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Extra virgin olive oils with high phenolic content as an ingredient of artisanal ice cream: consumer acceptance

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Extra virgin olive oils with high phenolic content as an ingredient of artisanal ice cream: consumer acceptance

We aimed to evaluate the acceptance of artisanal ice cream prepared with extra virgin olive oil (EVOO) as the main lipid ingredient. Two formulations were developed using an EVOO from Brazil (BrEVOO) and another from Greece (GrEVOO), both with high content of phenolics. Acceptance test using a hedonic scale was applied. Principal component analysis (PCA) and multiple linear regression (MLR) analysis were carried out to highlight significant attributes affecting the ice cream acceptance. No statistical significant differences (p>0.05) were observed between ice creams for aroma, flavor, consistency, appearance, and overall acceptance. Regarding PCA, the first two components explained 80% of the total variability and allowed to observe that the global acceptance was mainly correlated with aroma and flavor. We concluded that EVOOs can be an effective ingredient to promote functional and/or health properties to novel foods.

Keywords: Functional food, Consumer satisfaction, Principal component analysis, Antioxidant properties, Home-made ice-cream.

Introduction

Consumers are increasingly interested in new eating experiences that are healthy and pleasurable (Akbari, Eskandari, & Davoudi, 2019; Aschemann-Witzel, Varela, & Peschel, 2019; Dias et al., 2018). In this context, the development of new functional food formulations has been expanding over the years and a huge amount of novel foods are being developed using ingredients with health benefits, such as natural antioxidants and fats with healthier fatty acid profile (Bakshi, Chhabra, & Kaur, 2020; Villamil et al., 2020).

Extra virgin olive oil (EVOO) has been widely studied because of its beneficial health properties. Its regular consumption has already been associated with lower risks of colon, breast and skin cancer, as well as with beneficial effects on aging, coronary heart disease, Alzheimer's and other neurodegenerative diseases. These properties are attributed to the synergistic interaction of its components, especially monounsaturated fatty acids (65-83%), with emphasis on oleic acid (C18:1), and phenolic compounds (up to 2%), mainly hydroxytyrosol and derivatives (oleuropein and tyrosol). The characteristic EVOO fatty acid profile has been pointed out as the main responsible for the effects of lowering plasma levels of low-density lipoprotein and controlling of total cholesterol justifying other protective effects of this food matrix on blood pressure, coronary, thrombotic, autoimmune and inflammatory disorders. The biological properties of EVOO phenolic compounds have also been reported, being the main ones the antioxidant, anti-inflammatory and antimicrobial activities (Jimenez-Lopez et al. 2020; Lanza & Ninfali 2020).

Brazil´s olive oil production has recently emerged and since the production of the first batches, in 2008, data evidenced the good quality of Brazilian olive oils, which fit the EVOO category (Ballus et al., 2015; Borges et al., 2017; Carvalho et al., 2020; Mello & Pinheiro, 2012;

Zago, Squeo, Bertoncini, Difonzo, & Caponio, 2019). The innovative character of EVOO use in desserts, such as frozen desserts, has been increasingly investigated (Sacchi et al., 2019). Among the frozen desserts, ice cream (particularly in its chocolate-flavored version) is the worldwide favorite, irrespective of culture, age, and socioeconomic level of people. Due to innovation and exposure to different cultures the consumption of ice cream has increased (Konstantas, Stamford, & Azapagic, 2019; Babu & Shams, 2015; Bullock, Lahne, & Pope, 2020; Gozan et al., 2020).

It is important to highlight the significant increase of ice cream market in Brazil. According to Brazilian Association of Ice Cream Industry, in 2019 Brazil consumed 1107 million liters of ice cream with a per capita consumption of 5.29 liters/year/inhabitant (Associação Brasileira das Indústrias e do Setor de Sorvetes, 2020). The purchase of commercial ice-cream by Brazilians increased 100% from 2002 to 2018 (IBGE, 2020). It is important to note that the commercial ice cream, a ultra-processed food, is associated with negative health outcomes when consumed in excess (Elizabeth, Machado, Zinõcker, Baker, & Lawrence, 2020; Carlos A. Monteiro & Cannon, 2019). This scenario reinforces the relevance and the need to investigate the development of healthier ice cream formulations.

The process of making the ice cream consists of the formation of a stabilized emulsion resulting from the freezing/beating process and air incorporation, forming a creamy, light and palatable mixture (Clarke, 2012; Goff, 2013). Ice cream is a complex food matrix which basically consists of frozen aerated oil in water emulsion containing partially coalesced fat clusters, air bubbles, ice crystals and a viscous serum, which also includes polysaccharides, mineral salts, proteins and water (Poursani, Razavi, Mazaheri Tehrani, & Javidi, 2020; Rolon, Bakke, Coupland, Hayes, & Roberts, 2017).

Although ice cream is a product with very desirable sensory attributes, such as refreshingly cool and delightfully sweet characteristics, its composition is usually not very healthy, due to the high content of animal fat and sugars and low content of micronutrients and bioactive compounds, especially the conventional commercial ice creams (An & Jiang, 2017; Kanse, Rani, Shingh, & Chopde, 2020). The use of a functional ingredient can lead to positive changes both in the nutritional and sensory profile of ice creams, in addition to promoting the supply of compounds with the potential to improve the human health (Espinoza, Purriños, Centeno, & Carballo, 2020; Gozan et al., 2020; Sacchi et al., 2019; Vieira et al., 2020).

The development of healthier ice cream formulations is within the context of "Dessert Flip", a strategy proposed by the Culinary Institute of America to increase not only the healthfulness but also sustainability of desserts, characterized by increasing the proportions of plant-based ingredients (fruits and nuts) and decreasing sugars and saturated fats (mainly animal fats) without reducing sensory acceptability (Kurzer, Spencer, Cienfuegos, & Guinard, 2020; Spencer & Guinard, 2018).

