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IMPACT OF THE 'KENT' MANGO (*Mangifera indica* L.) JAM FORMULATION WITH DIFFERENT GELLING AGENTS ON THE PHYSICOCHEMICAL AND SENSORY PROPERTIES

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ABSTRACT

Pectin content decreases as mango (*Mangifera indica* L.) maturity progresses. When making jam, a hydrocolloid will be required, which can impact the physicochemical and sensory properties of the processed product. The objective of this work was to evaluate the effect of two mango maturity stages (60 and 100 %) and four different gelling agents (pectin, xanthan gum, guar gum, and corn starch) on the physicochemical and sensory properties of jams, using a commercial jam as a control. Eight treatments were obtained, and a completely randomized experimental design was applied. The experimental unit was a glass jar (250 g) of jam with three replicates for physicochemical and sensory analysis. Analysis of variance and comparisons of means with Tukey's test were carried out with SAS® software. The physicochemical properties of the jam were affected according to its formulation. Those with 100 % ripe mango plus pectin or corn starch showed maximum pH values of 3.7 and 3.8, respectively, but lower acidity (0.6 %). The jams with 60 % ripe mango and pectin or corn starch had higher levels of dietary fiber (1.42 and 1.47 %) and protein (0.97 and 0.79 %), with no differences from the control. In terms of texture, the formulation with 60 % ripe mango plus pectin was statistically superior to the other jams. The jam with 60 % ripe mango and corn starch had the highest sensory color and was comparable to the control, but in hue, it was instrumentally different from the other formulations. Changes in fruit maturity from 60 to 100 % and the type of gelling agent modified the physicochemical properties and sensory color of 'Kent' mango jam, confirming the effect of formulation on the attributes evaluated.

Keywords: mango ripening, microbiological analysis, texture profile, sensory analysis.

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INTRODUCTION

In Mexico, mango (*Mangifera indica* L.) is largely consumed as a fresh fruit. One of the largest producing cultivars is 'Kent', with about 26 000 ha planted (SIAP, 2020). Mango production is mainly destined for export. To market 'Kent' mango, an acceptable level of maturity with a firmness of 121.6 N and 7.4 °Brix are required (NMX-FF-058-SCFI-2006). Mangoes that do not meet the minimum export criteria may be distributed domestically or may be used in the high value-added food industry.

The amount of pulp varies among different mango cultivars such as 'Criollo Mara', 'Irwin', 'Gleen', 'Zill', 'Haden', 'Carrusell', 'Manzana', 'Tommy', 'Valencia Pride', and 'Palmer', while others such as 'Sprinfels', 'Ford', and heavier 'Kent' have high pulp contents (75 %), requiring at least 65 % for the processing market (Ramírez-Méndez *et al*., 2010). When mangoes reach eating maturity, their acidity is reduced, their soluble ~~s~~ solid content increases by more than 15 %, and develop yellow and orange colors (Villamizar-Vargas *et al*., 2019), which are important attributes for the processing industry.

Jam is a product formulated from fruit and sugar, plus the addition of acidifiers and pectin to obtain a gel. Gelation is achieved when the mixture reaches 65 °Brix by adding acidifier and pectin from 0.5 to 1 % (Ávila-Cubillos, 2015). Acidity can be obtained by citric acid from lemon juice, while gelation can be achieved with different hydrocolloids such as modified starch, agar, carrageenan, high and low methoxyl pectin, gums, alginate, and methyl and hydroxymethyl cellulose, among others (Wüstenberg, 2015). Increasing concentrations of 0.8 to 1.2 % pectin plus 50 to 70 % sucrose in ripe mango jam have been reported to increase hardness, shear work, thickening, and adhesion work, while sensory acceptability improves only when sucrose in the processed product increases (Basu and Shivhare, 2010). In a similar study, the gelling agents high methoxyl pectin, carboxymethyl cellulose, and sago starch (*Metroxylon sagu*) used in the formulation of mango jam modified the sensory and textural characteristics (hardness, shear work, stickiness, and adhesion work) of the processed product (Javanmard *et al*., 2012).

In jams, the gelling ingredient commonly utilized is pectin, a substance found in mango fruit (San Martín-Hernández *et al*., 2020). However, as ripening continues, total soluble solids increase, acidity and firmness decrease, and pectin content decreases due to the effect of endogenous pectinases that degrade pectin polymeric chains (Jamsazzadeh Kermani, 2015; Villamizar-Vargas *et al*., 2019). Therefore, to achieve proper gelation in a jam, some specific substance is required for that purpose.

