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Elaboration of wild passion fruit (*Passiflora cincinnata* Mast.) liqueur: a sensory and physicochemical study

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Abstract: Liqueur is an alcoholic beverage composed of a mixture of water, alcohol, sugar and substances that add flavour and aroma. Wild passion fruit is a product with good agricultural and nutritional characteristics, and is a low-cost, regional fruit that could be used to elaborate new products. The goal of this study was to develop passion fruit (*Passiflora cincinnata* Mast.) liqueurs and evaluate their chemical, physical and sensory characteristics. 5 formulations were prepared with defined pulp and syrup concentrations (F1, F2, F3, F4 and F5). The following physicochemical parameters were evaluated: alcohol degree (ºGL), density, pH, total titratable acidity, total soluble solids (TSS), reducing and non-reducing sugars and colour parameters. A sensory acceptance test was applied. The formulations F4 and F5, produced with 640g pulp/70ºBrix syrup and 500g pulp/55ºBrix syrup, respectively, showed the highest acceptance scores, probably due to their acid pH, high acidity and soluble solids values. In general, the beverages developed were considered feasible, aimed at aggregating value to a regional fruit and increasing family incomes. The high sensory acceptance indicated market potential for this aggregated value product.

Key words: alcoholic beverage, family agriculture, elaboration, acceptance, colour parameters, physicochemical.

INTRODUCTION

Liqueur is a beverage made from fruits with the addition of honey or sucrose and generally taken after large meals. Liqueurs can be defined as distilled alcoholic products, sweetened, and aromatized with substances having a compatible taste (Barros et al. 2010). It has an alcohol degree of from 15 to 54% by volume at 20 ºC with a sugar concentration above 30 grams per litre (Brasil 2009). It is elaborated with potable ethyl alcohol of agricultural origin, or by a simple alcoholic distillation of agricultural origin, or by adding products of animal or vegetable origin, flavouring (taste and aroma) substances, dyes and other additives to an alcoholic beverage (Brasil 2009).

Liqueur preparation is based on the alcoholic maceration of fruits or the distillation of fruit-based aromatic macerates. Its quality depends not only on an adequate mixture of ingredients, but mainly on the preparation process (Almeida et al. 2012). The proportions of fruits and solvents, the ethanol concentration and the maceration time are of great importance to give origin to liqueurs with unique aroma and taste (Cunha et al. 2017).

The production of liqueurs presents commercial relevance in Brazil, being considered an alternative to overcome problems related to wastage in fruit production by developing a product with a greater value (Oliveira et al. 2020). The commercialization of such products aggregates values to raw materials with visual aspects and forms inferior to those demanded by the fresh fruit market, but which are nevertheless in a good state of conservation and with excellent sensory and nutritional value (Oliveira et al. 2020).

Of the raw materials used to develop liqueurs, the passion fruit is native to Tropical America, includes more than 150 species which can be used for human consumption (Silva et al. 2020). One of these varieties is the wild passion fruit (*Passiflora cincinnata* Mast.), which occurs spontaneously in the semiarid region in the northeast of Brazil and is considered a wild fruit native to the Caatinga region (Oliveira et al. 2002). For example, in rural Brazilian areas, wild passion fruits are cultivated for subsistence and in an extractive way for sale as fresh fruits, dried fruits, teas and juices made from the pulp, commercialized to control anxiety and insomnia, amongst other indications (de Lavor et al. 2018).

Native species and/or those adapted to the dry conditions, produced without the use of agrochemicals, are arousing the interest of consumers and of small fruit pulp processing industries, consequently increasing the family income of farmers in semiarid regions (Santos et al. 2021). It is therefore essential that research organs engage themselves in developing, characterising, and testing foods produced with regional raw materials, due to their highly desirable properties.

Liqueurs represent an important alternative for the processing, exploitation and consumption of wild passion fruits, aggregating value to native fruits from the semiarid north-eastern area of Brazil, little exploited economically. Hence the goal of this study was to develop wild passion fruit (*Passiflora cincinnata* Mast.) liqueurs using formulations with different fruit and pulp proportions, developed according to a simple experimental design, and evaluate their acceptability and physicochemical characteristics.

MATERIALS AND METHODS

Obtaining the raw materials

The wild passion fruits (*Passiflora cincinnata* Mast.) were acquired locally in the town of Guanambi (Geographic coordinates 14° 13’ 22” S, 42° 46’ 51” W), Brazil. The fruits were previously selected observing certain characteristics such as colour, physical damage, ripeness, skin quality and size.

