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Sensory optimization of a flavor mix for a milkshake-like beverage formulated with residual grain from the amaranth popping process

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ABSTRACT

Objective: To identify an optimal combination of sweet, coffee, and chocolate flavors to maximize liking of sensory attributes in a beverage formulated with residual grain from amaranth popping.

Design/Methodology/Approach: We evaluated nine mixtures formulated with refined sucrose, instant coffee, and cocoa powder. Formulations were plotted in the simplex coordinate system. We prepared a milkshake-like beverage using residual grain from the amaranth popping process (RGAPP) as base. Sucrose, coffee, and cocoa were used as flavoring agents. We conducted a consumer study to identify the optimal mixture that maximized liking, acceptability, and purchase intent.

Results: When testing the overall liking of the prepared milkshake-like product, we observed favorable reactions to those formulations that contained more sucrose and cocoa powder. Consumers found formulations 1 (30% coffee and 70% sucrose), 2 (70% sucrose and 30% cocoa powder), and 7 (30% sucrose and 70% cocoa powder) tastier than the others. The formulations with high coffee and low sucrose content were the least liked. Formulation 8 (70% coffee and 30% cocoa powder) had the lowest overall liking score for the milkshake-like beverage.

Study Limitations/Implications: The results represent a segment of mostly young consumers (81%), between 18 and 24 years old.

Recommendations/Conclusions: Consumers showed interest in the developed products as they usually drink different kinds of beverages in the morning. There was a significant difference between formulations, mainly due to the different levels of sucrose. The use of flavorings is a viable strategy for the development of milkshake-like beverages formulated with residual grain from the amaranth popping process aimed to harness the benefits that this ingredient can offer to human nutrition.

Keywords: Amaranth, Residual grain, Popping, Milk-shake, Optimization.

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INTRODUCTION

In Mexico, amaranth is mainly consumed in its popped form. The popping process has several purposes: to provide flavor, color, texture, and aroma to amaranth grains; improving the antioxidant activity (Muyonga *et al.*, 2014); and reducing the impact of antinutritional agents such as tannins, oxalates, and phytates (Gamel *et al.*, 2006). The anatomical composition of amaranth varies naturally, due to the position of its grains in the panicle and their maturation speed and other factors. This variation has consequences on the popping process since it causes differences in grains' popping ability. The amount of unpopped grain —or residual grain from the amaranth popping process (RGAPP)— can reach up to 10% of the total grain weight. This grain is usually separated from popped grain and is not used for the production of amaranth bars (alegrias) to avoid product rejection. Using this byproduct —which has already gone through a thermal process— in milkshake-like beverages could be an option for its commercial use.

Consumer lifestyle has changed throughout the years. Although it has been shown that breakfast is important for a healthy lifestyle, a considerable number of teenagers and adults go out in the morning without having this meal (Hallström *et al.*, 2011). While this situation is related to socioeconomic factors, it is also true that today's accelerated lifestyles reduce the time people dedicates to prepare food. One way to reduce the time spent preparing breakfast is to drink milkshake-like beverages made by blending premixed dehydrated ingredients with milk. Although RGAPP has potential as an ingredient for the preparation of milkshake-like beverages, amaranth's characteristic aroma and flavor could limit consumer acceptance. Tanimola *et al.* (2016) found that using amaranth in pasta can reduce liking by 1.7 (flavor) and 1.3 (aroma) units in the hedonic scale, compared with products prepared with wheat flour. Zula *et al.* (2020) found a similar pattern in bread: color, flavor, aroma, and texture acceptance decreased when the amount of amaranth in bread formulations increased.

One way to improve liking and acceptance is to use a mixture of ingredients that blend adequately with amaranth. Coffee, chocolate, and sucrose are common flavors, familiar among consumers (Holkar *et al.*, 2019). This makes them excellent candidates for the formulation of milkshake-like beverages to drink during breakfast.

Therefore, the objective of this study was to identify an optimal combination of sucrose, coffee, and chocolate flavors that maximizes sensory attribute liking for a beverage based on popped amaranth residual grain.

