DEVELOPMENT AND CHARACTERIZATION OF TAHITI LEMON AND CRAVO JELLY

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The objective of this study was to develop and characterize lemon jellies using fruit albedo pectin. The jellies were elaborated with two cultivars of lemon (Tahiti and Cravo) and two types of pectin (albedo and industrial). The steps were reception and selection, washing and sanitization, juice extraction, formulation, preparation of albedo pectin, cooking and concentration, packaging, thermo-inversion, cooling, labeling and storage. The jellies were characterized as to pH, titratable acidity, soluble solids, coloration, yield, texture profile, moisture, microbiological and sensorial analysis. The applied treatments did not influence the yield, elasticity, luminosity, b* value, soluble solids and moisture of the jellies. There was an isolated influence of the pectin factor on the adhesiveness, cohesiveness and pH and interaction between pectin and lemon factors for a* value, hardness and titratable acidity. The elaboration of Tahiti and Cravo lemon jelly allows us to obtain satisfactory final product regarding the coloration, texture, pH, titratable acidity, soluble solids, moisture, yield and with good sensorial acceptance characteristics, with an average above 7.0. The use of lemon albedo satisfactorily replaces industrial pectin, showing to be a viable alternative to the use of this byproduct in addition to reducing the processing cost.

Keywords: *Citrus latifólia Tanaka*; *Citrus limonia Osbeck*; by-product; albedo.

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1. INTRODUCTION

Brazil ranks third in the world ranking of fruit producing countries, with a production that has surpassed 40 million tons in recent years. Agribusiness has been emphasizing citrus due to the expansion of the market and the improvement of the sector (Andrade, 2017).

Citrus plants are part of the genus Citrus, from the Rutaceae family and the subfamily Aurantioidae. Lemons and acidic limes, such as Tahiti [Citrus latifolia (Yu. Tanaka) Tanaka] have a higher acid content. Hybrid lemons were also found, such as Cravo lemon (Citruslimonia Osbeck), a natural hybrid formed from mandarin (C. reticulatasensu Swingle) and true lemon (C. limon (L.) Burm. f.] (Wrege et al., 2006; Rebequi et al., 2009).

Among the most consumed lemon cultivars, the Tahiti lemon and the Cravo lemon are fruits of high productivity that can be harvested all year round. However, due to the high availability and the low market price, many losses and cultivar waste occur. Thus, processing may be a viable alternative to reduce losses and add value to the lemon, as in the preparation of jellies, the second most commercially relevant product for the Brazilian fruit canning industry (Caetano, 2010).

Jelly is the product obtained by cooking whole fruits or pieces, or pulp or fruit juice, with sugar and water and concentrated until reaching a gelatinous consistency, being able to undergo the addition of glucose or invert sugar (Brazil, 1978).

However, the volume of material discarded by the industries that process lemon is, on average, 45% of the fruits. This residue has great potential to be used as an excellent raw material for the pharmaceutical, food and feed industries (Vilas Boas, 2001), thus justifying the development of products with lemon albedo instead of industrial pectin. The albedo is the white fibrous part that is found internally to the fruit peel, it is rich in pectin, a polysaccharide found in the albedo of citrus fruits, that can be used to add value to other products. In Minas Gerais, the albedo of these species is already being used for handmade confectionery (Godoy et al., 2005). The application of lemon by-products in the preparation of jellies has been studied and it was verified that it is possible to obtain jelly with adequate physical-chemical quality and good sensory acceptance (Masmoudi et al., 2010).

Considering the physic-chemical characteristics of the lemon, together with its local availability, the lack of its derivatives in the market and the possibility of adding value to the fruit, the objective of this work was to develop and characterize Cravo and Tahiti lemon jellies using industrial pectin and albedo.

2. MATERIAL AND METHODS

The experiment was developed at the Federal Institute of Education, Science and Technology, campus Barbacena - MG, industrialization and vegetable processing sector, physicochemical analysis laboratory, sensorial analysis and microbiological food analysis.

Obtaining Lemon Albedo pectin

The preparation of this pectin followed the stages of reception and selection of the lemons; pre-washing and sanitizing in sodium hypochlorite solution 100 mg L^{-1} for 10 minutes; separation of the albedo from the epicarp with a grater; cooking for 10 minutes in stainless steel cookware with enough water to cover the albedo and addition of sodium bicarbonate (15 g L^{-1}). After cooking the albedo was washed in tap water to remove the bicarbonate, then crushed in a blender and reserved for use.

