

Replacement of gelatin with *Opuntia ficus-indica* mucilage in flavored pink and unflavored white marshmallows. Part 2: Consumer liking

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ABSTRACT

Mucilage from the cladodes of *Opuntia ficus-indica* is under investigation for application in several foodstuffs. Since it can not form gels on its own, it is advised to be used in combination with other hydrocolloids. The aim of this study was to compare consumer liking of flavored and unflavored marshmallows made with wet mucilage, to that of a flavored and unflavored control sample (with 100% gelatin), as well as a flavored and unflavored commercial brand. Ninety-two consumers tasted the following six samples: white commercial (*Manhattan*); white control (gelatin); white mucilage (75% mucilage + 12.5% agar + 12.5% xanthan); pink commercial (*Manhattan*); pink control (gelatin); and pink mucilage (75% mucilage + 12.5% agar + 12.5% xanthan). Consumer liking was tested for taste, aftertaste, texture, as well as an overall acceptability of liking. The white mucilage marshmallows had the lowest ranking for taste, aftertaste, texture and overall acceptability, and differed significantly ($p < 0.05$) from all the other samples. However, the pink mucilage marshmallow did not differ from the pink commercial one (which had the highest rankings for taste, aftertaste, texture, and overall acceptability) and pink control marshmallow. The differences between the white and pink mucilage marshmallows ranged between 2.75 and 2.89 on the hedonic scale. It could be concluded that flavoring successfully masked the distinctive aroma of the mucilage in the marshmallows, thereby also increasing scores for texture and overall acceptability.

Keywords: *Opuntia ficus-indica*, consumer liking, marshmallows, mucilage, gelling agent.

INTRODUCTION

Marshmallows are one of the earliest confections known to humankind (Olver, 2000). Originally, they were made from the root sap of the marshmallow (*Althaea officinalis*) plant, a genus that is native to parts of Europe, North Africa and Asia. The first marshmallows were prepared by boiling pieces of the marshmallow root pulp with sugar until thick, whereafter the mixture was strained and cooled. As far back as 2000 B.C., Egyptians combined the marshmallow root with honey and reserved this candy for gods and royalty (Petrusso, 2014).

Gelatin is used in whipped confections, such as marshmallows, where it serves to lower the surface tension of the syrup, stabilize the foam through increased viscosity, set the foam via gelation and prevent sugar crystallization (GMIA, 2012). Furthermore, it is also responsible for the chewy, bouncy texture of marshmallows (Karim and Bhat, 2008).

Gelatin is unique, because when mixed with water, it forms a thermally-reversible, elastic and clear gel (De Vries *et al.*, 2004). These gelatin gels have a melting temperature just below body temperature (< 35°C), so the gel product literally melts in the mouth and releases intense flavor immediately as it dissolves, which is a difficult quality to replicate with other hydrocolloids (Karim and Bhat, 2008).

Gelatin makes marshmallows chewy by forming a tangled three-dimensional network of polymer chains (Glicksman, 1982). Once gelatin is dissolved in warm water (dubbed the 'blooming stage'), it forms a dispersion, which results in a cross-linking of its helix-shaped chains. The linkage in the gelatin protein network, called 'junction zones', trap air in the marshmallow mixture and immobilize the water molecules in the network (Burey *et al.*, 2008). As mentioned previously, gelatin melts at temperatures < 35°C, because the junction zones are only bound by weak hydrogen bonds (De Vries *et al.*, 2004). Gum-on-gum interaction tends to produce synergistic textures and there are many combinations to choose from. One of the most used is when guar gum is often added to xanthan gum to reduce cost, increase viscosity and improve texture, while xanthan gum prevents syneresis (Sakharam and Meschi, 2008).

The genus *Opuntia* is characterized by the production of a hydrocolloid, commonly known as mucilage, which forms molecular networks that are able to retain large amounts of water, resulting in colloidal and very viscous suspensions or jellied masses (Sepulveda *et al.*, 2007). Mucilage is present in the characteristic slimy fluid secreted by cladodes and fruits. Two distinctive, water-soluble, high-molecular-weight, pectic polysaccharide materials occur in *Opuntia* cladodes and fruits, namely mucilage and a calcium-sensitive gelling fraction. Mucilage do not gel in the presence of calcium. Pectin with a low degree of methoxylation occurs in the cell wall and can be extracted using a mild alkali process, aided by a chelating agent; this pectin shows remarkably good gelling properties in the presence of CaCl₂, by a cooperative Ca²⁺ "egg-box" binding mechanism (Goycoolea and Cardenas, 2003).

