Tesis para obtener el grado de
Maestra en Biotecnología

"Potenciación de sensaciones gustativas inducidas por el olor en alimentos para adultos mexicanos con peso normal y obesos"

Presenta: Tania Ortega Rico
Matricula: 2202800460
tan.or@hotmail.com

Asesores
Dr. Héctor Bernardo Escalona
Dra. Charlotte Sinding
Dr. Gustavo Pacheco López

Sinodales:
Dra. Patricia Severiano Pérez
Dr. Gustavo Pacheco López
Dr. Cesar Romero Rebollar
Dra. María Aurora Pintor Jardines

División de Ciencias Biológicas y de la Salud
Posgrado en Biotecnología
México, 30 marzo del 2023

Master's degree in Biotechnology

“Odor-induced taste enhancement in Mexican adults with obesity and normal-weight”

Project by: Tania Ortega Rico
2202800460

Supervised by: Dr. Héctor Bernardo Escalona Buendía (UAM-Iztapalapa) & Charlotte Sinding (Centre for Taste and Feeding Behavior - CSGA)

Advisor: Gustavo Pacheco Lopez (UAM- Lerma)

Mexico, 2023

The present project was carried out in the sensory analysis laboratory at the Universidad Autónoma Metropolitana (UAM), campus Iztapalapa, Mexico City.

This work started in the mid-2020, with the COVID pandemic, postponing the sensory evaluations in February 2022; followed by a research stay at CSGA-INRAE in France, Dijon from June to August and finally data analysis from September to November 2022. Despite the shortened time, the project could be performed successfully.

Acknowledgments

I would like to express my sincere gratitude to my supervisor Dr. Hector Bernardo Escalona Buendia who made this work possible, for his valuable support throughout the process and enormous enthusiasm.

I wish to extend my special thanks to the Dr. Charlotte Sinding, Dr Thierry Thomas-Danguin, Dr. Gustavo Pacheco and Marianela Santoyo for the motivation, knowledge and for giving me the confidence to working on this opportunity.

I would also like to give a special thanks to my dear family; my mother and father who always supported me in any situation and their confidence to carry out this project, to my dear sister for her advices and for being ever available for me and for my grandparents who always believed in me.

Thanks to my friends and classmates who always helped me in any problem, especially to Salvador Cruz, Araceli Arellano, Aurora Pintor and to my all the people involved in the sensory family.

RESUMEN

Potenciación de sensaciones gustativas inducidas por el olor en alimentos para adultos mexicanos con peso normal y obesos

El aroma y el gusto juegan un papel importante en la percepción del sabor, por lo tanto, la percepción de la sal y el azúcar pueden ser potenciadas a través de aromas congruentes al gusto percibido. OITE (Odor-induced taste enhancement), por sus siglas en inglés, es un fenómeno que se deriva de la integración del gusto y del olor tendiendo como resultado la percepción del sabor.

En este trabajo se utilizó el fenómeno OITE para potenciar el sabor dulce y salado en personas de peso normal (PN) y con obesidad (OB) usando pruebas de ordenamiento (Ranking test), además se evaluó el agredo, familiaridad y se aplicó escala justo como lo esperaba (JAR) a las soluciones con odorante. Asimismo, los participantes llenaron dos cuestionarios sobre comportamiento alimentario (DEBQ & DFS). Treinta y nueve personas de peso normal (PN: 25 kg/m^2< IMC) y treinta y cinco personas con obesidad (OB: IMC ≥ 30 kg/ m^2) participaron en evaluaciones sensoriales las cuales se dividieron en dos sesiones; sesión dulce y sesión salada. Para la parte dulce, los participantes evaluaron dos bases; el agua de Jamaica y el jugo de manzana, agregando los odorantes “vainilla mx”, “golden syrup” y “sugar type” para la base agua de Jamaica y el odorante “vainillina fr” para la base jugo de manzana. En el caso de la parte salada, los participantes evaluaron tres bases; el chayote, el maíz y chicharos con los odorantes “tocino mx” y “res” para la base chayote, odorante “cebolla frita” y “cilantro” para la base maíz y odorante “tocino fr” para la base de chicharos. Cada clasificación se realizó con 4 soluciones, 3 con una concentración creciente de sal/azúcar (S1 a S3), y la cuarta contenía la menor concentración de azúcar/sal con un odorante añadido. Los participantes tenían que clasificar las 4 botellitas según la intensidad de la dulzura o la salinidad. Los resultados mostraron que las personas con obesidad experimentaron una ligera mayor tendencia a percibir una mejora de la dulzura inducida por el olor que las personas de peso normal. En contraste, las personas con peso normal mostraron una tendencia ligeramente mayor a percibir una mejora en la salinidad inducida por el olor que las personas obesas.

ABSTRACT

Odor-induced taste enhancement in Mexican adults with obesity and normal-weight

Odor and taste play an important role in flavour perception and it is well known that the chemical composition of the matrix and consequently its structure influences release and perception of flavour. OITE (Odor-induced taste enhancement), is a phenomenon that derives from the integration of taste and odor into flavor perception in order to enhance the taste perception.

In this work, the OITE phenomenon was used to enhance the sweet and salty taste in people of normal weight (PN) and with obesity (OB) using ranking tests. In addition, pleasantness, familiarity and JAR scale was applied with solutions with odorant. Moreover, participants filled out two questionnaires on eating behaviour (DEBQ & DFS). Thirty-nine people of normal weight (PN: 25 kg/m^2 < BMI) and thirty-five obese people (OB: BMI ≥ 30 kg/m^2) participated in sensory evaluations which were divided into two sessions; sweet session and salty session. For the sweet part, the participants evaluated two bases; Jamaicas water and apple juice. The “vanilla mx”, “golden syrup” and “sugar type” odorants were added to the Jamaica water base and the “vanillin fr” odorant were added to the apple juice base. In the case of the salty part, the participants evaluated three bases; the chayote, corn and green peas with the odorants "mx bacon" and "Beff" to the chayote base, odorant " onion fried" and "coriander" to the white corn base and odorant "bacon fr” for the green pea base. Each ranking was performed with 4 solutions, 3 with increasing salt/sugar concentration (S1 to S3), and the fourth contained the lowest sugar/salt concentration with an odorant added. The participants had to classify the 4 bottles according to the intensity of sweetness or saltiness. The results showed that people with obesity (OB) experienced a slight tendency to perceive a higher odor induced sweetness enhancement than normal weight people (NW). In contrast, people with normal weight showed a slightly higher trend to perceive odor induced saltiness enhancement than obese people.

1.1 Odor-taste interaction 9
1.2 Odor-induced taste enhancement (OITE) 10
1.3 Odor-induced sweetness enhancement (OISwE) 12
1.3.1 Sweet taste preferences in consumers 13
1.3.2 Sweetener effects 14
1.4 Odor-induced saltiness enhancement (OISaE) 16
1.4.1 Preferences for salty taste 17
1.4.2 Substitutes for salt 18
1.5 Sensory methods for taste evaluation 18
1.5.1 Descriptive Sensory Evaluation 19
1.5.2 Affective Sensory Evaluation 19
1.5.3 Discriminative Sensory Evaluation 20
1.6 The Perception of Flavor 21
1.6.1 Olfactory perception of food 22
1.7 Sugar and salt regulation in Mexico (NOM-051) 23
2. Justification 23
3. Hypothesis 24
4. Objectives 24
4.1 General 24
5. Material and methods 25
A) Material 25
i) Participants 25
ii) Solutions 27
a) Pre-test 27
b) General test 31
B) Methods 32
i) Pre-test 32
ii) General test 33
6. Results and discussion 39

i) Pre-test 39

ii) General test 43

6. Conclusion 71

7. Annexes 73

Bibliography 82

1. Introduction and background

1.1 Odor-taste interaction

We know that odor and taste are essential elements to be able to choose one food or another. Flavour perception is determinant for the acceptability of food products by consumers (Tournier et al. 2007). Perceptions of the flavors of foods or beverages reflect information derived from multiple sensory afferents, including gustatory, olfactory, and somatosensory fibers (Small & Prescott, 2005).

Odor and taste play an important role in flavour perception and it is well known that the chemical composition of the matrix and consequently its structure influences release and perception of flavour (Tournier et al., 2007). Eating is a multisensory experience where inputs from different sensory modalities are combined to make a judgment. Research on cognitive integration of food sensory qualities revealed that food sensory cues are integrated across different sense modalities (Nanay, 2017). Senses are activated not only by means of corresponding sensory cues but also via cross-modal interactions with non-corresponding sensory cues. For instance, hearing a coffee machine can trigger a sensation of the taste of coffee without any exposure to the sensory taste of the coffee. The auditory input of the sound of the coffee machine triggers, via a cross-modal interaction with the gustatory sense modality, a gustatory mental sensation of coffee.

Both smell and taste respond to chemical stimuli, one of the ways of perceiving odors that greatly influences taste is the retronasal route. When smells are perceived in this way, they are known as aromas, referring to the sensation due to the perception of volatile substances by the nose through the retronasal route once the food has been introduced into the mouth. The olfaction through retronasal route is maximal when exhaling and enables us to receive the qualities of the products that we have just ingested. Aromas can through interactions in the brain influence the taste, and after integration with taste produce the flavor. (Barba et al., 2018).

Studies in neuroscience have shown that taste and smell inputs are processed conjointly in the same zone of the cerebral cortex, and that taste perception is often an outcome of this conjoint cognitive processing of olfactory and gustatory inputs (Panksepp, 2004).

1.2 Odor-induced taste enhancement (OITE)

The sense of smell plays a major role in flavour perception, information coming from the gustatory and the olfactory systems are likely to be combined at a higher level of processing in the brain to give rise to a unique perception referred to as 'flavour' (Abdi, 2002). We experience food as a unitary perception, which we commonly call "taste". This common "taste" is actually a holistic perception of at least olfactory and gustatory inputs, called "flavor perception". Sugar, salt and fat are decisive for food acceptability. A reduction of salt and sugar often results in poor food acceptability. However, it is known that sugar and salt perception can be enhanced by aroma, Odor-induced taste enhancement (OITE) is a phenomenon that derives from the integration of taste and odor into flavor perception (Sinding et al., 2021). For enhancements to occur, it is believed that the taste and aroma must be harmonious or congruent with each other (Schifferstein & Verlegh, 1996). It is possible for congruency to arise from learning through repeated exposure to a particular aroma and taste combination (Prescott, 2012). During the perception of a congruent mixture of taste and aroma, it is thought that cross modal interaction is integrated in specific areas of the brain.

Odor-induced taste enhancement has been reported by researchers who explained the phenomenon as a result of perceptual interactions between taste and odor and it has been reported for solid and liquid items (Laaksonen et al. 2016).

It has been suggested that obese subjects are more sensitive than lean subjects to odors associated with food. For example, Proserpio et al., (2017), found the increasing concentration of butter aroma without the addition of calories, were perceived in a more intense way by people living with obesity (OB) than normal weight people (NW). Obese individuals perceive sensory characteristics in a different way as normal-weight subjects do because of the altered taste sensitivity often reported in individuals with a higher Body Mass Index (BMI) (Bertoli et al., 2014). The fact that the OB group perceived the salty solutions as less salty than the NW group possibly reflects higher dietary levels of salt in the OB group diet. In fact, previous studies have shown that salt intensity ratings are dependent upon the level of salt consumed habitually, in that higher salt consumption leads to lower intensity scores. A similar explanation might also be true for the lower sucrose intensity scores in the OB group. Indeed, individuals who have a lower sensitivity for sweetness have a higher intake of added sugar (Duffy, Peterson, Dinehart, & Bartoshuk, 2003).

Gender in terms of odor detection, women are more sensitive in odour detection, identification, discrimination, and memory tests than men (Doty & Cameron, 2009), also they perform better than men in olfactory functions. The addition of butter aroma in the custard dessert that OB women were found to perceive the sweetness, vanilla flavour and creaminess more intense than OB men (Proserpio et al., 2017, 2016). Obese women gave to samples added with butter aroma liking scores that were higher than normal weight women, supporting the hypothesis that a greater liking could result in more consumption of this type of product by overweight women.

Cultural factors are one of the most powerful determinants of which food we consume. Nevertheless, there has been surprisingly little research on how perception of, and preference for food might vary across cultures. (Valentin et al., 2006).

Le Mée (2006) reported cross-cultural perceptual differences between French and a Chinese panel in their description of biscuits, some flavour attributes perceived by the French panel were not relevant to the Chinese panel. In another study, Nguyen et al., (2001), showed that for French subjects sweetness enhancement was higher in the presence of vanilla than of lemon, the opposite was observed for

Vietnamese subjects. Vanilla is very often used in France to flavour sweet dishes but not in Vietnam. In contrast, the association between lemon and sweet is less frequent in France than in Vietnam where lemon soft drinks are very popular. Moreover, for French subjects, strawberry is more often associated with a sour taste or a red colour than with a sweet taste as it is for American subjects (Sauvageot et al. 2000). The association between strawberry and sweet is very frequent in American food (milk shake, ice cream, yogurts), it is less frequent in French food.

In this way, it is possibly to understand that the ability of an odour to enhance taste does not seem to be universal: An efficient sweet taste enhancer in a given culture might not be as useful in another one.

1.3 Odor-induced sweetness enhancement (OISwE)

An odour-induced taste enhancement is said to occur if the perceived sweet intensity of the mixture is greater than the perceived sweet intensity of the sweetener alone. Inversely an odour-induced taste suppression is said to occur if the perceived sweet intensity of the mixture is smaller than the perceived sweet intensity of the sweetener alone. Odor-induced sweetness enhancement permits a reduction of sugar by especially aromas that have been shown to be a potential sweetness enhancer in several studies.In this context, taste odor interaction refers to a modification in perceived taste intensity in the presence of an odor (Valentine et al., 2006). For instance, participants exposed to the smell of vanillin, which is an extract of vanilla, had higher ratings of sweetness and taste pleasantness than participants not exposed to it. The exposure to food-congruent smells has led also to stronger salivation and to the consumption of higher quantities of food (Krishna et al., 2014). In the same way, a sweet solution will taste sweeter in the presence of a vanilla aroma even though the vanilla aroma does not activate taste receptors. It seems that sweet taste perception might be modified in the presence of an odour and that this effect is not due to changes in the physico-chemical properties of tastants in the presence of odorants since it can be observed when odorants and tastants are presented separately.

Frank and Byram (1988) reported that the perceived sweetness of whip cream samples increased when a strawberry aroma was added. The same type of effect was obtained by other authors in presence of several aromas including almond, caramel, coffee, lemon, peach and vanilla and for several sweeteners such as sucrose, fructose, aspartame and saccharine. Also, Cliff and Noble (1990) using a peach aroma showed that increasing the concentration of aroma increased not only the intensity of perceived sweetness of a glucose solution but also its duration.

Thai et al. (2011) found that smelling vanillin enhances the perceived sweetness and the consumption of sugar-free pastry. Other odors such as chocolate and cinnamon are found to enhance sweetness perception and boost consumption of pastry (Koubaa, 2017).

Smelling congruent food odors enhances taste perception and boosts consumption (Valentine et al. 2006) and Lui et al., (2021) examined some aroma-active compounds in brown sugar that could enhance sweetness.

The most recent study by Aveline et al (2022), evaluated odour induced sweetness enhancement (OISwE) using sweet base solutions; apple juice, cocoa and water adding an odorant to the solutions. As a result obese people experienced OISwE in the apple juice with vanillin odorant but not the normal weight people, oppositely with vanilla odorant OITE was found only in normal weight people. In the cocoa beverage, the frenchvanilla and furaneol odorant produced OISwE in obese people but not in Normal-weight people.

1.3.1 Sweet taste preferences in consumers

Human desire for sweet taste spans all ages, ethnicities, and cultures, a variety of factors ranging from genetics and race/ethnicity to nutritional deficiencies, chronic disease, medication use, and addictions, the positive hedonic response to sweet taste is a universal trait (Bartoshuk, et al., 2006). Throughout evolution, sweetness has had a role in human nutrition, helping to orient feeding behavior toward foods providing both energy and essential nutrients. Infants and young children in particular base many of their food choices on familiarity and sweet taste (Drewnowski et al., 2012).

The most striking effect was that young children liked more intensely sweet solutions than did adults, with the more adult-like pattern emerging only during adolescence (Desor et al, 1987). For example, in a recent study of 930 participants, children preferred 11 teaspoon (~44 g) of sugar in an 8-oz (240 mL) glass of water, nearly twice the sugar concentration of a typical cola.

The appetite for sweet-tasting foods and drinks can take place in the context of a healthy motivation of intake, and control mechanisms (alliesthesia, sensory-specific satiety, postingestive hormonal changes, etc.) can effectively suppress appetite (wanting) for sweet-tasting products (Frankham et al., 2005; Brondel, 2007).

Studies suggest that men prefer higher sweet intensities than women (Monneuse, 1991) also the liking for sweetness may change during the course of a meal. Sweetness preferences are reported to be higher before a meal than after a meal, reflecting perhaps the organism's need for energy (Laeng et al., 1993). Persons who frequently consume sweet-tasting products show a preference for sweeter beverages when tested in the laboratory; this effect is the same for frequent consumers of non nutritive and nutritive sweeteners (Mahar & Duizer, 2007).

1.3.2 Sweetener effects

Sweeteners can be classified into calorie, low-calorie and non-calorie compounds. Calorie-sweeteners include natural sugars (Grembecka, 2015), such as sucrose, glucose, fructose, maltose, lactose, and trehalose. They are mainly present in fruits, honey, milk, dairy products, and mushrooms (Rippe, 2010) and their caloric values is on average 4 kcal/g. Their sweetening power is measured in relation to sucrose, which is considered as a reference sugar (Fitch, 2012). Low calorie and non-calorie sweeteners provide no or few calories and are characterized by a high sweetness taste. Low-calorie sweeteners include polyols or sugar alcohols, which are low-digestible compounds obtained from the replacement of an aldehyde group with a hydroxyl one (Billaux et al., 1991). The most common polyols are sorbitol, xylitol, maltitol, mannitol, erythritol, isomalt, and lactitol; they are naturally found in fruits, vegetables, and mushrooms (Grembecka, 2015). Non-calorie sweeteners (also known as artificial sweeteners) are mostly obtained by chemical synthesis (except Stevia rebaudiana), and are characterized by minimal or absent nutritional content (Fitch, 2012). They include saccharin, aspartame, acesulfame-k, and sucralose (Shwide-Slavin et al., 2012).

Artificial sweeteners have also been added to a plenty of foods for those who want a sweet taste without the calories. These sweeteners range from about 180 times sweeter to as much as 13,000 times sweeter than sugar. Recent research has linked artificial sweeteners to a number of health problems, including metabolic syndrome, a decrease in kidney function, and possibly even a disruption in the regulation of blood sugar caused by changes in the microbiota (Bartolotto, 2015).

The negative impact of consuming sugar-sweetened beverages on weight and other health outcomes has been increasingly recognized; therefore, many people have turned to high-intensity sweeteners like aspartame, sucralose, and saccharin as a way to reduce the risk of these consequences. However, scientific consensus has emerged suggesting that consumption of sugar-sweetened products, especially beverages, is casually linked to increases in risk of chronic, debilitating diseases including type 2 diabetes, cardiovascular disease, hypertension and stroke (Swithers, 2013). One approach that might be beneficial would be to replace sugar-sweetened items with products manufactured with artificial sweeteners that provide sweet tastes but with fewer calories. Unfortunately, evidence now indicates that artificial sweeteners are also associated with increased risk of the same chronic diseases linked to sugar consumption. Several biologically plausible mechanisms may explain these counterintuitive negative associations. The use of artificial sweeteners may also be particularly problematic in children since exposure to hyper-sweetened foods and beverages at young ages may have effects on sweet preferences that persist into adulthood (Swithers, 2015).

1.4 Odor-induced saltiness enhancement (OISaE)

Odor-induced saltiness enhancement is a way to reduce the amount of NaCl in food. In recent years, health concerns related to salt have led to extensive research on low-salt foods. One major remaining issue is to reduce sodium content while still providing the salty fix, to maintain food appreciation, acceptance and choice.

The overconsumption of salt is a global health issue and widely recognized for contributing to cardiovascular diseases, stroke, and renal diseases (He & MacGregor, 2009). A high sodium diet leads to water retention and a consequent increase in blood volume that might trigger an elevation in blood pressure (Strazzullo et al., 2009). It is well established that high-salt (1 g salt=0.4 g sodium) intake is the major cause of raised blood pressure and accordingly leads to cardiovascular diseases. High salt intake is the major cause of raised blood pressure and accordingly leads to cardiovascular diseases. Recently, it has been shown that high salt intake is associated with an increased risk of obesity through sugar-sweetened beverage consumption (Ma et al., 2015).

One of the main consequences of decreasing salt content is that the sensory characteristics are affected. Sodium chloride has also a role in, e.g. texture, aroma release, plays a major role in protecting food against microorganisms (Taormina, 2010) and as a fermentation aid. As a consequence, decreasing salt in food leads, most of the time, to a decrease in food acceptability by consumers (Breslin & Beauchamp, 1997).