Liqueur production

The liqueurs were produced in the Bromatology Laboratory of the Federal Institute of Education, Science and Technology Baiano (IFBaiano), Campus Guanambi, Bahia, Brazil. A preliminary test was carried out varying the independent variables: fruit pulp and syrup contents. After that, a total of 5 formulations were defined (Table I).

To produce the liqueur (Figure 1), the fruits were washed with neutral detergent, sanitized with sodium hypochlorite (100 ppm) for 20

Table I. Experimental design for the processing of wild passion fruit liqueurs.

Real values		
Formulations	Wild passion fruit pulp (g)	Syrup (ºBrix)*
F1	360	40
F2	640	40
F3	360	70
F4	640	70
F5	500	55

F1...F5 – Wild passion fruit liqueur; *Using 1000 mL of syrup per treatment.

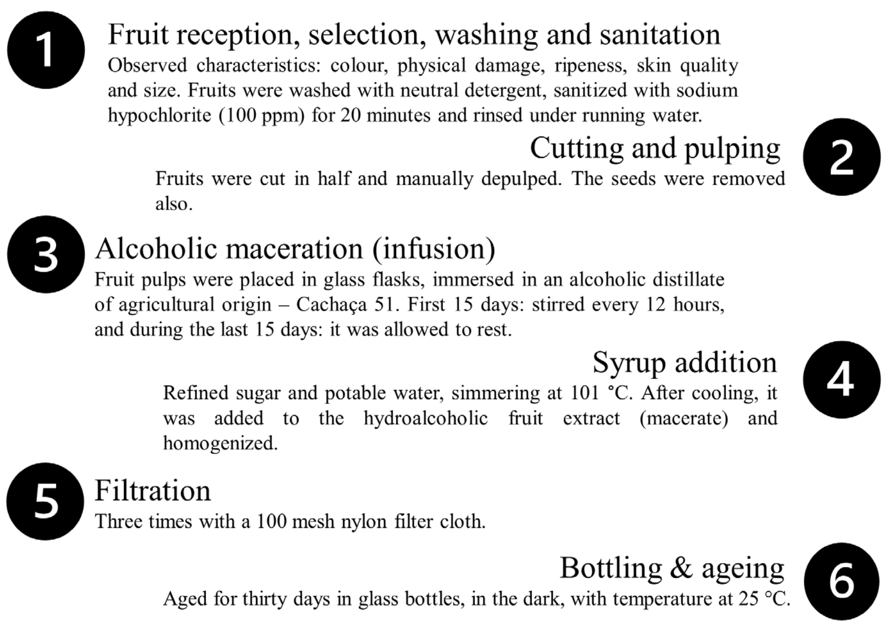

Figure 1. **Flowsheet of the wild passion fruit liqueur production. Source: adapted from Penha (2006).**

minutes and rinsed under running water. The fruit pulp was placed in glass flasks, immersed in an alcoholic distillate of agricultural origin (cane spirit – Cachaça 51, Pirassununga, Brazil) with an alcohol degree of 39% (v/v) (Alamprese et al. 2005) and submitted to maceration with different fruit pulp concentrations for thirty days. During the first 15 days, the macerate was stirred every 12 hours, and during the last 15 days, it was allowed to rest (Alamprese et al. 2005).

After maceration, different concentrations of syrup were added according to Table I. The syrup was prepared from a solution of refined sugar (União – São Paulo, Brazil) and potable water by simmering at 101 °C. After cooling, it was added to the hydroalcoholic fruit extract (macerate) and homogenized. It was then filtered three times with a 100 mesh nylon filter cloth to remove pulp residues and aged for thirty days in glass bottles, in the dark, with temperature at 25 °C.

Physicochemical analysis of the liqueur

The physicochemical parameters analysed were: Alcohol degree (ºGL), density, pH value, total titratable acidity, total soluble solids (TSS), reducing and non-reducing sugar, ratio of the total soluble solids to the titratable acidity (TSS/TTA ratio), all determined according to the norms of the Association of Official Agricultural Chemists- AOAC (2005). The colour parameters of L*, a*, b* C* and h* were evaluated using a Konica Minolta CR-5 colorimeter. All analyses were performed in triplicate, per sample. The hexadecimal codes, indicating the specific colours of the liqueurs were determined with Nix Free Colour Converter.