Since fat is a main component and plays an important role in ice cream matrix, the use of healthier fat replacers is a great challenge for the rheological, physical and sensory characteristics of the ice cream (Güven, Kalender, & Taşpinar, 2018; Javidi & Razavi, 2018). Data previously published by this research group showed that the ice cream with EVOO presented good characteristics of air incorporation and melting, and good stability of the phenolic compounds and the antioxidant capacity (Zago et al., 2018). In order to complement these findings, the aim of this study was to evaluate the consumer acceptance of the artisanal ice cream prepared with EVOO as the main lipid ingredient.

Materials and Methods:

Ice-cream formulation and preparation

Two formulations of lemon ice cream were developed using two monovarietal Koroneiki EVOOs, purchased at local retailers, one from Brazil (BrEVOO) and another from Greece (GrEVOO), both with high content of phenolic compounds (BrEVOO: 525.9 mg/kg; GrEVOO: 526.9 mg/kg, data previously published by our group (Zago et al., 2018)). The ingredients of the formulations were: Sicilian lemon (*Citrus* x *limon* L.) juice (52.5%), EVOO (18%), skimmed milk powder (12%), sucrose (9%), pasteurized fresh cream (8%) and unflavored gelatin powder (0.5%). The amount of the ingredients was based on the results of previous tests which aimed to achieve a proportion that would not affect the emulsion and result in a product with adequate texture and flavor characteristics. All ingredients were purchased at local retailers. Ninety percent of the total fat in both formulations comes from EVOO (Zago et al., 2018). For preparing the ice-creams, all ingredients were manually mixed to complete homogenization. Subsequently, the mixture was placed in an artisanal ice cream maker (Cuisinart® ICE-21) for 30 minutes and then placed in a sterilized container and stored at -18 ºC as shown in Figure 1.

Figure 1. Flow chart of the process steps of the artisanal ice-creams.

Microbiological analysis

The microbiological quality of both ice creams was assessed by the determination of the most probable number of thermotolerant coliforms, the detection of *Salmonella* spp., and the enumeration of coagulase-positive *Staphylococcus* according to American Public Health

Association (APHA, 2015). The results were compared to the Brazilian Legislation (Brasil, 2001).

Consumer test

Seventy-seven non-trained and potential consumers of ice-cream volunteers from the State University of Rio de Janeiro, Brazil, were recruited to perform the sensory analysis of ice creams samples using a 9-point hedonic scale, where 9 = extremely desirable and 1 = extremely undesirable. Aroma, flavor, consistency, appearance and overall acceptance were the sensory attributes evaluated. Volunteers answered a questionnaire previously to the analysis and were considered potential consumers of the samples those who reported liking ice cream and olive oil, and consuming olive oil at least once a week.

Then, the sour taste was evaluated through the ideal scaling: less than ideal, ideal and more than ideal. The ice creams were also submitted to the purchase intention test through a scale structured in three points where "1 - I would certainly buy; 2 - I have doubts if I would buy; 3 - I would certainly not buy" (Adolfo Lutz Institute, 2008).

The participants received a sample of each ice cream coded with three digits in random order for not allowing its identification. The sensory analysis of the two products occurred separately and between each of the tastings a glass of water was offered to minimize the residual taste of the previous sample.

The results were expressed as the mean score for each attribute and the acceptability index (AI) was calculated as follows: AI (%) = A*100/B, where A was the mean score obtained for each formulation and B was the maximum score obtained (Adolfo Lutz Institute, 2008).

The study protocol was approved by the Research Ethics Committee (Pedro Ernesto University Hospital, State University of Rio de Janeiro, Brazil, number 2.694.935).

Statistical analysis

Student's *t*-test at 95% confidence level was performed. Principal component analysis (PCA) was carried out on the autoscaled data matrix to explore the data. Multiple linear regression (MLR) was used to relate the independent variables (x, sensory descriptors) to the overall acceptance (y, response) according to the following mathematical model: $y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4$. The dataset was first randomly split in training set and test set (70% and 30% of the whole dataset, respectively). The training set was then used to calculate the model coefficients. Afterward, the obtained model was used to predict the response on the test set. The significance of the coefficients was calculated according to the Student's t-test at 5% significance level. Multivariate data analysis was carried out in MATLAB environment (R2019a, The MathWorks, Inc. MA, USA).

Results and Discussion

The use of EVOO as main lipid ingredient in the artisanal ice-creams produced in this research showed good acceptance by consumers for all the evaluated attributes, and aroma and flavor were the attributes that influenced the overall acceptance.

The production and consumption of foods that contribute to health are a target of food scientists, since diet is directly related to the prevalence of many diseases in the world (Malgor, Sabbione, & Scilingo, 2020). In this way, the development of a dessert like ice cream using

innovative ingredients and with high content of bioactive compounds can be an interesting alternative.

The incorporation of functional ingredient, with antioxidant action, in ice creams has already proved effective in increasing the antioxidant capacity of these foods (Sacchi et al., 2019). The addition of grape sediment, deposited at the bottom of wine barrels, in ice-cream resulted in a significant increase in the antioxidant capacity of the samples (Hwang, Shyu, & Hsu, 2009). Ice-cream made with Russian olive flour showed greater antioxidant capacity than control, and this effect was attributed to the presence of phenolic compounds (Çakmakçi et al., 2015). Ice-creams supplemented with chia oil presented higher levels of phenolic compounds and higher antioxidant capacity than the control ice creams (Ullah, Nadeem, & Imran, 2017). Chamchan et al. (2017) prepared functional ice creams with reduced sugar content added of ginger and lemongrass extracts and found higher content of phenolic compounds and higher total antioxidant capacity than the control. The antioxidant capacity (> 400 mg/kg for Folin-Ciocalteau assay and > 1900 µmol Fe^{+2} /kg for FRAP assay, for both EVOOs addition, Brazilian and Greek) of the ice-creams in this study was previously published (Zago et al., 2018).

