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LIQUOR PRODUCTION FROM BY-PRODUCTS OF MANGO PROCESSING (*Mangifera indica* L. Haden)

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ABSTRACT

The use of agro-industrial by-products, such as peels, seeds, leaves, stems, or roots, is growing significantly because they contain compounds with biological activity; this activity could benefit human health. An option of use is the elaboration of liquors by maceration at spirit beverages. This study develops a liquor of mangoes by-products, dry and fresh, macerated with different spirit beverages, and analyzes their physicochemical characteristic and consumer acceptance. The best results were for liquor from dried mango by-products macerated with rum (280), ranking a preference of 58% at the preference test and almost equaling the sensory characteristics of commercial control. These results point to the mango by-products as an option for designing liquor with good acceptance on the market.

Keywords:
Spirit beverage, consumer acceptance, maceration, preference test.

RESUMEN

El uso de subproductos agroindustrias, como cáscara, semillas, hojas, tallos o raíces, está aumentando notoriamente debido a su contenido de compuestos con actividad biológica; la cual podría beneficiar la salud humana. Una opción de uso es la elaboración de licores por maceración en bebidas alcohólicas. Este estudio desarrolla un licor de subproductos de mango, secos y frescos, macerados con distintas bebidas alcohólicas, y analiza sus características fisicoquímicas y la aceptación de consumo. Los mejores resultados fue un licor con subproductos secos de mango macerados con run (280), con un rango de preferencia del 58% en la prueba de degustación y con similitud a las características sensoriales de un control comercial. Estos resultados indican que los subproductos de mango son una opción para elaborar licores con buena aceptación en el mercado.

Palabras clave:
Bebida alcohólica, aceptación de consume, maceración, prueba de degustación.

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1. Introduction

Using by-products from the food industry has gained significant importance, as they provide a source of bioactive compounds, including antioxidants and additives like colorants and texturizers used within the food sector (Nirmal et al., 2023). A particularly intriguing application for fruit by-products is the production of liqueurs since the peels and seeds retain a substantial quantity of compounds that not only enhance the aroma and flavor of the liqueurs even offer biological benefits for the health of consumers. These compounds are extracted through maceration with various distillates, such as rum, whiskey, vodka, or brandy (Śliwińska et al., 2015).

Examples of the use of by-products from the juice industry, such as apple peel, beetroot, and black chokeberry were macerated with a 40% alcohol mixture and analyzed for their phenolic profile, antioxidant activity, and consumer acceptance. Although this study did not compare these products with any commercial liquors, the general acceptance ratings ranged from 6.3 to 7.4 on a scale of 9. The aromas and flavors, distinct to each type of fruit, scored between 4.5 and 6.7 out of 9, indicating the potential of utilizing these peels as raw materials for liquor production (Petrović et al., 2021).

Mango (Mangifera indica L. Haden) is one of the most widely cultivated and globally consumed fruits, both in its fresh form and processed products. In 2023, global production of mango, mangosteen, and guava was projected to reach 2.3 million tons, with mango accounting for 75% of this total. Mexico, renowned for its mango production, holds the leading position in worldwide exports (FAO, 2024). According to the Agrifood and Fisheries Information Service (SIAP, 2024), on August 31st, 2024, the total mango production in Mexico was 2,161,763.98 tons, and approximately 30% of this production is a raw material for the food industry, with only the pulp being used in various products. Consequently, around 260,411 tons of mango by-products were generated during the industrial processing of this fruit. This study aimed to assess whether mango by-products, typically used in candy production, could also serve as a viable option of liquor production for the local market of Celaya, Mexico.

2. Materials and methods

Experimental design

For preparing the liquor, the created formulations were based on raw materials derived from the mango by-products, specifically bone and peel in two distinct forms. The first form utilized fresh mango with whole bone and peel and the second form involved the drying and crushing of the peel and bone using a stone disc mill. The alcoholic distillates employed in the process were rum and sugarcane distillate with alcohol content of 38% (V/V) and 20% (V/V), respectively. Table 1 describes the experimental design for the liqueur formulations.

