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Original article

Impact of consumer familiarity on acceptability and purchase intent of a novel amaranth-based coffee creamer

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Summary The objective of the study was to identify the impact of consumer familiarity on liking, acceptability, purchase intention and textual description of a novel cream substitute formulated with popped amaranth flour. Four formulations were evaluated in different proportions of amaranth vs. a control. A total of 400 consumers from two regions participated (Veracruz: familiar with coffee and Tlaxcala: familiar with amaranth). Consumers from both regions had significant differences in liking the attributes of the different formulations. Liking across regions was mainly a function of product aroma. Regarding the acceptance of the product, it was found that the attributes flavour, colour and overall liking were significant ($P < 0.05$) for consumers from Veracruz, whereas appearance and mouthfeel were significant ($P < 0.05$) for consumers from Tlaxcala. In purchase intent, overall liking was significant for both regions ($P < 0.05$). In relation to the impact of amaranth on purchase intention, Tlaxcala showed higher purchase willingness. The words used for sensory characterisation and that are important for both regions were the amaranth aroma, and the creamy flavour in the formulation with the highest amaranth content. The findings of this study allowed for understanding the potential of amaranth to formulate new creamers in a cross-cultural context, considering consumers from two different levels of familiarity with specific crops.

Keywords Acceptability, amaranth, consumers, creamer, familiarity.

Introduction

Worldwide, coffee and amaranth are well known for their health benefits. Coffee is one of the most consumed beverages worldwide (BCA, 2022). In contrast, despite its nutritional quality, the consumption of amaranth is still limited. However, consumers' level of familiarity with crops and products can be decisive in the adoption process (Fischer & Frewer, 2009). Familiarity can include different elements of the experiences between consumers and products and is usually considered a key element in the purchasing and consumption process. In some cases, unfamiliarity can cause negative effects on hedonic responses and purchase intention (Jeong & Lee, 2021). One way to accelerate consumer adoption of amaranth is to develop new products formulated with this grain (Balakrishnan & Schneider, 2022). Popped amaranth can be an alternative for the formulation of vegetable cream substitutes for coffee preparation. The study of consumer familiarity in the development of new products formulated with amaranth can help understand the key elements for the adoption of amaranth in the consumer diet.

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In Mexico, it was estimated that from 2019 to 2020, daily coffee consumption was approximately 89 million cups per day (Kantar Insights Mexico, 2019). A recent review (Barrea *et al*., 2021) has found an association of coffee consumption with the prevention of diseases related to inflammation and oxidative stress, such as obesity, metabolic syndrome and type 2 diabetes. Additionally, it appears to be linked to a reduced risk of several cancers and a lower likelihood of all-cause mortality. Being a drink that is consumed at any time of the day in different presentations and is associated with customs such as celebrations and funerals, among others (Cabal-Prieto *et al*., 2022). The way coffee is consumed is defined by the geographical region. In Mexico, the most common way to consume coffee is by adding milk. Particularly in the Metropolitan area and the Valley of Mexico, vegetable substitutes or powdered creams are commonly added to coffee (Kantar Insights México, 2019). This trend of adding milk or some substitute is also observed in countries like Spain and Colombia (Statista, 2015; Nielsen, 2018). Cream substitutes help enhance the flavour and aroma of coffee (Tan *et al*., 2021). However, it has been observed that these substitutes of animal origin are related to digestive problems such as lactose intolerance and allergic reactions (Zingone *et al*., 2017; Abbring *et al*., 2019). This is why cream substitutes based on coconut and almond have emerged (Qamar *et al*., 2020; Vega, 2020).

