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Original

Jaboticaba peel for jelly preparation: an alternative technology

Aproveitamento tecnológico da casca de jabuticaba para elaboração de geléia

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Abstract

The peel of jaboticaba is attractive regarding its nutritional, functional and sensory aspects. However, its use for consumption is still restricted due to the need of technological development in order to obtain processed preparations for its inclusion in the human diet. The purpose of this study was to produce jelly using the peel of jaboticaba and to characterize it chemically and sensorially. Diferent formulations were prepared, all with 50% of sugar and with different proportions of peel, pulp and pectin. The formulations, which were tested for preference, were the following: F1a (80% of peel, 20% of pulp and 0.5% of pectin) and F3b (50% of peel, 50% pulp and 1.0% of pectin). These formulations showed chemical composition of 216.44 mg phenolic compounds, 148.00 mg gallic acid.100 g^{-1}, 10.42 mg flavonoids, and 12.10 mg catechin.100 g^{-1}, and 80% acceptability index. The peel presented higher levels of nutrients than the pulp, especially as source of fiber, carbohydrates and natural pigments. Results indicated the feasibility of technological nutritional harnessing of the jaboticaba peel in obtaining jelly. The results also indicated good sensory and nutritional characteristics, acceptability, and antioxidant properties of natural pigments.
Keywords: *peel of jaboticaba; use of technology; jelly; acceptability; pigments; myrciaria.*

Resumo

A jabuticaba apresenta casca atrativa do ponto de vista nutritivo, funcional e sensorial. Todavia, o aproveitamento da casca para o consumo ainda é restrito por necessitar de tecnologias para a obtenção de preparações processadas para sua inclusão na dieta humana. O objetivo deste trabalho foi elaborar geléia utilizando casca de jabuticaba e caracterizá-la química e sensorialmente. Foram elaboradas formulações, todas com 50% de açúcar e com diferentes proporções de casca, polpa e pectina. As formulações foram submetidas a teste de preferência, e duas geléias preferidas, a F1a (80% de casca, 20% de polpa, e 0,5% de pectina) e a F3b (50% de casca, 50% de polpa, e 1,0% de pectina), apresentaram composição química para fenólicos de 216,44 e 148,00 mg de ácido gálico.100 g^{-1}, para flavonoides de 10,42 e 12,10 mg de catequina.100 g^{-1} e um índice de aceitabilidade de 80%. A casca de jabuticaba apresentou maiores teores de nutrientes que a polpa, destacando-se como fonte de fibras, carboidratos e pigmentos naturais. Os resultados indicaram a viabilidade do aproveitamento tecnológico e nutricional da casca de jabuticaba para a obtenção de geleia. Os resultados também incidiram boas características sensoriais, nutritivas, aceitabilidade, e propriedades antioxidantes de pigmentos naturais.
Palavras-chave: *casca de jabuticaba; aproveitamento tecnológico; geléia; aceitabilidade; pigmentos; myrciaria.*

1 Introduction

The jaboticaba is a plant of the Myrciaria genus, native from Brazil; there are numerous species, well known in the Midwest and Southeast regions of the country (BRASIL, 2002). The tree has a large morphological variability from 3.4 to 5.6 m in height, ovoid, spherical or umbeliforme crown shape of 4.8 to 7.0 m in diameter, main stem with intense branching, compact dense or sparse foliage (JESUS et al., 2004). Fruits grow on the tree trunk (BRASIL, 2002), they are predominantly of intense dark purple color on the peel, firm-texture, pleasant appearance with sweet pulp of white-violet color (OLIVEIRA et al., 2003). They also present 1.5 to 3.1 seeds per fruit on average (JESUS et al., 2004). This fruit can be consumed fresh or used in the manufacture of jams, jellies, liquor or wine. Jaboticaba presents interesting nutritional values - 14.86 to 24.67 mg of ascorbic acid per 100 g of pulp (OLIVEIRA et al., 2003). Geòcze (2007) found levels of total phenolic compounds present in liquors of jaboticaba, as well antioxidant activity similar to those reported for wine, suggesting that the phenolic compounds in jaboticaba show antioxidant activity similar to the one of grapes.

