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# Effect of colour on exotic fruit flavour perception

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## ABSTRACT

Colours and their influence on the human mind have been heavily investigated. Several studies have shown that colours and different contexts may modify human perception. Although the influence of colour in flavour has been studied before, there hasn't been much emphasis in the Latino population. Because of this, we chose to question the influence of this visual attribute on food. Therefore we hypothesised that different food colours may change the perception of flavour by influencing the way the consumer perceives the taste may be (although it may be different from the actual one), pairing it with what they regard as a congruent taste and colour. The sample was composed by 91 colombian men and women ranging from ages 18 to 25, we tested jellies of three different fruit flavours (mango, lulo and soursop) on three different colours (red, yellow and green), each sample was evaluated for sweetness and sourness perception by visual analogue scales. The results of the study showed that the sourness of the lulo is perceived higher when paired with the green colour and lower with the red, according to one way ANOVA ( $p < 0,05$ ). This result was replicated with the soursop and mango, showing a strong tendency. Also, we found a trend regarding the sweetness perception and the colour yellow with the mango, lulo and soursop.

In contrast, the colour green was perceived as the one with lower sweetness on lulo and soursop. According to the literature, the results show an association of sweetness with yellow, and an association of sourness with green, it is noted that there actually exists a change of flavour perception in terms of colour. As a product of the study we can conclude, in Latino population these colours have a similar behaviour in the perception of flavour for these fruits.

### **1. Introduction**

At first sight, it is hard to tell what is it that makes us choose between one product from another. When talking about food, we may think that the process of eating or consuming something starts when we put it in our mouth, but it could really start since the moment we see or smell it, from the moment we communicate with it. Senses are connected in such a deep level that you may know the taste of something by just seeing it. But what happens if it doesn't look as it tastes? Nowadays, studies on colour attractiveness have focused on detecting universal colour preferences, on culturally related preferences and on preferences arising from gender, race, age, and personality (Kauppinen-Räsänen & Luomala, 2010); also, "the taste perceived by humans for food varies by age, sex, habits, and emotional status" (González Carnero, de la Montaña Miguélez, & Míguez Bernárdez, 2002). Accordingly, to better understand these senses we mean to Beauchamp & Mennella (2011) defining the flavour as "a perceptual quality elicited by molecules associated with foods and beverages", allowing us to identify changes that have different types of food on a person that consumes generally. Thus, whenever a person eats food, information received by the taste cell is carried to the brain through multisensory processing, where the integration of information is performed (Miranda-Saucedo, 2011). Thereby, eating is an action that requires the use of multiple senses in which each receives a stimulus from the same object. The sense of taste is able to give us the ability to select and discriminate foods that allow us to feel pleasure and delight (Miranda-Saucedo, 2011). The selection, organization and interpretation of information received from these, allows us to create a perception for understanding the world with significance and coherence (Baptista, del Fátima León, & Mora, 2010). Packages, forms and colours are the first channels of communication that product or even the company has with consumer, this is why "if the new information is congruent with the actual, then the new information tends to strengthen existing relationship with consumer" (Clow & Baack, 2010)

Just like that the senses may be defined as communication channels that allow us to have our own perception of the environment. Each sense helps us to get a subjective view of the world, but together the communication between each sense creates better information than each one alone (Calvert, 2001). The combination of the senses in the same experience helps to enrich the impact and the remembrance for the consumer, as long as the information that the consumer receives generates superadditivity. Because of this, if the knowledge that they provide is not complementary, it could generate disinformation in the consumer, causing that the experience with the object, in this case, with the food may not equal enriching. Because of this, the real challenge for marketing is to create messages that are congruent with consumer expectations, starting with details as what is the colour of the product communicating to the individual, making the buying experience more satisfying (Clow & Baack, 2010).

By the way, the colour could be a powerful tool in marketing, since it generates greater attractiveness to the product, as well as it provides immediate information by the stimulus. Also, (Spence, Levitan, & Shankar, 2010) on multisensory flavour perception the role of colour is a clear example of a cognitive influence. Although, research recognizes that colour is an influential design element, empirical studies on colours with marketing implications are rare (Kauppinen-Räsänen & Luomala, 2010).

