Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.68521

Use of peels in the formulation and acceptance of white pulp pitaya jellies

Deniete Soares MAGALHÃES[1], Renata Amato MOREIRA[1*], Moacir Pasqual[1], Eduardo Valério de Barros VILAS BOAS[2], Leila Aparecida Salles PIO[1]

Abstract

The generation of agroindustrial waste has become a serious environmental problem, which conflicts with the need for sustainability sought by modern agriculture. An alternative that helps minimizing these effects is the use of residues, such as fruit peel, in food production. The objective of this study was to evaluate the viability of the mesocarp of the white-fleshed red pitaya (*Hylocereus undatus*) in the preparation of jellies, verifying the influence of different percentages of pulp replacement per mesocarp (0, 20, 40 and 60%) on the physicochemical, microbiological, and sensorial characteristics of the final products. The jellies presented good acceptability among consumers, with the 60% substitution level being the most accepted. Besides the mesocarp not altering the flavor of the jellies, its use increases the attractiveness to the consumer in addition to contributing to cost reduction and environment preservation.

Keywords: by-products, *Hylocereus undatus*, nutraceutical food.

Practical Application: The use of fruit peels in the production of food, besides contributing to environmental sustainability by reducing waste, is a source of nutrients and enables the improvement of the quality of certain products. The influence of different percentages of pulp replacement per mesocarp on jellies presented good acceptability among consumers, besides the mesocarp not altering the flavor of the jellies, its use increases the attractiveness for consumer due to the pink coloring of the peel.

1 Introduction

Pitayas belong to the Cactaceae family and grow in tropical and subtropical America. The species *Hylocereus undatus* presents fruit of pink coloration in the exocarp (peel), intense red in the mesocarp, and white in the endocarp (pulp), with innumerous dark seeds (Marques et al., 2011).

The national trade of pitaya is mainly concentrated in CEAGESP (*Companhia de Entrepostos e Armazéns Gerais de São Paulo* – Trading Post and General Warehouse Company of São Paulo). In 2017, 604 tons of the fruit were sold, equivalent to 99% of the volume marketed throughout the country (Companhia de Entrepostos e Armazéns Gerais de São Paulo, 2021).

The fruit has gained prominence in the exotic fruit market due to its sensorial characteristics (Moreira et al., 2011), with emphasis on the sweet and mild flavor (Lima et al., 2013), and high vitamin and mineral content, presenting high levels of potassium. The pitaya fruit can be consumed both raw and processed in a range of commercial products such as ice-cream, jellies, juices, syrups, and sweets (Nurul & Asmah, 2014).

Worldwide, fruit and vegetable waste rates are higher than those of any other food product, with approximately half of all fruits and vegetables produced being wasted (Food and Agriculture Organization of the United States, 2018). The losses arise from cultivation, post-harvesting, processing, distribution, to the consumption itself, reaching high waste rates, which can compromise the environment.

Recently, several researchers studied the use of residues generated by agroindustry in the development of food products, such as the employment of fruit mesocarp in the production of jellies, thus increasing its added value (Randolpho et al., 2020). The economic use of fruit residues from agroindustry or the *in natura* market, combined with the development of technologies to minimize losses in production processes, could considerably contribute to the country's economy and reduction of environmental impacts. The objective of this study was to evaluate the acceptability of jellies prepared with different percentages of mesocarp and pulp of white-fleshed red pitaya by analyzing the physical, physico-chemical, microbiological, and sensorial characteristics of the final products.

2 Material and methods

2.1 Jelly formulation and preparation

Ripe fruits of red pitaya (*H. undatus*) were collected in the orchard of the Federal University of Lavras (UFLA) and sent to the post-harvest laboratory, where they were washed with neutral detergent, sanitized with 200 ppm sodium hypochlorite (NaClO) for 15 minutes, and rinsed under running water. After drying the fruits at room temperature, the scales and exocarp

Received: 11 Aug., 2021
Accepted: 15 Feb., 2022
[1] *Departament of Agriculture, Universidade Federal de Lavras – UFLA, Lavras, MG, Brasil*
[2] *Departament of Food Science, Universidade Federal de Lavras – UFLA, Lavras, MG, Brasil*
*Corresponding author: Renata_amato@hotmail.com

were removed with the aid of a knife and discarded. Then, the mesocarp and pulp were manually separated and packed in individual plastic bags until the jellies were prepared.

Water, sugar, pectin, and fruit pulp or pulp + peel (mesocarp) were used as the ingredients for jelly development. The formulations varied only in the ratios of peel used in substitution to pulp. A pre-test was performed in the laboratory to determine the proportions of the ingredients to be used. Initially, juice was prepared as raw material for jellies, using 60% water and 40% pulp (or pulp + mesocarp). The mesocarp was crushed in a blender with water and the pulp was added after homogenization. Before blending, the pulp and mesocarp were cut into small pieces with the aid of a knife and added to the juice, so that the seeds remained whole during the jelly preparation process. Then, the pulp/mesocarp mix was homogenized during the boiling process with the aid of a spoon. In all formulations, 60% juice and 40% sugar were used, with addition of 1% citrus pectin over the sugar + juice ratio. The different pulp and mesocarp ratios used in the preparation of the juices are shown in Table 1.