Geòcze (2007) studied the fraction of phenolic compounds, ethyl acetate, extracted from alcoholic extract of red wine, discovering biological effects such as effective antioxidant activity, vasodilator activity in small vessels, as well as hypolipidaemic activity observed after chronic treatment in mice fed with hypercholesterolemic diet. Several studies have reported the association of cholesterol-lowering drugs and serum antioxidants in reversing diseases of cardiovascular origin.

Flavonoids are compounds whose chemical structure is formed by fifteen carbon atoms in basic nucleus, arranged in

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the configuration C6-C3-C6, with two aromatic rings linked by three units of carbon, which may or may not form a third ring. Catechin, quercetin, and Glabridin (AVIRAM; FUHRMAN, 2002) are among the most studied flavonoids. They are found in various foods from the human diet, as in apple, broccoli, grapes, tea and red wine; its bioactive substances have been investigated by many researchers around the world. The potential beneficial effect of phenolic compounds struturally present in flavonoids is related to many biological effects that go beyond this initial activity (SCHULDT, 2005).

Natural antioxidants are used as food preservatives controlling lipid oxidation in oils, fats and fatty foods (ANDREO; JORGE, 2006), relate the use pell of jabuticaba normally discarded by liquor industry and juices. The use peel of jaboticaba dried and mixed in foods increases nutritional value and the functional them (BOBBIO; BOBBIO, 2003).

Ascheri et al. (2006), relate the use pell of jabuticaba normally discarded by liquor industry and juices. The use peel of jabuticaba dried and mixed in foods increases nutritional value and the functional them.

Gondim et al. (2005), in order to encourage the full utilization of food determined by chemical composition of fruits peel, found that they contain higher levels of nutrients than the edible parts.

The peel of fruits are nutritionally important to the diet, they are economically viable and can perfectly be included in food. In order to encourage the use of food waste, this study aimed to develop jaboticaba jelly using the peel and to characterize it chemically and sensorialy.

2 Materials and methods

Fruits of jaboticaba (*Myrciaria* spp.) were harvested in Diamantina, located in Alto do Jequitinhonha valley, State of Minas Gerais. The fruits were harvested between October and December 2007, commercially fit for consumption.

These fruits were transported to the laboratory for Technologies and Biomass in the Cerrado (LTBC), Federal University of Jequitinhonha and Mucuri Valleys, JK Campus, where they were selected by eliminating the bruised and possibly damaged ones. The fruits were washed in running water, pulped manually and had the seeds removed in a Walita Master® microprocessor with polyethylene sheet and subsequent screening. Peel and pulp were packed, identified and frozen at -18 °C until use.

2.1 Physical characteristics of fruits

About 30 fruits were separated, randomized, were evaluated the mass: determined on an analytical balance and expressed in grams; diameters of fruits: quantifed with the help of the digital caliper rule and expressed in milimeters; percentage in pulp yield: calculated by mass difference of fruits, seeds and peels.

2.2 Formulations of jellies

Pulp and peel were thawed and mixed in three different proportions, Table 1. About 500-600 mL of filtered water was added to each formulation followed by grinding for 1 minute, and then completed to 1000 mL. The pH of the formulations was adjusted to 3.2 with the use of citric acid.

For the preparation of the jellies, each formulation was taken to simmer, where sucrose was added to obtain 65 °Brix (BRASIL, 1978). Then pectin was added and the mix was withdrew from the fire when it reaches the point of jelly, or in other words, by transferring a drop of jelly in a clear bowl with cold water by transferring a drop of jelly in a cup with cold water, without breaking. The jelly was then immediately transferred to glass jars with metal caps, closed, hot reversed, and quenched in water. The jellies pots were identified with labels and kept under refrigeration for further evaluation.

2.3 Sensory preference test

The research was carried out preferably in different formulations, Table 1, which were offered to two groups of panelists. The first group received the jelly with 0.5% pectin and the second with 1.0% pectin in 50 mL cups.

Each group comprised 40 untrained panelists, both men and women, in a total of 80 people. Participants were randomly selected from different age groups and social classes, they were not related to the investigators whatsoever, and signed an informed consent according to Resolution 196/96 of the Ministry of Health (BRASIL, 2003). The test was conducted in individual booths, where each panelist received three samples of jellies coded with random numbers and letters. The optimal formulation was determined by the preference test conducted according to the method described by Monteiro (1984).