Using well-selected odours has been proposed to compensate for sodium chloride reduction in food, due to the cross-modal interactions between odour and taste (Nizar et al. 2021). It has been used several salty aromas just like smoked bacon

(Merlo et al, 2021), soy sauce (Ting et al. 2021), beef stock (Sinding et al., 2021), sardine (Syarifuddin, 2016) are some examples of this.

Aveline et al., (2022) evaluated green pea soup and salty water with different odorants to saltiness enhancement. Normal weight and obese people experienced OITE phenomenon by the bacon odorant in the green-pea soup, but not with smoked garlic odorant.

Altered salt perception may be a risk factor for, or a result, of obesity, as altered salt taste perception has been reported in obese individuals by some investigators but not by others (Bobowski, 2015; Yoon 2012; Yi, 2014).

Whether salt taste perception is different in obesity remains uncertain due to mixed psychophysical findings. Several studies showed no significant salt taste sensitivity differences between individuals with and without obesity (Bertoli, 2014).

In studies that report differences, some of them show higher salt sensitivity in obese individuals compared to those without obesity. Yet, other studies report lower salt sensitivity in obese individuals compared to those without obesity. Additionally, studies on salt taste preferences have yielded mixed results in individuals with obesity. These discrepancies may be due to methodological differences.

1.4.1 Preferences for salty taste

International recommendations suggest that for the average person, salt (NaCl) intake should be less than 5–6 g per day (WHO, 2007). The average current daily consumption is approximately 10–12 g of NaCl per day, while an intake of 3 g of NaCl per day would be sufficient.

It has been reported that consumers view low-sodium products as bland, tasteless, and boring (Malherbe, 2003). Further, a high-sodium diet may lead consumers to have a preference for high-sodium foods (Kim and Lee, 2009).

A study conducted by Kim and Lee (2009) found that participants who reported a liking for soups or stews that were high in sodium showed a preference for significantly saltier soup ($P = 0.010$) compared with those who were not frequent fast-food consumers.

1.4.2 Substitutes for salt

Various methods have been proposed to reduce the salt content in food. For example, there is a widespread concern about salt substitutes, i.e. KCl, which allow reduction of the NaCl content by up to 50% in meat products (Desmond, 2006). However, KCl has negative sensory characteristics, such as strong bitterness, weak saltiness, and metallic properties (Desmond, 2006). Despite these findings, the total or partial substitution of sodium chloride by potassium chloride has been widely used for many foods (Toldrá & Barat, 2009).

1.5 Sensory methods for taste evaluation

Sensory evaluation involves the development and use of principles and methods for measuring human responses to food (Sidel et al., 1981). Sensory evaluation has been defined as scientific discipline used to evoke, measure, analyze, and interpret reactions to those characteristics of foods and materials as they are perceived by the senses of sight, smell, taste, touch, and hearing.
Sensory evaluations may be divided into three groups based on the type of information that they provide; discrimination, descriptive, and affective.

1.5.1 Descriptive Sensory Evaluation

Descriptive analysis is a method used to objectively describe the nature and magnitude of sensory characteristics.

Labeled scales are commonly used for between-groups comparisons. The labels consist of adjective/adverb intensity descriptors (e.g., a "very strong"). The relative distances among descriptors are essentially constant but the absolute perceived intensities they denote vary with the domain to which they are applied (e.g., a "very strong" rose odor is weaker than a "very strong" headache), as if descriptors were printed on an elastic ruler that compresses or expands to fit the domain of interest. Variation in individual experience also causes the elastic ruler to compress or expand. Finally some innate behaviors or preferences might be encoded genetically: super-tasters perceive the most intense tastes; nontasters, the weakest; and medium tasters, intermediate tastes (Bartoshuk et al., 2004).

Another scale used for descriptive sensory evaluation is the Just about right (JAR) scales that measure the appropriateness of the level of a specific attribute, and are used to determine the optimum levels of attributes in a product (Lawless, 1998). Consumers are asked whether a sensory characteristic of a product (e.g., saltiness/ sweetness) is too high, too low, or just about right.

1.5.2 Affective Sensory Evaluation

In this evaluation, includes acceptance/preference testing of the sample. Within the affective tests are the hedonic scales that are well tried and tested in consumer research for capturing liking data (Stone and Siddel, 1985). In consumer tests, the nine-point hedonic scale has been widely employed for data collection, however, previous studies have indicated a better performance of the linear hedonic scale as compared to the nine-point hedonic scale.

Unstructured or linear hedonic scales are represented by a line, anchored at their extremes with the minimum and maximum degrees of acceptance (disliked extremely and liked extremely). The line size may vary according to the test requirements. Very short lines can reduce the power of discrimination of products by judges, while very long lines prevent the judges from being accurate in their assessments (Pimentel, 2016). The use of unstructured or linear hedonic scale has the advantage of giving judges more freedom to express their sensory perceptions; reduce contextual effects; accurately assess the acceptance, because it is possible to mark any point on the scale.

1.5.3 Discriminative Sensory Evaluation

In the ranking test, assessors are asked to order a selection of coded samples in increasing or decreasing intensity/pleasantness/typicity of a specific perceived sensory attribute. Samples are randomized across the assessors (O'Sullivan, 2017). Ranking test was used for classify the intensity of saltiness or sweetness of the samples given, from the less intensity to the most intensity of salt/ sweet perception.

In previous test, R-index analysis was used to evaluate the ranking test. The R-index measures the degree of difference between a standard or control sample, designated as the 'noise' sample, and a comparison sample, designated as a 'signal' sample,. It measures the probability of effectively distinguishing between two samples in a paired comparison. A value of 1.0 indicates that the samples are perfectly discriminable, while a value of 0.5 indicates that the samples cannot be distinguished. For confounded samples, R-indices range between these two, higher values indicating better discrimination. The noise sample is generally taken as the sample having the lowest intensity of the attribute in question, while 'signal' samples have higher intensities. (Cliff et al., 2000).

Therefore, the R-index procedure presents some advantages in the sensory differentiation of two food products, although traditional tests of this type are quick and brief. The most important advantage of the R-index procedure is in multiple differentiation tests, where several similar samples are compared to determine the degree of differentiation between them and with a standard (Escalona, 1995).

1.6 The Perception of Flavor

What most people refer to as “taste” when describing their experience of food (“That tastes good, Mom”) is usually a combination of taste, from stimulation of the receptors in the tongue, and olfaction, from stimulation of the receptors in the olfactory mucosa. This combination, which is called flavor, is defined as the overall impression that we experience from the combination of nasal and oral stimulations (Lawless, 2001). Flavour is arguably the most fascinating aspect of eating and drinking. It uses a complex variety of senses and processes, that incredibly work together to generate a unified, and hopefully pleasurable, experience (Stevenson, 2010).

Taste perception occurs during gustation as taste active compounds stimulate taste receptors on the tongue. Most taste researchers describe taste qualities in terms of five basic taste sensations: salty, sour, sweet, bitter, and umami (which has been described as meaty, brothy, or savory, and is often associated with the flavor-enhancing properties of MSG, monosodium glutamate) (Goldstein,2010).

Gustation refers to the sense of taste, corresponding to the sensation produced when tastants interact with taste receptors of taste receptor cells located on taste buds in the oral cavity, mainly on the tongue but also on the soft palate, and in the pharyngeal and the laryngeal regions of the throat (Breslin & Huang , 2006).

Sweetness refers to gustatory perception, or to taste impressions that result from stimulation of the taste receptors located primarily on the tongue. Sweet compounds cause an automatic acceptance response and also trigger anticipatory metabolic responses that prepare the gastrointestinal system for processing these substances.

On the other hand, salty tastes often indicate the presence of sodium, when people are deprived of sodium or lose a great deal of sodium through sweating, they often seek out foods that taste salty in order to replenish the salt their body needs (Goldstein,2010). Moreover, Sodium chloride, once dissociated into ions (individual atoms that carry an electrical charge), imparts salt taste. It is now widely accepted that it is the sodium ion (Na^+) that is primarily responsible for saltiness, although the chloride ion (Cl^-) plays a modulatory role (Bartoshuk, 1980).

1.6.1 Olfactory perception of food

In addition to tastants, food and drink release volatile chemicals that reach the olfactory mucosa by the retronasal route, from the mouth through the nasopharynx, that connects the oral and nasal cavities. Although pinching the nostrils does not close the nasal pharynx, it prevents airflow between mouth and nose and odorants cannot reach the olfactory receptors (Murphy & Cain, 1980).

The fact that olfaction is a crucial component of flavor may be surprising because the flavors of food seem to come from the mouth. It is only when we keep molecules from reaching the olfactory mucosa that the importance of olfaction is revealed. One reason for this mislocalization of flavor is because food and drink stimulate tactile receptors in the mouth, which creates oral capture, in which the sensations we experience from both olfactory and taste receptors are referred to the mouth (Small, 2005). Thus, when you "taste" food, you are usually experiencing flavor, and the fact that it is all happening in your mouth is an illusion created by oral capture (Todrank & Bartoshuk, 1991).

1.7 Sugar and salt regulation in Mexico (NOM-051)

Official Mexican Standard NOM-051-SCFI/SSA1-2010, General labeling specifications for pre-packaged food and non-alcoholic beverages-Commercial and health information.

Mexico Releases Clarifications to NOM-051 Labeling, the purpose of this Official Mexican Standard is to establish the commercial and health information that must appear in the labeling of prepackaged products intended for the consumer, whether manufactured in Mexico or abroad, marketed in national territory, as well as to determine the characteristics of such information and to establish a front labeling system, which must clearly and truthfully warn about the content of critical nutrients and ingredients that represent health risks in excessive consumption (NOM, 2020).New labeling consists of five stamps when a product has excess calories, sodium, trans fats, sugars and saturated fats. The amount of these nutrients in the products will be tagged based on the Nutrient Profile of the Pan American Health Organization (PAHO), when they exceed the amount of sugars, saturated fat, trans fat, sodium and calories.

It will be considered excess of sodium when the product contains ≥ 350 mg sodium in 100g or 100 ml. On another hand, excess of sugar when the product contains ≥10 kcal of free sugar in 100g or 100 ml.

The selections of the appropriate evaluations were based on clearly defined objectives for the project; descriptive and affective test were required to measure the level of familiarity, the salt/sugar intensity perceived and the pleasantness of the sample given. Moreover, for discrimination evaluation, ranking test was performed by the panelist.

2. Justification

The overconsumption of salt and sugar are a global health issue that could contribute to cardiovascular diseases, stroke, renal diseases and obesity. Various methods have been proposed to reduce the salt and sugar content in food, however they may have consequences; sugar substitutes may also be harmful and salt substitutes have negative sensory characteristics. Therefore, looking for a strategy to reduce sugar or salt without losing acceptability appear as a relevant objective to improve health, and the odour-induced taste enhancement could be a relevant strategy to reach this goal.

3. Hypothesis

To the best of our knowledge, just few researchers studied odor-taste interactions in people with obesity compared with normal weight people for sweetness (Proserpio et al 2017; Aveline et al., 2022) and for saltiness (Aveline et al., 2022) and there is no investigation about odor induced taste enhancement studied with Mexican population. We wanted to contribute to these studies by comparing the enhancement effect of 4 sweet and 5 salty-associated odors in obese and normal weight people with simple (water) and complex bases (Jamaica water, apple juice, chayote, white corn and green peas). Based on the mentioned studies, we hypothesized that it is possible to enhance the perception of taste sensations in food bases through aromas in Mexican population, possibly finding a higher odor induced sweetness and saltiness enhancement in obese people in comparison with normal weight people.

4. Objectives

4.1 General

This research is related to French EATERS project (PI: C Sinding) from (INRAE-CSGA) which investigated the sensory and neurobiology of odour induced taste enhancement, the brain mechanism of flavour perception in people with obesity and normal weight. Moreover, this investigation is in collaboration with Mexican researchers (UAM-Iztapalapa/Lerma) and was part of a PhD thesis (M. Santoyo) to highlight the impact of culinary traditions on “Odour induced taste enhancement”, comparing the French and Mexican obese and normal weight populations that was approved by the ethical committee by the reference number CEI.2022.009

The main objective of this project was to identify one or more solutions (salty and sweet) for the odour-induced taste enhancement for Mexican population with different body weight (normal weight vs people living with obesity).

4.2 Specific

- To validate the concentration of the odorants that achieves a greater enhancement of the sweet and salty taste.
- To compare the effect of different odorants to enhance the sweet and salty taste.
- To compare the behavior odor-induced taste enhancement in normal-weight and in obese people.

5. Material and methods

A) Material

i) Participants

The number of participants estimated to obtain a confidence level of 75% was a minimum of 31 participants (calculated by Sample Size Calculator https://calculator.net/). This means 31 or more sensory evaluations are needed to have a confidence level of 75% that the real value is within ±10% of the measured/surveyed value. We recruited 46 normal weight people and 49 people living with obesity. However, participants who performed very poorly on rankings (70% of bad ranking performing) were excluded because we supposed they did not understood the instructions (a good ranking was S1<S2<S3), S1, S2 and S3 represent the three levels of tastants’ concentration. At least 74 people participated in this sensory evaluation; 33 men (19 to 42 years old) and 41 women (18 to 40

years old), we evaluated 39 normal weight (NW: 25 kg/m^2< body mass index) and 35 participants living with obesity (OB: body mass index ≥ 30 kg/m^2). In order to categorize between normal weigh and people with obesity, participants were asked to take off their shoes to be weighed (kg) and measured (m^2), in this way body mass index (BMI) was calculated using the formula MBI= (weigh)/ ($height^2$). The majority of participants came from Iztapalapa and Estado de Mexico region and the average of educational level is mostly bachelor's degree.

Participants were recruited by flyers (e-mails). Before the sensory evaluation participants should not eat, drink or smoke at least 1 hour 30 min before the sessions. The experimental procedure was explained to each participant before recruitment and before each test session. If they were agreed about the information sheet, they had to sign an informed consent document and at the end they received a present for the time spent performing the study.

Study inclusion criteria:

- AGE: Age range between 18-60 years (increased possibility of olfactory system deficiency after 60 years, see Sorokowska et al., 2017).

Study exclusion criteria:

- Body mass index (BMI> 18.5kg / m^2) (IOM, 2009).
- Pregnancy or breastfeeding
- Bariatric surgery.
- Food allergies
- Neurodegenerative diseases (Parkinson, Alzheimer).
- Neurological problems (example: head trauma).
- Cardiovascular disease
- Hypertension.
- History of eating behavior problems (anorexia, bulimia).
- Type 1 or 2 diabetes.
- Psychiatric problems with treatment (bipolar disorder, schizophrenia).
- Diet without sugar or salt
- Special diet - self restrictive (Vegetarian, vegan).
- To have continuously resided more than 90 days abroad.

- Chronic sinusitis
- Person who cannot move without help
- Protected adults under guardianship or conservatorship
- People with intellectual disabilities who do not allow a good understanding of the requested tasks.
- Neurological disorders.
- To have progressive cancer being treated (excluding hormone therapy)
- To have a congenital or acute immunosuppression (for example: HIV, malignant hemopathy due to organ transplantation ...)
- Being on dialysis or having severe chronic kidney disease
- To have a chronic respiratory disease.
- To have cirrhosis
- To have severe sickle cell syndrome or have a history of splenectomy.

ii) Solutions

a) Pre-test

We selected 3 Mexican products that were usually eaten by Mexican people; we chose white corn and chayote for salty products and Jamaica's water for sweet products. All the food bases (Mexican products) were traditionally prepared to finally get them in liquid form.

Pre-tests were performed with 8 to 10 internal panelists to the UAM laboratory. They evaluated salty and sweet base solutions to determine the sugar/salt concentrations and the odorants choices.

The objective of the pretest was to identify the best OITE solutions that enhance the taste perceptions to apply to the general test.

Sweet beverages

The preparation for the concentrated Jamaica's water was made following the steps below (Fig. 1). The Jamaica's water was the only food base that was not centrifuged because it was liquid since the beginning.

1. Boil 1.5 L of water in a container.
2. Weight 200 grs of Jamaica's flower.
3. Add Jamaica's flower in the well.

4. Let infuse for 5’ in stirring mode.
5. Filter once using the strainer.
6. Finally, the concentrated solution of Jamaica’s water is obtained.

Fig. 1. Preparation for the concentrated Jamaicas water

We were focus on obtain the ideal Jamaica’s water with the most popular Jamaica and sugar concentrations. 12 solutions of Jamaica’s water were prepared; 4 water solutions each with different concentrations of Jamaica’s flower, and 6 sugar concentrations (Table 1). The sugar and jamaica concentration proposed were established by traditional recipes of Mexican people.

Table 1. Solutions with different concentrations of Jamaica and sugar

	Jamaica concentration (w/v)	Sugar concentration (w/w)
Solution 1	1.9 %	4%
		8%
		12%
Solution 2	2.4 %	8%
		12%
Solution 3	2.9 %	3%
		6%
		9%
		12%
Solution 4	3.3 %	4 %

	8 %
	12 %

Salty beverages

Concerning to the salty bases, we focused in prepared a typical chayote soup. Based on this we used chayote puree incorporating water, following the steps indicated below (Fig. 2).

1. Chayote puree (Gerber) is weighed
2. Add 8 grams of water for each 10 grams of chayote puree
3. Blend until get a homogeneous puree and prepare vials for centrifugation
4. Centrifuge the vials at 13,000 RPM, at 6°C for 15 min, maximal acceleration at the begging and minimal deceleration at the end (Centrifuge ROTINA 420-R).
5. The supernatant is recovered and frozen until use.

Fig. 2. Preparation for the chayote solution

Moreover, we prepared pozole dish with the white corn adding no salt as it’s commonly prepared (Fig. 3).

1. Pre-cooked white maize is weighed (500g).
2. Drain the water from the bag of “El Norteño” brand corn, then the white corn is rinsed with potable water.

3. Then the corn is poured into a container, water is added to let it soak for 30 minutes, after that time water is removed.
4. In pressure cooker add the white corn already clean and 1.5 L potable water to let it cook for 1 hour.
5. Gerber water is added to the cooked white corn.
Add 560ml of potable water to the cooked white corn
6. Put everything in the blender until get a homogeneous puree and add 200 ml Gerber water.
7. Weigh the puree and add 75% of the puree with Gerber water
8. Blend and prepare vials for centrifugation
9. Centrifuge the vials at 13,000 RPM, at 20°C for 25 min, maximal acceleration at the begging and minimal deceleration at the end (Centrifuge ROTINA 420-R).
10. The supernatant is recovered and frozen until use.

Fig. 3. Preparation for the white corn solution

Once the salty and sweet bases were prepared, ranking tests were performed with the odorants described in the Table 2. Odorants concentrations were recommended by Firmenich International SA., Geneva, Switzerland. For Jamaica's water, chayote and white corn were evaluated 8, 5 and 7 odorants respectively.

Table 2. Odorants for the pre-test evaluation

OITE	Bases	Brand bases	Odorants	Brand of aromas
Sweetness	Jamaica (Hibiscus)	Chedraui	Vanilla 531T Vanilla mx Vanilla 636	Firmenich

			Creamy Vanilla	
			Sugar Type	
			Golden syrup	
			Honey	
			Lychee	
Saltiness	Chayote	Gerber Cosecha Natural	Chicken boiled	Firmenich
			Bacon flavor	
			Smoked fish	
			Beef boiled	
			Bonito	
	White corn	El Norteño	Celery	Firmenich
			Onion nat	
			Oregan	
			Onion fried	
			Coriander	
			Bacon flavor	
			Smoked fish	

b) General test

Performing the general test, we incorporated two bases more; apple juice for the sweet part and green peas for the salty part. These bases were already evaluated by Aveline et al., 2022 at INRAE in Dijon-France and OITE was found with Vanillin FR odorant for apple juice and Bacon FR odorant for green peas.

Preparation of the sweet base, the initial apple juice (Carrefour- France) 10% sugar diluted with water until 2% sugar. Sucrose was added to obtain 4%, 6 % and 8% final concentration of sugar for the ranking task.

For the green peas preparation, it was done in the following steps (Fig. 4)

1. The frozen pea is weighed.

2. Gerber water is added until completing 50% of its weight.

a. For example, for 250 grams of peas, add up to 500 grams of GERBER water.

3. The water is recovered and brought to a boil. (approx. 5 mins, temp 85º)

4. Add the peas and wait for the second boil. (approx. 8 mins, temp 90º)

5. A calculation is made so that the pea is 60% and the water 40%

6. Blend and prepare vials for centrifugation

7. Centrifuge the vials at 13,000 RPM, at 6°C for 15 min, maximal acceleration at the begging and minimal deceleration at the end (Centrifuge ROTINA 420-R).

