







Development and characterization of a liqueur from discarded 'Ataulfo' baby mango (*Mangifera indica* (L.) Wall) as an upcycling option

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ABSTRACT

Objective: To develop and characterize a fruit liqueur by upcycling mango cv. 'baby Ataulfo' (discarded fruit) blended with *Agave cupreata* mezcal.

Design/methodology/approach: Two ripeness stages —physiological (PM) and consumption (CM)— were evaluated. Mango concentrates (PM: 26 °Brix, 1:2 pulp:water; CM: 23 °Brix, 1:3 pulp:water) were blended with mezcal. Physicochemical traits, proximate composition, and volatile compounds were determined by gas chromatography. Shelf life was estimated at 35 °C through first-order color kinetics. A 5-point hedonic test ($n=79$; 18-29 years) assessed sensory traits.

Results: CM showed higher TSS (26.86 °Brix) and flavour index (FI=87.5) than PM (21.23 °Brix; FI=41.10). Both complied with NOM-142-SSA1/SCFI-2014: methanol 200.66-206.41 mg 100 mL⁻¹ AA; acetaldehyde 11.57-12.56; furfural 1.75-2.29; higher alcohols 64.44-65.30; ABV 14.95-16.57% (v/v). LPM exhibited greater color stability ($k=2.60 \times 10^{-3} \text{ day}^{-1}$; $t_{1/2}=266.59$ days) than LMC ($k=4.90 \times 10^{-3}$; $t_{1/2}=141.45$ days). Sensory analysis revealed significant differences ($p<0.05$): LPM scored higher in mouthfeel, sweetness, acidity, aftertaste, and overall impression, while LMC was preferred for colour and odour.

Limitations/implications: The narrow panel age (18-29 years) and accelerated storage conditions limit extrapolation. Nonetheless, the study illustrates a viable upcycling strategy with socio-economic benefits for mango and mezcal producers.

Conclusions: Upcycling 'baby Ataulfo' into a mezcal-based liqueur is feasible, compliant with volatile-compound regulations, and sensorially acceptable. The PM-based formulation (LPM) showed superior stability and consumer acceptance, highlighting its industrial potential.

Keywords: mango liqueur; mezcal; volatile compounds; shelf-life.

INTRODUCTION

The mango cultivar (cv.) 'Ataulfo' is a fruit native to Mexico, recognised for its high pulp content (69%), with the peel representing 19% and the seed representing 8.5% of its total weight. This fruit stands



out for being an excellent source of vitamins A and C, as well as for its high sugar content. Compared to other varieties, ‘*Ataulfo*’ mango has a longer shelf life and is highly appreciated for its sensory characteristics: fleshy pulp, juicy texture, elongated shape and an attractive yellow colour when ripe for consumption (Mendoza-Hernández *et al.*, 2020; Rivas-Robles *et al.*, 2024).

However, one of the main problems associated with this cultivar is the production of small-sized fruits, known as ‘*baby Ataulfo*’ mangoes, whose weight is less than 118 grams. This characteristic renders them unattractive to both domestic and international markets, resulting in economic losses for producers. In addition, the proportion of these small fruits tends to increase with each production cycle (Escalera-Mota *et al.*, 2022; Hernández-Guerrero *et al.*, 2015).

This problem originated in the 1980s. In the state of Chiapas, orchards that previously produced up to 15 tons per hectare reduced their yield to only 5 tons per hectare. In the state of Nayarit, losses ranging between 80% and 90% are reported due to this same incidence. In that entity, adult trees older than 10 years present an incidence of 47%, in contrast to young trees, whose affliction is only 1.7% (Hernández-Guerrero *et al.*, 2015; Gehrke Vélez, 2007). In the state of Guerrero, particularly in the municipalities of the Costa Grande region, all municipalities producing common mangoes have this problem, with an incidence of nearly 45%, which translates into significant losses (García Osuna *et al.*, 2002).