Based on research on jam development, this study hypothesized that the behavior of the physicochemical and sensory attributes of jam are modified by using 'Kent' mango pulp with different ripening degrees and different gelling agents in its formulation. The objective of this work was to evaluate the effect of the formulation of jam made with different gelling agents and mango with 60 and 100 % ripeness on the physical, chemical, and sensory attributes of the product.

MATERIALS AND METHODS

Plant material and fruit determinations

The jams and the evaluation of their physicochemical parameters were carried out at the nutrition laboratory of the Food and Development Research Center (CIAD) in Culiacán, Sinaloa, Mexico. The 'Kent' mango was obtained from the supply market *in* Culiacán. Corn starch, high methoxyl pectin, guar gum, and xanthan gum were purchased as food-grade gelling agents from Bioproceso® (Culiacán, Mexico). The fruits were washed with potable water, surface disinfected with NaClO (150 mg L^{-1}) for 10 minutes, and rinsed with water. Based on standard procedures and those reported in the literature, the physicochemical analysis of the fruit (total soluble solids, pH, titratable acidity, firmness, and color) was carried out. The mango pulp was obtained to make the jams according to its maturity. Based on firmness and total soluble solids reported by the National Mango Board in USA (NMB, 2019) for 'Kent' mango at the harvest site (Table 1), the fruits were classified as mangoes with 60 and 100 % maturity. Firmness (N) was determined at two opposite points of the equatorial zone of the fruit without pericarp using a penetrometer (Ametek® Chatillon CS225 Series, Agawam, USA) equipped with a flat cylindrical probe of 8 mm diameter (Ø).

Table 1. 'Kent' mango maturity at harvest in the country of production (NMB, 2019).

Maturity attribute	Maturity scale				
	1	2	3	4	5
Firmness (N)	213–98	129–62	93–49	49–22	27–4
Total soluble solids (°Brix)	6–8	7–12	11–15	12–17	16–20
Proportional maturity (%)	1–20	21–40	41–60	61–80	81–100

Color was measured at two opposite points in the equatorial zone of the interior of each sliced lateral "cheek" section of the fruit using a colorimeter (Minolta® CR-3000, Tokyo, Japan) that recorded L^* (lightness), a^*, and b^* values in CIE L^* a^* b^* space. The hue angle (°) and color saturation (chroma) were calculated with the formulas: hue (°) = $\tan^{-1}$ (b/a); chroma= $(a^2+b^2)^{1/2}$.

Titratable acidity (TA), pH, and total soluble solids (TSS) were evaluated, respectively, by methods 942.15, 981.12, and 932.12 of the AOAC (2000). The determination of TSS in °Brix was made with 10 g of sample using a refractometer (Mettler Toledo® RE40D, Barcelona, Spain); pH and TA in the same processed sample were measured with a titrator (Mettler Toledo® DL-21, Schwerzenbach, Switzerland) using NaOH (0.1 N) until the equivalence point at pH 8.2.

Jam making

Jam was made according to methodologies reported by Basu and Shivhare (2010) and CODEX STAN (CXS 296-2009) (Codex Alimentarius, 2020), with some modifications for the addition of lemon juice and gelling agents. Mango pulp (200 g) was mixed with sucrose (40 %), Mexican lemon juice (0.2 %), water (50 mL), and a gelling additive (1.2 %). Subsequently, by boiling, the mixture was evaporated at 90 °C until obtaining a TSS of 65 °Brix. The jam was placed in sterilized glass jars (250 mL), pasteurized (NOM-130-SSA1-1995) for 20 min at 85 °C, cooled, and stored at room temperature for 20 d until physical, chemical, and sensory characterization.

Variables evaluated

Color (brightness, chroma, and hue)

Color was analyzed in two jam subsamples of 20 g per repetition and treatment on a Petri dish (90 mm Ø). With the colorimeter (Minolta® CR-3000, Tokyo, Japan), the values of L^* (brightness), a^*, and b^* in the jams were obtained, with which the hue angle (°) and chroma were determined with the formulas: hue (°)= $\tan^{-1}(b/a)$; chroma= $(a^2+b^2)^{1/2}$.