8. The supernatant is recovered and frozen until use

Fig. 4. Preparation for the green peas solution

B) Methods

This interdisciplinary project was divided into 2 stages: Sensory evaluation for a pre-test and sensory evaluation for a general test (normal-weight and people living with obesity).

i) Pre-test

Initially participants were recruited for the pilot test, they could participate once per session. In each session, 4 to 6 samples were presented in each session, taking into account that 6 is the maximum samples to evaluate to avoid fatigue, they were presented all samples with a code number (Fig. 5).

Participants received different concentrations of the base solution, they were asked to rank the samples according to the increasing taste intensity. Three samples contained the base solution with increasing salt or sucrose concentrations and one contained the lowest salt/sucrose concentration and the odorant.

They rinsed their mouth with clean drinking water. Even more, they were asked to point the sample they liked the most, they disliked the most and mark the most, in the case of Jamaica's water, they had to indicate the most traditional Jamaica's water.

Fig.5 Representation of the ranking test for the pilot test

ii) General test

The sensory evaluations for general test were organized in two sessions; the first one participant evaluated salty solutions, at the end of the first session they were weighted and measured. A week after the same participants evaluated the sweet solutions and filled two questionnaires about food behavior; The Dutch Eating Behavior Questionnaire (DEBQ) and The Dietary Fat and Free Sugar-Short Questionnaire questionnaire (DFS).

Before the sensory evaluation participants should not eat, drink or smoke at least 1 hour 30 min before the sessions. The experimental procedure was explained to each participant before recruitment and before each test session. Participants signed an informed consent form to participate in the study (annexed) and received a present for the time spent performing the study.

In the sweet part, participants evaluated two bases; the Jamaica's water and the apple juice with different sugar concentrations and different aromas added. In the salty part, participants evaluated three bases; the chayote, maize and green peas with different salty concentrations and different odorants added (Table 3). The odorants and sugar/salt concentrations were obtained from the pilot-test. Additionally, each odorant was tested in water base with sucrose/salt.

Table 3. Concentration (w/w) of each odorant and taste compound in each base. S1, S2 and S3 represent the three levels of tastants' concentration used for each ranking task. The solutions were prepared with sucrose/salt.

Food base	aroma/odorant	S1	S2	S3	S1+odorant
Sweet solutions					
Apple juice	Vanillin FR	4%	6%	8%	4%+0.03%
Jamaica's water	Vanilla mx	3%	5%	7%	3%+0.03%
Jamaica's water	Sugar type	3%	5%	7%	3%+0.05%
Jamaica's water	Golden syrup	3%	5%	7%	3%+0.03%
Water	Vanillin FR	4%	7%	10%	4%+0.06%
Water	Vanilla mx	3%	5%	7%	3%+0.03%
Water	Sugar type	3%	5%	7%	3%+0.05%
Water	Golden syrup	3%	5%	7%	3%+0.03%

Food base	aroma/odorant	S1	S2	S3	S1+odorant
Salty solutions					
Green peas	Bacon FR	0.25%	0.50%	0.75%	0.25%+0.005%
Chayote	Beef	0.50%	0.60%	0.70%	0.5%+0.01%
Chayote	Bacon	0.50%	0.60%	0.70%	0.5%+0.01%
Maize	Onion fried	0.70%	0.80%	0.90%	0.7%+0.01%
Maize	Coriander	0.70%	0.80%	0.90%	0.7%+0.01%
Water	Bacon FR	0.10%	0.18%	0.25%	0.1%+0.005%
Water	Beef	0.25%	0.30%	0.35%	0.25%+0.01%
Water	Bacon	0.25%	0.30%	0.35%	0.25%+0.01%
Water	Onion fried	0.35%	0.40%	0.45%	0.35%+0.01%
Water	Coriander	0.35%	0.40%	0.45%	0.35%+0.01%

The participants had to use a computer or tablet to follow the instructions, they received a glass of water to rinse between each sample and if needed during the ranking task, a container with a straw was used for spitting the solutions (Fig. 6).

Fig. 6 Representation of performing sensory evaluation for the general test

In order to perform the ranking test, panellist will have to rank 4 bottles according to the increasing sweetness or saltiness intensity. The solutions will be delivered using a spray bottles. To perform the task, the panellist will have to spray two pulses of each solution in the mouth. Rank the 4 bottles according to the increasing taste intensity and finally rinse the moth with water and spit in a container.

Sweet and salty solutions were evaluated in different steps; a) the ranking test with the 4 solutions, b) the level of pleasantness, just-about-right and familiarity were applied to evaluate each solution with odorant.

Once the panelist performed ranking task, panelist gave back the 4 solutions to the cabin. Inside the cabin, the bottle containing the solution with aroma was selected to give it back to the panelist to evaluate pleasantness, just-about-right and familiarity using an unstructured or linear scale (Fig. 7).

Pleasantness

Just About Right

Familiarity

No Familiar Very familiar

Opened question

What dish/ plate remind you with this solution? ___________________

Fig. 7 Scales for pleasantness, just-about-right, familiarity evaluation and opened question.

After the sensory tests were completed, participants answered the DEBQ and DFS questionnaires. DBEQ comprises 33 items that characterize eating behaviors personality traits, enabling to assess the level of “external eating”, “emotional eating,” and “restrained eating”. Responses are given on a scale from never to frequently (more Detailed in Annex 3). The Dietary Fat and Free Sugar-Short Questionnaire (DFS) was applied as an instrument to estimate dietary intake of saturated fat and free sugar (Annex 4)

C) Statistical analysis

i) Pre-test

For the data analysis, we used R-index, in this way the differences between the samples were determined.

In order to calculate R- index, we used the equation (Fig. 8) (Brown, 1974):

Subject's Response Matrix

	Rank 1st	Rank 2nd	Rank 3rd	Rank 4th	Total
Product 1 (S_1)	a	b	c	d	N_{S1} (=a+b+c+d)
Product 2 (S_2)	e	f	g	h	N_{S2} (=e+f+g+h)
Product 3 (S_3)	i	j	k	l	N_{S3} (=i+j+k+l)
Reference (N)	m	n	o	p	N_N (=m+n+o+p)

$$\text{R-Index (\%) for } \mathbf{S_1} = \frac{a(n+o+p)+b(o+p)+cp+\frac{1}{2}(am+bn+co+dp)}{N_{S1}N_N} \times 100$$

$$\text{R-Index (\%) for } \mathbf{S_2} = \frac{e(n+o+p)+f(o+p)+gp+\frac{1}{2}(em+fn+go+hp)}{N_{S2}N_N} \times 100$$

$$\text{R-Index (\%) for } \mathbf{S_3} = \frac{i(n+o+p)+j(o+p)+kp+\frac{1}{2}(im+jn+ko+lp)}{N_{S3}N_N} \times 100$$

Fig. 8 Illustration of a response matrix given for the calculation of the R- index indicating product similarity when 4 products (including reference were tested using a similarity classification with a reference product.

OITE occur when the solution with the aroma is perceived as significantly more intense than from the standard (sample without aroma). Compering the R-index values, we can analyze which aromas better enhanced the sweetness in each solution. The probability of correctly identifying sample as saltier or sweeter at random or by guessing is 50% R- index value. On the other hand, if the R-index value was below 50%, it indicates that solutions with odorant were perceived as less salty/sweet comparing with solution without odorant

ii) General test

A Wilcoxon test was performed in XLSTAT to compare the ranking test between the odorant-added solution and the rest of the solutions (S1, S2 & S3) in obese and normal weight groups. The solutions with the odorant were compared with each of the other solutions without odorant, for all the bases.

Moreover, Mann Whitney test was used to compere if there were significant differences between NW and OB for pleasantness, JAR and familiarity. Additionally, Friedman test was performed to compare the pleasantness, JAR and familiarity between solutions with odorant.

In NCSS, T-Test was used to test to compare the hunger state at the begging of the session and at the end of the session between the groups.

DEBQ questionnaire comprises 33 items that characterize eating behaviors personality traits. For this questionnaire, the average score of personality traits items was calculated for external eating, emotional eating (defined and diffused) and restrain eating. The score of the DFS was calculated for each subject, for each item; the frequency consumption of saturated fat (questions: Q1:Q12), free sugar (questions Q17 + Q20:Q26) and saturated and free sugar (remaining questions).

In the same way, Mann Whitney test was applied to perform statistical comparisons between NW and OB in both questionaries' and, to facilitate the understanding, it was considered as significant when $p<0.05$ (*), $p<0.01$(**) and $p<0.001$(***).

6. Results and discussion

i) Pre-test

Analysis of frequencies was applied to know the ideal Jamaica's water. In the table 4 the most pleasant Jamaica's water and the most traditional was solution with 2.9% w/v of jamaicas flower and 9% sucrose.

Table 4. Percentage of participants (55 participants) who liked, disliked and selected the solution as the most representative of Jamaica's water for each solution with different sucrose concentrations. Solution 1 (1.9%w/v jamaica), Solution 2 (2.4% w/v jamaica), Solution 3 (2.9% w/v jamaica) and Solutions 4 (3.3% w/v jamaica).

% Sucrose (p/v)													
	12%	8%	4%	12%	8%	12%	9%	8%	6%	3%	12%	8%	4%
	Solution 1			**Solution 2**		**Solution 3**					**Solution 4**		
Like	2.5	7.5	0	5	10	16	**18**	7.5	5	2.5	12.5	8.5	5
Dislike	0	0	0	10.8	5.4	5.4	2.7	8.1	5.4	35.1	5.4	21.6	0
Traditional water	6.9	11.6	0	9.3	9.3	10.4	**28**	4.6	2.3	0	8.1	9.3	0

The Jamaica's infusion was prepared maximum 1 day before and the final solution with sugar and odorants was prepared the day of the test.

We could notice that sugary solutions (9-12% w/w sugar concentrations) with the aromas added were more liked than lower sugar concentration solutions (3% w/w sugar concentrations).

OISwE if found when the sample with the odorant is perceived different from the standard (sample without the odorant). Comparing the R-index values, we can analyze which odorant enhanced the sweetness in the solution. The table 5 shows the different sugar concentrations solutions of Jamaica's water with different odorants evaluated and the R-index respectively.

The significance of the R index for discriminative tests is obtained from table of Arturo Hernandez (2007) where from the column of α= 0.05 and with the number of judgments (10), corresponding to the signal, the value of 24.04 is obtained, which indicates that the R index should be at least 74.04% to be significant.

The added odorant solutions with the highest R-index values were: Vanilla mx (0.03% w/w), Golden syrup (0.03% w/w) and Sugar type (0.05% w/w), obtaining 84.91%, 78.80% and 74% respectively in Jamaica water (Table 5). These odorants were the best to enhance the sweetness of the Jamaica's water; these odorants were selected to perform the general test.

Solution with Vanilla 636 had an R index value of 50% that means only half of the comparisons would be correctly identify with higher sweetness. Therefore, we cannot consider that there is a significant difference as the odorant solution was only detected randomly or by guessing. Solution with Vanilla 531T odorant had 47.63% R-index value, indicating this odorant did not enhance the sweetness in the Jamaica's water.

Table 5. R-index value of sugar concentration with No odorant vs sugar concentration with odorant.

Sensory evaluation	Number of participants	Sugar concentration (w/w)	Odorant	R-index compared with the solution without aroma
A	16	3 %	Golden syrup	39.45 %
	16		Vanilla-Cream	55.46 %
B	13	4%	Golden syrup	51.47%
	13		Vanilla 636	50 %
C	13	4%	Sugar type*	74.00 %
	13		Honey	62.72 %
D	13	5%	Vanilla 531T	57.98 %
	13		Vanilla mx	73.07 %
	13	7%	Vanilla 531T	47.63 %
	13		Vanilla mx	84.91 %
E	14	3%	Lychee	57.63 %
	14		Vanilla mx	58.67 %
F	19	5%	Honey	52.63 %
	19		Golden syrup	54.43%
	19	7%	Honey	72.57%
	19		Golden syrup	78.80%
G	21	4%	Sugar type*	59.12 %
	21		Vanilla mx	74.62 %
	21	6%	Sugar type*	59 %
	21		Vanilla mx	75.5 %

Concerning to the salty part, shown in table 6, the added aroma solutions with the highest R-index values were: Beef boiled (0.01% w/w) and Bacon flavor (0.01% w/w), obtaining 97.19% and 91.31% respectively in chayote. These aromas were the best to enhance the saltiness of the chayote puree.

We could notice that Beef boiled aroma had high R index values with different salt concentrations in the “sensory evaluation B, Beef boiled with 0.5% salt concentration had R-index value of 84.02% and Beef boiled with 0.8% salt concentration had R-index values 47.04%. Panelist could notice the difference with the aroma added and perceived the solutions saltier when the salt concentration is lower. Djordjevic et al (2004) mention that within the weak salt concentration, solutions were perceived as saltier. In sensory evaluation D, Beef boiled had different R-index values with the same 0.6% salt concentration; however, Beef boiled had the highest value compared with the other odorants values.

Some aromas did not enhance the saltiness for chayote base, chicken boiled had the lowest R-index value; 37.84% showing that solutions with odorant were perceived less salty compared with solution without odorant.

Table 6 R-index value of salt concentration with No odorant vs salt concentration with aroma for Chayote base.

Sensory evaluation	Number of participants	Salt concentration (w/w)	Odorants	R-index compared with the solution without aroma
A	12	0.5%	Bacon flavor	91.31 %
	12		Chicken boiled	37.84 %
	12	0.8%	Bacon flavor	42.70 %
	12		Chicken boiled	62.5 %
B	12	0.5%	Beef boiled	84.02%
	12		Smoked fish	65.68%
	12	0.8%	Beef boiled	47.04%
	12		Smoked fish	51.77%
C	18	0.5%	Bonito	47.68%
	18		Beef boiled	46.29%
	18	0.7%	Bonito	54.32%
	18		Beef boiled	64.19%
D	25	0.6%	Beef boiled	65.20%
	25		Bacon flavor	55.04%
	25		Bonito	47.76%
	14	0.6%	Beef boiled	97.19%
	14		Smoked fish	53.06%
	14		Chicken boiled	44.89%

In the table 7, the added aroma solutions with the highest R-index values were: Onion fried (0.01% w/w) and Coriander (0.01% w/w), obtaining 81.80% and 70.66% respectively. That means these aromas were the best to enhance the saltiness of the maize. Celery odorant had an R index value of 50% that means only half of the comparisons would be correctly identify with higher saltiness. Therefore, we cannot consider that there is a significant difference as the odorant solution was only detected randomly or by guessing.

Table 7 R-index value of salt concentration with No aroma VS salt concentration with aroma for maize base

Sensory evaluation	Number of participants	Salt concentration (w/w)	Aromas	R-index compared with the solution without aroma
A	11	0.7%	Coriander	36.77%
	11		Onion fried	81.80%
	11	0.9%	Coriander	70.66%
	11		Onion fried	44.21%
B	14	0.7%	Celery	50%
	14		Oregano	44.38%
	14	0.9%	Celery	52.29%
	14		Oregano	46.42%
C	12	0.8%	Onion Nat	57%
	12		Bacon	52%
	12		Smoked fish	49%

ii) General test

OITE in sweet solutions

Fig. 9 shows the OITE solutions of each ranking task compared with the solutions with no aroma. There were 3 types of enhancement a) OITE solutions was between solutions S1 and S2, b) OITE solutions was perceived as sweet as S2 and c) OITE solution was perceived as sweet as solution S2 and S3. The comparisons of the ranking scores by solution within each ranking task are in annex 1.

Normal weight people

Focusing on Normal Weight participants, solutions Jamaica with Vanilla mx, Water with Golden Syrup, Water with Vanilla mx and Water with Vanillin FR were perceived between the first and the second concentration. These aromas were the ones that enhance the sugar concentration, phenomenon OITE were found. For Jamaica with Vanilla mx, Water with Golden Syrup, Water with Vanilla mx, the odorants allowed reducing the sugar to 25% and for Water with Vanillin FR the reduction of the odorant was 27.2% maintaining the sweetness perception. On the other hand, we could see that S1+odorant solutions of Jamaica with Golden Syrup, Jamaica with Sugar Type, Apple with Vanillin FR, Water with Sugar Type were perceived like the (S1) first concentration with no odorant added, noticing no difference between them ($p>0.05$), that means OITE phenomenon was not found with these aromas.

People living with obesity

In the case of people with obesity, the OITE phenomenon was found in the solutions Water with Golden syrup, Water with Vanilla mx and Water with Vanillin FR, they were perceived between the first and the second concentration, reducing the sugar to 25%, 25% and 27.2% respectably. Moreover, in the solutions Jamaica with vanilla mx and Apple juice with Vanillin OITE was detected as the second concentration, reducing the sugar to 40% and 33.3% respectably. However, Jamaica with Golden syrup, Jamaica with Sugar type and Water with sugar type were the ones that had no OITE effect, having no differences between S1+odorant and the (S1) first concentration with no odorant added ($p>0.05$).

An odour-induced taste enhancement is said to occur if the perceived sweet intensity of the mixture is greater than the perceived sweet intensity of the same solution but without the odorant. In this analysis of (OISwE) we noticed that both; obese and normal weight detected a good interaction odorant-taste OITE in almost the same solutions, OB experienced OITE in 5 of the 8 solutions tasted and NW experienced OITE in 4 of 8 solutions (Table 8). These results do not consistently support the theory that people with obesity have been shown to have altered sensitivity to food reward (Stice, 2019); in both groups the behaviour for OITE phenomenon was pretty similar. Even though, OITE occurred in both the NW and the OB population for sweet and salty tastes but OB was perceived higher sweet OITE than NW supported by Aveline et al. (2022).

Moreover, it has been reported that all odours do not have the same effect on sweet perception; also the same odour does not induce a similar effect in taste enhancement (Valentin, 2006) that was the case for normal weight people in the odorant Vanillin FR; having OITE effect in water but not in apple juice.

On the other hand, both Vanilla mx and Vanillin FR aromas were a good option for the sweet enhancement because in all solutions using these odorants (except apple juice for NW) OITE phenomenon was found; giving evidence that odorants like vanilla, that is the most common aroma for sweetness, people associate vanilla odorant as a sweet odorant (Dravnieks, 1985).

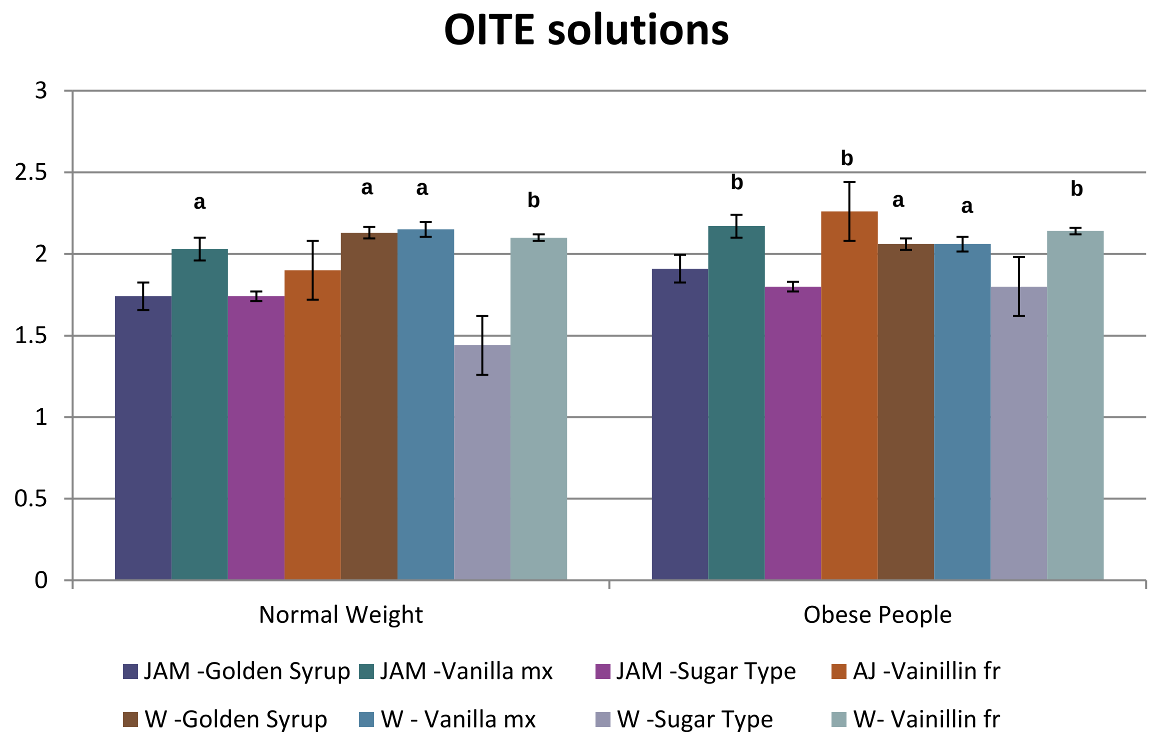

Fig. 9 Average of the ranking sweetness intensity. Each bar corresponds to the mean ±SE. Normal weight people (NW) and people living with obesity (OB). OITE solutions, indicated if an odorant-added solution (S1 + odorant) is significantly different (Wilcoxon test, $p<0.05$) from the solutions containing no odorant (S1, S2, S3). ([a]) Letters that show enhancement S1< OITE< S2 and ([b]) enhancement OITE=S2. Food base solutions: Jamaicas water (JAM), Apple Juice (AJ), and Water (W).