Mezcal is a distilled Mexican alcoholic beverage that has a Denomination of Origin (DO) in nine states of the Republic, including the state of Guerrero, which has this designation in full (López, 2018). This beverage is made from the fermentation of sugars contained in the cooked heads (pineapples) of the agave and is subsequently subjected to a distillation process. However, mezcal faces serious problems, including the clandestine nature of much of its production due to the lack of certification. This situation poses a significant health risk, as many of these beverages originate from processes of dubious origin (Salinas-García *et al.*, 2023). According to data from the Government of Mexico (2025), in the state of Guerrero, more than 90 % of the annual mezcal production is marketed irregularly, with high levels of volatile compounds that exceed the limits allowed by the official standard (NOM-070-SCFI-2016).

The production of liqueurs from tropical fruits acquires commercial relevance when it is proposed as an alternative for the use of fruits at risk of waste, allowing the transformation of these resources into products with higher added value (Leonarski *et al.*, 2021; Pinto *et al.*, 2017). There is a growing trend in the development of new fruit-based liqueurs, driven by the demand for minimally processed products. Today’s consumers are increasingly demanding and show a clear preference for innovative beverages with low preservative content that maintain the sensory characteristics typical of the raw material used in their production (Petrović *et al.*, 2021). Likewise, the market presents an inclination towards products compatible with vegetarian lifestyles, which implies the exclusion of ingredients of animal origin, such as dairy bases, in the formulation of alcoholic beverages (Pinto *et al.*, 2022). Therefore, the objective of the following work is the elaboration and characterization of a liqueur from mango cultivar ‘*baby Ataulfo*’ to mezcal as a strategy to take advantage of a commercially wasted fruit. Its transformation into liquor allows for the rescue of this

resource, giving it added value. Additionally, the sustainable use of agricultural resources is encouraged. This can generate new economic opportunities for mango and mezcal-producing communities.

MATERIALS AND METHODS

Biological material

For the present investigation, fruits of mango cv. '*baby Ataulfo*' at two stages of maturity, physiological (PM) and consumption (CM), were harvested in an orchard in the town of San Jerónimo de Juárez, in the municipality of Benito Juárez, Guerrero, Mexico, with the coordinates 17° 08' 09" north latitude and 100° 28' 08" west longitude and taken to the laboratory. On the other hand, an artisanal mezcal made from *Agave cupreata* (*Agave papalote*), with an alcohol content of 38% by volume, was used. The sample was obtained in the town of Mazatlán, which belongs to the municipality of Chilpancingo de los Bravo, located in the central region of the state of Guerrero. Its geographical coordinates are 17° 37' 34" north latitude and 99° 27' 53" west longitude.

Physical-chemical analysis

The morphology, colour and firmness of the fruits used for the preparation of the liqueurs were evaluated, as well as total soluble solids (TSS), total titratable acidity (TTA), pH and flavour index (FI) according to the methodologies proposed by Maldonado-Astudillo *et al.* (2016) and Maldonado-Astudillo *et al.* (2019).

For the determination of proximate chemical composition (PCA), the official methods proposed by the Association of Official Analytical Chemists (AOAC, 1997) were used. Moisture content was determined using AOAC 925.10, ash content by AOAC 923.03, fat by AOAC 920.39, protein by AOAC 984.13, and carbohydrate was calculated by difference.

Liquor formulation

Two concentrates were developed from mango with the two maturity grades: one for consumption maturity (CM), with a pulp-water ratio of 1:3 and adjusted to 23 °Brix, and another for physiological maturity (PM), with a ratio of 1:2 and 26 °Brix. Both concentrates were supplemented with 10% citric acid and 5% sodium benzoate.

To prepare the final liquor in a one-liter presentation, 580 mL of the corresponding concentrate and 420 mL of *Agave cupreata* mezcal (38% alc. vol.) were mixed, obtaining two products: consumption maturity liquor (LMC) and physiological maturity liquor (LPM).

Determination of alcohol content and volatile components

After formulation, 250 mL of liquor from both formulations was collected at 20 °C and transferred to a distillation flask with 100 mL of water and boiling beads. The system was connected to a steam trap cooler. The distillate was collected in a volumetric flask that had previously contained 20 mL of distilled water, which was kept in an ice bath. On approaching the final volume, distillation was stopped, and the volumetric flask was topped up with water until a temperature of 20 °C was reached. The mixture was homogenized

and transferred to a graduated cylinder, and the alcohol strength was measured with an alcoholmeter.

