCTION

Food is important to sustain life (Rozin *et al.*, 1999); thus, food choice has always been a part of everyday life. However, food choice is not as simple as it could appear and people are different in their choices (Johansen *et al.*, 2011). In fact, everyday food choice is a complicated behavior and often is driven by a number of factors such as biology and physiology, motivation, sociology, economics, and perception-, memory-, emotion-, social- and decision psychology (Johansen *et al.*, 2011; Köster, 2009; Rozin, 2007). Each of these factors target different part of the question "*why* does *who* eat *what*, *when*, and *where*?" For instance, biology (*e.g.* energy balance), physiology, and motivation and decision psychology each attack the "why", while sociology (*e.g.* culture, tradition), and social psychology target the "who". To find the answer for the "what" question, economics, consumer science, perception- and memory-, and learning psychology have major contribution. Finally, almost all of these disciplines have answers to the "where" and "when" questions (Köster, 2009).

From the perspective of economics and commercial interest, simple food consumption surveys can provide basic economic information (Rozin, 2007) about people's food choices as it relates to manufacturing. Food choice also determines nutritional status and because diet influences health and disease, it is essential to understand what is eaten. However, from other perspectives simply understanding what is eaten is far less important than understanding *why* those foods are eaten. The processes by which people make their food choices become key when we want to create new successful products, change eating behaviors to more sustainable products, or encourage people to eat foods that may be more healthful than current options but not typical in their diet.

Therefore, it is essential to study people's motivations of food choices, especially under the influences of eating contexts and cultures as these two factors provide the setting for food choices to occur. Meiselman (2008) brought in the importance of "meals" in studying food choice. Pliner & Rozin (2000) discuss the psychological perspective of meals that involve availability of food, effort to obtain or consume food, palatability and preference, mood, variety and sensory-specific satiety, learning and expectation, social factors, cultural standard and memory, and location. The social perspective is used to define "meal" as a structured social event where food is eaten. The historical and biological perspectives of a meal are discussed in Meiselman (2009) with history that demonstrates the dynamics of a meal and biological dimensions that cover all physiological, sensory, and satiety aspects of a meal. Last but not least is the cultural/social perspective. This is considered the most important aspect of meals because meals are one of the main points of cultural and social interactions (Meiselman, 2009).

The influence of culture on food choice has been long acknowledged (Aboud, 2011; Furst *et al.*, 1996). Similarities and differences in motivations for food choices among different groups of people from different countries were explored in a number of studies. Prescott, Young, O'Neill, Yau, & Stevens (2002) found that Taiwanese and Malaysian (ethnically Chinese) consumers are similar in considering health, natural content, weight control and convenience as the most important food choice factors, whereas it was price for Japanese, and sensory appeal for New Zealanders. Sensory appeal, purchase convenience, and health and natural content were found to be the most important motives for food choice of consumers in six Western Balkan Countries; while ethical concern and familiarity were the least important (Milošević, Žeželj, Gorton, & Barjolle, 2012). Pieniak, Verbeke, Vanhonacker, Guerrero, & Hersleth (2009) reported that weight control, price, ethical concern, convenience, natural content, health, sensory appeal, and familiarity have the same meaning and similar structural characteristics across cultures in Europe. Sensory and availability were found to be the most important factors for Russian consumers, followed by price (Honkanen & Frewer, 2009).

The United States is the target population of a number of studies about food attitudes and eating behavior. Rozin *et al.* (1999) reported that Americans considered themselves much lower in their own sense of being healthy eaters compared to Japanese, Belgians, and French. The obesity rate in the U.S. has increased at alarming rates since 1970 and now the U.S. is considered to have one of the highest levels of obesity in the world (Wells & Buzby, 2008; Hawks *et al.*, 2003). The high obesity rate in the U.S. has raised a question on what Americans have been consuming each year (Wells & Buzby, 2008). Meat is an important portion of diet in the U.S., providing approximately 40% of dairy energy intake and 20% of dairy fat intake (Daniel *et al.*, 2011). While milk consumption in the U.S. has been decreased over the past several decades, the consumption of carbonated drinks and juices has been increased (Duffey & Popkin, 2007; Cavadini *et al.*, 2000). According to Wells & Buzby (2008), Americans consumed foods and beverages that are high in fats and carbohydrates (*e.g.* grains, meat, nuts) at higher amount than dietary guideline and consumed too few more healthy foods such as lower fat milk and milk products, fruits, and vegetables.

Beside Europe, U.S. and some other developed countries, little is published about food motivation and eating behavior of other populations in the world. Turkey is among those countries with little published about their food behavior. Turkey has a unique geographical and cultural position as the country is located between Europe and Asia (Akbay *et al.*, 2007). Chambers *et al* (2016) have made an attempt to document some main motivations that drive the Turks into choosing different foods and beverages for different eating occasions. The authors found that Liking is a key motivation for all Turkish food choices for all eating occasions. In addition, Natural Concerns and Choice Limitation are more important for breakfast and dinner while Sociability, Variety Seeking, and Social Norms are the important motivations for lunch choices of the Turkish people. From a dietary point of view, the average Turkish diet mainly comes from grains, fruits and vegetables, which are available throughout the year. Bread, macaroni and bulgur are the main staple and legumes such as lentils, chickpeas and dried beans are widely consumed in Turkey (Akbay *et al.*, 2007; FAO, 2001). Sweets such as Turkish delight and baklava, and tea also play an important role in Turkish people's diet (Taviloglu, 2016; Batu & Kirmaci, 2009). Red meat such as lamb and beef are also presented in Turkish cuisine, however, the consumption tends to be decreased in

recent years because of an increase in price (Akbay *et al.*, 2007). While the average diet in Turkey is adequate to meet the recommended daily intake of energy and most nutrients, the consumption of animal protein, calcium, riboflavin and vitamin A are still lower than recommended (Akbay *et al.*, 2007; FAO, 2001). Although the average Turkish person generally meets the nutrient intake requirement, micronutrient deficiencies are an important problem for younger children. In addition, a number of Turkish adults also face with obesity and coronary heart disease (Hodoğlugil & Mahley, 2006; Onat, 2004; FAO, 2001).

Given the similarities (religious populations but secular governments, primary European genetic descent, considerable international trade, wide food availability) and differences (culture, religion, foods consumed) in the U.S. and Turkish populations and the fact that matching survey data on eating motivations were available from both countries, it is interesting to investigate and compare the *motivations* behind everyday food choices of those two populations. That was the main objective of this study.

2. MATERIALS AND METHODS

2.1. Participants

The original studies (Phan & Chambers 2016, Chambers *et al*, 2016) were approved by the Internal Review Board of Kansas State University (#7297). Participation in the study was absolutely voluntary. The participants were informed that this study was about their food consumption on a daily basis. To be qualified for the study, people have to be 18 or older and have been living in the corresponding country (United State for U.S. participants and Turkey for Turkish participants) for at least 10 years. One hundred and ninety eight (198) people have participated in the survey in the U.S. All U.S. respondents lived in Kansas, a state in the Midwest of the country. One hundred forty-one (141) was the number of the participants in the survey in Turkey. Compared to the U.S. group, the Turkish group was more diversified in term of geography. Thirty three percent (33%) of the Turkish participants lived in Aegean region; 30% was from Marmara Sea, and the rest were from Central Anatolia (12%), Black sea (11%), Southeastern Anatolia (8%), Mediterranean (3%), and Eastern Anatolia (3%).

2.2. The online survey questionnaire

The core of the questionnaire was developed based on The Eating Motivations Survey (TEMS) (Renner *et al.*, 2012). The questionnaire was modified by adding two motivation constructs, Variety Seeking and Choice Limitation. Table 1 presents the 17 motivations with their corresponding subscales. The survey was created in English and this version was used for the U.S. participants. The same questionnaire was also translated into Turkish by a native Turkish speaker, and was proof-read by five Turkish students to validate the translation. The questionnaires were then launched in Qualtrics (Qualtrics, Provo, UT, USA) for both groups of participants.

The participants were asked to indicate which of the following: breakfast, mid-morning snack, lunch, mid-afternoon snack, dinner, and evening/late-night snack was their latest eating occasion. Then, they had to specifically list the foods and beverages (at max 7 items) they have consumed in that eating occasion, such as chicken, beef, apple, banana, cookie, chocolate, wine, tea, water, etc. This had to be as specific as possible. Then, for each item listed, the participants chose all the motivation subscales that applied for that specific food/beverage item, using the Check-All-That-Apply procedure. It took about 10 minutes, on average, for the participants to complete the survey.

2.3. Data analysis

Descriptive analysis was used to report the demographic data for both groups of people. The specific food and beverage items were recorded and classified based on the eating occasions as well as food groups such as cereal grain and pasta, dairy, meat, poultry, fast foods, beverage, and so on. The classification was done based on the USDA National Nutrient Database for Standard Reference Release 28 (USDA, 2015) and the Dietary Guidelines for Turkey (Republic of Turkey Ministry of Health, 2006).

Table 1. The modified version of the eating motivation questionnaire used in this study. This questionnaire consisted of 50 motivation subscales covering 17 motivation constructs.

Construct	Motivation subscales
Liking	because I have an appetite for it
	because it tastes good
	because I like it
Habit	because I'm accustomed to eating it
	because I usually eat it
	because I am familiar with it
Need and Hunger	because I need energy
	because it is pleasantly filling
	because I'm hungry
Health	to maintain a balanced diet
	because it is healthy
	because it keeps me in shape (e.g. energetic, motivated)
Convenience	because it is quick to prepare
	because it is the most convenient
	because it is easy to prepare
	because someone made it for me and it is the choice
Pleasure	because I enjoy it
	in order to indulge myself
	in order to reward myself
Traditional Eating	because it belongs to certain situations
	out of traditions (e.g. family traditions, special occasions)
	because I grew up with it
Natural Concerns	because it is natural (e.g. not genetically modified)because it contains no harmful substances (e.g. pesticides, pollutants, antibiotics)
	because it is organic
Sociability	because it is social
	so that I can spend time with other people
	because it makes social gatherings more comfortable
Price	because it is inexpensive
	because I don't want to spend any more money
	because it is on sale
Visual Appeal	because the presentation is appealing (e.g. packaging)
	because it spontaneously appeals to me (e.g. situated at eye level, appealing colors)
	because I recognize it from advertisements or have seen it on TV
Weight Control	because it is low in calories
	because I watch my weight
	because it is low in fat
Affect Regulation	because I am sad
	because I am frustrated
	because I feel lonely
Social Norms	because it would be impolite not to eat it
	to avoid disappointing someone who is trying to make me happy
	because I am supposed to eat it
Social Image	because it is trendy
	because it makes me look good in front of others
	because others like it
Choice Limitation	because it was what was served
	because it is the only choice
Variety Seeking	because I like to eat a variety of different foods each day
	because I don't like to eat the same food for the same meal everyday

The motivation data from the 50 motivation subscales were also collected for those food/beverage items. These 50 motivations subscales were then classified into the 17 motivation constructs (Table 1). Hence, we had a three-way data table corresponding to eating occasions, food groups, and motivation constructs. To omit the influence of the sample sizes due to the unequal numbers of the food items reported per eating and food group, count data were transformed into percentages before analyzing. Correspondence Analysis (CA) (Husson, Lê, & Pagès, 2011) and Multiple Factor Analysis (MFA) (Pagès, 2004) were used to examine the motivation constructs for eating occasions as well as food groups for both groups of participants to examine whether there was a difference between US and Turkey in their motivations for food choices. The findings from CA

were validated by a proportion test using Pearson's chi-squared test statistics. All analyses were performed in R.3.2.3 (R Development Core Team, Vienna, Austria, 2007) using FactorMineR package (Lê, Josse, & Husson, 2008).

3. RESULTS AND DISCUSSION

3.1. Differences between U.S. and Turkish respondents in daily food consumption

Six different eating occasions were found in a daily diet of the Americans (Table 2). These were breakfast (7-9 a.m.), mid-morning snack (8-11 a.m.), lunch (11 a.m.-1 p.m.), mid-afternoon snack (1-5 p.m.), dinner (5-8 p.m.), and late-night snack (8 p.m.-midnight). U.S. respondents consumed only one or two food and beverage items for breakfast and snack times, but more choices for lunch and dinner (2-4 items).

The Turkish diet was more focused on the main meals, which were breakfast, lunch, and dinner, than snacks. None of the Turkish respondents reported a mid-morning snack (Table 2). The main eating the Turkish people had in the morning was breakfast, which was sometime between 7 and 11 a.m. Lunch was between 11 a.m. and 5 p.m. while a mid-afternoon snack was from 1 to 8 p.m. Dinner was from 5 to 8 p.m., and a late-night snack was between 8 p.m. and midnight. Turkish people seemed to be more flexible in term of time to eat a specific meal/snack than the U.S. people.

Table 2. The main eating occasions reported by the respondents from two countries: US and Turkey. The number in parentheses is the corresponding percentage of the each eating occasion within each consumer group.

Most recent eating	US	Turkey
Breakfast	53 (27%)	30 (21%)
Mid-morning snack	19 (10%)	0 (0%)
Lunch	67 (34%)	26 (19%)
Mid-afternoon snack	20 (10%)	11 (8%)
Dinner	30 (15%)	47 (33%)
Late night snack	8 (4%)	27 (19%)

The U.S. group reported a total of 477 food and beverage items for all six eating occasions. These items were originally grouped into 17 food groups (baked products, beverages, breakfast cereals, cereal grains and pasta, dairy and eggs, fast foods, fruits and fruit juices, legumes, meals and sides, nuts and seeds, pork, poultry, sausages and luncheon meats, snacks, soups, sweets, and vegetables) with the beverages group broken down into eight subgroups: alcoholic, coffee, soda, tea, water, shake, chocolate drinks, and unspecified. These data has been published in Phan & Chambers (2016). The Turkish group reported 304 food items that were classified into 10 food groups, i.e. protein, cereal grains and pasta, vegetables, soups, fruits, dairy, baked products, sweets, tea, and water (Chambers *et al.*, 2016). These results suggested that American diet contained more varieties of foods and beverages than Turkish diet.

Within the scope of this paper, selected food groups were chosen to present the food choice patterns for different eating occasions of the U.S. group of respondents (Figure 1). It's no surprise to find breakfast cereals and coffee were mainly consumed at breakfast. Baked products, dairy and eggs were also the foods the Americans were more likely to choose to start a day. Fast foods were found to be the main one reported for lunch. The U.S. respondents in this study were those who often had lunch at work. Therefore, fast foods seemed to be a reasonable choice for a meal they only had about an hour to eat.

Dinner was linked to meat, vegetables, cereal grains, pasta, and alcoholic beverages. This meal had the most varieties of foods and was often consumed at home with family or friends. For snacking, American respondents consumed fewer items than for meals. Snack foods, nuts, seeds, and fruits were the most common choices for all snacks throughout the day. A food choice pattern could be seen here in the American diet: choices for meals tended to involve the main nutrition groups of carb, protein, fiber, or fat and normally come with a large portion; while choices for snacking were foods that were portable, maybe high calories but could be consumed with a small portion.

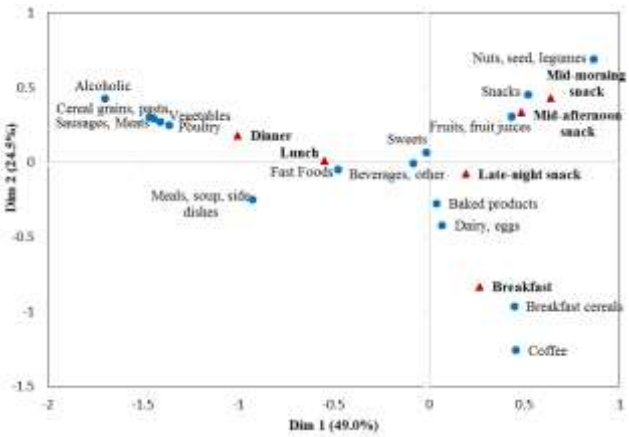


Figure 1. Correspondence between food groups and eating occasions for U.S. respondents.

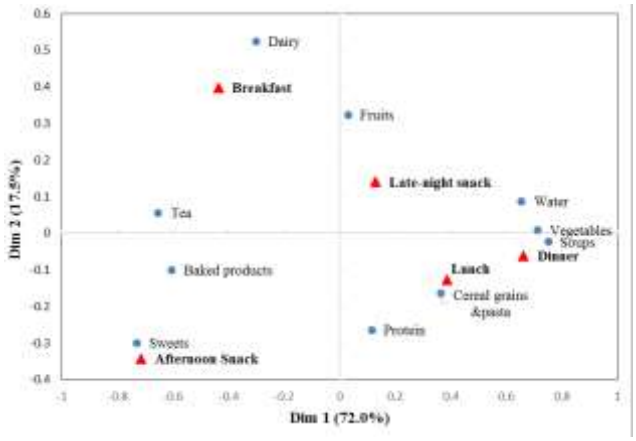


Figure 2. Correspondence between food groups and eating occasions for Turkish respondents.

Despite consuming fewer food groups, the Turkish respondents ate more diversified food items for one eating occasion than the American counterparts (Figure 2). Baked products, dairy, vegetables, and sweets were consumed at all five eating occasions. However, some main trends could be pointed out. Dairy was more dominant at breakfast while sweets and baked products were the choices for mid-afternoon snack. Soups and vegetables were foods for dinner in Turkish diet. Lunch was heavily based on cereal grains and some source of protein. Tea was the drink for breakfast and afternoon snack. No alcoholic beverage was consumed, which was not surprising given 98% of the Turkish population are Muslim. These findings confirmed that Turkish diet was heavy in carb but low in protein (Bilgic & Yen, 2014). The tendency of choosing foods which were portable and come at small portion for snack times was also observed in the Turkish diet.

3.2. Motivations associated with five eating occasions from U.S. and Turkish respondents

To facilitate the comparison between the two groups of consumers in their motivations for meals/snacks, multiple factor analysis (MFA) was performed on the motivation data of only five eating occasions, including breakfast, lunch, mid-afternoon snack, dinner, and late-night snack. Figure 3 presents the individual and factor maps resulting from MFA. For the U.S. respondents, dinner was associated with traditional eating and sociability aspects. Breakfast was more about convenience, habit, and (low) price. Lunch was also all about convenience for the U.S. group. These were consistent with Rappoport *et al.* (2001). Turkish people also considered sociability when choosing foods for dinner. However, other factors such as cost and availability also come to play in Turkish dinner choices. Breakfast for the Turks was not about convenience; instead health, natural concerns, and tradition were the priorities. The two groups had similar motives for late-night snacks, pleasure and to some extent sociability. U.S. respondents prioritized weight control and natural concerns when deciding what to eat for a mid-afternoon snack while habit was a major motivation for many Turkish people for that same eating. This finding was valid given that tea and sweets (often traditional Turkish sweets such as baklava, Turkish delights, etc.) was the main thing the Turkish respondents consumed at mid-afternoon snack, while Americans chose nuts, seeds and fruits for this particular snacking.

MFA provided separate factor analysis for the two groups of respondents to study the motivation patterns associated with the five eating occasions per each group. From these two separate analyses, liking was found to be the most important motivation associated to all food choices for meals and snacks of both American and Turkish groups. Chi-squared test statistics (results have been published in Phan & Chambers (2016) for the US population) confirmed this finding. This result could be inferred from Figure 3, where liking was not specifically associated with any eating occasion especially for the Turkish group, suggesting that it was, in fact either not part of any eating occasions (clearly not the case) or part of all eating occasions. Liking seemed to link more to late-night snacking for the U.S. group. This was because of the high correlation between liking and pleasure (R = 0.743) for that occasions, where pleasure was the dominant motivation for that snacking. The fact that liking was not well presented in this map for the U.S. group indicated its relation to other eating occasions, but its domination for late-night snacking. This points to the problem of mapping pointed out by Yenket, Chambers & Adhikari (2011) who noted that it is critical to examine the original data in mapping studies because the mapping sometimes can aggregate data to the point that it appears misleading, when in fact it is simply a matter of one attribute or product providing a larger influence than expected on the map.