TA (% citric acid) and pH

Similar to the fruit, pH and TA were measured in 10 g of each jam with an automatic titrator (Mettler Toledo® DL-21, Schwerzenbach, Switzerland) using NaOH (0.1 N) up to the equivalence point pH 8.2.

Proximal analysis

In jams, ash, fat, protein, total dietary fiber, and moisture contents were quantified by AOAC (2000) methods 942.05, 920.39, 988.05, 985.29, and 925.10, respectively.

Texture profile analysis (TPA)

The texture profile was evaluated in the jams, where the parameters measured in N mm^{-1} were adhesiveness, consistency, viscosity, shear work, and firmness in Newtons. The texturometer used (AMETEK® Test & Calibration Instrument LS1, Largo, USA) was operated with the Neygen Plus 3 software. The determinations were made using a cylindrical probe with a 50 mm Ø sample holder and a 40 mm Ø flat strut. The jam was placed in the sample holder up to a height of 8 cm. Then, using the flat strut with a 50 Newtons load cell, consecutively without waiting time, two compression cycles were performed at a rate of 0.25 mm s^{-1} until a deformation of 25 % in height of the specimen was achieved (Farahnaky *et al*., 2014).

Microbiological analysis

Microbiological analysis was performed on each jam formulation, according to the Official Mexican Standard (NOM-130-SSA1-1995) for foods packaged in hermetically sealed containers and subjected to heat treatment, for aerobic mesophiles (NOM-092-SSA1-1994), molds and yeasts (NOM-111-SSA1-1994), and total coliforms (NOM-113-SSA1-1994). In addition, to evaluate the possibility of microbial growth, water activity was measured in each jam with an AquaLab® 3TE (METER Group, Pullman, USA).

Sensory analysis

Sensory evaluation was performed with an untrained panel (72 people) at CIAD, Culiacán, Mexico. To perform this analysis, the jams were timed for one hour at room temperature, and 3 to 5 g were served in 15 mL beakers labeled with three random digits. For each sample, panelists were provided with white bread and water to neutralize the palate. Sensory properties: color, odor, taste, texture, and overall acceptability were evaluated on a 9-point hedonic scale (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, and 1 = dislike extremely) (Basu and Shivhare, 2010). Data were evaluated with an analysis of variance followed by a mean comparison test with the Tukey test ($p \leq 0.05$) (Lawless and Heymann, 2010).

Experimental design and statistical analysis

The experimental design was completely randomized. The one-way classification factor was the mango jam formulation with eight levels, plus a commercial jam as a control. The treatments were obtained by combining two stages of mango maturity (60 and 100 % ripe) with four gelling additives (high methoxyl pectin, xanthan gum, guar gum, and corn starch). The experimental unit was a jar with 250 g of jam and three replicates. Data for physical, chemical, and sensory attributes were subjected to analysis of variance, and averages were compared with the Tukey test ($p \leq 0.05$) using SAS v9.4 2012 (SAS®, Cary, USA).

RESULTS AND DISCUSSION

The 100 % ripe mango had lower titratable acidity, firmness, and color (hue and brightness), but higher TSS (Table 2). As the fruit ripens, the content of organic acids decreases (Quintero *et al*., 2013) and the amount of TSS increases (Cárdenas-Coronel *et al*., 2012).

Firmness and TSS recorded in mango fruit (Table 2) may be suitable for jam processing. The higher the TSS content of the fruit, the higher the sugar content (Cárdenas-Coronel *et al*., 2012), favoring the lower incorporation of this ingredient in jam. In the processing industry of mango products, pulps are expected to reach TSS equivalent to 13 °Brix (Cañizares-Chacín *et al*., 2009) and low firmness to facilitate industrial processing.

Color, TA, and pH

The color was affected according to the jam formulation. In the three-color attributes, the control jam showed the lowest values and was statistically different from formulation two. The jam with 60 % ripe mango and corn starch had the highest hue

Table 2. Physical and chemical attributes in 'Kent' mango fruit at 60 and 100 % maturity.