The cooking process started with the addition of juice in an aluminum utensil and heating over an industrial stove. After boiling started, 1/3 of the total proportion of sugar mixed with pectin was added by constantly stirring with a spoon to ensure complete dilution of pectin and avoid the formation of agglomerates. Subsequently, the remainder of the sugar was added and the soluble solids content was monitored until 65° Brix and gelatinous consistency. Afterwards, the warm jelly was removed from the flame and potted in sterilized 100-mL glass vials. The closure was made with metal lids, internally varnished, and provided with sealing rings. The vials were reversed for 5 minutes, which allowed hermetic closure. In order to ensure product safety, a subsequent thermic treatment for airtight food preservation was carried out by immersing the vials in boiling water for 10 minutes, followed by slow cooling.

The average time of preparation for each jelly was 20 minutes. Afterwards, each sample was stored in a cool place until analysis.

2.2 Analyses performed

Jelly coloration analysis was performed using the Minolta CR-400 colorimeter in the CIELab mode (standard illuminant D65 and observation angle of 2°, following the methodology defined by the manufacturer), evaluating the L*, a*, C* and °h coordinates, where L* represents clarity and varies between 0 (totally black) and 100 (totally white); a* represents the color variation from green to red and ranges from −80 (green) to +100 (red); b* represents the color variation from blue to yellow and ranges from −50 (blue) to +70 (yellow); c* indicates the chromaticity or purity of the color, and °h represents the angle at which the coloration is measured. The different samples were conditioned in a white-bottomed vessel and readings were performed at four different points for each jelly.

The texture was determined using a Stable Micro System texturometer, model TATX2i, equipped with an HDP/90 platform and a 6 mm diameter P/6N needle probe with a velocity of 5 mm s^{-1}, a penetration of 10 mm distance, and a time of 5 seconds. Three replicate measurements were made and the following variables were collected: hardness, adhesiveness, elasticity, cohesiveness, gumminess, chewiness, and resistance.

The titratable acidity was determined by titration of 10 mL of the homogenate with 0.1 N NaOH with the aid of a pH meter. The final titration point was pH 8.2 and results were expressed as percentage of malic acid. The pH was determined using a digital pH. Soluble solids, expressed in %, were measured using a digital refractometer. The methodologies recommended by the Association of Official Analytical Chemists (2019) were followed.

The sensorial analyses for color evaluation, flavor, aroma, consistency, and overall impression of different jellies formulations were carried out in the Sensory Analysis Laboratory of the Department of Food Science, UFLA, Lavras-MG, using the structured hedonic scale of nine points, corresponding to: 1 (dislike extremely), 2 (dislike very much), 3 (dislike moderately), 4 (dislike slightly), 5 (neither like nor dislike), 6 (like slightly), 7 (like moderately), 8 (like very much), and 9 (like extremely). The acceptability test was carried out by 105 tasters, jelly consumers, of both sexes and different age groups. Tasters were offered salted water biscuit as a tasting vehicle and drinking water to rest the palate between the samples. The project was approved by the local ethics committee (number 1.522.860) prior to performing the analysis.

The most probable number (MPN g^{-1}) of coliforms per gram of sample at 35 and 45°C, the presence or absence of Salmonella, and the number of colony forming units (CFU) of molds and yeasts, were also determined in the Microbiology Laboratory according to methodologies proposed by the International Commission on Microbiological Specifications for Foods (2011) and da Silva et al. (2017).

2.3 Experimental design

A completely randomized design (CRD) with four replicates was used. Each experimental unit consisted of a 10–mL vial. Four formulations of pitaya jellies with different proportions of mesocarp as substitute for pulp (0, 20, 40 and 60%) were studied. The results were evaluated through analysis of variance. Mean

Table 1. Mass (g) of the ingredients of the pitaya jelly formulation with different percentages of mesocarp and pulp.

Pulp (%)	Mesocarp (%)	Ingredients (g)				
		Pulp	Mesocarp	Water	Sugar	Pectin
100	0	420	0	280	465.5	11.65
80	20	336	84	280	465.5	11.65
60	40	252	168	280	465.5	11.65
40	60	168	252	280	465.5	11.65

tests we performed to evaluate the sensory analysis and texture profile data, whereas polynomial regression models were selected based on the F-test and the coefficient of determination for the other analyses. The software SISVAR (Ferreira, 2011) was used. For the analysis of linear correlations, the software GENES (Cruz, 2009) was used, where the Pearson correlation coefficient (r) was obtained, considering significant correlations when $p < 0.05$.