Pleasantness, JAR & Familiarity

A Mann Whitney analysis was performed to compare the pleasantness, JAR & familiarity between groups (Normal weight and people living with Obesity). Also, averages were reported by graphics in order to see the tendency of each aroma-base.

Pleasantness of aroma-food base solutions, noticing that for each solution there was significant differences between NW and OB in Jamaica with Sugar type (p=0.03) having a superior mean in obese people (M=7.134 SD=2.74) more than Normal weight people (M=5.797 SD=2.45).

Normal weight people preferred Water with Vanillin FR (M=6.594 SD=2.67), designated as the most pleasant solutions. On the other hand, Jamaica with Vanilla mx (M=4.784 SD=2.51) and Water with Sugar type (M= 5.343 SD= 1.91) were considered as the less pleasant solutions. In the OB group, solutions were not perceived different in term of pleasantness, there were not significant differences between solutions (p>0.05).

It is important to mention that the pleasantness indicated by participants included the interaction not only between the sugar concentration and certain aroma, but also the interaction including the food base; the mix of these three components.

Solutions of Apple juice with vanillin FR and water with the same odorant were the solutions with the highest sugar concentration, and they were also the more pleasant ones. Compared to authors that mention people prefer consumption of sugary drinks instead of unsweetened beverages (Jones, 2019). According to Aveline studies (2022), participants liked the solutions with the highest sucrose concentration in apple juice and cocoa beverage.

In accord with researchers, obese people tend to indicate high hedonic responses to the sweetness they perceived (Bartoshuk, 2006). In our study no significant differences of pleasantness between the solutions were found in OB.

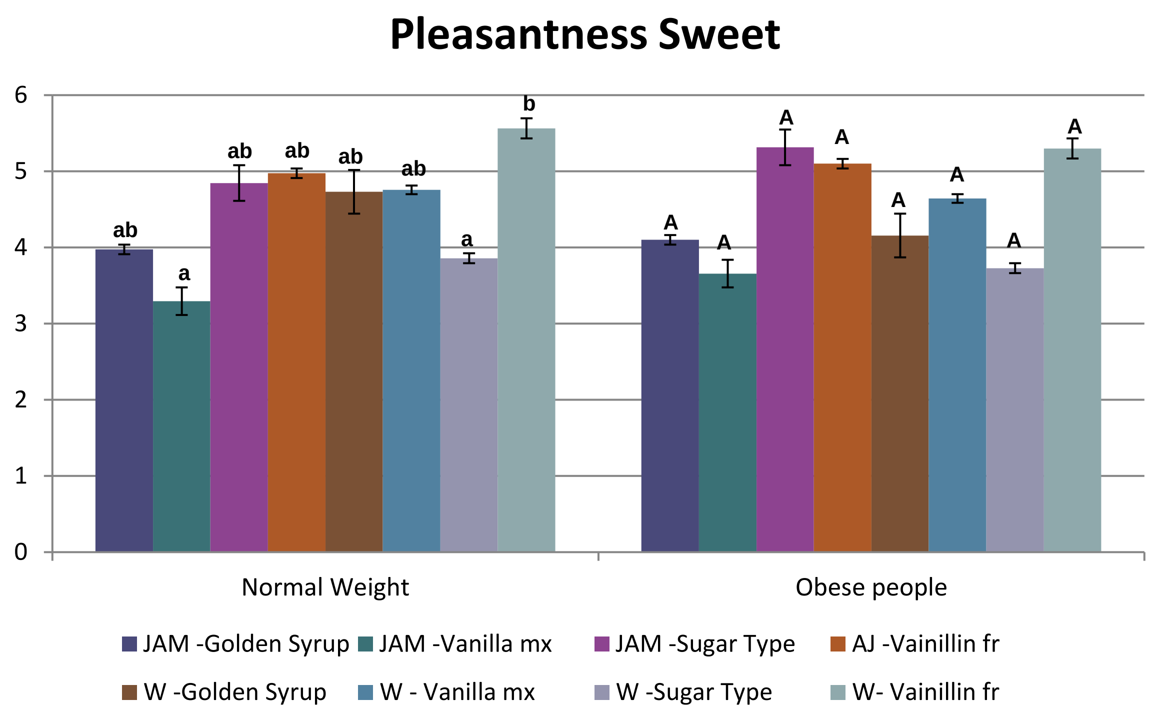

Fig. 10 Average pleasantness of the Sweet OITE solutions. Comparison of means±SE between solutions with aroma (Friedman test, $p<0.05$), in Normal weight (NW) and people with obesity (OB). Different lowercase letters indicate significant differences for NW and different capital letters indicate significant differences for OB. Food base solutions: Jamaicas water (JAM), Apple Juice (AJ), and Water (W).

About JAR scale of aroma-food base solutions, noticing that for each solution there was no significant differences between NW and OB (Mann Whitney, $p>0.05$).

Normal weight participants evaluated the solutions Apple juice with Vanillin FR and Water with Vanillin FR above the just-about-right level, meaning that they perceived these solutions as sweeter than their reference of a just-about-right solution (fig. 11). The solutions evaluated with higher JAR contained more sugar than the other ones. Jamaica with Sugar type solution was marked below the JAR scale, meaning that participants perceived it as the less sweet that they expected.

In obese people, Apple juice and Water with Vanillin FR were perceived sweeter than JAR reference. On the other hand, Water with Sugar type was considered less sweet that JAR scale.

Jamaica's water may have been considered as less sweet because of the characteristic aroma and flavour propitiated by organic acids, such as malic and ascorbic, and by volatile compounds, such as terpenoids, esters and aldehydes (González et al., 2009). Moreover, the exotic aroma character of roselle tea result from the interaction of terpenoids with floral notes, fatty acids with acidic notes and the sugar degradation products with a caramel-like odorants (Pino et al ., 2006).

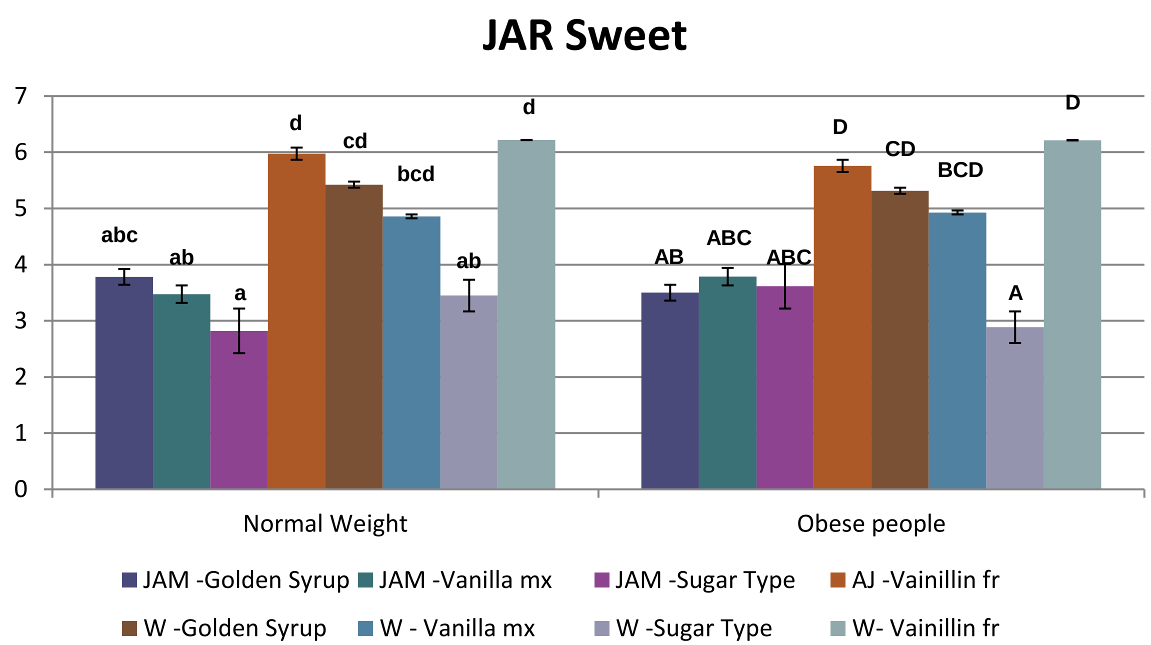

Fig. 11 Average Just About Right level of the Sweetness OITE solutions. Comparison of means±SE between solutions with aroma (Friedman test, $p<0.05$), in Normal weight (NW) and people with obesity (OB). Different lowercase letters indicate significant differences for NW and different capital letters indicate significant differences for OB. Food base solutions: Jamaicas water (JAM), Apple Juice (AJ), and Water (W).

Regarding familiarity, for each solution there was no significant differences between NW and OB (Mann Whitney, p>0.05).

For Normal weight people, the most familiar solutions were Jamaica with Sugar type (fig. 12). Water with Sugar type was the less familiar solution.
In Obese people, the most familiar solution was Jamaica with Sugar type. Moreover, Water with Sugar type was the less familiar solution.

Results showed that Water with sugar type was the less pleasant solution and also the less familiar by Normal weight participants. The correlation between familiarity and pleasantness was shown by Small et al. (2004) that the authors found that the degree of familiarity of an odor–taste mixture affects its hedonic value.

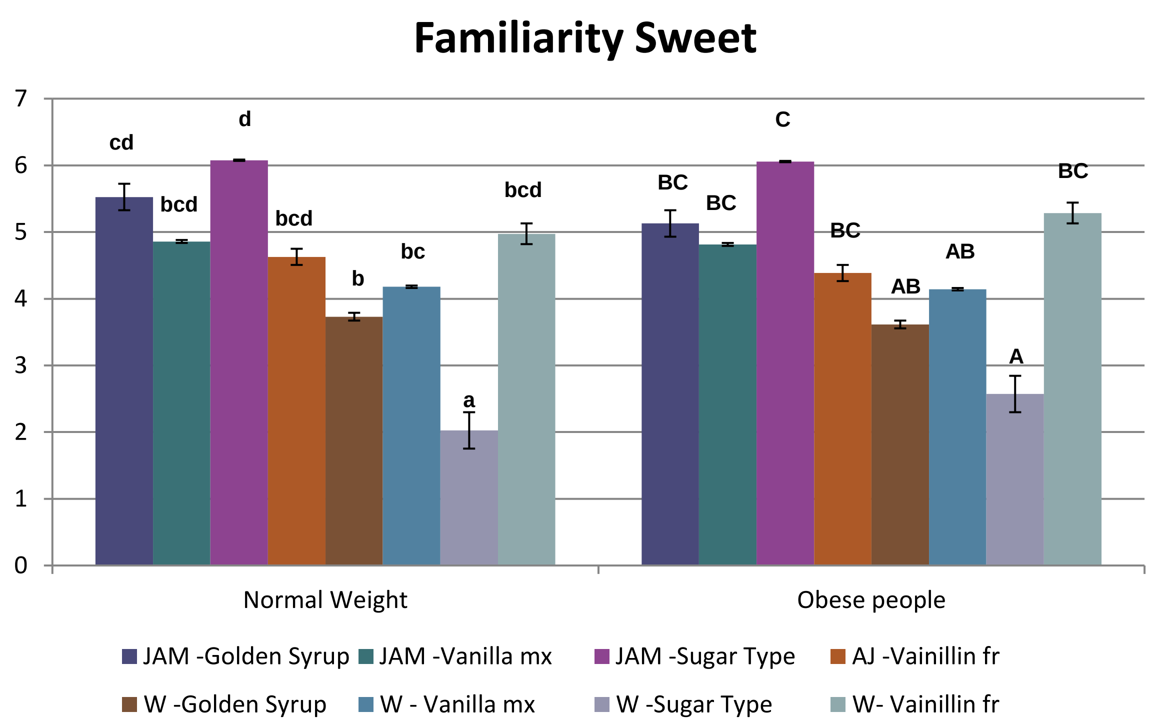

Fig. 12 Average familiarity of the Sweet OITE solutions. Comparison of means±SE between solutions with aroma (Friedman test, p<0.05), in Normal weight (NW) and people with obesity (OB). Different lowercase letters indicate significant differences

for NW and different capital letters indicate significant differences for OB. Food base solutions: Jamaicas water (JAM), Apple Juice (AJ), and Water (W).

Words for sweetness

Figs. 13, 14 and 15 show the dishes/food that was evoked by the Jamaica, apple juice and water solutions with their associated aroma.

In the case of the Jamaica's water, people not only perceived Jamaica they also marked fruit, candy, sweet and vanilla, because of the Vanilla mx aroma that was detected in the solutions in both Normal weight and Obese people.

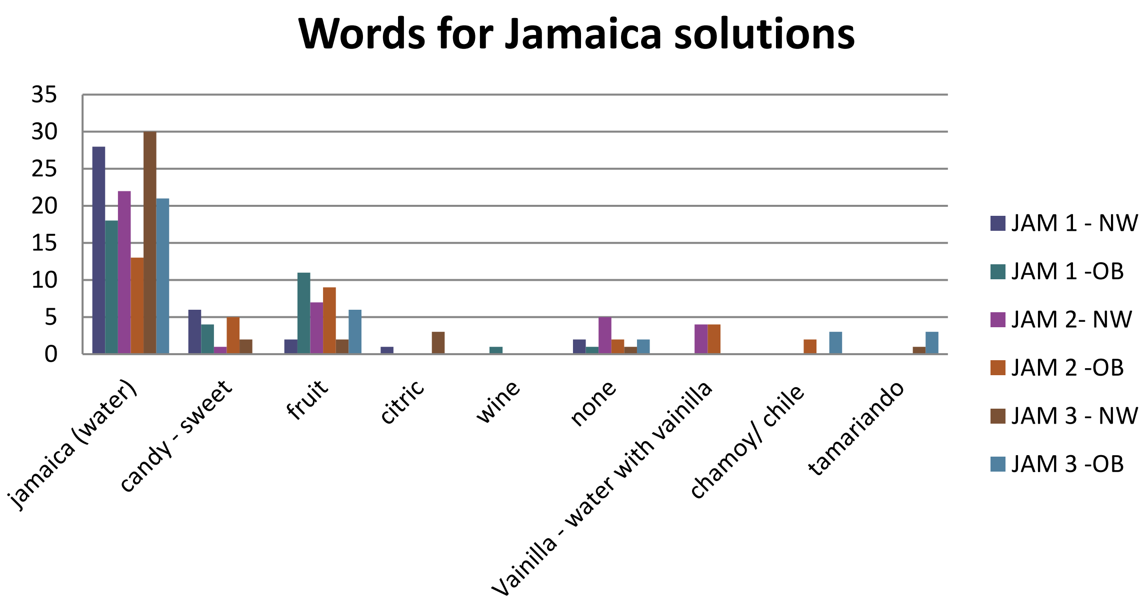

Fig. 13 Distribution of scores about dishes/food remembered by the Jamaica solutions tasted. JAM 1 (Jamaica base with Golden syrup odorant), JAM 2 (Jamaica base with Vanilla mx odorant) and JAM 3 (Jamaica base with sugar type odorant).

The identification ability increases when the target is familiar (Rabin et al.,1989). The apple juice solution evoked the "apple" in NW but not in OB. In these solutions fruit and candy-sweet were the most noted, it follows that Vanillin FR aroma was evoked as a flavour too.

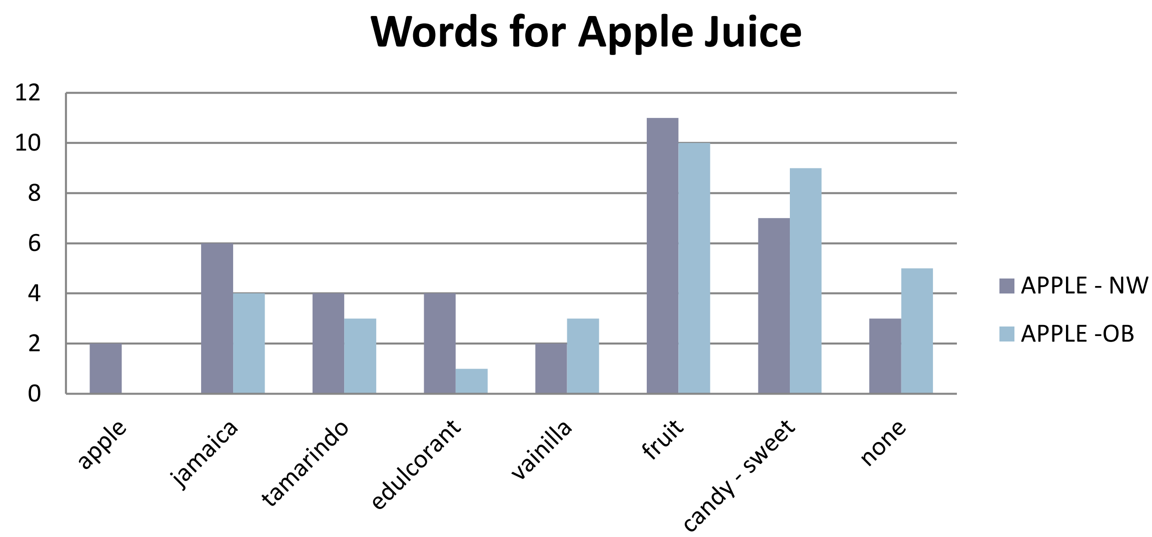

Fig. 14 Distribution of scores about dishes/food evoked by the Apple juice solutions. APPLE (Apple juice with Vanillin FR odorant).

For solutions with water and aroma, we can notice that people perceived sweet flavours for example candy, vanilla, caramel and some people did not. It has reported that some individuals have a better sensitivity for certain odorants compared to other individuals (Keller et al., 2007). Moreover, water is not complex enough to be categorized as a more complex drink.

According to Dravnieks, (1985), it is said that some odours that are often experienced in combination with sweet taste, are commonly described as "smelling sweet", noticing that participants describe odours solutions like sweet taste solutions, without knowing what they perceived an aroma and not a savour.

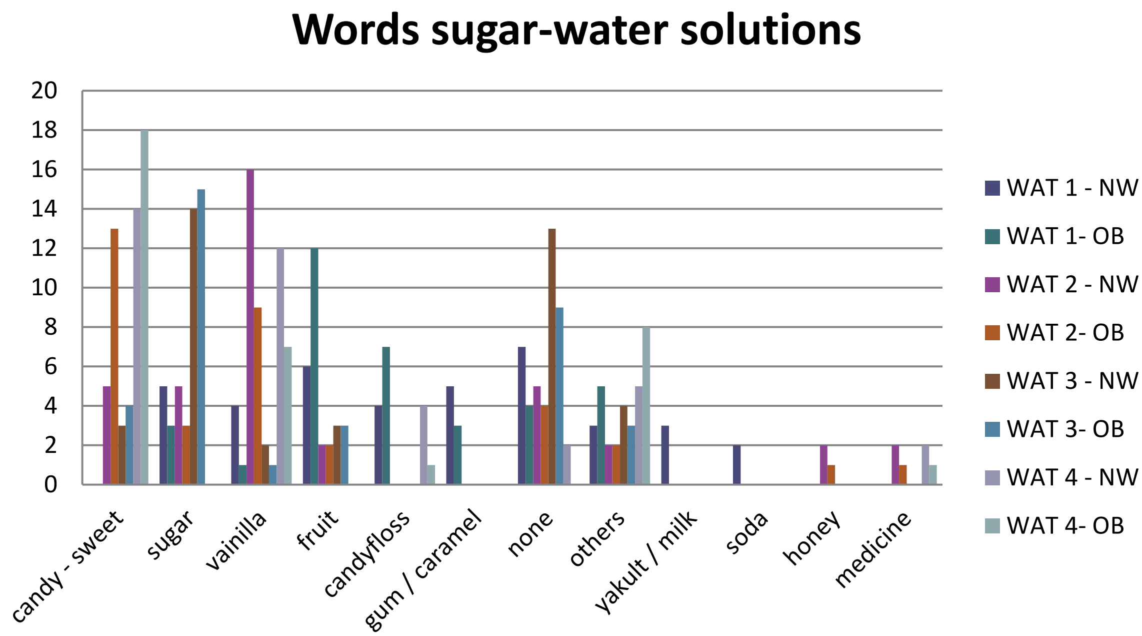

Fig. 15 Distribution of scores about dishes/food remembered by Water solutions tasted. WAT 1 (Water with Golden syrup odorant), WAT2 (Water with Vanilla mx odorant), WAT 3 (Water with sugar type odorant) and WAT 4 (Water with Vainillin FR odorant).

There was no relation between pleasantness and the OITE phenomenon. Some authors mentioned that the hedonic rating is not related to the degree of odor-induced taste enhancement (Table 8) (Hendrik, 1996; Aveline et al., 2022).