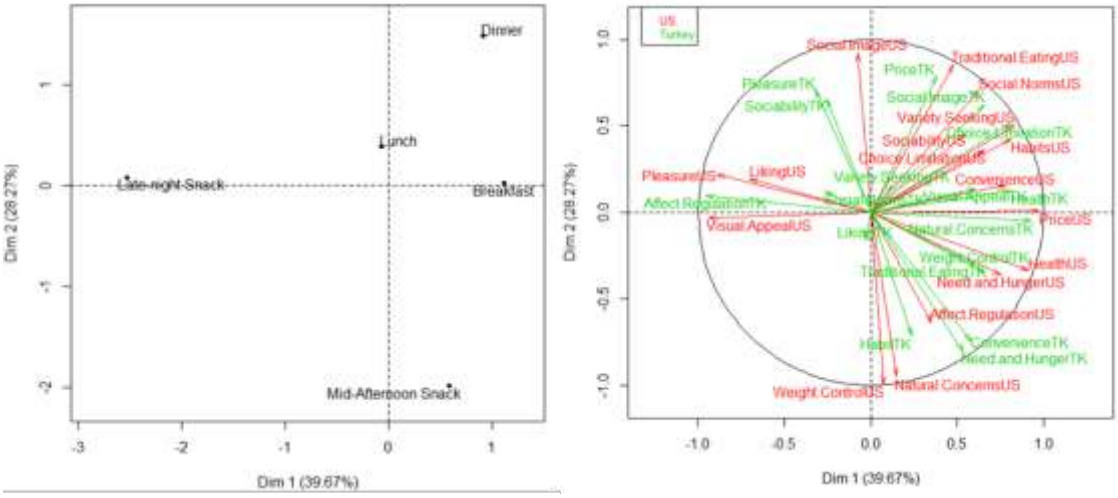
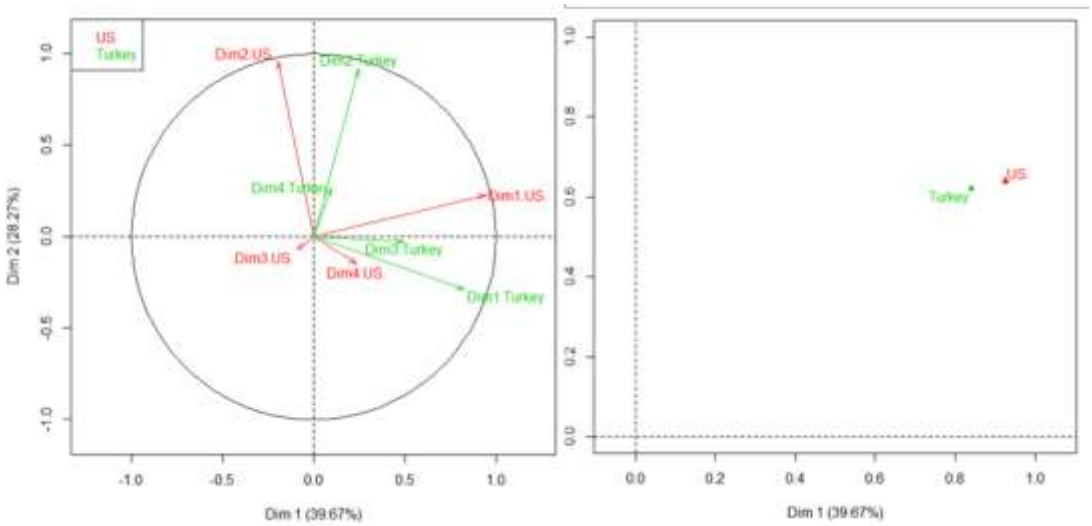


Figure 3: Motivation constructs of eating occasions from both US and Turkish respondents. US-respondents; TK-Turkey.



(4a) (4b)

Figure 4. The similarity between U.S. and Turkish respondents in motivation patterns associated to eating occasions. (4a) Presentation of the factors from separate analyses; (4b) Presentation of the group variables

The MFA technique also compared these two analyses to see if these two groups were similar in their patterns. Figure 4a presents the factors from the separate analyses side by side. Figure 4b presents how close these two groups of respondents were to each other in terms of motivations for eating occasions. Despite some discrepancies discussed above, the two groups still shared similar motivations when choosing foods for a specific eating occasion.

3.3. Motivations associated with food groups from US and Turkish respondents

Figure 5 provided motivations associated with nine food groups in daily Turkish cuisine. Sweets such as jam, chocolate, honey, and sweet desserts were mainly associated with liking and the social motivation. Water was associated with Natural Concern, Health, Liking, and Choice Limitation. There was no surprise that water consumption was not driven by Visual Appeal, Variety Seeking, Traditional Eating and Affect Regulation, since it had no other flavor or color added. Tea consumption was linked with Liking, Traditional Eating, and Choice Limitation. Tea is an important part of Turkish diet as Turkish people start drinking tea from breakfast until bedtime. It is always available and ready to drink in every home and work place (Taviloglu, 2015). Baked products such as breads were mainly associated with liking and fundamental motivations including need and hunger, and habit. This is supported by a report from FAO (2001) indicating that the main energy for Turkish people comes from baked products such as bread.

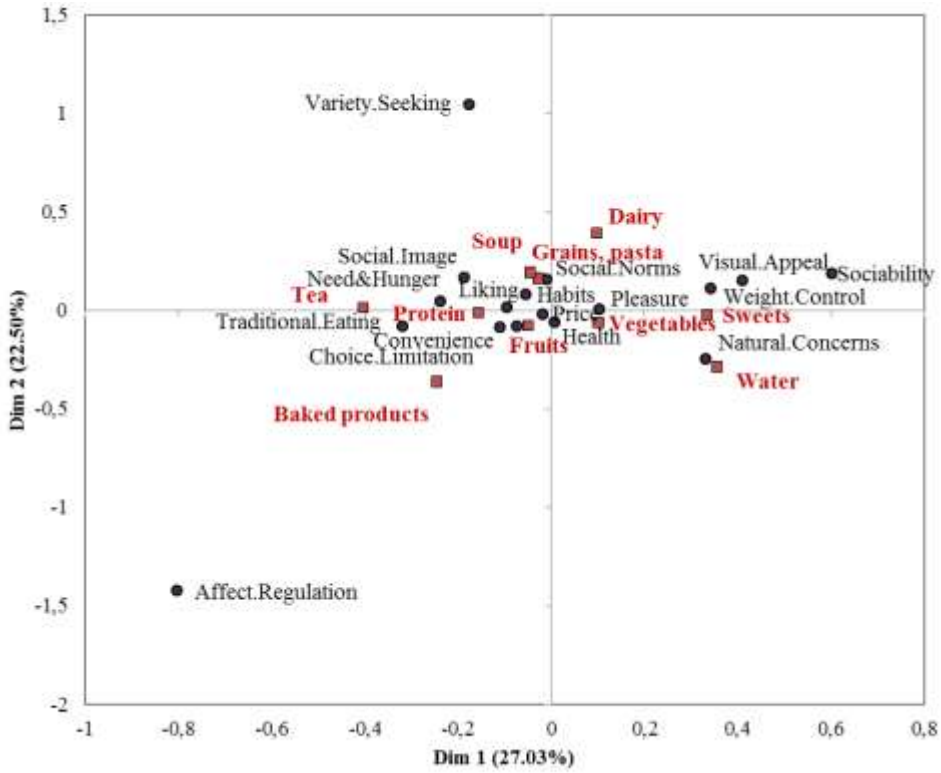


Figure 5. The factor map representing the motivations associated with nine common food groups in the daily diets of the Turkish respondents.

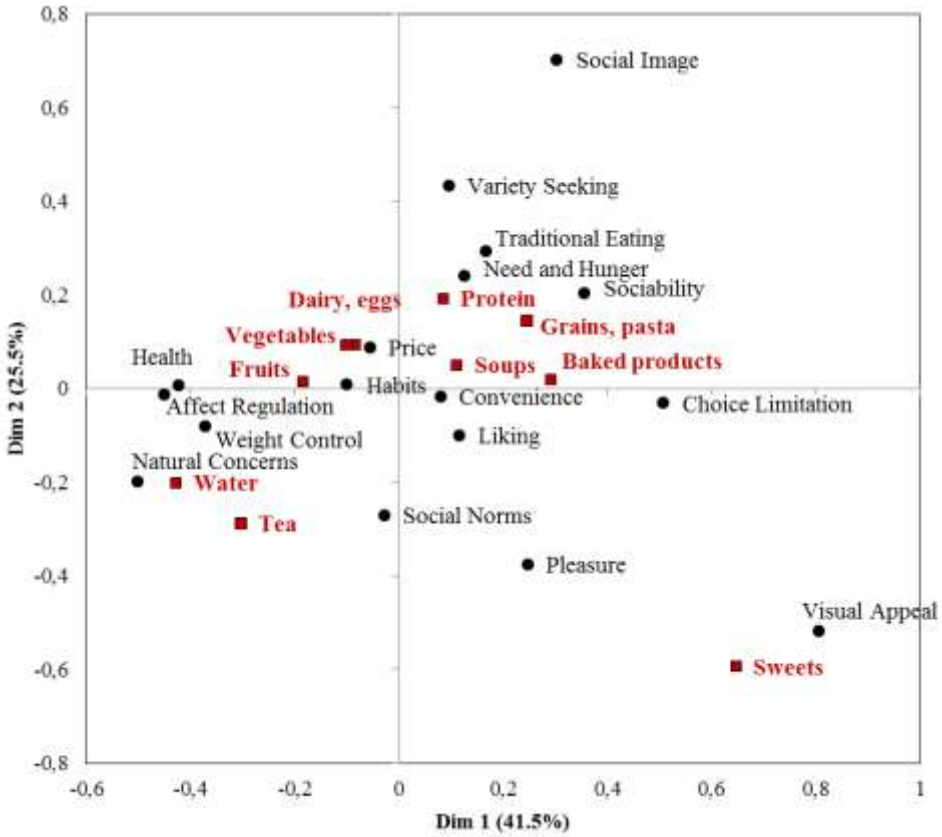


Figure 6. The factor map representing the US respondents' motivations associated with the nine similar food groups as from Turkish respondents

3.4. Motivations associated with food groups from US and Turkish respondents

Figure 5 provided motivations associated with nine food groups in daily Turkish cuisine. Sweets such as jam, chocolate, honey, and sweet desserts were mainly associated with liking and the social motivation. Water was associated with Natural Concern, Health, Liking, and Choice Limitation. There was no surprise that water consumption was not driven by Visual Appeal, Variety Seeking, Traditional Eating and Affect Regulation, since it had no other flavor or color added. Tea consumption was linked with Liking, Traditional Eating, and Choice Limitation. Tea is an important part of Turkish diet as Turkish people start drinking tea from breakfast until bedtime. It is always available and ready to drink in every home and work place (Taviloglu, 2015). Baked products such as breads were mainly associated with liking and fundamental motivations including need and hunger, and habit. This is supported by a report from FAO (2001) indicating that the main energy for Turkish people comes from baked products such as bread.

Protein, fruit and vegetable products shared similar motivation patterns. Turkish people linked these food groups to liking, pleasure, habit, natural concerns, and need and hunger. Consumption of soup, cereal grain, pasta and dairy products were also driven by liking, pleasure, need and hunger, habit, and health as well as variety seeking. Variety seeking, which related to the willingness to try a variety of foods, appeared to be associated with only these specific food groups for Turkish participants. The Turks usually altern between several types of soup for dinner and *pilav* rice is often served as an alternative for bread to change the taste in dinner.

The motivations associated with specific food groups for US respondents had a more explicit pattern than Turkish respondents (Figure 6). Liking was an important driver of consumption for all food groups. However, other motivations affected also their decision on selecting specific food categories. While sweets were important for the socializing meaning with family in Turkey, Americans consumed sweets mainly because of pleasure. They ate sweets because they "enjoy eating it" and "like it", and nowhere did it have a health consideration. Visual appeal also influenced sweets consumption in U.S. but it was not as important as pleasure. Variety seeking was an important motivation for various food groups including fruits, vegetables, dairy, eggs and higher caloric foods (*e.g.* protein, grains, pasta, baked products, and soup). Additionally, U.S. people also chose most of food groups because of habits and price. Beside those motivations, health, natural concern, and weight control were the main motivations for fruits, vegetables, dairy and eggs consumption. Water and tea were linked with similar motivations including natural concerns, weight control, affect regulation, and health. However, traditional eating, the major motivation for drinking tea in Turkey, was not associated with tea or beverage consumption in general in the United States.

Similarly to Turkish people, Americans consumed protein, grains, pasta, baked products, and soup because of need and hunger. However, consumption of these food groups was also driven by sociability and convenience. Fast foods became a part of American life because of convenient and economics reasons (Morris et al., 1996). In addition, people in the U.S. can more easily access to various pre-made mixes (e.g. bread, muffin, cake mix) or ready-to-eat products (e.g. sausage patties, and roasted beef) with reasonable price. Thus, convenience is the expected motivation for this food group.

4. CONCLUSION

Despite differences in geographic, history and culture, American and Turkish shared some similarities in eating motivation. The two groups of people appreciated good foods. Therefore, they prioritized Liking as the most important factor in food choices, regardless of eating occasions. Turkish respondents also were motivated by fundamental motivations such as Need and Hunger, and Habits as their U.S. counterparts to choose staple foods for main meals. Health and Natural concerns were the motives for fruits and vegetables for both groups. The two groups were very different in beverage consumption with U.S. groups consuming more stimulating drinks such as coffee and alcohol while Turkish people, restricted by their culture and religion, consumed more tea and water. Turkish peoples' choices for breakfast and dinner were influenced by Traditional Eating while the same motivation was not considered important for breakfast by U.S. participants who were more concerned with convenience. Sweets were consumed as "indulgent' foods for U.S. participants but were considered to be part of 'socializing' and

given a different meaning for Turkish consumers. These findings revealed how eating patterns and motivations can be similar but also vary depending on culture.

REFERENCES

Aboud, F. E. (2011). Cultural perspectives on the interactions between nutrition, health, and psychological functioning. *Online Readings in Psychology and Culture*, 10, 2.

Akbay, C., Boz, I., & Chern, W. S. (2007). Household food consumption in Turkey. *European Review of Agricultural Economics*, 34, 209-231.

Batu, A., & Kirmaci, B. (2009). Production of Turkish delight (lokum). *Food research international*, 42, 1-7.

Bilgic, A. & Yen, S. T. (2014). Demand for meat and dairy products by Turkish households: a Bayesian censored system approach. Agricultural Economics, 45, 117-127.

Cavadini, C., Siega-Riz, A. M., & Popkin, B. M. (2000). US adolescent food intake trends from 1965 to 1996. *Archives of disease in childhood*, 83, 18-24.

Chambers, D., Phan, U. T., Chanadang, S., Maughan, C., Sanchez, K., Di Donfrancesco, B., & Esen, E. (2016). Motivations for Food Consumption during Specific Eating Occasions in Turkey. *Foods*, 5, 39.

Daniel, C. R., Cross, A. J., Koebnick, C., & Sinha, R. (2011). Trends in meat consumption in the USA. *Public health nutrition*, 14, 575-583.

Duffey, K. J., & Popkin, B. M. (2007). Shifts in patterns and consumption of beverages between 1965 and 2002. *Obesity*, 15, 2739-2747.

FAO. (2001). Nutrition Country Profile of Turkey. Food and Nutrition Division, Rome.

Furst, T., Connors, M., Bisogni, C. A., Sobal, J., & Falk, L. W. (1996). Food choice: a conceptual model of the process. *Appetite*, 26, 247-266.

Hawks, S. R., Madanat, H. N., Merrill, R. M., Goudy, M. B., & Miyagawa, T. (2003). A cross-cultural analysis of 'motivation for eating'as a potential factor in the emergence of global obesity: Japan and the United States. *Health promotion international*, 18, 153-162.

Hodoğlugil, U., & Mahley, R. W. (2006). Smoking and obesity make a bad problem worse: genetics and lifestyle affect high density lipoprotein levels in Turks. *Anadolu kardiyoloji dergisi: AKD= the Anatolian journal of cardiology*, 6, 60-67.

Honkanen, P., & Frewer, L. (2009). Russian consumers' motives for food choice. *Appetite*, 52, 363–371

Husson, F., Lê, S., & Pagès, J. (2011). Exploratory multivariate analysis by example using R. Boca Raton, FL: CRC Press.

Johansen, S. B., Næs, T., & Hersleth, M. (2011). Motivation for choice and healthiness perception of calorie-reduced dairy products. A cross-cultural study. *Appetite*, 56, 15-24.

Köster, E. P. (2009). Diversity in the determinants of food choice: A psychological perspective. *Food quality and preference*, 20, 70-82.

Lê, S., Josse, J., & Husson, F. (2008). FactoMineR: An R package for multivariate analysis. Journal of Statistical Software, 25, 1-18.

Lyerly, J. E., & Reeve, C. L. (2015). Development and validation of a measure of food choice values. *Appetite*, 89, 47-55.

Meiselman, H. L. (2008). Dimensions of the meal. *Journal of Foodservice*, 19, 13-21.

Meiselman, H. L. (2009). Dimensions of the meal: A summary. In H. L. Meiselman (Ed.), Meals in science and practice: Interdisciplinary research and business applications. Boca Raton, FL: Woodhead Publishing Ltd and CRC Press LLC, pp. 1-15.

Milošević, J., Žeželj, I., Gorton, M., & Barjolle, D. (2012). Understanding the motives for food choice in western Balkan countries. *Appetite*, 58, 205-214.

Onat, A. (2004). Lipids, lipoproteins and apolipoproteins among Turks, and impact on coronary heart disease. *Anadolu Kardiyol Derg*, 4, 236-45.

Pagès, J. (2004). Multiple factor analysis: Main features and application to sensory data. *Revista Colombiana de Estadística*, 27, 1-26.

Pliner, P., & Rozin, P. (2000). The psychology of the meal. In H. L. Meiselman (Ed.), Dimensions of the meal: The science, culture, business, and art of eating. Gaithersburg, Md: Aspen Publishers, pp. 19-46.

Phan, U. T. X., & Chambers, E. IV. (2016). Application of an eating motivation survey to study eating occasions. *Journal of Sensory Studies*, 31, 114-123.

Prescott, J., Young, O., O'neill, L., Yau, N., & Stevens, R. (2002). Motives for food choice: A comparison of consumers from Japan, Taiwan, Malaysia and New Zealand. *Food Quality and Preference*, 13, 489-495.

Rappoport, L. & Huff-Corzine, L. (2001). Conceptual difference between meals. *Food Quality and Preference*, 12, 9-17.

Renner, B., Sproesser, G., Strohbach, S., & Schupp, H. T. (2012). Why we eat what we eat. The Eating Motivation Survey (TEMS). *Appetite*, *59*, 117-128.

Republic of Turkey, Ministry of Health. (2006). Dietary Guideline for Turkey. Available online http://www.saglik.gov.tr/EN/belge/2-78/dietary-guidelines-for-turkey-pdf-563-mb.html.

Rozin, P. (2007). Food choice: an introduction. *Understanding consumers of food products*, 3-29.

Rozin, P., Fischler, C., Imada, S., Sarubin, A., & Wrzesniewski, A. (1999). Attitudes to food and the role of food in life in the USA, Japan, Flemish Belgium and France: Possible implications for the diet–health debate.*Appetite*, *33*, 163-180.

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

Taviloglu E. Turkish Tea and Coffee Culture. Available online: http://turkishfood.about.com/od/BeveragesSpirits/a/Turkish-Tea-And-Coffee-Culture.htm (accessed on 23 June 2016).

United States Department of Agriculture. (2015). The national nutrient database for standard reference release 28. Available online: http://ndb.nal.usda.gov/ndb/foods.

Wells, H. F., & Buzby, J. C. (2008). *Dietary assessment of major trends in US food consumption, 1970-2005*. Washington: US Department of Agriculture, Economic Research Service.

Yenket, R., Chambers E. IV, & Adhikari, K. (2011). A comparison of seven preference mapping techniques using four software programs. *Journal of Sensory Studies*, *26*, 135-150.

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EVALUATION OF TABLETS FOR UNDERGRADUATE SCHOOLWORK

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ABSTRACT

Electronic reading (e-reading) device has been available for decades and there are many studies that have been published based on those devices. However with continuously changing tablet marketplace, there is a lack of studies looking at current devices. In order to understand the effect of tablets on undergraduate students, we conducted a consumer study to: 1) Determine the most beneficial tablet size for college students in their academic pursuits and 2) Determine the necessary types of support from academic libraries for college students conducting schoolwork using a tablet. An initial focus group study guided a consumer survey of 121 undergraduate students. The focus group study identified reading and note taking as key academic activities for tablet users. The participants were also interested in receiving quick help from the library and using electronic journal articles available from the library. A consumer survey took place at a university campus a month later. Each survey respondent answered a set of questionnaires using both large and small tablets of either Android or iOS operating system. The survey data showed that overall, larger tablet was preferred for academic use. Tablet size was not an important factor in reading or note taking ($p \geq 0.05$) but perceived portability of a tablet size increased preference for that tablet size ($p = 0.0078$). In addition, the library's instant messaging feature was found to be equally successful in both full and mobile website when viewed on a tablet ($p \geq 0.05$). Many students who use HTML only or both HTML and PDF formats to view electronic journal articles when on a computer switched to PDF only when on a tablet. Our findings can assist tablet manufacturers in making a suitable tablet targeted for higher education use and guide academic libraries in improving accessibility to e-source for a growing number of undergraduate tablet users.

Keywords: *tablet, e-reading, consumer testing, focus group, library*

1. INTRODUCTION

A form of electronic reading (e-reading) device has been available for decades and there are many studies on that subject. We understand from these studies that such devices may be helpful to college students. However, these devices are very dissimilar to devices currently available. Even some devices that are recognized as immediate precursors to the current devices are far lacking in features compared with current devices. At present time, it is largely unclear which of the current lineup of tablets is the most suitable option for college students and how academic libraries can best assist these tablet users. In order to answer these questions, we conducted a consumer study of undergraduate students to determine the most beneficial tablet size for college students in their academic pursuits and necessary types of support from academic libraries for college students conducting academic work using a tablet.

In 2010, Apple released its first tablet, iPad, and brought tablets into the mainstream of devices available for US consumers. According to Morse (2011), a tablet is a "medium-sized portable personal computer where a pen or touchscreen is used as the primary interface." Until recently, Apple's iPad had dominated the market but with increasing popularity of tablets, a number of promising competitors have entered the market. They include Samsung Galaxy Tab running on Android operating system, particularly affordable Amazon Kindle Fire, and the Microsoft Surface tablet that promises superior functions (Bort 2013). In May of 2011, comScore (2011) reported that among non-computer device digital traffic in the US, tablet traffic was 22% compared to 68% for mobile phone devices suggesting that tablets play a substantial role

despite having been widely used since only about 2010.