Sensory analysis

The acceptance test was applied in the Sensory Analysis Laboratory of the IFBaiano Campus, Guanambi – BA, Brazil, using 60 individuals (male and female) in the age range from 18 to 50 years old, characterized as an adult alcoholic beverage consumer public. A non-structured 10 cm scale demarcated by quantitative expressions at the extremes was used, as follows: 0 (disliked extremely), 5 (neither liked nor disliked) and 10 (liked extremely) (Villanueva et al. 2005), evaluating the sensory attributes of colour, aroma, flavour and overall acceptability. The samples were served individually in a monadic way in plastic cups coded with random three-digit numbers, containing about 20 mL of sample, and accompanied by a glass of water and unsalted slice of toast to clean the palate. Each taster evaluated 5 liqueur samples, and the evaluations were carried out in individual booths under artificial light at a temperature between 22 and 24 º C.

The buying intention of the liqueurs was also verified using a five-point structured mixed scale with scores between 1 (certainly would not buy) and 5 (certainly would buy) the product (Meilgaard et al. 2007).

Statistical analysis

The physicochemical data were obtained from the analyses carried out in triplicate for all the parameters. To assess the assumption of normality of the results, the Shapiro-Wilk test was conducted. After that, the data was submitted to an Analysis of Variance (ANOVA). The Tukey multiple means test was used for results with significant differences. Pearson Correlation test was performed between the physicochemical analyses and the sensory parameters. The STATISTICA programme version 7 was used, adopting a significance level of 5%. A clustered heatmap was also developed with ClustVis Webtool, with Euclidean clustering distance and ward algorithm as clustering method.

RESULTS AND DISCUSSION

Physicochemical analyses

The values for the densities of the samples varied from 0.98060 to 0.98460, showing no statistical difference between the formulations (Table II). The alcohol contents ranged between

Table II. Physicochemical characterization of the wild passion fruit (*Passiflora cincinnata* Mast.) liqueur formulations.

Formulations	F1	F2	F3	F4	F5
TSS (°Brix)	28.40 ± 0.01[c]	26.10 ± 0.12[d]	46.40 ± 0.44[a]	46.00 ± 0.14[a]	36.00 ± 0.21[b]
Alcohol content (ºGL)	15.09 ± 0.19[b]	17.00 ± 0.26[a]	16.90 ± 0.12[a]	16.80 ± 0.10[a]	16.90 ± 0.12[a]
pH value	3.60 ± 0.01[a]	3.50 ± 0.02[a]	3.60 ± 0.01[a]	3.60 ± 0.01[a]	3.60 ± 0.01[a]
Total titratable acidity (TTA) (g/100mL)	10.30 ± 0.31[b]	14.30 ± 0.25[a]	10.60 ± 0.25[b]	14.40 ± 0.75[a]	11.00 ± 0.06[b]
TSS/TTA ratio	2.77 ± 0.08[c]	1.84 ± 0.03[d]	4.40 ± 0.09[a]	3.22 ± 0.17[b]	3.29 ± 0.03[b]
Reducing sugars as glucose (g/100mL)	9.70 ± 0.25[d]	12.30 ± 0.20[c]	23.20 ± 0.42[a]	24.50 ± 0.21[a]	15.70 ± 0.06[b]
Non-reducing sugars as sucrose (g/100mL)	11.62 ± 0.29[b]	8.74 ± 0.13[c]	16.51 ± 0.15[a]	15.26 ± 0.21[a]	15.26 ± 0.24[a]
Total sugar (g/100mL)	21.32 ± 0.35[c]	21.04 ± 0.60[c]	39.71 ± 0.23[a]	39.76 ± 0.29[a]	30.96 ± 0.41[b]
Density at 20 °C	0.98060 ± 0.00066[a]	0.98325 ± 0.00033[a]	0.98260 ± 0.00100[a]	0.98460 ± 0.00074[a]	0.98410 ± 0.00064[a]

F1... F5 – Wild passion fruit liqueur; used 1000ml of syrup in each formulation; Cane spirit Cachaça 51.
The analyses were carried out after ageing.
Means with the same letters in one column did not differ significantly according to Tukey's test (p<0.05).