Aveline et al. (2022) assumed that congruence is necessary for OITE to occur, since incongruent odor-taste may not produce OITE; Vanilla is a congruent odour for the sweet solutions, including golden syrup and sugar type, because these aromas are usually related with sweet food. However, despite they are congruent, the fact that sugar type was marked as not familiar, and it may influence avoiding the OITE effect.

Moreover, incorrectly identified stimuli seem unfamiliar and may evoke neophobia, which decreases their pleasantness (Hendrik et al., 1996), in this case Water with sugar type aroma was defined as the less familiar therefore being the less pleasant

The ability of an odour to enhance sweet taste does not seem to be universal (Valentin, 2006). In the case of apple juice, vanillin produced OITE in French participants with obesity (Aveline et al., 2022), as well as the present study only Mexican participants with obesity had OITE effect, in normal weight people did not.

Table 8. Sweet solutions evaluated if there was OITE, most or least pleasantness, JAR and least or most familiar, depending on the solution.

		NW	OB	NW	OB	NW	OB	NW	OB
		OITE		pleasantness		JAR		familiarity	
1	Jamaica aroma Golden Syrup	NO	NO		SAME				
2	Jamaica aroma Vanilla mx	YES	YES	LEAST	SAME				
3	Jamaica aroma Sugar Type	NO	NO		SAME	LEAST		MOST	MOST
4	Apple juice aroma Vainillina FR	NO	YES		SAME	MOST	MOST		
5	Water aroma Golden Syrup	YES	YES		SAME				
6	Water aroma Vanilla mx	YES	YES		SAME				
7	Water aroma Sugar Type	NO	NO	LEAST	SAME		LEAST	LEAST	LEAST
8	Water aroma Vainillina FR	YES	YES	MOST	SAME	MOST	MOST		

OITE in salty solutions

Fig. 16 shows the OITE solutions of each ranking task compared with the solutions with no aroma. There was 3 types of enhancement a) OITE solutions was between solutions S1 and S2, b) OITE solutions was perceived as salty as S2 and c) OITE solution was perceived as salty as solution S2 and S3 (table 3). The comparisons of the ranking scores by solution within each ranking task are in Annex 2.

Normal weight people

Focusing on Normal weight people, we can see in Chayote with Beef the lowest concentration of salt with the aroma/odorant added (S1 + odorant) was evaluated as the first (S1), and second (S2) concentration, they were evaluated as the same ($p>0.05$), OITE was not found. In chayote with Bacon MX there was no difference between first concentration and the first concentration with aroma, they were perceived the same (p=0.189) OITE was not found either.

In the case of White corn with coriander, Green peas with Bacon FR and Water with Bacon FR, the lowest concentration of salt with the aroma/odorant added (S1 + odorant) were perceived like the (S2) second concentration with no odorant added, OITE phenomenon detected, reducing the salt to 12.5%, 50% and 44.4% respectively, while maintaining the saltines perception. Then, White corn with onion fried, Water with Beef, Water with bacon MX and Water with Onion fried, we found OITE phenomenon. For all these solutions, the lowest concentration with the aroma was perceived as salty as the second (S2) and the third (S3) concentration of salt, reducing the salt to 22.2%, 28.5%, 28.5% and 22.2% respectively. Finally in Water with Coriander, people perceived the lowest concentration with aroma like a concentration between the fist and the second, reducing the salt to 6.25% while maintaining the saltines perception.

Results in people living with obesity

About data of obese participants, we can see that see in Chayote with Beef and White corn with onion fried, the lowest concentration of salt with the aroma/odorant added (S1 + odorant) was perceived as salty as the first (S1) concentration, second (S2) and third (S3) concentration of salt, all were evaluated as the same ($p>0.05$), having no OITE effect. For Chayote with Bacon MX and White corn with Coriander the lowest concentration of salt with the aroma/odorant added (S1 + odorant) was evaluated as the first (S1), and second (S2) concentration, they were evaluated as the same ($p>0.05$) having no OITE phenomenon.

On the other hand, Green peas with Bacon FR and water with Bacon FR had enhancement until the second concentration (S2) reducing the salt to 50% and 44.4% while maintaining the saltines perception. Moreover, solutions Water with Beef, Water with Bacon MX and Water with Onion fried, the lowest concentration of salt with the aroma/odorant added (S1 + odorant) was perceived as the second (S2) and third (S3) concentration of salt, reducing the salt to 28.5%, 28.5% and 22.2%. Finally, Water with Coriander was detected between the fist and the second concentration, reducing the salt to 6.25%.

In this analysis of odour induce saltiness enhancement (OISaE), as we could see, participants in both groups mixed all the salt concentrations of Chayote solutions with their corresponding aromas Beef and Bacon MX. We can attribute that this happened because of the more similar two sensations are, the more often they will be confused (Hendrik et al., 1996). Moreover, chayote is a vegetable that contains carbohydrates (6.3g / 100g) that confers a thick product, in the same way it has been reported that an increase of hydrocolloids concentration generally leads to a decrease in aroma and taste perception (Tournier et al., 2007).

Opposite to Aveline results (2022) that people with obesity experienced a better odor-induced taste enhancement with salty solutions. In this study Odor induced saltiness enhancement people with normal weight had an OITE effect in to a greater extent than in obese people, that might be because salty taste sensitivity appears related to weight excess with lower sensitivity with increasing BMI (Bertoli et al., 2014).

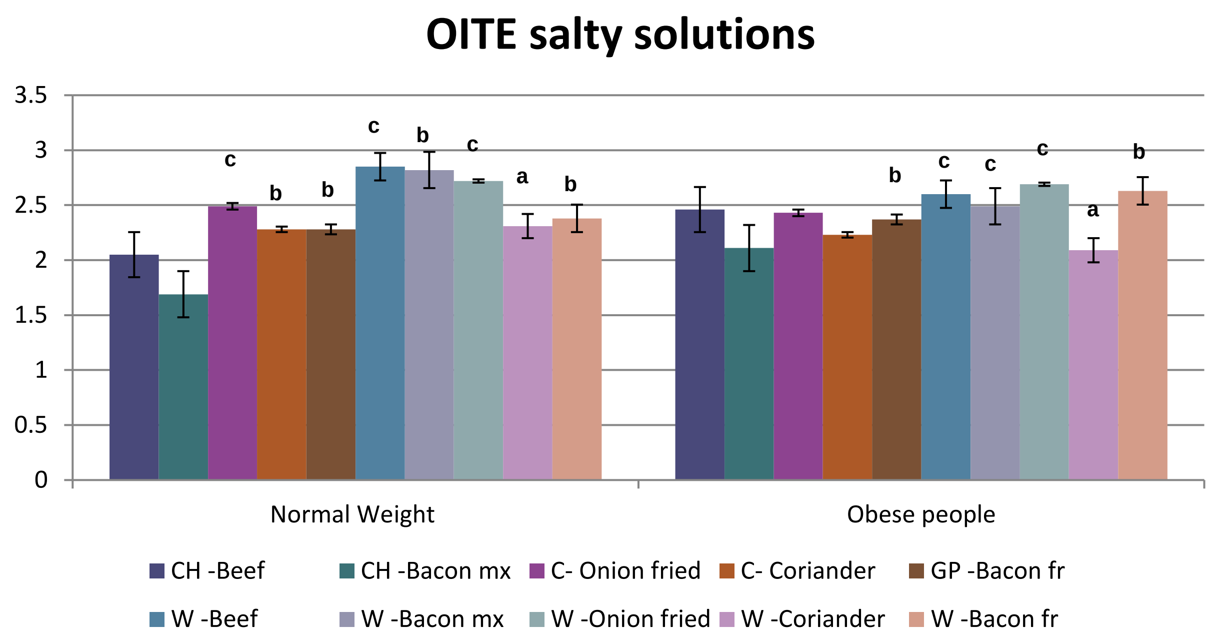

Fig. 16 Average of the ranking saltiness intensity. Each bar corresponds to the mean ±SE. Normal weight people (NW) and people living with obesity (OB). OITE solutions, indicated if an odorant-added solution (S1 + odorant) is significantly different (Wilcoxon test, $p<0.05$) from the solutions containing no odorant (S1, S2, S3). ([a]) Letters that show enhancement S1< OITE< S2, ([b]) enhancement OITE=S2 and ([c]) enhancement OITE= S2= S3. Food base solutions: Chayote (CH), White corn (C), Green pea (GP), Water (W).

Pleasantness, JAR & Familiarity

A Mann Whitney analysis was performed to compare the pleasantness, JAR & familiarity between groups (Normal weight and people living with obesity). Also averages were reported by graphics in order to see the tendency of each aroma-base.

About pleasantness of aroma-food base solutions, noticing that there was no significant differences between NW and OB people (Mann Whitney, $p>0.05$).

We can observe in Normal weight people marked solutions Water with bacon MX (M= 4.68 SD= 2.53), Water with Coriander (M= 4.43 SD= 2.104), Water with Beef

(M= 4.27 SD= 2.094), Water with Bacon FR (M= 3.74 SD= 2.137), Chayote with Beef (M= 3.679 SD= 3.020), Chayote with Bacon MX (M=3.58 SD=3.11), White corn with coriander (M=3.77 SD=2.18) and Green peas with Bacon FR (M=3.77 SD= 2.69). However the less pleasantness was White corn with Onion fried (M=1.81 SD= 1.84).

In obese group, pleasantness of solutions was different, they marked White corn with onion fried (M= 1.66 SD= 2.359) as the less liked. In addition, the most pleasantness solutions was Water with Coriander (M=5.151 SD=2.349).

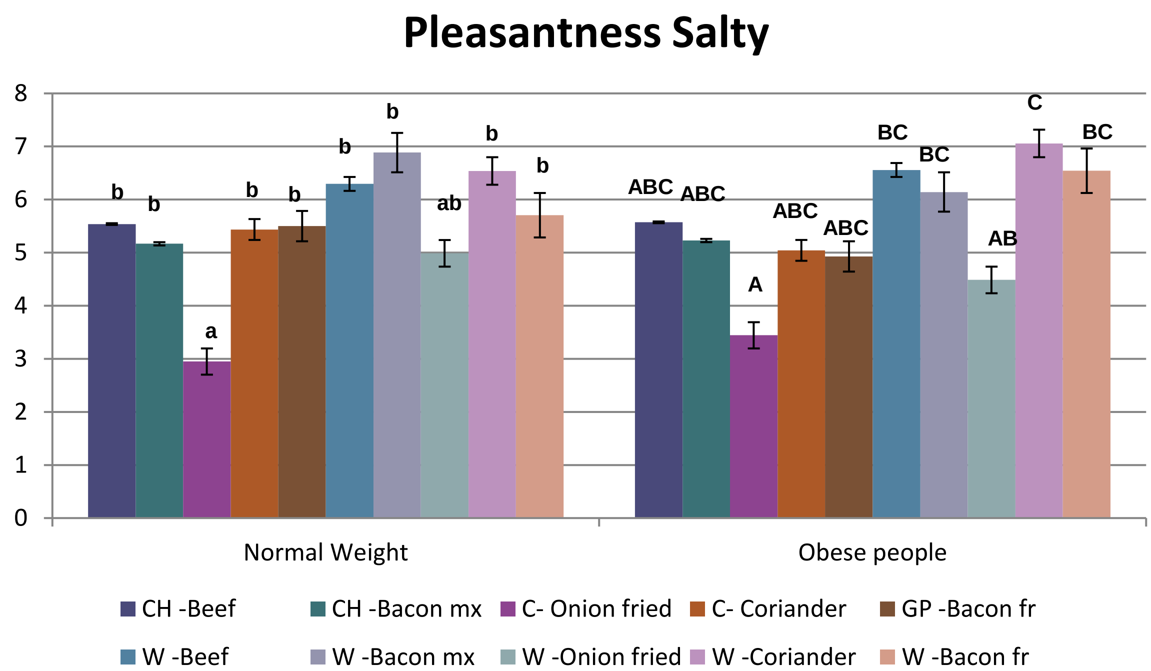

Fig.17. Average pleasantness of the Salty OITE solutions. Comparison of means±SE between solutions with aroma (Friedman test, $p<0.05$), in Normal weight (NW) and people with obesity (OB). Different lowercase letters indicate significant differences for NW and different capital letters indicate significant differences for OB. Food base solutions: Chayote (CH), White corn (C), Green pea (GP), Water (W).

The JAR results indicated that there was no significant differences between NW and OB people (Mann Whitney, p>0.05).

Normal weight participants evaluated the solution White corn with onion fried (M= 6.464 SD= 2.714) above the just-about-right, meaning that they perceived these two solutions them saltier than their reference of just-about-right solutions. Water with Bacon FR (M= 2.88 SD= 2.17) was marked below the JAR scale, meaning that participants perceived the solution as less salty that they expected.

In Obese participants, white corn with Coriander (M= 6.33 SD= 1.79) and white corn with onion fried (M= 6.51 SD= 2.53) were perceived saltier than just-about-right reference. Water with Bacon FR was the solution perceived as the less salty (M= 2.394 SD= 2.35).

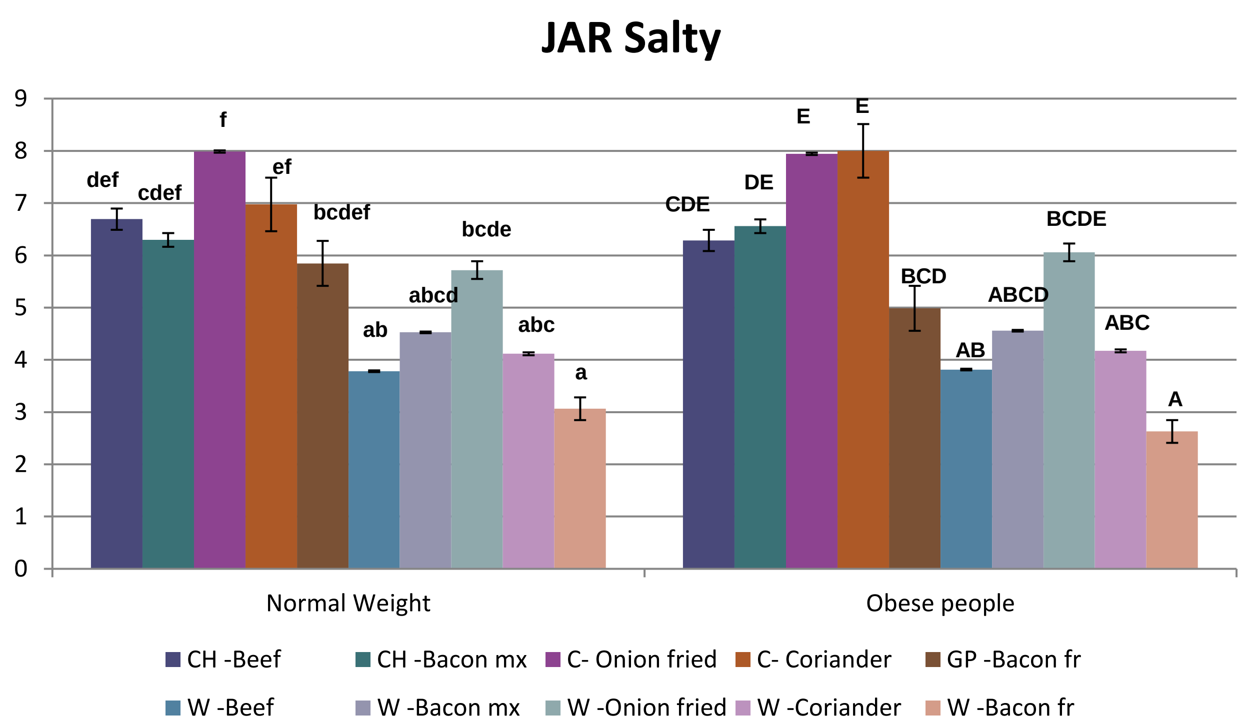

Fig. 18 Average Just About Right level of the saltiness OITE solutions. Comparison of means±SE between solutions with aroma (Friedman test, p<0.05), in Normal weight (NW) and people with obesity (OB). Different lowercase letters indicate significant differences for NW and different capital letters indicate

significant differences for OB. Food base solutions: Chayote (CH), White corn (C), Green pea (GP), Water (W).

About familiarity of aroma-food base solutions, there was no significant differences between NW and OB people (Mann Whitney, p>0.05).

In Normal weight people, the most familiar solutions were Chayote with Bacon MX (M=5.06 SD=3.45) and Water with Bacon MX (M=5.02 SD=3.02) but solutions Water with Coriander (M= 2.743 SD= 2.85) was the least familiar for the Normal weight participants.

In Obese participants, the solutions Water with Beef (M=4.79 SD=3.30) and Water with Bacon MX (M=5.58 SD=3.64). On the other hand, Water with coriander (M=3.17 SD= 2.98) was less familiar the solutions.

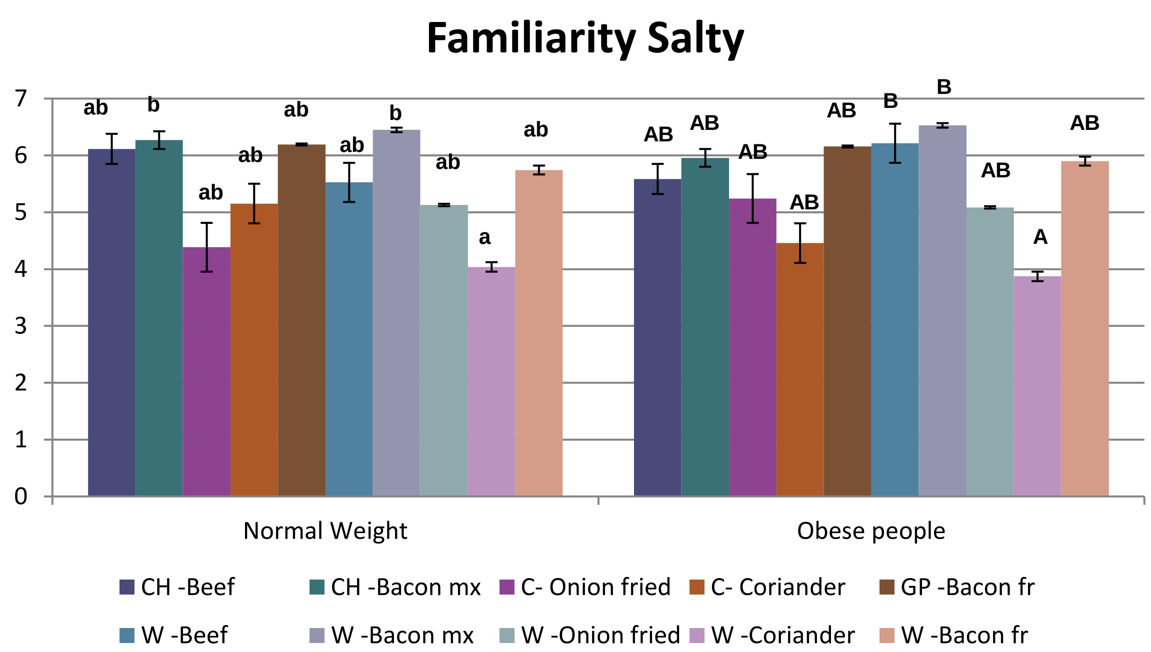

Fig. 19 Average familiarity of the Sweet OITE solutions. Comparison of means±SE between solutions with aroma (Friedman test, p<0.05), in Normal weight (NW) and people with obesity (OB). Different lowercase letters indicate significant differences

for NW and different capital letters indicate significant differences for OB. Food base solutions: Chayote (CH), White corn (C), Green pea (GP), Water (W).

Comparing the pleasantness of Normal weight people with familiarity of Normal weight we can confirm that flavour percepts are perceived and hedonically evaluated based on the extent to which the specific combination of unisensory components resembles a familiar food item (Lim and Johnson 2012).

Normal weight participants marked white corn with onion fried the less pleasantness solution, the same one perceived not the most familiar, this might be explained by the mere-exposure effect, the psychological phenomenon describing the tendency for humans to develop preferences for things that are familiar. That mere-exposure plays a role in the development of odor preferences has been suggested by previous studies that found positive correlations between pleasantness and familiarity (Distel et al. 1999).

Words for saltiness

Figs. 20, 21, 22 and 23 show the dishes/food that was evoke by Chayote, White corn, Green peas and water solutions with their associated aroma respectively.

Frequently encountering odorant/tastant combinations could result in the formation of a cognitive association between the smell of the odorant and the taste of the tastant (Hendrik et al., 1996). For example, bacon odor may be called 'salty' because it is usually perceived in combination with a salty taste.

In the case of Chayote, in addition of mentioning chayote or vegetables consumers perceived also Beef and chicken, and that’s because of the aroma. The white corn solution, the perception was not very clear by the participants, marking Onion that was an aroma used in the solutions. Green pea and vegetables were correctly detected; moreover Normal weight people related the solution also with Soup and stock. For solutions with water and aroma, we can notice that people perceived flavours, just like meat, ham, soup, stock (because of the aromas).