Sight plays an important role in the process involving the action of eating, since the first interaction we have with food may be through it, giving a prerequisite to the other senses, encouraged to become their own perception of what they will experience further. The flavour of a food or beverage is defined as the perceptual combination of three anatomically distinct sensory systems, namely smell (cranial nerve), oral chemical somatosensory stimulation (cranial nerve ) and taste (cranial nerves) (Beauchamp & Mennella, 2011). Of all senses the one that predominates the most in food perception is the sight "Colour can have an important meaning on the behavior and cognition of people" (Elliot & Maier, 2013).

Colours in edible products are guiding consumers to help them identify it's flavour through an association, which can be based on past experiences that are responsible of defining the perception people have about food. For example, like (Duque Hurtado, 2014) said sensorial marketing may be defined as "marketing that involve all of consumer sense's and affect their perception, their judgment and the behaviour about some product or service". Nevertheless, perception is the way in which the brain interprets sensory stimuli received across the senses. Through involuntary preferences and priority selection, (Vargas Melgarejo, 1994), perception creates value judgments upon individuals, which resort to them on a later situation triggered by a similar stimuli to the one that first caused it.

There is a large number of articles seeking to study the influence of basic features such as colour and shape in the way we perceive an object. In a field such as food, colour is a feature with a high influence on the perception and origination of expectancy that someone can have in regard to taste; besides pointing out that colour has the ability to maintain the attention of consumers' in some cases (Kauppinen-Räsänen & Luomala, 2010). In addition to what was mentioned above, Singh (2006) showed that "people make up their minds within 90 seconds of their initial interactions with either people or products. About 62-90 percent of the assessment is based on colours alone" therefore, the importance of the colour is recognized by many researchers, and must be implemented when creating a congruent product for the customer; because if the individual visually perceives through colour, it can result in a pleasant stimuli generated by a correspondence between colour and flavour when consumed.

The aim of product colour is to attract the customers attention, "some studies suggest that consumers prefer offerings for which all sensory impressions are congruent." (Schifferstein & Howell, 2015). Likewise, "the cognitive processing of food images is influenced by incidental aspects of their visual appearance" (Shen, Wan, Mu, & Spence, 2015) as the colour found in food; this is a source of immediate information for the individual, "colour cues can influence the experience of flavour, both by influencing identification and perceived intensity of foods" (Shermer & Levitan, 2014). Thus, the customer could be attracted by a product, if it conveys a congruent message to each one of the multisensory channels.

Therefore, the consumer may choose promptly between substitute products, choosing the one that has more congruent information with the consumers expectations. Thereby, some colours in food can influence the connotation related to the flavour. "The results of the studies reported, tell a remarkably consistent story: the colour yellow and possibly green black (and possibly also purple/violet) is widely associated with bitter, salty is white, or possibly blue, sour is yellow, and sweet is pink and/or red" (Spence , et al., 2015).

An example of how the brain works in this type of situations, is to observe a congruent crossmodal relation between colours and the sour taste, because the brain needs to integrate all of this multisensory information in order to derive trustful results; as Shankar, Levitan & Charles (2010) say: "some colours

tend to give us a perception about the taste of food, many researchers have argued that colour may play a particularly influential role in our experience of flavour, in this way, our perception of the flavour of food and drink emerges from the integration of information provided by multiple unisensory". For example, the colour cues can influence the experience of flavour, both by influencing identification and perceived intensity of foods (Shermer & Levitan, 2014). Also, for the special case of food, people frequently tend to change their perceptions of the taste according to the food colour and the different attributes they observe (Kauppinen-Räsänen & Luomala, 2010). Also, we found that the author Pantin-Sohier (2009) affirms that "package colour is a non-verbal attribute capable of bestowing meaning on the product and able to directly influence evaluations and brand selection", causing the individual having a prejudice of the product from their experiences with the their previous feature or simply food with similar attributes interactions. It means, that sensory relation is perceived by more than one sense. Applied to other research, the colours presented tangible results with respect to generating attractiveness in people, "according to one study, red and yellow arouse greater interest than green".

