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DEVELOPMENT AND EVALUATION OF JELLY MADE WITH PEACHES OUTSIDE THE *IN NATURA* CONSUMPTION STANDARD, SWEETENED WITH CANE BROTH

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ABSTRACT
The preparation of jellies from peaches outside the standard is a way of using the fruit. Thus, the present work aimed to develop and evaluate peach jellies sweetened with sugarcane juice, made with fruits of two peach cultivars (Maciel and Top Bilt) that were out of the standard for fresh consumption. Two formulations were developed, which were elaborated with 45% peach pulp, 33% apple pulp, 20% sugarcane juice, and 2% lemon juice. In the characterization of the jellies, the following were evaluated: color (L*, a* and b*), firmness, pH, titratable acidity, soluble solids, moisture, total phenolic compounds, carotenoids, vitamin C, anthocyanins, and mold and yeast counts. After approval by the research ethics committee, the acceptance test was applied with 100 untrained tasters of both sexes. The results of the analyzes were compared by means of analysis of variance and Tukey's test at the 5% level. It was found that the jellies made with the peach cultivars are statistically different only regarding the parameters of color, a* and b* values and pH, and statistically equal regarding L*, firmness, titratable acidity, soluble solids, vitamin C, carotenoids and phenolic compounds. It is concluded that, even without the addition of commercial sucrose, the jellies of both cultivars have the potential as objects of new research about their manufacture to be made available in the market, as they present good purchase intentions.

1. Introduction

China is the world's largest producer of peaches, with an estimated production of 14.5 billion tons in 2020. Brazil is in sixth position with a production of 220 million tons (Analysis, 2020), cultivated in an area of approximately 15,995 hectares, with Rio Grande do Sul being the state with the highest production (IBGE, 2019).

The peach is a fleshy fruit belonging to the Rosaceae family which is cultivated in temperate and subtropical climates. It is highly perishable during post-harvest storage, due to its high water content, which culminates in a short shelf life under environmental conditions (Mir et al., 2018; Zhang et al., 2020). It is classified as a climacteric fruit, as it presents an increase in ethylene emission and respiration at the beginning of ripening, accompanied by a change in color, texture, and aroma (Minas et al., 2018).

According to FAO (2021), a loss of up to 50% of fruits and vegetables is estimated in developing countries. This represents, not only the loss and waste of food, but also natural resources and investments made by farmers and the country. Like other fruits, peaches can present high losses, mainly due to rapid ripening, low marketing prices, various difficulties in the production flow, or even because they do not fit the profile desired by the consumer (size, or physiological defects), even with appreciable amounts of nutrients. In this way, it can be used as a raw material for the elaboration of other fruit products (Brasil, 2005). These products include jellies, as they come from processing by cooking whole edible fruit or vegetable parts and/or pieces in the most diverse forms, pulp/juice or aqueous extracts thereof, homogenized with other ingredients that help to obtain the desired technological characteristics, such as sugar, pectin, acids and water, among other ingredients and additives allowed by current legislation, which must be concentrated until they have a gelatinous consistency, having the shape of the container in which it is packaged after processing (Oliveira et al., 2018).

The replacement of commercial sugar in jelly formulations is a challenge, as it directly influences the sweetness, viscosity, texture development and reduction of water activity (Sandrou & Arvanitoyannis, 2000; Pereira et al., 2013). Therefore, it is necessary to seek alternatives and ingredients to replace commercial sugar in the formulation.

However, the preparation of jelly added with sugarcane juice is a means of diversifying and meeting the demands of the consumer market, which is increasingly looking for quality and differentiated products that have high nutritional value, whether for aesthetic, physiological or health reasons (Reissig et al., 2016).

In light of the above, this study aimed to develop and evaluate peach jelly sweetened with sugarcane juice, made with fruits of two peach cultivars (Maciel and Top Bilt) that were out of the standard for fresh consumption.

2. Materials and methods

2.1. Materials

The experiment was carried out at the Federal Institute of Education, Science and Technology, Barbacena campus – MG, industrialization and processing of vegetables sector, physical-chemical analysis laboratory, sensory analysis and microbiological analysis of food laboratory.

The two peach cultivars used in the preparation of the jellies (Maciel, yellow pulp and Top Bilt, white pulp) were donated by the Rural Community Association of Mantiqueira do Palmital of Barbacena -MG. Fruits that do not fit *in natura* commercialization standards were used, that is, those already ripe and slightly soft, with small mechanical injuries, irregular size and shape, but without visible microbial contamination.

