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Taste perception and purchase intent of oil-in-water spreads: effects of oil types and salt (NaCl or KCl) concentrations

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Abstract

Associations of sodium-intake with heart-related problems are creating awareness toward reducing sodium. Potassium chloride (KCl), a substitute for sodium chloride (NaCl), has the disadvantage of imparting bitterness at high concentrations. We evaluated physical characteristics, taste perception, and purchase intent of KCl and NaCl in oil-in-water spreads/emulsions composed by olive, rice bran, and soybean oils. Consumers (N=300) evaluated saltiness/bitterness of emulsions prepared with 65% oil, and NaCl (0.5 and 1.0%) or KCl (0.75 and 1.5%). Olive oil spreads (104.07–107.43 Pa*s) had higher viscosity compared to other spreads (59.16–74.96 Pa*s). Type of oil had significant effects on bitterness, overall taste liking, and viscosity. Taste liking decreased due to bitterness of olive oil spreads (mean-drop=1.72–2.43). Purchase intent was positively associated with saltiness and pH, and increased with oil claims (increase=1.3–22.1%) compared to sodium claims (increase=0.0–12.9%). These findings are useful for understanding taste perception of emulsions.

Keywords: sodium reduction, oil-in-water emulsion, sensory liking, health claims, KCl

Introduction

In recent years, health problems attributed to elevated concentrations of sodium chloride (NaCl) in foods have raised demand for low-sodium products. Around one third of the US adult population has high blood pressure, only half of them have their condition under control (CDC, 2012). Hypertension, a key factor for heart-disease and death, has an economic impact of approximately \$47.5 billion in the US, annually (CDC, 2012; Kochanek *et al.*, 2011). Sodium ingestion for healthy adults must not exceed 2,300 mg per day (USDA, 2010); however, it is estimated that American adults consume roughly 3,400 mg of sodium per day (Palar & Sturm, 2009). The association of elevated sodium intake with hypertension and heart-related problems is creating awareness in society toward reducing sodium in foods (Havas *et al.*, 2007; Dötsch *et al.*, 2009). To accomplish this goal, different approaches have been developed including stealth

sodium reductions, saltiness potentiation, multisensory applications, and physical modifications of salt crystals (Rodrigues *et al.*, 2016; Kuo & Lee, 2014; Henry & Taylor, 2010).

Sodium reduction strategies include modifications in composition and structure of foods and beverages (Cruz *et al.*, 2011). For instance, salt boosters such as monosodium glutamate (MSG) can create chemical stimulations to increase saltiness perception (Henry & Taylor, 2010). Other approaches to sodium reduction include modifications in size and morphology of salt-crystal, the use of inert fillers and inhomogeneous salt distributions, and modifications in viscosity and hardness of food systems. Product modifications may optimize stimulation of taste receptors in order to increase perceived saltiness (Busch *et al.*, 2013). Nevertheless, food industry faces a problematic task because most of consumers are unwilling to accept any change regarding the sensory characteristics of their foods. Additionally, salt (NaCl) is the most used functional ingredient in the industry (Heshmati, 2014). Potassium chloride (KCl) is the best-known substitute for sodium chloride, but it has the disadvantage of imparting bitter taste at high concentrations (Henry & Taylor, 2010). Guàrdia *et al.* (2008) demonstrated that fermented sausages with 50% KCl substitutions had similar sensory descriptive scores compared to that of control treatments (100% NaCl). Gomes *et al.* (2011) and Felicio *et al.* (2016) stated that partial substitutions (up to 25%) of NaCl by KCl in Minas fresh chesses were acceptable to consumers. The acceptance level of KCl substitutions depends, largely, on the composition of the food (Horita *et al.*, 2016; Hooge & Chambers, 2010).

The perception and solubility of aromatic compounds are higher in oil than in water systems (Valentová & Pokorný, 1998). Oil affects perception by increasing viscosity in beverages, and extending time of retention of tastants in the mouth (Bakker & Mela, 1996). Koriyama *et al.* (2002) found that oil in emulsion systems did not affect sweetness or saltiness but decreased sourness and bitterness. In food-emulsion models, Shamil *et al.* (1991) demonstrated that fat increased saltiness in salad creams but decreased bitterness in Cheddar cheeses. In theory, if oil has an effect on saltiness and bitterness, sodium reductions could occur through substitutions with KCl in emulsions, without significantly affecting product acceptability in consumers. Changes imparted by oil on taste or flavour compounds, and physical intervention in taste receptors can produce overall changes in taste perception (Lynch *et al.*, 1993). Our previous studies concluded that oil in emulsion systems exhibited a bitterness-suppressing effect at recognition threshold levels (< 0.12 g/100 ml of KCl; Torrico *et al.*, 2015), and a saltiness–

enhancing effect at consumer consumption levels (0.5% to 1.5% of KCl; Torrico & Prinyawiwatkul, 2015). However, food matrices are more complex systems in which binary and tertiary interactions can occur among basic tastes and flavours. Moreover, different oil systems can have different effects on taste perception (Koriyama *et al.*, 2002).

Sodium reduction is a subject of growing concern in the minds of consumers, governments, and food industry (WHO, 2010). Development of new technologies and further studies are needed in order to fully comprehend interactions of human taste perception and physical properties of foods and beverages. The objective of this study was to evaluate saltiness and bitterness perception of KCl and NaCl in oil-in-water spread/emulsion systems composed by olive, rice bran, and soybean edible oils. The relationship between physical properties and consumers' perception was determined, as well as purchase intention of KCl and NaCl spreads/emulsions, including health claims related to oil and sodium content.

Materials and Methods

Preparation of the oil-in-water spread samples

Ozarka[®] spring water (Nestle Waters North America, Greenwich, CT, USA) with commercial vegetable extra virgin olive oil (Great Value[®], Walmart, AR, USA), rice bran oil (Riceland[®], Stuttgart, AR, USA), or soybean oil (Great Value[®], Walmart, AR, USA) were used as base formulations for all oil-in-water spread samples. Saladizer[®] 243 M powder from TIC Gums[®] (White Marsh, MD, USA) was used as a stabilizer, whey protein isolate (Grande Ultra[®], Grande Custom Ingredients Group, Lomira, WI, USA) provided gelation, vinegar (Great Value[®], Walmart, AR, USA) was used as an acidifier, sodium chloride (NaCl) (Great Value[®], Walmart, AR, USA) and potassium chloride (KCl, 99%) (Letco Medical, Decatur, AL, USA) were used as main taste compounds for all oil-in-water spread formulations.