Attribute	Fruit maturity	
	60 %	100 %
Total soluble solids (°Brix)	14.07 ± 1.21[†]	18.05 ± 0.47
TA (% citric acid)	0.98 ± 0.13	0.57 ± 0.03
pH	3.83 ± 0.05	4.30 ± 0.04
Firmness (N)	74.24 ± 1.11	7.13 ± 0.56
Brightness	66.50 ± 2.79	64.03 ± 0.29
Chroma	40.17 ± 3.06	52.69 ± 0.89
Hue (°)	97.12 ± 2.96	74.23 ± 0.59

[†]Average values (n = 4) ± standard deviation.

(74°) and was reduced by 12.5 % when 100 % ripe mango was used in formulation six. Similarly, when fruit of higher maturity was used in the jams, lightness declined. The highest lightness (39.2) of formulation two declined when 100 % ripe mango was used, and the reduction was accentuated by 17.5 and 16.7 % in jams with xanthan and guar gums, respectively. The jams with corn starch, 60 % ripe mango, and 100 % ripe mango had the highest chroma with values of 22 and 21, respectively, although statistically similar results can be obtained when using guar or xanthan gums, but without important changes due to fruit maturity (Table 3).

Table 3. Effect of mango jam formulation and control on brightness (L*), chroma, hue, titratable acidity (TA), and pH.

Formulation			*L**	Chroma	Hue	TA	pH
No.	Fruit maturity	Gelling agent			(°)	(% citric acid)	
1	60 %	Pectin	34.25 ab	13.30 c	69.23 ab	1.08 ab	3.47 cd
2		Corn starch	39.20 a	21.93 a	74.07 a	0.94 bc	3.57 bcd
3		Xanthan gum	35.33 ab	16.00 abc	64.67 bc	1.05 ab	3.56 bcd
4		Guar gum	35.00 ab	16.90 abc	63.77 bcd	1.16 a	3.40 d
5	100 %	Pectin	33.26 ab	14.60 bc	56.37 d	0.62 e	3.72 ab
6		Corn starch	37.10 ab	20.57 ab	64.80 bc	0.61 e	3.83 a
7		Xanthan gum	32.35 b	14.57 bc	58.72 cd	0.91 cd	3.62 bc
8		Guar gum	32.65 b	16.13 abc	57.40 cd	0.79 d	3.60 bcd
Control			32.10 b	14.65 bc	57.75 cd	0.78 d	3.5 cd
		HSD[†]	6.18	6.65	8.13	0.14	0.21
		p-value	0.0108	0.0021	< 0.0001	< 0.0001	< 0.0001
		Coefficient of variation (%)	6.40	12.90	4.70	5.22	2.23

[†]HSD: honest significant difference; a, b, c, d: averages with different letters in columns indicate statistical differences (Tukey, $p \leq 0.05$).

In 'Kent' mango pulp, the most abundant carotenoids are β-carotene (responsible for the orange color) and violaxanthin (yellow color) (Rodríguez-Velázquez and Zamora-Peredo, 2018). As mango ripens, the hue changes from pale yellow to yellow-orange (Venkateswarlu and Reddy, 2014), reducing both hue from 91 to 79 °, as well as brightness at consumption maturity (Nolasco-González and Osuna-García, 2017), a condition that influenced the hue and brightness of the jam. Invariably, at fruit maturity, corn starch gave the jam greater luminosity, hue, and chroma. The gelling agents used were yellowish, except for white corn starch, an aspect that could influence the color of the jams. When corn starch was used to coat dehydrated pumpkin slices, their brightness, chroma, and hue increased ($p \leq 0.05$) (Song *et al*., 2018).

Formulation affected the pH and TA of the jams (Table 3). The highest TA and pH values were recorded for formulations four and six, respectively, which were 49 and 9 % higher than the control jam. Formulations with 100 % ripe mango plus pectin or corn starch showed the highest pH with 3.7 and 3.8, respectively, but lower acidity (0.6 %). A pH value ≤ 4.6 is adequate for a jam (NOM-130-SSA1-1995). In this case, all jams presented pH values within the standard. As the fruit ripens, organic acids degrade and pH increases (Quintero *et al*., 2013).

In climacteric, starch is degraded by α-amylase, β-amylase, and other hydrolases, generating sugars and residues (hydroxyls) (Ubonbal *et al*., 2017) that can raise pH, and consequently, acidity is reduced. Pectin, consisting of a mixture of pectinic acids, can increase acidity, while corn starch, composed of starch with amylose and amylopectin chains (Bertoft, 2017), tends to reduce acidity. However, the effect of these gelling agents on the acidity of the jam is irrelevant because of the low concentration (1.2 %) used. Therefore, the effect of fruit maturity was determinant in the acidity and pH of the jams. In food, pathogenic bacteria inhibit their growth at pH levels below 3.8 (Hamad, 2012), which favored the microbiological quality of the formulations and was confirmed by microbiological analysis.