Samples were analyzed using a gas chromatograph (PerkinElmer model 8600) equipped with an ionization detector. 1 μL of the sample was injected into the chromatograph. The chromatographic column used was 4 m \times 0.32 mm i.d. and was filled with Carbowax 1500 at 15% in Chromosorb W (80-100 mesh). The gas used in the mobile phase is Nitrogen at a flow rate of 20 mL min^{-1} as a carrier; the oven, injector, and detector temperatures were maintained at 93, 150, and 200 $^{\circ}\text{C}$, respectively. Variations resulting from the integration of chromatographic peaks and the width of the data observation window were checked. Once the optimal working conditions were established, each sample was analyzed. The chromatographic peaks used in the analyses corresponded to the following individual standards: acetaldehyde, methyl acetate, ethyl acetate, methanol, ethanol, sec-butanol (2-butanol), n-propanol, iso-butanol (2-methyl-1-propanol), iso-amyl (3-methyl-1-butanol), and n-amyl (1-pentanol). This methodology was proposed by de Oliveira *et al.* (2022) and Reyes Galindo (2020).

Shelf life

The prepared formulations were analyzed for 30 days in a forced convection oven (Luzeren model DHG-9070a, Beijing, China) at a constant temperature of 35 $^{\circ}\text{C}$. During this time, colour changes (brightness) were evaluated using a spectrophotometer (X-Rite Model Ci62 X-Rite Inc., Grandville, MI, USA) by measuring 10 mL of liquor every three days. At the end of this period, reaction rate constants (k) were determined. Finally, using first-order chemical kinetics to calculate the half-life $\left(t^{\left(\frac{1}{2}\right)}\right)$, the time required for half the initial concentration of a reagent to react, using a mathematical model described below:

$$t^{\left(\frac{1}{2}\right)} = \frac{\ln 2}{k}$$

Sensory analysis

A hedonic scale was applied to 79 affective judges, selected based on the following criteria: age between 18 and 29 years, habitual consumption of alcoholic beverages, liking for mango and absence of allergies or medical conditions that would prevent their participation. The two liquor formulations, LPM (543) and LMC (926), were evaluated using a five-point scale, where five corresponds to “I like it a lot” and 1 to “I dislike it a lot”. The attributes evaluated were colour, odour, mouthfeel, sweetness, acidity, aftertaste and overall impression.

Statistical analysis

Physical, chemical, volatile compounds and sensory analyses were evaluated using a Student's t-test for two groups, with a significance level of $p \leq 0.05$. The results were expressed as the average of three replicates \pm standard deviation, using GraphPad Prism version 9.4 statistical software.

RESULTS

The liqueurs made with mango cv. '*baby Ataulfo*' were well evaluated in sensory tests and presented good physical and chemical properties, thanks to the quality of the fruit and the differences in its maturity at the time of formulation. Despite its smaller size, the mango showed a pulp rich in sugars, good firmness and a balanced flavour between sweetness and acidity. These attributes, together with adequate processing, resulted in liqueurs with pleasant organoleptic profiles. Both formulations (LPM & LMC) retained their sensory qualities during their shelf life, with LPM standing out for its greater stability and overall sensory preference, attributed to its firm texture, greater aromatic intensity and taste balance.

Physical characterization of the fruit and pulp of mango cv. '*baby Ataulfo*'

Table 1 shows the morphometric and biomass analyses of mango cv. '*baby Ataulfo*', where significant differences in DL, weight, pulp proportion and firmness were observed among the samples analyzed. This cultivar, smaller in size compared to its commercial version, maintains a proportionality between DL, TD and total mass. The CM sample shows a lower firmness, which translates into a softer flesh, while the PM sample shows greater resistance to deformation and, therefore, a firmer texture. Significant differences were also observed in flesh colour parameters, such as brightness, chromaticity and hue, with a general tendency towards yellow tones. As maturity advances, these values decrease, leaning towards more orange tones in CM.

Table 2 shows significant differences between the samples analyzed for TTA, pH, TSS and FI. Mango, rich in organic acids, presents a high concentration of citric acid, which contributes to its acidity. In PM, higher TTA and lower pH values are observed. Mango cv. '*baby Ataulfo*' is characterized by its sweetness, which is reflected in its high TSS content.