3 Results and discussion

3.1 pH, titratable acidity, and soluble solid analyses

For jellies it is recommended a pH around 3.2, aiming at reducing the presence of microorganisms and avoiding exudation of the jelly liquid (syneresis) (Oliveira et al., 2018), which was not observed in this study. The pH of our samples presented quadratic behavior, increasing with the addition of the mesocarp in the samples from 4.64 to 4.93. Titratable acidity, in contrast to pH, decreased linearly with addition of mesocarp, with variations between 1.37 and 1.17% of malic acid (Figure 1).

Although the pH of the jellies under study was higher than that recommended, according to Silva et al. (2018), this pH value does not prevent commercialization. Similarly, while working on the development and characterization of oat-enriched orange jelly, Oliveira et al. (2016) found high pH values ranging from 4.2 to 4.23. Moreover, while studying the characteristics and stability of umbu-cajá jelly, Oliveira et al. (2014) observed that the pH remained above 3.2, showing no syneresis in the products, although the low titratable acidity (0.8%) may have contributed to prevent their formation. Each fruit or parts of fruit have intrinsic characteristics that may interfere with the final quality of the product, such as pH, acidity, and soluble solids.

According to Oliveira et al. (2013), the acidity provides a valuable information about the state of conservation of food. In fact, once decomposition starts, the concentration of hydrogen ions in the samples changes. According to do Bú et al. (2021), acidity above 1.00% is another factor that can cause syneresis. Souza et al. (2016) also found high acidity values in tamarind jelly produced from yellow passion fruit albedo with and without pectin, with the highest detected value corresponding to 1.91% of tartaric acid. Melo Neto (2012) reported high acidity in their formulations of pitanga jellies, ranging from 1.25 to 1.50% of citric acid. Damiani et al. (2012) found 1.17–1.27% of citric acid in mixed strawberry guava and marolo fruit jelly formulations during storage. Thus, it is noted that jellies have intrinsic characteristics according to the properties of the fruit, which can determine the final quality of the product.

Soluble solids content did not show statistical differences, presenting average values of 65%, which is within the standards required by Brazilian legislation (Sousa et al., 2020).

3.2 Texture profile analysis

The texture of the jelly is directly related to gel formation, which is a variable dependent on acid concentration, pectin, soluble solids, storage time, and temperature (Oliveira et al., 2015).

In the analysis of the texture profile, hardness, adhesiveness, elasticity, cohesiveness, gumminess, chewiness, and resistance of the jellies were evaluated, and the average values obtained were 491.41N; −203.95; 0.93; 0.62; 301.95; 280.69, and 0.18, respectively. The results showed that the evaluated properties did not vary considerably as a function of the pulp replacement per mesocarp, regardless of the substitution level. Based on these results, we can infer that the different jelly formulations had no influence on the texture profile of the samples, which allows the addition of the mesocarp without interference in the texture characteristics of the product.

3.3 Jelly coloration analysis

In this study, the different formulations presented different visual aspects, either by coloration or by seed distribution (Figure 2).

The first consumer contact with a product is usually with the visual presentation, when the color and the appearance stand out (Oliveira et al., 2015). All products have an expected appearance and color that interfere with their acceptability, directly affecting the flow of this product.

According to Figure 3, the coloration parameters (L*, a*, C*, and °h) were significantly influenced by the different formulations.

The L* coordinate was significantly higher in the jelly with 0% mesocarp than it was in other jellies, decreasing as proportions

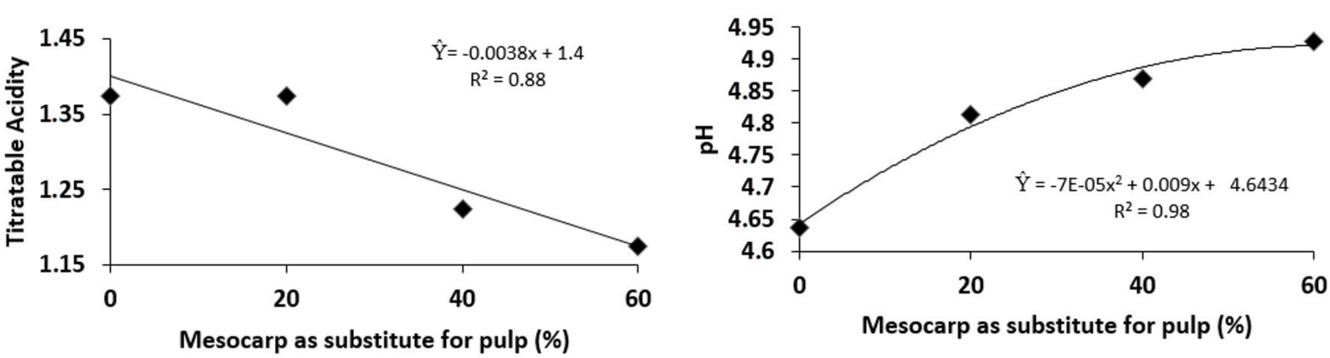

Figure 1. Average values, regression equation, and coefficient of determination of titratable acidity and pH jellies formulated with different percentages of mesocarp.