2.4 Acceptability test

The favorite jellies were evaluated for acceptability through hedonic scale of five points based on the methodology of Miller (1984). In this study, we used 52 untrained panelists, chosen randomly, who, in individual cabins, received about 25 g of jelly. In order to evaluate the samples the form shown in Figure 1 was used.

2.5 Physicochemical and chemical characterization of peel, pulp, and favorite jaboticaba jelly

The peel, pulp, and favorite jaboticaba jelly were evaluated for: pH - determined by digital pH meter (pH/ION METER 450); total acidity (TTA) - determined by titration with NaOH according to standard analytical standards of Adolfo Lutz Institute (IAL, 2005); total soluble solids (TSS) - measured in bench refractometer and expressed as °Brix, with

Table 1. Ingredients (%) in three different formulations to obtain the jellies of peel of jaboticaba, UFVJM, Diamantina – MG, 2008.

Fotmulations	Peel	Pulp	Pectin	Sugar
F1a	80.0	20.0	0.5	50.0
F1b	80.0	20.0	1.0	50.0
F2a	20.0	80.0	0.5	50.0
F2b	20.0	80.0	1.0	50.0
F3a	50.0	50.0	0.5	50.0
F3b	50.0	50.0	1.0	50.0

[a]0.5% of pectin; [b]1.0% of pectin.

Table 2. Average values of the physical fruits of jaboticaba (n = 30), UFVJM, Diamantina – MG, 2008.

Parameters	Average values ± standard deviation	(%)
Mass of fruit (g)	6.59 ± 1.32	100.00
Mass of peel (g)	1.32 ± 0.04	20.03
Mass of seed (g)	0.27 ± 0.01	4.10
Mass of pulp (g)	5.00 ± 1.54	75.87
Length (mm)	20.85 ± 3.95	-
Diameter (mm)	22.73 ± 4.84	-

Acceptability test

Name:________________________________Data: ________

Age: ____ Gender: ( ) Female ( ) Male

You Smoke: ( ) yes (very) (low) (rarely) ( ) no

Please evaluate the sample using the scale below to describe how much you like or dislike the product with notes in accordance to the corresponding option:

5 ( ) I really enjoyed
4 ( ) I like
3 ( ) Do not like
2 ( ) I thought bad
1 ( ) I found bad

Suggestions/Comments:________________________________

Figure 1. Model for evaluating the acceptability of jaboticaba peel and pulp jelly through hedonic scale of five points.

all tests performed according to IAL (INSTITUTO..., 2005); chemical composition - moisture, total protein, fats, fiber, ash and carbohydrates - carried out according to methods by AOAC (1995); caloric value of the peel, pulp, and favorite jelly were calculated using the following conversion Atwater factors: 9 kcal.g^{-1} lipid, 4 kcal.g^{-1} protein and 4 kcal.g^{-1} carbohydrate (DE ANGELIS, 1977); phenolic quantified using gallic acid as standard (SINGLETON; ROSSI JUNIOR, 1965); and flavonoids were determined colorimetrically using the default pyrocatechin (ZHISHEN; MENGCHENG; JIANMING, 1999).

3 Results and discussion

The physical characteristics of jaboticaba in this study, Table 2, are within the range reported by Oliveira et al. (2003), with jaboticaba *Sabará* from different regions of the State of São Paulo, where the fruits presented the average mass between 3.56 and 7.40 g. The results were also similar to the mass of the fruits studied by Jesus et al. (2004), which ranged from 1.6 to 4.5 g, with jaboticaba *Sabará*.

The average fruit diameter was 2.27 cm, with value compatible to that found by Oliveira et al. (2003), also with jaboticaba in the region of Gravel-SP, with an average diameter of 2.33 cm. Jesus et al. (2004) studied four groups of jaboticaba *Sabará* according to morphological characteristics and found the value of 1.30 g of pell, which was similar to the results of this study.

The tested fruits showed high percentage of pulp (75.87%), similar to the highest values reported by Oliveira et al. (2003), who studied different varieties of jaboticaba and found 58.79 to 76.80% of pulp. According to the physicochemical analysis of the raw material, it seems that the peel contains a higher amount of nutrients that the pulp, these results were also reported by Gondim et al. (2005).

The TSS and TTA were 26.76 and 25.64 in the pulp and peel, respectively, higher than those found by Geòcze (2007), 16.30 and by Oliveira et al. (2003), 7.43 to 18.98 in the pulp of jaboticaba.