For preparing oil-in-water spreads, ingredients were first weighed using an analytical balance (Mettler-Toledo, MS105, LCC, Columbus, OH, USA) according to formulations (Table 1). Then, water, vinegar and the rest of fixed ingredients (except oil) were mixed using a food processor (Black & Decker, FP1450, Beachwood, OH, USA) for 15 sec. in order to obtain a homogenous spread. Subsequently, oil (olive, rice bran, or soybean) was gradually added for 30 sec. in the work bowl of the food processor. Oils, NaCl and KCl varied according to the sample formulation (Table 1). After forming the emulsion, each spread sample was poured into 500 mL

plastic containers and kept at 4 °C prior to testing. Concentrations of NaCl and KCl were pre-determined according to their relative saltiness intensity values establish in Torrico & Prinyawiwatkul (2015). Preliminary tests showed that 65% oil emulsions had a homogenous, thinner and stable consistency compared to other oil concentrations. Based on these initial observations, the percentage of oil in each treatment remained fixed at 65% (Table 1). Currently, our research group is assessing the effects of different oil concentrations on taste perception of oil-in-water spreads.

Physical characteristics of the oil-in-water spreads

Viscosity was measured in Pa*s units with a viscometer (model DV-E, Brookfield Engineering Labs Inc., Middleboro, MA, USA) at 1 rpm with a S64 spindle. The pH of each spread sample was measured using a pH meter (Milwaukee Mi 180 Bench Meter, Rocky Mount, NC, USA). Water activity (a_w) of each spread sample was measured using a water activity meter (HygroLab 3, Rotronic AG, Bassersdorf, Switzerland). The colour of each emulsion was measured with a portable Minolta Baking Meter BC-10 (Konica Minolta, Tokyo, Japan), and results were presented in L^* , a^* , and b^* units. Whiteness index (WI) was obtained as described by Boun & Huxsoll (2003):

$$WI = 100 - [(100 - L^*)^2 + a^{*2} + b^{*2}]^{1/2}$$

Where L^* = lightness, a^* = + for redness and – for greenness, and b^* = + for yellowness and – for blueness. The average of three measurements for each spread treatment was evaluated for all physical characteristics.

Sensory evaluation and purchase intent of the oil-in-water spreads

The research protocol for this study was approved (IRB# HE 15 to 9) by the Louisiana State University Agricultural Center, Institutional Review Board. The consumer study was held at the Sensory Analysis Laboratory in the Animal and Food Sciences Laboratory building, Louisiana State University, Baton Rouge, Louisiana, USA. Sensory sessions were performed in partitioned booths illuminated with modern LED lights (configured with colour RGB = 0, 255, 0) inside a conditioned room with a set temperature of 21 °C. Panellists from a pool of faculty, staff, and students from Louisiana State University were recruited and pre-screened using the following criteria: 1) regular consumers of spread or mayonnaise products based on self-reported

responses, and 2) not having taste/smell disorders and/or kidney/liver problems. Three hundred (N=300) untrained panellists participated in the consumer test. Each participant completed a digital questionnaire using the Compusense[®] *five* (Compusense Inc., Guelph, Canada) computerized data collection system. Participants were required to sign a consent form approved by the Louisiana State University Agricultural Center, Institutional Review Board before taking the test. Each sample was labelled with a random 3-digit code and placed in lidded transparent containers that were accompanied with unsalted crackers and room-temperature water for palate cleansing between samples tasting. The consumers were simultaneously presented with only 3 samples out of the 12 possible treatments (Table 1) using a Balance Incomplete Block (BIB) design [$t = 12$, $k = 3$, $r = 25$, $b = 100$; generated by Compusense[®] *five*]. For the sensory test, a total of 75 observations (repetitions) were collected for each spread formulation. At the beginning of the digital questionnaire, consumers were asked about demographics (gender, age, and ethnicity), mayonnaise consumption (Yes or No), and awareness of sodium reduction (Yes or No). For the sensory evaluation, consumers were asked to rate saltiness and bitterness intensity of the spread samples using a 100-point labelled magnitude scale (LMS; Green & others, 1993). Saltiness and bitterness were also assessed using a 5-point just about right scale (JAR; 1 = much too weak, 3 = just about right, 5 = much too strong). Consumer rated overall taste liking using a 9-point hedonic scale (1 = dislike extremely, 5 = neither dislike nor like, 9 = like extremely) (Peryam & Pilgrim, 1957). Purchase intent [Question: Would you purchase this new spread if it was available at a reasonable price where you normally shop?] of each spread sample was determined using a 3-point scale (1 = Yes, 2 = Maybe, and 3 = No). Purchase intent was assessed before (original) and after consumers had been informed about benefits/claims associated with 1) low or no sodium consumption [Claim: A high sodium diet increases your risk of heart disease, kidney disease, and stroke], and 2) use of healthy oils [Question: This product is made with (extra virgin olive oil, rice bran oil, or soybean oil). Would you purchase this new spread if it was available at a reasonable price where you normally shop?].