On the other hand, during the implementation of the investigation, it was possible to determine that the role of the sense of smell and taste is becoming of greater importance. It had been overestimated the relationship between these two senses without dig down into the information they both in relation to taste or smell, like Navalles (2011) said a scent contains a great persuasive capacity information also the olfactory palette of each person is different and is defined depending on personal tastes of each consumer, as well as the different aromas respond to social and cultural reasons of origin, even social status may have an influence on this, therefore, to possess an olfactory memory we must have been exposed to an experience. All this information that was put into the sensation of the people who were part of the sample, showed that the perceived information by the brain can be combined with what is stored from previous experiences, spewing erroneous test results. Some colours tend to give us a perception about the taste of food, but the olfactory sense and the memory play an important role in the final results of the experiment. A food colour that suggests sweetness and matches the real taste of it, will make the consumer obtain a pleasant experience while eating thanks to the congruence between the sense of vision and taste which may seem to bear no relation at all; generating a crossmodal correspondence. Spence and others investigators (2015) defined the crossmodal correspondences as "matchings between apparently unrelated sensory features and dimensions". It means, that sensory relation is perceived by more than one sense. Applied to other research, the colours presented tangible results with respect to generating attractiveness in people, "according to one study, red and yellow arouse greater interest than green" (Pantin-Sohier, 2009). Similarly, according to Velasco, Woods, Deroy, & Spence (2015) the crossmodal correspondence can explain the fact that people tend to adjust information of the environment through their senses. With this research we seek to assess the interaction between the senses of taste and sight, in order to identify possible changes of perception that may allow us to evaluate whether the information obtained by a sense can modify the information of another. Which colours communicate and their impact on consumer psychology are applied daily and for many years in different fields like food, for example "the red colour stimulates appetite because of its effect on our metabolism, making red a popular colour choice among fast-food restaurants, the yellow colour is also employed by fast-food moguls to hijack customers' interests - they gain customers' attention, increase their appetite, and encourage them to eat (Singh, 2006) also, "spicy foods and the colour red both are associated with heat, and even pain" (Shermer & Levitan, 2014).

One of the earliest studies where we found evidence of the effect of crossmodal correspondences is the study of Spence (2011) that ensures "between crossmodal correspondences exist all possible pairings of sensory Modalities"; for example, it is possible to find correspondence between the smell and colour with the taste. Nowadays, you can find plenty of research related to crossmodal correspondence, but

only a few of them study exotic fruit and Latin American culture. Hence this study will try to prove that if the colours of the product change, the perception on the flavour of the product may change too, also, depending the colour that is used, the perception will relate with a variable, more sweet or more sourness; and it will use Colombian participants for the research with three exotic fruits: Mango, a fruit of the Intertropical Zone of fleshy and sweet pulp, foremost among its main features its good taste. The mango comes from Peru and it grown in tropical America. Also it can be found in Hawaii, India, Philippines and Australia. Guanabana (Soursop - *Annona Muricata*). Finally, Lulo that is a subtropical perennial plant from northwestern South America. This fruit has a citrus flavour, sometimes described as a combination of rhubarb and lime.

## 2. Methods

This research was based on the study by the guru of Neuromarketing, Charles Spence, which is based on the analysis of a perceived sensory relationship for more than one sense, between consumer expectations and experience with the product, which are vital in the decision-making process (Spence, 2011). On the other hand, we rely on the colour theory of Grossman & Wisenblit, and the scale of words and forms bouba-kiki-maluma take by Charles Spence, in order to identify perceived changes in the taste of the fruit given the alteration of its natural colour.

Ninety one (41 female) aged between 18 and 25 years (mean age = 20 years) from Colombia were given three different jelly flavours of exotic fruit to sample: Mango, Soursop and Lulo. These jellies were prepared by modifying their base colours and using different colour such as: Red, Green and Yellow. The specific reason why we chose these flavours is because they are highly recognizing flavours in the Colombian society. The reason why the natural colour of the jelly was modified was to analyse if the change in colour could change the flavour perception.