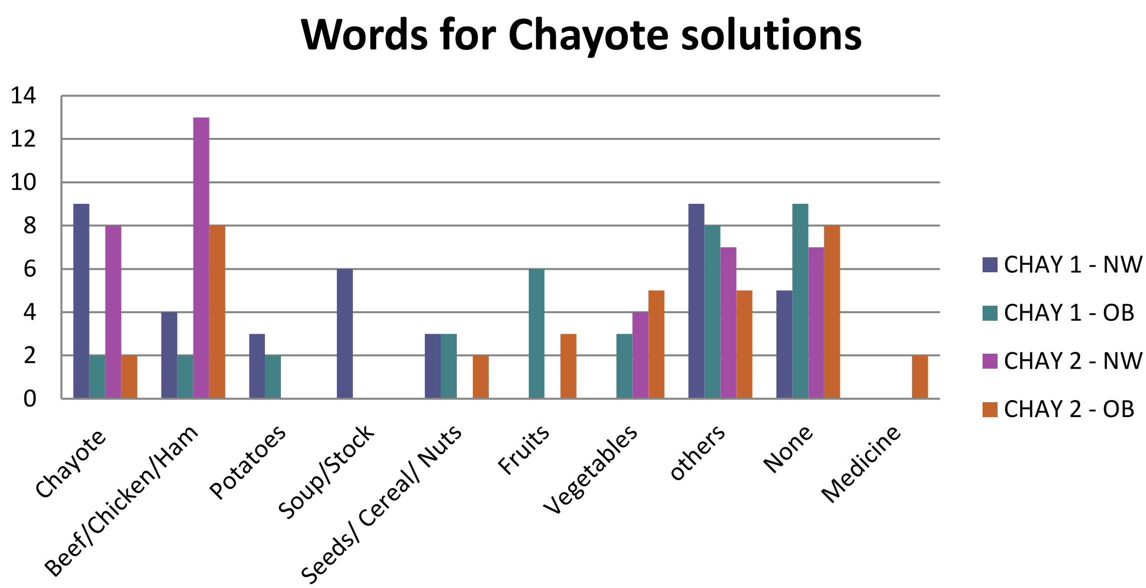

Fig. 20 Distribution of scores about dishes/food remembered by the Chayote solutions tasted. CHAY 1 (Chayote base with Beef odorant) and CHAY 2 (Chayote base with Bacon MX odorant) for NW: Normal Weight and OB: People with obesity.

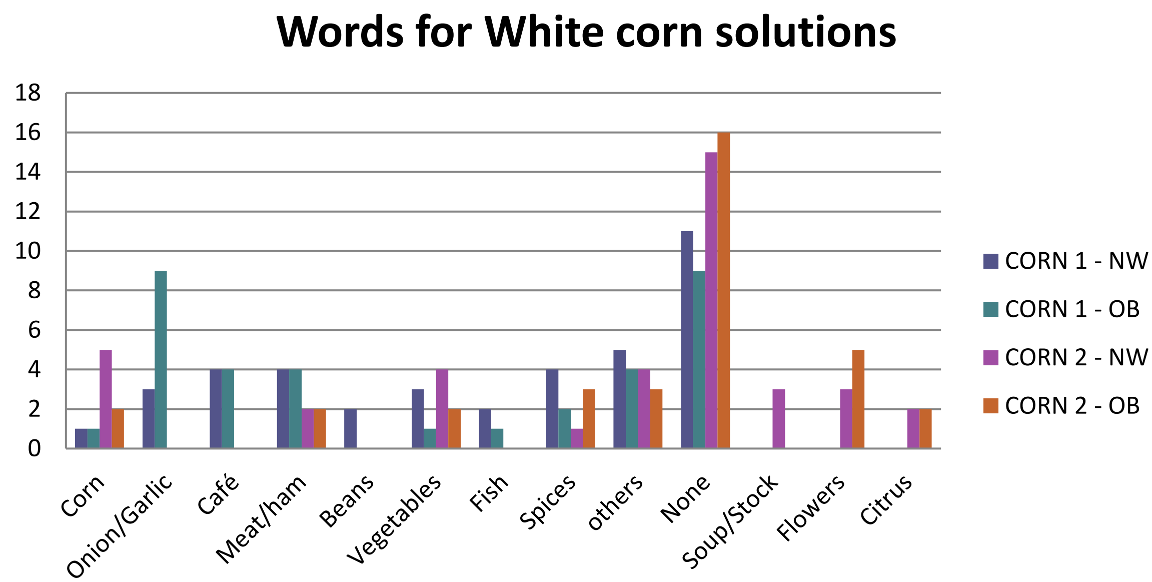

Fig. 21 Distribution of scores about dishes/food revoked by the White corn solutions. CORN 1 (White corn base with Onion fried odorant) and CORN 2 (White corn base with coriander odorant) for NW: Normal Weight and OB: People with obesity.

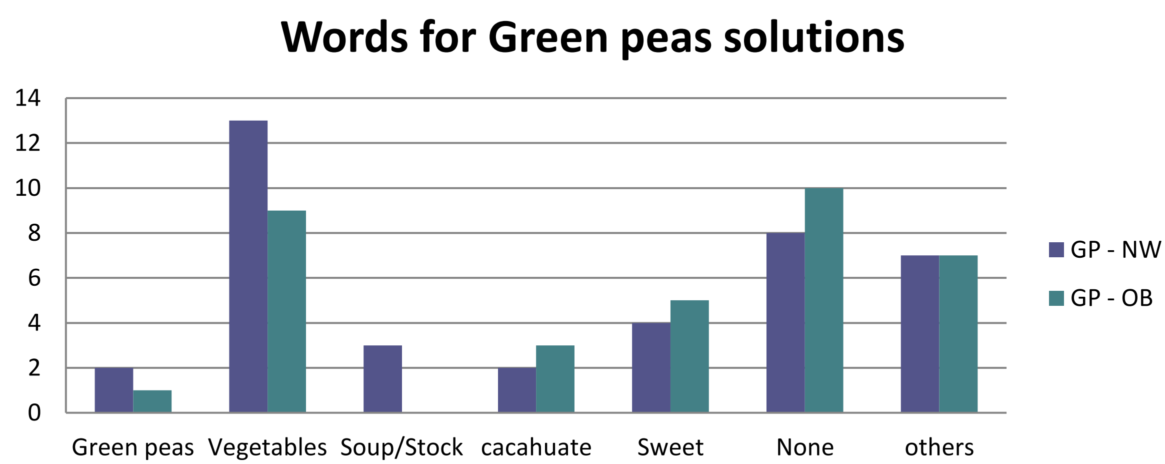

Fig 22. Distribution of scores about dishes/food remembered by the Green pea solutions tasted. GP 1 (Green pea base with Bacon FR odorant) for NW: Normal Weight and OB: People with obesity.

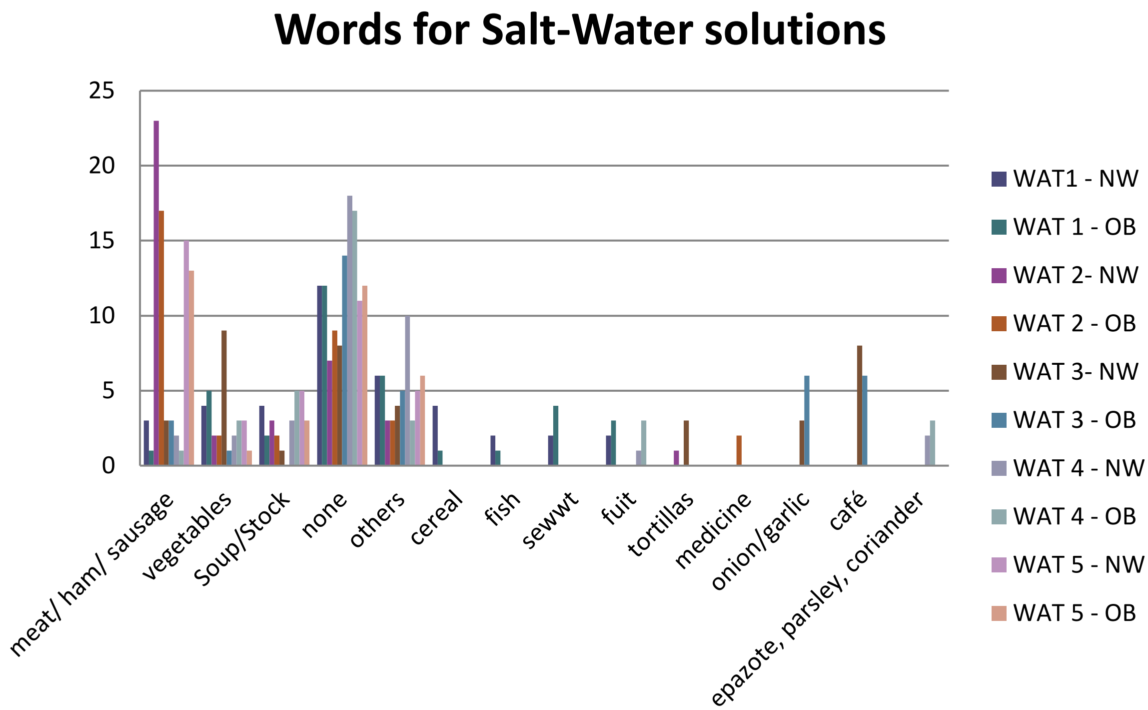

Fig. 23 Distribution of scores about dishes/food evoked by Water solutions with odorant tasted. WAT 1 (Water with Beef odorant), WAT2 (Water with Bacon MX odorant), WAT 3 (Water with Onion fried odorant), WAT 4 (Water with Coriander odorant) and WAT 5 (Water with Bacon FR) for NW: Normal Weight and OB: People with obesity.

These findings suggest that congruency acts as a necessary condition for odor-induced taste enhancement: enhancement will occur only in congruent tastant/odorant combinations, but the degree of congruency is not related to the degree of enhancement (Hendrik et al., 1996). We could consider that Beef and Bacon MX may have no congruent odorant for the chayote base, that could be a factor of no having OITE effect.

In the table 9, we can see that Water with sugar type is not familiar as a consequence it was not pleasantness, hoverer the relation between pleasantness and familiarity is no very clear, Moreover there has been reported no correlation between OITE and pleasantness align with these previous findings (Aveline, et al., 2022).

Individuals from the same species do not necessarily perceive the same odor in a particular odorant, and more generally, they do not present the same sensibility to odor cues (Frumin et al., 2013) that is why we found a variety of responses related with certain odorants.

According to the data, participants both, normal weight and obese (p=0.955) add salt to dishes only after taste them. Moreover participants both, normal weight and obese (p= 0.201) usually add 1 or 2 teaspoons of sugar to the beverages, cereal or food.

Table 9. Salty solutions evaluated if there was OITE, the most or least pleasantness, JAR and least or the most familiar, depending on the solution.

		NW	OB	NW	OB	NW	OB	NW	OB
		OITE		pleasantness		JAR		familiarity	
1	Chayote aroma Beef	NO	NO	MOST					
2	Chayote aroma Bacon MX	NO	NO	MOST				MOST	
3	White corn aroma onion fried	YES	NO	LEAST	LEAST	MOST	MOST		
4	White corn aroma Coriander	YES	NO	MOST			MOST		
5	Green peas aroma Bacon FR	YES	YES	MOST					
6	Water aroma Beef	YES	YES	MOST					MOST
7	Water aroma Bacon MX	YES	YES	MOST				MOST	MOST
8	Water aroma Onion fried	YES	YES						
9	Water aroma Coriander	YES	YES	MOST	MOST			LEAST	LEAST
10	Water aroma Bacon FR	YES	YES	MOST		LEAST	LEAST		

Another factor that attributes OITE is that the evaluation was correctly perform since the odor-induced enhancement disappears or changes to suppression when the number of appropriate response scales is increased. According to Frank et al. (2003), these shifts result from the use of different concepts working of the target attribute under various task instructions. In contrast ratings of multiple appropriate attributes forces an analytical approach and taste enhancement is eliminated.

Expectations evoked by colors , written information and labelling have all been shown to affect taste intensity judgments, these factors were avoided in the sensory tests when participants evaluating the samples.

We can see in the summary in the table 10, the salty and sweetness solutions that had OITE effect, analysing that some of them had a better enhancement than others.

There is a cultural aspect involved, using the same apple juice and green peas by Aveline et al (2022). He found OITE for OB French people in apple juice (OITE=S2), in the same way, in our results OITE was found for OB Mexican people too (OITE=S2). Moreover, in both French and Mexican people OITE was found in NW and OB but in different level; in the study of Aveline et al (2022), the enhancement of bacon FR odorant was (S1 < OITE < S2), in this study the enhancement was higher (OITE =S2) see Table 10.

Table 10. Equivalence of the OITE solutions and the level of sugar/salt concentration; a) OITE solutions was between solutions S1 and S2, b) OITE solutions was perceived as salty as S2 and c) OITE solution was perceived as salty as solution S2 and S3

	NW	OB
Jamaica aroma Vanilla mx	S1<OITE<S2	OITE=S2
Apple juice aroma Vanillin FR	**NO OITE**	OITE=S2
Water aroma Golden Syrup	S1<OITE<S2	S1<OITE<S2
Water aroma Vanilla mx	S1<OITE<S2	S1<OITE<S2
Water aroma Vanillin FR	S1<OITE<S2	S1<OITE<S2
White corn aroma onion fried	OITE = S2=S3	**NO OITE**
White corn aroma Coriander	OITE=S2	**NO OITE**
Green peas aroma Bacon FR	OITE=S2	OITE=S2
Water aroma Beef	OITE = S2=S3	OITE = S2=S3
Water aroma Bacon MX	OITE = S2=S3	OITE = S2=S3
Water aroma Onion fried	OITE = S2=S3	OITE = S2=S3

Water aroma Coriander	S1<OITE<S2	S1<OITE<S2
Water aroma Bacon FR	OITE=S2	OITE=S2

Results of the questionnaires

The table 11 shows no difference in hunger state in the beginning of the session (p= 0.570) either at the end of the session (p= 0.364) between Normal weight vs Obese. Also, it is noticed that for DEBQ there were differences in restriction (p=0.022), emotional (p=0.000) eating behaviours between groups (NW vs OB) even in defined emotions (p=0.000), with superior average scores in OB participants. Similarly, studies have shown that people with obesity have higher restrained and emotional scores that partly explain their weight status (Cebolla et al., 2014). There were no significant differences in external (p=0.151) and diffuse emotions (p=0.067). Develop of the DEBQ questionnaire in the annex 3.

Highlighting that obese people restrict restricting food intake because of weight, present increase in appetite or food intake, as a consequence of negative mood states and result of contact with the sensory qualities of food (triggered by the sight and smell of food or the presence of other people eating) (Llunch et al., 1996). Besides this, other factors involved in the development of obesity are multiple and interrelated, just like diet, eating behaviour disorders, sedentary lifestyle, psychological factors, genetics, environmental factors (Mitanchez et al., 2017).

Within Normal weight men vs Normal weight women (see table 12), we did not find differences in restriction (p=0.221), external (p=0.622) and emotional eating behaviours (p=0.132). Moreover, differences were found between Obese men vs Obese women in restriction (p=0.025) but no difference in external (p=0.218) and emotional eating behaviours (p=0.858). According to this, women are the ones that are more affected. Some studies have reported a higher frequency of emotional eating in women than in men (Spoor et al., 2007; Laitinen et al., 2002; Camilleri et al., 2014).

Table 11 shows that for the DFS, no significant differences between groups (NW vs OB) were observed in saturated fat (p=0.205), free sugar (p=0.058) and in saturated fat and sugar (p=0.245). Despite the results, Blundell et al., 2001, mention that there is a preference for high energy-dense over low energy-dense foods by obese people. (Develop of the DFS questionnaire is in the annex 4).

Moreover, we can see in the table 12, no differences between Obese men vs Obese women in saturated fat (p=0.606), Free sugar (p=0.054) neither on fat and free sugar (p=0.762). For NW people, there was no significant differences in saturated fat (p= 0.390), neither on fat and free sugar (P= 0.134), but it was significant differences in free sugar (p= 0.027). It has been reported that the consumption of energy, sugary drinks, and alcohol in milliliters and kilocalories per week, was higher in men (Caravalí-Meza et al., 2015). Likewise, it has been reported men demonstrate a rather uncritical and traditional adherence to eating profiles and pattern giving more importance to taste pleasantness and eating pleasure. Men are more taste-driven in their food choices (Teratanavat and Hooker, 2006), while women have been reported to be more likely than men to mention more vegetables or less fat or balance as a part of a healthy diet (Margetts et al., 1997).

It has been shown that depressed patients perceived the majority of odor mixtures (67%) as significantly less pleasant compared to healthy subjects (Atanasova, 2012).

People with obesity present a higher sensitization of the reward system to food cues (Kenny, 2011) which is involved in the flavor network (Sinding, Aveline, Brindisi, & Thomas-Danguin, 2022) that might be the reason OITE increased in OB compared with NW in sweet solutions.

Furthermore, salty taste sensitivity appears related to weight excess with lower sensitivity with increasing BMI (Bertoli et al., 2014).

Table 11. Mean scores (Standard deviation) of hunger state and questionnaires items by groups. Mann Whitney * Significant at p<0.05, ** Significant at p<0.01, *** Significant at p<0.001

	Normal Weight (NW)	**Obese (OB)**	**Comparison NW vs OB**
Hunger state beginning of session	3.3(2.97)	3.7 (2.85)	NS
Hunger state at the end of session	4.6(3.24)	4.0(3.15)	NS
DEBQ restriction score (SD)	2.7 (1.37)	2.9 (1.29)	**
DEBQ external score (SD)	2.7(1.31)	2.9 (1.25)	NS
DEBQ emotional score (SD)	2.4 (1.30)	2.7(1.29)	***
DEBQ emotional defined score (SD)	2.4 (1.30)	2.8 (1.30)	***
DEBQ emotional diffused score (SD)	2.3(1.27)	2.6(1.28)	NS
DFS saturated fat score (SD)	2.1 (1.25)	2.2 (1.26)	NS
DFS free sugar score (SD)	1.8 (1.03)	2.0 (1.15)	NS
DFS fat and free sugar score (SD)	2.0 (1.07)	2.0(1.14)	NS

Table 12. Mean scores (Standard deviation) of questionnaires items by groups; Normal weight (NW) and people with obesity (OB) and gender (Men and women). Mann Whitney Significant at p<0.05, ** Significant at p<0.01, *** Significant at p<0.001 mean (SD)

	NW-men	NW-women	comparison	OB - men	OB - women	comparison
DEBQ restriction score (SD)	2.5 (1.42)	3.2 (1.25)	NS	2.5 (1.28)	3.0 (1.30)	*
DEBQ external score (SD)	2.6 (1.40)	2.9(1.3)	NS	2.7 (1.20)	3.0 (1.26)	NS
DEBQ emotional score (SD)	2.2 (1.31)	2.5 (1.37)	NS	2.8 (0.09)	2.7 (1.16)	NS
DFS saturated fat score (SD)	2.0 (2.07)	2.0(1.1)	NS	2.3 (1.27)	2.2 (1.28)	NS
DFS free sugar score (SD)	1.6 (0.85)	1.9(1.0)	*	2.2(1.16)	1.8(1.15)	NS
DFS fat and free sugar score (SD)	1.8 (1.00)	2.0 (1.09)	NS	2.1 (1.08)	2.0 (1.19)	NS

Demographic data

Geographic details of the sample are presented in the Fig. 24 “Municipalities”, showing that the majority of participants were from Estado de Mexico and Iztapalapa; corresponding to the Mexico City and metropolitan zone.

The data and results were mainly limited because the majority of participants came from Iztapalapa and Estado de Mexico region, places that are highlighted like needly locations, having 30.04% of the economically active population has lower income levels (INEGI, 2018). The average of educational level is mostly bachelor's degree, according to Data-Mexico, in 2020, the main academic degrees of the population of Iztapalapa were Secondary (403k people or 28.4% of the total), High School or General Baccalaureate (370k people or 26.1% of the total) and Bachelor's degree (268k people or 18.9% of the total).