15.09 and 17.0% v/v, values close to those found by (Coelho et al. 2019) who developed a liqueur from mango skins and standardized the alcohol content at 18%. The beverages conformed to the Brazilian legislation, which stipulates that to be classified as a liqueur, the final alcohol content of the beverage should be between 15 and 54% v/v at 20 ºC (Brasil 2009). Fruit liqueurs with alcohol contents between 15 and 40% have been showing increasing consumer demand on the market, since consumers tend to look for culturally traditional products, which present good quality and unique flavours (Sokół-Łętowska et al. 2014).

Formulation F2 obtained the lowest value for total soluble solids (ºBrix of 26.1), whereas formulations F3 and F4 presented values of 46.4 and 46.0 ºBrix, respectively, which could be associated with the greater amount of syrup used in these formulations. Jesus Filho et al. (2018) suggested that liqueurs with lower alcohol contents and intermediate sugar levels tended to be better accepted sensorially.

The total sugar content varied from 21.04 to 39.76 g/100 mLg/100 mL, F2 showing the lowest concentration and F3 and F4 the highest, data coherent with the ºBrix measurements for the same formulations. The reducing sugar contents of the formulations followed the same behaviour as the total sugar and ºBrix contents, with F1 showing the lowest concentration (9.70 g/100 mL) and F3 and F4 the highest concentrations, of 23.20 and 24.50 g/100 mL, respectively. On the other hand, the non-reducing sugar contents, potentially represented by sucrose, were lowest in F2 (8.74 g/100 mL) and highest in F3 (16.51 g/100 mL).

The pH values of the formulations varied from 3.5 to 3.6, showing no statistical difference. On analysing a strawberry with passion fruit albedo liqueur, Magalhães et al. (2014) found a pH value of 3.96, close to that obtained in the present study. Low pH values can be important for fruit liqueurs, since they restrict microbial growth, favouring the shelf life of the product. For example, Ziegler et al. (2018) verified that fruit products with a pH lower than 4.0 may present better inhibition potential against *Listeria monocytogenes*. The values for total acidity of the formulations presented statistical difference ($p>0.05$), varying from 10.3 to 14.4 g/100 mL, probably due to the variation in the amount of pulp used. Formulations F2 and F4, which contained the highest pulp concentrations, showed the greatest total titratable acidities, and F1 and F3 showed the lowest values (Table I). Lower values of 0.04g ± 0.00/100 mL were found by Oliveira & Santos (2011) for acai liqueur, and Dias et al. (2011) found 130.10 mg/100 mL, higher than the values found in the present study, for yellow passion fruit liqueur.

The minimal TSS/TTA ratio found in the present study was 1.84 for the beverage F2, while the highest value of 4.40 was found for F3, a value close to that found by Villa et al. (2021) for dovyalis liqueur, with a maximum of 3.51. The parameter of the TSS/TTA ratio is used to indicate the flavour, since it can evidence a predominance of acidity or sweetness, or whether these two tastes are balanced (Barros et al. 2019). Thus, a ratio close to 1 indicates a relatively low predominance of one over the other, favouring the development of a final product with a more balanced flavour. It must be pointed that a higher concentration of fruit pulp may influence in the reduction of the TSS/TTA ratio, for fruit are considered as sources of acids, mainly citric acid (de Carvalho et al. 2018). For example, Formulation 2 had a higher fruit pulp content than Formulation 1 (640 g vs 360 g), which resulted in a higher TTA (14.30 g/100 mL vs 10.30 g/100 mL) and a lower TSS/TTA ratio (1.84 vs 2.77). The syrup may exert opposite function. Sucrose is considered as a soluble sugar, therefore, can increase the overall TSS/TTA ratio when in higher concentrations (Wei et al. 2020). This can be seen when comparing rations between Formulations 1 (2.77) and 3 (4.40); 2 (1.84) and 4 (3.22), that diverged only in syrup percentages.

Colour parameters

The values for luminosity (L*) varied from 90.90 to 95.00, showing statistical difference between the formulations, those containing less pulp showing greater luminosity (Table III). According to Oliveira et al. (2015a), working with soursop liqueurs, the values for L* remained light after processing, with L* varying from 55.71 to 61.27. According to Lancaster et al. (1997), pigments present in fruits, such as chlorophyll and carotenoids, may be responsible for lowering L* values. The higher concentration of fruit pulps may also be responsible for an increase of the turbidity of the liqueurs, which can interfere in the passage of light through the liquid and result in a lower L* value (Sin et al. 2006).