Dahlstrom, de Boor, Grunwald, Vockley (2011) and the Pearson Foundation (2012) found that tablets have educational value for undergraduate students. More recently, International Data Corp. (IDC), announced that the category of tablets that are less than eight inches has overtaken larger tablets in terms of total units being shipped (2013). This is one of the areas that requires further investigation because larger tablets may be more suitable for academic purposes of undergraduate students despite its declining popularity. Weisberg (2011); Revelle, Messner, Shrimplin, Hurst (2012), and Sloan (2012) showed that undergraduate students are receptive towards electronic literature. Weisberg's study noted that pros of e-textbook included convenience and portability, lower cost compared with print textbook, content search function, and the e-textbook being an appropriate media for the current generation. A study by Shrimplin, Revelle, Hurst, Messner (2011) recognized the "searchability" function in particular as being helpful in academic work. Dahlstrom *et al.* (2011) and Angeletaki's (2011) study found that students view accessibility and portability as the most important feature of digital text on e-reading devices.

Since 2007 when electronic readers became widely available, many studies have been conducted to evaluate effectiveness of e-readers in an academic setting. Studies that have been recently completed concluded that e-readers are largely inadequate for use in higher learning, particularly against more powerful tablets (Weisberg 2011; Angeletaki 2011; Princeton University 2010; Marmarelli and Ringle 2009; Thayer *et al.* 2011; Pollock 2012; Bayliss, Connell, Farmer 2012). In contrast, studies by Sloan (2012), Huthwaite *et al.* (2011), Marmarelli and Ringle (2011), Miller (2012), and Dodds, Callender, Henry (2013) found Apple iPad to be helpful to students in conducting academic work due to reasons such as large LCD screen, color touch screen, processing speed, internet access, printing capabilities, and the ability to interact with e-texts via annotations, highlights, and search functions. A mobile application (app) is an important element when discussing tablet capabilities because they can provide users with many additional capabilities. According to Weisberg (2011), Sloan (2012), Pollock (2012), and Tees (2010), apps played an important role in increasing students' preference for tablets.

Previous studies have touched on the issue of e-reading device size. These studies generally looked at either the size of e-readers, which tended to be small, or the size of tablets, which tended to be large. However none of these studies have carefully looked at different sizes of tablets. It is unclear whether consumer preference for size is due to price, function, appearance, or some combination thereof. In particular, college students' preference in regards to size should be studied to verify the optimal size for academic use. In Pollock's study (2012) and in Foasberg's study (2011), the participants criticized e-readers for having small screens.

For the most part, academic libraries have not been able to keep pace with rapidly rising use of tablets. It is unclear what type of support students want from their libraries although they generally want a library to provide more material (Princeton 2010). Foasberg (2011) found that 86% of the students who own e-readers purchased the e-reading materials through the e-reader's vendor, *e.g.* Amazon, possibly because libraries do not have enough materials for e-readers. For libraries, the rising popularity of tablets may be particularly welcome. Unlike e-readers, tablets can more fluidly work with different document formats through apps. For example, Dewan (2012) stated that e-journals are tremendously popular with students and that their ease of access is making print journals obsolete. Although e-journal articles may be difficult to use with e-readers due to its frequent PDF format, tablets have been able to bypass this issue through the use of apps in Pollock's study (2012) and in Marmarelli and Ringle's study (2011). Furthermore, Cassidy, Martinez, Shen (2012) found that 75% of faculty were willing to recommend e-books to their undergraduate students. In such instance, students may utilize library to gain access to e-books. It would be beneficial to understand whether tablets may aid in accessing library's academic electronic resources.

Research objectives

From past studies, it is apparent that tablets can be helpful and are desirable to college students. To find out which of the current lineup of tablets is the most suitable option for college students and to understand what type of support college students require from their school libraries, this study will attempt to accomplish the following objectives. 1) Determine the most beneficial tablet size for college students in their academic pursuits, and 2) Determine the necessary types of support from

academic libraries for college students conducting academic work using a tablet.

2. MATERIALS AND METHODS

2.1. Focus Groups

2.1.1. Panelists

Nineteen undergraduate students from Kansas State University in Manhattan, KS participated in three focus groups of 5-8 persons per group. Each focus group was evenly split in terms of gender with a 5-person group consisting of 3 males and 2 females. The participants were recruited via a posting on the daily university e-newsletter. The participants were screened to be owners of a tablet or a tablet-like electronic mobile device, including a touchscreen based smartphone, who have used the device within the past week and were willing to bring the device to the focus group meeting.

2.1.2. Setting

Focus group discussions took place in a well-lit room in Human Ecology building of Kansas State University in September 2013. The room shared a wall with another room where a researcher took notes and videotaped the sessions behind a two-way mirror. The focus group room contained a large round table in the center of the room. The participants and the moderator sat around the table with the moderator's back to the two-way mirror. A dry-erase board was set up a few feet away from the table to the right of the moderator. The participants were served snacks and water.

2.1.3. Test design and group discussion

A moderator with training from RIVA Training Institute (Rockville, MD, USA) moderated all three focus groups and participated in refining of the moderator's guide. Focus groups lasted approximately 80-90 minutes. The participants signed an informed consent form prior to the discussion and received payment and debriefing statement at the end of the discussion.

The group discussion topics closely followed moderator's guide and all three focus groups were able to discuss all main topics of interest per moderator's guide. Main topics covered by the moderator's guide included what undergraduate students consider academic work, why some materials are better suited for tablets, pros and cons of different tablet sizes, other academic materials wanted by undergraduate students, and how the library can better support the undergraduate tablet users. For the portion on improving the library support, participants were encouraged to use their own device. Throughout the focus group portion of the study, small tablet size referred approximately to the size of an Apple iPhone, medium tablet size referred approximately to the size of an Apple iPad Mini, and the large tablet size referred approximately to the size of an Apple iPad.

The researcher behind the two-way mirror took extensive field notes during the discussion. The participants were aware that they were being audio and video recorded and that a researcher was observing the group discussion. At the completion of each focus group, the moderator and the researcher compared notes on overall and specifics of the group discussion.

2.1.4. Data analysis

Immediately following each focus group discussion, the moderator and the researcher reviewed the session to ensure that both parties are in agreement as to what transpired and what insights were gained from that group discussion. Within several days of the completion of the three focus groups, the researcher pooled data from all three group discussions and derived main themes and specific insights from them. The participants were not asked for feedback on the analyzed data.

2.2. Consumer Survey

2.2.1. Samples

Eight tablets were obtained from various retail outlets that were available in Kansas. The eight tablets comprised of two titanium silver Samsung Galaxy Tab 2 (10.1) tablets, two titanium silver Samsung Galaxy Tab 2 (7.0) tablets, two white Apple iPad 2 tablets, and two white Apple iPad Mini tablets. Physical properties of tablets are listed in Table 1.

Table 1. Physical properties of four types of tablets. *Data compiled from www.samsung.com and support.apple.com.

Tablet Type	Body Height (in)	Body Width (in)	Body Depth (in)	Display Size (in)	Weight (lb)
Galaxy 10.1	**6.9**	**10.1**	**0.38**	**10.1**	**1.28**
Galaxy 7.0	**7.6**	**4.8**	**0.41**	**7.0**	**0.76**
iPad 2	**9.50**	**7.31**	**0.34**	**9.7**	**1.33**
iPad Mini	**7.87**	**5.30**	**0.28**	**7.9**	**0.69**

2.2.2. Sample preparation

In order to maintain homogeneity of the home screen's appearance within the constraints of operating system, only the essential apps and shortcut icons used in the study were visible. The shortcut icons for the study were a shortcut to the book used for the reading section, note taking app Evernote (Evernote, Redwood City, California, USA) for the note taking section, shortcut to a journal article for the e-journal article format section, and a web browser. Additionally, iOS tablets needed an app, Skitch (Evernote, Redwood City, California, USA), on the home screen because unlike the Android tablets that allowed users to use Skitch through Evernote, iOS tablet users needed to access Skitch separately from Evernote. Both shortcut icons opened their content on the web browser. To ensure that every consumer received tablets in the same condition, a member of the research team closed the browser, cleared the notes, and wiped off fingerprints on tablets prior to distribution. Tablets were charged in between usage. Tablets were connected to the Internet via Wi-Fi.

2.2.3. Consumers

One hundred twenty-one undergraduate students from Kansas State University in Manhattan, KS participated in the study over seven weekdays. The participants were recruited via a posting on the daily university e-newsletter, flyers in the student union and the main library of the university campus, business cards that were handed out in the library by a researcher, and chalk announcements written on the sidewalk immediately surrounding the library. Recruiting materials indicated the times and the location of the study. The students took part in the study in the order that they arrived at the study location. Up to four participants were able to complete the questionnaire at the same time.

2.2.4. Setting

In October 2013, the consumer survey took place in a small study room at the main library, Hale library, of Kansas State University. The well-lit room contained a desk that can comfortably sit six students. The room was enclosed in the building with windows looking out to the library study area. At any given time, a maximum of four participants and two researchers sat in the room.

2.2.5. Test design

An alternating set of two sizes of Android OS tablets and a set of two sizes of iOS tablets were given to consumers in the order of entrance to the testing room. Depending on the availability of tablets, a set out of alternate order was also given to participants. Four of the six sections of the questionnaire required the participants to use one or both sizes of tablets in a particular order. There were eight combinations of tablet size viewing order for each OS for a total of sixteen different viewing order and device combinations. The presentation order of sixteen questionnaire (each containing a specific viewing order and device assignment) were completely randomized and that random order was repeated.

2.2.6. Sample evaluation

After signing the informed consent form, a consumer was provided with a survey questionnaire, two different sizes of tablets, a pen, and one page instruction sheet on how to use a particular tablet and its applications. In addition, a member of the research team verbally explained important contents of the instruction sheet. A respondent returned all material to the research team upon completion of the questionnaire then was paid $10 and given a debriefing statement.

The survey questionnaire had six sections. The first section consisted of demographic and technology usage questions. The second section evaluated tablets' reading function. In this section, pages 5 and 17 of the book *Financial Crisis and Free Market Cure* by John Allison was provided as a reading material (Allison, 2012). The book was chosen because of its availability through the website CourseSmart. CourseSmart is "the world's largest library of eTextbooks and digital course materials that instructors could access instantly" and therefore was an appropriate way to evaluate how an undergraduate student may use tablet for reading course material (CourseSmart, 2013). Through the website, consumers were given the option to use its table of contents to quickly navigate the book. The particular pages 5 and 17 of the book were chosen because they were of similar length between 1250 and 1350 characters and of similar mean syllables per word at 1.58 and 1.49 mean syllables per word.

The third section looked at tablet's note taking function. This section required consumers to use Evernote/Skitch. These apps were chosen because they were free, available on both operating systems and were widely regarded as one of the best note taking app (Casabona, 2013; Kazmucha, 2013; Ochs, 2013). The fourth section explored consumers' use of the library website's feature that lets patrons

instant message a librarian. The fifth section investigated undergraduate students' preference for an e-journal article format. For this section, the participants were directed to use the article *Celebrity Endorsement, Brand Credibility and Brand Equity* by Spry *et al.* (2011). This article was chosen because it was an article that offered both PDF and HTML formats and available to the Kansas State University undergraduate students. The sixth section requested comments from consumers on portability and general preference for a tablet size.

2.3. Data Analysis

Microsoft Excel, Version 14.0 (Microsoft Incorporation), a part of Microsoft Office Professional Plus 2010 was used to determine sums, means, and percentages of the raw data. To determine differences in various response variables, analysis of variance (ANOVA) and t-tests were performed at 5% significance level. When appropriate, post-hoc means separation was conducted using Fisher's protected Least Significant Difference (LSD). In order to evaluate relationships between variables, chi-squared test of independence was performed at 5% significance level. When the requirement for chi-squared test could not be met, Fisher's exact test was conducted at 5% significance level. Analyses were completed using SAS® statistical software (version 9.3, SAS Institute Inc.) in addition to Microsoft Excel.

3. RESULTS

3.1. Focus Groups

3.1.1. What students classify as "schoolwork"

When asked about what constitutes as schoolwork, focus group participants included activities that are directly and indirectly related to school. School assignments and study methods such as taking notes and reading were mentioned alongside more unconventional tasks such as breaks between studying, and watching and listening to motivational speeches for their positive effect. A great portion of the schoolwork required technology. Technology-related schoolwork as described in the focus group discussions can be divided into two categories: school-assigned and student-initiated. School-assigned activities included downloading e-textbooks, taking online exams, watching online lectures, preparing PowerPoint presentation, reading e-textbooks, and using Dropbox. Student-initiated activities included accessing the school's academic website, checking e-mail, setting up assignment reminders, recording audio, using apps such as StudyBlue to make flashcards, using the World Wide Web to research projects or any topic of curiosity, and watching educational videos. Additionally, the participants often noted technology-related activities that allowed them to share items and thoughts with others such as using apps for setting up group meetings, accessing Facebook for afterschool activities, and sharing notes with multiple students by taking photos of notes.

3.1.2. Pros and cons of tablets

Focus group participants shared many pros and cons of tablets. The majority of the pros can be categorized as the ability to gather the latest information. Some of the frequently mentioned capabilities of a tablet included sharing information with others through social media, email, etc.; conducting research via many avenues such as dictionaries and Wikipedia that can easily be updated; accessing continuous stream of new versions of various apps; sharing notes with others using screenshots; seeing certain class handouts like graphs in color instead of a black and white photocopy; turning in an assignment right before class; and instantly communicating with professors via online web tools. Another theme of the pros list was the portability of the tablets in terms of its compact physical size. Additionally a few students added that tablets are more engaging than traditional learning methods and that they add entertainment value with a variety of contents such as videos and animations.

The list of cons had three themes. The first theme focused on technology deficiencies including problems that a lack of Internet connectivity would present. Also, the general reliability of tablets compared to physical books, pen, and paper notebooks was perceived as a con. Participants noted that tablets are complex devices while books, pen, and paper notebooks are simple products with minimal required maintenance.

The second theme captured issues with adaptation of technology. Students noted that some people may not learn tablet technology as quickly as others or that note taking or drawing diagrams and figures might more easily be done on paper. Many of the participants also had strong opinions on the ease of using virtual keyboards with some saying that

typing on an actual keyboard is easier and more comfortable. Some of those students argued that even portable wireless keyboards connected to tablets are not good enough to alleviate the problem of a small uncomfortable keyboard.

The third and the most frequently mentioned theme dealt with ways to check technology's enormous power. Several participants brought up the issue of tablets allowing copying and pasting of contents too easily along with possibility of promoting student absences in classes because others can easily take notes and share with absent students. On the flipside of the entertainment value added by tablets, participants were wary that tablets are too entertaining and could easily distract students, both the user and the ones around the user, during a class or a study session. The distraction was mentioned as one of the reasons why an instructor might not allow tablets in a class. Several focus group discussion participants also mentioned the possibility of professors not allowing students to video/audio record lectures.

In addition, the focus group participants repeatedly expressed their concerns over the cost. There were two sides to the issue of the cost. On one side, the tablets were presented as being a high cost item. Some students mentioned that because they already have other electronic devices such as a laptop and a smartphone, that they could not justify purchasing a tablet. On the other side, several participants noted that although the initial cost of a tablet is high, that it may help save money in the long run because apps and e-textbooks are cheaper than traditional software and textbooks. Some students also suggested that certain high-priced tablets might replace a computer completely, eliminating a need for a laptop and thus actually saving money.

3.1.3. Comparing three sizes of tablet-like mobile electronic devices

When asked for reasons to purchase or to avoid a particular size of tablet, participants across all focus groups gave many negative reasons for the small size (~5"), not much negative or positive reasons for the medium size (~7"), and many positive reasons for the large size (~10"). The overarching reasons for the inadequacies of the small size were that the size prevented it from being effectively used in schoolwork. The large size was noted for positive attributes such as its large screen that is suitable for reading, greater portability compared with that of a laptop, and thin profile. However, it was also criticized for being too large for many bags and pockets. When the participants were further probed on how the medium size compared to the large size, they noted that medium has positive qualities such as being small enough to fit in a purse or on a small desk in classrooms. Some of the drawbacks of the medium size were that it is too small for taking notes unless it is used with an external keyboard and that it cannot complete certain functions, like taking calls or viewing videos, as well as the small or the large size respectively due to its in-between size.

3.1.4. How the library can better support undergraduate students

When given a choice of using a library's full website versus mobile website, many focus group participants chose the full site, including several who were using small smartphones. The reasons they gave for preferring the full site over the mobile site included a desire to view the website in the form that it would be in on a computer, additional information provided by the full site, and habit. The reasons the students gave for avoiding the mobile site included a lack of functionality and presence of large lists that are difficult to scroll through. Some participants did note that the mobile site was quicker to load. Additionally, all focus groups mentioned that it is easy to locate the "ask a librarian" feature in the full site. "Ask a librarian" is a website feature that allows the person to connect with one of the librarians quickly via instant message over the Internet. The students who attempted to find the feature using the mobile site reported that the feature was located in a less obvious area of the website.

When asked about the various resources at the library, the focus group participants listed a number of available resources that they found while browsing the website. Despite that, the students did not claim to have used many of those resources besides a few popular ones. One helpful use for electronic mobile devices that students mentioned was finding a new book immediately when the original book they found was not adequate. When probed about electronic articles, the participants said that they normally view them on a computer because they can quickly switch among tabs and windows, copy and paste information from the article to their personal file, and effortlessly save the article.

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Table 2. Demographics. *13.8% responded that they do not have a job. **Includes devices the respondents use without ownership. ***Total time spent for the four listed devices is 100%.

Section A. Frequency of Technology Usage*			
Frequency of Usage		***For Work Reasons***	***For Personal Reasons***
Infrequently		**25.7%**	**20.2%**
Neither Infrequently nor Frequently		**2.8%**	**0%**
Frequently		**57.8%**	**79.8%**
Section B. Device Ownership			
Non-smartphone cellphone – 17.4%		**Mini-Sized Tablet – 5.5%**	
Smartphone – 81.7%		**Laptop – 98.2%**	
Standard-Sized Tablet – 33.0%		**Desktop – 25.9%**	
Section C. Operating System (OS) of Devices			
Device	***Apple OS***	***Android OS***	***Windows OS***
Smartphone	**58.9%**	**38.9%**	**2.2%**
Standard-sized Tablet	**62.9%**	**31.4%**	**2.9%**
Mini-sized Tablet	**85.7%**	**0%**	**0%**
Laptop	**26.0%**	**n/a**	**74.0%**
Desktop	**7.7%**	**n/a**	**88.5%**
Section D. Usage of Devices**			
Device	***Number of Users (%)***	***Average % Time Spent on Device****	
Smartphone	**84.9%**	**56.2%**	
Tablet	**38.3%**	**19.8%**	
Laptop	**97.1%**	**37.8%**	
Desktop	**37.4%**	**20.4%**	

3.1.5. Undergraduate students' wish list for the library

When asked about reasons for visiting the library, the participants listed activities including reading various materials, group projects, printing, studying, and homework. The participants were then asked what they would wish for from their school library. Several wishes were repeated throughout focus groups. The students requested a library app that would be superior to the mobile site because an app is designed with a specific device in mind and works seamlessly while loading quickly. The participants also requested a location/map services that would allow them to pinpoint their location in the library on their mobile electronic devices. Lastly, some students requested an e-textbook check out where a person may check out the e-textbook for an hour to make copies of necessary pages.

3.2. Consumer Survey

One hundred nine respondents met the screening criteria and completed the survey questionnaire. Respondents completed fifty-eight questionnaires using Apple tablets and fifty-one questionnaires using Samsung tablets

3.2.1. Demographics

Out of one hundred nine responses, eight respondents were over 25 years old. The undergraduate students were evenly divided in terms of gender with 54 females and 55 males. Almost all participants were full time students. A majority of respondents used technology frequently in their lives and owned a variety of devices that mostly operated on either Apple, Android, or Windows operating system (Table 2, Sections A and C). Most respondents used the Apple operating system for mobile devices while a minority of participants used the same for computers. Many more students used smartphones and laptops compared to tablets and desktop computers regardless of ownership and the percentage of time spent on devices reflects that trend. Many students believe that tablets will continue to be an important educational tool in the future (Hart, 2015).

3.2.2. Which tablet size is preferred for reading?

Focus group discussions pointed out reading as one of the main schoolwork activities for a tablet. Survey results indicated that there is no significant difference between the two tablet sizes in terms of

consumers' likelihood of using a tablet for reading ($p \geq 0.05$). Furthermore, there was no significant difference in consumers' likelihood of using a tablet for reading for owners vs. non-owners of a tablet ($p \geq 0.05$). Similarly, there was no significant difference in consumers' likelihood of using a tablet for reading among participants who use varying amounts of technology for work or for personal reasons ($p \geq 0.05$).

We also examined whether the likelihood of using a tablet for reading might be different based on the percentage of time a consumer spends on a particular device. For all four devices (smartphone, tablet, laptop, and desktop), there was no significant difference among three groups representing consumers that were unlikely, neutral, and likely to use a tablet for reading ($p \geq 0.05$). However for the desktop users, the mean percentage of time spent for those unlikely to use tablets for reading was 14.1 compared to 6.1 for those who were likely to use tablets for reading. The p-value for this difference was $p = 0.051$ suggesting a potential for difference.

3.2.3. *Which tablet size is preferred for note taking?*

Focus group discussion pointed to note taking as a schoolwork activity that many students may want to perform using a tablet. Unlike reading, results indicated a significant difference in consumers' likelihood of using a tablet for note taking in regards to the two tablet sizes ($p < 0.05$). The group who disliked both the 7" and 10" tablet sizes were significantly less likely to take notes on a tablet than the groups who liked one or both sizes ($p < 0.05$) (Table 3).