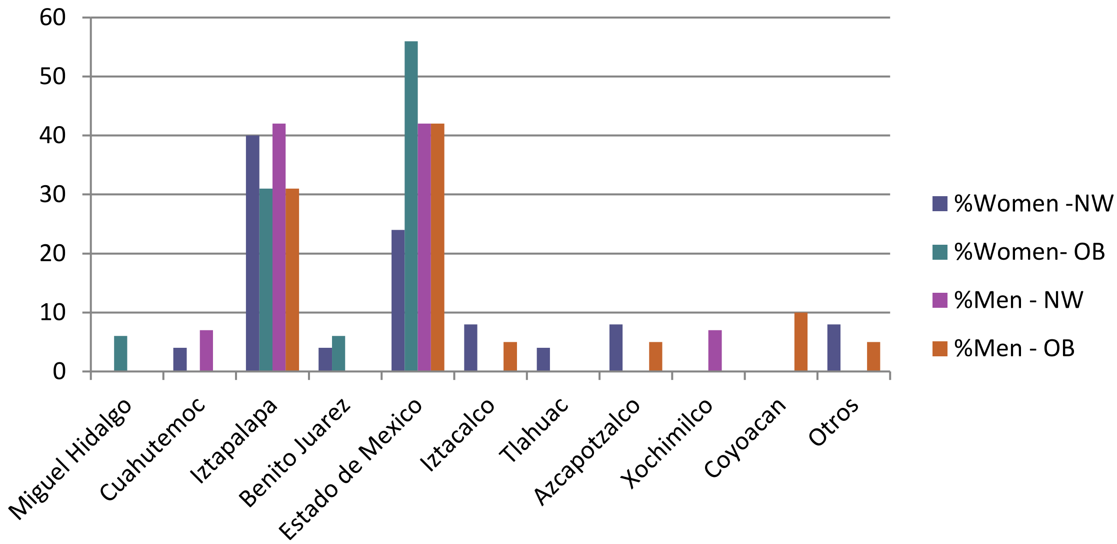

Fig. 24. Scores of Mexican city zones of participant's location.

6. Conclusion

To sum up, the study revealed that odorant concentrations were correctly apply to have a OITE phenomenon which was found in sweet solutions; Vanilla mx odorant for Jamaica's water for NW and OB, Vanillin FR odorant in Apple juice for NW, and Golden Syrup, Vanilla mx, Vanillin FR odorants in sweet water for NW and OB.

On the other hand for salty solutions, OITE was in Onion fried and Coriander odorants in White corn for NW, Bacon FR odorant in Green pea in both groups NW and OB. Finally, Beef, Bacon MX, Bacon FR, Onion fried, Coriander odorants in salty water for NW and OB.

It seems that pleasantness is not necessary to occur OITE, neither familiarity. Comparing the results there are no patron between pleasantness and OITE as well as familiarity and OITE, further studies still needs to be done to clarify the correlation between them.

People with obesity experienced a slight tendency to perceive a higher odor induced sweetness enhancement than normal weight people in apple juice solution with vanillin fr odorant. In contrast, people with normal weight showed a slightly higher trend to perceive odor induced saltiness enhancement than obese people in

White corn solution with onion fried and coriander odorant. Nevertheless, even though we found a pattern, it would be better to keep working on to validate the impact of obesity.

DEBQ and DFS questionnaires showed people living with obesity are more exposed to develop certain eating behaviors, especially in restriction (restricting food intake because of weight), emotional (increase in appetite or food intake, as a consequence of negative mood states) and emotional defined (referring to eating in response to anger or irritation). Furthermore, the results of the DFS questionnaires indicated no significant differences NW and OB in saturated fat and free sugar intake.

The solutions with odorant that released OITE effect could be suggested to be applicable to products that the objective is to reduce sugar or salt. As a perspective, it would be interesting to further understand the OITE phenomenon by comparing the same Mexican solutions with participants from another nationality to find out if there is a cross cultural factor involved.

7. Annexes

Annexe 1. Comparison between the sweet solutions, indicating if S1 + odorant (coloured cell) is significantly different (p <.0.05) from the solution S1, S2 and S3 (Wilcoxon test) for normal weight and obese people.

Normal Weight participants ranking			**Participants living with obesity ranking**		
Jamaica aroma Golden Syrup	Mean of ranks	p-value	Jamaica aroma Golden Syrup	Mean of ranks	P-value
Jamaica 3%	1.69	0.88	Jamaica 3%	1.86	0.73
Jamaica 3% OITE A	1.74		Jamaica 3% OITE A	1.91	
Jamaica 5%	2.87	**<0.0001**	Jamaica 5%	2.89	**0.00**
Jamaica 7%	3.69	**<0.0001**	Jamaica 7%	3.34	**0.00**
Jamaica aroma Vanilla mx	Mean of ranks	P-value	Jamaica aroma Vanilla mx	Mean of ranks	P-value
Jamaica 3%	1.41	**0.01**	Jamaica 3%	1.57	**0.04**
Jamaica 3% OITE B	2.03		Jamaica 3% OITE B	2.17	
Jamaica 5%	2.87	**0.00**	Jamaica 5%	2.74	0.06
Jamaica 7%	3.69	**<0.0001**	Jamaica 7%	3.51	**0.00**
Jamaica aroma Sugar Type	Mean of ranks	P-value	Jamaica aroma Sugar Type	Mean of ranks	P-value
Jamaica 3%	1.59	0.56	Jamaica 3%	1.69	0.53
Jamaica 3% OITE C	1.74		Jamaica 3% OITE C	1.80	
Jamaica 5%	2.77	**<0.0001**	Jamaica 5%	3.03	**<0.0001**
Jamaica 7%	3.90	**<0.0001**	Jamaica 7%	3.49	**<0.0001**
Apple juice aroma Vainillina FR	Mean of ranks	P-value	Apple juice aroma Vainillina FR	Mean of ranks	P-value
Apple juice 4%	1.77	0.50	Apple juice 4%	1.74	0.04
Apple juice 4% OITE D	1.90		Apple juice 4% OITE D	2.26	
Apple juice 6%	2.72	**0.00**	Apple juice 6%	2.54	0.21
Apple juice 8%	3.62	**<0.0001**	Apple juice 8%	3.46	**0.00**

Normal Weight participants ranking			Participants living with obesity ranking		
Water aroma Golden Syrup	Mean of ranks	P-value	Water aroma Golden Syrup	Mean of ranks	P-value
Water 3%	1.36	**0.00**	Water 3%	1.29	**0.00**
Water 3% OITE A	2.13		Water 3% OITE A	2.06	
Water 5%	2.85	**0.00**	Water 5%	2.91	**0.00**
Water 7%	3.67	**<0.0001**	Water 7%	3.74	**<0.0001**
Water aroma Vanilla mx	Mean of ranks	P-value	Water aroma Vanilla mx	Mean of ranks	P-value
Water 3%	1.33	**0.00**	Water 3%	1.37	**0.00**
Water 3% OITE B	2.15		Water 3% OITE B	2.06	
Water 5%	2.85	**0.00**	Water 5%	2.97	**0.00**
Water 7%	3.67	**<0.0001**	Water 7%	3.60	**<0.0001**
Water aroma Sugar Type	Mean of ranks	P-value	Water aroma Sugar Type	Mean of ranks	P-value
Water 3% OITE C	1.44		Water 3%	1.49	0.10
Water 3%	1.64	0.24	Water 3% OITE C	1.80	
Water 5%	3.10	**<0.0001**	Water 5%	2.94	**<0.0001**
Water 7%	3.82	**<0.0001**	Water 7%	3.77	**<0.0001**
Water aroma Vainillina FR	Mean of ranks	P-value	Water aroma Vainillina FR	Mean of ranks	P-value
Water 4%	1.28	**0.00**	Water 4%	1.40	**0.00**
Water 4% OITE D	2.10		Water 4% OITE D	2.14	
Water 7%	3.03	**0.00**	Water 7%	2.83	**0.01**
Water 10%	3.59	**<0.0001**	Water 10%	3.63	**<0.0001**

Annex 2. Comparison between the salty solutions, indicating if S1 + odorant (coloured cell) is significantly different (p <0.05) from the solution S1, S2 and S3. (Wilcoxon test) for normal weight and obese people.

Normal Weight participants ranking			Obese participants ranking		
Chayote aroma Beef	Mean of ranks	P-value	Chayote aroma Beef	Mean of ranks	P-value
Chayote 0.5%	2.21	0.59	Chayote 0.5%	2.37	0.67
Chayote 0.5% OITE E	2.05		Chayote 0.5% OITE E	2.46	
Chayote 0.6%	2.59	0.06	Chayote 0.6%	2.43	0.93
Chayote 0.7%	3.15	**0.00**	Chayote 0.7%	2.74	0.32
Chayote aroma Bacon MX	Mean of ranks	P-value	Chayote aroma Bacon MX	Mean of ranks	P-value
Chayote 0.5%	2.03	0.19	Chayote 0.5%	2.06	0.88
Chayote 0.5% OITE F	1.69		Chayote 0.5% OITE F	2.11	
Chayote 0.6%	3.00	**0.00**	Chayote 0.6%	2.69	0.06
Chayote 0.7%	3.28	**0.00**	Chayote 0.7%	3.14	**0.00**
White corn aroma onion fried	Mean of ranks	P-value	White corn aroma onion fried	Mean of ranks	P-value
White corn 0.7%	1.90	**0.04**	White corn 0.7%	2.03	0.19
White corn 0.7% OITE G	2.49		White corn 0.7% OITE G	2.43	
White corn 0.8%	2.51	0.92	White corn 0.8%	2.60	0.56
White corn 0.9%	3.10	0.06	White corn 0.9%	2.94	0.11
White corn aroma Coriander	Mean of ranks	P-value	White corn aroma Coriander	Mean of ranks	P-value
White corn 0.7%	1.77	**0.04**	White corn 0.7%	2.17	0.83
White corn 0.7% OITE H	2.28		White corn 0.7% OITE H	2.23	
White corn 0.8%	2.85	0.05	White corn 0.8%	2.51	0.29
White corn 0.9%	3.10	**0.01**	White corn 0.9%	3.09	**0.02**
Green peas aroma Bacon FR	Mean of ranks	P-value	Green peas Chicharo aroma Bacon FR	Mean of ranks	P-value
Green peas 0.25%	1.74	**0.03**	Green peas 0.25%	1.71	**0.01**
Green peas 0.25% OITE I	2.28		Green peas 0.25% OITE I	2.37	
Green peas 0.5%	2.62	0.33	Green peas 0.5%	2.69	0.32
Green peas 0.75%	3.36	**0.00**	Green peas 0.75%	3.23	**0.02**

Normal Weight participants ranking			Obese participants ranking		
Water aroma Beef	Mean of ranks	P-value	Water aroma Beef	Mean of ranks	P-value
Water 0.25%	1.59	**0.00**	Water 0.25%	1.91	**0.01**
Water 0.25% OITE E	2.85		Water 0.25% OITE E	2.60	
Water 0.3%	2.38	0.11	Water 0.3%	2.66	0.80
Water 0.35%	3.18	0.22	Water 0.35%	2.83	0.47
Water aroma Bacon MX	Media de rangos	P-value	Water aroma Bacon MX	Mean of ranks	P-value
Water 0.25%	1.41	**0.00**	Water 0.25%	1.83	**0.04**
Water 0.25% OITE F	2.82		Water 0.25% OITE F	2.49	
Water 0.3%	2.46	0.17	Water 0.3%	2.74	0.56
Water 0.35%	3.31	0.07	Water 0.35%	2.94	0.09
Water aroma Onion fried	Mean of ranks	P-value	Water aroma Onion fried	Mean of ranks	P-value
Water 0.35%	1.69	**0.00**	Water 0.35%	1.63	**0.00**
Water 0.35% OITE G	2.72		Water 0.35% OITE G	2.69	
Water 0.4%	2.41	0.33	Water 0.4%	2.66	0.94
Water 0.45%	3.18	0.13	Water 0.45%	3.03	0.25
Water aroma Coriander	Mean of ranks	P-value	Water aroma Coriander	Mean of ranks	P-value
Water 0.35%	1.62	**0.01**	Water 0.35%	1.54	**0.04**
Water 0.35% OITE H	2.31		Water 0.35% OITE H	2.09	
Water 0.4%	3.00	**0.01**	Water 0.4%	2.86	**0.01**
Water 0.45%	3.08	**0.01**	Water 0.45%	3.51	**0.00**
Water aroma Bacon FR	Mean of ranks	P-value	Water aroma Bacon FR	Mean of ranks	P-value
Water 0.10%	1.62	**0.00**	Water 0.10%	1.37	**0.00**
Water 0.10% OITE I	2.38		Water 0.10% OITE I	2.63	
Water 0.18%	2.59	0.51	Water 0.18%	2.69	0.75
Water 0.25%	3.41	**0.00**	Water 0.25%	3.31	**0.03**

Questionnaires

Annex 3. DEBQ Questionnaire (Lluch et al., 1996).

DEBQ questionnaire comprises 33 items that characterize eating behaviors personality traits. Three scores were calculated from the 33 items to assess the level of “external eating”, “emotional eating,” and “restrained eating”. Within the emotional eating section, “defined” and “diffused” emotional eating scores were calculated. Responses are given on a scale from never to frequently.

The **restriction** scale (10 items; 4, 7, 11, 14, 17, 19, 22, 26, 29 & 31) seems to be directed specifically towards the concept of restriction in the common sense of the term, that is to say "restricting food intake because of weight". The items relate to the intention to have deliberate and planned weight control.

The Food **emotivity** Scale (13 items; 1, 3, 5, 8, 10, 13, 16, 20, 23, 25, 28, 30 & 32) includes items that refer to clearly *defined emotions* (9 items;1, 5, 13, 16, 20, 23, 25, 30 & 32) and *diffuse emotions* (4 items; 3, 8, 10 & 28), which may trigger different food responses. The questions relate in particular to the increase in appetite or food intake, as a consequence of negative mood states.

The **externality** scale (10 items; 2, 6, 9, 12, 15, 18, 21, 24, 27 & 33) contains items that measure the subjects' sensitivity to external food stimuli. The questions relate more specifically to increased appetite or food intake, as a result of contact with the sensory qualities of food (triggered by the sight and smell of food or the presence of other people eating).

Responses are given on a scale from never to frequently.

Restrained eating

1. If you have put on weight, do you eat less than you usually do?
2. Do you try to eat less at mealtimes than you would like to eat?

3. How often do you refuse food or drink offered because you are concerned about your weight?

4. Do you watch exactly what you eat?

5. Do you deliberately eat foods that are slimming?

6. When you have eaten too much, do you eat less than usual the following days?

7. Do you deliberately eat less in order not be become heavier?

8. How often do you try not to eat between meals because you are watching your weight?

9. How often in the evening do you try not to eat because you are watching your weight?

10. Do you take into account your weight with what you eat?

Emotional eating

11. Do you have the desire to eat when you are irritated?

12. Do you have a desire to eat when you have nothing to do?

13. Do you have a desire to eat when you are depressed or discouraged?

14. Do you have a desire to eat when you are feeling lonely?

15. Do you have a desire to eat when somebody lets you down?

16. Do you have a desire to eat when you are cross?

17. Do you have a desire to eat when you are approaching something unpleasant to happen?

18. Do you get the desire to eat when you are anxious, worried or tense?

19. Do you have a desire to eat when things are going against you or when things have gone wrong?

20. Do you have a desire to eat when you are frightened?

21. Do you have a desire to eat when you are disappointed?

22. Do you have a desire to eat when you are emotionally upset?

23. Do you have a desire to eat when you are bored?

External eating

24. If food tastes good to you, do you eat more than usual?

25. If food smells and looks good, do you eat more than usual?
26. If you see or smell something delicious, do you have a desire to eat it?
27. If you have something delicious to eat, do you eat it straight away?
28. If you walk past the baker, do you have the desire to buy something delicious?
29. If you walk past a snack-bar or a cafe, do you have the desire to buy something delicious?
30. If you see others eating, do you also have the desire to eat?
31. Can you resist eating delicious foods?
32. Do you eat more than usual when you see others eating?
33. When preparing a meal, are you inclined to eat something?

Annex 4. DFS Questionnaire

Think about the food you have eaten over the past year. Remember breakfast, lunch, dinner and eating out. Please select the option that best describes how often you have consumed each of the following food or drink items.

The participants had to choose how many times they consumed this food during the last month, “less than 1 per month”, “2–3 per month”, “1–2 per week”, “3–4 per week” and “5 + per week”.

1 Mince, beef or lamb, for example, in hamburgers, nachos or bolognaise

2 Beef or pork such as steak, ribs, roasts or in sandwiches

3 Fried chicken or chicken burgers

4 Sausages, frankfurts or salami

5 Bacon

6 Salad dressings (not low fat)

7 Margarine, butter or oil in cooking

8 Eggs (not egg whites alone)

9 Pizza

10 Cheese or cheese spread (not low fat)

11 French fries, fried potatoes

12 Corn chips, potato chips, popcorn with butter

13 Doughnuts, pastries, croissants

14 Cakes, cookies

15 Ice cream (not sorbet or low fat)

16 Chocolate

17 Lollies

18 Spreads incl. peanut butter, jam, honey

19 Pancakes or French toast

20 Sports drinks (e.g. Gatorade) or energy drinks (e.g. Red Bull)

21 Soft drink (not including diet)

22 Milk (full fat only). Include milk drunk by itself or in cappuccinos, milkshakes, hot chocolates etc.

23 Other sweetened beverages (e.g. juice with added sugar, cordial, sweetened teas)

24 White bread (white bread only)

25 In the past year, how many times have you eaten food from a takeaway or fast food restaurant for example McDonalds, KFC, Mexican, Chinese, Thai, Italian (pizza or pasta)?

26 In the past week, how many teaspoons of sugar have you added to your beverages, cereal or food?

Informed consent form

Formulario de consentimiento
Ejemplar para el experimentador

Apellidos: ……………………………………………………...

Nombre: ………………………………………………..

declaro que he leído toda la información dada sobre "Cómo nuestro cerebro percibe los alimentos" con respecto a mi participación en este estudio.

Declaro estar informado de que:

- En cualquier momento, puedo interrumpir mi participación en el estudio sin consecuencias.

- En cualquier momento, los responsables del estudio pueden interrumpir mi participación en este estudio.

Declaro:

× **Cumplir** con los criterios de inclusión:

- Tener entre 18 y 60 años

× **No cumplir con** los criterios de exclusión siguientes:

- Embarazo o lactancia
- Alergias alimentarias
- Sinusitis crónica
- Diabetes
- Enfermedad cardiovascular
- Persona que no puede movilizarse sin ayuda
- Adultos protegidos bajo tutela o curatela
- Personas con discapacidad intelectual que no permiten una buena comprensión de las tareas solicitadas.
- Haber residido de forma continua más de 90 días en el extranjero.
- Enfermedades neurodegenerativas (Parkinson, Alzheimer)
- Trastornos neurológicos
- Antecedentes de trastornos alimentarios (anorexia, bulimia).
- Índice de masa corporal (IMC<18.5kg/m^2)
- Hipertensión
- Cirugía bariátrica.
- Trastornos psiquiátricos con tratamiento (trastorno bipolar, esquizofrenia).
- Dietas especiales-auto restrictivas (veganas, vegetarianas)
- Dietas sin azúcar ni sal.
- Tener cáncer progresivo en tratamiento (excluida la terapia hormonal)
- Tener una inmunosupresión congénita o aguda (por ejemplo: VIH, hemopatía maligna por trasplante de órganos ...)
- Estar en diálisis o tener una enfermedad renal crónica grave
- Tener una patología respiratoria crónica.
- Tener cirrosis
- Tener un síndrome de células falciformes grave o tiene antecedentes de esplenectomía.

-

× Acepto que los datos personales que me conciernen recopilados durante este estudio pueden estar sujetos a procesamiento automatizado por parte de los organizadores de la investigación.

CDMX a ……………..

Firma con la mención "Declaro que he leído y entendido toda la información mencionada en este documento". ______________________________

Bibliography

Abdih (2002), 'What can cognitive psychology and sensory evaluation learn from each other?', Food Qual Pref, 13, 445-451.

Atanasova,B.(2012).Hedonicolfactoryperceptionindepression:relationship betweenself-valuationandautonomicresponse. Psychology 3, 959–965.doi: 10.4236/psych.2012.311144

Aveline, C., Leroy, C., Brindisi, M. C., Chambaron, S., Thomas-Danguin, T., & Sinding, C. (2022). Influence of obesity on saltiness and sweetness intensity enhancement by odors. Food Quality and Preference, 102, 104685.

Barba, C., Beno, N., Guichard, E., & Thomas-Danguin, T. (2018). Selecting odorant compounds to enhance sweet flavor perception by gas chromatography/olfactometry-associated taste (GC/O-AT). Food Chemistry, 257(October

Bartolotto Carole.(2015) Does Consuming Sugar and Artificial Sweeteners Change Taste Preferences The Permanente journal vol. 19, doi:10.7812/TPP/14-229

Bartoshuk LM (1980). Sensory analysis of the taste of NaCl Biological and behavioral aspects of salt intake. Kare MR, Fregly MJ, Bernard RA, editors. New York: Academic Press; 1980. pp. 83–98 https://www.ncbi.nlm.nih.gov/books/NBK50958/

Bartoshuk, L. M., Duffy, V. B., Hayes, J. E., Moskowitz, H. R., & Snyder, D. J. (2006). Psychophysics of sweet and fat perception in obesity: problems, solutions and new perspectives. https://doi.org/10.1098/rstb.2006.1853

Bartoshuk, L.M., Duffy, V.B., Green, B.G., Hoffman, H.J., Ko, C.-W., Lucchina, L.A., Marks, L.E., Snyder, D.J. and Weiffenbach, J.M. (2004), “Valid across-group comparisons with labeled scales: the gLMS versus magnitude matching”, Physiology & Behavior, Vol. 82, pp. 109-114.