MATERIALS AND METHODS

Amaranth was provided by the company NUTRIAMTO S. de R. L. de C. V., located in the Mixteca region, Villa de Chilapa de Díaz municipality, Oaxaca, Mexico. The following ingredients were used for the flavor mixture in the optimization process: Hershey's® unsweetened cocoa powder bought in bulk; unbranded refined sucrose bought in bulk; and Nescafé® Classic instant coffee. San Marcos® whole milk was used to prepare the milkshake.

Mixture design

Flavor mixtures were distributed in the simplex coordinate system, making sure that the mixtures had at least two ingredients. Nine formulations were established (Table 1). Sucrose, instant coffee, and cocoa were weighed in powder form. The RGAPP flour content was kept constants for all formulations.

Mixture preparation for the beverage

Three-hundred g of RGAPP flour were mixed with 200 g of the corresponding flavoring mixture, according to the formulations shown in Table 1. The mixing process was carried out manually, gradually adding the formula ingredients until a completely uniform blend was obtained. The mixtures were stored in 1-kg airtight plastic bags and preserved at room temperature until they were used in the consumer study. During the study, the beverages were prepared using 30 g of mixture (RGAPP flour with the corresponding flavoring mixture) per 250 mL of milk. The ingredients were blended using a conventional blender.

Consumer study

The consumer study was conducted at the Universidad Tecnológica del Centro de Veracruz and the Colegio de Postgraduados - Campus Córdoba. Samples were served in 3-oz souffle cups with approximately 40 mL of milkshake. A three-part questionnaire was used to collect the consumers' responses: 1) Demographics (age, gender, occupation, whether or not and how often the respondents consume amaranth); 2) Liking of each of the sample's attributes —appearance, color, aroma, particles, flavor, aftertaste, and overall liking— in the nine point hedonic scale, where 1=dislike extremely, 5=neither like nor dislike, 9=like extremely (Saw-Eaw *et al.*, 2007); and 3) Acceptance, purchase intent, and purchase intent with information about the benefits of amaranth responses were collected in a binomial scale (yes/no).

Consumer age was distributed as follows: 81% were 18-24 years old; 11%, 25-34 years old; 5%, 35-44 years old; and 3%, 45-54 years old. The gender of the evaluators was distributed as follows: 45% were women and 55% were men. According to their occupation, 85% were

Table 1. Ingredient percentage for each formulation.

Formulation	Coffee (%)	Sucrose (%)	Cocoa (%)
1	30	70	0
2	0	70	30
3	25	50	25
4	70	30	0
5	50	25	25
6	25	25	50
7	0	30	70
8	70	0	30
9	30	0	70

students, 13% workers, and 2% both (they studied and worked). Most of the consumers (68% relative frequency) live in Córdoba, Fortín de las Flores, Cuitláhuac, and Yanga (in Veracruz State, México), whereas the rest (38%) live in different parts of the Veracruz State, Mexico. When asked whether they regularly eat amaranth, 51% of consumers responded they actually do, 48% answered that they do not, and 1% said that they were not acquainted with amaranth.

Experimental design

To avoid fatigue bias, each consumer evaluated only two out of the nine formulations. A balanced incomplete-block design was used (Plan 11.3a, Cochran and Cox, 1957). Since the original design only has eight repetitions per formulation, the design was replicated sevenfold. Each formulation was assessed 56 times by a total of 252 consumers. Mean comparisons were conducted using Tukey's test (significance level, 0.05). Data analysis and charts were developed with R in the RStudio integrated development environment.

RESULTS AND DISCUSSION

Table 2 shows the average liking results regarding the appearance, color, aroma, particles, flavor, aftertaste, and overall liking of the milkshake-like beverages. The analysis of variance identified the liking differences between formulations, taking into consideration each attribute independently. There was a significant difference in appearance liking. Formulation 2 (70% sucrose and 30% cocoa powder) and formulation 8 (70% coffee and 30% cocoa powder) obtained the highest and lowest scores, respectively. Color and aroma liking were similar for the nine formulations. There were significant differences in the liking of particle sensation in the beverage. The highest particles liking scores were achieved by formulations 1 (30% coffee and 70% sucrose) and 2 (70% sucrose

Table 2. Difference between formulations per attribute*.