Table 3. Mean Likelihood of Note Taking Using Tablets Instead of Other Methods. Mean values were calculated using a 7-point scale with 1 point = very unlikely to take notes using a tablet and 7 point = very likely to take notes using a tablet.

Preferred Tablet Size for Note Taking	N	Mean	Standard Deviation
Larger	**61**	**4.61**	**1.97**
Smaller	**35**	**4.20**	**1.92**
Both	**10**	**5.20**	**1.62**
Neither	**3**	**1.33**	**0.58**

As with reading, there was no significant difference in consumers' likelihood of using a tablet for note taking for owners vs. non-owners of a tablet ($p \geq 0.05$). Additionally, there was no significant difference in the likelihood of using tablet for note taking among students who use varying amounts of technology for work and for personal reasons ($p \geq 0.05$). There also was no significant difference ($p \geq 0.05$) when comparing how students who spend varying percentages of time on four devices (smartphone, tablet, laptop, desktop) differ in likelihood of using a tablet for note taking.

3.2.4. *Other factors affecting tablet size preference*

Comments from a question regarding overall preference for a tablet size for schoolwork yielded 99 responses (10 respondents did not answer the question) with 62, 33, 3, and 1 preferring larger size, smaller size, both sizes, and neither sizes respectively. Because it is necessary for most purchasers to choose one of the sizes, analyses included only the data from 95 respondents with a specific size preference. Overall tablet size preference was not significantly different for varying percentage use of four devices, smartphone, tablet, laptop, and desktop ($p \geq 0.05$).

During the focus group discussions, the participants repeatedly mentioned the issue of portability, indicating its importance. The consumer survey found that the smaller tablet was perceived as more portable than the larger tablet. It also found that there was a relationship between overall preferred tablet size and the portability of tablet sizes ($p < 0.01$). Although the larger size was preferred overall, there was a trend of increasing preference for smaller size with increased perceived portability of the smaller size over the larger size.

Focus group discussion indicated a possible gender difference in overall tablet size preference. The consumer survey found a significant relationship between gender and overall tablet size preference ($p < 0.05$) with phi coefficient of 0.24, indicating a moderately strong relationship. The results showed that a greater portion of females prefer larger size than males.

3.2.5. *User experience with library website*

One of the frequently mentioned aspects of the library website was its "Ask a Librarian" feature that allowed library patrons to instant message questions to a librarian. It is a popular feature that needs to be easy to use and easy to find. During the evaluation, consumers were asked to send to and receive from a library staff a short message. Of the respondents, 88.1% reported being able to use the feature and 82.6% noted that they received a response back. 58.3% of consumers, used full website to access this feature.

Table 4. Relationship between E-Journal Article Formats Used on a Computer and on a Tablet

% of participants n = 104		Format Used on a Computer			
		HTML	PDF	Both	*Total*
Format used on a tablet	HTML	6.73	9.62	4.81	*21.15*
	PDF	6.73	53.85	18.27	*78.85*
	Total	*13.46*	*63.46*	*23.08*	*100.00*

Majority of the students thought the instant message feature was easy to use. Similarly, 71.4% indicated a satisfactory experience using the feature with a tablet. The results indicated no significant main effects or interaction effect of tablet size or full vs. mobile website on student satisfaction with the instant message feature ($p \geq 0.05$). Additionally, the consumers' level of experience with the library's website did not have a significant effect on their satisfaction with the instant message feature ($p \geq 0.05$).

3.2.6. *Viewing e-journal articles on a tablet*

Focus group discussion found that students read electronic articles, particularly on a computer, to complete schoolwork. Access to electronic articles is one of the main offerings of academic libraries and it is necessary to understand student preference for viewing electronic article to provide them with a seamless service. From the survey, we found that a majority of the students use PDF format to view e-journal articles on a computer and a tablet. When using a tablet to view an e-journal article, there was no significant relationship between the tablet size and the article format ($p \geq 0.05$). However there was a strong relationship between preferred article format and the device choice – tablet or a computer ($p < 0.05$, Cramer's V value = 0.28). Table 4 shows that there were many respondents who use HTML only or both HTML and PDF formats on computers who switched to using PDF only on tablets.

3.2.7. *Effect of tablet operating system*

Although this study did not focus on operating systems of tablets, we analyzed the related data to rule out any possible effects. There was no significant difference in likelihood of reading or note taking with a tablet between the iOS testers and the Android OS testers ($p \geq 0.05$). However the p-value for the note taking t-test was 0.06 suggesting that there may be a difference where Apple tablet users, with a mean of 4.8 ± 1.9, are more likely to take notes using a tablet than Samsung tablet users who had a mean of 4.1 ± 2.0. We also found that a tablet OS did not have a significant relationship with overall tablet size preference ($p \geq 0.05$). Additionally, there was a moderately strong relationship between preferred e-journal article format and operating system ($p < 0.05$, Phi coefficient = 0.22). More iOS testers preferred PDF format than Android testers.

4. DISCUSSION

Focus group discussions supported the idea that a tablet can be an essential tool for undergraduate students. Many activities that students classified as schoolwork were technology driven. Additionally, we found that students demanded immediate access to schoolwork materials in agreement with studies by Angeletaki (2011) and Dahlstrom *et al.* (2011) Technology and accessibility are two of the main features of a tablet (Huthwaite 2011; Sloan 2012; Pollock 2012; Miller 2012). It is also important to note that schoolwork encompassed a lot of content consumption, a task in which tablets are particularly suited for (Pogue 2010). Although tablets have a great potential in assisting students with schoolwork, they were still considered as an addition, instead of replacement, in the current lineup of devices. This is apparent in demographic data from the consumer survey where respondents spent less time on tablets than on smartphones or computers. The focus group participants criticized tablets on several occasion but many of these issues can be resolved with increasing student adaptation to tablet technology. It is important to observe whether tablet adaptation trend will be similar to the positive e-reading device adaptation trend seen in Weisberg's paper (2011).

In examining the two tablet sizes (~7" and ~10"), focus group participants discussed that the larger size would be better for reading and note taking than the smaller size. However the consumer survey result indicated that this is not the case. Even though there was a significance difference in likelihood of using tablet for note taking, it may be prudent to discount this because the group driving that difference liked neither sizes of tablet for note taking. Tablet size may not have affected the likelihood of reading because undergraduate students read different sized books and as long as the display and the format is clear, smaller font is generally not an issue for the college-age group. Perhaps conducting a similar study on a group of older undergraduates will yield different results. It is less clear why the tablet size did not have any

significant effect on the likelihood of note taking. It is possible the trend will change if the participants are asked to write notes with fingers or a stylus. In this study, participants were given free rein to create notes in any format and thus may have resulted in most consumers typing words instead of writing them.

When looking at other factors that influence overall tablet size preference for schoolwork, it is important to address the issue of portability and gender. Portability is an important factor in students' choice of mobile electronic devices (Angeletaki 2011; Dahlstrom *et al.* 2011). Because portability has many facets in addition to size such as durability, this study asked consumers which tablet size, the larger (~10") or the smaller (~7"), was more portable. The responses indicated that students were mostly only focused on size and weight and therefore the smaller tablet was chosen as the more portable tablet. Despite this, a majority of consumers preferred the larger size overall for schoolwork and remained so in a Pearson Survey (2014) and was expected to increase in 2015. This suggests that function and capability of a larger screen is more important to undergraduates than portability.

Focus groups suggested that females might be more interested in a smaller tablet compared to males for reasons including that a smaller tablet is more suitable for carrying in a purse. However the consumer survey indicated that females more strongly preferred a larger tablet than males. This problem warrants a further research because females generally prefer a smaller tablet (Drinkwater 2013).

This study showed that ownership of a tablet or frequent use of technology does not make a student more likely to read or take notes using a tablet. This suggests that there is no hidden benefit of tablet that becomes apparent with ownership or greater experience with technology. It could be that tablets are intuitively designed to be easy to use and therefore do not need users to be greatly experienced for activities within the context of this study.

When examining the instant message with a librarian feature, we determined that neither tablet size nor mobile vs. full website had any effect on users' satisfactory experience using the feature. This is helpful for the library because it suggests that this feature can be used equally well on full and mobile sites even though most students prefer the full site. The scope of this study did not encompass which library website, mobile or full, is more helpful to students. It is generally understood from the focus group discussion that the mobile site needs to be improved.

E-journal article format was evaluated in conjunction with tablet use because e-journal articles are important components of library offerings and this has not yet been fully studied for tablet users. The consumer survey showed that most students preferred the PDF format and especially so when using a tablet and particularly for the iOS tablets. This suggests that perhaps unlike when viewed from a computer, HTML formats are not yet designed to support tablet users. This is one of the areas where the library can better meet student needs by discussing the issue with publishers. This also shows a possible bias in the study, which was that the PDF format automatically opened on iOS devices but required several action from the Android users before they were able to view the article. In addition to improving the HTML format for tablet users, the library should also consider a few of the popular ideas presented during the focus group discussions. One of the ideas was an app for the library which focus group participants preferred over the mobile website. Another idea was to have a tracking map system that will let electronic mobile device users know immediately where they are in the library and where they can find the material they are looking for.

This study showed that students prefer larger tablet size. This study also gave insights on what the library is doing well currently and what it should consider going forward to better assist the increasing number of tablet-using patrons. To gain a more comprehensive understanding of student tablet users, a future study could look into the issue of tablet cost as suggested by focus groups. It would be helpful to understand what are must-have features of a tablet vs. optional features for students. Tablet manufacturers can act on information from such a study to customize tablets for undergraduate students.

REFERENCES

Allison, J.A. (2012) The Financial Crisis and the Free Market Cure: Why Pure Capitalism is the World Economy's Only Hope. New York: McGraw-Hill.

Angeletaki, A. (2011) E-Readers as a Studying Tool: A Project by the NTNU University Library, Trondheim. Serials, 24, S1-S6.

Bayliss, L., Connell, C. & Farmer. W. (2013) Effects of eBook Readers and Tablet Computers on Reading Comprehension. *International Journal of Instructional Media* 39, 131+.

Bort, J. The History of the Tablet, an Idea Steve Jobs Stole and Turned into A Game-Change. Available online at http://www.businessinsider.com/history-of-the-tablet-2013-5?op=1 [Accessed 2013].

Casabona. J., 10 Tablet Optimized Apps for Students. Available online at http://android.appstorm.net/roundups/productivity-roundups/10-tablet-optimized-apps-for-students/ [Accessed 2013]

Cassidy, E.D., Martinez, M., & Shen. L. (2011) Not in Love, Or Not in the Know? Graduate Student and Faculty use (and Non-use) of E-Books. *Journal of Academic Librarianship*, 38, 326-332.

comScore. comScore Introduces Device Essentials™ for Measuring Digital Traffic from all Devices, Enabling Optimization of Marketing Strategies and Customer Experience. Available online at http://www.comscore.com/Insights/Press_Releases/2011/6/comScore_Introduces_Device_Essentials [Accessed 2013].

CourseSmart. "Our Story." Available online at http://www.coursesmart.com/overview [Accessed 2013].

Dahlstrom, E., de Boor, T., Grunwald, P., & Vockley. M., (2011) ECAR National Study of Undergraduate Students and Information Technology, EDUCAUSE Center for Applied Research.

Dewan. P. (2012) Are Books Becoming Extinct in Academic Libraries? *New Library World*, 113, 27-37.

Dodds, K., Callender, D., & Henry, C. (2012) Making a Case for Technology in Academia. College & Research Libraries.

Drinkwater, D. iPad magazines just keep growing but women prefer smaller tablets: Hearst president." Available online at http://tabtimes.com/news/media/2013/02/14/ipad-magazines-just-keep-growing-women-prefer-smaller-tablets-hearst-president [Accessed 2014].

Foasberg. N.M. (2011) Adoption of E-Book Readers among College Students: A Survey. *Information Technology and Libraries*, 30, 108-122.

Hart, M. Poll: Most college students prefer laptops over tablets for school. https://campustechnology.com/articles/2015/09/23/poll-most-college-students-prefer-laptops-over-tablets-for-school.aspx [Accessed 2016].

Huthwaite, A., Cleary, C.E., Sinnamon, B., Sondergeld, P., & McClintock, A. (2011) Ebook Readers: Separating the Hype from the Reality.

International Data Corporation. IDC Forecasts Worldwide Tablet Shipments to Surpass Portable PC Shipments in 2013, Total PC Shipments in 2015. Available online at http://www.idc.com/getdoc.jsp?containerId=prUS24129713 [Accessed 2013].

iPad 2 - Technical Specifications. Available online at http://support.apple.com/kb/SP622 2013 [Accessed 2013].

iPad Mini - Technical Specifications. Available online at http://support.apple.com/kb/SP661 [Accessed 2013].

Kazmucha, A. Best iPhone and iPad Apps for College Students: Evernote, Notability, iTunes U, and More! Available online at http://www.imore.com/best-iphone-and-ipad-apps-college-students-evernote-notability-itunes-u-and-more [Accessed 2013].

Marmarelli and Ringle. (2011). The Reed College iPad Study. Portland, Oregon, USA: The Reed Institute.

Marmarelli, T. & Martin, R. (2009). The Reed College Kindle Study: The Reed College

Miller. W. (2012) ITeaching and Learning: Collegiate Instruction Incorporating Mobile Tablets. (Chapter 9). *Library Technology Reports*. 48, 54.

Pearson Foundation. "New Survey Finds Dramatic Increase in Tablet Ownership among College Students and High School Seniors." Available online at http://www.pearsonfoundation.org/pr/20120314-new-survey-finds-dramatic-increase-in-tablet-ownership-among-college-students-and-high-school-seniors.html [Accessed 2013]

Pearson Student Mobile Device Survey, National Report: College Students. http://www.pearsoned.com/wp-content/uploads/Pearson-HE-Student-Mobile-Device-Survey-PUBLIC-Report-051614.pdf [Accessed 2016]

Pogue, D. (2010) Looking at the iPad from Two Angles. *The New York Times*.

Pollock, D.E. (2012) E- Readers, our Readers, and Electronic Collections: A Pilot Study at a National Laboratory Library. Serials Review.

Princeton University, (2012) The Office of Information Technology. The E-Reader Pilot at Princeton

Revelle, A., Messner, A., Shrimplin, A., & Hurst, S. (2012) Book Lovers, Technophiles, Pragmatists, and Printers: The Social and Demographic Structure of User Attitudes Toward e-Books. *College & Research Libraries*, 73, 420-429.

Ryan Morse. Tablets...Theeeeeey're Back!. Available online at http://www.geeks.com/techtips/2011/tablet-history.asp [Accessed 2013].

Samsung Galaxy Tab™ 2 10.1 (Wi-Fi) 16GB. Available online at http://www.samsung.com/us/mobile/galaxy-tab/GT-P5113TSYXAR-specs [Accessed 2013].

Samsung Galaxy Tab™ 2 7.0 (Wi-Fi) 8GB. Available online at http://www.samsung.com/us/mobile/galaxy-tab/GT-P3113TSYXAR-specs [Accessed 2013].

Shrimplin, A.K., Revelle, A., Hurst, S., & Messner. K. (2011) Contradictions and Consensus — Clusters of Opinions on E-Books. *College & Research Libraries*, 72, 181-190.

Sloan, R.H. (2012) Using an e-Textbook and iPad: Results of a Pilot Program. *Journal of Educational Technology Systems*, 41, 87-104.

Spry, A., Pappu, R., & Cornwell, T.B., (2011) Celebrity Endorsement, Brand Credibility and Brand Equity. *European Journal of Marketing*, 45, 882-909.

Susie Ochs. 8 Essential Mobile Apps for College Students. Available online at http://www.pcworld.com/article/2047671/8-essential-mobile-apps-for-college-students.html [Accessed 2013].

Tees, T. (2010) Ereaders in Academic Libraries: A Literature Review. *Australian Library Journal*, 59, 180.

Thayer, A., Lee, C.P., Hwang, L.H., Sales, H., Sen, P., & Dalal, N. (2011) The Imposition and Superimposition of Digital Reading Technology. New York, NY: ACM.

Weisberg. M. (2011) Student Attitudes and Behaviors towards Digital Textbooks. *Publishing Research Quarterly*, 27, 188-196.

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DO SPICES HAVE THE SAME ODOR ON THE OTHER SIDE OF WORLD? EFFECT OF CULTURE ON SPICE ODOR PERCEPTION

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ABSTRACT

The goal of this study was to explore the role of the familiarity linked to a given culture on the perception of spices in France and Thailand. Six spices, among which three were more familiar to French people and three to Thai people, were presented alone, in binary and in ternary mixtures to 120 French and 120 Thai participants who had to identify (verbal task) or recognize (perceptual task) them.

In agreement with the literature, the results showed a significant effect of familiarity level. The more people are familiar with spices, the more they are able to recognize them. As expected, this effect was dependent on the task (verbal vs. perceptual) and participants' country. Thai assessors performed better in the perceptual task than in the verbal task, regardless of the familiarity level. No such effect was observed for French participants.

Keywords: *odor, spices, intercultural, perceptual task, verbal task*

1. INTRODUCTION

Almost all intercultural studies focusing on odor perception found that culture strongly affects olfaction capacities as sensitivity, discrimination, recognition, identification (Ayabe-Kanamura *et al.*, 1998; Distel *et al.*, 1999; Doty, Applebaum, Zusho & Settle 1985; Hübener *et al.*, 2001; Hudson & Distel, 2002; Patris *et al.*, 2004; Rabin & Cain, 1984) as well as odor representations (Chrea *et al.*, 2004, 2005). Familiarity has been suggested as a factor underlying this effect. For example, Chrea *et al.* (2004) showed that Vietnamese students are better at identifying the ginger odor than French students who are better at identifying the blackcurrant odor. Before that, Doty *et al.* (1985), using a standardized olfaction test (*i.e.* UPSIT) with Korean, Caucasian, African Americans and Native Japanese, observed that familiarity with the tested odorants influenced the identification performance of the participants. More recently, Sorokowska, Sorokowski & Hummel (2014) highlighted the importance of adapting odor identification tests like "Sniffin'Sticks" test (SST) to population with cultural and social differences.

Familiarity can be defined as an extrinsic characteristic of the stimulus. It is related to the individual experience, the individual exposure to products and it reflects the degree of knowledge of people for those products (Porcherot, 1995). In this context, a familiar odor can be defined as an odor encountered in everyday life whereas a non-familiar odor is not present in the individuals' daily environment (Sulmont, Issanchou & Köster, 2002). Then we can explore the effects of familiarity by studying different cultures which are not exposed to the same olfactory world and so do not have the same level of familiarity with different odors. The present study explores the role of familiarity on the perception of spice odors in France and Thailand.

The type of spices and the way they are used for cooking are completely different in France and Thailand. While spices are more associated with "exotic" dishes for French people, the traditional

Thai cuisine is composed of many different dishes cooked with spices like curry powders. As highlighted by Kim, Jombart, Valentin and Kim (2015), most cultural differences are expected to be more apparent in the traditional food items (*e.g.* green tea) than in other ones (*e.g.* yogurts, beverages, biscuits). Thus curry seems to be a good stimulus for exploring the influence of familiarity on odor perception. More precisely, we evaluated if cultural food habits (*e.g.* eating curry spices) would impact individuals' ability to identify (verbal task) or recognize (perceptual task) spice odors presented alone or in mixtures.

The human ability to identify odors in mixtures was already studied by Laing and his collaborators (Laing, Panhuber, Willcox & Pittman, 1984; Laing & Francis, 1989; Livermore & Laing, 1996, 1998; Jinks & Laing, 2001). These authors found that people's capacity to identify components in a mixture is limited to three to four components, even for trained or professional people. In the current study, the objective is not to find how many spices can be identified in spice mixtures but to evaluate if the familiarity with some spices can modify this ability. We addressed this issue using two tasks: a verbal task (*i.e.* identification task) and a perceptual task (*i.e.* immediate recognition task). An odor identification task can be considered as a semantic memory task in that it refers to an individual's general knowledge or experience with a specific odorant (Schab, 1991; Tulving, 1993). So we hypothesize that familiarity with spices would influence more the identification task than the immediate recognition one and that this effect would be modulated by participant country of origin. To check these hypotheses, we tested French and Thai participants on six different spices, among which three were more familiar to French participants and three more familiar to Thai participants. The spices were presented alone, in binary and in ternary mixtures and participants had to identify or recognize them in each sample.

2. MATERIAL & METHODS

2.1. Participants

One hundred and twenty volunteers were recruited in Thailand and in France. In each country, half of the participants carried out the perceptual task (n = 60 in each country) and the other half carried out the verbal task (n = 60 in each country).

Table 1. Demographic characteristics of the participants recruited in France (n = 120) and in Thailand (n = 120).

	France	Thailand
Gender		
Male	33%	33%
Female	68%	68%
Age	45±9 yr.	29±4 yr.
Education level		
University	78%	98%
High school	16%	1%
Secondary	4%	0%
Elementary	3%	1%
Cooking habits		
Everyday	37%	4%
Several times a week	42%	23%
Once a week	11%	15%
For special occasions	11%	58%

The inclusion criteria were: French/Thai nationality, age between 25 and 60 years old, to cook at least for some occasions. The demographic characteristics of participants for both countries are given in Table 1.