After defining the flavours and colours, we created crossings between them (Table 1). Then, we made the preparation of the jellies with their corresponding flavour and colour, with the same consistency and the same colour tone for each flavour.

**Table 1:** Combination colours and flavours for jellys.

Mango - Green	Lulo - Green	Soursop - Green
Mango - Yellow	Lulo - Yellow	Soursop - Yellow
Mango - Red	Lulo - Red	Soursop - Red

The participants tasted four jelly's (in a random order) and each participant responded a test for each sample; between samples, participants drank a gulp of water to remove the previous flavour. The test had four scales of association and two questions. For this, a value scale based on flavours (Sweet - Very Sweet, Acid - Very Acid) was created, and the results were matched with the results of the opinions of the people that participated in this research. In addition to this, the test subjects had to use a scale that goes from 0 to 10, where 0 its softest aspect and 10 its hardest aspect.

After testing the jelly, please mark a line on the scales their level of association with respect to flavour.

Sweet ←————→ Very Sweet

Acid ←————→ Very acid

Do you recognize the taste you're testing? Yes  No

¿What is it? \_\_\_\_\_

Fig. 1: The response sheet (in English) given to the Colombian participants.

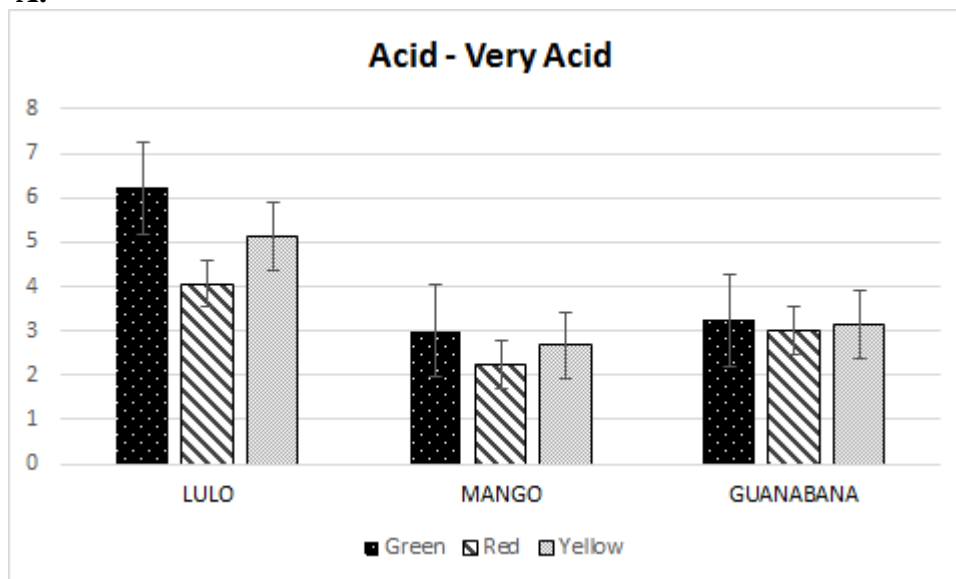
### 3. Results

The results according to the one way ANOVA ( $p < 0.05$ ); for the Acid – Very Acid variable, the taste of the flavours mango and soursop was perceived with a lower sourness level; nevertheless, lulo presented the highest perception of sourness with respect to the other two flavours, and showed the highest levels of perception of sourness of the three colours (first green with an average statistic of 6.221, second yellow with 5.14, and third red with 4.065).