The a* values ranged from -0.51 (F1) to 0.59 (F4). This could be due to the highest fruit pulp concentration on the F4 liqueur. However, all samples showed results near the 0 mark, indicating a low green and red coloration. The b* results varied from 17.83 (F1) to 29.00 (F4), indicating a light-yellow colour in the beverages, confirmed by their respective hexadecimal colour codes (Table III). According to Silva et al. (2020), the wild passion fruit pulp is yellow, but with less intensity than the common passion fruit (*Passiflora flavicarpa*), which can justify the findings of the present study.

The chroma values (C*) of the liqueurs varied from 17.8 to 29.0, corresponding to light yellow beverages. Formulation F4 showed the highest value for C* and F1 the lowest, the latter containing the least pulp and least syrup. In this case, the less the amounts of pulp and syrup, the less the colour, the contrary also being true. The influence of the fruit pulp towards a more intense coloration may be due to the presence of yellow pigments, such as carotenoids developed during the ripening of the fruit (Silva et al. 2020). The syrup may also have influence towards the colour parameters, for its heating process is able to develop non-enzymatic reactions that forms brown-coloured substances, mainly melanoidins (Gad et al. 2021).

The hue angle hº indicated that the liqueur formulations were distant from the 0º axis (red) and tending in the direction of the 90º axis (yellow), in agreement with the largest mean obtained for F1 of 91.6. The smallest mean for hº of 88.8 was obtained for formulation F4, but

Table III. Mean values for colour parameters obtained for the wild passion fruit (*Passiflora cincinnata* Mast.) liqueurs.

Formulations	L*	a*	b*	C	h°	Hexadecimal code
F1	95.00 ± 0.31^{a}	-0.51 ± 0.04^{d}	17.83 ± 0.16^{e}	17.80 ± 0.16^{e}	91.60 ± 0.14^{a}	#FAF0CE
F2	92.80 ± 0.09^{d}	-0.06 ± 0.01^{b}	23.81 ± 0.05^{b}	23.80 ± 0.05^{b}	90.10 ± 0.03^{c}	#F8EABD
F3	93.50 ± 0.15^{c}	-0.11 ± 0.02^{b}	22.55 ± 0.02^{d}	22.50 ± 0.02^{d}	90.30 ± 0.04^{c}	#F9ECC1
F4	90.90 ± 0.07^{e}	0.59 ± 0.02^{a}	29.00 ± 0.02^{a}	29.00 ± 0.02^{a}	88.80 ± 0.02^{d}	#F6E3AD
F5	94.00 ± 0.09^{b}	-0.23 ± 0.02^{c}	23.27 ± 0.04^{c}	23.20 ± 0.04^{c}	90.60 ± 0.04^{b}	#FBEDC1

F1... F5 – Wild passion fruit liqueur; used 1000ml of syrup in each formulation; Cane spirit Cachaça 51.
The analyses were carried out after ageing.
Means with the same letters in one column did not differ significantly according to Tukey's test (p<0.05).

this was also close to the 90º axis, indicating a light-yellow hue. In general, the results for the colour analysis were partially similar to those found by Santos et al. (2021), that described L* values from 51.06 to 52.23; C* values between 15.23 and 20.21 and h- from 97.24 to 100.28 while developing a fermented, alcoholic beverage with wild passion fruit. These parameters can present a strong correlation with the presence of phenolic compounds and, according to Barros et al. (2016), variations in the colour parameters between different samples could be attributed to the types and quantities of ingredients used, apart from the precipitation of bioactive compounds, which occurs during the processing and storage, depending on certain conditions such as temperature and pH value.

Sensory analysis

Acceptability

The acceptability values obtained for the wild passion fruit liqueurs (Table IV) indicated the presence of two groups from the statistical point of view ($p>0.05$). Formulations F4 and F5 showed the highest absolute values for acceptability (7.70 and 7.30, respectively) and were the formulations showing higher acidity and higher ºBrix, probably due to the larger pulp content used. Samples F1, F2 and F3 showed the lowest acceptability values (6.41, 6.60 and 6.75, respectively), but in general the results indicated good product acceptance since they were all above 5.00, which would indicate indifference from the sensory point of view. Petrović et al. (2019) found maximum acceptability values of 6.72 for herbal liqueurs, close to the values obtained in the present study, where a preference for liqueurs with higher total sugar and ethanol contents, represented by sample F4, was found, different from the findings of Jesus Filho et al. (2018), that identified higher acceptance scores while developing banana liqueur with lower alcohol content and intermediate sugar levels. Such divergences could be associated with the type of fruit used to prepare the liqueurs, leading to distinct sensory characteristics of the product.