Statistical analysis

A factorial treatment arrangement of 12 formulations (3 types of oil x 2 types of salt x 2 concentrations of salt) were evaluated in a BIB design for the physical and sensory properties of spread samples. Types of oil, salts, and concentrations of salts were considered the independent

variables. Physical parameters of spreads, consumer perception of saltiness and bitterness, and purchase intent were the dependent variables measured and compared among treatments. The collected data were analysed using the Statistical Analysis Software SAS ® (SAS, 2003). Analysis of variance (ANOVA) with a generalized linear mixed model procedure (GLIMMIX) and a Least Square Means was used to determine interactions and significant differences in the model. GLIMMIX procedure allowed the evaluation of fixed and random effects. An alpha value of 0.05 was set to test whether there was any significant difference among treatments. For physical and sensory characteristics of the spreads (type of oil x type of salt x concentration of salt), data were represented as means and standard deviation values (N=3 for physical, and N=75 for sensory characteristics). For JAR data, a penalty test (mean drop) was performed to measure the effects of sensory attributes (saltiness and/or bitterness) on overall taste liking. Mean drops were calculated as differences between overall taste liking scores rated at “not-JAR” (either too weak or too strong) minus liking scores at JAR. Market researchers and product developers use this analysis to identify directions for improvements in properties of the product that affect liking (Gaze *et al.*, 2015). A scatter plot graph was done to represent the mean drops as a function of the percentage of panellists that evaluated the attributes (saltiness and/or bitterness). Penalty test was assessed using XLSTAT Statistical Software version 2014.5.03 (XLSTAT, 2015). For purchase intent, affirmative and neutral responses (yes and maybe) were collapsed and compared against negative responses (no). The McNemar test was used to determine statistical differences in purchase intent before and after health claims were provided to consumers. Multivariate Analysis of Variance (MANOVA) was used to determine whether significant differences existed among spread samples when inter-correlations among all physical and sensory attributes were tested simultaneously. For the MANOVA, the principal component analysis (PCA) was performed to demonstrate correlations among the physical/textural/sensory qualities and spread samples as illustrated in the product-attribute bi-plot. PCA was conducted with a matrix of 12 spread samples (3 type of oil x 2 type of salt x 2 concentration of salt) x 8 attributes (4 physical and 4 sensorial). PCA reduces the dimensionality of the data set, and provides exploratory findings for detecting patterns and trends of the original variables (Matera *et al.*, 2014). Individuals and variables factor maps were obtained using the statistical software R (R, 2007) with the FactoMineR package (Lê *et al.*, 2008).

Results and Discussion

Physical characteristics of oil-in-water spreads

Viscosity among spreads differed significantly depending of type of oil ($P<0.05$). Olive oil spreads (104.07 – 107.43 Pa*s) had higher viscosity values compared to that of soybean oil and rice bran oil spreads (59.16 – 74.96 Pa*s). Type and concentration of salt had marginal effects on viscosity (Table 2). Krishna (1993) reported that olive oil, soybean oil, and rice bran oil had viscosity values of 107.5 m Pa s at 20 °C, 60 m Pa s at 20 °C, and 36.6 m Pa s at 30 °C, respectively. Thus, natural oil composition may partially explain the differences in viscosity of spread samples in this study. As regards the type of salt, viscosity for KCl emulsions were similar compared to that of NaCl emulsions (Table 2). These findings support previous studies on dynamic viscosity of KCl and NaCl solutions (Kestin *et al.*, 1981). Rheology of substances inside a food matrix may influence sensory perception (Rao, 2010). Therefore, viscosity may play an important role in the overall liking of products (Vingerhoedsa *et al.*, 2008).

There were few differences among all spread formulations in pH (4.34–4.47). These pH values are similar to the standard pH of a commercial mayonnaise (pH = 4.0; Smittle, 2000). Difference in pH values between spreads in this study and the standard pH of mayonnaise may be partially explained due to differences in salt concentration (0.5–1.5% in this study compared to 9–11% of the standard) and oil concentration (a fixed 65% in this study compared to 65–80% of the standard) (FDA, 2014). The degree of ionization and pH are important factors in emulsion stability (Kulmyrzaev & Schubert, 2004). Although, stability of the emulsions was not measured in the present study, variations in pH may possibly have an effect on shelf-life of spreads. Further evaluations have to be done to test this hypothesis.

Water activity (a_w) did not considerably change among spread treatments. Results from water activity showed values between 0.919 and 0.937, which are in line with FDA recommendations of ~ 0.925 for oil-in-water emulsions (such as mayonnaise and salad dressings). The determination of colour showed that whiteness index (WI) of spread treatments varied according to type of oil ($P<0.05$). This was expected since different oils have different natural pigments (chlorophyll, β -caroteno; Moyano *et al.*, 2010). The values for whiteness index were 68.13–68.58 for olive oil, 90.46–90.87 for soybean oil, and 85.03–85.88 for rice bran oil spreads (Table 2). All spreads had a yellowish tone and a light blue tone. Furthermore, olive oil spreads had the

largest deviation from an ideal whiteness ($WI = 100$). For this reason, green lights were used in the sensory booths to mask colour of spreads, and avoid sensory biases.

Demographic information about the participants in this study

A total of 300 untrained panellists participated in the consumer test. Gender distribution was somewhat even with 51.6% of participant being female and 48.4% male (Figure 1). The majority of participants were between 18 to 24 years old (83.8%), and 13.3% were between 25 to 34 years old (data not shown). White/Caucasian was the largest ethnic group (56.8%) of participants. Black/African American was the second largest group (15.9%), and Hispanic/Latinos (12.7%) (data not shown). From all participants, 79.2% confirmed that were mayonnaise (or other similar dressings) consumers, and 88.6% were aware about the importance of reducing sodium in foods (Figure 1).

Consumer test analysis of oil-in-water spreads

Saltiness perception was affected by salt concentration of each formulation ($P < 0.05$). However, the effect of salt concentration was larger in KCl emulsions (from 23.5–26.7 at 0.75% to 33.6–36.0 at 1.0%) compared to that of NaCl emulsions (from 26.1–30.3 at 0.5% to 31.7–35.6 at 1.0%). Type of oil had a marginal effect on saltiness of spreads ($P \geq 0.05$; Table 3). Salt concentration has a direct relationship with saltiness intensity (Henry & Taylor, 2010). Formulations with higher saltiness intensities were the ones with higher concentrations of salt (Table 3). Salty taste is produced by presence of Na^+ and K^+ cations which are bonded with negatively charged Cl^- anions found in emulsions (Frings & Bradley, 2006).