Liquor preparation

The fruits of Mangifera indica L. Haden, commonly called the “Petacón” mango, were bought from the Celaya food market. The fruit was carefully selected and handled manually. The disinfection uses a chlorine solution (15 mL of commercial chlorine per liter of water). After this, the peeling and pulping were completed manually, with the pulp being utilized to create mango-based products. The seeds were fragmented and dried in a forced convection oven at 55°C for 48 hours, while the peels were dried at 50°C for 40 h.

Table 1. Experimental design to test mango liqueur formulations.

Identifier*	Description
153	Whole and fresh peel and pit are washed and disinfected, and then macerated in rum with 38% (V/V) alcohol.
312	Whole and fresh peel and pit are washed and disinfected, and then macerated in sugarcane distillate with 20% (V/V) alcohol.
280	Dried and pulverized peel and pit, and macerated in rum with 38% (V/V) alcohol.
710	Dried and pulverized peel and pit, and macerated in sugarcane distillate with 20% (V/V) alcohol.
121	Commercial alcoholic beverage, mango flavored and carbonated, with 4.7% (V/V) alcohol

*The identifier code is based on sensory tests applied a head.

The dehydrated mango peels were processed in a "Black and Decker" brand blender, model BL1830SGM, at high speed for about 5 minutes until a fine powder was achieved. Meanwhile, the mango seed was ground using a manual grain mill and set to a 6 mm opening between the discs. The maceration was carried out by mixing 250 g of peel and 250 g of seed for each liter of rum (38% alc. vol.) and cane alcohol (20% alc. vol.) for both fresh and dry treatments. The flask was kept in a cool, dark place for a month, with soft shaking every three days. Subsequently, the macerate was filtered using a "sky blanket," followed by a secondary filtration through coffee maker filter paper No. 4. The resulting liquid was then stored in a glass flask.

To prepare the liquor, sugar was dissolved in water and brought to a boil. The resulting syrup, which was at room temperature, was then combined with the macerate to achieve a concentration of 12% alcohol by volume (alc. vol.) and 33 °Brix in a total volume of 750 mL. The glass container, sealed with a metal lid, was labeled and stored in a cool place, away from sunlight. To measure the °Brix of each sample, a portable hand-held Abbe refractometer model ZWAJ was used. A drop of the sample was placed on the device after it had been calibrated, and the measurement was recorded.

The titratable acidity was determined by taking 10 mL of the sample and placing it in a 100 mL Erlenmeyer flask along with three drops of phenolphthalein (an indicator solution). It was then titrated with 0.1 N NaOH. The acidity, expressed as grams of malic acid per 100 mL of liquor, is calculated using the formula: (volume of NaOH*N*67)/sample volume.

The pH was measured using a potentiometer with ion-selective electrodes, model Consort C3010, which had already been calibrated. For the measurement, 10 mL of the sample was placed in a 50 mL beaker, and the electrode was submerged to obtain the reading.

Sensory tests.

In the preference ranking tests, the panelists received five samples labeled with a unique 3-digit code (Table 1). Among these samples was a control sample labeled 121. The panelists were asked to rank the samples in ascending order, with one being the most preferred and five being the least, based on taste, smell, and color. To assess whether the preference for a specific liquor was due to taste rather than chance, the number of times each liquor was selected as the top choice was analyzed using the goodness-of-fit test, with a significance level (α) set at 0.01.

To evaluate and quantify the positive and negative attributes of mango liquor, a Quantitative Descriptive Analysis (QDA) method was employed to obtain an organoleptic score. The sensory perceptions assessed included taste, color, aroma, texture, sweetness, and transparency—attributes commonly found in fruit liqueurs. The evaluation scale ranged from one to five, where one represented the lowest intensity of perception and five represented the highest. For transparency, a score of 1 indicated a cloudy appearance, while a score of 5 indicated a crystalline appearance. Three samples were evaluated: samples 153 and 280, which were the preferred options from the ranking test, and a commercial control, sample 121. The test was conducted by a panel of 15 individuals who had experience consuming liqueurs.

The experimental data from the replicates of the physicochemical tests and the score test were analyzed using one-way ANOVA with a significance level of α=0.05 to assess the differences between formulations. Following this, the treatment means were further examined with the Tukey test, also applying a significance level of α=0.05.