2.1 Manufacture of jellies

The lemons were selected, pre-washed, sanitized, as previously described and the juice extracted in a Vitalex electric juicer, with the seeds discarded. The formulations are presented in Table 1 and included the following treatments: jellies with two lemon cultivars (Tahiti and Cravo) and two types of pectin (albedo and industrial).

Table 1 - Lemon jelly formulations

Ingredients	Industrial pectin (%)	Albedo pectin (%)
Lemon Juice (mL)	10	10
Sugar (g)	35	35
Pectin (g)	01	10
Water (mL)	54	45

The cooking and concentration of the ingredients were conducted until the final point was obtained, determined by the spoon test, observing the consistency of gel formation. The still hot jelly was quickly packed into 230 g capacity glass jars, pre-sterilized by boiling for 30 minutes, and the metal lids for 10 minutes. The hermetically sealed packages were thermo-reversed for 3 minutes to sterilize the free space and the lid; then cooled to a temperature of approximately 40°C, labeled for identification of the treatments applied and finally stored at room temperature until the time of analysis; on average 10 days.

2.2 Analysis

Analyses of color, pH, titratable acidity, soluble solids content, texture, moisture and yield were carried out in the jellies.

Color: determined with Konica Minolta CR400 colorimeter, using the previously calibrated L* a* b* (CIELAB) color scale system. The parameters L, a * and b * were determined according to the International Commission on Illumination (CIE, 1996). The a* values characterize the coloration in the region of red (+ a*) to green (- a*), whereas the value b* indicates coloration between the range of yellow (+ b*) to blue (- b*). The L value provides the brightness, which varies from white (L = 100) to black (L = 0) (Harder, 2005).

Texture: via the TA.XT (Stable Micro Systems) texturometer, according to AACC methodology (ABI, 2007). The operating conditions of the equipment were: cylindrical "probe" aluminum sensor with diameter of 3.3 cm, test speed 2.0 mm/s, distance 10.0 mm and force 1.0 g. For compression analysis, 100 g of jelly were used for each measurement. The parameters of firmness, cohesiveness, elasticity, adhesiveness, gumminess and chewing were evaluated (Pons, Fiszman, 1996).

pH: determined using TEKNA T-1000 pH-meter according to methodology proposed by Instituto Adolfo Lutz (IAL, 2008).

Titratable acidity (AT %): determined by titration according to the methodology proposed by the Adolfo Lutz Institute's Analytical Standards (IAL, 2008). 10 ml of the prepared sample was transferred to a 125 ml Erlenmeyer flask, adding 90 ml of distilled water and 2 to 4 drops of the phenolphthalein solution. The solution was then titrated with 0.1 M sodium hydroxide.

Soluble solids content (SS %): determined using the refractometry method using an Instrutherm RTD-45 refractometer (IAL, 2008).

Moisture: determined by gravimetry in drying oven and sterilization A4SE oil at 105°C until constant dry mass, according to the Adolfo Lutz Institute (IAL, 2008). 5 g of sample were weighed into porcelain capsules, then weighed into the oven with constant air circulation. The results were expressed in g 100 g-1.

Yield: determined using equation (1):

$$\text{Yield (\%)} = \frac{\text{Mass of jelly obtained x 100}}{\text{Mass of ingredients used}} \quad (1)$$

Microbiological Analysis: Mold and yeast counts: determined by the American Public Health Association (APHA) method (Silva et al., 2010). The result was compared to the limit established by Resolution - RDC No. 12 of January 2, 2001 (Brazil, 2001) establishing microbiological standards for food.

Sensory Analysis: this work was approved by the ethics committee of Southeast MG IF, number CAAE: 70889317.6.0000.5156. The acceptance test was applied according to the methodology described by Minim (2006) with 50 non-trained testers of both sexes in the sensory analysis laboratory of the Southeast IF campus MG Barbacena. The jelly samples, coded with three-digit numbers, were served with toast and a glass of 100 ml of water for cleaning the palate between sample evaluations. The attributes of color, odor, flavor, texture and overall acceptance were evaluated through a structured nine-point hedonic scale, with extremes at 1 - "extremely displeased" and 9 - "extremely enjoyed". The purchase intention analysis was also applied using a 5 - point scale ranging from 1 - Certainly we would not buy to 5 - Certainly would buy.

Statistical analysis

A completely randomized design in a factorial scheme was used, with the jellies elaborated with two lemon (Tahiti and Cravo) cultivars and two pectin types (albedo and industrial), with three replicates. The data were submitted to analysis of variance (ANOVA) and the means were compared by the Tukey test at 5% significance in the Sisvar 5.3 program (Ferreira, 2010).