The levels of total titratable acids (TTA) were lower than those reported in the literature, varying from 0.88 to 0.96 g of citric acid.100 g^{-1} of pulp (OLIVEIRA et al., 2003; Geòcze, 2007). The fat contents were 0.92 and 0.13% in the peel and pulp of jaboticaba, respectively, and these results are similar to the peel of fresh fruits reported by Sato and Cunha (2007), 0.14 and 0.33%.

The results of total protein were 1.38 and 0.27% in the peel and pulp, respectively. According to the amount of crude fiber found in this work, jaboticaba peel can be classified as high dietary fiber food. Ordinance No. 27 from the National Agency for Sanitary Surveillance (BRASIL, 1998a,b) confirms this result because it considers food as a source of fiber providing when it contains at least 3 g.100 g^{-1} of fiber solids and a minimum of 1.5 g of fiber per 100 g of liquid food; and two times this percentage is required to classify foods as sources of high-fiber.

Fibers are recommended in the prevention and treatment of constipation, diverticular disease of colon and colon cancer. It also improves the speed of intestinal peristaltic movement. Moreover, it regulates blood glucose, blood cholesterol and triglycerides (FRANCO, 2003; CUPPARI, 2005).

The peel of jaboticaba proved to be rich in phenolics and flavonoids, surpassing the levels of these compounds found in fresh fruits.

Flavonoids from the peel were higher than those reported by Abe et al. (2007) in different cultivars of grapes, ranging from 1.26 to 34.60 mg catechin.100 g^{-1}.

The contents of phenols in peel exceeded those found by Schuldt (2005) in grape juice, 4.0 mg acid galic.100 mL^{-1}. Studies with phenolic compounds, and especially with flavonoids, demonstrated their antioxidant capacity and their significant contribution to the diet, as well as their effect on the prevention of various diseases such as cardiovascular disease, cancer and neurological disease (HARBORNE; WILLIAMS, 2000; SÁNCHEZ-MORENO, 2002).

It is known that within the large group of phenolic compounds, the flavonoids and phenolic acids are ones that stand out and are considered the most common phenolic antioxidants from natural sources. These substances are widely found in the plant kingdom in fruits and vegetables (KARAKAYA, 2004). Phenolic compounds present in fruits and vegetables, are the compounds responsible for such antioxidant activity. Its final content can be influenced by factors such as maturity, species, cultivation practices, geographic origin, stage of growth, harvest and storage processes (KIM; JEONG; LEE 2003).

The jellies chosen by the panelists through the preference tests (Table 4) were F1a and F3b. Jellies with the highest concentrations of peels (80 and 50%) received the scores, whereas no jelly with 20% of peel was chosen. This shows positive results due to the fact that the highest the percentage of peel in this jelly the increased its nutritional value (Figures 2 and 3).

The moisture content of the formulations, Table 5, were in accordance with the legislation (BRASIL, 1978), which establishes a moisture content of at most 38% w/w for fruit jellies. Thus, the jellies in this study presented moisture contents within this safety range, which prevents the growth of filamentous fungi and yeasts. The World Health Organization - WHO (2003) recommends an intake of fiber from 20 to 30 g per day. Thus, the consumption of 50 g of jelly with jaboticaba peel meets this recommendation in about 2,6%. In the human diet, fibers have beneficial physiological effects in reducing the risk and treatment of diverticular disease of the colon, cancer and diabetes mellitus. They increase satiety in food intake and the volume of stool, regulate metabolism and excretion of cholesterol (CUPPARI, 2005).

Mean values followed by same letter in the lines do not differ at 5% level of probability.

WHO (WORLD..., 2003) recommended that the diet contain about 60% of its energy (Kcal) provided by carbohydrates. Thus, an adult who consumes 2000 kcal a day and ingests 50 g of jaboticaba jelly will meet 12.56% of precondition.

The acidity of the jellies in the study were higher than the levels found by Mota (2006) for blackberries, 1.22 to 1.55 g of ac.citric.100 g^{-1}.