Ice cream is a product that is not normally processed by heat, so the production process must comply with the Good Manufacturing Practices standards (Chamchan et al., 2017). For safety reasons, prior to the sensory analysis the microbiological quality of the ice creams was evaluated. The samples presented adequate values according to the limits established by Brazilian legislation (Brasil, 2001) as shown in Table 1.

Table 1. Microbiological analysis results.

An untrained panel of 77 regular ice cream consumers, adults between 18 and 60 years, both genders, conducted sensory analysis. According to Student's t-test no differences (p>0.05) were observed between ice creams for all sensory descriptors analyzed: aroma, flavor, consistency, appearance and overall acceptance (Table 2). Both ice creams presented AI ≥ 70% for appearance and consistency attributes, as shown in Table 2. A study conducted by Malgor et al. (2020) aimed to develop a lemon sorbet with amaranth. The sensory analysis with 60 untrained tasters obtained as a result an acceptability level of 80%.

Table 2. Acceptance test (AT) and acceptability index (AI) of the ice creams (n=77)

Sour taste response is elicited by acids, but at high concentrations may evoke an irritation sensation (Neta, Johanningsmeier, & McFeeters, 2007). In addition, the presence of an acid stimuli in cold foods (0 to 8°C) can increase the flow rate of saliva and intensify the sour taste perception (Dawes, O'Connor, & Aspen, 2000). Considering the large amount of Sicilian lemon juice (52.5%), an acid ingredient in the formulations, the ideal scaling for the sour taste, expressed in percentage, was used to verify how the tasters consider as ideal the sour taste in the two elaborated ice creams. Most tasters classified the sour taste as ideal, being 37% for BrEVOO and 47% for GrEVOO (Table 3). Regarding the purchase intention, less than 40% of tasters reported that they would certainly not buy the ice creams (Table 3). Similar result was found in the study by Alves et al. (2009) where 39% of the tasters said they "would not buy" frozen yogurt made with goat milk. It should be noted that the intention to purchase is closely related to the acceptability in the flavor parameter, since the consumer gives preference to the product that presents a more pleasant flavor (Morzelle, Lamounier, Souza, Salgado, & Vilas-Boas, 2012).

Table 3. Ideal scaling of the sour taste and purchase intention test of the ice creams (*n*=77)

The different non-sensory factors have a considerable influence on a consumer's food choice, and understanding the role of these factors provides better understanding of dietary behavior (Carrillo, Varela, Salvador, & Fiszman, 2011). Recent studies have classified the value attributes of food into those that can meet healthy nutritional and functional attributes (Bedoya-Perales, Pumi, Mujica, Talamini, & Padula, 2018; Lee & Yun, 2015), convenience (Carrillo et al., 2011), health and safety guarantees (FAO-ALADI, 2014; Nasir & Karakaya, 2014) and special characteristics that are an expression of cultural traditions (FAO-ALADI, 2014). As a result, when consumers make food purchasing decisions, health-related attributes and non-health-related attributes, such as taste or sensory appeal, familiarity and convenience, (Lee & Yun, 2015) are important.

PCA is a multivariate statistical technique applied to reduce the dimensionality of a set of observations and enables the conversion of original dependents variables into a new set of values of linearly uncorrelated variables named as principal components (PC) (Ghosh & Chattopadhyay, 2012; Tran, Burdejová, Ospienko, & Härdle, 2019). Usually, two or three PCs are sufficient to explain most of the total variability of the primary variables (Gumus, Ertas, Yasar, & Gumus, 2018; Mostafavi, 2019). In the present study PCA was used to explore the sensory characteristics of the ice cream formulations containing different EVOO and was applied to the sensory data presented in Table 2.

According to PCA analysis, the first two components explained around 80% of the total variability. In the score plot, no clusters were observed depending on the type of EVOO used.

The loading plot allowed to observe that the overall acceptance was mainly correlated with aroma and flavor (Figure 2) while seemed not correlated with appearance and consistency. MLR was used to identify significant factors influent in the global acceptance and the analysis confirmed the PCA results. In prediction the model showed promising R^2_{adj} (0.8 and 0.84 for BrEVOO and GrEVOO, respectively) and error (RMSEP) (0.9 and 1 for BrEVOO and GrEVOO, respectively).

Figure 2. The distribution of sensory attributes of extra virgin olive oil ice creams according to PC1 and PC2.

Figure 3. Regression coefficients ± confidence intervals ($\alpha = 0.05$).

EVOO ice-creams had similar acceptability by the consumers (Table 2) and, regardless of the oil used, flavor was the most affecting attribute (Figure 3). When BrEVOO was used, aroma was significant influent, too. In general, the rheological properties of ice cream decreased as a result of using dairy fat replacers (Akbari et al., 2019; Güven et al., 2018; Javidi & Razavi, 2018; Poursani et al., 2020). According to our findings the creaminess and meltdown, perceived as consistency by consumers, did not affected the overall acceptance. In a previously published study, our group demonstrated that the ice creams with 18% of EVOO showed high resistance to melting, suggesting the EVOO provides good interaction with the other components of the ice cream matrix making it cohesive and stable (Zago et al., 2018). Aroma and flavor, for both ice creams formulations of this study, were significantly affected by using EVOO, in agreement with the results reported in the literature for studies on healthy and functional ice cream formulations (Espinoza et al., 2020; Güven et al., 2018; Sacchi et al., 2019; Vieira et al., 2020; Yadav et al.,

2020). EVOO used in this study are high in total phenolic compounds (> 500 mg/kg, data previously published in Zago et al. (2018)). The high content of polyphenols in EVOO are related to bitterness and pungency (Aguilera, Jimenez, Sanchez-Villasclaras, Uceda, & Beltran, 2015; Genovese, Caporaso, di Bari, Yang, & Fisk, 2019; Issaoui et al., 2020; Zago et al., 2019). Data about the definition of the EVOO sensory profile preferred by Brazilian consumers are scarce. According to Antonialli et al. (2018), in a study with Brazilian consumers, even consumers from a non-traditional olive oil markets have a certain degree of knowledge of its intrinsic sensory attributes. So, the bitterness and pungency probably were identified in the ice creams by consumers.