Type of salt (NaCl or KCl), and salt concentration (0.75 and 1.5% for KCl, and 0.5 and 1.0% for NaCl) had marginal effects ($P \geq 0.05$) on bitterness of all oil-in-water spreads (olive, soybean or rice bran oil). NaCl spreads had similar bitterness intensity values (23.2–47.4) compared to that of KCl (24.8–43.8). Besides, higher salt concentrations produced moderately higher bitterness (from 24.7–39.6 to 23.2–47.4 for NaCl, and from 24.8–43.3 to 27.9–43.8 for KCl). Malone *et al.* (2003) stated that oil can have a suppressing effect on taste in emulsion systems. Type of oil and viscosity may affect the sensorial perception of emulsions (Vingerhoedsa *et al.*, 2008). Oil in emulsion systems can exhibit a bitterness-suppressing effect at recognition

threshold levels (Torricono *et al.*, 2015), and a saltiness–enhancing effect at consumer consumption levels (Torricono & Prinyawiwatkul, 2015).

The mechanism behind taste suppression in salts does not have a clear explanation yet. Studies have demonstrated that sodium cations impart saltiness and potassium cations impart saltiness and bitterness (Bartoshuk *et al.*, 1988). Proposed bitterness–suppression mechanisms include the formation of an ionic shield around specific G–protein coupled receptors, modulation of ion channels involved in taste transduction sequences, limiting access of lipophilic bitter compounds to receptors in the membrane, or the sodium interference with specific proteins or enzymes systems responsible for bitterness perception from inside the cell (Keast *et al.*, 2001). The influence of other cations such as K⁺ in bitterness transduction is still under investigation; nevertheless, it has been reported that oil in emulsion systems can suppress sweet and bitter tastes (Metcalf & Vickers, 2002).

According to sensory results (Table 3), type of oil was a significant factor affecting bitterness intensity of all spreads ($P \geq 0.05$). In general, olive oil spreads had higher bitterness intensities (39.6–47.4) compared to that of soybean oil and rice bran oil spreads (23.2–29.2). Different vegetable oils, by nature, have compounds that provide different thresholds for bitterness in consumers. For instance, olive oil has phenolic compounds that produce bitter taste. However, bitterness can be a positive property for this type of oil since consumers expect a level of bitterness from olive oil (Inarejos–Garcia *et al.*, 2009). The highest intensity of bitterness, as expected, was found on all olive oil formulations (Table 3).

Overall taste liking of all spread treatments was affected by type of salt, type of oil, and the interaction between these two main effects ($P < 0.05$). In general, NaCl spreads had higher liking scores (2.7–4.9) compared to that of KCl spreads (2.9–4.5). Differences in liking could be due to consumers being more used to consume NaCl as a tastant, and they may have little or no experience in tasting KCl. Even though untrained–consumers were unable to differentiate bitterness in emulsion samples, panellists were capable of perceiving different levels of metallic and chemical taste in KCl emulsions (Sinopoli & Lawless, 2012). Salt concentration did not have a significant effect on overall taste ($P \geq 0.05$) because liking or preference of consumers is not solely defined by levels of saltiness or bitterness, but it considers all flavour, aroma, and taste elements that a food/beverage can provide (Bachmanov & Beauchamp, 2007).

Overall taste liking of all spread treatments were low because the scope of this study was not intended to maximize acceptability of spreads, but to evaluate variations in liking depending on changes in oil and type of tastant used in the spread formulations. The different emulsions were only used as a model for evaluating taste behaviour. Nevertheless, the product could possibly improve its acceptance if it is served along with carriers like a piece of bread, crackers, or vegetables.

Penalty analysis of the oil-in-water spreads

The map of mean drops in liking based on the penalty analysis is shown in Figure 2. Overall, the majority of consumers rated samples as “too much” in bitterness and saltiness. Between 65 and 75% of consumers strongly penalized spreads made with olive oil product, considering it “too much” bitter (Figure 2). The “too much” bitter taste produced a drop of 1.72–2.43 points in the liking of olive oil samples. Generally, soybean oil and rice bran oil spreads were less penalized in bitterness than olive oil spreads. Torrico & Prinyawiwatkul (2015) concluded that oil had a bitterness suppression effect in oil-in-water emulsion made with KCl and 40% canola oil. Nevertheless, acceptance may also be related to other properties of food including appearance, aroma, texture, and trigeminal sensations (Lawless & Heymann, 2010).

Purchase intent analysis of the oil-in-water spreads

Positive (yes) and neutral (maybe) purchase intent were combined and compared against negative (no) responses. The type of salt and oil used in the spread formulations had an effect on the purchase intent of consumers (Table 4). Originally (before claiming health statements), all olive oil spreads had lower positive+neutral purchase intents (15.58–22.67%) compared to that of soybean oil and rice bran oil spreads (38.96–63.64%). Possibly, the most direct reason for this effect in purchase intent was the increased bitterness imparted by these samples (Table 3). Even though, it can be difficult, from a taste perspective, to formulate food systems (such as spreads and mayonnaise) using olive oil, it has been reported that consumers have a misleading perception of olive oil taste. As a result, these products tend to have higher penalizations in liking (Wang *et al.*, 2013). In the present study, bitterness of olive oil and KCl affected overall taste of the spread samples; thus, this effect directly decreased their purchase intent (Lawless & Heymann, 2010).

The purchase intent of spreads prepared with olive oil improved significantly after sodium and oil claims were provided (from 15.58–22.67 to 19.48–38.67 after sodium claim, and to 33.77–41.33 after oil claim; Table 4). In a similar manner, soybean oil and rice bran oil spreads had higher purchase intent values when health claims were acknowledged (from 38.96–63.64% to 51.95–70.13 % after sodium claims, and to 54.55–75.32% after oil claims). Nevertheless, purchase intent of olive oil spreads always remained low compared to that of other spreads (soybean oil and rice bran oil). As regard comparing claims, there were more significant increases in purchase intent (McNemar test; $P < 0.05$) when consumers were provided with oil claims compared to that of sodium claims (Table 4). Besides, all spreads with 1.5% KCl had significant increases in purchase intent when consumers were informed about the health claim related to sodium. Purchase intent results in the present study shown that consumers perceived olive oil spreads as healthy products. The intrinsic property of associating food products with health may be a determining factor for increasing purchase intent (Tarancón *et al.*, 2014). For understanding purchase intent and liking, further analysis of consumers choice needs to be performed using descriptive analysis and emerging sensory technologies (Check-all-that-apply, pivot profile, projective mapping, sorting, and flash profile) (Fonseca *et al.*, 2016).