Bertoli S, Laureati M, Battezzati A, Bergamaschi V, Cereda E, Spadafranca A, et al. (2014) Taste sensitivity, nutritional status and metabolic syndrome: implication in weight loss dietary interventions. World J Diabetes. 2014;5(5):717–23. https://doi.org/10.4239/wjd.v5.i5.717

.

Billaux MS, Flourie B, Jacquemin C, Messing B. (1991) Sugar alcohols. In: Marie S, Piggott JR, editors. Handbook of Sweeteners. Boston, MA: Springer.p. 72–103.

Blundell, J. E., Gillett, A., John, E., & Gillett, A. (2001). Control of food intake in the obese. Obesity Research, 9(4 November 2001), 263–270.

Bobowski NK, Mennella JA (2015). Disruption in the relationship between blood pressure and salty taste thresholds among overweight and obese children. J Acad Nutr Diet. 2015;115(8):1272–82. https://doi.org/10.1016/j.jand.2015.02.017

Breslin, P. A. S., & Beauchamp, G. K. (1997). Salt enhances flavour by suppressing bitterness.

Breslin, P. A., & Huang, L. (2006). Human taste: peripheral anatomy, tastetransduction, and coding. Taste and smell, 63, 152-190.

Brondel L, Cabanac M. (2007). Alliesthesia in visual and auditory sensations from environmental signals. Physiol Behav. 2007;91:196–201.

Brown J. (1974). Recognition assessed by rating and ranking. Brit J Psycho 65:13–22.

Camilleri G, Mejean C, Kesse-Guyot E, Andreeva V, Bellisle F, Hercberg S, Peneau S. (2014) The Associations between Emotional Eating and Consumption of Energy-Dense Snack Foods Are Modified by Sex and Depressive Symptomatology

Caravalí-Meza, N., Jiménez-Cruz, A., Bacardi-Gascon, M., & Gómez-Miranda, L. M. (2015). Obesity and high health risk due to beberages consumption and obesity among high school students in méxico. Nutricion Hospitalaria, 31(5), 2324-2326.

Cebolla, A., Barrada, J. R., Strien, T. V., Oliver, E., & Ba˜nos, R. (2014). Validation of the Dutch Eating Behavior Questionnaire (DEBQ) in a sample of Spanish women. Appetite, 73, 58–64. https://doi.org/10.1016/j.appet.2013.10.014

Cliff M and Noble A (1990), 'Time-intensity evaluation of sweetness and fruitiness and their interaction in a model solution', J Food Sci, 55, 450-454.

Cliff, M.A., O'Mahony, M., fukumoto, I. and King, M.C. (2000), development of a ‘bipolar’ r-index1. Journal of Sensory Studies, 15: 219-229. https://doi.org/10.1111/j.1745-459X.2000.tb00266.x

Desmond, E. (2006). Reducing salt: A challenge for the meat industry. Meat science. Desor JA, Beauchamp GK. Longitudinal changes in sweet preferences in humans. Physiol Behav. 1987;39:639–41.

Desor, J. A., & Beauchamp, G. K. (1987). Longitudinal changes in sweet preferences in humans. Physiology & behavior, 39(5), 639-641. https://academic.oup.com/jn/article/142/6/1142S/4689065

Distel H, Ayabe-Kanamura S, Martínez-Gómez M, Schicker I, Kobayakawa T, Saito S, Hudson R. (1999). Perception of everyday odors—correlation between intensity, familiarity and strength of hedonic judgement. Chem Senses. 24(2):191–199. https://doi.org/10.1093/chemse/24.2.191

Djordjevic, J., Zatorre, R. J., & Jones-Gotman, M. (2004). Odor-induced changes in taste perception. Experimental Brain Research, 159(3), 405-408.

Doty, R. L., & Cameron, E. L. (2009). Sex differences and reproductive hormone influences on human odor perception. Physiology & behavior, 97(2), 213-228.

Dravnieks A. (1985). Atlas of odor character profiles. Philadelphia (PA): American Society for Testing of Materials.

Dravrueks,A. (1985) Atlas of Odor Character Profiles. ASTM Data Series DS 61, Philadelphia. Dubois.G.E. and Lee,J.F. (1983) A simple technique for the evaluation of temporal taste properties. Chem. Senses, 7, 237-247.

Drewnowski, Adam., Mennella, Julie A., Johnson, Susan L., Bellisle, France., (2012) Sweetness and Food Preference, The Journal of Nutrition , Volumen 142, Número 6, páginas 1142S – 1148S, https://doi.org/10.3945/jn.111.149575

Duffy, V. B., Peterson, J. M., Dinehart, M. E., & Bartoshuk, L. M. (2003). Genetic and environmental variation in taste: associations with sweet intensity, preference, and intake. Topics in Clinical Nutrition, 18(4), 209-220.

Escalona B, Hector B. (1995). Evaluación estadística de metodologías para pruebas sensoriales a través de estudios de caso. Tesis de maestría en biotecnología. Universidad Autónoma Metropolitana, México.

Fitch C, Keim KS, (2012) Academy of Nutrition and Dietetics. Position of the Academy of Nutrition and Dietetics: use of nutritive and nonnutritive sweeteners. J Acad Nutr Diet. 112:739–58. doi: 10.1016/j.jand.2012.03.009

Frank R and Byram J (1988), 'Taste-smell interactions are tastant and odorant dependent', Chem Senses, 13, 445^55.

Frank, R. A. (2003). Response context affects judgments of flavor components in foods and beverages. Food Quality and Preference, 14(2), 139-145.

Frankham P, Gosselin C, Cabanac M. (2005). Diet induced weight loss accelerates onset of negative alliesthesia in obese women. BMC Public Health. 2005;5:112.

Frumin,I.,Sobel,N.,andGilad,Y.(2013).Doesauniqueolfactorygenomeimplya unique olfactoryworld? Nat.Neurosci. 17, 6–8.doi:10.1038/nn.3608

Goldstein, E. B. (2010). Sensation and perception (8th ed.). Belmont, CA: Wadsworth, Cengage Learning.

González,S.., Estarrón, M., Gómez, J.F. and Andrade, I. (2009). Effect of the Temperature on the Spray Drying of Roselle Extracts (Hibiscus sabdariffa L.. J. Plant

Grembecka M. (2015) Natural sweeteners in a human diet. Rocz Panstw Zakl Hig. 66:195–202.

Grembecka M. (2015) Sugar alcohols—their role in the modern world of sweeteners: a review. Eur Food Res Technol.

He, F. J., & MacGregor, G. A. (2009). A comprehensive review on salt and health and current experience of worldwide salt reduction programmes. Journal of Human Hypertension.

Hendrik N.J Schifferstein, Peeter W.J Verlegh (1996), The role of congruency and pleasantness in odor-induced taste enhancement, Acta Psychologica, Volume 94, Issue 1

Hernández Montes, A. (2007). Evaluación sensorial de productos agroalimentarios (No. TX546. H47 2007.).

Jones, A. C., Kirkpatrick, S. I., & Hammond, D. (2019). Beverage consumption and energy intake among Canadians: analyses of 2004 and 2015 national dietary intake data. Nutrition journal, 18(1), 1-14

Keller, A., Zhuang, H., Chi, Q., Vosshall, L. B., & Matsunami, H. (2007). Genetic variation in a human odorant receptor alters odour perception. Nature, 449(7161), 468-472.

Kenny, P. J. (2011). Reward mechanisms in obesity: new insights and future directions. Neuron, 69(4), 664-679.

Kim, G. H., & Lee, H. M. (2009). Frequent consumption of certain fast foods may be associated with an enhanced preference for salt taste. Journal of Human Nutrition and Dietetics, 22(5), 475-480.

Koubaa, Y. (2017), “Odour-induced taste enhancement and consumption of low-sugar pastry”, International Journal of Market Research, Vol. 59 No. 6, pp. 749-765.

Krishna, A., Morrin, M. and Sayin, E. (2014), “Smellizing cookies and salivating: a focus on olfactory imagery”, Journal of Consumer Research, Vol. 41 No. 1, pp. 18-34.

Laaksonen, O., Knaapila, A., Niva, T., Deegan, K. C., & Sandell, M. (2016). Sensory properties and consumer characteristics contributing to liking of berries. Food quality and preference, 53, 117-126.

Laeng B, Berridge KC, Butter CM.(1993). Pleasantness of a sweet taste during hunger and satiety: effects of gender and “sweet tooth”. Appetite. 1993;21:247–54

Laitinen J, Ek E, Sovio U (2002). Stress-related eating and drinking behavior and body mass index and predictors of this behavior.

Lawless HT, Heymann H (1998). Sensory evaluation of food: principles and practices. Aspen Publishers, Inc. Gaithersburg, Maryland.

Lawless, H. (2001). Taste. En E. B. Goldstein (Ed.), Blackwell handbook of perception. Oxford, UK: Blackwell

Le Mée, D. (2006). Using a Descriptive Sensory panel across different countries and cultures. Food Quality and Preference, 17(7–8), 647-648.

Lim J, Johnson MB. 2012. The role of congruency in retronasal odor referral to the mouth. Chem Senses. 37(6):515–522.

Liu, J., Wan, P., Xie, C., & Chen, D. W. (2021). Key aroma-active compounds in brown sugar and their influence on sweetness. Food Chemistry, 345, 128826. https://doi.org/10.1016/j.foodchem.2020.128826

Lluch, A., Kahn, J. P., Stricker-Krongrad, A., Ziegler, O., Drouin, P., & Méjean, L. (1996). Internal validation of a French version of the Dutch Eating Behaviour Questionnaire. European Psychiatry, 11(4), 198-203.

Ma, Y., He, F. J., & MacGregor, G. A. (2015). High Salt IntakeNovelty and Significance. Hypertension, 66(4), 843–849. https://doi.org/10.1161/HYPERTENSIONAHA.115.05948 https://www.ahajournals.org/doi/full/10.1161/HYPERTENSIONAHA.115.05948

Mahar A, Duizer LM. (2007). The effect of frequency of consumption of artificial sweeteners on sweetness liking by women. J Food Sci. 2007;72:S714–8.
Malherbe, M. (2003) Consumer acceptability and salt perception of food with a reduced sodium content J. Fam. Ecol. Consum. Sci., 31, p. 8

Margetts, B.M.,Martinez, J.A., Saba, A.,Holm, L. andKearney, M. (1997), “Definitions of ‘healthy’ eating: a Pan-EU survey of consumers attitudes to food, nutrition and health”, European Journal of ClinicalNutrition, Vol. 51, pp. 23-29.

Merlo, T. C., Lorenzo, J. M., Saldaña, E., Patinho, I., Oliveira, A. C., Menegali, B. S., ... & Contreras-Castillo, C. J. (2021). Relationship between volatile organic compounds, free amino acids, and sensory profile of smoked bacon. Meat Science, 181, 108596.

Mitanchez, D., Jacqueminet, S., Nizard, J., Tanguy, M. L., Ciangura, C., Lacorte, J. M., ... & Dommergues, M. (2017). Effect of maternal obesity on birthweight and neonatal fat mass: a prospective clinical trial. Plos one, 12(7), e0181307.

Monneuse MO, Bellisle F, Louis-Sylvestre J (1991). Impact of sex and age on sensory evaluation of sugar and fat in dairy products. Physiol Behav. 1991;50:1111–7

Murphy, C., & Cain, W. S. (1980). Taste and olfaction: Independence vs. interaction. Physiology and Behavior, 24, 601–606.

Nanay, B. (2017), "Multimodal mental imagery", Cortex, Vol. 105, pp. 125-134.

Nguyen H D, Valentin D, Ly M H, Chrea C and Sauvageot F (2001), When does smell enhance taste? The effect of culture and odorant/tastant relationship, Poster presented at the 4th Pangborn Sensory Science Symposium Dijon, France.

Nizar Nasri, Noelle Beno, Chantal Septier, Christian Salles, Thierry Thomas-Danguin, (2021) Cross-modal interactions between taste and smell: Odour-induced saltiness enhancement depends on salt level, Food Quality and Preference, Volume 22, Issue 7 https://www.sciencedirect.com/science/article/abs/pii/S0950329311000784

O'Sullivan, Maurice G. (2017). A Handbook for Sensory and Consumer Driven New Product Development.Woodhead Publishing https://doi.org/10.1016/C2014-0-03843-9

Panksepp , J. (2004),Neurociencia afectiva: Los fundamentos de las emociones humanas y animales,Oxford University Press.

Pimentel, T. C., da Cruz, A. G., & Deliza, R. (2016). Sensory evaluation: sensory rating and scoring methods.

Pino, J. A., Márquez, E., & Marbot, R. (2006). Volatile constituents from tea of roselle (Hibiscus sabdariffa L.). Revista CENIC Ciencias Químicas, 37(3), 127-129.

Prescott, J. (2012). Chemosensory learning and flavour: Perception, preference and intake. Physiology & Behavior, 107(4), 553-559.

Proserpio, C., Laureati, M., Invitti, C., Cattaneo, C., & Pagliarini, E. (2017). BMI and gender related differences in cross-modal interaction and liking of sensory stimuli. Food Quality and Preference, 56, 49-54.

Proserpio, C., Laureati, M., Invitti, C., Pasqualinotto, L., Bergamaschi, V., & Pagliarini, E. (2016). Cross-modal interactions for custard desserts differ in obese and normal weight Italian women. Appetite, 100, 203-209.

Rabin, M.D.,Cain,W.S.,and Cain,J.(1989).“Attention and learningin the perception of odor mixtures,” in Perception of Complex Smells and Tastes, edsD. G. Laing,W.S.Cain,R.L.McBride,andB.W.Ache(Sidney:AcademicPress), 173–188.

Rippe JM. (2010) The health implications of sucrose, high-fructose corn syrup, and fructose: what do we really know? J Diabetes Sci Technol. 4:1008– 11. doi: 10.1177/193229681000400433

Sauvageot F, Nguyen H. D. and Valentin D. (2000), Les mots voquent –ils des saveur? Une comparaison entre tudiants de France, du Vietnam et des U.S.A, Sciences des Aliments, 20, 491-522.

Schifferstein, H.N. and Verlegh, P.W. (1996), “The role of congruency and pleasantness in odor-induced taste enhancement”, Acta Psychologica, Vol. 94 No. 1, pp. 87-105.

Shwide-Slavin C, Swift C, Ross T. (2012) Nonnutritive sweeteners: where are we today? Diabetes Spectr. 25:104–10. doi: 10.2337/diaspect.25.2.104

Sinding, C., Aveline, C., Brindisi, M. C., & Thomas-Danguin, T. (2022). Flaveur et obésité. Cahiers de Nutrition et de Diététique

Sinding, C. & Thibault, Henri & Hummel, Thomas & Thomas-Danguin, Thierry. (2021). Odor-Induced Saltiness Enhancement: Insights Into The Brain Chronometry Of Flavor Perception. Neuroscience. 452. 126-137. 10.1016/j.neuroscience.2020.10.029. https://www.researchgate.net/publication/346901532_Odor-Induced_Saltiness_Enhancement_Insights_Into_The_Brain_Chronometry_Of_Flavor_Perception/citation/download

Small DM, Voss J, Mak YE, Simmons KB, Parrish T, Gitelman D. (2004). Experience-dependent neural integration of taste and smell in the human brain. J Neurophysiol. 92(3):1892–1903.

Small, Dana M. & Prescott, John. (2005). Odor/taste integration and the perception of flavor

Spoor S, Bekker M, Van Strien T, van Heck G. (2007) Relations between negative affect, coping, and emotional eating. Appetite

Stevenson, R. (2010). The Psychology of Flavour. Oxford University https://doi.org/10.1093/acprof:oso/9780199539352.001.0001

Stice E, Burger K. (2019) Neural vulnerability factors for obesity. Clinical Psychology Review https://doi.org/10.1016/j.cpr.2018.12.002

Stone, H., and Sidel, J.L. (1985). Sensory Evaluation Practices, pp. 230–236. Academic Press, London.

Strazzullo, P., D'Elia, L., Kandala, N. B., & Cappuccio, F. P. (2009). Salt intake, stroke, and cardiovascular disease: meta-analysis of prospective studies. Bmj, 339.

Swithers, Susan E.(2015). Artificial sweeteners are not the answer to childhood obesity,Appetite,Volume 93, https://doi.org/10.1016/j.appet.2015.03.027.

Swithers,Susan E. (2013).Artificial sweeteners produce the counterintuitive effect of inducing metabolic derangements. Trends in Endocrinology & Metabolism, Volume 24, Issue 9. https://www.sciencedirect.com/science/article/abs/pii/S1043276013000878

Syarifuddin, A., Septier, C., Salles, C., & Thomas-Danguin, T. (2016). Reducing salt and fat while maintaining taste: An approach on a model food system. Food Quality and Preference, 48, 59-69.

Taormina, P. J. (2010). Implications of salt and sodium reduction on microbial food safety. Critical Reviews in Food Science and Nutrition, 50(3), 209–227.

Teratanavat, R. andHooker, N.H. (2006), "Consumer valuations and preference heterogeneity for a novel functional food", Journal of Food Science,Vol. 71No. 7, pp. S533-S541.

Thai, P. (2011), "Sweetness intensity perception and pleasantness ratings of sucrose, aspartame solutions and cola among multi-ethnic Malaysian subjects", Food Quality and Preference, Vol. 22 No. 3, pp. 281-289.

Ting Zhou, Yunzi Feng, Thierry Thomas-Danguin, Mouming Zhao, (2021) Enhancement of saltiness perception by odorants selected from Chinese soy sauce: A gas chromatography/olfactometry-associated taste study, Food

Chemistry, Volume 335, https://www.sciencedirect.com/science/article/abs/pii/S0308814620315260

Todrank, J., & Bartoshuk, L. M. (1991). A taste illusion: Taste sensation localized by touch. Physiology and Behavior, 50, 1027–1031.

Toldrá, F., & Barat, J. M. (2009). Recent patents for sodium reduction in foods. Recent patents for sodium reduction in foods, 1, 80–86.

Tournier,C ., Sulmont-Rossé C., Guichard, E .(2007). Flavour perception: aroma, taste and texture interactions. Food, 1 (2), Global Science Books

Valentin, D., Chrea, C and Nguyen, DH (2006). Taste-odour interactions in sweet taste perception. CSEG, France

WHO, World Health Organisation (2007). Reducing salt intake in populations. Report of a WHO forum and technical meeting. In WHO document production services. Geneva, Switzerland.

Yi SS, Kansagra SM. (2014) Associations of sodium intake with obesity, body mass index, waist circumference, and weight. Am J Prev Med. 2014;46(6):e53–e5. https://doi.org/10.1016/j.amepre.2014.02.005.

Yoon YS, Oh SW. (2012)Sodium density and obesity; the Korea National Health and Nutrition Examination Survey 2007–2010. Eur J Clin Nutr. 2012;67:141–6. https://doi.org/10.1038/ejcn.2012.204.

Casa abierta al tiempo
UNIVERSIDAD AUTÓNOMA METROPOLITANA

ACTA DE EXAMEN DE GRADO

No. 00303

Matrícula: 2202800460

Potenciación de sensaciones gustativas inducidas por el olor en alimentos para adultos mexicanos con peso normal y obesos.

En la Ciudad de México, se presentaron a las 15:00 horas del día 30 del mes de marzo del año 2023 en la Unidad Iztapalapa de la Universidad Autónoma Metropolitana, los suscritos miembros del jurado:

DR. GUSTAVO PACHECO LOPEZ
DR. CESAR ROMERO REBOLLAR
DRA. PATRICIA SEVERIANO PEREZ
DRA. MARIA AURORA PINTOR JARDINES

Bajo la Presidencia del primero y con carácter de Secretaria la última, se reunieron para proceder al Examen de Grado cuya denominación aparece al margen, para la obtención del grado de:

MAESTRA EN BIOTECNOLOGIA

DE: TANIA ORTEGA RICO

TANIA ORTEGA RICO
ALUMNA

y de acuerdo con el artículo 78 fracción III del Reglamento de Estudios Superiores de la Universidad Autónoma Metropolitana, los miembros del jurado resolvieron:

APROBAR

Acto continuo, el presidente del jurado comunicó a la interesada el resultado de la evaluación y, en caso aprobatorio, le fue tomada la protesta.

REVISÓ

MTRA. ROSALIA SERRANO DE LA PAZ
DIRECTORA DE SISTEMAS ESCOLARES

DIRECTOR DE LA DIVISIÓN DE CBS

DR. JOSE LUIS GOMEZ OLIVARES

PRESIDENTE

DR. GUSTAVO PACHECO LOPEZ

VOCAL

DR. CESAR ROMERO REBOLLAR

VOCAL

DRA. PATRICIA SEVERIANO PEREZ

SECRETARIA

DRA. MARIA AURORA PINTOR JARDINES