The ice creams produced in this study, in addition to being potential functional foods, meet the new public health recommendations related to increasing consumption of natural and minimally processed foods and home-made culinary preparations, because are directly related to healthier food choices and support socially and environmentally sustainable food system (Devia, Forli, Vidal, Curutchet, & Ares, 2021; Frankowska et al., 2020; Carlos Augusto Monteiro et al., 2015).

This research represents a new culinary trend in dessert-flip in the context of plant-based diet. The use of extra virgin olive oil as a fat flip strategy in addition to contributing with the health and environment benefits, can add value and innovation to the homemade ice-cream sector. Ice-cream, besides being the most popular dessert in the world, is considered by many people as a comfort food (Spence, Navarra, & Youssef, 2019). Thus, the development of an artisanal ice-cream recipe, with added functional value, and well accepted by consumers, in addition to being a healthier option, is also in accordance with an important aspect of gastronomy, the affective culinary. The use of ingredients commonly used in cooking recipes associated with the process

steps that involves low technological sophistication are innovative aspects of the ice-cream developed in this research.

Conclusions

The ice creams production process developed in this study is in accordance with the Good Manufacturing Practices standards, since the microbiological analysis of the samples presented adequate values according to the limits established by legislation. This is very important in the context of artisanal production, which involves processes with less technological sophistication, contributing to increase the challenge of producing a safe food from the sanitary point of view.

According to consumer test, both ice creams presented good acceptance for the appearance and consistency attributes. Regression coefficients showed that aroma and flavor significantly influenced the overall acceptance in novel ice-creams based on EVOO as main lipid ingredient. This may have been reflected in the purchase intention of the product, since about 40% of the consumers, who knew that ice-creams had EVOO as ingredient, reported that they would certainly not buy the ice cream.

EVOOs with high content of phenolic compounds have great potential as lipid ingredient in the artisanal ice creams and can be an effective alternative to promote functional and/or health properties to novel foods.

Declaration of competing interest

The authors report no conflict of interest.

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References

Adolfo Lutz Institute. (2008). *Physicochemical Methods for Food Analysis. Eletronic version* (Eletronic). Adolfo Lutz Institute. Retrieved from https://www.ial.sp.gov.br/resources/editorinplace/ial/2016_3_19/analisedealimentosial

Aguilera, M. P., Jimenez, A., Sanchez-Villasclaras, S., Uceda, M., & Beltran, G. (2015). Modulation of bitterness and pungency in virgin olive oil from unripe "Picual" fruits. *European Journal of Lipid Science and Technology*, *117*(9), 1463–1472. https://doi.org/10.1002/ejlt.201400432

Akbari, M., Eskandari, M. H., & Davoudi, Z. (2019). Application and functions of fat replacers in low-fat ice cream: A review. *Trends in Food Science and Technology*, *86*(October 2018), 34–40. https://doi.org/10.1016/j.tifs.2019.02.036

Alves, L. de L., Richards, N. S. P. dos S., Becker, L. V., Andrade, D. F. de, Milani, L. I. G., Rezer, A. P. de S., & Scipioni, G. C. (2009). Aceitação sensorial e caracterização de frozen yogurt de leite de cabra com adição de cultura probiótica e prebiótico. *Ciência Rural*, *39*(9), 2595–2600. https://doi.org/10.1590/S0103-84782009005000204

An, R., & Jiang, N. (2017). Frozen yogurt and ice cream were less healthy than yogurt, and adding toppings reduced their nutrition value: evidence from 1999-2014 National Health and Nutrition Examination Survey. *Nutrition Research*, *42*, 64–70. https://doi.org/10.1016/j.nutres.2017.04.013

Antonialli, F., Mesquita, D. L., Valadares, G. C., de Rezende, D. C., & de Oliveira, A. F. (2018).

Olive oil consumption: a preliminary study on Brazilian consumers. *British Food Journal*, *120*(7), 1412–1429. https://doi.org/10.1108/BFJ-03-2017-0166

APHA. (2015). *Compendium of Methods for the Microbiological Examination of Foods* (15th ed.). Washington, DC: American Public Health Association.

Aschemann-Witzel, J., Varela, P., & Peschel, A. O. (2019). Consumers' categorization of food ingredients: Do consumers perceive them as 'clean label' producers expect? An exploration with projective mapping. *Food Quality and Preference*, *71*(January 2018), 117–128. https://doi.org/10.1016/j.foodqual.2018.06.003

Associação Brasileira das Indústrias e do Setor de Sorvetes. (2020). Consumo brasileiro em milhões de litros. Retrieved January 30, 2020, from http://www.abis.com.br/mercado/

Babu, S., & Shams, S. (2015). Factors Influencing Consumers Choice of Icecream: A Study on Impulse Buying Behavior. *Journal of Marketing*, *16*(1), 225–242.