Multivariate analysis

The individual factor map shows the relative position of each spread sample considering all sensory and physical attributes altogether (Figure 3). The variable factor map shows the interactions between attributes explained by the first two principal components (73.21% of total variability). By observing the clustering of samples in the individual factor map, olive oil samples were separated from the other spreads considering all characteristics. Separation between groups occurred along principal component 1 (horizontal axis), which was mainly composed by attributes such as viscosity, bitterness, water activity, whiteness index and overall taste liking. The separation of olive oil spreads from other samples is explained by differences in physical and sensory properties (Tables 2 and 3). Olive oil samples were the most bitter, viscous, darkest, and least accepted products of all spread formulations.

In terms of sensory and physical attributes, overall taste liking was negatively associated with bitterness and viscosity. Purchase intent was positively associated with saltiness and pH. Collectively, based on Tables 2, 3 and 4, and Figures 2 and 3, the results indicated that type of

oil affected bitterness, overall taste liking, viscosity, water activity, and whiteness index of spread samples. Moreover, purchase intent of spreads was positively affected by the type of product health-claims (oil or sodium). In general, oil claims produced a larger effect on consumers' decision for purchasing the spreads compared to that of sodium claims. Replacing NaCl with KCl is a big challenge for the food industry as it affects not only sensory acceptability but also physico-chemical characteristics and shelf-life of products (Dos Santos *et al.*, 2015). Besides, product developers need to adjust formulations according to current trends of making healthier products. This study provides relevant information to the food manufacturing industry regarding interactions between the type of oil and the type of salt that potentially affect physical and sensory characteristics of spread formulations. Further studies are required to test these interactions in different food products.

Conclusion

This study demonstrated that type of oil had significant effects on bitterness, overall taste liking, viscosity, water activity, and whiteness index of spread samples. Type of salt had a marginal effect on all physical and sensory characteristics. In general, olive oil spreads had the highest viscosity and the lowest whiteness index among all spreads. Moreover, olive oil spreads had the highest bitterness and lowest overall taste liking. In that regard, soybean oil and rice bran oil spreads were less penalized in bitterness compared to that of olive oil. Overall taste liking was negatively associated with bitterness and viscosity. Purchase intent was positively associated with saltiness and pH. Comparing health/product claims (sodium vs. oil), there were more significant increases in purchase intent when consumers were provided with oil claims compared to that of sodium claims. These findings are useful for understanding consumers taste perception of oil-in-water emulsion products.

References

- Bachmanov, A. A., & Beauchamp, G. K. (2007). Taste receptor genes. *Annual Review of Nutrition*, (27), 389–414.
- Bakker, J., & Mela, D. J. (2009). *Flavor-food interactions* (Vol. 633). American Chemical Society.

- Bartoshuk, L. M., Rifkin, B., Marks, L. E., & Hooper, J. E. (1988). Bitterness of KCl and benzoate: related to genetic status for sensitivity to PTC/PROP. *Chemical Senses*, 13(4), 517–528.
- Boun, H. R., & Huxsoll, C. C. (1991). Control of minimally processed carrot (*Daucus carota*) surface discoloration caused by abrasion peeling. *Journal of Food Science*, 56(2), 416–418.
- Busch, J., Yong, F., & Goh, S. (2013). Sodium reduction: Optimizing product composition and structure towards increasing saltiness perception. *Trends in Food Science & Technology*, 29(1), 21–34.
- CDC. (2012). *Vital Signs: Awareness and Treatment of Uncontrolled Hypertension Among Adults* — United States, 2003–2010. Centers for Disease Control and Prevention.
- Cruz, A. G., Faria, J. A., Pollonio, M. A., Bolini, H. M., Celeghini, R. M., Granato, D., & Shah, N. P. (2011). Cheeses with reduced sodium content: Effects on functionality, public health benefits and sensory properties. *Trends in Food Science & Technology*, 22(6), 276–291.
- Dos Santos, B. A., Campagnol, P. C., Cruz, A. G., Morgano, M. A., Wagner, R., & Pollonio, M. A. (2015). Is There a Potential Consumer Market for Low-Sodium Fermented Sausages?. *Journal of Food Science*, 80(5), S1093–S1099.
- Dötsch, M., Busch, J., Batenburg, M., Liem, G., Tareilus, E., Mueller, R., & Meijer, G. (2009). Strategies to reduce sodium consumption: a food industry perspective. *Critical Reviews in Food Science and Nutrition*, 49(10), 841–851.
- FDA. (2014). *Evaluation and definition of potentially hazardous foods – Chapter 4. analysis of microbial hazards related to time/temperature control of foods for safety*. Retrieved July 3, 2016, from U.S. Food and Drug Administration: <http://www.fda.gov/Food/FoodScienceResearch/SafePracticesforFoodProcesses/ucm094147.htm>
- Felicio, T. L., Esmerino, E. A., Vidal, V. A. S., Cappato, L. P., Garcia, R. K. A., Cavalcanti, R. N., Freitas, M. Q., Conte Junior, C. A., Padilha, M. C., Silva, M. C., Raices, R. S. L., Arellano, D. B., Bolini, H. A. M., Pollonio, M. A. R., Cruz, A. G., (2016). Physico-chemical changes during storage and sensory acceptance of low sodium probiotic Minas cheese added with arginine. *Food Chemistry*, 196, 628–637.