2.2. Stimuli

Six spices were first selected from a pilot study run in France and Thailand. The pilot study consisted of an online questionnaire followed by an identification and matching pre-test. The objective of the questionnaire was to study the habits of French and Thai people regarding spices. It was composed of 21 questions about spices consumption, cooking and buying habits. Eight hundred and twenty-six French and 550 Thai people answered this questionnaire. Based on the results of the questionnaire, 15 spices were selected for the identification and matching pre-test. The 15 spices were presented in blind condition and participants (n = 120 in France and Thailand) were asked to smell each spice and to identify it (n = 60 in France and Thailand) or to match it with the corresponding picture (n = 60 in France and in Thailand). The six spices for the final test were selected as the ones with a significant difference of scores between France and Thailand. Among these six spices three were more familiar to French people (better identified and matched by French than by Thai people: cinnamon, cumin, star anise) and three to Thai people (better identified and matched by Thai than by French people: garlic powder, curcuma and lemongrass). All the spices were used in their powder form, except lemongrass which was used in its fresh form.

Table 2. Details of the individual, binary and ternary mixtures with their familiarity levels (nb of familiar spices) for France and Thailand.

Mixture	Familiarity level	
	France	Thailand
Single spices		
Cinnamon	1	0
Cumin	1	0
Star anise	1	0
Garlic powder	0	1
Lemongrass	0	1
Curcuma	0	1
Binary mixtures		
Garlic pwd + Lemongrass	0	2
Garlic pwd + Star anise	1	1
Cinnamon + Star anise	2	0
Ternary mixtures		
Curcuma + Garlic pwd + Lemongrass	0	3
Star anise + Curcuma + Garlic pwd	1	2
Cumin + Cinnamon + Curcuma	2	1
Cumin + Star anise + Cinnamon	3	0

The six spices were then used to make a total of 13 samples: six samples of single spices, three samples of binary spice mixtures and four samples of ternary spice mixtures (Table 2). All the samples varied according to their familiarity level for French and Thai people. The 13 samples were presented in 60mL amber glass flasks entirely wrapped in aluminum paper and drilled with 12 little holes made with the tip of a compass. A total of 3gr of spices (or mixed spices) was put in each flask (*i.e.* 3gr of the single spice, 1.5gr of each spice for the binary mixtures and 1gr of each spice for the ternary mixtures).

2.3. Procedure

2.3.1. Verbal task: identification test

Participants were presented with the 13 flasks one by one according to a balanced presentation order. They were informed that each flask may contain one or more than one spice(s). They were asked to smell the first bottle and to identify the spice(s) inside by selecting the name(s) of the identified spice(s) among the six names proposed on the answer sheet. When participants have finished with the first bottle, the experimenter took back the flask and the answer sheet. Then they waited for 15s before the experimenter gave them the second flask and so on till the thirteenth flask. They could smell each flask as many times as they wanted. The orders of the names of the spices on the answer sheet were balanced between participants following a Latin square but were the same for one participant.

2.3.2. Perceptual task: immediate recognition test

Participants were first presented with six reference un-named flasks coded from A to F. They were informed that each flask contained only one spice and they were asked to smell each flask in a balanced presentation order. Then, they were presented with the 13 flasks one by one, according to a specific order, balanced among all the participants. They were informed that each flask may contain one or more than one spice(s). They were asked to smell the first flask and to find the reference flask(s) corresponding to the spice(s) they smelled in the coded flask. They could smell the flasks as many times as they wanted.

2.4. Data analysis

Data were analyzed using signal detection theory, by computing the Hits, False Alarms, Correct Rejections and Misses. To enable comparison of the results for the single spices, binary and ternary mixtures, we used two indices as suggested by Livermore and Laing (1996): Correct Score (CS) and Absolutely Correct Score (ACS). The CS is defined as the sum of the number of hits and correct rejections for each of the 13 flasks.

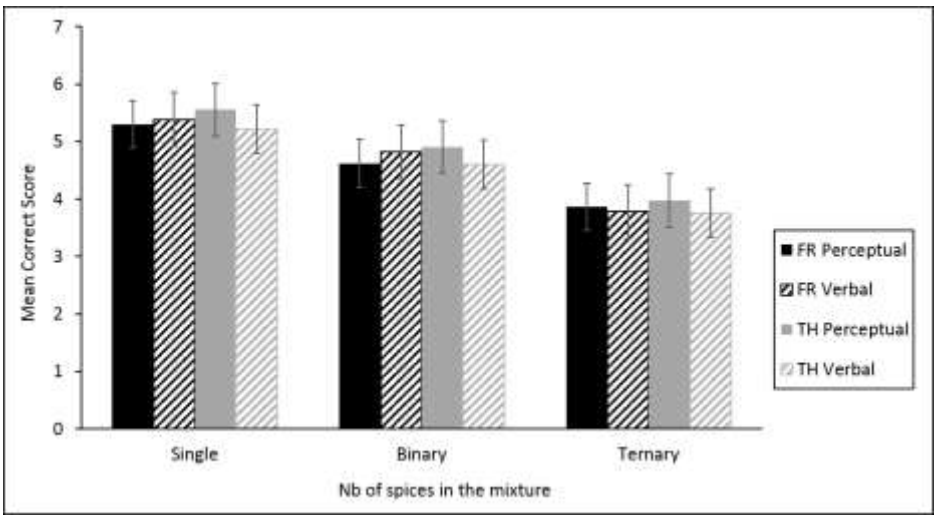

Figure 1. Mean Correct Score for each country (France/Thailand) and each type of task (perceptual/verbal) presented for single spices, binary and ternary mixtures. Bars indicate the standard errors of the means.

The maximum CS obtainable for each flask and each participant was six, which, for example, for single spices corresponds to one hit and five correct rejections. The ACS takes a value of 1 when all the spices of a flask were correctly identified and there was no false alarm. Otherwise, it is set to 0. Analyses of Variance (ANOVA) were conducted to evaluate the effect of the different factors (country, type of task, number of spices and level of familiarity) on the results.

3. RESULTS AND DISCUSSION

The first result in agreement with the literature (Laing & Francis, 1989; Laing & Glemarec, 1992; Livermore & Laing, 1996) is that globally the immediate recognition and identification of odors decrease with the number of spices in the mixture (Figure 1).

A three-way ANOVA was performed to evaluate the effect of country (France/Thailand), type of task (verbal/perceptual) and number of spices in the samples (single/binary/ternary) on CS means, followed by a Duncan test. The results confirm the main effect of the number of spices on CS scores (F = 138.02, p < 0.0001). Whatever the country and the task, the CS for single spices (5.36±0.06) are better than for the binary mixtures (4.74±0.06), which are also better than for the ternary mixtures (3.84±0.06). This decrease in the performance is illustrated by the raw data showing that out of the 240 tested ternary mixtures (4 mixtures × 60 participants × 2 countries), only 14 (5.8%) has an ACS equal to 1, meaning that the three spices of the mixtures were correctly recognized or identified and that there were no false alarms. This poor result highlights the difficulty for the participants to deal with a ternary mixture. Given the low results for ternary mixtures, only the results for single spices and binary mixtures will be considered in the following analyses.

As the objective of the study was to evaluate the influence of familiarity (in relation with participants' culture) on individuals' ability to identify or recognize spice odors presented alone or in mixtures, we then analyzed the data for single spices and binary mixtures independently with two separate four-way ANOVAs to evaluate the effect of country (France/Thailand), type of task (verbal *vs* perceptual) and familiarity level on CS index. Interestingly, they first show that Thai participants are not globally better than French participants for spice perception presented alone (F = 0.34, p = 0.56) or in binary mixture (F = 0.15, p = 0.70). We could have expected Thai participants to outperform French ones due to the Thai habit to buy, cook and eat a lot of spices (*e.g.* curry) compared to French people. Even though we selected familiar and non-familiar spices for both groups of participants, the strong Thai eating habits could have masked this familiarity effect. This is not the case. On the contrary, as we hypothesized, there is a global significant effect of familiarity level on the CS for single spices (F = 34.67, p < 0.0001) as well as for binary mixtures (F = 35.66, p < 0.0001). The more participants are familiar with spices, the more they are able to recognize or identify them when presented alone or in mixture. These results strengthen previous literature on the impact of familiarity on odor perception (*e.g.* Ayabe-Kanamura

et al., 1998; Chrea *et al.*, 2005; Distel *et al.*, 1999; Doty *et al.*, 1985; Hübener *et al.*, 2001).

However, this familiarity effect has to be interpreted by considering its interaction with the country for single spices (F = 49.30, p < 0.0001; Figure 2a.] and binary mixtures (F = 7.33, p < 0.001 Figure 2b.). For single spices, Thai participants performed better for familiar spices (Level = 1) than for unfamiliar spices (Level = 0) whereas no such effect is observed for French participants.

Moreover, the inter-individual variability is higher for unfamiliar spices than for familiar ones for both French and Thai participants, which strengthen the positive effect of familiarity with spices on their perception. For binary mixtures, French participants surprisingly performed better for the unfamiliar binary mixture (Level = 0) than for the two other mixtures (Levels = 1 and 2). Yet their correct scores are better when the binary mixture contains two familiar spices than only one familiar spice. Thai participants have also better scores for unfamiliar mixture (Level = 0) compared to the mixture with one familiar spice (Level = 1) but their scores are really better when the binary mixture contains two familiar spices (Level = 2).

The ANOVAs results also show an interaction between the country and the task (verbal *vs.* perceptual) for both single spices (F = 14.84, p = 0.0002; Figure 3a.] and binary mixtures (F = 10.82, p = 0.0012; Figure 3b.).

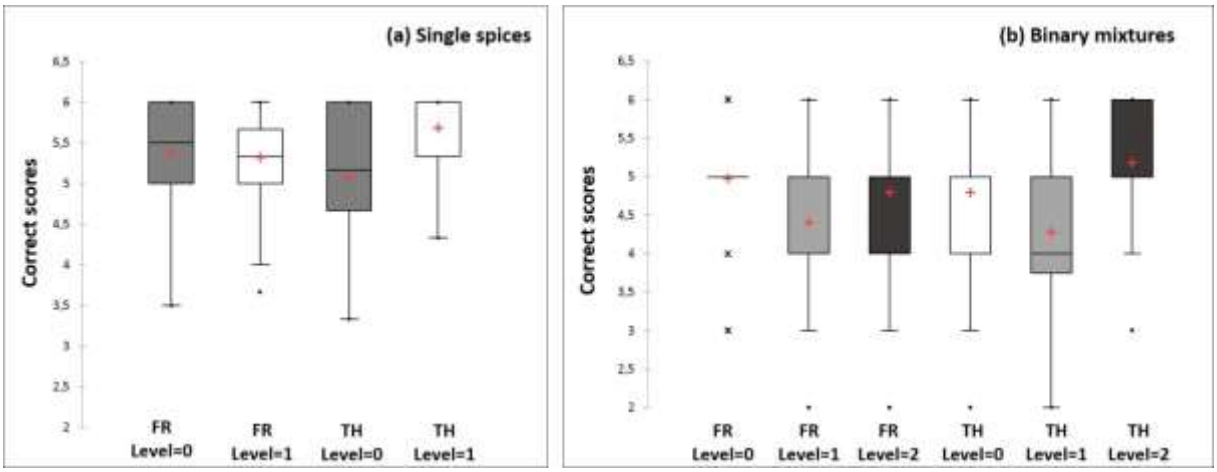

Figure 2. Box plots of correct score distributions calculated for French (FR) and Thai (TH) participants for: (a) Single spices for the unfamiliar (grey boxes, Level=0) and the familiar spices (white boxes, Level=1), and for (b) Binary mixtures for the three levels of familiarity (Level=0, Level=1 and Level=2).

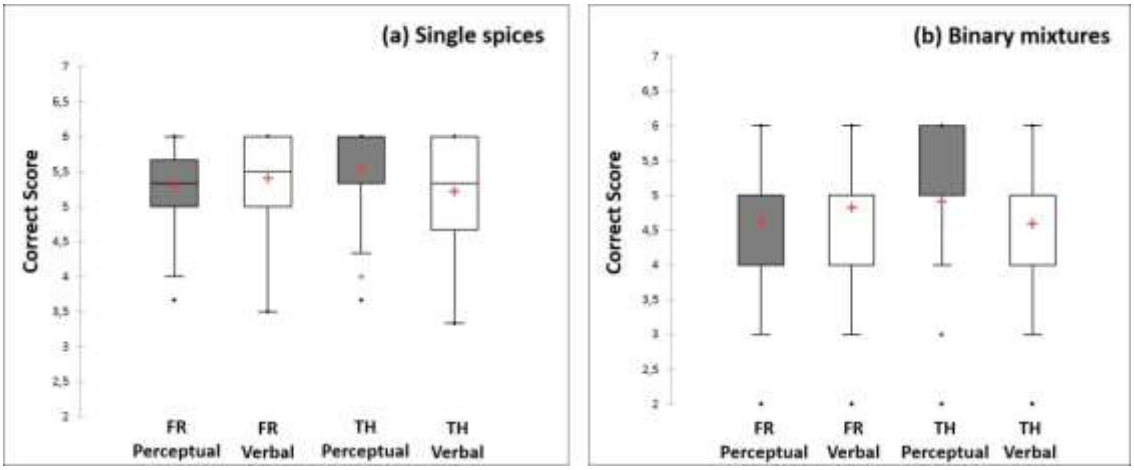

Figure 3. Box plots of correct score distributions calculated for French (FR) and Thai (TH) participants for the perceptual (grey boxes) and verbal (white boxes) tasks for: (a) Single spices and (b) Binary mixtures.

Thai participants performed better in the perceptual task than in the verbal task for both single spices (5.56±0.56 for perceptual *vs.* 5.22±0.73 for verbal task) and binary mixtures (4.91±0.94 for perceptual *vs.* 4.59±1.07 for verbal task). This result is independent of the familiarity level. No such effect is observed for French participants. On the contrary, they tend to have better scores for the verbal than for the perceptual task. These results go against our hypothesis that familiarity influences more the verbal processes than the perceptual processes. This hypothesis was based on the fact that the odor identification task is a semantic memory task which refers to individuals' experience with specific odorant stimuli (Schab, 1991; Tulving, 1993). The more people are exposed to odors —in our case to spice odors— associated with their names, colors or other sensory characteristics, the more they would memorize these odors and their names. The fact that Thai participants performed better for the perceptual task than for the verbal task regardless of the level of familiarity would indicate that they recognized the odor of the tested spices but they did not know their names. Thai people are exposed to a lot of different spices from their childhood due to their food habits linked to their culture. Nevertheless, the Thai participants of this study are mainly young people (mean age = 29±4 years old) who mostly cook only for special occasions (58% of the Thai panel, Table 1). These characteristics could explain why the Thai participants of this study did not know the spice names and so performed worse for the verbal task than for the perceptual one.

4. CONCLUSION

The goal of this study was to explore further the role of familiarity linked to the culture in the perception of spices in France and Thailand. We compared the performance of French and Thai participants in a verbal identification task and a perceptual recognition task with spices presented alone or in mixtures. The results showed a global effect of the familiarity level which is more important for Thai than for French participants. The more Thai people are familiar with the spices they smelled, the more they are able to recognize them when presented alone or in mixtures. Moreover, Thai participants are better for recognizing than for identifying spices whereas there is no difference between these two processes for French participants. Taken all together, these results strengthen previous literature on the impact of familiarity of odor perception and highlight that this effect depends on several factors like the type of task or personal characteristics (*e.g.* age, cooking habits). These different factors should be studied more precisely in next studies.

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REFERENCES

Ayabe-Kanamura, S., Schicker, I., Laska, M., Hudson, R., Distel, H., Kobayakawa, T. & Saito, S. (1998). Differences in perception of everyday odors: A Japanese-German crosscultural study. *Chemical Senses*, 23: 31-38.

Chrea, C., Valentin, D., Sulmont–Rossé, C., Ly Mai, H., Hoang Nguyen, D. & Abdi, H. (2004). Culture and odor categorization: agreement between cultures depends upon the odors. *Food Quality and Preference*, 15: 669-679.

Chrea, C., Valentin, D., Sulmont–Rossé, C., Hoang Nguyen, D. & Abdi, H. (2005). Semantic, typicality and odor representation: A cross-cultural study. *Chemical Senses*, 30: 37-49.

Distel, H., Ayabe-Kanamura, S., Martinez-Gomez, M., Schicker, I., Kobayakawa, T., Saito, S. & Hudson, R. (1999). Perception of everyday odors – Correlation between intensity, familiarity and strength of hedonic judgement. *Chemical Senses*, 24: 191-199.

Doty, R. L., Applebaum, S., Zusho, H. & Settle, R. G. (1985) Sex differences in odor identification ability: a cross-cultural analysis. *Neuropsychologia*, 23(5): 667-672.

Hübener, F., Masuda, Y., Laska, M., Kobayakawa, T. & Saito, S. (2001). Evaluation of cross-cultural differences in odor perception in Japanese and

Germans. *Paper presented at the 4th Pangborn Sensory Science Symposium*, Dijon, France.

Hudson, R. & Distel, H. (2002) The individuality of odor perception. In C. Rouby, B. Schaal, D. Dubois, R. Gervais & A. Holley (Eds.), *Olfaction, taste, and cognition*. Cambridge, London: Cambridge Press.

Jinks, A. & Laing, D. G. (2001) The analysis of odor mixtures by humans: evidence for a configurational process. *Physiology & Behavior*, 72: 51-63.

Kim, Y.-K., Jombart, L., Valentin, D. & Kim, K.-O. (2015) Familiarity and liking playing a role on the perception of trained panelists: A cross-cultural study on teas. *Food research International*, 71: 155-164.

Laing, D. G., Panhuber, H., Willcox, M. E. & Pittman, E. A. (1984) Quality and intensity of binary odor mixtures. *Physiology & Behavior*, 33: 309-319.

Laing, D. G. & Francis, G. W. (1989) The capacity of humans to identify odors in mixtures. *Physiology & Behavior*, 46: 809–814.

Laing, D. G. & Glemarec, A. (1992) Selective attention and the perceptual analysis of odor mixtures. *Physiology & Behavior*, 52: 1047-1053.

Livermore, A. & Laing, D. G. (1996) The influence of training and experience on the perception of multicomponent odor mixtures. *Journal of Experimental Psychology: Human Perception & Performance*, 22: 267–277.

Livermore, A. & Laing, D. G. (1998) The influence of odor type on the discrimination and identification of odorants in multicomponent odor mixtures. *Physiology & Behavior*, 65(2): 311-320.

Patris, B., Chrea, C., Phan Thanh, A., Valentin, D., Nguyen, D. H. & Sheu, C. F. (2004). Effect of familiarity on odor threshold: A cross-cultural study. *Paper presented at the 14th ISOT meeting*, Kyoto, Japan.

Porcherot C. (1995). Contribution à la mesure de la familiarité et de la complexité d'arômes alimentaires : pertinence de ces concepts pour expliquer les préférences des consommateurs. *Thèse*, Université de Bourgogne, Dijon, France.

Rabin, M. D. & Cain, W. S. (1984) Odor recognition: familiarity, identifiability and encoding consistency. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 10: 316-325.

Schab, F. R. (1991) Odor memory: Taking stock. *Psychological Bulletin*, 109: 242-251.

Sorokowska, A., Sorokowski, P. & Hummel, T. (2014) Cross-Cultural Administration of an Odor Discrimination Test. *Chemosensory Perception*, 7: 85-90.

Sulmont C., Issanchou S. & Köster E. P. (2002). Selection of odorants for memory tests on the basis of familiarity, perceived complexity, pleasantness, similarity and identification. *Chemical Senses*, 27: 307-317.

Tulving, E. (1993) What is episodic memory? *Current Directions in Psychological Sciences*, 2: 67-70.

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CROSS-COUNTRY RESEARCH WITH KIDS: OBSERVATIONS & LEARNINGS

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ABSTRACT

Consumer research studies across multiple countries frequently are found in published literature, but studies with children across countries are not as available. As part of a larger project, quantitative testing with children ages 7-12 was conducted in the United States and Ghana. Although effort was made to maintain consistency in the recruitment of participants and data collection between the two countries, many variables emerged. The objective of this report is to identify those differences in an effort to make researchers aware of the adaptability needed when conducting cross-country research with children. Variables compared between countries include facilities, samples, data collection, session scheduling, duration of fielding, recruitment, and compensation. In addition, although all arrangements may be confirmed before testing begins, adaptability "in country" will be highlighted because unexpected issues may arise that require immediate changes in protocols. Although there were many differences between the countries in protocols, the differences were minimized to the extent possible and the results were similar. Having an in-country partner for consumer studies with children is highly recommended to be prepared for variability and to identify adaptations needed, particularly where cultural norms, laws, facilities, and expectations may vary widely from those in the researchers home country.

Keywords: *kids, cross-cultural, multi-country*

1. INTRODUCTION

Globalization has been an important force in the food industry and research, making it necessary for food professionals to consider problems within a global context. To understand a range of consumers and their needs across cultures, sensory research has become increasingly global in recent decades. Even when cultures share a language, important differences may be observed through sensory testing. A recent study among bilingual consumers suggests that culture, rather than language, plays a key role in differences that often are observed in cross-cultural sensory studies (Ramaroson Rakotosamimanana, Arvisenet & Valentin, 2015). Similarly, Antmann *et al.* (2011) observed differences in creaminess perception among consumers from Argentina, Spain, and Uruguay, despite their shared language. Comparing results from beverage testing conducted with English-, Portuguese- and Spanish-speaking consumers, van Zyl & Meiselman (2016) concluded that culture differences impact usage of emotion words and should therefore be considered when developing an emotion tool for cross-cultural use.