Bakshi, A., Chhabra, S., & Kaur, R. (2020). Consumers` Attitudes Toward Functional Foods: A Review. *Current Topics in Nutraceutical Research*, *18*(4), 343–347. https://doi.org/10.37290/ctnr2641-452x.18:343-347

Ballus, C. A., Quirantes-Piné, R., Bakhouche, A., da Silva, L. F. de O., de Oliveira, A. F., Coutinho, E. F., … Godoy, H. T. (2015). Profile of phenolic compounds of Brazilian virgin olive oils by rapid resolution liquid chromatography coupled to electrospray ionisation time-of-flight mass spectrometry (RRLC – ESI-TOF-MS). *Food Chemistry*, *170*, 366–377. https://doi.org/10.1016/j.foodchem.2014.08.054

Bedoya-Perales, N. S., Pumi, G., Mujica, A., Talamini, E., & Padula, A. D. (2018). Quinoa expansion in Peru and its implications for land use management. *Sustainability*, *10*(2), 1–13. https://doi.org/10.3390/su10020532

Borges, T. H., Pereira, J. A., Cabrera-Vique, C., Lara, L., Oliveira, A. F., & Seiquer, I. (2017). Characterization of Arbequina virgin olive oils produced in different regions of Brazil and Spain: Physicochemical properties, oxidative stability and fatty acid profile. *Food Chemistry*, *215*, 454–462. https://doi.org/10.1016/j.foodchem.2016.07.162

Brasil. (2001). *Rdc Nº 12, De 2001 - Regulamento Técnico Sobre Os Padrões Microbiologicos Para Alimentos*. ANVISA - Agência Nacional de Vigilância Sanitária.

Bullock, K., Lahne, J., & Pope, L. (2020). Investigating the role of health halos and reactance in ice cream choice. *Food Quality and Preference*, *80*(July 2019), 103826. https://doi.org/10.1016/j.foodqual.2019.103826

Çakmakçi, S., Topdas, E. F., Kalin, P., Han, H., Sekerci, P., Köse, L. P., & Gülçin, I. (2015). Antioxidant capacity and functionality of oleaster (Elaeagnus angustifolia L .) flour and crust in a new kind of fruity ice cream. *International Journal of Food Science and Technology*, *50*(2), 472–481. https://doi.org/10.1111/ijfs.12637

Carrillo, E., Varela, P., Salvador, A., & Fiszman, S. (2011). Main Factors Underlying Consumers' Food Choice: A First Step For The Understanding Of Attitudes Toward "Healthy Eating." *Journal of Sensory Studies*, *26*(2), 85–95. https://doi.org/10.1111/j.1745-459X.2010.00325.x

Carvalho, A., Olmo-García, L., Gaspar, B., Carrasco-Pancorbo, A., Castelo-Branco, V., & Torres, A. (2020). Evaluating Quality Parameters , the Metabolic Profile , Extra Virgin Olive Oils from Brazil. *Molecules*, *25*(4193), 1–24.

Chamchan, R., Sinchaipanit, P., Disnil, S., Jittinandana, S., Nitithamyong, A., & On-nom, N. (2017). Formulation of reduced sugar herbal ice cream using lemongrass or ginger extract. *British Food Journal*, *119*(10), 2172–2182. https://doi.org/10.1108/BFJ-10-2016-0502

Clarke, C. (2012). *The science of ice cream* (2nd ed.). Cambridge: Royal Society of Chemistry.

Dawes, C., O'Connor, A. M., & Aspen, J. M. (2000). The effect on human salivary flow rate of the temperature of a gustatory stimulus. *Archives of Oral Biology*, *45*(11), 957–961. https://doi.org/10.1016/S0003-9969(00)00070-4

Devia, G., Forli, S., Vidal, L., Curutchet, M. R., & Ares, G. (2021). References to home-made and natural foods on the labels of ultra-processed products increase healthfulness perception and purchase intention: Insights for policy making. *Food Quality and Preference*, *88*(August 2020), 104–110. https://doi.org/10.1016/j.foodqual.2020.104110

Dias, F. da S. L., Lima, M. F., de Velasco, P. C., Salles-Costa, R., de Carvalho Sardinha, F. L., & do Carmo, M. das G. T. (2018). Were policies in Brazil effective to reducing trans fat from industrial origin in foods? *Revista de Saude Publica*, *52*, 1–9. https://doi.org/10.11606/S1518-8787.2018052000292

Elizabeth, L., Machado, P., Zinõcker, M., Baker, P., & Lawrence, M. (2020). Ultra-Processed Food and Health Outcomes: a narrative review. *Nutrients*, *12*(1955), 1–33.

Espinoza, L. A., Purriños, L., Centeno, J. A., & Carballo, J. (2020). Chemical, microbial and sensory properties of a chestnut and milk ice cream with improved healthy characteristics. *International Journal of Food Properties*, *23*(1), 2271–2294. https://doi.org/10.1080/10942912.2020.1856135

FAO-ALADI. (2014). *Tendencias Y Perspectivas del Comercio Internacional de Quinua*. Santiago: FAO-ALADI.

Frankowska, A., Rivera, X. S., Bridle, S., Kluczkovski, A. M. R. G., Tereza da Silva, J., Martins, C. A., … Reynolds, C. (2020). Impacts of home cooking methods and appliances on the GHG emissions of food. *Nature Food*, *1*(12), 787–791. https://doi.org/10.1038/s43016-020-

00200-w

Genovese, A., Caporaso, N., di Bari, V., Yang, N., & Fisk, I. (2019). Effect of olive oil phenolic compounds on the aroma release and persistence from O/W emulsion analysed in vivo by APCI-MS. *Food Research International*, *126*(March), 108686. https://doi.org/10.1016/j.foodres.2019.108686

Ghosh, D., & Chattopadhyay, P. (2012). Application of principal component analysis (PCA) as a sensory assessment tool for fermented food products. *Journal of Food Science and Technology*, *49*(3), 328–334. https://doi.org/10.1007/s13197-011-0280-9

Goff, H. D. (2013). *Ice Cream* (7th ed.; H. D. Goff & R. W. Hartel, Eds.). Boston: Springer US.