Table IV. Acceptability means obtained for the wild passion fruit (*Passiflora cincinnata* Mast.) liqueurs.

Formulations	F1	F2	F3	F4	F5
Acceptability	6.41^{b}	6.60^{b}	6.75^{b}	7.70^{a}	7.30^{a}

F1... F5 – Wild passion fruit liqueur; used 1000ml of syrup in each formulation; Cane spirit Cachaça 51.
The analyses were carried out after ageing.
Means with the same letters in the row did not differ significantly according to Tukey's test ($p<0.05$).

Buying intention

The buying intention test as applied to the wild passion fruit liqueurs (Figure 3) showed overall good buying intention for the liqueurs by the tasters. Formulation F5 obtained the highest percentage of tasters who decided they would definitely buy this liqueur, 18 of the 60 tasters (30%) defining this intention for F5, and 1 taster (1.67%) said he would definitely not buy F5. Seventeen tasters (28.33%) defined they would certainly buy formulation F4 and 8 tasters (13.34%) defined they would certainly not buy F4. On a different perspective, formulation F1 had the highest number of tasters that would certainly not buy (8.06%) and the Formulation 2 showed least number of tasters that certainly would buy it (20.96%). Formulations F4 and F5 had high total sugar contents, while F1 and F2 had the lowest values for this variable. These findings may support the idea that Brazilian alcoholic beverage consumers may prefer sweeter liqueurs, as discussed by Leonarski et al. (2021). Overall, the results indicate a great potential for the insertion of the developed liqueurs on the market as products with aggregated value.

Pearson correlation analysis

The results from Pearson correlation are described below (Table V). The correlations between buying intention and the physicochemical parameters were weak overall. However, regarding the acceptability, most correlations were found to be moderate or strong. The colour parameters L*, C* and h° all showed strong correlations. C* parameter showed a positive correlation (0.85), while L* and h° showed negative correlations (-0.71 and -0.77, respectively). These results may indicate the preference of the tasters towards a liqueur with a more saturated, dark, slightly further from the yellow colour. According to Spence (2015), the colour of a food product represents an intrinsic sensory characteristic of great importance when establishing expectations regarding its consumption. The change in the intensity or saturation of the colour of beverages can influence the sensory experience of consumers and, consequently, the final acceptance of the evaluated product, as confirmed in the present study.

Table V. Pearson correlations between physicochemical and sensory parameters.

Analysis	Acceptability	Buying Intention
TSS	**0.64**	0.14
Alcohol Content	**0.50**	0.02
pH	0.37	**0.58**
TTA	0.42	**-0.51**
TSS/TTA	0.25	0.34
Reducing Sugars	**0.68**	-0.02
Non-reducing Sugars	**0.58**	0.52
Total Sugar	**0.68**	0.17
Density	**0.86**	0.23
L*	**-0.73**	0.33
a*	**0.79**	-0.25
b*	**0.85**	-0.09
C	**0.85**	-0.10
h°	**-0.77**	0.25

Values of r ≥ 0.5 or ≤ -0.5 are in bold.

Positive and strong/moderate correlations were found between acceptability and: density (0.86), TSS (0.64), reducing sugars (0.68), total sugar (0.68) and non-reducing sugars (0.58). Since liqueurs are considered as sweetened alcoholic beverages, it is expected that higher sugar contents influence positively in the overall acceptability of the formulations in the present study. Also, it is discussed that the brazilian tasting preferences may be inclined towards sweeter flavoured food products (Leonarski et al. 2021).

A positive, moderate correlation was found between alcohol content and acceptability (0.50). Gomes et al. (2015) found that sweetness was a relevant attribute towards a good acceptance of mead, but ethanol content was not, partially diverging from the present study. It must be noted that cultural diversity must be considered when developing a new product, since tasting patterns may differ between locations (Nascimento et al. 2020). Therefore, liqueurs with higher sugar and alcohol contents, moderately acids, with more colour saturation and less lightness may be more appreciated by the tasters that participated in this study.