The studied jellies presented high levels of phenolic compounds, consistent with the content found in several varieties of grape jelly studied by Falcão et al. (2007), which ranged from 63.4 to 235.4 mg GAE.100 g^{-1}. The levels of flavonoids and phenolic produced in the jellies were lower than the values found in the peel of jaboticaba. However, the jellies still showed high levels of these compounds in comparison to levels in grape juice, which contained 0.39mg.100 mL^{-1} and 4.0 mg.100 mL^{-1} (SCHULDT, 2005).

For the final test for selection of jellies (F1a and F3b), 52.27% of judges were women, 47.73% were men, and they were all between the age of 18 to 54 years, 100% of the total consumers, knew jabuticaba. 93.18% of them appreciate jabuticaba, 77.27% of them already had proved some product made of Jabuticaba. The assessment of preference, 52.20% of the judges preferred the formulation F1a, while 47.73% chose the F3b, indicating that the highest concentration of peel F1a positively affected the quality of sensory attributes.In Figure 4 we can observe that the panelists gave scores equal to or greater than 4.0, showing that both samples had positive attributes, other attributes obtained 4.0 score.

Table 3. Average values (%) of the assessments of physical and chemical characteristics of the peel and pulp of jaboticaba used in the preparation of jellies, UFVJM, Diamantina – MG, 2008.

Constituents (%)	Peel	Pulp
Moisture	75.80 ± 0.37	88.77 ± 0.13
Dry matter	24.20 ± 0.37	11.23 ± 0.13
Ether extract	0.92 ± 0.11	0.13 ± 0.01
Protein	1.38 ± 0.13	0.27 ± 0.01
Fiber	8.00 ± 0.41	1.11 ± 0.23
Ash	0.54 ± 0.08	0.06 ± 0.01
Carbohydrate	13.36 ± 0.82	9.66 ± 0.21
Energy (kcal)	63.12 ± 2.37	40.09 ± 0.84
ATT (g acid citric.100 g^{-1})	0.31 ± 0.06	0.53 ± 0.05
TSS (° Brix)	8.10 ± 0.01	14.17 ± 0.15
TSS/TTA	25.64 ± 1.55	26.76 ± 3.17
pH	3.25 ±0.01	3.46 ± 0.01
Phenolic (mg galic acid.100 g^{-1})	1006.44 ± 149.06	45.74 ± 1.50
Flavonoids (mg catechin.100 g^{-1})	87.80 ± 13.46	2.96 ± 0.15

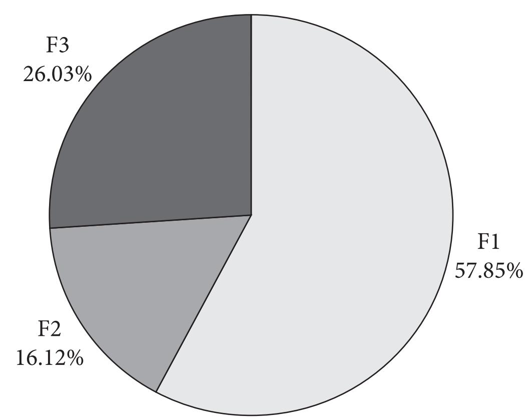

Figure 2. Percentage of preference test (n = 40) for the formulations of jaboticaba jellies with 0.5% of pectin with different concentrations of peel and pulp.

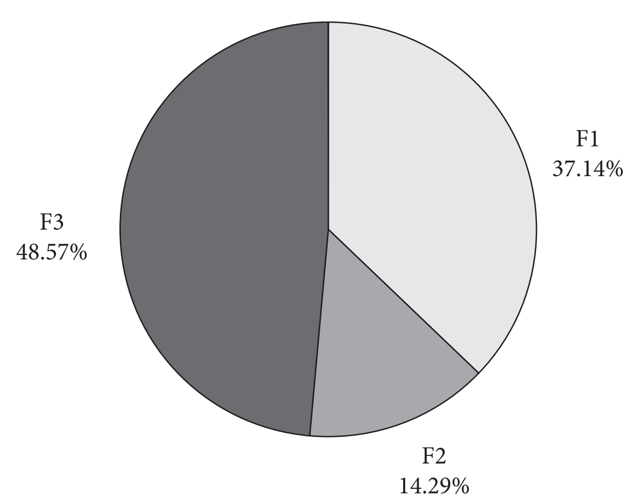

Figure 3. Percentage of preference test (n = 40) for the formulations of jaboticaba jellies with 1.0% of pectin with different concentrations of peel and pulp.