Cultivars Top Bilt and Maciel were selected for the preparation of the jellies because they present white and yellow pulp, respectively, and because they are those with the highest production and highest loss rates in the rural community of Mantiqueira do Palmital in Barbacena. The selected fruits were: pre-washed, sanitized with chlorinated water (100 mg L^{-1} 10 min^{-1}). Afterwards, they were blanched in boiling water for 5 minutes, cooled and crushed in an industrial blender, Visa LQL – 25 – stainless steel.

Pre-tests were performed to define the jelly formulation, taking into account the gel formation, and sensory attributes (color, flavor and aroma), the formulation with 45% peach, 33% apple, 20% sugarcane juice and 2% lemon juice had better sensory and gel formation characteristics. After defining the formulation, the jellies were prepared following the steps of cooking and concentration of ingredients until reaching the final point, determined by an Atago brand manual refractometer (28 – 32% soluble solids - SS), standardized at 30% SS. The hot jelly was placed in glass jars (capacity of 230 g), previously sterilized by boiling for 30 minutes and with metal lids boiled for 10 minutes. The closed packages underwent an inversion term (3 minutes), to sterilize the free space and the lid; cooled in running water until reaching an internal temperature of approximately 40 °C (temperature measured with a Benetech Infrared thermometer). The packages were labeled to identify the treatments and finally stored refrigerated until analysis time. The duration was, on average 10 days, to help better conservation until the result of the microbiological analysis was obtained, in order to carry out the sensory analysis. The jellies were evaluated for color, firmness, pH, titratable acidity (AT %), soluble solids (SS %), moisture, total phenolic compounds, total carotenoids, vitamin C, microbiological analysis, and sensory analysis.

2.2 Analyzes

2.2.1.Coloring

Determined with a Konica Minolta CR400 colorimeter, using the L, a* and b* color scale system (CIELAB), previously calibrated, with the reading being carried out in the pot itself.

2.2.2.Firmness

Determined using a cylindrical aluminum probe with a diameter of one inch, test speed 2.0 mm/s, distance 10.0 mm and force 0.10 N. For compression analysis, 50 g of jelly were used for each measure (Pons & Fiszman, 1996).

2.2.3.pH

Using pH-meter TEKNA T-1000 according to the methodology proposed by Instituto Adolfo Lutz (IAL, 2008). The pH-meter was previously calibrated using buffer solutions (pH 4.0 and 7.0).

2.2.4. Titratable acidity (TA)

Determined by titration with a standardized 0.1 N sodium hydroxide solution, using phenolphthalein as an indicator. According to the methodology proposed by the Analytical Norms of Instituto Adolfo Lutz (IAL, 2008).

2.2.5.Soluble solids (SS g/100 g).

Determined by the refractometry method, using an Instrutherm RTD-45 refractometer (with a reading range between 28-32% soluble solids) (IAL, 2008).

2.2.6.Humidity

Determined by gravimetry in a Deleo A4SE drying and sterilization oven at 105 °C until constant dry mass, according to Instituto Adolfo Lutz (IAL, 2008).

2.2.7.Total phenolic compounds

Extracts were obtained as described by Brand Williams; Cuvelier; Berset (1995) and adapted by Rufino et. al (2007). Gallic acid was used as a reference standard and the results expressed in milligram equivalents of the acid itself (mg GAE 100 g^{-1} fresh matter).

2.2.8.Total carotenoids

The extraction and determination was carried out according to the technique described by Rodriguez-Amaya (1999).

2.2.9.Vitamin C

Determined by the Balentine method, which is based on the oxidation of ascorbic acid by potassium iodate as proposed by Tavares (1999).

2.2.10.Anthocyanins

Quantified following the differential pH method, proposed by Giusti; Wrolstad (2001), which follows the equation:

$$A = (A510nm - A700nm)\ pH = 1.0 - (A510nm - A700nm)\ pH = 4.5 \quad (1)$$

The content of monomeric anthocyanins (AM) was calculated as cyanidin-3-glycoside (PM = 449.2) using the equation:

$$AM\ (mg.100\ mL\text{-}1) = A \times PM \times dilution\ factor\ \varepsilon\ (22900) \times 1 \quad (2)$$

Where: A= Absorbance and ε = Molar Absorbance

2.2.11.Microbiological analysis

Mold and yeast counts were determined by the method of the American Public Health Association (APHA) (Silva et al., 2010). The result was compared with the limit established by Resolution - RDC no 12 of January 2, 2001 (Brasil, 2019) which establishes microbiological standards for food.