Heatmap analysis

The grouping of the multivariate statistical analysis shown in the heatmap (Figure 2) was done as a function of the physicochemical parameters of the liqueur formulations and acceptability. The formation of 2 clusters between analyses can be seen, the first on the top, characterised by TTA, TSS/TTA, alcohol content, a*, pH, density, h°, L* and acceptability, and the second by b*, C*, non-reducing sugars, reducing sugars, TSS and total sugar. Regarding the samples, two clusters are also present, one containing samples F3 and F4 and the other

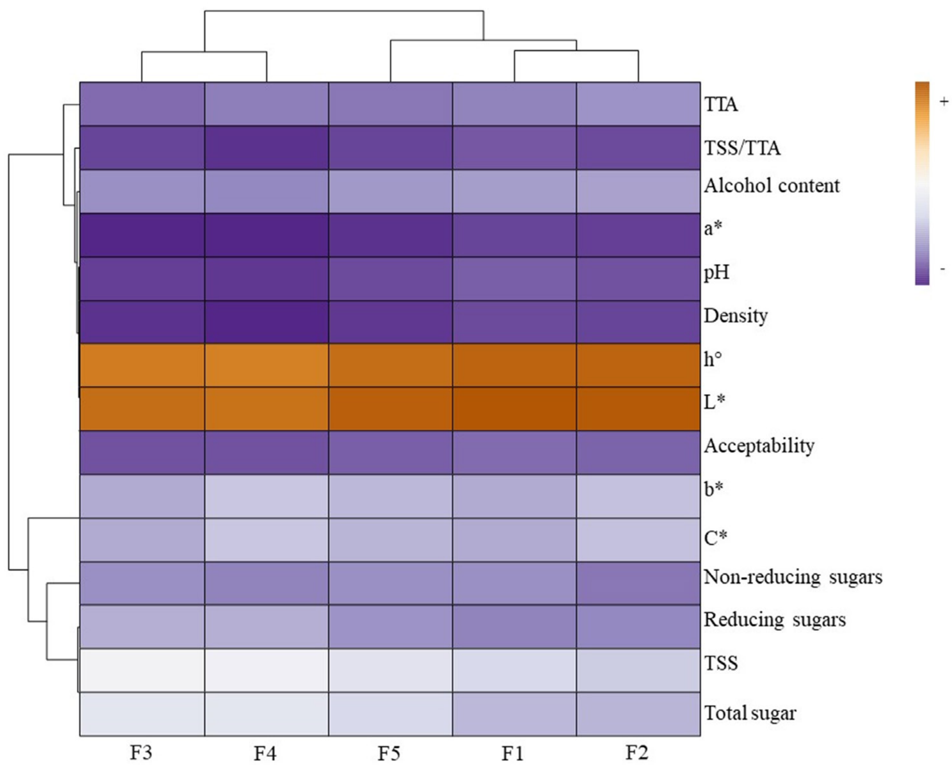

Figure 2. **Multivariate analysis in the form of heatmap of the evaluated parameters of the wild passion fruit (*Passiflora cincinnata* Mast.) liqueur formulations.**

divided into two subgroups, the first with only sample F5, and the last with F1 and F2. On relating the physicochemical parameters and statistical analysis to sample acceptance, one can see that F4 liqueur was the most accepted and its differences from the other formulations are visible by the heat map: lower L* and h°; and higher a*, b*, C*, TTA, reducing sugars and total sugar. It can shed light to the fact that these parameters are of great relevance when it comes to reaching a good acceptability of a liqueur.

Liqueurs commercial potential

The production cost of the liqueurs ranged from 3.77 to 3.94 United States Dollars (USD) (Table VI). Considering a profit margin of 50%, the commercial values had a minimum of 5.66 USD and a maximum of 5.92 USD. These results indicate that the developed liqueurs show competitive market potential, since commonly available liqueurs worldwide are usually of much higher price, with the example of an orange flavoured liqueur from a known brand, that can be found for around 22 USD (Shang et al. 2020). This can even highlight the possibility of exportation, since the wild passion fruit pulp is capable of adding value to liqueur beverages, since it is an exotic fruit, rich in bioactive compounds (Silva et al. 2020).

The Brazilian fruit market has been showing good growth potential, principally considering the possibility of developing innovative processes and products of high quality, when using fruits with inadequate conditions for sale but hygienically safe (Oliveira et al. 2015b). The development of fruit liqueurs is an important possibility to add value to those sorts of fruits. The liqueur market in Brazil is very connected with the culture of the Northeast region. It is solidified as source of income for many rural families that utilize mainly fruits for its production (Silva et al. 2021). The local liqueur

Table VI. Commercial value of the liqueur formulations.