Gozan, M., Ramadhan, M. Y. A., Harahap, A. F. P., Sari, C. N., Muharam, Y., Purwanto, W. W., & Tristantini, D. (2020). Techno-Economic Analysis of Healthy Herbal Ice Cream Product. *International Journal of Technology*, *11*(5), 931–940. https://doi.org/10.14716/ijtech.v11i5.4327

Gumus, Z. P., Ertas, H., Yasar, E., & Gumus, O. (2018). Classification of olive oils using chromatography, principal component analysis and artificial neural network modelling. *Journal of Food Measurement and Characterization*, *12*(2), 1325–1333. https://doi.org/10.1007/s11694-018-9746-z

Güven, M., Kalender, M., & Taşpinar, T. (2018). Effect of using different kinds and ratios of vegetable oils on ice cream quality characteristics. *Foods*, *7*(7). https://doi.org/10.3390/foods7070104

Hwang, J., Shyu, Y., & Hsu, C. (2009). LWT - Food Science and Technology Grape wine lees improves the rheological and adds antioxidant properties to ice cream. *LWT - Food Science and Technology*, *42*(1), 312–318. https://doi.org/10.1016/j.lwt.2008.03.008

IBGE. (2020). *Pesquisa de orçamentos familiares 2017-2018: avaliação nutricional da disponibilidade domiciliar de alimentos no Brasil / IBGE - Instituto Brasileiro de Geografia e Estatística, Coordenação de Trabalho e Rendimento.* Rio de Janeiro: IBGE.

Issaoui, M., Delgado, A. M., Caruso, G., Micali, M., Barbera, M., Atrous, H., … Chammem, N. (2020). Phenols, Flavors, and the Mediterranean Diet. *Journal of AOAC International*, *103*(4), 915–924. https://doi.org/10.1093/jaocint/qsz018

Javidi, F., & Razavi, S. M. A. (2018). Rheological, physical and sensory characteristics of light ice cream as affected by selected fat replacers. *Journal of Food Measurement and Characterization*, *12*(3), 1872–1884. https://doi.org/10.1007/s11694-018-9801-9

Jimenez-Lopez, C., Carpena, M., Lourenço-Lopes, C., Gallardo-Gomez, M., M. Lorenzo, J., Barba, F. J., … Simal-Gandara, J. (2020). Bioactive compounds and quality of extra virgin olive oil. *Foods*, *9*(8), 1–31.

Kanse, S., Rani, R., Shingh, S., & Chopde, D. (2020). Development of antioxidants and vitamin C enriched gelato ice cream by incorporating Gulkand. *Multilogic in Science*, *10*(2), 1–8.

Konstantas, A., Stamford, L., & Azapagic, A. (2019). Environmental impacts of ice cream. *Journal of Cleaner Production*, *209*, 259–272. https://doi.org/10.1016/j.jclepro.2018.10.237

Kurzer, A., Spencer, M., Cienfuegos, C., & Guinard, J. X. (2020). The Dessert Flip: Consumer preference for desserts with a high proportion of fruit and nuts. *Journal of Food Science*, *85*(11), 3954–3968. https://doi.org/10.1111/1750-3841.15462

Lanza, B., & Ninfali, P. (2020). Antioxidants in extra virgin olive oil and table olives: Connections between agriculture and processing for health choices. *Antioxidants*, *9*(1). https://doi.org/10.3390/antiox9010041

Lee, H. J., & Yun, Z. S. (2015). Consumers' perceptions of organic food attributes and cognitive

and affective attitudes as determinants of their purchase intentions toward organic food. *Food Quality and Preference*, *39*(2015), 259–267. https://doi.org/10.1016/j.foodqual.2014.06.002

Malgor, M., Sabbione, A. C., & Scilingo, A. (2020). Amaranth Lemon Sorbet, Elaboration of a Potential Functional Food. *Plant Foods for Human Nutrition*, *75*(3), 404–412. https://doi.org/10.1007/s11130-020-00818-y

Mello, L. D., & Pinheiro, M. F. (2012). Aspectos físico-químicos de azeites de oliva e de folhas de oliveira provenientes de cultivares do RS, Brasil. *Alimentos e Nutrição*, *23*(4), 537–548.

Monteiro, Carlos A., & Cannon, G. J. (2019). The role of the transnational ultra-processed food industry in the pandemic of obesity and its associated diseases: problems and solutions. *World Nutrition*, *10*(1), 89–99. https://doi.org/10.26596/wn.201910189-99

Monteiro, Carlos Augusto, Cannon, G., Moubarac, J. C., Martins, A. P. B., Martins, C. A., Garzillo, J., … Jaime, P. C. (2015). Dietary guidelines to nourish humanity and the planet in the twenty-first century. A blueprint from Brazil. *Public Health Nutrition*, *18*(13), 2311–2322. https://doi.org/10.1017/S1368980015002165

Morzelle, M. C., Lamounier, M. L., Souza, E. C., Salgado, J. M., & Vilas-Boas, E. V. de B. (2012). Nutritional and sensory characteristics of ice cream from savana fruits. *Journal of Candido Tostes Dairy Institute*, *67*(387), 70–78. https://doi.org/10.5935/2238-6416.20120052

Mostafavi, F. S. (2019). Evaluating the effect of fat content on the properties of vanilla ice cream using principal component analysis. *Journal of Food Measurement and Characterization*, *13*(3), 2417–2425. https://doi.org/10.1007/s11694-019-00162-z

Nasir, A. A., & Karakaya, F. (2014). Underlying motivations of organic food purchase intentions.