Figure 2. Appearance of pitaya jellies formulated with different levels of mesocarp as substitute for pitaya pulp. From left right: 0, 20, 40 and 60% of mesocarp.

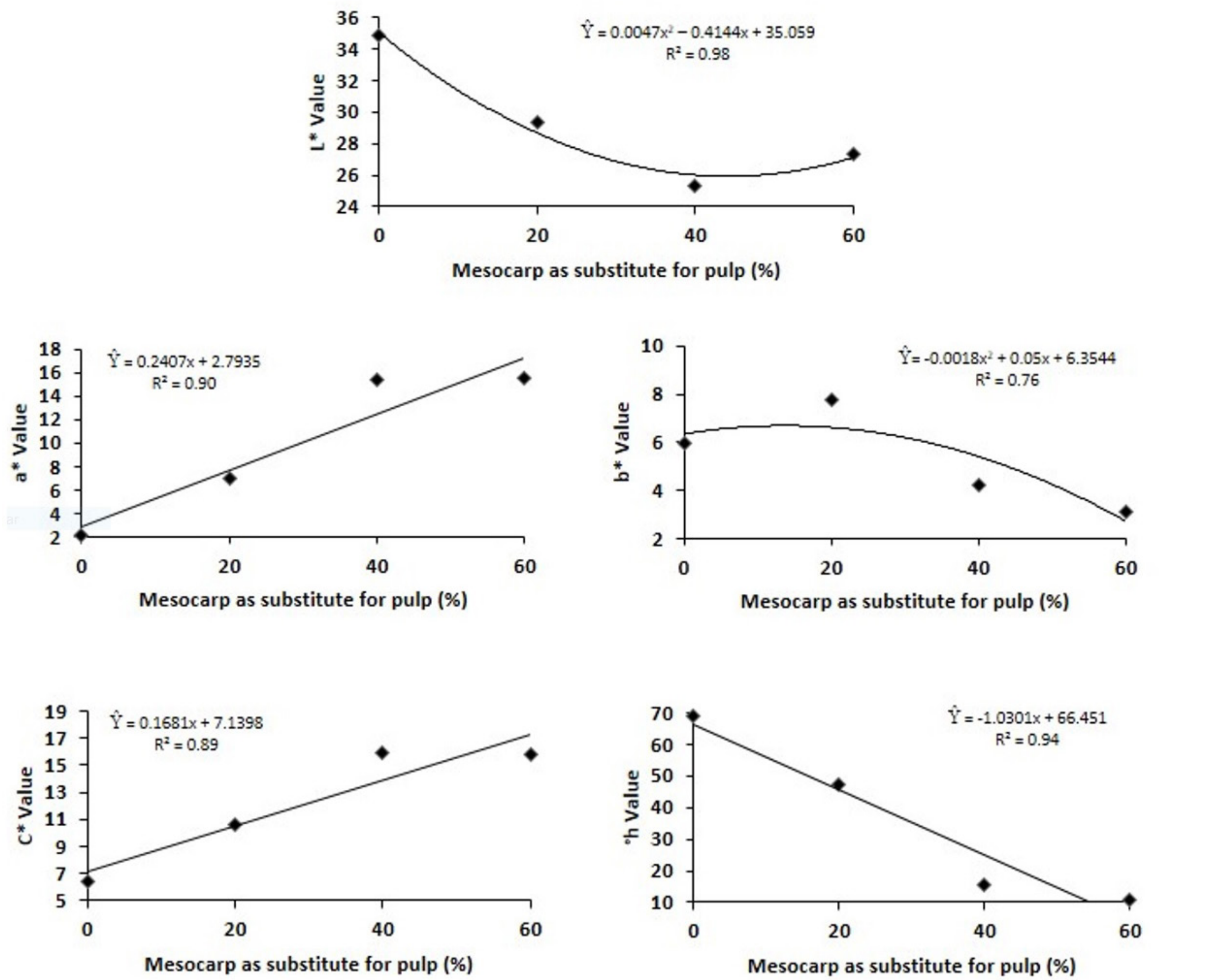

Figure 3. Average values, regression equations, and determination coefficients of L*, a*, b*, c*, and °h parameters for jellies formulated with different percentages of mesocarp. L* represents clarity, a* represents the color variation from green to red, b* represents the color variation from blue to yellow, c* indicates the chromaticity or purity of the color, and °h represents the measurement angle.