Furthermore, mucilage is a complex polymeric carbohydrate, with a highly branched structure, which contains varying proportions of L-arabinose, D- galactose, L-rhamnose, and D-xylose, as well as the galacturonic acid in different proportions. There are also minerals present, such as Ca²⁺ and K⁺, carbohydrates and dietary fiber (Sepulveda *et al.*, 2007). Although both materials share similarities in the composition profile of their neutral constituent sugar residues, pectin has a significantly greater amount of linear polygalacturonic acid. This difference causes very different physicochemical and functional properties, underlying the potential applications of these polysaccharides in a wide variety of fields (e.g., foods, biotechnology and medicine).

Many popular uses in different countries shed light on the numerous mucilage properties, making this an interesting ingredient for the food industry, because of its viscosity properties.

In South Africa, mucilage has been included into various products in various research studies: Turkish delight (confectionary); carrot cake; seed bread; mayonnaise; ice cream; and yogurt to replace various ingredients (De Wit and Fouche, 2015). Nowadays,

consumers are becoming more aware of their own health and health foods. Thus, the demand for health foods is increasing, because of their functions of lowering the risks of chronic health diseases. Also, some religions exclude the use of certain animal by-products, such as gelatin. By replacing such a product with an ingredient of plant origin, a huge range of products will be made available to a broader consumer market.

The aim of this study was, therefore, to evaluate consumer liking of the 75% mucilage + 12.5% xanthan + 12.5% agar formulation (Du Toit *et al.*, 2016), with that of the control marshmallows (containing gelatin) and one commercial brand. Three marshmallow samples were left uncolored and unflavored, and were compared to the liking of three pink-colored, strawberry-flavored samples.

MATERIALS AND METHODS

Marshmallows

Six marshmallow samples were prepared: 75% mucilage + 12.5% xanthan + 12.5% agar; 100% gelatin (control); commercial brand white (*Manhattan*); strawberry flavored and pink colored 75% mucilage + 12.5% xanthan + 12.5% agar; strawberry flavored and pink colored 100% gelatin; and commercial brand pink (*Manhattan*).

The formulation of the recipe for the control marshmallows (white and pink) are given in Table 1. The gelatin was soaked in cold water. The sugar, salt, syrup and rest of the water were heated and stirred to dissolve the sugar. After the mixture reached a temperature of 118°C (sea level), the gelatin was added. The stiffly beaten egg whites were added to the hot mixture, whilst continuously mixing, until thick and creamy. The mixture was then poured into a greased pan, cooled overnight and cut into 25-mm squares. The squares were rolled in a mixture of corn flour and icing sugar to prevent it from sticking together, and stored in an airtight container (Foods and Cookery, 1991).

Table 1. Formulation of marshmallow used as control (Foods and Cookery, 1991).

Ingredient	Percentage (%)
Gelatin	2.29
Water, cold, to soak gelatin	11.45
Egg whites	9.16
Sugar	45.78
Water	28.62
Syrup*	2.00
Salt	0.13
Flavoring, strawberry**	0.57
Coloring, pink, commercial**	2-3 drops

*Golden syrup is a thick, amber-colored form of inverted sugar syrup made in the process of refining sugar cane or sugar beet juice into sugar, or by treatment of a sugar solution with acid. It is used in a variety of baking recipes and desserts.

**Pink control; white control has no flavoring and coloring.

For the mucilage-containing marshmallows, 75% mucilage was combined with 12.5% agar and 12.5% xanthan, and the same method was used as with the control sample. Mucilage was extracted from the cladodes, by using the method of Du Toit and De Wit (2011). As mentioned earlier (Bensadón *et al.*, 2010), the stabilizing properties of mucilage are similar to those of xanthan and guar gums. Agar-agar was also chosen, because it is commercially used in South Africa in chocolate candies to stabilize the marshmallow layer, such as *Cadburys Chocolate log* (Made in South Africa by Mondelez South Africa (PTY) LTD. 18 Harrowdene Office Park, Kelvin Drive, Woodmead Sandton, 2129, SA.). This combination was chosen, as it showed the most desired textural attributes of all the combinations evaluated in previous studies (Du Toit *et al.*, 2016). Half of the samples from each treatment were left unflavored and uncolored, (representing the white mucilage formulation), while the other half were colored pink and flavored with strawberry flavoring (representing the pink formulation).