3. RESULTS AND DISCUSSIONS

Color: L* value: The variable L*, which represents the luminosity, varying from white (L* = 100) to black (L* = 0) was not influenced by any of the evaluated factors, presenting a general average of 31.54.

The lightness of the jellies was lower in relation to the luminosity of the raw material used (lemon juice). This fact may have occurred because the luminosity is related to the soluble solids present in the product (Moro et al., 2013). The lower luminosity can also be explained by the oxidation reactions of ascorbic acid and caramelization, which occurred during the processing of the jellies, resulting in darkening (Fellows, 2006).

Value a*: There was a significant effect of the interaction of the cultivar factors of lemon x pectin for the a* value of the studied jellies. Table 2 shows the results of the factor unfolding.

Table 2 - Deposition of the lemon and pectin factors of the a * coloration of the lemon jellies.

		Lemon	
		Tahiti	Cravo
Pectin	Industrial	-0.203 bB	0.196 aA
	Albedo	-0.353 bA	0.330 aA

* Means followed by same letters, lower case in the lines and upper case in the columns, are statistically equal by the test of Tukey to 5% of significance.

As for the development of lemon cultivars in each pectin, there were differences for the two pectins, with the Cravo lemon jams presenting higher a* values for albedo pectin than for industrial pectin, indicating reddish coloration.

In the evaluation of the jellies for the pectin factor in each lemon cultivar, there was a significant difference in the a* value only for Tahiti lemon jellies, presenting higher value for those made with albedo pectin than those manufactured with industrial pectin, both indicating greenish coloration. In general, when only lemons are evaluated, the value of a* (0.263) lemon jelly has an average value greater than Tahiti (-0.278), consistent with the color of the raw material (juice) used Table 2. In general, the coloration of the jellies was different from the juices which may have occurred due to the dilution with the other ingredients and the heat treatment of the cooking. In the evaluation of pectin alone, Jellies made with albedo pectin had an average value of a* (-0.012); industrial pectin (-0.004).

Value b:* There was no significant difference between the treatments applied, nor interaction between the factors for the b* value of the jellies studied. The mean of the treatments was 6.02, showing a predominance of a more yellowish color.

Texture: The most used texture parameters in jellies are hardness, cohesiveness and elasticity, also mentioning adhesiveness (Xavier, 2008), all of which are evaluated in this study.

Hardness: According to Szczesniak (2002), the hardness (H) is the force necessary to reach a certain deformation and can also be called firmness. In sensory analysis, it is defined as the force required to compress a food between molar teeth at the first bite (Minim et al., 2000).

There was a significant effect of the interaction of the lemon x pectin cultivar factors on the hardness of the jellies studied. Table 3 shows the results of the factor unfolding.

There were differences in the hardness of the two pectin in the formulations with industrial pectin. Tahiti lemon jellies had higher values and in the formulations with albedo pectin the Cravo lemon jellies had higher hardness as can be seen by the Tukey test. In the evaluation of the jelly for the pectin factor in each lemon cultivar, there was a significant difference in the hardness only for Tahiti lemon jellies, with those made with industrial pectin having higher hardness than those made with albedo pectin.

Table 3 - Deposition of the lemon and pectin factors of the hardness (Newton) of the lemon jellies.

		Lemon	
		Tahiti	Cravo
Pectin	Industrial	4.69 aA	2.03 bA
	Albedo	0.96 bB	1.20 aA

*Means followed by same letters, lower case in the lines and upper case in the columns, are statistically equal by the Tukey test to 5% of significance.

It was observed that Tahiti lemon jellies presented higher hardness (2.83 N) than those elaborated with Clove lemon (1.62 N) and when comparing only pectin, industrial pectin jellies presented higher hardness (3.36 N) than those made with albedo pectin (1.08 N). This variation is possibly due to the higher concentration of industrial pectin in relation to the albedo pectin, since the latter, even though it was added in greater proportion (Table 1), was elaborated in a handmade way. Values close to those of this study were identified for melon peel jelly and melon peel with the addition of orange juice (2.03 and 2.26 N) (Alves et al., 2016).

Adhesiveness: related to the force necessary to remove part of the food that is adhered to the mouth during chewing (Szczesniak, 2002). The greater the adhesiveness of the gel, the greater the difficulty of it being disintegrated in the mouth (Menezes, 2008).