increased up to 40%, followed by a slight increase in the jelly with 60% mesocarp. This trend can be explained by the fact that the pitaya used in the jelly preparation was white and the added mesocarp was red and visibly darker, which made the final product also become darker. Darkening of the jelly was noted by the addition of up to 40% of the mesocarp. However, with the addition of 60% mesocarp an inverse phenomenon was observed, with a slight increase in the L* value due to the dispersion of the dark seeds in the jelly. In fact, the high concentration of mesocarp in the 60% sample caused a decrease in the concentration of seeds, which are present only in the pulp, resulting in a slightly lighter-colored jelly. The changes in coloration seen in Figure 2 were also objectively confirmed with changes in the values of a*, °h, b*, and C*, with a* and °h showing the best correlation. The increase in the value of a* and reduction of °h correlate with the reddening of the jelly due to the addition of increasing amounts of the reddish mesocarp. In fact, the greater and farther from zero the value a*, and the smaller and closer to zero the °h, the redder the product. The increase in C* indicates a final product with highly vivid colors, due to the addition of the mesocarp. The small reduction of b* suggests a slight loss of yellow tones, which makes the jelly somewhat pink with 20% of the mesocarp to intense red with 60% of the mesocarp.

The reddish coloration of the pitaya mesocarp is due to the presence of natural pigments called betalains, which are characterized as a class of nitrogenous, water-soluble pigments that provide attractive colors to groups of fruit and flowers and are indicated for use as a natural dye in foods. Moreover, in pitaya mesocarp, betalains are present in high concentration and are resistant to heating (100 °C). This pigment is rich in antioxidant properties, which implies a jelly with higher functional value. In addition, the mesocarp is a rich source of dietary fibers (Mello et al., 2014).

These results demonstrate the significant influence of the mesocarp on the change in jelly coloration, which is greatly important for consumer acceptability.

3.4 Acceptability analysis

The acceptability test was conducted using 105 jelly consumers, of both sexes and different age groups, who evaluated the color, taste, consistency, and overall impression attributes (Table 2).

Regarding the attribute color, on a scale of 1 to 9, the average scores were below 6.0 for the 0% and 20% mesocarp formulations and above 6.0 for 40 and 60% formulations. Interestingly, the formulation with 60% of mesocarp obtained the best evaluation as the formulation with a clear predominance of red color, differently from the others that presented colors ranging from pink to orange-red. This result indicates a higher consumer preference for more intense red-colored jellies, which is in line with the assertion of Hirsch et al. (2012) that consumers generally prefer strongly colored and bright fruits. Given the promising results found in this study, the statement above can be extended to by-products such as jellies.

The flavor, according to consumers, was similar in all jellies, with no statistical difference, at 5% probability by the tukey test, and presented an average value of 6.98, which corresponds to a positive judgment. Similar results were obtained by Vanderlei et al. (2020) when working with Chia grape belly jelly. The authors concluded that the introduction of grape belly did not interfere with the taste of the jellies. Although, in this study, the increase in mesocarp amount caused a reduction in titratable acidity and a consequent increase in pH (Figure 1), these small but significant changes were not sufficient to impact the flavor of the jelly. The non-significant changes in the flavor of the jelly coincided with the non-significant changes in the soluble solids, which remained approximately 65%, despite the level of pulp replacement per mesocarp. In fact, sugars, predominant components of the product, influence taste sensitivity more than organic acids do.

Regarding consistency, the formulations with 40 and 60% gave similar results higher than those of formulations with lower mesocarp amounts, indicating that the addition of mesocarp improved the texture of the jellies. However, the texture profile analysis did not show statistically significant differences. This result may have been influenced by the presence of the seeds, which, according to the tasters, provoke a "crunchiness" sensation varying with the amount of seeds as a function of the substitution of the pulp with mesocarp. The consistency of jelly is a consequence of two factors, that is, the continuity, related to pectin concentration, and hardness, related to sugar and acid concentration (Krolow, 2013). The texture properties are important in the perception and acceptability of the food, and a reflection of the chemical composition of the food and its structure.

The 60% mesocarp formulation received the highest overall impression score, differing statistically from the other formulations. Thus, it can be affirmed that the substitution of pulp with mesocarp considerably improved the acceptability parameters of the jellies by the consumers. In a study conducted by Lago-Vanzela et al. (2011) on the chemical and sensory characterization of cajá-manga peel and pulp jelly, the sensorial analysis indicated that the product elaborated from the peel presented satisfactory acceptance for all the evaluated attributes. Vanderlei et al. (2020), who evaluated Chia grape belly jelly from

Table 2. Average values, mean, and coefficient of variation (CV) of the sensorial analysis of jellies formulated with different pulp/mesocarp percentages.

Pulp (%)	Mesocarp (%)	Score (averages)			
		Color	Taste	Consistency	Overall impression
100	0	5.81c	6.97a	6.9ab	6.86bc
80	20	5.91c	6.75a	6.53b	6.61c
60	40	7.45b	7.20a	7.15a	7.31ab
40	60	8.1a	6.99a	7.19a	7.43a
Mean		6.82	6.98	6.94	7.05
CV		22.23	21.41	22.29	18.55

Averages followed by the same letter in the column do not differ from each other at the 5% significance by the Tukey's test.

the vinicola production of the São Francisco submedio region, concluded that the products presented high acceptability among consumers. Moreover, Amaral et al. (2012), who conducted a sensory analysis of passion fruit pulp and peel jellies, concluded that the products presented significant acceptability and good intention of consumption and purchase, with the overall evaluation showing superior results for peel jelly compared to pulp jelly.