The commercial brand *Manhattan* (Manufactured by Premier Foods, South Africa 1 Joist Street, Islando, 1609, South Africa) also showed textural properties similar to the control and 75% mucilage + 12.5% xanthan + 12.5% agar combination (Du Toit *et al.*, 2016). The marshmallows were melted on the stove in a double cooker and poured into containers, to resemble the shape of the other samples.

Samples were cut into cubes of 1x1x1cm and rolled in a mixture of icing sugar and corn flour (Foods and Cookery, 1991). Samples were evaluated simultaneously, under white lights and served on white polystyrene trays. Bottled water was used as a palate cleanser and between samples. The liking of taste, aftertaste, texture and overall acceptability were evaluated on a structured line scale, ranging from 1 (dislike extremely) to 9 (like extremely) (Figure 1). The nine-point hedonic scale has been used routinely in food science research for the past 60 years and is a scale of liking. It should be emphasized that the numbers on the scale are alternative names for the categories. For example, if the category 'like extremely' is assigned the number '9', the category has not become a number; it has merely been given a new name 'nine' and is no more numerical than ranks (Wichchukit and O'Mahony, 2014).

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

Figure 1. Nine-point hedonic scale of liking (Stone and Sidel, 2004).

Consumer panel

Ninety-two consumers, 21 male and 71 female panelists, aged 18 to older than 60 years, were sourced from staff and students from the Bloemfontein campus of the University of the Free State, Bloemfontein, South Africa (Table 2). All had to be regular consumers of marshmallows, indicating that they consume it at least once every two weeks. The percentage split for the age profile was as follows: younger than 18 years (4%); 20-29 years (74%); 30-39 years (3%); 40 – 49 years (6%); 50-59 years (6%); and older than 60 years (7%). The majority of the panel members were, thus, mainly students, being in the younger

age group from 18 to 39 years old (81%), while only 19% were in the age group of 40 years to older than 60 years, representing students and staff members.

Table 2. Age and gender profile of consumer panel.

Gender	Number of panelists	Age (Years)	Percentage split of total number of panelists
Female	71	18-19	4
Male	21	20-29	74
		30-39	3
		40-49	6
		50-59	6
		Older than 60	7

Statistical analysis

The significance for the liking of taste, aftertaste and texture, as well as overall acceptability, measured for each treatment, was tested by means of a one-way analysis of variance (ANOVA). When applicable, Fisher's LSD-test ($p < 0.05$) was applied to determine the direction of the differences between treatment mean values (NCSS, 2007). The two sample *t*-test was performed to determine the effect of age (NCSS, 2007).

RESULTS AND DISCUSSION

The ANOVA on the effect of gender, age and marshmallow type on the liking of sensory properties of the samples is summarized in Table 3. It was decided that *p*-values smaller than 0.05 would be considered as a significant difference. For age, there was a significant ($p < 0.05$) effect for the liking of aftertaste, while all the marshmallow types showed significant ($p < 0.05$) effects for liking of taste, aftertaste, texture and overall acceptability.

Table 3. ANOVA on the effect of gender, age and marshmallow type on the liking of the sensory properties of marshmallows.

Sensory property	Age	Gender	Marshmallo w type	Age X	Gender X	Age X
				Marshmallo w type	Marshmallo w type	Marshmallo w type
Taste	$p = 0.0889$	$p = 0.4163$	$p = 0.0123$	$p = 0.3542$	$p = 0.6397$	$p = 0.5706$
Aftertaste	$p = 0.0124$	$p = 0.0901$	$p = 0.0234$	$p = 0.4028$	$p = 0.7754$	$p = 0.3435$
Texture	$p = 0.0576$	$p = 0.9846$	$p = 0.0145$	$p = 0.6699$	$p = 0.8227$	$p = 0.1346$
Overall acceptability	$p = 0.0752$	$p = 0.6602$	$p = 0.0165$	$p = 0.2987$	$p = 0.7375$	$p = 0.1943$