There was an isolated influence of the pectin factor on the adhesiveness of the jellies. The jellies elaborated with industrial pectin presented higher adhesiveness (-4.44 N.s - Newton/second) than those made with albedo pectin (-1.39 N.s). This suggests that jellies with albedo pectin dissolve better in the mouth. Results similar to those reported by Alves et al. (2016) of -2.54 N.s and -3.38 N.s in jellied melon bark and melon bark with the addition of orange juice, respectively.

Cohesiveness: is the level of deformation of the sample between teeth before rupture, or how much food can be compressed before breaking (Szczesniak, 2002).

There was an isolated influence of the pectin factor on the cohesiveness of the jelly. Jellies made with industrial pectin presented higher cohesiveness (1.04) than those made with albedo pectin (0.88).

Lower scores have been reported. Xavier (2008), in studies with coffee jelly, obtained cohesiveness of 0.52 and Alves et al. (2016) obtained values of 0.47 and 0.06 for melon peel jelly and melon peel with the addition of orange juice, respectively.

Elasticity: Elasticity is defined as the ability of a deformed material to return to its initial condition after removal of the deformation force (Szczesniak, 2002).

The treatments of lemon and pectin cultivars did not influence the elasticity of the jellies, with a general average of 0.033. This value was lower than those reported by Xavier (2008), 0.91 in coffee jelly and Alves et al. (2016), 0.78 in melon peel jelly and 0.98 in melon peel jelly with the addition of orange juice.

pH: The pH of the samples was influenced by the pectin factor alone. Jellies made with albedo pectin presented higher pH (3.35) than those made with industrial pectin (3.15), indicating that the addition of sodium bicarbonate in the preparation of albedo pectin did not negatively interfere in the maintenance of pH of jellies.
The studied jellies follow the values cited by Torrezan (1998) which states that the gel is formed only at pH around 3 and at pH above 3.4 gelling does not occur.
Close values were reported by Gomes et al. (2013) and Silva et al. (2012), who obtained pH of 3.33 for passion fruit jelly with carrot and 3.3 for mixed pineapple jelly with passion fruit, including albedo, respectively.
Titratable acidity: As can be seen in Table 4, the titratable acidity (TA) of the jellies was influenced by the interaction between the lemon and pectin factors.
There was a difference between the pectin and pectin levels, but for both pectin and albedo pectin, Tahiti lemon TA was higher.

Table 4 - Deposition of the lemon and pectin cultivar factors of the AT (%) of the lemon jellies.

		Lemon	
		Tahiti	Cravo
Pectin	Industrial	1.10 aA	1.03 bA
	Albedo	1.11 aA	0.91 bB

*Means followed by same letters, lower case in the lines and upper case in the columns, are statistically equal by the Tukey test to 5% of significance.

In evaluating the AT of the pectin factor for each lemon cultivar, there was a significant difference only for the jelly elaborated with Cravo lemon, where the jelly made with industrial pectin showed higher TA than those elaborated with albedo pectin. For Tahiti lemon, the two pectin types presented statistically similar % TA. In a general comparison only among lemons, Tahiti lemon jelly was on average more acidic (1.11%) than Clove lemon (0.97%) and when comparing only pectin types, the Industrial pectin jellies presented on average higher acidity (1.07%) than albedo pectin (1.01%). According to Jackix (1988), the acidity should be between 0.5 and 0.8% and in jellies with acidity above 1% syneresis may occur. However, although the developed jellies were not stored, this characteristic was not observed.
Studies on jellies of different fruits found variation in acidity content such as 0.77% for passion fruit jelly with carrot (Gomes et al., 2013) and 1.23% for papaya jelly with araçá-boi (Viana et al., 2012). These differences may be related to differences in the formulation, acidity characteristics of the fruits used and also the concentration time employed.
Soluble solids (%): The soluble solids content was not influenced by any of the evaluated factors (pectin x lemon cultivar), with a general average of 80.21%.
According to Jackix (1988) in practice, the soluble solids content in a ready jelly ranges from 64 to 71%. The optimum sugar concentration is on average 67.5%. According to the legislation, the minimum total soluble solids content is 62% w/w; 65% w/w for common/extra fruit jelly, respectively (Brazil, 1978).
The value of soluble solids (80.21%) found in this study was higher than that reported by Gomes et al. (2013) of 65.75% for passion fruit jelly with carrots and