The nine-point structured hedonic scale is probably the most used affective method among the available sensory methods to measure consumer acceptance and preference for one or more products, due to the reliability and validity of its results and simplicity of use by the tasters (Dutcosky, 2019). Interestingly, it was observed that 87.5% of the average scores presented values above 6, which corresponds to a positive result on the scale of acceptability of the product by the consumer. The highest average for color was 8.1, for flavor 7.20, for consistency 7.19, and for overall impression was 7.43, which endorsed the use of the pitaya mesocarp in the manufacture of jellies.

Correlation analyses are important to indicate interferences between variables that are related to each other. Correlation studies allow to determine how much one variable interferes in the result of another. Thus, a correlation analysis between objective measures of color and subjective (sensorial) is presented in Table 3.

Importantly, color coordinates (L*, a*, b*, C*, and °h) and product acceptability variables (color, flavor, consistency, and overall impression) showed a significant positive correlation with a*, C*, and °h. The coloration variables also contributed to the overall impression of the jellies. We observed a significant and positive correlation with a* and significant negative correlation with L*, b*, and °h, demonstrating the importance of the product coloration and confirming that the red jellies are more visually appealing to the consumer than the others. On the other hand, there was no interference of the coloration with flavor and consistency, proving that the addition of the mesocarp does not alter the flavor of the jelly, but positively contributes to the final acceptance of the product. Although the correlations between pH, acidity, soluble solids, and texture with the sensorial variables were also evaluated, they were not statistically significant.

Therefore, the results of this study are promising because endorse the substitution of pulp by mesocarp without altering the taste of jellies, and show that mesocarp introduction is highly improves the acceptability characteristics of the product by consumers. This contributes to the significant reduction of the costs associated with increased the product yield and to the considerable reduction of environmental impact related to the reuse of fruit parts that would be discarded. In addition, our study contributes to add value to pitaya and is a viable alternative to extend the stock time of the product in the market, which is important for seasonal fruits and concentrated harvesting.

3.5 Microbiological analysis

The average results of the microbiological analysis (Table 4) performed on the samples with different levels of pitaya mesocarp as substitute for pulp were within the limits allowed by Anvisa's RDC n°12 (Brasil, 2001), which stipulates the following standards for fruit jellies: maximum of 104 CFU g^{-1} for molds and yeasts, absence of *Salmonella* in 25 g of sample, and maximum of 102 MPN g^{-1} for coliform at 45 °C.

The results suggest that jelly processing was conducted following good practices of manipulation and hygiene of products and utensils, besides the effectiveness of the conservation methods employed. Since low pH and high soluble solids content limit microbial growth, the growth of bacteria that are deteriorating and/or causing foodborne diseases is minimal in these conditions (International Commission on Microbiological Specifications for Foods, 2011).

Table 3. Correlations ($p < 0.05$) between color, flavor, consistency e overall impression of the notes of the sensorial analysis with color (L*, a*, b*, C and Hue) of the jellies of the white-fleshed dragon fruit formulated with different percentages of pulp/mesocarp.

	Color	Flavor	Consistency	Overall impression
L*	−0.251^{ns}	−0.221 ^{ns}	−0.229 ^{ns}	−0.529*
a*	0.561*	0.147 ^{ns}	0.197 ^{ns}	0.513*
b*	−0.340 ^{ns}	0.424 ^{ns}	−0.422 ^{ns}	−0.689*
C*	0.576*	0.236 ^{ns}	0.116 ^{ns}	0.351 ^{ns}
°h	−0.525*	−0.0229 ^{ns}	−0.217 ^{ns}	−0.594*

* correlations ($p<0.05$). ^{ns} Not significant. L* represents clarity. a* represents the color variation from green to red. b* represents the color variation from blue to yellow. c* indicates the chromaticity or purity of the color. °h represents the measurement angle.

Table 4. Average values of the microbiological analysis of jellies containing different percentages of mesocarp as substitute for pulp.

Pulp (%)	Mesocarp %	Molds and Yeasts (CFU g^{-1})[1]	Salmonella (25 g^{-1})	Coliforms at 35 °C (MPN g^{-1})[2]	Coliforms at 45 °C (MPN g^{-1})[2]
100	0	Absent	Absent	Absent	Absent
80	20	Absent	Absent	Absent	Absent
60	40	Absent	Absent	Absent	Absent
40	60	Absent	Absent	Absent	Absent

1 – CFU g^{-1} = colony forming units per gram of sample; 2 – MPN g^{-1} = most probable number per gram of sample.