The consumption of foods based on plant sources has increased in recent decades. According to studies carried out by Hartman Group, in the United States, half of consumers have purchased a plant-based food, where 43% of the population has ever consumed alternative milk and 30% has consumed alternative dairy products (Vega, 2020). Given this scenario, amaranth is an alternative to solve malnutrition problems because it is an important source of amino acids (i.e., lysine, tryptophan, threonine, leucine, among others), carbohydrates and minerals (i.e., P, K, Mg, Ca, among others) (Martínez-Villaluenga *et al*., 2020; Pirzadah & Malik, 2020; Añón, 2023; Schmidt *et al*., 2023). It is also attributed functional properties (i.e., antioxidants, antitumor and moisturising) with which it can treat degenerative diseases (Martirosyan *et al*., 2007; Venskutonis & Kraujalis, 2013; Aditya *et al*., 2020). Despite the benefits of amaranth, its annual per capita consumption in Mexico is only 43 g, which is considered very low compared to other grains such as corn (346.4 kg) and wheat (61.4 kg) (SIAP, 2021). One way to boost consumer adoption of amaranth is to develop new products such as vegetable cream substitutes formulated with popped amaranth flour. To understand the key elements for the adoption of this food, it is necessary to carry out research focused on the familiarity of consumers. The role of food familiarity is relevant even in children, as their dietary development usually begins with pivotal associations, psychological judgements and a child's reactions to novel foods. Positive experiences such as emotions and physical reactions associated with novel food consumption are critical for shaping adult diets (Aldridge *et al*., 2009). In their review, Heath *et al*. (2011) suggest that using picture books to increase visual exposure to fruits and vegetables could increase familiarity, thus improving children's willingness to include them in their diets. Mattavelli & Rizzoli (2022) proposed a different strategy based on comparative thinking instead of direct exposure to improve the perceived familiarity of novel foods. Their second study, conducted with two ethnic foods (Lechon Manol from the Philippines and Bibimbap from South Korea), was compared in terms of similarities and differences with Italian food. An increase in familiarity and perceived closeness was found using this comparative thinking strategy. Considering a different context, Xu & Zeng (2022) studied the influence of familiarity with local food consumption on tourists visiting Huangshan City, China. They found that low familiarity was favourable as it reduced their aversion and motivated the consumption of local foods. In tourists with food neophobia, aversion was attenuated. Furthermore, consumer familiarity is usually related to the individual experiences between the person and the product and is a key element for product development and the purchasing and consumption process (Chocarro *et al*., 2009; Fischer & Frewer, 2009; Nacef *et al*., 2019; Jeong & Lee, 2021). It has been found that generally, consumer's familiarity with a product can grant higher acceptance (De Albuquerque *et al*., 2019), and unfamiliarity can cause negative effects on hedonic responses and purchase intent (Sierra *et al*., 2020; Jeong & Lee, 2021). Currently, research has also been developed where the effect of familiarity is studied in an intercultural scenario (Blancher *et al*., 2007; Tu *et al*., 2010; Baharuddin & Sharifudin, 2015), where it was evident that the geographical factor can affect the sensory perception of consumers, which is also associated with the experience and consumption habits. The objective of the study was to identify the impact of consumers' familiarity on liking, acceptability, purchase intention and textual description of a novel cream substitute formulated with popped amaranth flour.

Materials and methods

Materials

Coffee

The coffee was purchased in a local store in Huatusco, State of Veracruz, Mexico (a coffee-growing region) in a roasted and ground presentation that included a

mixture of three varieties (Costa Rica, Colombia and Castillo) in a proportion of 33.3% and whose production is aimed at export.

Amaranth

The selected amaranth grain corresponded to the species *Amaranthus cruentus*, a Creole variety from the town of San Mateo Coatepec, Municipality of Atzitzihuacán, State of Puebla, México. Its moisture content was 12% (measured according to the methodology of Ramírez-Pérez *et al.*, 2018) and its protein content was 15.19% and fibre content was 8.52% (according to the American Association of Cereal Chemists methods 32.10.01 and 46.10.01, respectively; AACC, 1999).

Amaranth grain processing

The amaranth grains were popped using fluidised bed equipment developed at the Colegio de Postgraduados Campus Puebla, Mexico (Argumedo-Macías, 2019). The popping temperature ranged between 200 and 210 °C. The popped amaranth grain was pulverised for 2 min in pulverising equipment (High-Speed Multifunction Grinder model HC 700, CGOLDENWALL, Guangzhou, China) according to the equipment indications.

Consumer study

Consumers were selected based on the following criteria: (i) availability to take the tests; (ii) regular consumption of coffee and amaranth; (iii) not having allergies to any product and (iv) being in good health (Ramírez-Rivera *et al.*, 2024). In each region, the surveyed group included a total of $n = 200$ consumers. The statistical power of the test was 0.99 for a moderate effect of ($f = 0.25$) for two groups with a significance level of 0.05 and a sample size of 200 per group (Cohen, 1988). Prior to participating in the study, consumers were briefed regarding the study aims and the formulation composition (ingredients) to allow them to decide whether they participate or not in case they had an allergy or aversion to any of the ingredients. Consumers signed a consent letter. No sensitive personal information was collected from the participants. The guidelines of the Declaration of Helsinki for ethical considerations of studies involving human subjects were followed. The study was approved by the Research Sub-direction of Campus Córdoba of Colegio de Postgraduados.

Study regions and demographic characteristics of consumers

Two regions were selected for the study: (i) The Veracruz region represented by the Huatusco Municipality is characterised by having adequate conditions for coffee production. Consumers from this region were expected to be more familiar with coffee, as Huatusco coffee production contributes 17.7% of Veracruz state production (Williams-Linera, 2007; Nava-Tablada & Hernández-Sánchez, 2017). (ii) The Tlaxcala region is characterised by being the second state with the highest production of amaranth (2226.65 tonnes), which represents 22.5% of national production (SIAP, 2021, 2022). Consumers from this region were expected to be more familiar with amaranth.

Consumers from Veracruz and Tlaxcala regions were affiliated with the Tecnológico Nacional de México (TecNM). From the Veracruz region (TecNM, Huatusco campus), a total of 200 responses were collected. Most consumers (82.5%) were between 18 and 25 years old. The rest were 26–35, 36–45, 46–55 and more than 55 (7.5%, 6.5%, 2.5% and 1%, respectively) years old; 61% were female and 39% were male. Regarding occupation, 84% were students, 14.5% employees and 1.5% farmers. The predominant type of settlement was urban (58.5%), followed by rural (26%) and suburban (15.5%). Regarding consumers from the Tlaxcala region (TecNM, Altiplano de Tlaxcala Campus), a total of 200 responses were collected: 97% were students, 1.5% employees and 1.5% farmers. The age range of the respondents was 18 to 25 years old (97%) followed by 26–35 (2.5%), and more than 55 (0.5%). Regarding sex, 51% were male and 49% were female. The predominant type of settlement was rural (50.5%) followed by urban (23.5%) and finally suburban (26%). The experiment was carried out at the facilities of the TecNM Campus Huatusco and Campus del Altiplano de Tlaxcala, where a room was equipped with lighting, absence of external odours and noise, and adequate ventilation.