close to that found by Cardoso et al. (2010) in cherry tomato jelly of 77.6%.
In jellies with high soluble solids, caramelization may occur, considered a texture defect, since jellies with low content may not have gel formation. The studied jellies presented high soluble solids concentration, and for that reason an initial caramelization stage was observed.
Moisture: there was no significant difference between the treatments applied, nor interaction between the factors for the moisture of the jellies studied. The average of the treatments was 21.56%, agreeing with the legislation, which establishes maximum moisture value in common/extra fruit jelly, from 38% w/w to 35% w/w, respectively (Brazil, 1978).
Moisture content slightly higher than that of this work has been reported. Silva et al. (2012) obtained moisture of 25.8% in mixed pineapple jelly with passion fruit, including peel and Viana et al. (2012) found an average moisture of 27.6% for papaya jelly with araçá-boi.
Yield: there was no significant difference between the treatments applied, nor interaction between the factors for the yield of the jellies studied, indicating that the substitution by pectin of the albedo did not affect the yield of the jellies. The average of treatments was 36.18%, lower than that of Caetano (2010), who found an average yield of 55.28% in acerola jelly. However, this attribute can be influenced by different factors such as formulation, initial moisture content of the matter concentration conditions, soluble solids content of the final product, among others.
Microbiological analyzes: the results indicated that the elaborated jellies comply with the legislation regarding the microbiological standards.
Acceptance test: There was no effect of any of the evaluated factors (lemon, pectin and interaction between lemon and pectin) for the attributes of color, odor, texture and overall impression of the jellies. The values of the general averages obtained are presented in table 5.

Table 5 - General averages obtained in the acceptance test of lemon jellies.

Attribute	Color	Odor	Texture	Global impression
Score	7.84	7.40	7.60	7.37

This result indicates that the cultivar of lemon or the type of pectin used in the elaboration of the jellies did not influence their acceptance. The average score above 7.0, "moderately enjoyed", on the hedonic scale indicates good sensory acceptance as to attributes of color, odor, texture and overall impression.

The flavor was influenced in isolation by the pectin factor. The jelly made with industrial pectin showed higher sensory acceptance represented by a higher mean (7.46) than that of the lemon albedo (6.89). The industrial pectin jellies presented lower pH and higher acidity than those made with albedo pectin (Table 5), suggesting that the more acidic jelly has a greater acceptance as to the flavor, although for the sweetness, the jellies presented average SS content of 80.21%.

Considering the average of 7.0 obtained in the evaluated attributes, one can affirm that lemon jelly is a product with market potential and that it meets the new demands of innovative and sustainable products.

The purchase intention was influenced only by the pectin factor. The results indicated that jellies with industrial pectin showed higher purchase intent (3.88) than those made with albedo pectin (3.53). Considering that score 3 corresponds to ‘maybe would buy’ and score 4, would possibly buy’, the industrial pectin jelly may have a greater market chance, possibly because of the higher acceptance of the taste identified in the acceptance test. However, the jellies of pectin types fall within score 3 (maybe would buy).

CONCLUSION

The elaboration of Clove and Tahiti lemon jelly allows us to obtain satisfactory final product regarding the characteristics pH, titratable acidity, soluble solids, moisture and yield. The sensorial analysis indicated that the lemon jellies of the two cultivars and pectin types show good sensory acceptance with an average of more than 7.0. Although lemon albedo pectin satisfactorily replaces industrial pectin in the preparation of Tahiti and Cravo lemon jellies.

Resumo:

O objetivo desse estudo foi desenvolver e caracterizar geleias de limão utilizando pectina do albedo dos frutos. As geleias foram elaboradas com duas cultivares de limão (Tahiti e Cravo) e dois tipos de pectina (albedo e industrial). As etapas foram recepção e seleção, lavagem e sanitização, extração do suco, formulação, preparo da pectina do albedo, cocção e concentração, envase, termo-inversão, resfriamento, rotulagem e armazenamento. As geleias foram caracterizadas quanto a pH, acidez titulável, sólidos solúveis, coloração, rendimento, perfil de textura, umidade, análise microbiológica e sensorial. Os tratamentos aplicados não influenciaram o rendimento, elasticidade, luminosidade, valor b*, sólidos solúveis e umidade das geleias. Ocorreu influência isolada do fator pectina para a adesividade, coesividade e pH e interação entre os fatores pectina e limão para o valor a*, a dureza e acidez titulável. A elaboração de geleia de limão Tahiti e Cravo permite a obtenção de produto final satisfatório quanto as características coloração, textura, pH, acidez titulável, sólidos solúveis, umidade, rendimento e com boa aceitação sensorial, com média superior a 7,0. A utilização do albedo do limão substitui satisfatoriamente a pectina industrial, mostrando-se uma alternativa viável para o aproveitamento deste subproduto além de reduzir o custo de processamento.

Palavras-chave: *Citrus latifólia Tanaka*; *Citrus limonia Osbeck;* subproduto; albedo.

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