Formulation	Appearance	Color	Aroma	Particles	Flavor	Aftertaste	Overall Liking
1	5.30±1.83ab	5.45±2.12a	6.19±1.53a	5.18±1.71ab	5.33±1.86ab	5.23±1.85ab	5.46±1.71ab
2	5.59±1.77a	5.75±1.50a	5.80±1.50a	5.45±1.81a	5.93±2.04a	5.50±1.83[a]	5.78±1.92a
3	5.29±1.93ab	5.75±1.60a	6.21±1.82a	4.64±1.73ab	4.78±1.77abc	4.68±1.90abc	4.85±1.75abc
4	4.98±2.38ab	5.46±1.79a	6.45±1.67a	4.56±1.73abc	3.87±1.92cd	4.09±1.75cd	4.45±1.83bc
5	5.00±1.80ab	5.75±1.73a	6.45±1.59a	4.50±1.87abc	3.75±2.04cd	4.30±1.69bcd	4.25±2.00cd
6	5.50±1.55ab	5.82±1.53a	5.69±1.76a	4.52±1.65abc	4.45±1.88bc	4.57±1.88abc	4.64±1.92bc
7	5.38±1.45ab	5.89±1.63a	5.47±1.92a	4.80±1.82ab	4.64±1.98bc	4.57±1.95abc	5.09±1.79abc
8	4.48±2.08b	5.21±2.13a	5.52±2.12a	3.52±1.90c	2.96±2.12d	3.30±2.15d	3.29±1.75d
9	5.05±1.60ab	5.48±1.61a	5.55±1.73a	4.35±2.02bc	4.09±1.92cd	4.09±2.04cd	4.31±1.61cd
p-value	0.0403	0.507	0.054	5.18e-06	7.29e-15	4.58e-08	9.36e-12

* Mean values ± standard deviation. Means with the same letter in the same column are not significantly different according to Tukey's test (α=0.05). Formulations: 1 (30% coffee and 70% sucrose); 2 (70% sucrose and 30% cocoa powder); 3 (25% coffee, 50% sucrose, and 25% cocoa powder); 4 (70% coffee and 30% sucrose); 5 (50% coffee, 25% sucrose, and 25% cocoa powder); 6 (25% coffee, 25% sucrose, and 50% cocoa powder); 7 (30% sucrose and 70% cocoa powder); 8 (70% coffee and 30% cocoa powder); 9 (30% coffee and 70% cocoa powder).

and 30% cocoa powder). The highest effect of particles was observed in formulation 8 (70% coffee and 30% cocoa powder), with a 3.52 liking score, which indicates that consumers moderately disliked this combination. All formulations had the same amount of RGAPP flour. It is therefore possible that the remaining ingredients had an effect on particle perception. Likewise, a significant difference (p-value=7.3e-05) regarding flavor was found. Formulations 1 and 2 had the highest liking scores, while formulation 8 had the lowest. This result was probably a consequence of the high concentration of coffee and the lack of sucrose in this formulation. This pattern was also recorded in the aftertaste and overall liking attributes. On one end, formulations (particularly 2) with the highest percentages of sucrose had higher liking scores in the appearance, particles, flavor, aftertaste, and overall liking categories. On the other end, formulation 8, with a high percentage of coffee and no sucrose, had the lowest liking scores for the same attributes. This behavior suggests that sucrose concentration and the sweet flavor may have influenced the consumers' responses regarding particles, aftertaste, and overall liking. However, it is unlikely that this influence reached the appearance attribute, since it was evaluated before the consumer tasted the sample.

Most consumers identified the taste of amaranth (83%); among them, 43% thought that amaranth was an adequate flavor —which confirms that the amount of amaranth in the formulation was adequate—, while 25% identified a slight taste of amaranth. Only 15% identified an intense flavor, while 17% did not identify the flavor. Some consumers described strange flavors, such as burnt, earth, and medicine.