Questionnaire design

The questionnaire was designed in sections (Herrera-Corredor *et al.*, 2007). Section I. Demographic information: age, gender, education, type of locality, municipality and occupation were included. Section II. Familiarity in terms of habits and product knowledge: in this section, consumers were asked to respond about their habits and knowledge of amaranth and coffee, type of consumption, preparation, consumption schedule, aromas that they like and dislike, traditions related to consumption and benefits they perceive. Section III. Product liking was carried out where each consumer rated attributes, appearance, colour, aroma, flavour, mouthfeel and overall liking using a 9-point hedonic scale (1 = dislike extremely, 5 = neutral, 9 = like extremely) (Peryam & Pilgrim, 1957). Section IV: they were asked to describe the attributes of aromas that they liked and disliked, flavours that they liked and disliked and mouthfeel.

Section IV: finally, they evaluated the acceptability and purchase intent of formulations (before and after knowing the creamer was formulated with amaranth) using a binomial scale (yes/no) (Sae-Eaw *et al.*, 2007).

Preparation of coffee formulations with amaranth-based creamer

The brewed coffee was blended with different proportions of flour obtained from pulverised amaranth, refined sugar and commercial creamer, as shown in Table 1. The proportions of brewed coffee, sugar and creamer were determined in preliminary work to ensure the level of sugar and creaminess using a mixture design (data not included). The coffee-amaranth drinks were prepared as follows: (i) brewed coffee was prepared in a coffee maker according to the guidelines of the Specialty Coffee Association (SCA, 2018), which specify using 8.25 g of grain (±0.25 g) for every 150 mL of purified water. (ii) Subsequently, popped amaranth flour, refined sugar and commercial cream substitute (Member's Mark) were mixed in the proportions indicated in Table 1 to be added to the previously brewed coffee. The mixture was stirred manually for 120 s before being served to participating consumers. Samples were kept at ±50 °C in thermal jugs (Rapoza Collective) before serving.

Experimental conditions for sensory evaluation of the formulations

An incomplete block design was used to avoid fatigue effects due to the evaluation of five formulations. Therefore, each consumer received two 30 mL samples according to the incomplete balanced block design Plan 11.2: $t = 5$, $K = 2$, $r = 4$, $b = 10$, $\lambda = 1$, $E = 0.62$ type V (Cochran & Cox, 1957). In this study, each formulation was evaluated $n = 160$ times. Glasses of water were also given to consumers to reduce any carry-on effects among samples.

Table 1 Characteristics of the creamer formulations

	Ingredients			
Formulations	Coffee (% v/v)	Sugar (% w/v)	Pulverised Popped Amaranth Flour (% w/v)	Commercial cream substitute (% w/v)
CTRLA0	90	3.5	0	6.5
AM2	90	3.5	2	4.5
AM3	90	3.5	3	3.5
AM4	90	3.5	4	2.5
AM5	90	3.5	5	1.5

Coffee: Coffee drink prepared according to the Specialty Coffee Association (SCA) with 8.25 g of beans (±0.25 g) per 150 mL of purified water. Sugar: trademark white sugar, Amaranth: pulverised popped amaranth flour, Commercial Cream Substitute: trademark cream substitute. v/v, Volume–volume ratio; w/v, Weight–volume ratio.

Statistical data analysis

The Chi square test was used to determine the dependence between variable demographic characteristics of familiarity (habits) with the regions. A two-way analysis of variance was performed to determine significant differences between formulations and between regions with a significance level of $\alpha = 0.05$. Tukey's test was used for mean comparisons. Multiple Factor Analysis was used to visualise liking results between regions. Acceptability and purchase intent were evaluated using Multiple Logistic Regression Analysis (Herrera-Corredor *et al.*, 2007). For the textual description of the formulations, the FAST function (Cadoret *et al.*, 2009) of the SensoMineR package ver 1.26 for R was used. The statistical tests were carried out in the software R ver 4.3 in the RStudio Integrated Development Environment, version 2023.06.0 Build 421.