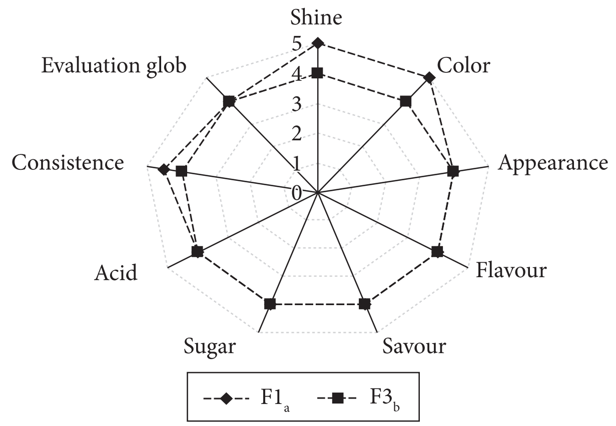

Figure 4. Sensory characteristics of jaboticaba jellies average scores apportioned by panelists (n = 52).

Table 4. Preference (%) by judges the formulations of the jellies of jabuticaba peels.

Formulations	Peel (%)	Pulp (%)	Preference (%)
F1 a	80.0	20.0	57.85
F1 b	80.0	20.0	37.14
F2 a	20.0	80.0	16.12
F2 b	20.0	80.0	14.29
F3 a	50.0	50.0	26.03
F3 b	50.0	50.0	48.57

Table 5. Average values (standard deviation) of physicochemical evaluations of the preferred jellies made with the peel of jaboticaba, UFVJM, Diamantina – MG, 2008.

Constituents (%)	$F1_a$	$F3_b$
Moisture	22.63 ± 1.80^a	22.88 ± 1.23^a
Dry matter	77.37 ± 1.80^a	77.12 ± 1.23^a
Ether extract	0.24 ± 0.04^a	0.26 ± 0.02^a
Protein	0.22 ± 0.02^a	0.19 ± 0.01^a
Fiber	1.45 ± 0.63^a	1.08 ± 0.30^a
Ash	0.09 ± 0.03^a	0.09 ± 0.01^a
Carbohydrate	75.36 ± 1.68^a	75.50 ± 1.28^a
Energy (kcal)	303.87 ± 6.59^a	304.54 ± 5.24^a
ATT (g ac. citric.100 mL^{-1})	1.98 ± 0.17^a	1.67 ± 0.08^b
Phenolic (mg ac. galic.100 g^{-1})	216.44 ± 1.36^a	148.44 ± 8.30^b
Flavonoids (mg catequina.100 g^{-1})	10.42 ± 0.76^a	12.10 ± 1.36^a

The F1a formulation stood out with the highest scores for brightness, color and consistency. This sample had a higher percentage of peel, which indicated that the peel added positively to the attributes.

The average scores and the frequency of responses for both jellies are shown in Table 6.

According to the survey of acceptability several panelists attributed scores higher than or equal to 4, which can highlight the wide acceptance of sensory quality of the jellies.

Table 6. 52 marks awarded by the assessors of $F1_a$ and $F3_b$ formulations and the frequency of responses in search of the degree of acceptability by the panelists, UFVJM, Diamantina – MG, 2008.

Formulations	Note	Frequency of responses (%)	
		≤3 points	≥4 points
F1a	4.0 ± 1.12	23.26	76.74
F3b	4.0 ± 0.65	11.91	88.09

F1a = 80% peel and 20% pulp; F3b = 50% peel and 50% pulp.

Both F1a, F3b are considered accepted and with an acceptance of 80%. According to Teixeira et al. (1987), food product with index of acceptability more 70% may be considered acceptable.

The results of the sensory evaluation showed that jellies containing the peel of jaboticaba had sensory quality characteristics that allow for its use as raw material in preparing jellies.

4 Conclusions

The peel of jaboticaba is attractive regarding its nutritional, functional and sensory aspects. The concentration of nutrients in the peel is greater than in the pulp. The jaboticaba peel is rich in fiber and it is a source of polyphenols and flavonoids. The jaboticaba peel can be used as feedstock for the production of jelly with sensory quality, nutritional and functional values.

The preoared jellies proved to have sensory quality, and nutritional and functional values, allowing to minimize waste, besides being a good source of polyphenols and flavonoids.

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