Proximal analysis

Jam formulation affected dietary fiber, protein, and ash content (Table 4). Statistical differences were found between 'Kent' mango jams and the control, which had 50 % less ash. In mango jam with lemon pectin, levels of 0.7 % protein, 46 % moisture, and 0.62 % ash have been recorded (Emelike and Akusu, 2019), equivalent to this work. In mango, ash content varies from 0.17 to 0.5 g 100 g^{-1} of fresh pulp (Ara *et al*., 2014), values that can impact formulations, as observed in this study.

The formulation affected the fiber values, which were twice as high in the 60 % ripe mango and corn starch jam compared to the 100 % ripe mango and xanthan gum jam, but showing no differences with the control. In protein, differences were observed between the pectin-based formulation with 60 % ripe mango (1.2 times more protein) and the jam with corn starch and 100 % ripe mango. In dietary fiber and protein, the lowest values were obtained in the 100 % ripe mango formulations. The reduction in fiber and protein is due to changes in mango ripening (Lobo and Sidhu, 2017). In

Table 4. Effect of mango jam formulation and control on proximate properties (% wet basis).

No.	Formulation: Fruit maturity	Formulation: Gelling agent	Dietary fiber (%)	Protein (%)	Ash (%)	Moisture (%)
1	60 %	Pectin	1.42 ab	0.97 a	0.40 a	37.33 a
2		Corn starch	1.47 a	0.79 ab	0.34 a	46.46 a
3		Xanthan gum	1.18 ab	0.73 ab	0.35 a	45.04 a
4		Guar gum	1.36 ab	0.73 ab	0.39 a	43.72 a
5	100 %	Pectin	0.87 abc	0.53 ab	0.31 a	44.01 a
6		Corn starch	0.71 bc	0.45 b	0.33 a	45.94 a
7		Xanthan gum	0.49 c	0.69 ab	0.30 a	46.00 a
8		Guar gum	0.82 abc	0.68 ab	0.30 a	46.53 a
Control			1.36 ab	0.64 ab	0.16 b	38.22 a
		HSD[†]	0.71	0.47	0.14	11.13
		p-value	0.0033	0.0498	0.0027	0.0894
		Coefficient of variation (%)	12.60	13.30	11.00	4.80

[†]HSD: honest significant difference; a, b, c: averages with different letters in columns indicate statistical differences (Tukey, $p \leq 0.05$).

'Kent' mango, the solubilization and enzymatic depolymerization of pectic substances and starches associated with dietary fiber change as maturity advances (Cárdenas-Coronel *et al*., 2012), where protein content also tends to decrease.

Texture profile analysis (TPA)

The formulation type affected the attributes of the TPA. Three trends were distinguished in the formulations: 1) when fruit maturity changed from 60 to 100 %, TPA values decreased; 2) the corn starch-based jam showed the lowest value in each TPA attribute, with this trend accentuated when 100 % ripe mango was used; 3) among the formulations, the jam with 60 % ripe mango and pectin had the highest records in the attributes of adhesiveness, consistency, shear work, viscosity, and firmness, which were 91, 106, 100, 82, and 235 % superior to the control, respectively, and this superiority was even greater with 9, 7, 8, 8, and 16 times in the same attributes evaluated in comparison with the corn starch and 100 % ripe mango jam (Table 5).

The primary cell wall consists mostly (85 %) of cellulose, hemicellulose, and pectins, but during fruit ripening, these compounds are degraded by expansins, glucanases, transglycosylases, xylosidases, polygalacturonases, pectinases, pectin methyl esterases, and other hydrolases, generating a softening of the tissue (Cosgrove, 2015). As 'Kent' mango ripens, firmness abates on average from 235 to 15 N (Nolasco-González and Osuna-García, 2017), reducing further in 100 % ripe fruit to 7 N (Table 2).

In this study, we observed that TPA parameters were significantly increased in the formulation based on 60 % ripe fruit and pectin compared to the control. Pectin, in

Table 5. Effect of mango jam formulation and control on adhesiveness, consistency, shear work, viscosity, and firmness.