Agribusiness, *30*(3), 290–308. https://doi.org/10.1002/agr

Neta, E. R. D. C., Johanningsmeier, S. D., & McFeeters, R. F. (2007). The chemistry and physiology of sour taste - A review. *Journal of Food Science*, *72*(2), 33–38. https://doi.org/10.1111/j.1750-3841.2007.00282.x

Poursani, P., Razavi, S. M. A., Mazaheri Tehrani, M., & Javidi, F. (2020). Rheological, physical, and sensory properties of non-fat ice creams as affected by selected fat replacers. *Journal of Food Processing and Preservation*, (April), 1–11. https://doi.org/10.1111/jfpp.15010

Rolon, M. L., Bakke, A. J., Coupland, J. N., Hayes, J. E., & Roberts, R. F. (2017). Effect of fat content on the physical properties and consumer acceptability of vanilla ice cream. *Journal of Dairy Science*, *100*(7), 5217–5227. https://doi.org/10.3168/jds.2016-12379

Sacchi, R., Caporaso, N., Squadrilli, G. A., Paduano, A., Ambrosino, M. L., Cavella, S., & Genovese, A. (2019). Sensory profile, biophenolic and volatile compounds of an artisanal ice cream ('gelato') functionalised using extra virgin olive oil. *International Journal of Gastronomy and Food Science*, *18*, 100173. https://doi.org/10.1016/j.ijgfs.2019.100173

Spence, C., Navarra, J., & Youssef, J. (2019). Using ice-cream as an effective vehicle for energy/nutrient delivery in the elderly. *International Journal of Gastronomy and Food Science*, *16*, 100140. https://doi.org/10.1016/j.ijgfs.2019.100140

Spencer, M., & Guinard, J. X. (2018). The Flexitarian Flip™: Testing the Modalities of Flavor as Sensory Strategies to Accomplish the Shift from Meat-Centered to Vegetable-Forward Mixed Dishes. *Journal of Food Science*, *83*(1), 175–187. https://doi.org/10.1111/1750-3841.13991

Tran, N. M., Burdejová, P., Ospienko, M., & Härdle, W. K. (2019). Principal component analysis in an asymmetric norm. *Journal of Multivariate Analysis*, *171*, 1–21.

https://doi.org/10.1016/j.jmva.2018.10.004

Ullah, R., Nadeem, M., & Imran, M. (2017). Omega-3 fatty acids and oxidative stability of ice cream supplemented with olein fraction of chia (Salvia hispanica L .) oil. *Lipids in Health and Disease*, *16*(34), 1–8. https://doi.org/10.1186/s12944-017-0420-y

Vieira, F. G. K., De Salles, R. K., Mannes, P., Kami, A. A., Búrigo, T., Geraldo, A. P. G., & Moreno, Y. M. F. (2020). Development and Acceptance of an Ice Cream as Food Alternative for Cancer Patients. *Journal of Culinary Science and Technology*, *18*(2), 89–97. https://doi.org/10.1080/15428052.2018.1509752

Villamil, R., Robelto, G., Mendoza, M., Guzmán, M., Cortés, L., Méndez, C., & Giha, V. (2020). Development and health implications of functional dairy food products: A review. *Revista Chilena DieNutricion*, *47*(6), 1018–1028.

Yadav, G., David, J., Thakur, S. N., Shukla, S., Kumari, A., Yadav, V., & Shalini. (2020). Evaluation of sensory attributes in different levels of Tapioca in pro-biotic Ice cream. *The Pharma Innovation Journal*, *9*(February), 404–407. https://doi.org/10.22271/tpi.2020.v9.i1g.4313

Zago, L., Caldeira, R. M., Lima, C. F., Rosado, C. P., Campos, A. C., & Moura-Nunes, N. (2018). Qualidade tecnológica, nutricional e funcional de sorvete artesanal de limão siciliano elaborado com azeite de oliva extra-virgem como principal ingrediente lipídico. In *Avanços e Desafios da Nutrição no Brasil* (1st ed., pp. 342–358). Ponta Grossa: Atena Editora.

Zago, L., Squeo, G., Bertoncini, E. I., Difonzo, G., & Caponio, F. (2019). Chemical and sensory characterization of Brazilian virgin olive oils. *Food Research International*, *126*(July), 108588. https://doi.org/10.1016/j.foodres.2019.108588

Table 1. Microbiological analysis results.

Analysis	Results		
	BrEVOO	GrEVOO	RDC No. 12*
Thermotolerants coliforms/g (MPN/g)	< 3.0	< 3.0	5 × 10
Salmonella sp (absence/25 g)	Absent	Absent	Absent
Coagulase-positive *Staphylococcus*/g (CFU/g)	$< 10^2$	$< 10^2$	5×10^2

*RDC Resolution No. 12, of January 2, 2001, Brazilian legislation, (Brasil, 2001).

MPN/g: Most Probable Number per gram; CFU/g: Colony-forming Units per gram. BrEVOO: ice cream formulation with Brazilian extra virgin olive oil; GrEVOO: ice cream formulation with Greek extra virgin olive oil.

Table 2. Acceptance test (AT) and acceptability index (AI) of the ice creams (*n*=77)

	AT (mean ±SD)			AI (%)	
Sensory Attributes	BrEVOO	GrEVOO	*P**	BrEVOO	GrEVOO
Aroma	6.2 ± 1.5	6.1 ± 1.8	*p*>0.05	69	68
Flavor	5.6 ± 1.8	5.2 ± 1.9	*p*>0.05	62	58
Consistency	6.8 ± 1.9	6.7 ± 2.1	*p*>0.05	76	74
Appearance	7.0 ± 2.3	7.0 ± 2.4	*p*>0.05	78	78
Overall acceptance	5.9 ± 2.0	5.6 ± 2.2	*p*>0.05	66	62

SD: standard deviation, BrEVOO: ice cream formulation with Brazilian extra virgin olive oil; GrEVOO: ice cream formulation with Greek extra virgin olive oil.