For age group, there was a significant ($p=0.0124$) difference between the liking for aftertaste, meaning that the older group (40 to older than 60 years old) of consumers ranked the liking of the aftertaste higher than the younger group (18 to 39 years old) (Table 4). Both rankings were situated in the 'like slightly' region of the hedonic scale, with the rank of the older group situated more to the 'like moderately' side of the scale. Liking of aftertaste was included to determine whether the consumers would detect the grassy aroma of the mucilage (Rothman *et al.*, 2012). In especially the pink samples the aftertaste was predominantly sweet due to the addition of strawberry flavoring, which is one of the top six

preferred food-related flavors (Hoffman, *et al.*, 2016). Although only 19 % of the panelists in the present study fell into the age group 40 years to older than 60 years, it is still a valid result, confirming Hoffman and co-workers' (2016) findings that older adults (older than 55 years) find sugar more pleasant at higher concentrations, such as in confectionaries, compared with young adults (18 to 35 years) and middle-aged adults (36 – 55 years) (Petry, 2002).

Table 4. Effect of age group on the liking of sensory properties of marshmallows types.

Sensory property	Younger than 18 to 39 years	40 to older than 60 years	Significance level (p < 0.05)
Taste	6.43 ± 2.15	6.80 ± 1.64	p = 0.0889
Sweet aftertaste	6.26 ^a ± 2.08	6.78 ^b ± 1.63	p = 0.0124
Texture	6.11 ± 2.32	6.55 ± 1.78	p = 0.0576
Overall acceptability	6.39 ± 2.09	6.76 ± 1.59	p = 0.0752

Means with different superscripts in the same row differed significantly, according to two sample *t*-test.

In Table 5 the effect of the mucilage inclusion on the liking of taste, aftertaste, texture and overall acceptability is shown. The lowest ranking for the liking of taste was given to the mucilage white sample, representing 'dislike slightly' on the hedonic scale. This sample differed significantly ($p < 0.05$) from the control white and the *Manhattan* white samples, as well as all the pink samples. The control white sample differed significantly ($p < 0.05$) from all the samples, except the *Manhattan* white, while the *Manhattan* white sample differed significantly ($p < 0.05$) from the mucilage white, control pink and *Manhattan* pink. The mucilage pink differed significantly ($p < 0.05$) from the mucilage white and control white samples. For the liking of taste, the *Manhattan* pink sample had the highest ranking and did not differ from the control pink and mucilage pink samples. It was interesting to note that all the pink samples, including the mucilage pink sample, were ranked higher than 7 on the hedonic scale, indicating that the panel liked these samples 'moderately' to 'very much' (Figure 1). The strawberry flavoring was thus successful in masking the grassy flavor of the mucilage (Rothman *et al.*, 2012), as there was an increase of almost three categories in ranking, on the hedonic scale, from the white unflavored to the pink strawberry flavored mucilage sample.

Table 5. Effect of marshmallow type on the liking of the sensory properties of the samples.

Sample	Taste	Aftertaste	Texture	Overall Acceptability
Mucilage White	4.26 ^a ± 2.30	4.20 ^a ± 2.23	3.93 ^a ± 2.28	4.21 ^a ± 2.18
Control White	6.34 ^b ± 1.89	6.38 ^{bc} ± 1.65	6.08 ^{bc} ± 1.98	6.38 ^b ± 1.76
Control Pink	7.32 ^d ± 1.41	7.08 ^d ± 1.59	7.40 ^d ± 1.65	7.38 ^c ± 1.32
<i>Manhattan</i> White	6.47 ^{bc} ± 1.84	6.10 ^b ± 1.89	5.66 ^b ± 2.00	6.22 ^b ± 1.81
Mucilage Pink	7.11 ^{cd} ± 1.58	7.01 ^{cd} ± 1.51	6.68 ^{cd} ± 1.72	7.10 ^c ± 1.48
<i>Manhattan</i> Pink	7.51 ^d ± 1.42	7.37 ^d ± 1.30	7.42 ^d ± 1.64	7.48 ^c ± 1.38

Means with different superscripts in the same column differed significantly ($p < 0.05$), according to Fisher's LSD-test.