Results and discussion

Characterisation of consumption habits between regions

Table 2 shows the results of the habits of amaranth and coffee consumers between both regions (Veracruz and Tlaxcala). The result of the Chi square test showed dependence between the type of coffee consumed and the region ($P < 0.0001$). The standardised

Table 2 Habits of amaranth and coffee consumers between the regions (Veracruz and Tlaxcala)

	P value
Coffee	
Type of coffee (options: home roasted and ground, domestic roasted and ground, export roasted and ground, specialty roasted and ground, soluble)	<0.0001
Preparation (options: with sugar, with milk, with powdered cream and alone)	<0.0001
Consumption schedule (options: breakfast, lunch, dinner and between meals)	<0.0001
Amaranto	
Type of amaranth (options: buy from a local producer, buy in supermarkets, buy in a grocery store, produce and resell at home)	0.0001
Form of consumption (options: traditional sweets, joys, drinks, breakfast cereal, with fruit, salad, gruel, with yogurt, sauces, smoothies and grain)	<0.0001
Consumption schedule (options: breakfast, lunch, dinner and between meals)	0.01

residual (ER) values for Tlaxcala (5.87) and Veracruz (−5.87) indicated that soluble coffee is more common in Tlaxcala (59.8%) than in Veracruz (22.0%). On the other hand, coffee roasted and ground at home was more consumed in Veracruz (ER = 5.81, 33%) than in Tlaxcala (ER = −5.81, 7%). The results may be due to the fact that consumers in Veracruz, belonging to one of the coffee-growing regions with a high coffee production (11 530 tonnes) at the state level (SIAP, 2022), have more knowledge regarding the coffees that are currently produced. In relation to coffee preparation, dependence ($P < 0.0001$) with the region was also found. Consumers from Tlaxcala (16.4%) prepare their coffee more with powdered cream compared to consumers from Veracruz (5.3%). In general, consumers from both regions drink coffee at the same times except ($P < 0.0001$) that in Veracruz (5.8%), it is also common to drink it at lunch. Regarding the way of obtaining amaranth for consumption, dependence ($P < 0.0001$) with the region was found. Tlaxcala consumers usually obtain amaranth from a local producer (ER = 2.79, 38%), and Veracruz consumers buy amaranth in conventional stores (ER = 3.59, 50.5%). The above may be due to the fact that consumers in Tlaxcala are familiar with amaranth and have higher availability of the grain as they are located in a highly amaranth productive region (2226.65 tonnes) (SIAP, 2022) in contrast to consumers from Veracruz. Regarding the form of amaranth consumption, dependence on the region ($P < 0.0001$) was only associated with higher consumption of amaranth in the form of traditional sweets in Veracruz (63.2%) compared to Tlaxcala (50.8%). This result agrees with what was reported by Rojas-Rivas *et al.* (2020) and CIMMYT (2022), who mentioned that amaranth is consumed in the form of a cereal bar known as 'alegrias'.

Knowledge regarding coffee and amaranth across regions

Table 3 shows the result of the textual analysis in relation to the knowledge and aromas that coffee consumers like and dislike. Consumers from Veracruz used only five words (floral, cinnamon, citrus, strong and bitter) to describe the aromas they like compared to consumers from Tlaxcala, who used 10 words (vanilla, toasted, cinnamon, sweet, loaded, strong, bitter, milky, earthy and citrus). In the case of the aromas that they do not like, it was found that consumers from Veracruz mentioned the word acid; this result agrees with Quintero *et al.* (2021), who indicated that the rejection of coffee samples is related to acidity. In the case of the benefits of coffee, consumers in both regions agree that coffee is an inducer to reduce sleep. The results shown above reveal different points: (i) Tlaxcala consumers are little familiar with coffee, and this agrees with Tu *et al.* (2010), who indicated that familiarity has an influence on the sensory description for the characterisation of foods: (ii) The agreement between consumers from both regions regarding the benefits of coffee also coincides with what was mentioned by Ramírez-Prada (2010) and Samoggia & Riedel (2019), who indicated that coffee has multiple benefits (reduction in neurodegenerative diseases, type 2 diabetes, liver disease and ergogenic functions) and also contributes to sleep composition. In the case of amaranth, it was observed that consumers from both regions did not give words for the aspects of the aromas that they like or dislike. This may be because amaranth does not have a wide sensory diversity of aromas as is the case with coffee (Bhumiratana *et al.*, 2019). However, regarding the benefits of amaranth, consumers in both regions agreed that this food has nutritional effects. According to Martínez-Salvador (2016), amaranth has one of the highest nutritional contents in protein, iron, calcium, fibre and fat compared to other grains such as corn, wheat and rice. Regarding tradition or custom, it was found that consumers from Veracruz associate amaranth with words such as family gatherings, traditional sweets, breakfast, traditional festivals and consumers from Tlaxcala associate this food with the words food, traditional sweets and traditional festivals. The mentioned words have been reported as positive memories

Table 3 Identification of agreed words in relation to the knowledge that consumers have regarding coffee and amaranth

Aspect	Consensual words	Region
Coffee		
Liked aromas	Floral, cinnamon, citrus, strong, bitter	Veracruz
Disliked Aromas	Acidic	
Benefits	Reduce sleep	
Tradition or custom	–	
Liked aromas	Vanilla, toasted, cinnamon, sweet, heavy, strong, bitter, milk, earthy, citrus	Tlaxcala
Disliked aromas	–	
Benefits	Reduce sleep	
Tradition or custom	–	
Amaranth		
Liked aromas	–	Veracruz
Disliked aromas	–	
Benefits	Nutritive	
Tradition or custom	Family gatherings, traditional sweets, breakfast, traditional festivals	
Liked aromas	–	Tlaxcala
Disliked aromas	–	
Benefits	Nutritive	
Tradition or custom	Food, traditional sweets, traditional festivals	

(Cabal-Prieto *et al.*, 2022), which may possibly be associated with the nostalgia that is generated in the consumer (Espinoza-Ortega, 2021).