2.2.9.Acceptance test

This work was submitted to the Human Research Ethics Committee of the IF Southeast MG and approved in accordance with CAAE: 01681718.1.0000.5588. The acceptance test was applied according to the methodology described by Minim (2006) with 100 untrained tasters of both sexes in the sensory analysis laboratory of the IF Sudeste MG Barbacena campus. Potential jelly consumers were selected among staff, students and professors from the Barbacena campus, over 18 years old. The jelly samples, coded with three-digit numbers, were served accompanied by toast and a 100 mL glass of water to clean the palate between sample evaluations. The attributes color, odor, flavor, texture and global acceptance were evaluated through a structured nine-point hedonic scale, with extremes at 1 - "I disliked extremely it" and 9 - "I liked it extremely". The purchase intent test was also applied using a 5-point scale ranging from 1 - Certainly would not buy to 5 - Certainly would buy.

2.2.12.Statistical analysis

A completely randomized design was used, with the jellies made with two peach cultivars (Top Bilt and Maciel) with three replications, and analyzed in triplicate. The data obtained were subjected to analysis of variance (ANOVA) and means were compared by Tukey test at 5% significance in Sisvar 5.3 program (Ferreira, 2010).

The Acceptance Test was analyzed using the Internal Preference Map (MDPREF) methodology (Macfie; Thomson, 1994), which allowed the generation of the multidimensional affective sensory space, formed by the 100 tasters, the 2 studied samples and the 5 evaluated attributes. The data was analyzed statistically as mentioned above.

3. Results and discussions

The results of the analysis of color, firmness, pH, titratable acidity, soluble solids, moisture, phenolic compounds, carotenoids, vitamin C and anthocyanins are shown in Table 1.

Table 1. Physical and physicochemical characterization of the jellies.

Analysis	Cv. *Maciel*	Cv. *Top Bilt*
Color – L*	43.40 **	
a*	9.38 a*	4.30 b
b*	21.18 a	15.07 b
Firmness (N)	1.65**	
pH	3.87 b	4.21 a
Titratable acidity (%)	2.64**	
Soluble solids (%)	30**	
Moisture (%)	29.98**	
Total Phenolic Compounds (mg GAE 100 g^{-1})	2.10**	
Carotenoids (mg100 g^{-1})	0.050**	
Vitamin C (mg100 g^{-1})	0.0015**	
Anthocyanins (mg100 g^{-1})	ND	

*Equal letters, on the line, do not present significant difference. **No significant difference. ND: not detected.

The L* parameter, which indicates white (closer to 100 = light) and black (further than 100 = dark), representing luminosity, had an average of 43.40, indicating that the jellies of the two cultivars are slightly dark. Lower L* values (24.85) are reported by Santos et al (2021) in abiu diet jam with chia, indicating a darker color than the peach jams in the present study. This is probably due to the raw materials (abiu and chia) used.

There was a significant difference between the samples, regarding the a* parameter. The jelly made with peach of the Maciel cultivar had a higher a* value (9.38) when compared to that made with Cv. Top Bilt, a* (4.30), a fact possibly justified by the color of the peach cultivar Maciel pulp, which is yellow. However, both indicated color tending towards red because positive a* values indicate a tendency towards red (+a*) and negative values for green color (-a*). Lower value for the same parameter is reported by Santos et al. (2021) in diet abiu jelly with chia (0.72), indicating that the peach jellies have a color that tends more towards red than the diet abiu jelly with chia.

Positive b* values indicate yellow coloring and negative values, blue. In this variable, the samples differed from each other, and the jelly made with Cv. Maciel peach showed a higher b* value (21.18), which was already expected due to the color of the cultivar's pulp, in relation to Top Bilt (15.07). A lower value for the same parameter is reported by Santos et al. (2021), in abiu diet jelly with chia (6.69), indicating that the peach jellies have more yellowish visual characteristics than the abiu diet jelly with chia.

The average firmness of the jellies was 1.65 N. Alower value for the same parameter was found by Oliveira et al. (2014), in the characterization of Umbu-cajá diet jellies, finding values between 0.23 and 0.43 N. A factor that can be explained by the difference in fruit species, despite having other characteristics that are very similar.