The mucilage white sample scored the lowest ranking for the liking of aftertaste, representing 'dislike slightly' on the hedonic scale. This low rank may be due to the grassy flavor of the mucilage (Rothman *et al.*, 2012). This sample was significantly ($p < 0.05$) less liked than all the other samples. The control white sample differed significantly ($p < 0.05$) from the mucilage white, control pink and *Manhattan* pink, the latter having the highest rank of all the samples. The *Manhattan* white sample differed significantly ($p < 0.05$) from the mucilage white, mucilage pink, control pink and *Manhattan* pink. The mucilage pink sample was ranked significantly ($p < 0.05$) higher for aftertaste than mucilage white and *Manhattan* white. There was no difference amongst the mucilage pink, control pink, and *Manhattan* pink samples. Mucilage pink differed significantly ($p < 0.05$) from mucilage white and *Manhattan* white (Table 5).

The mucilage white sample had the lowest rank for the liking of texture ('dislike moderately') and differed significantly ($p < 0.05$) from all the other samples. The control white sample differed significantly ($p < 0.05$) from mucilage white, control pink and *Manhattan* pink. *Manhattan* white differed significantly ($p < 0.05$) from mucilage white, mucilage pink, control pink and *Manhattan* pink. Texture liking was the only attribute where mucilage pink could not be ranked higher than seven on the hedonic scale. This sample only differed significantly ($p < 0.05$) from mucilage white and *Manhattan* white. Although the mucilage pink sample did not score higher than seven, the ranking for its liking of texture did not differ from that of the control pink and *Manhattan* pink samples; the latter scored the highest numerical ranking for the liking of texture (Table 5). From these results, it is clear that the addition of strawberry flavoring positively influenced the flavor/taste of the mucilage marshmallow and also changed the consumer's perception of the texture. There was, again, an increase of almost three categories in the ranking on the hedonic scale, from the white unflavored mucilage marshmallow to the pink, strawberry flavored mucilage marshmallow (Table 5). A positive correlation was found for 'intention of buying and – texture' in a study where isomaltulose replaced sucrose in pink strawberry-flavored marshmallows. Different combinations of sugars were used, as well as different levels of gelatin. Authors concluded that texture defines acceptability and intention of buying this type of product (Periche *et al.*, 2015).

In a study by Gress *et al.* (2009), the use of agar alone to replace gelatin produced marshmallows of inferior quality, as determined by a panel of ten trained judges. It is also known that agar gels can not melt in the mouth, as its melting temperature is 85°C (Condrasky, 2014) and thus needs to be chewed. On the other hand, xanthan gum is a general thickener, which can have a somewhat slimy texture at higher levels, when used on its own. For this reason, it is often used in combination with other hydrocolloids and starches, such as konjac flour, where it produces an extremely elastic gel, suitable for chewy candy (Sakharam and Meschi, 2008). In a previous study by Du Toit *et al.* (2016), it was concluded that the best combination to replace gelatin was 75% mucilage (liquid) + 12.5% xanthan (powder) + 12.5% agar (powder), as it only differed significantly from the control (100% gelatin) sample in regard to shear value, as measured by the Warner Bratzler Shear Force.

In a study by Saint-Eve *et al.* (2004), it was confirmed that a single aroma complex, such as strawberry, led to low-fat yogurts being perceived as thicker and stickier, by using three sensory methodologies, namely sorting, free-choice profiling and descriptive analysis.

Kostyra and Barylko-Pikielna (2007) studied the effect of fat levels and guar gum addition in mayonnaise-type emulsions on the sensory perception of smoke-curing and salty taste. They found that it was the addition of guar gum that led to intensity differences in flavor and taste, rather than the different fat levels. Thus, it can be speculated that there could be an interaction between the hydrocolloids and flavorings, resulting in a better sensory perception of the textural properties in the present study. Gelatin, being a protein, already aids in the distribution of flavorings and colorings, despite being responsible for the characteristic foam-like texture of marshmallows (De Vries *et al.*, 2004; Karim and Bhat, 2008; GMIA, 2012). Periche *et al.* (2015) used 20 trained panelists and a nine-point hedonic scale to evaluate various attributes, including strawberry flavor of five pink marshmallows formulations, consisting of different sugar mixtures, levels of gelatin and amounts of strawberry flavoring. The marshmallow formulation which had double the amount of flavoring was rated the best, as panelists liked a more intense aroma in this kind of product.