Comparison of liking at the formulation level and consumers of both regions

Table 4 shows the ANOVA results for consumer liking. It was observed that there are significant differences ($P < 0.05$) in the sensory liking of the five attributes evaluated with respect to the control (cream substitute without amaranth). For the overall appearance attribute, the CTRLA0 sample obtained the highest score ($P < 0.05$) and the AM2 and AM3 formulations had scores of 6.61 and 6.66, respectively. These values placed these formulations in the 'I liked it slightly' zone. and 'I liked it moderately' according to the hedonic scale. Formulations AM4 and AM5 obtained the lowest scores with values of 6.45 and 6.19, respectively. In relation to the colour, aroma and flavour attributes, the control sample and the AM2 and AM3 formulations presented similar preference scores ($P > 0.05$) compared to the AM4 and AM5 formulations, which presented the lowest scores. In the parameters mouthfeel and overall liking, the CTRLA0 and the AM2 formulations were rated similarly ($P > 0.05$) but different ($P < 0.05$) to the rest of the formulations. The results of the comparison of preference between regions can be seen in Table 4. It was observed that in the parameters: appearance, colour, flavour, mouthfeel and overall liking, no differences were found ($P > 0.05$) between regions. This result agrees with the research of Prescott *et al.* (1997), who evaluated sucrose levels in orange juice, corn flakes and ice cream using panels located in Australia and Japan and reported similarities in the scores between both panels. Tu *et al.* (2010) reported that there were no significant differences in the preference between Vietnamese and French for the hedonic evaluation of soy yogurts. However, it was found that for the aroma parameter, consumers from Veracruz gave the highest ($P < 0.05$) score (6.91) compared to consumers from Tlaxcala (6.68), with which it can be assumed that this result derived from the familiarity that Veracruz consumers have with coffee. Nacef *et al.* (2019) found that consumers' familiarity with products reduces the negative effects, increasing their acceptance. Fenko *et al.* (2010) indicated that culture plays a role in determining the relative importance of sensory categories.

The partial plot in Fig. 1 indicated the first dimension was key to explain treatment variability (89.89%), as most of them clearly align to this dimension. Also, treatments were also aligned according to their amaranth content, indicating a clear effect of this ingredient on consumer perception. However, it seemed that dimension 2 was more correlated to the agreement between regions, indicating more agreement in AM2, AM3 and AM4 and less agreement for the extreme amaranth content treatments (CTRLA0 and AM5). In the correlation circle (Fig. 2), it can be observed most variables are correlated to the first dimension for both regions. For the Veracruz region, two groups of variables were identified: appearance, colour and aroma were closely correlated, as were flavour, overall liking and mouthfeel (suggesting overall liking was very correlated to flavour and mouthfeel). For the Tlaxcala region, no clear grouping of variables was found.

Table 4 Mean consumer ratings for acceptability of 5 coffee formulations added with amaranth-based creamer

	Attribute					
Formulation	**Appearance**	**Colour**	**Aroma**	**Flavour**	**Mouthfeel**	**Overall liking**
CTRLA0	7.06 ± 1.27[a]	6.99 ± 1.41a	7.31 ± 1.40a	6.37 ± 1.60[a]	6.42 ± 1.59a	6.63 ± 1.43a
AM2	6.61 ± 1.51b	6.77 ± 1.49ab	6.90 ± 1.81b	6.20 ± 1.72[a]	6.35 ± 1.61ab	6.40 ± 1.58ab
AM3	6.66 ± 1.41b	6.81 ± 1.48ab	6.98 ± 1.56ab	5.97 ± 1.89ab	5.96 ± 1.93bc	6.09 ± 1.73bc
AM4	6.45 ± 1.62bc	6.58 ± 1.58bc	6.72 ± 1.62b	5.52 ± 1.97bc	5.61 ± 1.99 cd	5.85 ± 1.76 cd
AM5	6.19 ± 1.58c	6.31 ± 1.63c	6.05 ± 1.76c	5.28 ± 1.97c	5.31 ± 2.00d	5.51 ± 1.84d
Pr(>F)	<0.0001*	<0.0001*	<0.0001*	<0.0001*	<0.0001*	<0.0001 *
Region						
Tlaxcala	6.61 ± 1.59a	6.73 ± 1.61a	6.68 ± 1.83b	5.85 ± 1.98[a]	5.91 ± 1.98a	6.14 ± 1.78a
Veracruz	6.58 ± 1.43a	6.65 ± 1.45a	6.91 ± 1.52a	5.88 ± 1.78[a]	5.94 ± 1.78a	6.06 ± 1.64a
Pr(>F)	0.794	0.379	0.0144*	0.794	0.788	0.41

Average of 160 repetitions for each treatment based on 400 consumers, 200 repetitions per region using a 9-point hedonic scale (1 dislike extremely, 5 = neither like nor dislike, 9 = like extremely). Means within the same column followed by different letters are significantly different ($P < 0.05$).
CTRLA0: Sugared coffee drink with 6.5% commercial cream substitute, AM2: Sugared coffee drink, with 4.5% commercial cream substitute and 2% pulverised amaranth flour, AM3: Coffee drink with sugar, with 3.5% commercial cream substitute and 3% pulverised amaranth flour, AM4: Coffee drink with sugar, with 2.5% commercial cream substitute and 4% pulverised amaranth flour, AM5: Coffee drink with sugar, with 1.5% commercial cream substitute and 5% pulverised amaranth flour.
*Significant at $\alpha = 0.05$.