The pH is directly related to the conservation of jellies, as the lower the pH, the higher the difficulty for pathogenic bacteria growth. In addition, it is important for the texture of the jellies, as it is related to the acidity index, where values below 3.5 cause a break in the gels during processing, while values above 4.7 do not allow gel formation (Food Ingredients Brazil, 2013). There was a significant difference between the samples evaluated in terms of pH, with the highest being that of jelly from the Top Bilt cultivar (4.24). Other researchers have also found similar values, obtaining results from 4.44 to 3.68 for analyzes in mountain guava jellies, both being within the ideal established by the literature (Santos et al. 2017). Lower values for the same parameter were reported by Ben Rejeb et al. (2020), when analyzing jellies with reduced sugar content formulated from citrus fruits (ranging from 2.74 to 3.56 for sour orange and Sangue orange jellies, respectively), and by Santos et al. (2021), in abiu jelly with chia diet, where they report a pH of 3.22 for the respective product. The difference in pH values found is probably due to the raw material used in the preparation of the respective jellies, however a low pH contributes to the increase of the shelf life of the product, and a pH below 3.0 favors syneresis in jellies (Teles et al., 2017).

As for titratable acidity, there was no significant difference between samples (2.64%). This result is inferior to that of Santos et al. (2017), who found 1.70%, which is probably due to the raw material used in each experiment. Obtaining low titratable acidity values, together with high soluble solids levels and the pH, ensures certain microbiological stability of the product, since such conditions make microbial multiplication difficult.

Although the jellies did not receive added commercial sucrose, an average content of 30% SS was obtained, which is justified by the addition of sugarcane juice, naturally rich in sucrose. Similar values were found by Bernert et al. (2015) in tamarillo diet jelly (37% SS). And lower values were reported by Sousa et al. (2020) in buriti diet jelly (25.20% SS), Santos et al. (2021) in abiu diet jelly with chia (18.75% SS), and Bem Rejeb et al. (2020) in jellies with reduced sugar content formulated from citrus fruits (ranging from 26.93 to 28.42%). The soluble solids content can be associated with the moisture content, as the higher soluble solids content will indicate the lower moisture content of the jelly, which is also related to higher product conservation.

The average humidity of the jellies was 29.98%, within that required by legislation, which is a maximum of 35% (Brasil, 1978). A higher moisture values are reported by Santos et al. (2021) in abiu diet jelly with chia (61.06%), and by Sousa et al. (2020), in buriti diet jelly (64.18), expected results for diet products without the addition of sucrose, which normally requires the addition of preservatives to ensure the durability of these jellies.

With regard to phenolic compounds, there was no statistical difference between the samples, with an average of 2.10 mg GAE100 g^{-1}. The levels of phenolic compounds identified in this study are similar to those found for jabuticaba jelly evaluated by Rezende (2011), who found values ranging from 2.12 to 2.21 g L^{-1}.

Anthocyanin analysis was performed in the jellies, but there was no identification of this compound, which can be attributed to the high instability of these compounds to thermal processing, or even the small concentration of the compound in view of its high variability among peach genotypes. In general, those presenting red coloration tend to have a higher anthocyanin content (Cantín et al. 2009).

As for the carotenoids values, 0.050 mg/100 was obtained, with no significant difference between the samples. However, this parameter is highly variable among peach cultivars, and is more concentrated in the skin (Brown et al. 2014), which may indicate that the fruits used in the preparation of jams were already poor in such compounds.

There was no significant difference between samples for vitamin C, with a mean of 0.0015 mg 100 g^{-1}. Low vitamin C values are usually identified in processed foods, especially when cooked, as these compounds are highly unstable at high temperatures and can be degraded during the preparation of the jelly. In studies carried out by Neiva et al. (2016), it was also observed that Vitamin C can be degraded very quickly in aqueous solutions under both anaerobic and aerobic conditions. However, a study indicates that the content of vitamin C in peaches can vary according to the genotype, climate, conditions and cultural practices (Cantín et al. 2009). Data obtained by Geçer (2020), corroborate the aforementioned, with levels ranging from 7.79 to 9.84 mg 100 g^{-1} of Vitamin C for different peach cultivars. This may indicate that the raw material used in the preparation of jams was already poor in vitamin C.

3.1.Microbiological characterization

The results of the analyzes of molds and yeasts indicated that there was no development of these microorganisms in the jellies. As such they are suitable for consumption and comply with the legislation (Brasil, 2019). This result indicates that the application of good manufacturing practices was efficient in obtaining the microbiological safety of the jellies.

3.2.Acceptance Test

In the sensory acceptance test, the results indicated that the jelly made with the Top Bilt cultivar obtained, in general, higher acceptance, which can be observed in the internal preference map (Figure 1), due to the higher number of vectors and their approximation to the appearance and odor attributes, located closer to the center of the graph. This, indicates that they obtained higher averages. The jelly from the Maciel cultivar was farther from the center, for the attributes of appearance (A), odor (O) and flavor (S).