In the present study, three distinct groupings of marshmallows were noted for the liking of overall acceptability, namely, the lowest ranking mucilage white sample, then the other two white samples, and finally the cluster of three pink samples. The mucilage white sample had the lowest ranking for overall acceptability, representing 'dislike slightly' on the hedonic scale; this sample differed significantly ($p < 0.05$) from all the other samples. The control white and *Manhattan* white samples both differed significantly ($p < 0.05$) from the mucilage white and three pink samples. The three pink samples did not differ, again stressing the importance of flavoring to mask any unwanted flavors, such as the grassy flavor associated with mucilage. The sample that had the highest numerical ranking for overall acceptability was the *Manhattan* pink sample.

It is not possible for the authors to comment on the significant differences between the white and pink *Manhattan* marshmallow samples, as the formulation of these marshmallows is not of public knowledge. It was found in a previous study (Du Toit *et al.*, 2016), that the shear values of three brands of pink commercial marshmallows were significantly ($p < 0.05$) lower than that of the corresponding white commercial marshmallows. It, thus, appears that the South African consumer favors a softer, flavored and colored marshmallow to a white, unflavored and uncolored marshmallow.

It should again be stressed that ranking on the hedonic scale, is a representation of a category on the hedonic scale. The simplest illustration that the assigned number is merely a new label is that if 'eight' is subtracted from 'nine', the answer is 'one'. Yet, if 'like very much' is subtracted from 'like extremely', the answer is hardly likely to be 'dislike extremely' (Wichchukit and O'Mahony, 2014). Furthermore, the fact that commercial marshmallows were ranked as 'liked moderately', can be attributed to the fact that it may not have been the best tasting marshmallows in South Africa. The main reason for its inclusion was the similarity it showed to the mucilage-containing marshmallow and the control sample (gelatin), in regard to textural properties (Du Toit *et al.*, 2016). From the study done by Du Toit *et al.* (2016), it was concluded that texture was the sensory property mostly affected by the reformulations.

Color is an important quality attribute in the food industry and it influences consumer's choice and preferences. The correlation between color and other sensory quality attributes is well established (Pathare *et al.*, 2013). In a study by Spence *et al.* (2015), they reviewed

the growing amount of scientific research showing that people steadily associate specific colors with particular tastes. The color white is widely associated with salty, because of the whiteness of sodium chloride, while pink and/or red colors are associated with sweetness, because sweetness is more often present in red foodstuffs, such as berries and cherries, than in yellow, white, brown or orange foodstuffs (Dematte *et al.*, 2006). These cross-modal correspondences are consistent across different cultures and at least over the last three decades, despite the wide cultural differences in the use of colors across cuisines (Zhou *et al.*, 2015). In the present study the same conclusions could have been drawn from the consumers, when presented with pink and white samples, awarding higher rankings to sweet taste for the pink samples than to the white samples, when in fact at least four of the samples had exactly the same sugar content (Table 1). In a study by Periche *et al.* (2015), a positive correlation was found for 'colour and overall appearance' of pink strawberry flavored marshmallows, containing different sugars and levels of gelatin.

To illustrate the positive effect of pink coloring and strawberry flavoring on the perception of the consumer, the frequencies of the hedonic scale rankings per marshmallow sample, for the liking of the four sensory properties were determined (Figure 2). Each of the graphs can be divided into two parts: i) bars pointing upwards, indicating the positive or "like" side of the hedonic scale, ranging from "like extremely" to "neither like nor dislike"; and ii) bars pointing downwards, indicating the negative or "dislike" side of the hedonic scale, categorized as between "dislike slightly" to "dislike extremely". The first three graphs on the left side of each of the figures represent the frequency of use of the hedonic tags for the white samples, while the pink samples are situated on the right side of each figure. In general, the positive hedonic ratings were assigned more regularly than the negative rankings. It is clear that the negative indicators were used more frequently for the white marshmallow samples, with high frequencies being assigned to the white mucilage marshmallow, for all attributes tested. The highest frequency of negative hedonic ranking was recorded for the texture of the mucilage white sample (Figure 2C). However, for the liking of this attribute, all three white marshmallow samples showed an increase in the use of negative hedonic rankings. For the pink samples, the liking of texture had the most frequent usage of negative hedonic ranking by the panel members (Figure 2C). All the pink samples also had the highest frequency of use for the positive hedonic rankings.