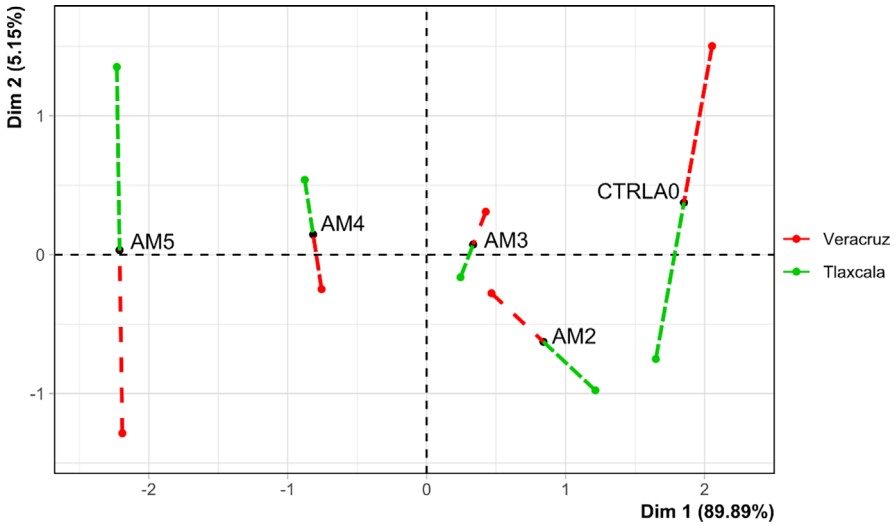

Figure 1 Partial plots comparing treatments between regions. AM2: Sugared coffee drink, with 4.5% commercial cream substitute and 2% pulverised amaranth flour, AM3: Coffee drink with sugar, with 3.5% commercial cream substitute and 3% pulverised amaranth flour, AM4: Coffee drink with sugar, with 2.5% commercial cream substitute and 4% pulverised amaranth flour, AM5: Coffee drink with sugar, with 1.5% commercial cream substitute and 5% pulverised amaranth flour.

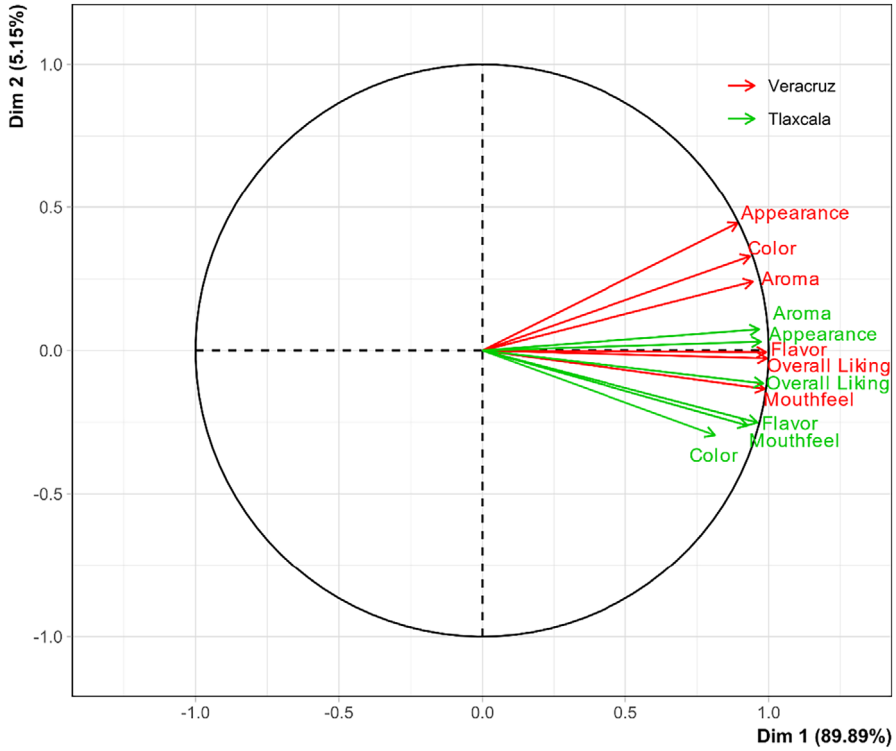

Figure 2 Correlation circle comparing variables between regions.