The higher acceptance of the jelly from this cultivar indicates that it should be preferred for the manufacture of jellies, because although the formulation was the same for the two cultivars, the jelly from the Top Bilt cultivar proved to be more accepted by consumers, reinforcing the importance of specific studies with different fruit cultivars to define that which to be used in the preparation of a given product.

Rejeb et al. (2020), when sensorially evaluating jellies formulated from four varieties of citrus fruits and with reduced sugar content, found that there were significant differences between the acceptability, in terms of flavor, odor, color, and sweetness of the jellies, however there was no variation on acceptability for texture. The jelly made from blood orange juice obtained greater acceptance.

Curi et al. (2019), when evaluating the processing of jellies from different fig cultivars, also found that although the elaborated jellies presented good sensory acceptability, they differed statistically in terms of color, with this parameter being strongly influenced by the cultivars used in the jellies elaboration. According to the authors, different fig cultivars give rise to jellies with different physical, chemical and rheological characteristics.

This corroborates the result of the present work indicating that fruits of different varieties (cultivars) result in products with distinct sensory characteristics. This contributes to the need to carry out more research on the formulation of jellies with different peach cultivars, considering that cultivar varieties provide a wide variety of products.

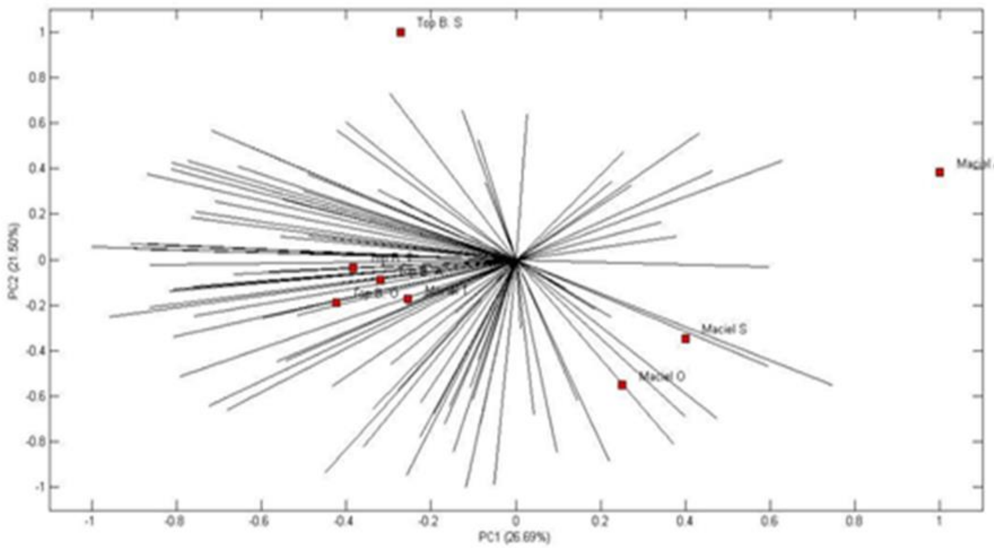

Figure 1. Internal preference map of the peach jam acceptance test.
Top B: Jelly from the Top Bilt cultivar; Maciel: Jelly from the cultivar Maciel; The appearance; S: taste; O: odor; T: texture and I: Global impression.

As for the purchase intention, there was no statistical difference between the jams of the two cultivars and the average was 3.96, being closer to the score 4 (possibly buy). This result suggests that, although sensorially, the Top Bilt jelly has greater acceptance among consumers, both can be produced and can be well marketed.

It can be said that jelly sweetened only with sugarcane juice, although not suitable for consumption by diabetics, serves the objective of offering natural food, without adding sugars or sweeteners. The products are healthier and probably of lower caloric value since the soluble solids content reached values lower than those recommended in the literature for jellies. Furthermore the jelly meets the sensory characteristics expected by the consumer, as identified in the acceptance test.

4. Conclusions

The jellies made with the peach cultivars Top Bilt and Maciel are statistically different only in terms of color, a* and b* and pH parameters they are, statistically equal in terms of L*, firmness, titratable acidity, soluble solids, vitamin C, carotenoids and phenolic compounds. It is concluded that, even without sugar and sweeteners added, jellies of both cultivars have the potential to be available in the market, as they present good acceptance and purchase intention.

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