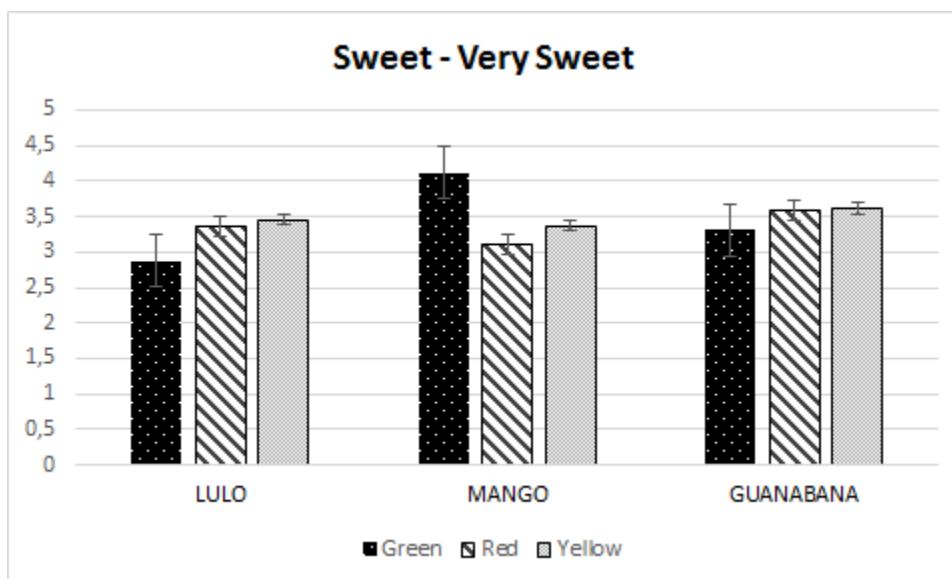
Secondly, we found that the soursop flavour was perceived as the second most acid one, especially when pared with green (with an average statistic of 3.244), followed by yellow (with an average statistic of 3.137) and finally red (with an average statistic of 3.005).

In third place, the mango fruit was percived as the less sour flavour. It was more acid when paired with the green colour (with an average statistic of 4.121), followed by yellow (with an average statistic of 3.37) and finally red (with an average statistic of 3.1). Concerning the Lulo fruit, sourness was perceive higher when paired with the green colour and lower with the red, this result has been replicated with the soursop and mango showing a strong tendency. The comparative graphic of this results is in Figure 3A.

A.



B.



**Fig. 3: A.** Graph univariate analysis of variance and analysis of homogeneous subsets for Acid - Very Acid Variable. **B.** Graph univariate analysis of variance and analysis of homogeneous subsets for Sweet - Very Sweet Variable.

Concerning, Sweet – Very Sweet variable, all fruit flavours were perceived as sweet. However, between those flavours, mango presented the highest perception of sweetness when paired with the colour green with an average statistic of 4.121, followed by samples of soursop flavour with two colours, yellow with an average statistic of 3,615 then red with an average statistic of 3,592. The sample flavour with the highest average between colours related with the perception of sweetness, was the mango fruit with a 3.53 of average; followed closely by the soursop fruit with a 3.505 average, lastly the lulo fruit averaged 3.229.

The Soursop sample showed small differences on the average statistics of the three colours, the lowest average was the colour green with 3.307. On the other hand, the samples of lulo gave an average statistic of 3.453 for yellow, followed by red with 3.358 and then green with 2.875 (see figure 3B). Indicating that the lulo flavour is the lowest easy flavour perceived like sweetest than soursop or mango. Also, concerning the sweetness perception, the results showed a higher tendency towards the colour yellow with mango, lulo and soursop fruit. In contrast, green is perceived as less sweet when paired with lulo and soursop, but is the highest variable on mango samples of sweet topic; suggesting that the colour green in the sweetest variable is inconsistent

Of the 234 samples taken only 17.3% of them were recognized with the correct flavour; for the rest of the samples that were not identified, the participants mentioned other type of flavour on the perception of the sample. On the other hand, participants identified 39.8% samples of mango, 8.1% of lulo and 4.7% of soursop.; in the case of the mango sample, it had 13 different results of flavour perception, lulo had 22 different results and finally, the soursop had 23 different results of perception. The samples of mango and lulo were easier to recognize with the colour yellow, while soursop samples were easier to recognize when paired with the colour green. Also, concerning the lulo samples, the second colour that helped participants recognize the correct flavour was green and red. While Mango samples with both green and red. In the case of soursop, green and yellow were the colours that helped recognize the flavour, specially green, in this results the red colour didn't have any sort of relationship with this flavour.



**Table. 2:** Colour - Flavour Responses of Colombian population. Top flavour responses are shown, with exact count in brackets. N = 91.