Impact of sensory attributes on acceptance and purchase intent

Table 3 shows the results for the multiple logistic regression analysis. Based on the p-values for each attribute's coefficients (estimated values), the most relevant attributes for the acceptance of the milkshake-like beverage (regardless of the formulation) were flavor (p=0.0024), aftertaste (p=0.0364), and overall liking (p=7.6e-10).

The following attributes had an impact on purchase intent (regardless of the formulation): appearance (p=0.0460), color (p=0.0313), flavor (p=0.0005), and overall liking (p=7.6e-10). As it can be seen, aftertaste was not critical to consumers, but appearance

Table 3. Key attributes for acceptance according to the logistic regression analysis.

Attribute	Estimate	Pr (>|z|)
Appearance	0.14	0.1437
Color	−0.01	0.8971
Aroma	−0.10	0.2331
Particles	0.12	0.2720
Flavor	0.39	0.0024*
Aftertaste	−0.27	0.0364*
Overall liking	0.99	7.6e-10*

* Pr (>|z|) values that indicate a statistically significant relation between attributes and product acceptance.

and color were. According to Piqueras-Fiszman and Spence (2015), a product's appearance is a sensory characteristic that may determine consumers' expectations about the product before they consume it. Consumers took into consideration more attributes for purchase intent (four) than for acceptance (three) (Table 4). After consumers were informed about the benefits of amaranth and asked again whether or not they would buy the product, only two attributes had an impact on purchase intent: appearance ($p=0.084$) and overall liking ($p=0.0010$). This trend —a significant change observed in consumers' answers— was confirmed with McNemar's test ($p=2.2e\text{-}16$). In this test, 178 answers changed from 'would not buy' to 'would buy' after consumers were informed about the benefits of amaranth.

Optimization

Formulations 2 (70% sucrose and 30% cocoa powder) and 7 (30% sucrose and 70% cocoa powder) had the highest appearance liking rating (Figure 1a). However, regarding color (Figure 1b) —which is a specific characteristic of appearance—, most formulations (2, 3, 5, 6, 7, and 9) obtained >5.5 liking scores. Formulation 7 (30% sucrose and 70% cocoa powder) obtained the highest score. This suggests that there are other appearance characteristics that could have had an impact on liking. Most formulations had favorable aroma liking scores (Figure 1c). However, unlike color, the highest liking scores were observed in the formulations with a higher percentage of coffee and sucrose. The highest aroma liking scores were recorded with formulations 1 (30% coffee and 70% sucrose) and 4 (70% coffee and 30% sucrose). According to Mahmud *et al.* (2020), aroma is a decisive factor for beverages, particularly for coffee. Liking of particle sensation in beverages (Figure 1d) was low, since no formulation obtained favorable scores. Liking scores for flavor, aftertaste, and overall liking (Figures 1e, 1f, and 1g) were higher for the formulations with a higher sucrose concentration. Likewise, the optimal region obtained when the attributes' optimal regions were superimposed also pointed towards the formulations with a higher sucrose concentration (Figure 1h).

Table 4. Key attributes for purchase intent according to the logistic regression analysis.

Attribute	Purchase intent		Purchase intent after providing information regarding amaranth benefits	
	Estimate	Pr (>|z|)	Estimate	Pr (>|z|)
Appearance	0.22	0.0460*	0.17	0.0284*
Color	−0.22	0.0313*	−0.10	0.1722
Aroma	−0.13	0.1563	0.02	0.6976
Particles	0.12	0.3105	−0.09	0.3060
Flavor	0.47	0.0005*	0.14	0.2065
Aftertaste	−0.15	0.2612	0.06	0.5505
Overall liking	0.95	7.06e-08*	0.40	0.0010*

* Pr (>|z|) values that indicate a statistically significant relation between attributes and purchase intent.