No.	Formulation: Fruit maturity	Formulation: Gelling agent	Adhesiveness ($N\ mm^{-1}$)	Consistency ($N\ mm^{-1}$)	Shear work ($N\ mm^{-1}$)	Viscosity ($N\ mm^{-1}$)	Firmness (N)
1	60 %	Pectin	49.75 a	73.47 a	123.41 a	47.36 a	11.63 a
2		Corn starch	14.88 c	18.56 ef	33.45 d	14.88 d	2.01 ef
3		Xanthan gum	20.62 bc	30.90 cd	51.52 c	20.00 cd	4.43 bc
4		Guar gum	25.08 b	45.46 b	65.77 b	29.43 b	5.55 b
5	100 %	Pectin	16.08 c	22.63 de	38.71 d	17.12 d	3.32 cde
6		Corn starch	5.14 d	8.86 f	13.90 e	5.40 e	0.68 f
7		Xanthan gum	14.37 c	25.04 cde	39.42 d	14.37 d	2.54 de
8		Guar gum	15.38 c	23.93 de	39.32 d	15.38 d	3.94 bcd
Control			26.00 b	35.68 bc	61.68 bc	26.00 bc	3.47cde
		HSD[†]	7.88	11.59	11.09	8.27	1.68
		p-value	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
		Coefficient of variation (%)	14.61	15.11	8.65	15.56	15.55

[†]HSD: honest significant difference; a, b, c: averages with different letters in columns indicate statistical differences (Tukey, $p \leq 0.05$).

its chemical structure, forms gels with water, favoring the stability of the matrix in food (Thakur *et al*., 2019), and therefore, the texture is maintained longer, justifying its preference in the preparation of jams, besides being a low-cost ingredient.

In the formulation of jam with corn starch, the lowest TPA values were obtained under the two conditions of fruit maturity. This is explained by the poor stability of the gel formed by the swelling of starch in mixtures with high sugar content. On the one hand, sugars interacting with water restrict the swelling of starch with water, decreasing the size of the granules formed, and consequently, viscosity diminishes. On the other hand, decreasing the granule size may favor the rearrangement of starch components, mainly amylose and amylopectin, which are aligned in parallel, precipitating and fracturing the gel formed, thus generating retrogradation (Fu *et al*., 2015), and together with storage at room temperature, may favor syneresis in the jam.

Microbiological analysis

Microbiological analysis showed the absence of aerobic mesophiles, molds, yeasts, and total coliforms in the processed jams and the control (data not shown). In water activity, which ranged from 0.82 to 0.845, no differences were found among the jams evaluated. Water activities close to 0.8 can be obtained in products with high sugar content. Foods with water activities greater than or equal to 0.86 are perishable due to their susceptibility to spoilage and the growth of pathogenic microorganisms, since these need water to survive (Hamad, 2012). The safety of the processed product was confirmed prior to sensory evaluation.

Sensory analysis

No differences were found in odor, taste, texture, and acceptability between formulations, except for sensory color. The corn starch jam with 60 % ripe mango recorded a color (7.46) similar to the control and was 23 % statistically superior to the formulation with xanthan gum and 100 % ripe mango (Figure 1). In a similar study, a sensory color of 7.35 evaluated on the same 9-point hedonic scale was reported in mango jam formulated with citrus pectin (Emelike and Akusu, 2019). This value is similar to the color results obtained in this study. Color is the first criterion consumers use in their purchase decisions (Wu and Sun, 2013). As mango ripens, the hue angle reduces (Nolasco-González and Osuna-García, 2017), a phenomenon that was corroborated in the instrumental analysis of both the raw material and the jams (Tables 2 and 3).