Although international sensory research is important, many published sensory studies focus on subjects in North American, European, or Asian cultures. African cultures are less represented in consumer research, but countries such as Ghana represent emerging markets with a young and growing population. As of the 2010 Census, Ghana's

population was 24.7 million, a 30.4% increase over the 2000 Census findings, with 38.3% of the population under 15 years old (Ghana Statistical Service, 2012). At this same time, the United States population grew only 9.7% from 2000 to 2010 and less than a quarter of the population was under 18 years old (Howden & Meyer, 2010). Furthermore, foods and beverages account for a larger portion of household spending in Ghana than is often observed in higher income markets. On average, half of household consumption in Ghana in 2010 was attributed to foods and beverages (The World Bank Group, 2016).

In addition to limited sensory research within African markets, there is little multi-country sensory research with children. Research with children and international research each present challenges that require careful consideration. Each requires the researcher to make decisions about what is possible and what is necessary in order to obtain meaningful results. For example, research recently published comparing results of children and adults in the US. Argentina, and Spain had to exclude children in the US because some of the samples included an ingredient that is not approved for the U.S., and the institutional review board in the US would only approve testing for adults and not children (Cardinal *et al.,* 2015). Sensory research with children requires the consideration of children's' developmental level in the planning and design of experiments (Popper & Kroll, 2005). Researchers conducting testing across cultures must understand the role of cultural differences that may impact research planning, such as customs, literacy, and etiquette (Goldman, 2006). The combination of these two can provide a unique set of obstacles that require adaptability on the part of the researcher, both in planning and while fielding.

The following paper details some of the challenges that were faced, alterations that were made, and suggestions for other researchers for the planning and execution of international research. A summary of these considerations is provided in Table 1. While the list of considerations is not intended to be exhaustive, it serves as a practical example, against which researchers may consider their own international research objectives and plans. Studies were conducted in the United States and Ghana to understand children's emotion responses to images of foods using emojis (cartoon images of faces commonly used in mobile and internet communications) and emotion words.

2. RESEARCH OUTLINE

Three studies were conducted as part of a larger research project to understand the emotions children experience in response to foods. The first study was a central location test conducted on the Kansas State University – Olathe Campus (Olathe, Kansas, USA) where 100 children evaluated images of food. The second test, held at the same location, involved 111 children evaluating actual food products. The final test was conducted across six primary schools in Accra, Ghana, where 120 children evaluated images of food. The following sections detail the differences in procedures and the adaptations that were made prior to arrival in Ghana, while in Ghana, and after returning to the U.S.

2.1. Adaptations Prior to Arrival in Ghana

2.1.1. Samples

Before conducting research in Ghana, two tests were fielded in the United States: 1) a test with eight food images (fresh spinach, baby carrots, orange juice, white grapes, cheddar cheese, chocolate graham snacks, lychee gummy candy, white bread) to reduce the set of words and emoji responses used for further testing with children, and 2) a second test with children evaluating tasted samples of the same foods shown in the image study.

For testing in Ghana, the original plan was to replicate the second U.S. study with Ghanaian children tasting six of the foods and reporting emotion responses to these samples. During recruitment inquiries to schools, a local collaborator communicated these plans to school administrators, but few schools expressed interest in participating in the research. This disinterest was unexpected, as several schools had expressed interest in the project after focus groups related to this research were held with children in Accra three months prior. After several schools declined to participate or failed to respond to the request, the local researcher probed to understand the hesitation of school staff and learned that there were concerns about conducting tests with foods in schools due to student food allergies. Based on this feedback, the decision was made to conduct a test similar to the second test, but with the eight food images used in the first study held in the U.S.

Table 1. List of considerations from this study for cross-cultural testing with children

	Were adjustments made for testing in Ghana?
Recruitment	
Form of Participant Contact	Yes
Timing of Recruitment	Yes
Screening Method	Yes
Child Assent	No
Parent Consent	No
Participants	
Age	Yes
Gender	No
Number of Participants	No
Type of Compensation	Yes
Fielding	
Samples Evaluated	Yes
Time of Day	Yes
Length of Sessions	Yes
Overall Time to Collect Data	Yes
Research Staff Responsibilities	Yes
Study Supplies	Yes
Testing Room Layout	Yes
Location Type	Yes
Data Collection	
Physical Form of Ballot	Yes
Ballot Language	No
Questions Asked	No
Sample Design	No
Question Design	No
Post-Study Data Handling	Yes

2.1.2. Recruitment

At the research center in the U.S., a database of consumers is maintained for study recruitment in the Kansas City metro region. Through this database, parents and legal guardians of children were contacted via email for internet screening using Compusense at-hand (Compusense Inc., Guelph, Ontario, Canada). For both studies in the U.S., recruitment began approximately one week prior to fielding. Children recruited for these studies ranged from 7 to 11 years old. Parents of qualified participants received confirmations and reminders of their appointments by email, through the Compusense at-hand scheduling system. Written parent consent and child assent were also obtained on the day of the study.

In Ghana, a local partner contacted primary schools in Accra to assess interest assisting with the research project. To adhere with the Institutional Review Board agreement for the research in Ghana, children under 12 years old were not allowed to participate in this study. Prior to fielding, researchers made the decision to limit participation to children 12 years old to minimize age differences between the groups of children. Similar to the U.S. image study, children were not screened for food allergies or dietary restrictions since children were only evaluating pictures of foods during the study. No central facility to conduct testing with more than 100 children was available, so the decision was made to bring testing into the schools. Contact with the schools was made through the principal, and in several cases required multiple phone calls or visits to the school to confirm that the school was willing to participate in the study. Once the school agreed to participate in the study, permission forms were provided to the school and sent home with children

to provide parent consent for study participation. Children's written assent was also obtained on the day of the study. Schools provided researchers with an estimate of the number of children that they anticipated would participate in the study. Students were screened by the in country partner at the school site on the day of testing.

2.1.3. Data Collection

In the U.S. all results were collected using Compusense at-hand, which allows the researcher to use designs to rotate appearance of samples and response choices. Questions can also be constructed so that the respondent must make a choice before continuing through the rest of the test. Collecting data in this way allowed for minimal missing data in the U.S. dataset and eliminated the risk of human error during manual data entry.

With limited or no internet in some schools where fielding occurred in Ghana, a paper ballot was used for data collection. English is the official language of Ghana and used in school, thus, ballots were not translated. Prior to arrival in Ghana, a researcher created a version of the questionnaire previously made in Compusense using a word processor. A draft of this questionnaire was reviewed by researchers in the U.S. and Ghana to assess clarity of the testing method once adapted to paper. After agreeing on a final version of the questionnaire, 120 unique questionnaires were constructed to include a randomly balanced presentation of the eight sample images, as well as randomized presentation of the emojis in the CATA questions. All ballots were printed in color in the United States prior to the study and transported to Ghana by the researchers.

2.2. Adaptations in Ghana

2.2.1. Compensation

For all studies in the United States, children were compensated in cash for their participation in the study. For Ghana, researchers worked with the local collaborator to identify appropriate compensation for the children and the schools. Children were each given a notebook, pencil, and eraser for their participation. The pencils and erasers were handed out with the questionnaire so that children could use those items to fill in their responses. Each school received pens, pencil, and a calendar for their efforts.

2.2.2. Scheduling and Location

In the U.S., the study dates were selected to maximize child availability, such as half-days or holidays in the local school systems. All sessions were conducted at the Sensory & Consumer Research Center at Kansas State University – Olathe. Study times were established by research staff during times when local school children would be available. Parents of qualified children were allowed to select the session that best fit their child's schedule. Each session lasted one hour, although most children completed the study within 30 minutes. Both studies in the U.S. were completed after one day of testing.

In Ghana, all research was conducted in the primary school during school hours to ensure child availability. The time of day was determined by school staff to align with break periods for 12-year-old students. Although times had been discussed between a researcher and the school staff prior to the study, several appointments did not start at the scheduled time because the children were not yet available to complete the survey. To accommodate multiple schools, study sessions were spaced out over the course of four days. Including travel throughout the city and fielding, researchers spent approximately four to five hours each day dedicated to fielding this research project.

2.2.3. Facilities

Testing in Olathe, Kansas, USA was conducted in a large multipurpose room, with tables arranged along the perimeter of the room. Each participant station faced the wall and contained an iPad® equipped with Compusense at-hand for data collection. A seating outside of the study room was provided for parents and siblings while they waited on-site for their child to complete the study.

Six different primary schools were used for study fielding in Ghana, each with different facilities for testing. The differences at each location made it necessary for the researchers to discuss their set-up plan at each school after seeing which room was provided for testing. At each site, researchers had five to 10 minutes before fielding to set-up the space in preparation for testing. The schools in Ghana varied from an air-conditioned international school, to an open-air local school with dirt flooring. In the latter school, children sat at chairs with wood slabs that served as their desk. There were not enough wood pieces for all the desks in the study classroom,

and several children at this location had to take the time to retrieve pieces of wood from elsewhere in the school. The rooms at this school did not have doors, which introduced distractions from peers who were not eligible to participate in the study, but interested in observing. A researcher and a teacher helped to keep participants on-task and to stop other students from interfering with the research activities. At another school, a library was used for fielding the study. Rather than the individual desks used in many of the classrooms, children in the library had to sit around large tables where they were able to face other students. To minimize distractions and avoid bias from other participants, two researchers circled the room and when necessary reminded students to maintain focus on the study tasks. Students who needed reminding to focus on the task often took longer to complete the survey than other children, and as a result fielding the study with a larger group of students or with possible distractions took longer than fielding at schools with fewer participants.

2.2.4. Number of Participants

In the United States, recruitment was capped at 120 participants for each study, with the goal of collecting data from 100 children per study. After participant cancellations and no-shows, 100 children participated in the first U.S. study with food images, while 111 children participated in the study with food samples.

In Ghana, 120 children who consented to participating in the study and were 12 years of age participated in the study. At least two children eligible to participate in Ghana opted out of the study after ballots were passed out and study instructions were given by the moderator. A possible reason for this may be the length of the ballot, which is readily apparent when using a printed questionnaire versus a computer-based questionnaire with no progress indicator.

Although schools provided estimates of the number of children participating in the study, the actual number of children available for testing varied on the day of fielding. Throughout the week of testing, researchers monitored participation levels and discussed plans to ensure the goal of 100 participants was reached. The final school provided the researchers with an opportunity to collect data from more than 120 children, but there was not adequate time prior to this session to allow for the design and color printing of additional ballots. As a result, 6 children from this school were selected to participate, resulting in a total of 120 participants across all 6 schools in Ghana.

2.3. Adaptations after Returning to the United States

Data Handling. In the U.S., all responses were recorded by participants using an iPad® equipped with Compusense at-hand. Children used anonymous usernames provided by study staff so that responses could not be linked to the child's identity.

All paper ballots were transported from Ghana by a researcher and data from paper ballots were entered by two technicians in the U.S. Due to the length of the questionnaire, an identical version of the paper questionnaire was designed in Compusense-at hand to simplify data entry. The designs used to create the randomizations of food images and emojis were included in the web-based questionnaire so that the questions displayed matched the printed format of the completed questionnaires. Prior to data entry, the researchers agreed on how to handle missing or duplicate responses to that questionnaire input was consistent. While entering data, each researcher kept notes on missing or duplicate data, and these notes were used to mark these data points as incomplete in the resulting data file. The researchers agreed to omit two ballots from inclusion in the data set because of excessive incomplete data.

3. DISCUSSION

While the data from this research showed similar usage of emotion words and emojis between the countries, the research plans were quite different between the two locations. The first change made in the initial planning of the study was the change from actual food samples to food images. While the intention was to collect data in Ghana using samples of food, feedback from school administrators revealed a need to revise this approach. This change led to a longer ballot to include food images and did not allow for collection of children's responses to tasted foods, however this freed up researchers on-site in Ghana to manage testing without sample preparation. Additionally, this change allowed for the evaluation of eight images rather than six food samples. In initial planning discussions with a local collaborator, the number of food samples to be

served was reduced from eight in the U.S. study to six food samples in Ghana to account for time needed for the serving and evaluation of foods. Once the choice was made to use images, the plans were revised to include all 8 images used in the first U.S. study.

Another major change to the study was the use of paper ballots versus an online questionnaire. Working with a local collaborator was key in understanding the challenges of conducting testing online, such as limited or no internet access and fluctuations in the availability of electricity. These conversations made it clear early in planning that moving forward with a web-based questionnaire was unrealistic for in-school testing in Ghana. Although the availability of electricity was not an issue during the actual conduct of this study (data could be stored on the local device), power outages were a factor in focus groups conducted for an earlier part of the larger research project. Additionally, the lack of appropriate internet access reduced the ability to download and upload actual data and ballots as needed to the tablet devices, which limited their use from a practical standpoint. Lost data would have been disastrous; thus, paper was employed to ensure data was not lost.

With the number of food images, emotion words, emojis and questions included in the survey, constructing organized ballots with balanced presentation was a more time-consuming task in a word processor as opposed to using a web-based survey tool. While Compusense at-hand will generate a pdf of the questionnaire, the program does not generate individual ballots containing the design for each panelist, so the ballots were created by a researcher. This required careful advance planning on behalf of the researchers prior to fielding in Ghana. It also made collecting additional data much more complicated than adding another participant to an online test. If possible, pre-testing is recommended to determine which elements of questionnaire design are necessary to preserve when adapting to a paper approach, and which elements do not impact the study results. For example, had previous results shown that emoji order did not impact the results of this study, a standard order of emojis could be established, greatly reducing the time needed to create paper ballots.

In addition to the time needed for creation, the printed questionnaire presented additional challenges while in Ghana. While a visual representation of the length was not provided for children in the U.S. completing the online questionnaire, in Ghana the length of the task was obvious due to the physical size of the ballot, which was 12 double-sided pages. The amount of pages may have negatively impacted some children's willingness to participate in the study, with at least two students in Ghana declining to participate after seeing the questionnaire. The length of the paper ballot also made it difficult to check for missing data within the time constraints of testing, while the online questionnaire used in the U.S. did not allow children to proceed if a response was missing. Although children in Ghana were reminded to provide a response for each question, several ballots contained missing data points.

While conducting research in Ghana provided a number of challenges, particularly in terms of researcher time needed for study execution, throughout fielding, the school staff and students helped to make the study run smoothly. At multiple schools, staff assisted in locating an appropriate space for the study and helped researchers identify 12 year olds for participation in the study. In the open-air school, a school staff member remained present throughout fielding to help manage children who were not participating in the hallway and keep students participating focused on completing the study. Although two children opted out of participating in the study, the majority of students were interested in participating in the study and were happy to make a contribution to the research.

Consumer testing in other countries is an important endeavor, but it comes with complications. Ideally, many of the issues that arise in such research could be circumvented with ample time, space, resources, and qualified participants, but such luxury is not always available. While sensory researchers aim to conduct carefully controlled studies with minimal variation, unanticipated variables may arise when researching in an emerging market. These variables present challenges for the researchers, but should not hinder scientists from conducting research in international locations. Establishing a relationship with a local research collaborator and consulting with them throughout the planning and execution of the study can help foreign researchers understand the environment and approaches that are most appropriate for meeting study objectives in an unfamiliar setting.

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REFERENCES

Antmann, G., Ares, G., Varela, P., Salvador, A., Coste, B., & Fiszman, S. M. (2011) Consumers' creaminess concept perception: A cross-cultural study in three Spanish-speaking countries. Journal of Texture Studies, 42, 50 – 60.

Cardinal, P., Zamora, M.C., Chambers, E. IV, Carbonell Barrachina, A., & Hough, G. 2015. Convenience sampling for acceptability and CATA measurements may provide inaccurate results: a case study with fruit-flavored powdered beverages tested in Argentina, Spain and USA. Journal of Sensory Studies, 30, 295-304.

Ghana Statistical Service. (2012) 2010 Population & housing census: summary report of final results. Available at: http://www.statsghana.gov.gh/docfiles/2010phc/Census2010_Summary_report_of_final_results.pdf.

Goldman, A. (2006) Important considerations in cross-cultural sensory and consumer research – introductory overview. Food Quality and Preference, 17, 647,

Howden, L. M., & Meyer J. A. (2011) Age and sex composition: 2010. United States Census Bureau. Available at: http://www.census.gov/prod/cen2010/briefs/c2010br-03.pdf.

Popper, R., & Kroll, J. J. (2005) Conducting sensory research with children. Journal of Sensory Studies, 20, 75 – 87.

Ramaroson Rakotosamimanana, V., Arvisenet, G., & Velentin, D. (2015) Role of languages in consumers' food description: Contrasting Malagasy and French descriptors of *Moringa oleifera*. Journal of Sensory Studies, 30, 181 – 194.

van Zyl, H. & Meiselman, H. L. (2016) An update on the roles of culture and language in designing emotion lists: English, Spanish, and Portuguese. Food Quality and Preference, 51, 72 – 76.

The World Bank Group. (2016) Global Consumption Database. Available at: http://datatopics.worldbank.org/consumption/country/Ghana

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PRELIMINARY INSIGHTS INTO WOOD APPLE WINE USING CONSUMER PERCEPTIVE MAPPING

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ABSTRACT

The objective of this study was to assess the preliminary insights of wood apple wines using consumer perceptive mapping method (Faye *et al.*, 2006). This method consists of two consumer tasks: (1) a perceptual free sorting task followed by a verbalisation, and (2) a hedonic task. The experiment was performed on seven products, conducted by 65 alcohol beverage consumers. A multiple correspondence analysis (MCA) was performed on the free sorting data to assess the consumer perception, whereas a one way within subject ANOVA was performed on the hedonic data to assess the consumer preference. These two data sets were then related by means of PrefMFA solution (Worch, 2013) for a better understanding of the consumer preference. The results showed that, for the consumer perception, the product space of wood apple wines could be interpreted in terms of their own sensory attributes. For the consumer preference, the preference map obtained by PrefMFA highlighted a zone of maximum liking close to our prototype, accepted by 70% of the consumers. In addition, the three sensory attributes as brown color, sour taste, and wood apple odour might be considered as the primary drivers of liking of wood apple wines. This study suggests that consumer perceptive mapping is an invaluable tool for research and development staff to quickly reveal consumer responses in product development process.

Keywords: *consumer perceptive mapping, sorting, PrefMFA, wood apple wine.*

1. INTRODUCTION

The understanding of consumers' perception and their preferences is key to success in the market place. Many consumer product companies believe if this information can be translated into new product concepts, throughout (re)formulation process, which will guide consumer food choices.

Preference mapping (Chang & Carroll, 1969; Carroll, 1972) has been a favorite method fitting for that purpose. For internal preference mapping, the information of consumers' preferences is internally revealed from the consumer liking data. Whereas, for external preference mapping, the consumer preference is related to sensory attributes of the products obtained from the trained panel, which is outside of the consumer data. This information is the utmost importance for the research and development process as it enables to identify the key sensory attributes that consumers are using to make assessment about liking. However, preference mapping has its own disadvantages. In fact, this method requires the descriptive information from the trained panel, which is not only time consuming, but this information is also not based on consumers' perception. That could be the reason researchers and practitioners are seeking an alternative method, obviating the need to train a sensory panel.

In 2006, Faye *et al.* proposed the consumer perceptive mapping method as an alternative to external preference mapping. Technically, consumer perceptive mapping consists of two consumer test phases: a hedonic task (hedonic sequential monadic test) and a free sorting followed by a verbalisation phase. By replacing the descriptive task of preference mapping by the free sorting task, consumer perceptive mapping reduces the panel training time and even more important it provides information very close to consumers.

Adapted from Faye *et al.* (2006) to our research context, the consumer perceptive mapping method was applied to develop a new food product from wood apple. This fruit, very popular in Mekong Delta, is used to make jam, powder, and (non-)alcoholic beverages. From a medical point of view, wood apple fruit is considered to be a natural source of anti-oxidants, anti-diabetic, anti-ulcerative, anti-tumour, and anti-microbial activity. Further information about bioactive compound of wood apple can be found in the article "Optimisation of extraction of bioactive compounds from *Feronia limonia* (wood apple) fruit using response surface methodology

(RSM)" (Ilaiyaraja, Likhith, Sharath Babu, & Khanum, 2015).

The objective of this study is to provide preliminary insights into wood apple wines. We addressed the three following questions: 1) How do consumers perceive and describe the product space of wood apple wines? 2) Which products do consumers prefer? and 3) Can consumer preference be understood and interpreted by means of descriptive information?

2. MATERIALS AND METHODS

2.1. Samples

The samples were seven wood apple wines, which differ in terms of type and alcohol content (Table 1). All the samples were stored in a refrigerator (15 °C) in their original packaging. One hour before the tasting session, they were kept at room temperature (25 °C). In the tasting session, the samples were coded by 3-digit numbers and served in plastic cups in 30 ml units. Potable water and unsalted crackers were available to the subjects for the purpose of palate cleaning.

Table 1: List of wood apple wines evaluated

Type	Product	Alcohol (% ABV)
Household	P3 (629)	20.8
	P4 (366)	19.8
	P6 (187)	20.0
Commercial	P1 (487)	19.8
	P2 (617)	19.9
	P5 (276)	21.9
Prototype	P7 (941)	19.8

2.2. Procedure

For the free sorting task, the subjects firstly received the entire set of samples was presented in a random order to avoid position and carryover effects. Then, each subject was asked to sort the samples into different groups according to their resemblances: two samples were sorted together if he/she perceived them as similar; *vice versa*, they were sorted in two different groups if he/she perceived them as different. The subjects were free to make as many groups as they wanted based on their own criteria. After the main task, the subjects were requested to describe each group with their own terms, the so-called verbalization phase. Further information about the free sorting task and its variations can be found in Valentin, Cholet, Nestrud & Abdi (2016).