COLOUR	MANGO	SOURSOP	LULO
Green	Peach (3), Lemon (3), Soursop (1), Pineapple (1)	Lemon (2), Mango (1), Kiwi (1), Peach (1)	Lemon (3), Orange (3), Feijoa (2), Green Apple (2), Pear (1), Kiwi (1), Grape (1), Raspberry (1)
Red	Peach (4), Strawberry (3), Raspberry (1), Orange (1), Tangerine (1)	Feijoa (2), Cherry (1), Strawberry (1), Tutti Frutti (1)	Mango (3), Strawberry (1), Papayuela (1), Soursop (1)
Yellow	Peach (4), Passion Fruit (2), Pineapple (1)	Pineapple (5), Mango (3), Peach (3), Papaya (1)	Passion Fruit (4), Pineapple (3), Orange (1), Lime (1), Kiwi (1), Papayuela (1), Grape (1), Blueberry (1)

#### 4. Discussion

On the three flavours, the perception of the colour green was higher than yellow and red in the acid - very acid variable. It can be inferred that the presentation of this three fruits should be found with the colour green (internally and/or externally), this perception is based on past events, since perception is never purely based in the present it has to draw on experience of the past (Sacks, 2007). Also in the present study this perception of colour on the taste is evident, in the relationship with the green colour in all samples of flavour (Lulo, Mango and Soursop). Thus a similar colour-flavour congruency effect may be expected in the context of visual search for flavour information on a product's packaging (Velasco, Wan, Knoeferle, Zhou, Salgado-Montejo, & Spence, 2015). So, as it mentioned above, for the special case of food, people frequently tend to change their perceptions of the taste according to the food colour and other attributes of it, throwing suppositions of the product (Kauppinen-Räsänen & Luomala, 2010). According to Spence, et. al. (2015) for the acid flavours, the green colour is widely associated with bitter or sour, followed by yellow and red. This is reflected in the results, because yellow presented the second highest perception on the three flavours while red had a lower perception of sourness. Congruent crossmodal relation between colours and sourness were found, because the brain needs to integrate all of this multisensory information in order to derive faithful and adaptive representations (Sanabria, Soto-Faraco, Chan, & Spence, 2005). This is complemented by Velasco, et al. say's (2015), they state that a similar colour-flavour congruency effect may be expected in the context of visual search for flavour information on a product's packaging, in this case, the package of the product was the same jelly (the aspect of this). Colours are part of the message that marketing communicates to consumer, which has to be effective and congruent having in consideration the previous experience the consumer may had, so he can see the product as the solution of his need (Clow & Baack, 2010).

The flavour of the lulo was perceived like the most acid in relation with soursop and mango, this may be due to the context exposition, which affects the perception of how the fruit colour should be, and evoke this flavour with a greater acidity, relating it with it's colour (the juice of the lulo is green). Conversely, mango was perceived with a lower flavour in the acid - very acid variable, since Latin American people usually perceive the flavour of fruits like sweetness and suppose that it can not have soreness and vice versa; and associate for example with mango, when it has a red colour in its peel, it

might to more sweet, so consumers use colours as stimulus-based information (Kauppinen-Räsänen & Luomala, 2010). According to Velasco, et al. (2015) the colour, in particular, may be one of the most important cues guiding people's flavour expectations, classification, search, and perception. Likewise, colour conveys critical information about the flavour of food and drink by providing clues as to edibility, flavour identity, and flavour intensity. Multiple unisensory provided large sets of information, from there emerges our perception of different flavours on food and beverages (Spence, Levitan, & Shankar, 2010).

On the other hand, the soursop's flavour on the acid - very acid variable, showed that all colours had the same size on the statistic media. Because the taste of this fruit isn't the strongest in the mouth, it impacts the other senses, making it difficult for the participants to guess to know which is the real flavour of the fruit. Of the many visual cues we receive (opacity, pearlescence, etc.), colour, in particular, seems to constitute a central part of our experience of food and drink, because of its role as an indicator of edibility, and because of its role in suggesting both the likely identity and intensity of flavour (Spence, Levitan, & Shankar, 2010).