Formulations	Production Cost* (BRL)	Production Cost* (USD**)	Profit Margin (%)	Commercial Cost* (BRL)	Commercial Cost* (USD**)
F1	21.44	3.77	50	32.16	5.66
F2	21.98	3.87	50	32.97	5.80
F3	21.91	3.86	50	32.87	5.79
F4	22.40	3.94	50	33.60	5.92
F5	21.95	3.86	50	32.92	5.80

*Per 1 litre of liqueur.
** Considering a conversion rate of 1 dollar (USD) per 5.68 reals (BRL).
These results considered the values in the local market of the materials needed to develop the liqueurs, in accordance with the amount necessary to produce each of them.

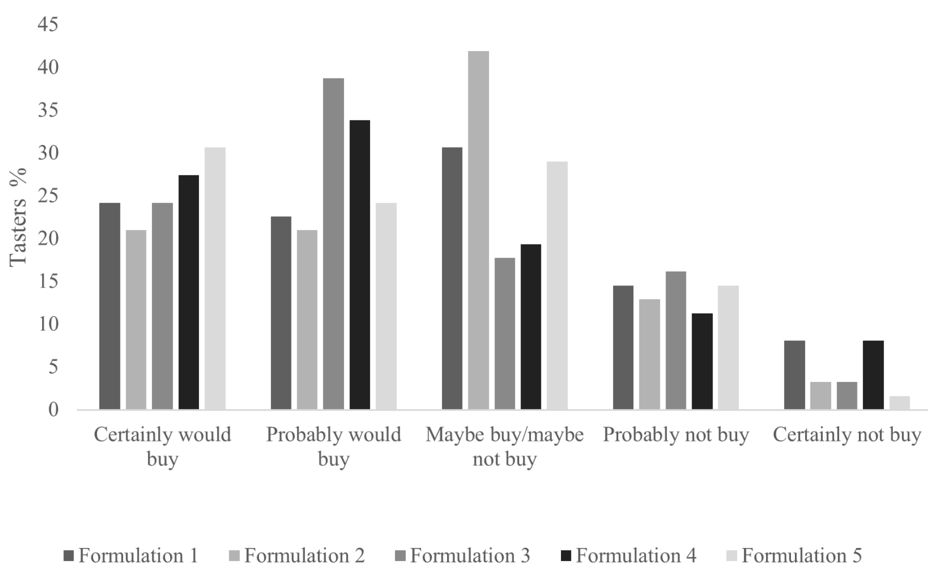

Figure 3. Buying intention for the liqueur formulations.

production is responsible for providing income to many families, as well as an important commercial competition against industrialized liqueurs, and supports the implementation of industries (Leonarski et al. 2021). Indications of a growth in the consumption of liqueurs in Brazil have been seen in the last few years. According to Statista (2021), the Brazilian liqueur market has a revenue of US$ 2.340 million in 2021, with a growth expectation of 7.99% per year from 2021 to 2025.

CONCLUSIONS

Wild passion fruit represents a good fruit option to elaborate liqueurs. The physicochemical analyses described liqueurs with characteristics in agreement with current Brazilian legislation and with scientific productions on this theme. The sensory analysis indicated that, in general, all the formulations were feasible, with potential for insertion on the market. Liqueurs F4 and F5, formulated in the proportion of 1:1 (pulp/cane spirit macerate: syrup) with 640g pulp/70ºBrix syrup and 500g pulp/55ºBrix syrup, respectively, presented the greatest potentials from the sensory point of view, indicating a tendency for greater acceptance of sweeter products by the public that took part in the analyses. The TSS/TTA ratios of formulations F4 and F5 presented a more balanced value for the sweetness and acidity. The colour parameters L*, C* and hº also stood out and could have contributed to a greater acceptance of formulations F4 and F5. With respect to buying intention, formulations F4 and F5 had the highest percentages with respect to the concepts of "certainly would buy", "probably would buy" and "maybe buy/maybe not buy". Pearson correlation identified that sugar and alcohol contents, as well as C* showed moderate/strong, positive correlation with acceptability, while L* and h° had a strong, negative correlation. Products with the physiochemical characteristics of formulations F4 and F5 show market and agro-industrial promise due to their technological and nutritional potentials, representing a feasible alternative to aggregate value to wild passion fruit (*Passiflora cincinnata* Mast.).

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