Regarding the proximal chemical composition of the pulp, significant differences were detected in moisture, ash and carbohydrates. These parameters are key to the nutritional and sensory quality of the fruit. Moisture influences texture, juiciness and palatability; ash content indicates the presence of minerals; and carbohydrate variation directly impacts

Table 1. Physical parameters mango cv. '*baby Ataulfo*'.

Variable	PM	CM	P value
DL (mm)	63.4±1.2	67.6±1.04	0.0004*
TD (mm)	42.82±2.03	41.38±1.6	0.250
Weight (g)	58.6±5.5	70.6±2.1	0.025*
Pulp (g)	28.7±1.81	35.23±1.7	0.010*
Firmness (N)	9.6±0.07	5.7±0.1	<0.0001*
Brightness (L*)	37.20±1.7	31.98±0.5	<0.0001*
Chromaticity	41.12±1.5	39.08±2.0	0.0025*
°Hue	75.12±1.6	68.41±0.8	0.0011*

PM: physiological maturity, CM: consumer maturity, DL: longitudinal diameter, TD: transverse diameter. Average of three repetitions ± standard deviation. A Student's t-test was performed ($p < 0.05$). Significant differences are indicated by (*).

Table 2. Chemical parameters of mango pulp cv. '*baby Ataulfo*'.

Variable	PM	CM	P value
TTA	0.51±0.05	0.30±0.02	0.0025*
pH (-)	3.54±0.03	3.87±0.03	0.0004*
TSS (°Brix)	21.23±0.05	26.86±0.05	<0.0001*
FI (-)	41.10±4.07	87.5±5.74	0.0003*
Moisture (%)	75.68±0.4	77.09±0.3	0.0132*
Ash (%)	0.86±0.09	0.66±0.0	0.0324*
Ethereal extract (%)	0.28±0.01	0.46±0.01	0.3844
Protein (%)	2.77±0.3	3.31±0.2	0.0792
Carbohydrates (%)	20.38±0.3	18.45±0.4	0.0055*

PM: physiological maturity, CM: consumer maturity, TTA: total titratable acidity (% citric acid), pH: the potential of hydrogen, TSS: total soluble solids, FI: flavour index (TSS/TTA). Average of three repetitions ± standard deviation. A Student's t-test was performed ($p < 0.05$). Significant differences are indicated by (*).

flavour, especially sweetness, factors that may depend on the stage of maturity and growing conditions.

Volatile components and shelf life in mango liquor from mango cv. '*baby Ataulfo*'

Table 3 shows significant differences in the concentrations of aldehyde and furfural. The presence of these compounds, along with the higher alcohols, has an important influence on the aromatic and taste profile of the liquor. These volatile compounds provide distinctive sensory characteristics, and their concentration can vary according to various factors, such as fruit ripeness, processing and storage conditions.

Likewise, shelf life was determined by colour kinetics based on the brightness parameter. The rate constant (k) indicates that the LMC formulation exhibits higher degradation, as its k value is 4.90E-03, whereas LPM shows a lower value of 2.60E-03. In terms of half-life, the LPM formulation reaches 266.59 days, compared to 141.45 days for LMC. In comparative terms, LPM has twice the shelf life: eight months versus four months for LMC, counted from the date of manufacture. This period represents the time during

Table 3. Ethanol, methanol, aldehyde, furfural and higher alcohols in mango liqueurs.

Variable	LPM	LMC	P value
Ethanol	16.57±0.0	14.95±0.0	Nd
Methanol	200.66±0.03	206.41±5.7	0.29
Aldehyde	12.56±0.2	11.57±0.04	0.033*
Furfural	2.29±0.02	1.75±0.02	0.001*
Hig. Alc.	65.30±0.6	64.44±1.9	0.7

LPM: liquor physiological maturity, LMC: liquor maturity of consumption. Ethanol (% Alc. Vol.). The results of methanol, aldehyde (acetaldehyde), furfural and Hig. Alc.: higher alcohols are shown in mg 100 mL⁻¹ of anhydrous alcohol. Average of three repetitions ± standard deviation. A Student's t-test was performed ($p < 0.05$). Significant differences are indicated by (*). Nd: not determined.

which the liquor retains its organoleptic properties, such as colour, flavour, odour and texture, as well as its physical and chemical stability, without undergoing alterations or oxidation processes that compromise its suitability for consumption. To maintain product stability, it is advisable to store it in sealed containers, shielded from direct sunlight, kept at ambient temperature, and protected from abrupt temperature fluctuations.