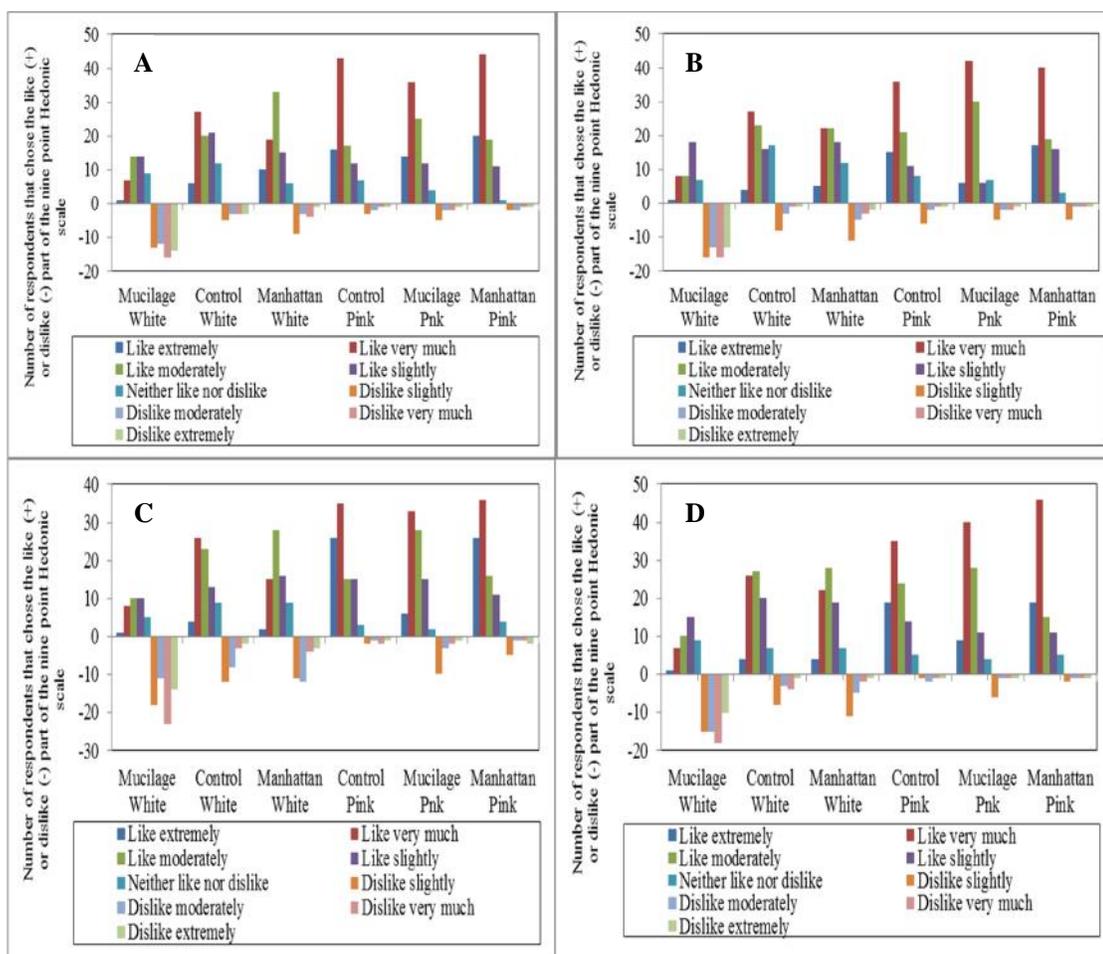


Figure 2. Frequency of the hedonic scale rankings per marshmallow sample, for the liking of A) taste, B) aftertaste, C) texture and D) overall acceptability.

CONCLUSIONS

Mucilage from the cladodes of *Opuntia ficus-indica* is under investigation for application in several foodstuffs. The results from the present study showed that flavoring successfully masked the distinctive taste and aftertaste of mucilage in marshmallows, thereby also increasing scores for texture and overall acceptability. It was thus concluded that the inclusion of mucilage in a colored and flavored confectionary product is a possibility.

The usage of wet mucilage, however, is questionable, since the quality and quantity of the mucilage are influenced by climate, temperature, and rainfall, as noted in literature. Therefore, research should continue on mucilage as a dried powder, as all the other hydrocolloids are dried. At first, the brown color, produced by heat during the drying process, and grassy flavor of the mucilage powder should be ignored in favor of developing a desirable combination with other hydrocolloids, to find a practical formulation. Furthermore, techniques, such as scanning electron microscopy, might shine a light on whether there is a synergistic effect when mucilage is combined with other hydrocolloids in a sugar-based confectionary.

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