- Fonseca, F. G., Esmerino, E. A., Tavares Filho, E. R., Ferraz, J. P., da Cruz, A. G., & Bolini, H. M. (2016). Novel and successful free comments method for sensory characterization of chocolate ice cream: A comparative study between pivot profile and comment analysis. *Journal of Dairy Science*, 99(5), 3408–3420.
- Frings, S., & Bradley, J. (2006). *Transduction channels in sensory cells*. (J. B. Stephan Frings, Ed.) John Wiley & Sons.
- Gaze, L. V., Oliveira, B. R., Ferrao, L. L., Granato, D., Cavalcanti, R. N., Conte Júnior, C. A., Cruz, A. G., & Freitas, M. Q. (2015). Preference mapping of dulce de leche commercialized in Brazilian markets. *Journal of Dairy Science*, 98(3), 1443–1454.
- Green, B. G., Shaffer, G. S., & Gilmore, M. M. (1993). A semantically-labeled magnitude scale of oral sensation with apparent ratio properties. *Chemical Senses*, 18(6), 683–702.
- Gomes, A. P., Cruz, A. G., Cadena, R. S., Celeghini, R. M. S., Faria, J. A. F., Bolini, H. M. A., Pollonio, M. A. R., & Granato, D. (2011). Manufacture of low-sodium Minas fresh cheese: Effect of the partial replacement of sodium chloride with potassium chloride. *Journal of Dairy Science*, 94(6), 2701–2706.
- Guàrdia, M. D., Guerrero, L., Gelabert, J., Gou, P., & Arnau, J. (2008). Sensory characterisation and consumer acceptability of small calibre fermented sausages with 50% substitution of NaCl by mixtures of KCl and potassium lactate. *Meat Science*, 80(4), 1225–1230.
- Havas, S., Dickinson, B. D., & Wilson, M. (2007). The urgent need to reduce sodium consumption. *Jama*, 298(12), 1439–1441.
- Henry, J. E., & Taylor, C. L. (Eds.). (2010). *Strategies to reduce sodium intake in the United States*. National Academies Press.
- Heshmati, A. (2014). Evaluation of heavy metals contamination of unrefined and refined table salt. *International Journal of Research Studies Biosciences*, 2(2), 21–24.
- Hooge, S., & Chambers, D. (2010). A comparison of basic taste modalities, using a descriptive analysis technique, for varying levels of sodium and KCl in two model soup systems. *Journal of Sensory Studies*, 25(4), 521–535.
- Horita, C. N., Farías-Campomanes, A. M., Barbosa, T. S., Esmerino, E. A., da Cruz, A. G., Bolini, H. M. A., Meireles, M. A. A., & Pollonio, M. A. R. (2016). The antimicrobial, antioxidant and sensory properties of garlic and its derivatives in Brazilian low-sodium frankfurters along shelf-life. *Food Research International*, 84, 1–8.

- Inarejos-Garcia, A., Androulaki, A., Salvador, M., Fregapane, G., & Tsimidou, M. (2009). Discussion on the objective evaluation of virgin olive oil bitterness. *Food Research International* (42), 279–284.
- Keast, R. S., Breslin, P., & Beauchamp, G. K. (2001). Suppression of bitterness using sodium salts. *CHIMIA International Journal for Chemistry* (55), 441–447.
- Kestin, J., Khalifa, H. E., & Correia, R. J. (1981). Tables of the dynamic and kinematic viscosity of aqueous KCl solutions in the temperature range 25–150 °C and the pressure range 0.1–35 MPa. *Journal of Physical and Chemical Reference Data*, 10(1), 57–70.
- Kochanek, K. D., Xu, J., Murphy, S. L., Minin, A. M., & Kung, H.-C. (2011). *Deaths: Final data for 2009*. National Vital Statistics Reports. National Vital Statistics Reports.
- Koriyama, T., Wongso, S., Watanabe, K., & Abe, H. (2002). Fatty acid compositions of oil species affect the 5 basic taste perceptions. *Journal of Food Science*, 67(2), 868–873.
- Krishna, A. G. (1993). Influence of viscosity on wax settling and refining loss in rice bran oil. *Journal of the American Oil Chemists Society*, 70(9), 895–898.
- Kulmyrzaev, A. A., & Schubert, H. (2004). Influence of KCl on the physicochemical properties of whey protein stabilized emulsions. *Food Hydrocolloids*, 18(1), 13–19.
- Kuo, W. Y., & Lee, Y. (2014). Effect of food matrix on saltiness perception—implications for sodium reduction. *Comprehensive Reviews in Food Science and Food Safety*, 13(5), 906–923.
- Lawless, H. T., & Heymann, H. (2010). *Sensory Evaluation of Food: Principles and Practices*. Springer Science & Business Media.
- Lê, S., Josse, J., & Husson, F. (2008). FactoMineR: An R package for multivariate analysis. *Journal of Statistical Software*, 25(1), 1–18.
- Lynch, J., Liu, Y.-H., Mela, D., & MacFie, H. (1993). A time—intensity study of the effect of oil mouthcoatings on taste perception. *Chemical Senses*, 18(2), 121–129.
- Malone, M., Appelqvist, I., & Norton, I. (2003). Oral behaviour of food hydrocolloids and emulsions. Part 2. Taste and aroma release. *Food Hydrocolloids*, 17(6), 775–784.
- Matera, J. A., Cruz, A. G., Raices, R. S. L., Silva, M. C., Nogueira, L. C., Quitério, S. L., Calvalcanti, R. N., Freiras, M. Q., & Conte Júnior, C. A. (2014). Discrimination of Brazilian artisanal and inspected pork sausages: application of unsupervised, linear and non-linear supervised chemometric methods. *Food Research International*, 64, 380–386.