For the preference task, a hedonic ranking was applied in this study rather than a hedonic rating. The reason for that is that ranking is an activity which most consumers find easy (Wichchukit & O'Mahony, 2014). From the perspective of the task, the subjects were asked to rank the seven samples from 1–very much disliked to 7–very much liked.

A convenience sample of sixty-five consumers (47 males and 18 females) were recruited on campus at TraVinh University in Vietnam. Age was between 25÷30 (39 subjects) and 30÷40 (16 subjects) selected according to the following criteria: regular consumption of high alcohol wines (over 15% ABV) willingness to participate regularly in this study. The experiment was conducted at a central location in a large room, whose environmental conditions were controlled (Boutrolle, Delarue, Arranz, Rogeaux, & Köster, 2007).

2.3. Data analysis

The data collected from the free sorting task was structured into a table, whose rows corresponded to the samples, columns to the subjects, and intersections between rows and columns to the name of group that a stimulus belonged to. This data table was analyzed by Multiple Correspondence Analysis (MCA), which aimed to identify groups of individuals with similar profile and the associations between variable categories (Husson, Lê & Pagès, 2011). Besides, in order to interpret the product space, the sensory attributes (*i.e.* terms) elicited by subjects in the verbalization phase were projected on MCA the configuration. This was done by computing the correlation coefficients between the attribute frequency (rating by all subjects) and MCA first two dimensions.

The data collected from the hedonic ranking task were structured into a table, whose rows corresponded to the samples, columns to the subjects, and intersections between rows and columns to the rank of the samples evaluated by the subjects. In order to determine significant differences between the products, a within subject ANOVA was used. In this analysis, *product* was treated as fixed factor, whereas *subject* was treated as random factor. When a significant effect was observed, a multiple comparison test using Tukey contrast was conducted to determine where the differences were located.

As mentioned before, the preference map was obtained by relating the sensory/descriptive data and the hedonic data. This map allowed to predict the consumer acceptance of a given product in terms of its sensory attributes. Different from the statistical procedure frequently adopted in PrefMap, in our case study, we used a PrefMFA solution proposed by Worch (2013) to obtain the preference map.

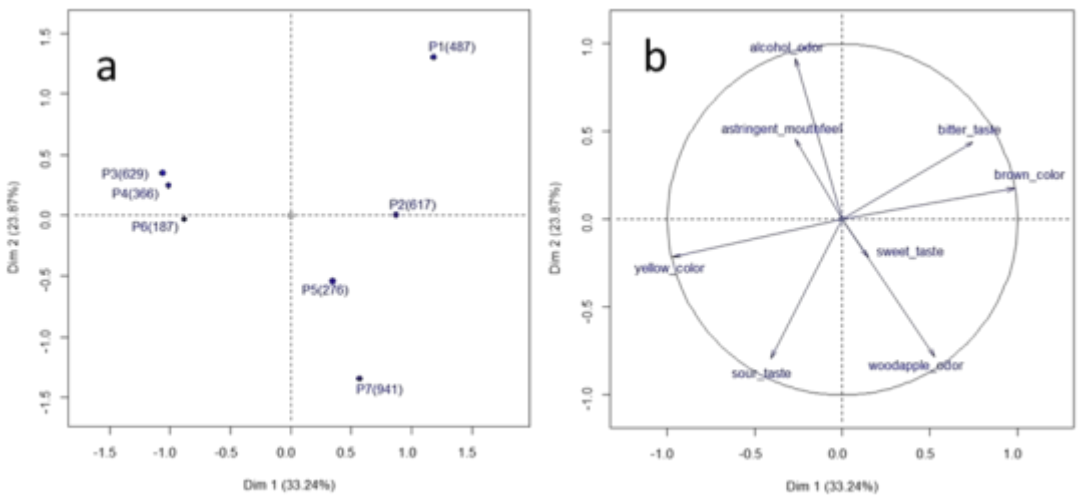

Figure 1. Representation of the products (a) and Representation of the sensory attributes (b) on the first factorial plane obtained from a MCA

Technically, PrefMFA is akin to Preference Mapping in the sense that the individual models were predicted by means of the external space. However, the core of PrefMFA was that its external space was obtained by Multiple Factor Analysis (MFA), which simultaneously considered both the sensory and hedonic data sets in one analysis. This solution enabled to better predict the individual models, consequently, to better understand the consumer preference. Further information about PrefMFA compared to Preference Mapping can be found in Worch (2013) and Lê & Worch (2014). It is important to note that, in our case study, the sensory data set obtained from the free sorting was treated as categorical variables in the PrefMFA procedure.

All the analyses were carried out using R software (R Core Team, 2016), version 3.3.0, with packages FactoMineR (Husson, Josse, Le, & Mazet, 2016) for performing MCA and PrefMFA, and package nlme (Pinheiro, Bates, DebRoy, Sarkar, & R Core Team, 2016) for performing one-way within subject ANOVA along with the *post hoc* test.

3. RESULTS

3.1. How do consumers perceive product space?

Figure 1 shows the representation of the products (a) and the representation of the sensory attributes (b) obtained from MCA. This representation is consensus over all the subjects on the first factorial plane. It is structured by Dim 1 and Dim 2, which accounted for 33.24% and 23.87% of the total variability of the data, respectively.

As shown in Figure 1a, the products P3, P4, and P6 opposite to the others forming Dim 1, whereas P1 opposites to P7 forming Dim 2. By being interpreted jointly with Figure b, thanks to the verbalisation phase, P3, P4, and P6 are gain associated with yellow, P1 is associated with brown and alcohol, and P7 is associated with brown, wood apple, and sour.

3.2. Which products do consumers prefer?

Figure 2 shows the bar plot representing the product averaged scores along with their error bars (±1.96×SE). P1, P2, and P7 seem to get a higher average score compared to the other products. The differences between the products are confirmed by the ANOVA. The results show that the product effect is significant (F = 11.86, p < 0.0001), meaning that there exists a difference between the products in overall liking.

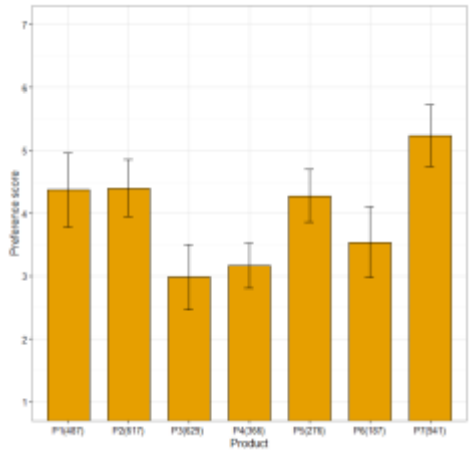

Figure 2: A bar graph – Representing the products' average scores along with their error bars .

To isolate where the differences are, a post-hoc test – multiple comparisons using Tukey contrasts was performed. The results (Figure 3) show that products P1, P2, and P7 are significantly preferred to products P3, P4, P5, and P6. In constrast no significant difference was observed between P1, P2, and P7.

```
                Estimate Std. Error z value Pr(>|z|)
P3 - P1 == 0  -1.38462    0.32770  -4.225 0.000501 ***
P4 - P1 == 0  -1.20000    0.32770  -3.662 0.005258 **
P3 - P2 == 0  -1.41538    0.32770  -4.319 0.000329 ***
P4 - P2 == 0  -1.23077    0.32770  -3.756 0.003629 **
P5 - P3 == 0   1.29231    0.32770   3.944 0.001686 **
P7 - P3 == 0   2.24615    0.32770   6.854 1.51e-10 ***
P5 - P4 == 0   1.10769    0.32770   3.380 0.015211 *
P7 - P4 == 0   2.06154    0.32770   6.291 6.63e-09 ***
P7 - P5 == 0   0.95385    0.32770   2.911 0.075725 .
P7 - P6 == 0   1.69231    0.32770   5.164 5.07e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
(Adjusted p values reported -- bonferroni method)
```

Figure 3. R output: Multiple comparisons of wood apple wines in consumer overall liking, using Tukey contrasts after a significant one way within subject ANOVA. Only significant differences are presented.

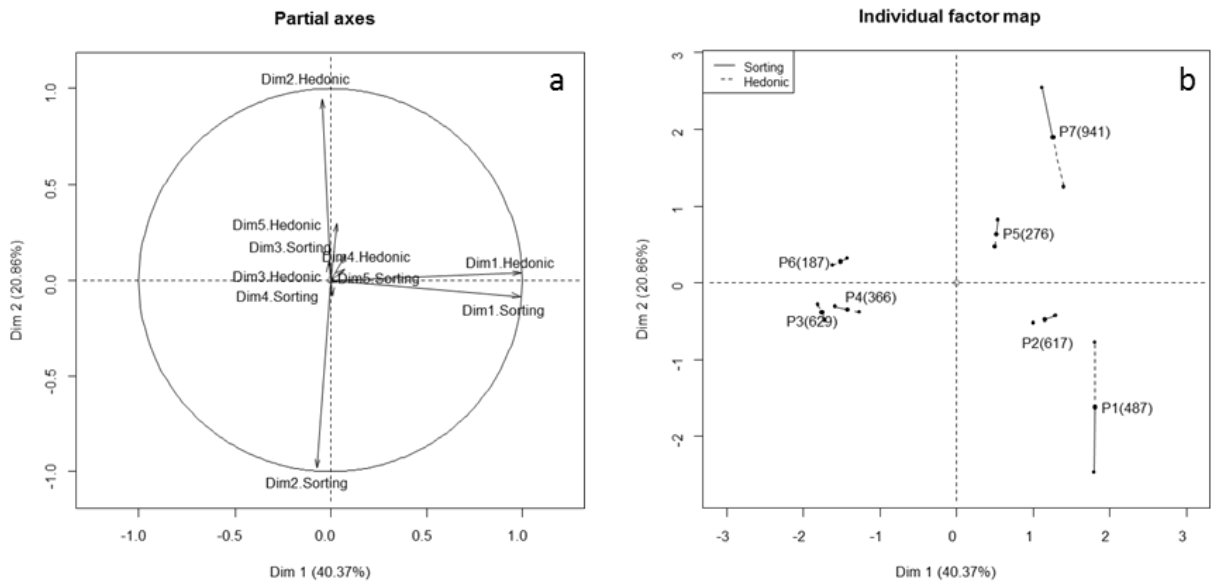

Figure 4: Representation of the dimensions of the two datasets (a) and of the partial points of the products (b) obtained by the separate analyses using MFA

3.3. Relating consumers' perception and preferences

Figure 4 shows the representations of the sensory and the hedonic data sets on the common space obtained by MFA. The results shown in Figure 4a confirm the strong relationship between the sensory and the hedonic group. *De facto* their Dim 1 and Dim 2 are positively and negatively correlated two by two on this plane.

In addition, Figure 4b shows the partial point representation obtained by projecting each group as supplementary on the MFA common space. The products most common to the two groups are P2, P3, P4, P5, and P6, whereas the products less common to the two groups are P1 and P7.

Figure 5 shows the surface response plot on the first factorial plane obtained from PrefMFA. This is a bi-dimensional preference map in which the hedonic scores were projected into the partial point representation of the sensory configuration within the first factorial plane of MFA (Figure 4b).

This surface response plot highlights a zone of maximum liking close to P1, P2 and P7: product P1 and P2 would be accepted by 60% of the consumers, whereas P7 would be accepted by 70% of the consumers.

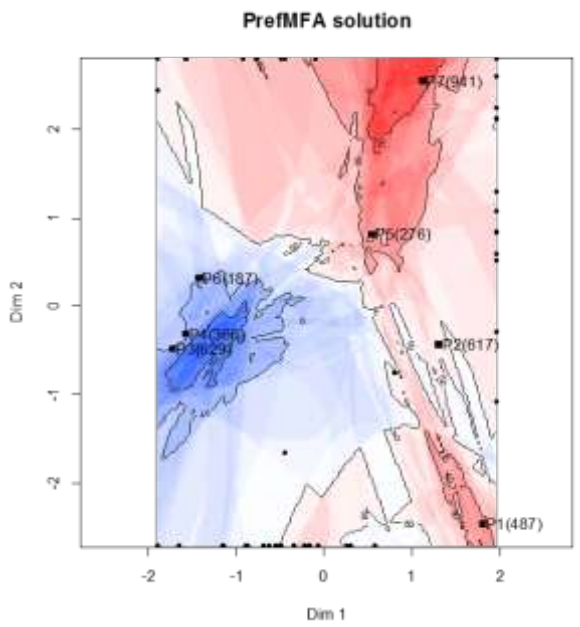

Figure 5: Surface response plot on the first factorial plane obtained by PrefMFA

4. DISCUSSION

The product space obtained by the free sorting can be understood and interpreted via the verbalization phase. As the subjects are naïve consumers, they tended to use more visual cues when describing the products, while focusing less on odor, aroma, and taste attributes. In fact, Dim 1 of the first factorial plane, provided by MCA (Figure 1b), is characterized by yellow and brown color. Thanks to function dimdesc (package FactoMineR), the correlation between Dim 1 and brown (resp., yellow) can be calculated and is equal to 0.98 with $p < 0.001$ (resp., -0.97 with $p < 0.001$). While Dim 2 of this plane is characterized by alcohol odor with a correlation equals to 0.91 ($p<0.01$); by sour taste, with a correlation equals to -0.78 ($p<0.05$); and by wood apple odor, with a correlation equals to -0.79 ($p < 0.05$).

Interestingly, the variability of the plane obtained for the sensory data set is very close to that obtained for the hedonic data set. It means that the consumers prefer the products which possess the attributes perceived as important. By relating the sensory data set to the hedonic data set, we might get further insights into wood apple wines. As shown in Figure 5, the consumers prefer the products on the right hand side of the preference map. In this, the most preferred product is P7, whose sensory attributes brown, wood apple, and sour can be considered as the drivers of liking of the wood apple wine product.

Remarkably, although alcohol goes in the opposite direction to wood apple and sour (Figure 1b), it seems to be irrational if one considers the less alcohol content the products have, the more preference they gain. In fact, the alcohol content of all the products is very similar (Table 1). The differences between our prototype (i.e. P7), and the other products are: the optimal ripeness of wood apple fruits and the soaking time are considered in the winemaking process. From our experiment, these two factors are crucial to the optimal balance between odor, aroma, and taste in the final product.

5. CONCLUSION

Formulation, evaluation, and reformulation are frequent activities of product development process – the lifeblood of the food industry. Thanks to consumer perceptive mapping method, consumer responses (perception and preferences in our context) to a new product can be quickly identified. The results show that the product space of wood apple wines can be interpreted in terms of their own sensory attributes. Furthermore, by relating to consumers' preferences the three sensory attributes, brown color, sour taste, and wood apple odor, might be considered as the primary drivers of liking of wood apple wine. However, it is premature to reformulate a new recipe based on these results due to the fact that the relative importance of the sensory attributes might not be consistently and linearly related to their intensities. Further studies should focus on the optimal intensity of sensory attributes and consumer motivational factors in order to develop this product. We expect that wood apple wine can be a unique food of Mekong delta, which brings not only an economic benefit but also constitutes an identity and regional heritage.

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REFERENCES

Boutrolle, I., Delarue, J., Arranz, D., Rogeaux, M., & Köster, E. P. (2007). Central location test vs. home use test: Contrasting results depending on product type. *Food Quality and Preference*, *18*(3), 490–499. http://doi.org/10.1016/j.foodqual.2006.06.003

Carroll, J. D. (1972). Individual differences and multidimensional scaling. In R. N. Shepard, A. K. Romney, & S. B. Nerlove (Eds.), *Multidimensional scaling: Theory and application in the behavioural*

sciences (Vol. 1, pp. 105–155). New York: Seminar Press.

Chang, J. J., & Carroll, J. D. (1969). *How to use MDPREF, a computer program for multidimensional analysis of preference data*. Murray Hill. NJ: Bell Telephone Laboratories (Tech. Rep.).

Faye, P., Brémaud, D., Teillet, E., Courcoux, P., Giboreau, A., & Nicod, H. (2006). An alternative to external preference mapping based on consumer perceptive mapping. *Food Quality and Preference*, *17*(7-8), 604–614. http://doi.org/10.1016/j.foodqual.2006.05.006

Husson, F., Josse, J., Le, S., & Mazet, J. (2016). FactoMineR: Multivariate exploratory data analysis and data mining. R package version 1.32. Retrieved from https://cran.r-project.org/package=FactoMineR

Husson, F., Lê, S., & Pagès, J. (2011). *Exploratory multivariate analysis by example using R*. London: Chapman & Hall/CRC.

Ilaiyaraja, N., Likhith, K. R., Sharath Babu, G. R., & Khanum, F. (2015). Optimisation of extraction of bioactive compounds from Feronia limonia (wood apple) fruit using response surface methodology (RSM). *Food Chemistry*, *173*, 348–354. http://doi.org/10.1016/j.foodchem.2014.10.035

Lê, S., & Worch, T. (2014). *Analyzing sensory data with R*. Chapman and Hall/CRC. http://doi.org/10.1201/b17502

Pinheiro, J., Bates, D., DebRoy, S., Sarkar, D., & R Core Team. (2016). nlme: Linear and nonlinear mixed effects models. R package version 3.1-122. Retrieved from http://cran.r-project.org/package=nlme

R Core Team. (2016). R: A language and environment for statistical computing, Vienna, Austria. R Foundation for Statistical Computing. Retrieved from https://www.r-project.org/

Valentin, D., Cholet, S., Nestrud, M., & Hervé, A. (2016). Projective Mapping and Sorting Tasks. In J. Hort, S. Kemp, & T. Hollowood (Eds.), *Descriptive analysis in sensory evaluation* (pp. 1–19). Wiley-Blackwell.

Wichchukit, S., & O'Mahony, M. (2014). The 9-point hedonic scale and hedonic ranking in food science: Some reappraisals and alternatives. *Journal of the Science of Food and Agriculture*, (October). http://doi.org/10.1002/jsfa.6993

Worch, T. (2013). PrefMFA, a solution taking the best of both internal and external preference mapping techniques. *Food Quality and Preference*, *30*(2), 180–191. http://doi.org/10.1016/j.foodqual.2013.05.009

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DO WE HAVE THE SAME EXPECTATIONS AND PREFERENCES IN TWO REGIONS OF FRANCE CONCERNING THE MAROILLES CHEESE?

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ABSTRACT

France is well known for its various pdo cheeses, these regional cheeses are typical from specific area, and it is the case of maroilles cheese. We aimed to investigate how familiarity with maroilles cheese impacts consumers' attitude, expectation and preferences in two different cities: lille located in the region of maroilles cheese and angers in an area where the maroilles is not really consumed. 305 consumers test was carried out with six commercial maroilles (three craft maroilles made with raw milk and three industrial maroilles made with pasteurized milk) in three conditions: blind (tasting without any information), expected (no tasting, only a photo of the packaging) and informed conditions (tasting with the photo of the corresponding packaging). The results indicate that the preference orders are quite similar between both cities and there is no clear difference of preference between craft and industrial maroilles cheeses. Disconfirmation and assimilation and contrast effects are observed and discussed.

Keywords: *preference, expectation, product familiarity, disconfirmation, maroilles cheese.*

1. INTRODUCTION

France is a country with a rich cheese history: There are more than 1200 varieties among which 400 are commonly consumed. French households consumed 26.7 kg of cheese per person in 2014 (CNIEL, 2016). Most French cheeses are strongly associated to a particular region and 45 of them are PDO-labelled (Protect Designation of Origin) with typical characteristics. Specific attitudes emerge from this typicality in relation with consumers' familiarity with the cheeses.

Previous studies focusing on consumer behavior have shown that product related experience or familiarity affects how consumers use available information to form product quality judgments (Rao & Monroe, 1988; Chocarro, Cortiñas, & Elorz, 2009; banović, 2012). Product familiarity appears to influence the effect of information on consumers' product choices and quality judgments. Familiarity is a prerequisite of product knowledge and may arise from personal experience with specific foods accumulated through purchasing and consuming (Chocarro *et al.,* 2009).

Consumer's expectation is often measured in terms of disparity degree between expected and perceived product quality (Andersson, 1973). The discrepancy generally observed between these two items is known as the "non-confirmation" (disconfirmation). Two types of results can be obtained. The first one, named assimilation effect, occurs when the evaluation of the product is congruent with the evaluation

of the extrinsic information. (Fornerino, *et al.,* 2006, Deliza, 1996) This assimilation effect occurs because the perceived quality is similar to the expected quality under the assumed positive effect of the extrinsic information. The second one, named contrast effect, occurs when the evaluation of the product in presence of information changed in the opposite direction from that of the extrinsic information, revealing a negative effect of this information.

The purpose of our study is to address these two questions: 1) how does familiarity with Maroilles affect consumers' attitude, expectation and preference? 2) Do consumers change their preference towards Maroilles when information (craft or industrial product) is provided?

2. MATERIALS AND METHODS

2.1. Participants

Three hundred and five (168 women and 137 men) regular cheese consumers aged from 18 to 70 years old were recruited for this study. One hundred and forthy four consumers (84 women and 60 men) were recruited in Lille a city of the north of France located in one of the two departments producing Maroilles cheese ; and 168 (84 women and 77 men) were recruited in Angers a city located in a department outside of the Maroilles cheese production region.

Participant recruitment was based on degree of cheese liking and frequency of cheese consumption. Only people who said they like cheese and consume more than once a month were involved in the study.