4 Conclusion

The substitution of the white pulp with the red mesocarp of pitaya increases the acceptability of the resulting jelly, with the 60% substitution being the most recommended for determining the highest scores of color, consistency, and overall impression, without significant changes in taste.

The partial replacement of the pulp with the mesocarp of pitaya must be considered in order to reduce costs and minimize environmental impacts related to waste.

The jellies produced with pitaya pulp and mesocarp are within the microbiological standards established by the Brazilian legislation.

Acknowledgements

The authors thank FAPEMIG, CAPES, and CNPq for the financial assistance, and the Federal University of Lavras (UFLA) for providing the materials and space used to conduct this study.

References

Amaral, D. A., de Souza Pereira, M. L., Ferreira, C. C., & Gregório, E. L. (2012). Análise sensorial de geleia de polpa e de casca de maracujá. *HU Revista*, 38(3-4). Retrieved from https://periodicos.ufjf.br/index.php/hurevista/article/view/2037

Association of Official Analytical Chemists – AOAC. (2019). *Official methods of analysis of the Association of Official Analytical Chemists* (21st ed.). Arlington: AOAC.

Brasil. Ministério da Saúde. Agência Nacional de Vigilância Sanitária. (2001). Resolução de Diretoria Colegiada (RDC nº. 12, de 02 de janeiro de 2001). *Diário Oficial [da] República Federativa do Brasil*.

Bú, S. A., Felinto, A. C. B., Marçal, E. J. A., Oliveira, I. M., Lima, J. A., Sousa, J. B., Melo, W. G., & Cavalcanti, M. S.. (2021). Produção e caracterização físico-química de geleia de menta enriquecida com spirulina (Spirulina platensis). *Research. Social Development*, 10(4), e30110414145. http://dx.doi.org/10.33448/rsd-v10i4.14145.

Companhia de Entrepostos e Armazéns Gerais de São Paulo – CEAGESP. (2021). *Pitaia*. São Paulo: CEAGESP. Retrieved from http://www.ceagesp.gov.br/guia-ceagesp/pitaia/

Cruz, C. D. (2006). *Programa Genes – Biometria* (1 ed., Vol. 1). Viçosa, MG: Editora UFV.

da Silva, N., Junqueira, V. C. A., de Arruda Silveira, N. F., Taniwaki, M. H., Gomes, R. A. R., & Okazaki, M. M. (2017). *Manual de métodos de análise microbiológica de alimentos e água*. São Paulo: Editora Blucher.

Damiani, C., Asquieri, E. R., Lage, M. E., Oliveira, R. A. D., Silva, F. A. D., Pereira, D. E. P., & Vilas Boas, E. V. D. B. (2012). Study of the shelf-life of a mixed araça (Psidium guineensis Sw.) and marolo (Annona crassiflora Mart.) jam. *Food Science and Technology (Campinas)*, 32(2), 334-343. http://dx.doi.org/10.1590/S0101-20612012005000050.

Dutcosky, S. D. (2019). *Análise sensorial de alimentos* (5. ed., 540 p.). Curitiba: Champagnat.

Food and Agriculture Organization of the United States - FAO (2018). *World food and agriculture – Statistical pocketbook 2018*. Rome: Food and Agriculture Organization of the United States.

Ferreira, D. F. (2011). Sisvar: a computer statistical analysis system. *Ciência e Agrotecnologia*, 35(6), 1039-1042. http://dx.doi.org/10.1590/S1413-70542011000600001.

Hirsch, G. E., Facco, E. M. P., Rodrigues, D. B., Vizzotto, M., & Emanuelli, T. (2012). Caracterização físico-química de variedades de amora-preta da região sul do Brasil. *Ciência Rural*, 42(5), 942-947. http://dx.doi.org/10.1590/S0103-84782012005000021.

International Commission on Microbiological Specifications for Foods – ICMSF, & Swanson, K. M. J. (2011). *Microorganisms in foods: use of data for assessing process control and product acceptance*. London: Springer.

Krolow, A. C. R. (2013). *Preparo artesanal de geleias e geleiadas* (Embrapa Clima Temperado. Documentos, 138). Pelotas: Embrapa Clima Temperado.

Lago-Vanzela, E. S., Ramin, P., Umsza-Guez, M. A., Santos, G. V., Gomes, E., & Silva, R. (2011). Chemical and sensory characteristics of pulp and peel 'cajá-manga' (Spondias cytherea Sonn.) jelly. *Food Science and Technology (Campinas)*, 31(2), 398-405. http://dx.doi.org/10.1590/S0101-20612011000200018.

Lima, C. A. D., Faleiro, F. G., Junqueira, N. T. V., Cohen, K. D. O., & Guimarães, T. G. (2013). Características físico-químicas, polifenóis e flavonoides amarelos em frutos de espécies de pitaias comerciais e nativas do cerrado. *Revista Brasileira de Fruticultura*, 35(2), 565-570. http://dx.doi.org/10.1590/S0100-29452013000200027.