3. Results and discussion.

Table 2 presents the results of the physicochemical evaluations of formulations derived from mango by-products in comparison to commercial control. The formulation labeled 153 recorded the highest pH value of 4.40, closely followed by formulations 312 and 710, which exhibited significantly similar values of 4.20. In contrast, formulation 280 displayed a lower pH of 3.43, while the commercial control had the lowest pH value at 3.20.

In terms of titratable acidity, formulation 280 ranked highest, followed by formulation 312 with a value of 6.01 and formulation 710 at 5.93. These acidity values correspond with the pH readings, although the acidity for formulation 153 was unexpectedly low at 3.38, suggesting it should exhibit similar acidity levels to those of formulations 312 and 710 or perhaps even an alkaline pH given the amount of titrated acid. The control (121) had the lowest acidity at 2.80, indicating it might show an alkaline pH. However, it is important to note that this is a carbonated beverage, which can affect pH due to the presence of dissolved CO_2. When CO_2 dissolves in water, it forms carbonic acid (H_2CO_3), the concentration of which decreases as CO_2 evaporates.

The soluble solids values presented in Table 2 indicate that formulation 153 had the highest value at 24.66, followed by formulation 710 at 15.0, and then formulation 280 at 12.33, which is statistically similar to formulation 312. The commercial control drink (121) had the lowest soluble solids values.

Table 2. Values of the physicochemical analysis carried out on liquors based on mango by-products and on the commercial control.

Analysis	153	280	312	710	121
pH	4.40a	3.43c	4.20b	4.19b	3.20d
Acidity (grams of malic acid/100 mL)	3.38d	6.31a	6.01b	5.93c	2.80e
Soluble solids (°Bx)	24.66a	12.33c	13.33bc	15.0b	6.33d

Different letters in the same row indicate significant difference between means with $\alpha<0.05$. 153, rum with fresh by-products; 280, rum with dry by-products; 312, sugarcane liquor with fresh by-products; 710 sugarcane liquor with dry by-products; 121, mango-flavored alcoholic beverage control.

The difference in soluble solids between formulations F1 and F3, both made with fresh mango by-products, can be attributed to the characteristics of the solvents used. Specifically, rum contains 48% (V/V) alcohol, while cane alcohol contains only 20% (V/V). Pinelo et al. (2005) reported that during the extraction of total soluble solids from grape pomace, ethanol performed better than water when compared with methanol and water. Similarly, Plaza et al. (2023) demonstrated that increasing the percentage of ethanol resulted in a higher amount of total soluble solids.

Figure 1 illustrates the results of the ranking test conducted on four formulations created from mango processing by-products. The most preferred formulations were identified as 153 and 280. This finding is supported by the goodness-of-fit test, a statistical analysis that assesses whether the frequency with which a particular nominal classification is selected reflects consumer preference for the product's characteristics rather than occurring by chance (Lind et al., 2012).

Particle size plays a significant role in the extraction process, and the choice of solvent can remarkably impact the yield of extracts, such as the total polyphenol content (TPC). Jovanović et al. (2017) showed that TPC concentrations increased with a decrease in particle size, reaching a maximum with a 50% alcohol solution as the solvent. In this study, the fresh mango seeds were not reduced in size compared to the dried by-products, which were pulverized. These variables may affect the extraction of aroma and flavor compounds during maceration.

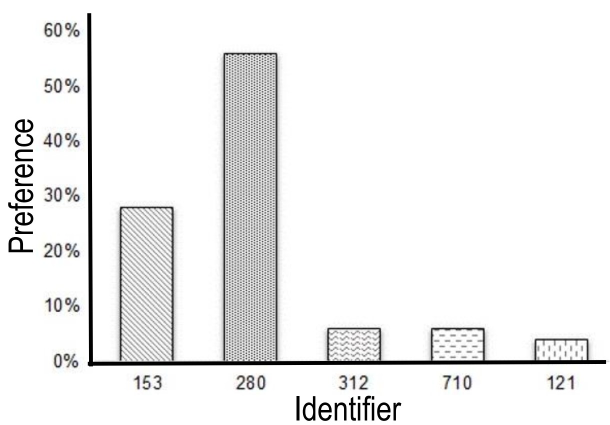

Fig. 1. Consumer preferences in sorting test. 153, fresh bone and peel macerated in rum with final alcohol of 12% (V/V); 280, dry bone and peel macerated in rum with final alcohol of 12%(V/V); 312, fresh bone and peel macerated in sugarcane distillate with final alcohol of 12%(V/V); 710, 312, fresh bone and peel macerated in sugarcane distillate with final alcohol of 12%(V/V).