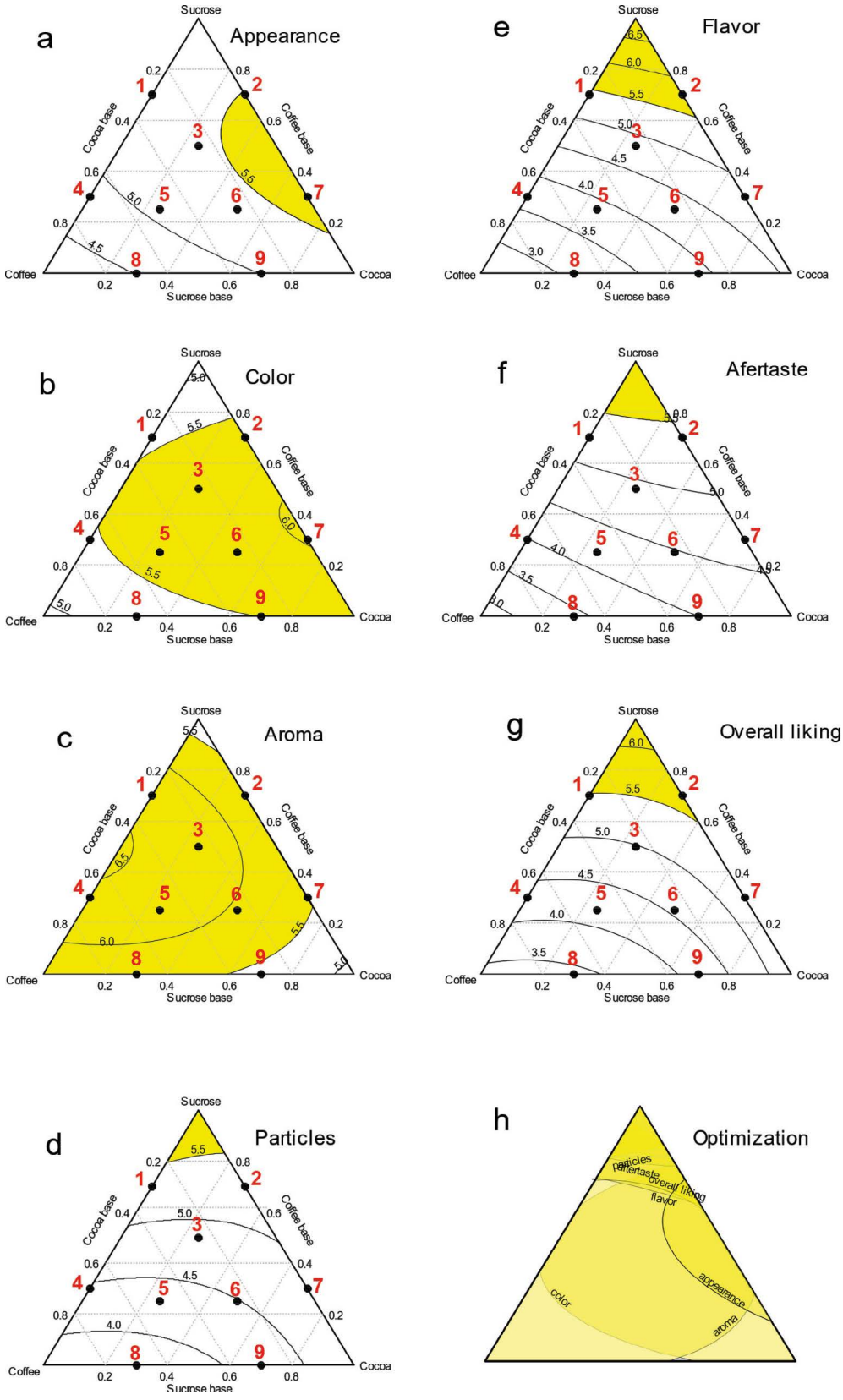

Figure 1. Optimal areas of attribute liking. Score of 5.5 or higher in the hedonic scale indicates a favorable liking.

CONCLUSIONS

Formulations showed liking differences for appearance, particles, flavor, aftertaste, and overall liking. Acceptance and purchase intent were determined by flavor, aftertaste, and overall liking. A favorable change in purchase intent was observed when consumers were informed about the benefits of amaranth. Sucrose and cocoa powder were the decisive ingredients for the liking level. The optimal region for the milkshake-like beverage formulation was in a sweet taste slightly combined with chocolate.

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