Sensory analysis of mango liqueur cv. ‘*baby Ataulfo*’

The results of the hedonic scale (level of liking) in mango liqueurs are shown in Figure 1. Significant differences were observed between these two samples in the attributes of colour, odour, flavour, aftertaste and overall impression. Sample 543 (LPM) presented the best acceptance in terms of mouthfeel, sweetness, acidity, flavour, and aftertaste and obtained the best overall impression from the judges. Sample 926 (LMC) showed the best level of liking in the attributes of colour and odour attributed to the state of maturity with which it was made.

DISCUSSION

Physical characterization of the fruit and pulp of mango cv. ‘*baby Ataulfo*’

The main problem for mango cv. ‘*Ataulfo*’ is the appearance of the so-called ‘*baby Ataulfo*’, a phenomenon that has been present since the 1980s, affecting the central producing states, including Chiapas, its place of origin (Gehrke Vélez, 2007). In Nayarit, losses reach 80-90% of production, with a trend of increasing each season (Hernández-Guerrero *et al.*, 2015).

Fruit morphological analyses in this study reveal smaller dimensions in DL and TD compared to the values reported by Maldonado-Astudillo *et al.* (2016), who recorded 119 mm for the longitudinal diameter and 80 mm for the transverse diameter for the standard cv. ‘*Ataulfo*’ mangos are grown in the Costa Grande of Guerrero.

According to NOM-188-SCFI-2012, mango cv. ‘*baby Ataulfo*’ should not exceed 118 g in weight, and the fruits analyzed in this study are below that limit. In contrast Maldonado-

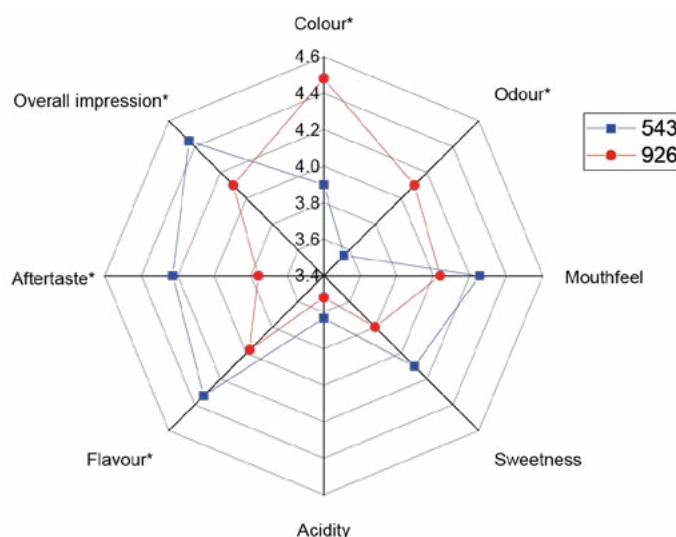


Figure 1. Sensory analysis of mango liqueurs (level of liking). Formulations: LPM (543) and LMC (926).

Astudillo *et al.* (2019) report an average weight of 387.8 g for commercially accepted mangoes, which evidences a considerable difference. In addition, although SIAP (2024) establishes an average of 69% pulp, the results obtained were lower, possibly due to the orchard's edaphic and climatic conditions.

Firmness is a key indicator of mango maturity and quality. As it matures, it decreases due to the enzymatic degradation of polysaccharides, such as starch, pectins, cellulose, and hemicellulose, which are essential for cell wall structure (Chomba *et al.*, 2025; Hor *et al.*, 2020). Previous studies by Maldonado-Astudillo *et al.* (2016, 2019) confirm that mangoes at eating maturity (CM) show lower firmness than those at physiological maturity (PM), which reinforces the relationship between firmness and degree of ripening.