The analysis of the score test relies on the olfactory-gustatory and retronasal senses, with their interpretations expressed through the degree of acceptability among panelists using a designated scale (Lawless & Heymann, 2010). Figure 2 illustrates the various characteristics evaluated on the score test scale and indicates that the sensory perception of formulation 280, which is based on rum and dry by-products, closely resembles the control (121). However, formulation 280 surpasses the control in terms of taste and aroma. In contrast, the formulation that utilizes rum and fresh by-products is quite similar to the control but is outperformed by it concerning taste and color. The observed differences in color and flavor could be attributed to the higher concentration of phytochemicals in the extracts, as formulation 280 benefits from a smaller particle size of the by-products. This finding aligns with Hanousek Čiča et al. (2020), who demonstrated that enhancing phytochemical compounds in carob extracts improved liquor aroma. Furthermore, research by Baggenstoss et al. (2008) examined the effects of moisture content (5.10, 10.04, and 14.70 g of water on a wet basis) in lightly roasted coffee. Their results indicated that the concentration of most compounds was higher in coffee extracts with an initial moisture content of 5.10 g, suggesting that moisture presence in the sample may impact the extraction of aromatic compounds.

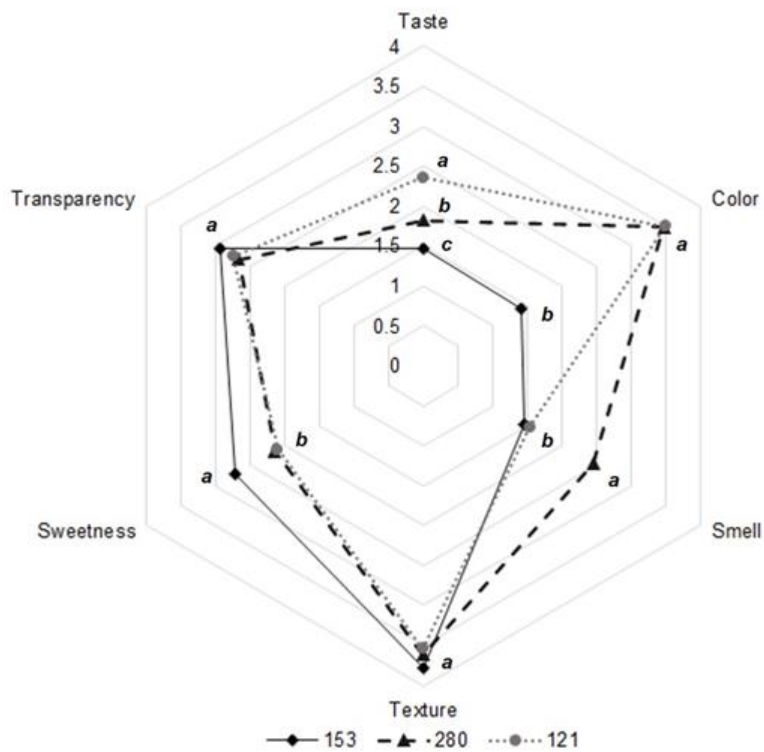

Fig. 2. Sensory qualities of mango liqueurs based on the results of the score test. Equal letters in the same quality indicate no significant difference between the means with α<0.05. 153, rum with fresh by-products; 280, rum with dried by-products; 121, mango-flavored alcoholic beverage control.

4. Conclusion

The results indicate that the type of distillate used for macerating the by-products, which is the base of the liquor, plays a significant role. In this study, both fresh and dry by-products macerated with rum received favorable feedback from the panelists during the preference test. Furthermore, in the scoring test, the maceration of dry by-products with rum exhibited the closest resemblance to the commercial control, suggesting it could be a strong contender in the liquor market. Additionally, the mango peel and seed by-products still demonstrate their capacity to impart appealing aromas and flavors to the liquors.

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