- 487 Metcalf, K. L., & Vickers, Z. M. (2002). Taste intensities of oil-in-water emulsions with varying
488 fat content. *Journal of Sensory Studies*, 17(5), 379–390.
- 489 Moyano, M. J., Heredia, F. J., & Meléndez-Martínez, A. J. (2010). The color of olive oils: The
490 pigments and their likely health benefits and visual and instrumental methods of analysis.
491 *Comprehensive Reviews in Food Science and Food Safety*, 9(3), 278–291.
- 492 Palar, K., & Sturm, R. (2009). Potential societal savings from reduced sodium consumption in
493 the US adult population. *American Journal of Health Promotion*, 24(1), 49–57.
- 494 Peryam, D. R., & Pilgrim, F. J. (1957). Hedonic scale method of measuring food preferences.
495 *Food Technology*, 11:9–14.
- 496 R Development Core Team (2007). *R: A Language and Environment for Statistical Computing*.
497 *R Foundation for Statistical Computing*. Vienna, Austria. ISBN 3–900051–07–0, URL:
498 <http://www.R-project.org/>.
- 499 Rao, M. A. (2010). *Rheology of Fluid and Semisolid Foods: Principles and Applications*.
500 *Principles and Applications*. Springer Science & Business Media.
- 501 Rodrigues, F. M., Rosenthal, A., & Tiburski, J. H. (2016). Alternatives to reduce sodium in
502 processed foods and the potential of high pressure technology. *Food Science and*
503 *Technology (Campinas)*, 36(1), 1–8.
- 504 SAS. (2003). *SAS/STAT User's Guide Version 9.1*. Cary, NC: SAS Institute Inc.
- 505 Sinopoli, D. A., & Lawless, H. T. (2012). Taste properties of potassium chloride alone and in
506 mixtures with sodium chloride using a check-all-that-apply method. *Journal of Food*
507 *Science*, 77(9), 319–322.
- 508 Shamil, S., Wyeth, L. J., & Kilcast, D. (1991). Flavour release and perception in reduced-fat
509 foods. *Food Quality and Preference*, 3(1), 51–60.
- 510 Smittle, R. B. (2000). Microbiological safety of mayonnaise, salad dressings, and sauces
511 produced in the United States: a review. *Journal of Food Protection*, 63(8), 1144–1153.
- 512 Tarancón, P., Sanz, T., Fiszman, S., & Tárrega, A. (2014). Consumers' hedonic expectations and
513 perception of the healthiness of biscuits made with olive oil or sunflower oil. *Food*
514 *Research International*, 55, 97–206.
- 515 Torrico, D. D., & Prinyawiwatkul, W. (2015). Psychophysical effects of increasing oil
516 concentrations on saltiness and bitterness perception of oil-in-water emulsions. *Journal*
517 *of Food Science*, 80(8), S1885–S1892.

- Torrico, D. D., Sae-Eaw, A., Sriwattana, S., Boeneke, C., & Prinyawiwatkul, W. (2015). Oil-in-water emulsion exhibits bitterness-suppressing effects in a sensory threshold study. *Journal of Food Science*, 80(6), S1404–S1411.
- USDA. (2010). *Dietary guidelines for Americans*. United States Department of Agriculture. Washington D.C.: Government Printing Office.
- Valentová, H., & Pokorný, J. (1998). Effect of edible oils and oil emulsions on the perception of basic tastes. *Food / Nahrung*, 42(06), 406–408.
- Vingerhoedsa, M. H., Wijka, R. A., Zoeta, F. D., Nixdorfa, R. R., & Akena, G. A. (2008, Junio). How emulsion composition and structure affect sensory perception of low-viscosity model emulsions. *Food Hydrocolloids*, 22(4), 631–646.
- Wang, S., Flynn, D., & Moscatello, B. (2013). *Consumer attitudes on olive oil*. UC Davis Olive Center.
- WHO. (2010). *Creating an enabling environment for population-based salt reduction strategies: report of a joint technical meeting held by WHO and the Food Standards Agency, United Kingdom, July 2010*. World Health Organization. WHO Press.
- XLSTAT. (2015). XLSTAT. (Addinsoft) Retrieved August 10, 2016, from <http://www.xlstat.com/en/>

Table 1 Formulations of oil-in-water spreads using olive, soybean or rice bran oil

Treatments ^{β§}	Olive oil (%)	Soybean oil (%)	Rice bran oil (%)	H ₂ O (%)	NaCl (%)	KCl (%)
OLV1	65.00	0.00	0.00	19.45	0.50	0.00
OLV2	65.00	0.00	0.00	18.95	1.00	0.00
OLV3	65.00	0.00	0.00	19.20	0.00	0.75
OLV4	65.00	0.00	0.00	18.45	0.00	1.50
SOY1	0.00	65.00	0.00	19.45	0.50	0.00
SOY2	0.00	65.00	0.00	18.95	1.00	0.00
SOY3	0.00	65.00	0.00	19.20	0.00	0.75
SOY4	0.00	65.00	0.00	18.45	0.00	1.50
RIC1	0.00	0.00	65.00	19.45	0.50	0.00
RIC2	0.00	0.00	65.00	18.95	1.00	0.00
RIC3	0.00	0.00	65.00	19.20	0.00	0.75
RIC4	0.00	0.00	65.00	18.45	0.00	1.50

^β All treatments had fixed concentrations of vinegar (8.90%), whey protein concentrate (5.4%), and TIC Gum (0.75%)

[§] OLV= Olive oil; SOY=Soybean oil; RIC= Rice bran oil

Table 2 Mean values^β for viscosity, pH, water activity (a_w) and colour of emulsion spreads

Salt	Salt (%)	Oil	Viscosity (Pa*s)	pH	a _w	Colour [§]
NaCl	0.50	Olive	107.06 ± 3.34 ^a	4.37 ± 0.02 ^{ef}	0.9368 ± 0.01 ^a	68.58 ± 0.45 ^d
		Soybean	69.45 ± 4.15 ^{bc}	4.41 ± 0.02 ^c	0.9258 ± 0.01 ^{bcd}	90.84 ± 0.43 ^a
		Rice bran	74.96 ± 10.08 ^b	4.38 ± 0.02 ^{de}	0.9247 ± 0.01 ^{bcd}	85.88 ± 0.40 ^b
	1.00	Olive	107.43 ± 1.49 ^a	4.34 ± 0.02 ^g	0.9240 ± 0.01 ^{bcd}	68.33 ± 0.26 ^d
		Soybean	66.06 ± 4.97 ^{cd}	4.39 ± 0.05 ^{cd}	0.9228 ± 0.01 ^{bcd}	90.75 ± 0.44 ^a
		Rice bran	67.43 ± 9.65 ^{cd}	4.36 ± 0.01 ^f	0.9185 ± 0.01 ^d	85.46 ± 0.63 ^{bc}
KCl	0.75	Olive	104.07 ± 1.54 ^a	4.43 ± 0.02 ^b	0.9305 ± 0.01 ^{ab}	68.36 ± 0.49 ^d
		Soybean	63.65 ± 5.91 ^{cde}	4.46 ± 0.01 ^a	0.9287 ± 0.01 ^{abc}	90.87 ± 0.31 ^a
		Rice bran	58.98 ± 4.09 ^e	4.47 ± 0.02 ^a	0.9243 ± 0.01 ^{bcd}	85.54 ± 0.49 ^{bc}
	1.50	Olive	105.38 ± 2.50 ^a	4.44 ± 0.44 ^b	0.9288 ± 0.01 ^{abc}	68.13 ± 0.42 ^d
		Soybean	62.88 ± 5.28 ^{de}	4.47 ± 0.00 ^a	0.9222 ± 0.01 ^{bcd}	90.46 ± 0.51 ^a
		Rice bran	59.16 ± 8.38 ^e	4.46 ± 0.01 ^a	0.9200 ± 0.01 ^{cd}	85.03 ± 0.72 ^c