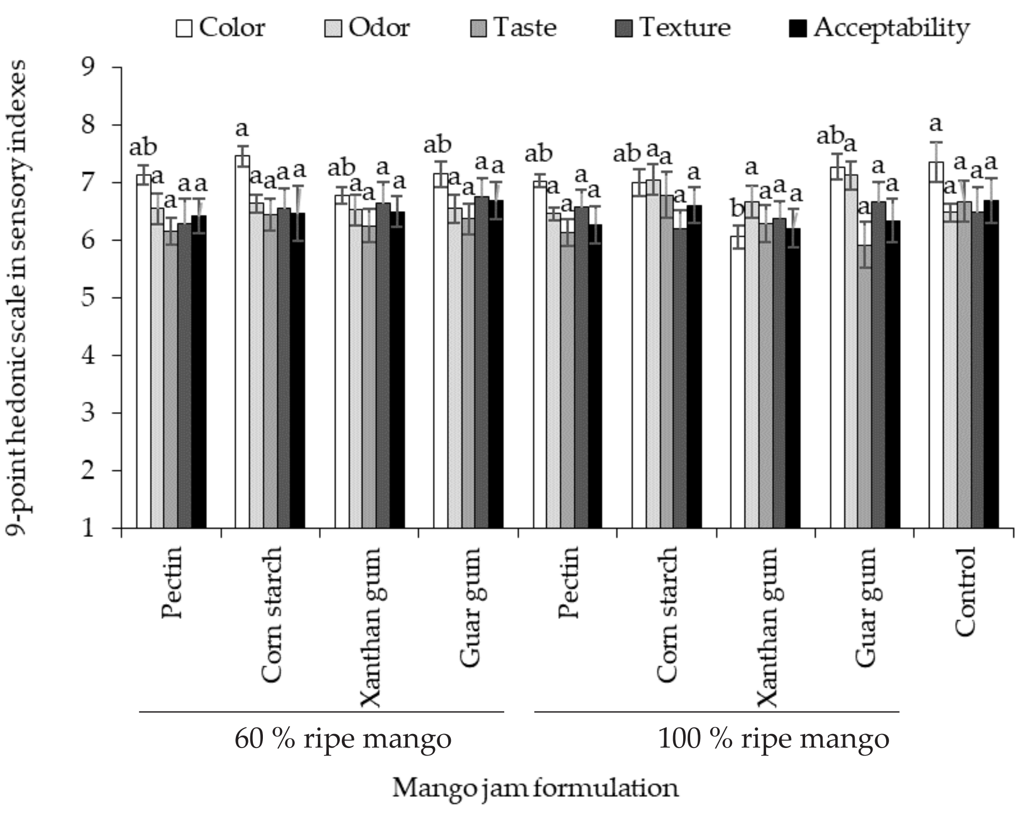

Figure 1. Color, odor, taste, texture, and sensory acceptability measured on a 9-point hedonic scale (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, and 1 = dislike extremely) in mango jam formulations with two maturity levels and four gelling agents, plus a commercial jam as a control. Bars ± standard deviation with different letters in each sensory index indicate statistical differences (Tukey, $p \leq 0.05$).

The results recorded for odor, taste, texture, and acceptability showed no effect of formulation, so based on these sensory attributes, the use of the four gelling agents and two stages of fruit maturity can be recommended. It is often difficult to distinguish sensory differences with untrained panels (Curtis, 2013), as observed in this study.

In general, 'Kent' mango at 60 % maturity and the gelling agents corn starch, xanthan gum, and guar gum can be used in the preparation of mango jams in the absence of pectin. This ease of changing gelling agents in the formulation of jam allows the use of mangoes that do not meet the quality criteria to be marketed fresh. Likewise, the production of these products is not limited to mango-producing areas, where their geographical location constitutes a barrier to obtaining raw materials such as gelling agents.

CONCLUSIONS

The physicochemical attributes of jam are modified according to the formulation of the processed product. Contrary to 100 % ripe fruit pulp, 60 % ripe pulp favors instrumental color (hue and brightness), sensory color, adhesiveness, consistency, firmness, viscosity, shear work, titratable acidity, dietary fiber, protein, and a lower pH value. On the other hand, the type of gelling agent induces differential responses among the formulations: a) when pectin is used, the texture profile attributes are superior to the other formulations; b) corn starch improves the values of dietary fiber, brightness, chroma, hue, and pH in relation to the control; and c) guar gum achieves a higher percentage of acidity than commercial jam. Combinations of 60 % ripe mango plus pectin or corn starch are suitable for the formulation of jams since they provide the best benefits in terms of physicochemical and sensory properties. A jam made with 60 % ripe mango and pectin reaches the highest level of texture profile, but when the gelling agent is replaced by corn starch, the highest levels of fiber, instrumental, and sensory color are achieved, with a sensory acceptability comparable to a commercial formulation.

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