Colour is a fundamental sensory attribute in the perception of food since it directly influences expectations about its flavour (Siller-Cepeda *et al.*, 2009). In this study, fruits at physiological maturity (PM) presented greater luminosity and chromaticity compared to those at consumption maturity (CM); this is in agreement with Diop *et al.* (2021), as mangoes advance in their ripening process, their luminosity decreases, giving rise to more intense, but less bright colour. According to Maldonado-Astudillo *et al.* (2016) mango cv. 'Ataulfo' reaches a hue angle of 88.7°, higher than the values observed in this analysis for 'baby Ataulfo': 75.12° in PM and 68.41° in CM. This suggests that the latter presents a less pure and more opaque yellow hue. As a climacteric fruit, mango continues to ripen after harvest, resulting in a loss of brightness and the development of yellow-orange hues, which is attributed to chlorophyll degradation and increased carotenoids (García Osuna *et al.*, 2002; López García & Trejo Duran, 2015; Wei *et al.*, 2021). These changes make the colour a reliable visual indicator of fruit maturity and quality.

Chemical characterization of mango pulp cv. 'baby Ataulfo'

In the chemical analysis of the pulp, it was observed that fruits at physiological maturity (PM) presented a higher concentration of total titratable acidity (TTA). This parameter decreases as mango ripening progresses, as organic acids are decomposed and transformed into sugars during this process (Dieye *et al.*, 2022). In contrast, the pH was higher in fruits at consumption maturity (CM), which is also associated with the advancement in the maturity stage, as the increase in pH is typical of sweeter and less acidic fruits.

A similar pattern was observed for total soluble solids (TSS), which increased with fruit maturity (Quintero *et al.*, 2013). In our analysis, TSS values in CM were within the range reported by Maldonado-Astudillo *et al.* (2019) for mango cv. 'baby Ataulfo', which ranged from 25.6 to 33.5 °Brix. According to NMX-FF-058-SCFI-2006, the minimum acceptable value for considering a quality mango is 8 °Brix, which is widely exceeded in both maturity stages evaluated. López García & Trejo Duran (2015) explain that the decrease in TTA in advanced ripening stages is due to the degradation of organic acids, which are transformed into sugars, reflected in the increase of TSS. This dynamic directly influences the flavour index (FI), which results from the relationship between sugars and acidity, and has a determining impact on the sensory perceptions of fruit flavour and aroma (Briceño *et al.*, 2005). According to Soto *et al.* (2004), an FI higher

than 50 is perceived as sweet, a value close to 50 is considered balanced and pleasant, while an SI lower than 50 is interpreted as acidic. In this study, with these criteria, CM is considered sweet, and PM is acidic.

The proximal chemical analysis (PCA) of the pulp of mango cv. '*baby Ataulfo*' is characterized by high water content, ranging from 75 to 78%, in agreement with Rivas-Robles *et al.* (2020), who reported 77.2% for discarded mangoes. In contrast Maldonado-Astudillo *et al.* (2016) report higher moisture (82.4%) in standard-size mangoes. Regarding ash and fat, our values were lower than those reported by Rivas-Robles *et al.* (2020), who recorded 2.58 and 0.77%, respectively. However, the protein content was higher than that reported by Pérez-Meza *et al.* (2024) in standard-size mangoes, who reported 0.34% in MF and 0.6% in MC. These differences may be due to maturity, storage conditions and fruit damage. Carbohydrates, after water, were the most abundant component, contributing sweetness to the pulp (Rivas-Robles *et al.*, 2024). In summary, the '*baby Ataulfo*' mango is distinguished by its high moisture and carbohydrates, low-fat content, and moderate levels of protein and ash.

Volatile components and shelf life in mango liquor from mango cv. '*baby Ataulfo*'