2.2. Samples

The Maroilles cheese was selected because 1) it is the most frequently consumed and the unique labelled cheese in the north of France, 2) it is available in a large variety of brands both from craft and industrial production and 3) it is made with raw or pasteurized milk. Six commercially available Maroilles cheeses were used as experimental samples: three craft Maroilles cheeses made with raw milk: Château Courbet (C cht cbt), Ferme de Cerfmont (C cerfmt), Ferme du Pont des Loups, (C pnt lps) and three industrial Maroilles cheeses made with pasteurized milk: Fauquet (P fqt), Lesire (P lesire), Leduc (P leduc). Samples were stored at 4 °C and served at room temperature during the tasting sessions. Maroilles cheese samples were purchased directly from producers (Nord and Aisne departments): for a given brand all samples were chosen from the same batch and across brands the difference in shelf-life was no more than six days.

2.3. Consumer test

Participants were involved into two tasting sessions performed in two different days one week apart. Each session lasted about 30 min. The sessions were held at the sensory laboratories of the Food Science Departments of ISA (Lille, North of France) and of ESA (Angers, West of France) designed according to ISO guidelines (ISO 8589, 2007). The test took place in individual booths under white light at room temperature between 20°C and 21°C. Data were collected using Fizz v2.31g software program (Biosystemes, Couternon, France).

During the first tasting (day 1), participants performed the blind and the expectation test. Firstly, they were asked to rate their liking degree of the six Maroilles cheese samples under blind conditions (*i.e.* without any information about the product). The only information provided to the participants was that they tasted Maroilles cheese samples. For each product, participants received a disk about 25 gr of cheese served in a plastic cup coded with a 3-digit number. Participants rated cheese samples liking degree using a 11-point scale anchored at the extremes with the terms ''extremely disliked'' (left of the scale) and ''extremely liked'' (right of the scale). After tasting each cheese, participants were instructed to rinse their mouth with mineral water.

After a short break of five minutes, participants were presented with images of the sample cheese packages on a computer screen. Their task was to rate their expected cheese liking score from the packaging without tasting

the sample (expectation test), using a 11-point scale anchored at the extremes with the terms ‘‘extremely disliked’’ (left of the scale) and ‘‘extremely liked’’ (right of the scale). The original packages of the Maroilles cheese were not modified. Each packaging mentions the brand and if the Maroilles is a craft or industrial. After a one-week interval, the same participants performed the informed test (day 2). Apart the fact that participants were provided with the product image and the Maroilles sample, the procedure was exactly the same as the one used in the blind test.

In order to balance the order and carryover effects, the presentation orders of the samples (Maroilles cheeses, images of the package, and Maroilles cheeses associated with image were chosen according William Latin squares. Assessors were also administered a questionnaire designed to evaluate their behavior and their general knowledge related to Maroilles cheese. The questionnaire was divided in three different parts: a) demographic questions, b) Maroilles cheese consumption habits, and c) knowledge about Maroilles cheese.

2.4. Data analysis

Data were analyzed with analysis of variance (ANOVA) considering the samples (six samples of Maroilles cheese) and the participants as factors and hedonic scores as the dependent variable, for each condition (blind, expected and informed) and each city (Angers, Lille). These analyses were followed by a Duncan test to compare the cheese samples. t-tests were used to compare Lille and Angers cities.

A disconfirmation of expectations is the difference between the expected evaluation and blind tasting evaluation. When this difference is significant, the disconfirmation of expectations could be associated with an assimilation or a contrast effect. The ratio (information - blind) / (expected - blind) was computed: A positive ratio indicates an assimilation effect and a negative ratio indicates a contrast effect.

Table 1. Maroilles cheese consumption and knowledge among different demographic groups participating in the consumer test. * p=0.05, ** p<0.01, *** p<0.001

	Angers		**Lille**		
Item	Number	%	Number	%	*P*-value Chi^2 or *t*-test
Sex					**0.280**
Men	**77**	47.83	**60**	41.67	
Women	**84**	52.17	**84**	58.33	
Age group					**0.116**
< 24 years	**15**	9.32	**5**	3.47	
(25 - 34) years	**31**	19.25	**31**	21.53	
(35 - 44) years	**26**	16.15	**29**	20.14	
(45 - 54) years	**43**	26.71	**35**	24.31	
(55 - 64) years	**28**	17.39	**35**	24.31	
> 65 years	**18**	11.18	**9**	6.25	
Maroilles consumption					**<0.0001*** **
yes	**15**	9.32	**109**	75.69	
no	**146**	90.68	**35**	24.31	
Maroilles knowledge (8 questions)	**3.006±1.267**		**4.132±1.160**		**<0.0001*** **

The difference between the assessment of packaging and the assessment with information indicates if the assimilation effect is partial or complete: A significant difference indicates that the assimilation effect is only partial, while no significant difference indicates a complete assimilation effect. All statistical analyses were performed using XLSTAT, Version 2015.4.01.21575.

3. RESULTS

3.1. Demographic and knowledge analysis

First, we seek to test the effects of gender, age consumption, and theoretical knowledge on the Maroilles in both cities.

Table 1 shows that there is no demographic differences between Angers and Lille consumers concerning the gender and the age. However, we can see that the difference is significant between both groups concerning their familiarity with Maroilles cheese and their theoretical knowledge: The participants of Lille consume more Maroilles cheese than those from Angers ($p < 0.0001$) and they have a higher score of Maroilles knowledge than those from Angers ($p < 0.0001$).

3.2. Hedonic rating analysis

Hedonic evaluation of Maroilles cheese in the three different experimental conditions (blind, expected and informed) has been performed to investigate the influence of familiarity and mode of production (craft or industrial) on consumers' preference. In the three conditions the liking score is higher for Lille consumers than for Angers consumers ($p > 0.05$).

Globally, the preference orders are quite similar between both cities and there is no clear difference of preference between craft and industrial Maroilles cheese. Nevertheless, in the blind condition (Figure 1a), the ANOVA results show that consumers from Angers are more discriminant in their preferences than consumers from Lille who significantly preferred one product among the others (C cht cbt). For each of the six cheeses, no significant difference (t-test) were found between both cities. In the expected condition (Figure 1b) and in the informed condition (Figure 1c) there is also no difference between craft and industrial Maroilles cheeses. However, there is a significant difference between Angers and Lille for four Maroilles cheeses in the expected condition (C cerfmt, C pnt lps, P fqt and P leduc) and for two Maroilles cheeses in the informed condition (P Fqt and P Leduc).

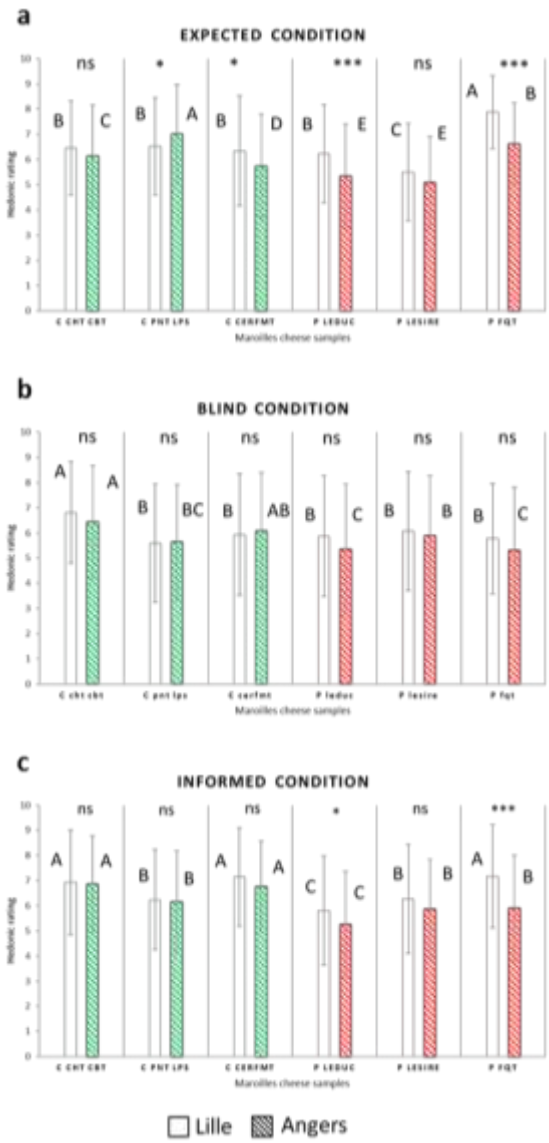

Figure 1. Consumer test results: hedonic mean ratings provided by consumers from Angers (hatched) and from Lille (empty) and standard deviation for craft (the three first) and industrial (the three last) Maroilles cheese samples under the three experimental conditions (a-Blind, b-Expected, c-Informed).

Table 2. Means scores for the three evaluation differentials (E = expected evaluation, B = blind evaluation, I = informed evaluation) for Angers consumers and Lille consumers Maroilles cheese.

Samples	City	E-B		I-B		E-I		(I-B)/(E-B)
		Mean	*p*	Mean	*p*	Mean	*p*	
C cht cbt	Angers	-0.317	0.149	0.422	0.063	-0.739	0.0002	-1.333
	Lille	-0.347	0.073	0.118	0.535	-0.465	0,016	-0.340
C cerfmt	Angers	-0.354	0.146	0.671	0.0010	-1.025	< 0.0001	-1.895
	Lille	0.403	0.122	1.201	< 0.0001	-0.799	0.0001	2.983
C pnt lps	Angers	1.373	0.0001	0.497	0.015	0.876	< 0.0001	0.362
	Lille	0.938	< 0.0001	0.646	0.002	0.292	0.115	0.689
P leduc	Angers	-0.012	0.956	-0.093	0.657	0.081	0.692	7.5
	Lille	0.361	0.132	-0.056	0.801	0.417	0.033	-0.154
P lesire	Angers	-0.807	0.0005	-0.031	0.888	-0.776	0.0003	0.038
	Lille	-0.583	0.007	0.201	0.326	-0.785	0.0002	-0.345
P fqt	Angers	1.317	< 0.0001	0.590	0.007	0.727	0.0002	0.448
	Lille	2.118	< 0.0001	1.396	< 0.0001	0.722	< 0.0001	0.659

3.3. Comparison of blind, expected and informed conditions

In order to study the disconfirmation, the assimilation and contrast effect, Table 2 presents the mean scores for the three evaluation differentials for each Maroilles cheese and each country: expected - blind, informed - blind, expected - informed.

A significant difference between expected and blind information shows a disconfirmation for two industrial Maroilles cheese (P lesire and P fqt) and one craft Maroilles cheese (C pnt lps). For Lesire Maroilles in both cities, the disconfirmation is expressed negatively, meaning that the taste is better than the expectations created by the packaging (the packaging devalues the product). For P fqt and C pnt lps Maroilles, the disconfirmation is expressed positively, meaning that the packaging has a positive influence.

It remains to interpret the disconfirmation of expectation observed in the three Maroilles cheese samples (P lesire, P fqt and C pnt lps) in term of assimilation [(F-B) / (A-B) <0] and contrast [(F-B) / (A-B) >0]. A significant effect of assimilation for the Maroilles cheese C pnt lps and P fqt was observed in both cities. For the Maroilles cheese P lesire a non-significant contrast effect was observed at Lille and a non-significant assimilation effect at Angers. For C pnt lps, P fqt and P lesire in the city of Angers, the assimilation is partial (E-I is significant). In the city of Lille, the assimilation is partial for the Maroilles cheese P fqt and complete for the Maroilles cheese C pnt lps.

Finally, to confirm the influence of the packaging, we ploted the regression lines corresponding to the models (informed - blind) = $\alpha + \beta$ (expected – blind) + ε, for the six Maroilles cheese in the both cities (figure 2).

The interpretation of the slopes of the regression lines provides information on the dominant effect (packaging or tasting): if the slope is less than 0.5 the sensory effect is more important than the packaging one, and *vice versa*. In Angers, the slopes for the six Maroilles Cheeses were less than 0.5, meaning that Angers consumers used extrinsic cues mentioned on the packaging for their preference choice. At Lille, for two craft products (C cht cbt a=0.49, C cerfmt a= 0.49), the consumers slightly favor the sensory information for their preference choice.

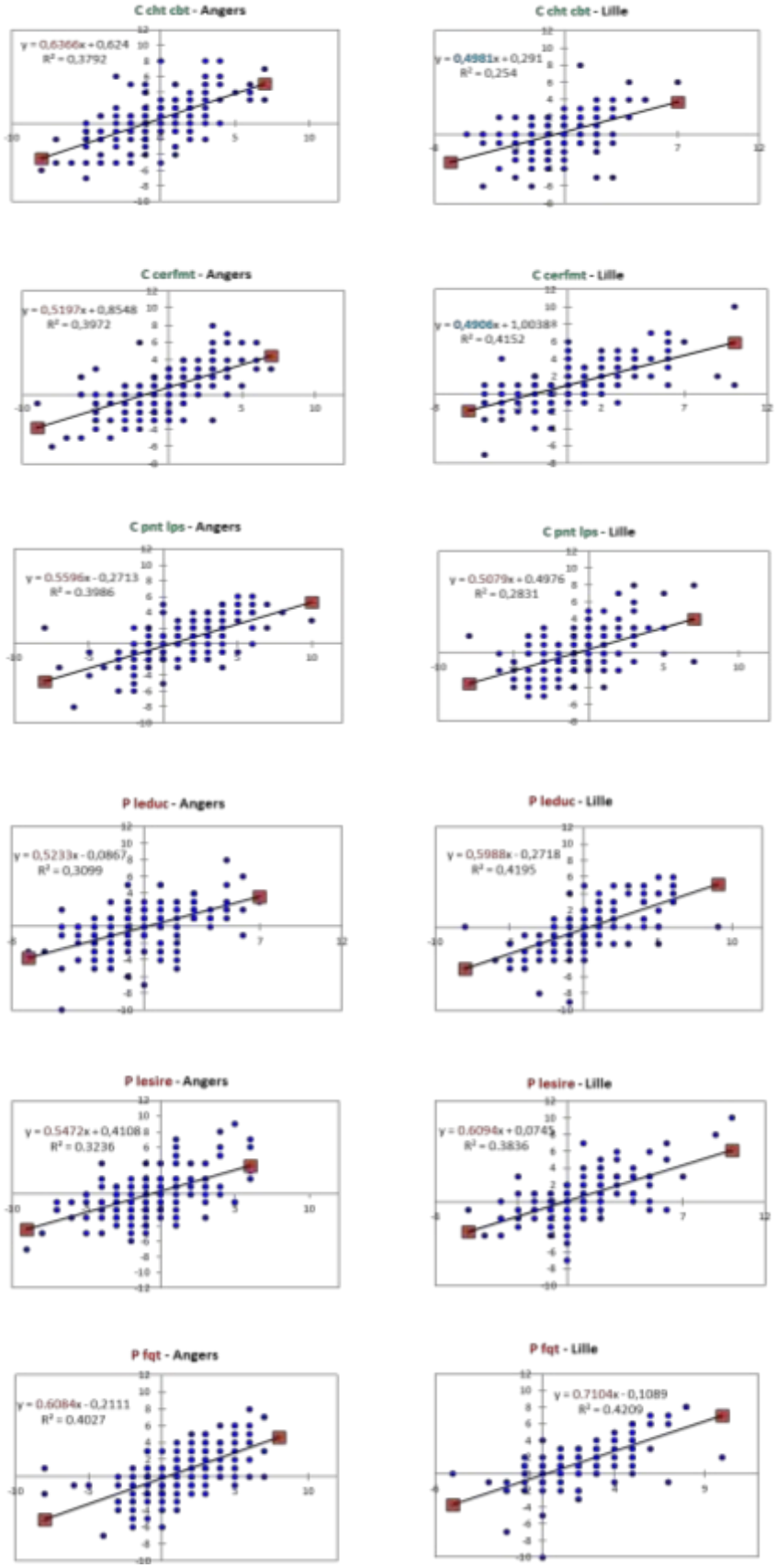

Figure 2. Linear model (informed - blind) = $\alpha + \beta$ (expected – blind) + ε, for the six Maroilles cheese.

4. DISCUSSION

Our research contributes to better understand the influence of familiarity and preference for consumption of Maroilles cheese. We found a significant difference in the hedonic evaluation of cheeses between both cities, in the three conditions: The liking score is globally higher for Lille consumers than for Angers consumers, which is in agreement with the literature. For example, Stein *et al.* (2003) found a positive correlation between familiarity and the level of liking in a study on the acceptance of bitter beverages.

In both cities, a confirmation of expectations effect for three cheeses (C courbet, C cerfmt, P Leduc), a positive disconfirmation of expectation effects for two others (P fqt, C loups), and negative disconfirmation of expectations for P lesire were observed.

In a previous study Schifferstein *et al.* (1999) found a weak assimilation in the case of positive disconfirmation. Inversely Siret & Issanchou (2000) reported a positive disconfirmation which involved greater assimilation from individuals. Our results are at odd with these results because, out of three cheeses only one (C loups) and only at Lille, a complete assimilation was found. It is possible that our results depend on other experimental conditions (using, brands, labels, etc.) (D'hauteville *et al.*, 2006).

Finally, we observed that tasting is less important than packaging information to decide the quality of the product, especially with consumer with lower level of familiarity (Angers). This fact is in accordance with the work of Villegas *et al* (2008) who studied how hedonic ratings and purchase intention were affected by information type (picture of real package or card with beverage type and nutritional facts). However, the mode of production (craft or industrial), even if it was mentioned on the packaging, did not influence consumers' preference choice. It is possible that this information interfered with other information on the packaging such as design, brand, or claims.

5. CONCLUSION

Often, studies on the influence of familiarity on preference compare people from distant countries (Prescott, 1997, 1998, Jaeger, 2000). These studies lead to clear cut differences in term of familiarity due to large differences in historical past, food accessibility; religious or cultural habits for example (Vabo and al., 2014). Our study shows that even within a country, consumer preferences are impacted by familiarity. This suggests that in our case the familiarity is essentially built on consumption frequency and theoretical knowledge. Our results need to be validated by similar studies with other products typical from an area to better understandi the concept of familiarity.

REFERENCES

Anderson, R.E. (1973). Consumer dissatisfaction: the effect of disconfirmed expectancy on perceived product performance, *Journal of Marketing Research*, 10, pp 38-44.

Banović, M., Aguiar Fontes, M., Barreira, M. M., & Grunert, K. G. (2012). Impact of product familiarity on beef quality perception. Agribusiness, 28, 157–172.

Chocarro, R., Cortiňas, M., & Elorz, M. (2009). The impact of product category knowledge on consumer use of extrinsic cues in a study involving agrifood products. *Food Quality and Preference*, 20, 176–186.

CNIEL (2016). L'économie laitière en chiffres. Caroline P. (dir.), 181 p.

Deliza, R., & MacFie, H. J. H. (1996). The generation of sensory expectations by external cues and its effect on sensory perception and hedonic ratings: A review. *Journal of Sensory Studies*, 11, 103–128.

D'Hauteville F., Perrouty J.P., (2005). Intrinsic and extrinsic quality cues: the mediating effect of expertise on consumer judgments

about the quality of wine, 2nd International Wine Colloquium, Sonoma, July 2005

Fornerino M., D'Hauteville F. et Perrouty J.P. (2006). La non confirmation des attentes comme mesure de la force d'une marque. Une approche expérimentale sur le jus d'orange, Actes de l'Association Française de Marketing, 22, Nantes, 19 pages. (2006)

ISO International Organization for Standardization (2007). Sensory analysis — General guidance for the design of test rooms. ISO 8589:2007, Geneva, Switzerland.

Jaeger, S. R. (2000). Uncovering cultural differences in choice behaviour between Samoan and New Zealand consumers: A case study with apples. *Food Quality and Preference*, 11, 405–417.

Prescott, J., Bell, G. A., Gillmore, R., Yoshida M.,O'sullivan, M., Korac, S., Allena, S. and Yamazaki, K. (1997). Cross-cultural comparison of Japanese and Australians responses to manipulations of sweetness in foods. *Journal of Food Quality and Preference*, 8, 45-55.

Prescott, J., Bell G. A., Gillmore, R., Yoshida M.,O'sullivan, M., Korac, S., Allena, S. and Yamazaki, K. (1998). Cross-cultural comparison of Japanese and Australians responses to manipulations of sourness, saltiness and bitterness in foods. *Journal of Food Quality and Preference*, 9, 53-66.

Rao, A.R., & Monroe, K.B. (1988). The moderating effect of prior knowledge on cue utilization in product evaluations. *Journal of Consumer Research*, 15, 253–264.

Schifferstein H.N., Kole A.P.V., and Mojet J. (1999), Asymetry in the disconfirmation of expectations for natural yogurt, *Appetite*, 32, 307-329

Siret, F., Issanchou, S. (2000). Traditional process: influence on sensory properties and on consumers' expectation and liking. Application to ''pâté de campagne''. *Food Quality and Preference*, 11, 217–228.

Stein LJ, Nagai H, Nakagawa M, Beauchamp GK. (2003). Effects of repeated exposure and health-related information on hedonic evaluation and acceptance of a bitter beverage. *Appetite*; 40, 119–29.

Vabø M, Hansen H. The Relationship between (2014), Food Preferences and Food Choice: A Theoretical Discussion. *International Journal of Business and Social Science*; 5, 145-157.

Villegas B., Caronell I., Costell E. (2009). Acceptability of milk and soymilk Vanilla beverages: Demographics consumption frequency and sensory aspects *Food Science and Technology International*, 15, 203–210.

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