^β Data are represented as means and standard deviation values (N=3). Concentrations of NaCl and KCl were pre-determined according to their relative saltiness intensity values establish in Torrico & Prinyawiwatkul (2015).

[§] Colour values expressed as whiteness index $\{WI = 100 - [(100 - L^*)^2 + a^{*2} + b^{*2}]^{1/2}\}$

^{a-c} Mean values with the same letter within the same column are not significantly different (P≥0.05)

Table 3 Mean values^β for saltiness, bitterness, and overall taste of emulsion spreads

Salt	Salt (%)	Oil	Saltiness	Bitterness	Overall taste
NaCl	0.50	Olive	30.3 ± 24.78 ^{abc}	39.6 ± 25.87 ^{ab}	2.7 ± 1.70 ^d
		Soybean	27.8 ± 18.68 ^{bcd}	25.3 ± 20.51 ^c	4.9 ± 2.02 ^a
		Rice bran	26.1 ± 20.27 ^{cd}	24.7 ± 21.21 ^c	4.7 ± 2.07 ^{ab}
	1.00	Olive	33.3 ± 19.02 ^{ab}	47.4 ± 25.50 ^a	2.7 ± 1.69 ^d
		Soybean	35.6 ± 19.29 ^a	23.2 ± 22.93 ^c	4.8 ± 1.87 ^a
		Rice bran	31.7 ± 19.74 ^{abc}	26.4 ± 21.56 ^c	4.8 ± 1.87 ^a
KCl	0.75	Olive	23.5 ± 21.18 ^d	43.3 ± 24.60 ^{ab}	3.0 ± 1.75 ^d
		Soybean	26.3 ± 25.70 ^{cd}	24.8 ± 19.59 ^c	4.5 ± 1.97 ^{abc}
		Rice bran	26.7 ± 22.28 ^{cd}	28.0 ± 24.06 ^c	4.2 ± 1.96 ^{bc}
	1.50	Olive	33.6 ± 24.21 ^{ab}	43.8 ± 25.70 ^{ab}	2.9 ± 1.63 ^d
		Soybean	34.0 ± 19.74 ^a	29.2 ± 21.17 ^c	4.2 ± 2.02 ^c
		Rice bran	36.0 ± 25.23 ^a	27.9 ± 24.68 ^c	4.1 ± 2.05 ^c

^β Data are represented as mean and standard deviation values (N=75). For saltiness and bitterness, values are based on 100–points labelled magnitude scale (LMS) scale. Overall taste liking scores were based on a 9–point hedonic scale. Concentrations of NaCl and KCl were pre–determined according to their relative saltiness intensity values establish in Torrico & Prinyawiwatkul (2015).

^{a–e} Mean values with the same letter within the same column are not significantly different (P≥0.05).

Table 4 Purchase intent (affirmative + neutral) of the spreads before and after sodium and oil claims

Treatment ^Ψ	Oil [§]	Salt	Salt (%)	PI–original ^θ (%)	PI–Sodium ^β (%)	PI–Oil ^α (%)
OLV1	Olive	NaCl	0.50	16.88	23.38	38.96**
OLV2			1.00	20.78	19.48	33.77**
OLV3		KCl	0.75	22.67	38.67**	41.33**
OLV4			1.50	15.58	24.68**	33.77**
SOY1	Soybean	NaCl	0.50	62.34	67.53	72.73**
SOY2			1.00	54.55	58.44	62.34
SOY3		KCl	0.75	55.26	59.21	61.84
SOY4			1.50	38.96	51.95**	57.89**
RIC1	Rice bran	NaCl	0.50	63.64	70.13	75.32**
RIC2			1.00	59.21	65.79	63.16
RIC3		KCl	0.75	53.25	61.04	54.55
RIC4			1.50	48.05	57.14**	58.44**

^Ψ Labels of the treatments evaluated on the study (from Table 1). Concentrations of NaCl and KCl were pre–determined according to their relative saltiness intensity values establish in Torrico & Prinyawiwatkul (2015).

^θ PI–original refers to the original purchase intent (PI) of the sample (purchase intent before knowing health benefits)

^β PI–Sodium refers to purchase intent after sodium claim (less or no sodium in the spread formulation)

^a PI–Oil refers to purchase intent after oil claim

****** Italicised and bold purchase intent values are significant different from their original purchase intent (before) after knowledge of health benefits associated with product consumption ($P < 0.05$) based on the McNemar test.

Figure 1 Gender, mayonnaise consumption, and sodium reduction awareness of 300 panellists from the consumer test.

Figure 2 Map of the mean drop based on the percentage of consumers who described saltiness and bitterness of spreads*

*OLV= Olive oil; SOY= Soybean oil; RIC= Rice bran oil; 1= 0.5% NaCl; 2= 1% NaCl; 3= 0.75% KCl; 4= 1.5% KCl; BITT= Bitterness; SALT= Saltiness.

Figure 3 Principal component analysis (PCA) product–attribute bi-plots (individuals and variables factor maps): A score plot of the first principal component (PC1) and second principal component (PC2) visualizing treatments* (NaCl and KCl spread systems) and sensory and physical attributes. *Treatment labels are shown in Table 1. (Type of oil-Concentration of salt-Type of salt).

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