The LPM and LMC liquor formulations comply with the limits established by NOM-142-SSA1/SCFI-2014 or volatile compounds: methanol ($\leq 300 \text{ mg } 100 \text{ mL}^{-1}$), aldehydes ($\leq 40 \text{ mg } 100 \text{ mL}^{-1}$), furfural ($\leq 5 \text{ mg } 100 \text{ mL}^{-1}$) and higher alcohols ($\leq 500 \text{ mg } 100 \text{ mL}^{-1}$). Both products fall within these ranges, ensuring regulatory compliance. In comparison, studies such as Giménez-López *et al.* (2025) reported on mango liquors cv. '*Tommy Atkins*' reports $99.76 \text{ mg } 100 \text{ mL}^{-1}$ methanol and $0.3 \text{ mg } 100 \text{ mL}^{-1}$ furfural, but higher levels of acetaldehyde ($99.76 \text{ mg } 100 \text{ mL}^{-1}$) and higher alcohols ($529.25 \text{ mg } 100 \text{ mL}^{-1}$). Other values for higher alcohols reported by de Oliveira *et al.* (2022) were $121.9 \text{ mg } 100 \text{ mL}^{-1}$ in '*Kent*' and $112.3 \text{ mg } 100 \text{ mL}^{-1}$ in '*Alphonso*', all higher than those obtained in this study. In addition, both formulations comply with the range allowed by Mexican alcohol regulations (13.5-55% alc. vol.), placing them within the category of beverages with a medium content (6.1-20.0% alc. vol.). Compliance with these specifications is essential to ensure the quality and safety of the final product.

The reaction rate constant (k) allows estimating the rate of thermal degradation: low values indicate higher stability. According to Loypimai *et al.* (2016), the LPM formulation showed twice the stability of LMC. Feitosa *et al.* (2020) found that, among various fruit liqueurs, guava liqueur was the most stable in terms of colour, while mango liqueur was the least. This degradation is primarily associated with oxidation processes (Patras *et al.*, 2010). The higher stability of LPM is attributed to its lower water content, intermediate alcohol content, and the use of preservatives and pH regulators. In addition, mango pulp provides nutrients with antioxidant properties, such as carotenoids, flavonoids, polyphenols, and tocopherols, whose concentration depends on the variety, maturity, climate, soil, and postharvest handling (Corrales-Bernal *et al.*, 2014). In particular, polyphenols, which are more abundant at physiological maturity, are the predominant antioxidants (Li *et al.*, 2014). An extended shelf life offers logistical and commercial advantages, allowing the product

to be stored for longer without compromising its safety or quality before consumption (Ekmeiro Salvador & Arevalo Vera, 2023).

Sensory analysis of mango liqueurs prepared from cv. ‘baby Ataulfo’

Both the LPM and LMC formulations received high acceptance ratings from sensory panellists, surpassing initial expectations. LPM achieved the highest scores in key sensory attributes including sweetness, acidity, flavour, aftertaste, mouthfeel, and overall impression indicating a well-balanced and appealing sensory profile. Conversely, the LMC formulation was particularly appreciated for its visual and olfactory characteristics, especially colour and aroma, which strongly influence consumers’ initial perceptions, as noted by Macedo *et al.* (2021) and Silva *et al.* (2021).

The dominant fruity aroma of LMC, paired with its colour resembling that of fresh mango, played a critical role in its favourable evaluation. Meanwhile, LPM was distinguished by its equilibrium between sweetness and acidity, which made it especially palatable. This finding supports the conclusions of Pina *et al.* (2018), who emphasize that consumers prefer liqueurs with clearly defined fruit flavours and minimal alcoholic aroma.

Mouthfeel was another decisive factor in sensory preference. LPM was rated higher in this dimension due to its thicker, more viscous consistency, resulting from a greater concentration of mango pulp an observation consistent with Leite *et al.* (2019), who underscore the role of texture in liqueur sensory evaluation.

Both formulations contained a moderate to low level of alcohol, a feature that, as noted by Carolyn *et al.* (2020), improves consumer acceptance by reducing the intensity of ethanol related sensations. Finally, while sensory evaluation is inherently subjective and influenced by individual perception—as emphasized by Urán (2022) the observed pattern consistently reflected a strong preference for both LPM and LMC.

CONCLUSIONS

Mango cv. ‘baby Ataulfo’ has proven to be a suitable raw material for the production of fruit liqueurs, as it complies with the established regulatory parameters. Both formulations evaluated are within the permissible limits of volatile compounds and offer particular sensory properties. The formulation made with physiologically mature fruit was the best evaluated by the judges. This process facilitates the reintegration of otherwise discarded fruit by assigning it functional utility and presenting a novel route for its inclusion in value-added manufacturing chains. Similarly, mezcal—frequently lacking official certification and marketed through informal means—finds in this proposal a practical and structured use scenario. In addition, it incorporates a sustainability component by using an undervalued resource, promoting its responsible use within a more efficient and conscious production chain.

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