Importance of sensory attributes in predicting acceptance and purchase intent

Acceptability of formulations

The acceptability results (from Logistic Regression Analysis) of the formulations are shown in Table 5. It was observed that for Veracruz consumers, the flavour ($P = 0.033$) was critical for formulation AM2, colour ($P = 0.022$) was critical for formulation AM3 and overall liking ($P = 0.013$ and $P = 0.003$) was also critical for formulations AM3 and AM4, respectively, to determine the acceptance of the product. For Tlaxcala consumers, acceptance of the AM5 formulation was determined by appearance and mouthfeel ($P = 0.030$ and $P = 0.046$, respectively). Similar results for flavour were found by Núñez-Limón *et al.* (2022) in milkshake-like beverages formulated with residual grain from the amaranth popping process. Particularly flavour plays a key role in acceptability since amaranth adds earthy flavours to products that consumers from Veracruz may find not common in coffee creamers compared to consumers from Tlaxcala, where flavour was not critical for acceptability of any formulation.

Purchase intent of formulations

The purchase intent (Table 6) of Veracruz consumers for all formulations was mainly determined by overall liking ($P < 0.05$), except in the AM2 formulation where the mouthfeel was critical ($P = 0.038$) in determining purchase intent (Table 6). For Tlaxcala consumers, purchase intent of the CTRLA0 formulation was impacted by colour and overall liking ($P < 0.05$). Purchase intent for the formulation AM3 was determined by flavour. For the AM2, AM4 and AM5 formulations, they were a function of the overall liking ($P < 0.05$). Mouthfeel was also critical for formulation AM5. Overall, attributes associated with perception in mouth (flavour and mouthfeel) were drivers for purchase intent in formulations with higher amaranth proportions. These results agree with Labbe *et al.* (2015), who indicated that coffee consumers gave higher importance to aroma and flavour.

Impact of information regarding amaranth as ingredient on purchase intent

To evaluate the impact of amaranth on purchase intention in the regions, the McNemar test was applied. For Veracruz, $P = 0.00012$ was obtained,

Table 5 Estimates of Pr(>|z|), to predict acceptability in coffee formulations added with amaranth-based creamer

	Formulation				
Attribute	**CTRLA0**	**AM2**	**AM3**	**AM4**	**AM5**
Veracruz					
Appearance	0.149	0.199	0.093	0.145	0.289
Colour	0.230	0.453	0.022*	0.072	0.363
Aroma	0.253	0.088	0.176	0.763	0.747
Flavour	0.164	0.033*	0.871	0.667	0.205
Mouthfeel	0.171	0.430	0.159	0.709	0.449
Overall liking	0.098	0.314	0.013*	0.003*	0.099
Tlaxcala					
Appearance	NC	0.997	0.598	0.999	0.030*
Colour	NC	0.997	0.910	1.000	0.158
Aroma	NC	0.998	0.631	0.999	0.580
Flavour	NC	0.996	0.060	0.999	0.351
Mouthfeel	NC	0.997	0.587	0.999	0.046*
Overall liking	NC	0.996	0.865	0.999	0.068

Based on logistic regression analysis (LRA), using a full model with 6 sensory attributes for 5 formulations, NC: Not calculated (information was not sufficient for function modelling).
*Significant. CTRLA0: Sugared coffee drink with 6.5% commercial cream substitute, AM2: Sugared coffee drink, with 4.5% commercial cream substitute and 2% pulverised amaranth flour, AM3: Coffee drink with sugar, with 3.5% commercial cream substitute and 3% pulverised amaranth flour, AM4: Coffee drink with sugar, with 2.5% commercial cream substitute and 4% pulverised amaranth flour, AM5: Coffee drink with sugar, with 1.5% commercial cream substitute and 5% pulverised amaranth flour.

Table 6 Estimates of Pr(>|z|), to predict purchase intent in coffee formulations added with cream substitute based on popped amaranth flour

	Formulation				
Attribute	**CTRLA0**	**AM2**	**AM3**	**AM4**	**AM5**
Veracruz					
Appearance	0.230	0.843	0.080	0.349	0.570
Colour	0.105	0.386	0.095	0.576	0.378
Aroma	0.172	0.489	0.617	0.595	0.865
Flavour	0.590	0.262	0.879	0.259	0.424
Mouthfeel	0.079	0.038*	0.482	0.277	0.600
Overall liking	0.030*	0.282	0.001*	0.040*	0.016*
Tlaxcala					
Appearance	0.228	0.608	0.425	0.254	0.073
Colour	0.044*	0.732	0.794	0.398	0.978
Aroma	0.532	0.089	0.187	0.901	0.904
Flavour	0.965	0.711	0.004*	0.144	0.642
Mouthfeel	0.130	0.242	0.265	0.750	0.038*
Overall liking	0.035*	0.004*	0.686	0.047*	0.001*

Based on logistic regression analysis (LRA), using a complete model with six sensory attributes for five formulations.
*Significant at $\alpha = 0.05$. CTRLA0: Sugared coffee drink with 6.5% commercial cream substitute, AM2: Sugared coffee drink, with 4.5% commercial cream substitute and 2% pulverised amaranth flour, AM3: Coffee drink with sugar, with 3.5% commercial cream substitute and 3% pulverised amaranth flour, AM4: Coffee drink with sugar, with 2.5% commercial cream substitute and 4% pulverised amaranth flour, AM5: Coffee drink with sugar, with 1.5% commercial cream substitute and 5% pulverised amaranth flour.

which indicated that consumer awareness of amaranth as an ingredient in the creamer formulation leads to an increase in purchase intent. The same trend was found for Tlaxcala, $P = 4.918e\text{-}10$. This may be related to the trend in the current behaviour of consumers who are increasingly inclined towards traditional, natural and local products (Nacef *et al.*, 2019), particularly those that are linked or associated with their origin, geographical and production method (Mejlholm & Martens, 2006). Likewise, Rojas-Rivas *et al.* (2020) found in their study of consumption and purchase intention of amaranth in Mexico the highest values in purchase intention for 'alegría' bars and granola.