Marques, V. B., Moreira, R. A., Ramos, J. D., Araújo, N. A. D., & Silva, F. O. D. R. (2011). Fenologia reprodutiva de pitaia vermelha no município de Lavras, MG. *Ciência Rural*, 41(6), 984-987. http://dx.doi.org/10.1590/S0103-84782011005000071.

Mello, F. R. D., Bernardo, C., Dias, C. O., Gonzaga, L., Amante, E. R., Fett, R., & Candido, L. M. B. (2014). Antioxidant properties, quantification and stability of betalains from pitaya (Hylocereus undatus) peel. *Ciência Rural*, 45(2), 323-328. http://dx.doi.org/10.1590/0103-8478cr20140548.

Melo Neto, B. A. D. (2012, February). Caracterização físico-química de geléia de pitanga roxa (Eugenia uniflora L.). In *VII CONNEPI-Congresso Norte Nordeste de Pesquisa e Inovação*. Palmas, TO: IFTO.

Moreira, R. A., Ramos, J. D., Araújo, A. D., & Marques, V. B. (2011). Produção e qualidade de frutos de pitaia-vermelha com adubação orgânica e granulado bioclástico. *Revista Brasileira de Fruticultura*, 33(spe1), 762-766. http://dx.doi.org/10.1590/S0100-29452011000500106.

Nurul, S. R., & Asmah, R. (2014). Variability in nutritional composition and phytochemical properties of red pitaya (Hylocereus polyrhizus) from Malaysia and Australia. *International Food Research Journal*, 21(4)

Oliveira, C. F. D., Pinto, E. G., Tomé, A. C., Quintana, R. C., & Dias, B. F. (2016). Desenvolvimento e caracterização de geleia de laranja enriquecida com aveia. *Revista de Agricultura Neotropical*, 3(3), 20-23. http://dx.doi.org/10.32404/rean.v3i3.1203.

Oliveira, E. N. A., da Costa Santos, D., Rocha, A. P. T., Gomes, J. P., Martins, J. J. A., & Martins, J. N. (2015). Caracterização físico-química, microbiológica e sensorial de geleias de umbu-cajá elaboradas com e sem a adição de sacarose. *Revista do Instituto Adolfo Lutz*, 74(2), 111-121.

Oliveira, E. N. A., Feitosa, B. F., & Souza, R. L. A. (2018). *Tecnologia e processamento de frutas: doces, geleias e compotas*. Mossoró: Editora IFRN.

Oliveira, E. N. A., Santos, D. D. C., Rocha, A. P. T., & Gomes, J. P. (2014). Desenvolvimento, caracterização e estabilidade de geleia tradicional de umbu-cajá. *Revista Brasileira de Fruticultura*, 36(3), 628-639. http://dx.doi.org/10.1590/0100-2945-366/13.

Oliveira, E. S., Andrade, C. K. O., de Caldas Pinto, M. D. S., Galdino, P. O., Targini, L. C., da Silva, R. A., & Maracajá, P. B. (2013). Qualidade de méis de Apis mellifera produzidos no sertão paraibano. *Informativo Técnico do Semiárido*, 7(1), 203-208. Retrieved from https://www.gvaa.com.br/revista/index.php/INTESA/article/view/2533.

Randolpho, G. A., Amaral, L. A., Arelhano, L. E., & Santos, E. F. (2020). Resíduos de frutas transformados em novos produtos alimentícios: uma revisão sistemática. *Multitemas*, 25(61), 297-311.

Silva, P. G. P., Pontes, A. R., dos Santos, L. G., Pacher, G. C., & da Silva, G. F. A. (2018). Composição proximal de resíduos de abacaxi (Ananas comosus) na produção de geleia tipo extra, avaliando suas características físico-químicas e sensoriais. *Cadernos de Agroecologia*, 13(2), 9-9.

Sousa, E. P., Lima, D. E. S., Costa, R. A., Lemos, D. M., Almeida, R. D., & Costa, J. A. (2020). Geleia Tradicional de Açaí e Cupuaçu: caracterização físico-química e perfil de textura. *Revista Geintec-Gestao Inovacao e Tecnologias*, *10*(4), 5715-5726.

Souza, F. D., Barbosa, F. D. F., & Rodrigues, F. M. (2016). Avaliação de geleia de tamarindo sem pectina e com pectina proveniente do albedo do maracujá amarelo. *Journal of Bioenergy and Food Science*, 3(2), 78-88. http://dx.doi.org/10.18067/jbfs.v3i2.52.

Vanderlei, D. R., Quadros, C. P., & Sá, C. S. (2020). Geleia de bagaço de uva e chia proveniente da produção vinícola da região do submédio São Francisco. *Brazilian Journal of Development*, 6(1), 4237-4248. http://dx.doi.org/10.34117/bjdv6n1-302.