Concerning the sweet - very sweet variable we did not find a significant difference between colour and flavour. Although the values are low in sweetness, an unexpected result was obtained, the green colour has a higher intensity in the perception of the mango. This fruit has a dark green glossy shell, which becomes dull green when ripe. The pulp is usually soft, with a slight yellowish colour. It is possible to find different varieties of this fruit around the world (with similar characteristics). Alvaro Ernesto Palacio Pelaez, Manager of Asohorfrucol says that 39% of the many varieties in the country corresponds to hilacha handle. In colombian households, the larger versions of the fruit are the most striking, therefore the Tommy atkins Mango has become very popular. It's worth mentioning that the mango is one of the sweetest fruits in the Colombian agricultural market, 100 grams of mango contains about 14 grams of sugar (USDA), the Soursop has about 13 grams of sugar in 100 grams (USDA), being almost equal in the amount of natural sugar content; finally the lulo, is classified as an acid fruit, containing only 3.7 grams of sugar per 100 grams of fruit (USDA). These evidence shows that the respondents of the perception survey are often altered by what they see, offering a verdict on the tasting without connecting the sense of taste and vision. As mentioned above, this happens depending on the level of exposure, when people see a given coloured food or drink item, it may induce different expectations regarding what they think the food or drink item is going to taste like (Spence, Levitan, & Shankar, 2010). As expressed briefly by Cengiz & Köse (2013) colour is a subjective term that changes according to each person's view.

The Tommy Atkins Mango unlike any other fruit has a characteristic sweetness to it, causing the reaction seen in the study, where participants associated the mango flavour (sweet) with the colour green. In this case, the brain of the participants could be looking for the right way to associate the taste with the colour apparently is assimilated to sugar that can have a Soursop, which therefore is green. Some colours tend to give us a perception about the taste of food, this happens because visual cues create expectations that can influence identification, discrimination, perceived pleasantness and intensity of particular flavours (Shermer & Levitan, 2014). This reflects the association people make with the colour green and sweetness throughout the study (this colour had the highest score in relation with the sweetest fruits).

In general only 17,32% of the total sample was successful, about 44 samples were perceived with the correct flavour, regardless of the colour they had; we can conclude that different aspects like colour and smell, influence the perception of the correct flavour on the food (jellies). According to Crisinel &

Spence (2012) a large number of research shows how sensory modalities such as colour, sound, taste, smell and shape are able to interact, generating a consumer experience. With this study, we could research we highlight different aspects of interaction between flavour and colour allowing us to develop future research that evaluates both the customer experience and satisfaction with the use of these sensory modalities. Authors such as Ngo, et al. (2013), emphasize the importance of crossmodal correspondence, since it may predict different types of consumer behavior from the moment of the purchase, allowing us to determine whether the attributes of the product succeed in improving the experience of consumption. Based on the results obtained in this research, steps could be given to take into account the colour of a product to easily identify the consumer's future behavior, creating better marketing strategies with only the preliminary observation of the product.

## 5. Conclusion

This results validate our hypothesis by proving that the existing colours may change the way we perceive food. It can be seen in the results that the colour of a jelly could determine the taste perception of the participants. The combination of information from different senses in the brain resulted in a multimodal perception in decision data each independently of jelly flavour. With our results, we can evidence that colours can communicate information to consumer, making the experience more satisfactory when they are congruent with what the consumer expects. For example, when people see colour green, they may expect and acid flavour, which in the case of lulo they received it and the congruency made the perception of sourness greater than with the other colours.

This results are important, specially for the industries, in order to make new products that will focus congruently on the Latin American market, establishing their products in consumers minds as more effective to fulfill their needs only by seeing their colour.

One of the limitations that we found in this experiment is the way it could be replicated in different latin american countries. Most of this exotic fruits are found in different countries, but it may be possible that they are not found and because of this the results of the study could change. It's advisable to develop research about relation between colour and flavour on other type of food and if it is possible, make it crosscultural. It's suggested that future studies focus on phonemes and forms, to corroborate the behavior of variables.

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