Textual analysis of the attributes evaluated in the formulations and limitations of the study

Table 7 shows the results of the textual analysis for the identification of consensus words. Regarding liked aromas, consumers from Veracruz indicated six words (amaranth, citrus, creamy, vanilla, milk and pleasant) compared to consumers from Tlaxcala, who indicated eight words (milk, creamy, earthy, sweet, amaranth, pleasant, bitter and vanilla). These findings agreed with Blancher *et al.* (2007), who observed that consumers originating from the place where the food is produced use fewer words to characterise a product compared to consumers located outside the context of food production.

In the case of the liked flavours, consumers from Veracruz indicated the words chocolate and vanilla and consumers from Tlaxcala indicated they like the milk flavour. In the negative aspects of aromas and flavours that consumers dislike, it was found that consumers from Veracruz mentioned the words harassing, burnt and thick, and consumers from Tlaxcala mentioned the words toasted and thick. According to Bhumiratana *et al.* (2019), the burnt attribute contributed to the rejection of coffee samples. Regarding the description of feel in the mouth, consumers from Veracruz related the formulations with the words thick, lumpy, soft, sweet, light and consumers from Tlaxcala related the formulations with the words creamy, soft, light and lumpy.

Future research opportunities could focus on applying dynamic sensory techniques, such as Temporal Dominance of Sensations (TDS), to better understand how consumers' perceptions evolve over time when evaluating coffee drinks made with amaranth-formulated creamers. Additionally, employing cognitive questionnaires that explore emotions and memories could help identify the underlying causes of consumer preferences.

Table 7 Identification of agreed words ($P < 0.05$) generated by consumers from Veracruz and Tlaxcala

Aspect to evaluate	Veracruz
Liked aromas	Amaranth, citrus, creamy, vanilla, milk, pleasant
Liked flavours	Chocolate, vanilla
Disliked aromas	Harassful, burned
Disliked flavour	Thick
Mouthfeel	Thick, lumpy, earthy, smooth
	Tlaxcala
Liked aroma	Milk, creamy, earthy, sweet, amaranth, pleasant, bitter, vanilla
Liked flavours	Milk
Disliked aromas	Toasted
Disliked flavours	Thick
Mouthfeel	Creamy, smooth, light, lumpy

Conclusions

Result from this study indicated significant differences in familiarity between regions in terms of habits and knowledge regarding amaranth and coffee. These differences had an impact on aroma liking. Overall, consumers from the Veracruz region liked more the aroma of products than those from the Tlaxcala region, which may be associated with coffee aromas. The product acceptance in the Veracruz region was determined by the attributes flavour, colour and overall liking, whereas in the Tlaxcala region only overall appearance and mouthfeel were critical. Purchase intent in the Veracruz region was affected by mouthfeel and overall liking, similar to the Tlaxcala region, where flavour was also critical. In terms of textual analysis, both regions similarly liked the creamy, milky, pleasant and vanilla flavours of the products. Consumers from the Tlaxcala region particularly liked the amaranth and earthy notes of the product that could be associated with familiarity with amaranth. However, disliking of products by consumers from Veracruz was based on attributes such as harsh, burnt and thick, whereas consumers from Tlaxcala disliked toasted and thick attributes. The findings of this study allowed for understanding the potential of amaranth to formulate new creamers in a cross-cultural context, considering consumers from two different levels of familiarity with specific crops.

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Author contributions

Lucía Sánchez-Arellano: Conceptualization; data curation; investigation; methodology; project administration; supervision; visualization; writing – original draft; writing – review and editing. **Emmanuel de Jesús Ramírez-Rivera:** Conceptualization; investigation; methodology; resources; visualization; writing – review and editing. **Mirna López-Espindola:** Conceptualization; investigation; methodology; resources; visualization; writing – review and editing. **Adrián Argumedo-Macías:** Conceptualization; investigation; methodology; resources; visualization; writing – review and editing. **Adán Cabal-Prieto:** Conceptualization; investigation; methodology; visualization. **José Manuel Juárez-Barrientos:** Conceptualization; investigation; methodology; resources; visualization; writing – review and editing. **José Andrés Herrera-Corredor:** Conceptualization; data curation; validation; methodology; project administration; software; supervision; visualization; writing – review and editing; writing – original draft; formal analysis.

Conflict of interest

There are no conflicts of interest to declare.

Ethical guidelines

Participation in this study was voluntary. Participants were informed regarding the objective of the study. Consumers were informed about data confidentiality. All participants were over the legal age for Mexico (18 years old).

Peer review

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declaration of generative AI in scientific writing

No generative AI tools were used in the writing process.

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