*P** Student`s t-test (significance level of 5%).

Table 3. Ideal scaling of the sour taste and purchase intention test of the ice creams (*n*=77)

Formulation	Ideal scaling (%) of the sour taste			Purchase intention test (%)		
	Less than ideal	Ideal	More than ideal	I would certainly buy	I have doubts if I would buy	I would certainly not buy
BrEVOO	31	37	32	22	39	39
GrEVOO	29	47	24	23	43	34

BrEVOO: ice cream formulation with Brazilian extra virgin olive oil; GrEVOO: ice cream formulation with Greek extra virgin olive oil.

Figure 1. Flow chart of the process steps of the artisanal ice-creams.

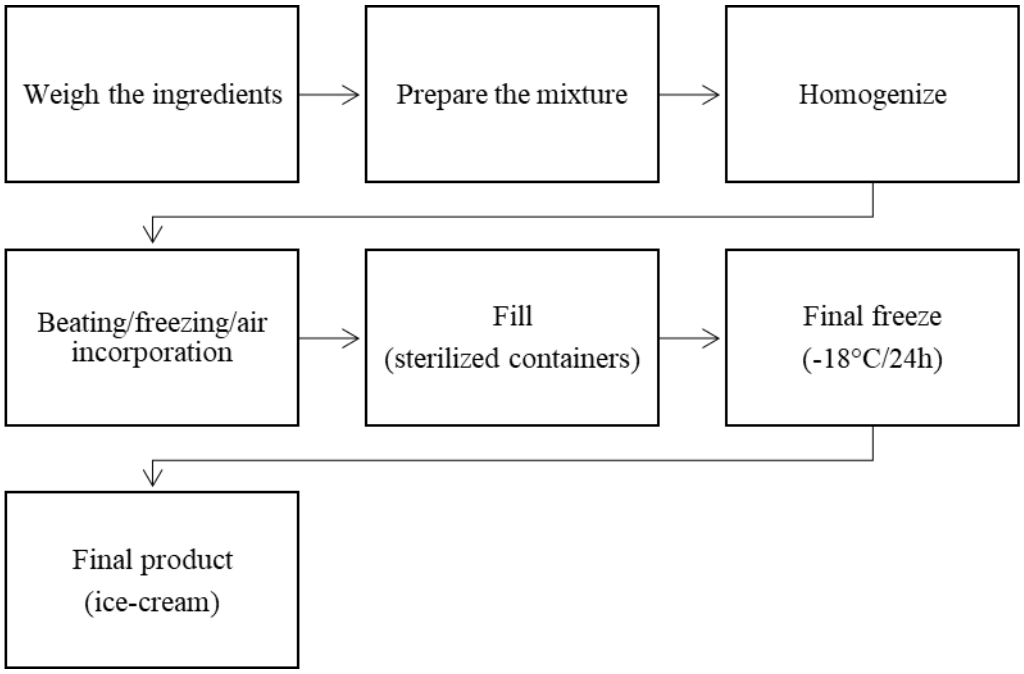

Figure 2. The distribution of sensory attributes of extra virgin olive oil ice creams according to PC1 and PC2.

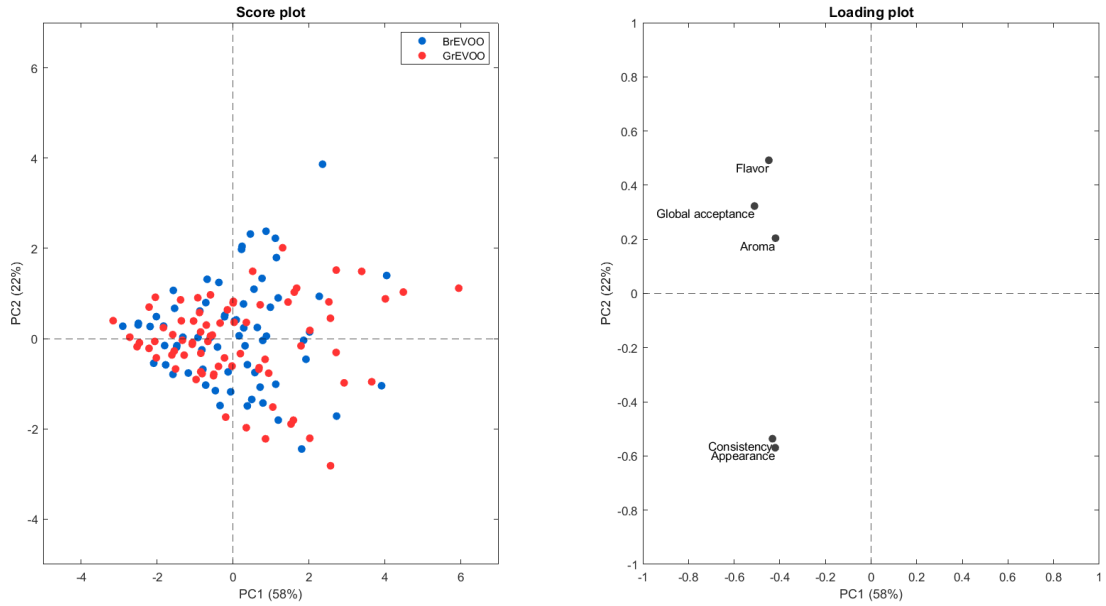

Figure 3. Regression coefficients ± confidence intervals (α = 0.05).

BrEVOO: ice cream formulation with Brazilian extra virgin olive oil; GrEVOO: ice cream formulation with Greek extra virgin olive oil.

* $p < 0.05$; *** $p < 0.001$ according to the Student's t-test.