**Physicochemical characterization and sensory evaluation of jellies made with guava peels (Psidium guajava L.)**

Guava (Psidium guajava L.) is a typically tropical and subtropical fruit, widely consumed in Brazil, as fresh fruit or in the form of processed products (Lima et al., 2002). It is estimated that nearly 70% of guava production is destined to industrialization (FrutiSéries 1, 2001), and agro-industries are further investing in increased production capacity. The industrialization results in increased quantities of generated co-products, which in many cases are considered operating costs for enterprises or as environmental pollution source (Bartholo, 1994). According to Junior et al. (2006), 40% of fruit industrialization is agricultural residues. In many cases, like in guava industrialization, the waste presents an interesting nutritional profile (4.8% protein, 2.4% ash, 1.4% fat, 22.2% carbohydrates and 9.3 of moisture) (Martínez et al, 2012), containing, approximately, 50% of dietary fiber (Jiménez-Escrig et al, 2001), and could be used as a raw material to other products.

Many studies (Oliveira et al., 2002; Nascimento et al., 2003; Royer et al., 2006) proposed the use of certain waste, such as peels and seeds, with adhered pulp for the manufacture of sweets in syrup, mass and jams, as these processes add value to co-products, resulting in nutritional products with good sensory acceptance. In addition, there is guaranteed and frequent market for these kind of product in Brazil, where sweets and jams consumption is expressive, especially in Minas Gerais state.

For processing jellies are used soluble extracts of edible plant parts, with added water, sugar and pectin (0.5 to 1.5%) and adjust the pH between 3 and 3.4, as necessary. The addition of other ingredients and additives obtain suitable consistency to ensure stability of product (Policarpo et al., 2007).

Thereby, the present study was developed to evaluate the use of guava peels extract in jelly production by assessing the effects of factors: extract/sugar ratio, citric acid...
Table 1. Full Factorial design used for the preparation of jams

<table>
<thead>
<tr>
<th>Treatments</th>
<th>E/S (kg/kg)</th>
<th>AC (g/Kg)</th>
<th>PC (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x₁</td>
<td>x₂</td>
<td>x₃</td>
</tr>
<tr>
<td>1</td>
<td>+</td>
<td>60/40</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
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<tr>
<td>3</td>
<td>+</td>
<td>60/40</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>40/60</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>+</td>
<td>60/40</td>
<td>+</td>
</tr>
<tr>
<td>6</td>
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<tr>
<td>7</td>
<td>+</td>
<td>60/40</td>
<td>-</td>
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<tr>
<td>8</td>
<td>-</td>
<td>40/60</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>50/50</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
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<td>50/50</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
<td>50/50</td>
<td>0</td>
</tr>
</tbody>
</table>

where: E/S: ratio extract/sugar; AC: citric acid concentration; PC: pectin concentration
xᵣ = coded variable Xᵣ = real variable

concentration and pectin content on the physicochemical, physical and sensorial properties of different formulations.

MATERIAL AND METHODS

Raw materials

Guavas were donated by FRUTILAVRAS (fruit growers Association of Lavras, Minas Gerais, Brazil) from the 2008/2009 season. The citrus pectin (Vetec brand), citric acid (Vetec brand) and refined sugar (União brand) were purchased from local market.

Processing Jellies

Fruits were washed and sanitized for 15 minutes in 200 ppm chlorine solution. Guavas were manually peeled, pulp were separated from peel and seeds, and both parties were subjected to five minutes bleaching in drinking water at 100°C to inactivate the peroxidase enzyme (Matsumo and Uritane, 1972). The peels were then disposed to bleaching water elimination, were frozen, packed in plastic polyethylene bags and stored at -18°C, for three days, until the time of use.

For the preparation of jellies, peels were first boiled in water with a ratio of 2:1, with the goal of extracting the maximum amount of soluble pectin, and ground in a industrial blender, on high rotation, until to obtain a smooth textured mass. This mass was filtrated in hand press (Macanuda, Brazil) for separating a clear statement, free of pieces of fruit, which was used in the jams preparation.

The extract, sugar and pectin (diluted with water in ratio 1:2) were mixed in an open pan of stainless steel (Macanuda, Brazil) and cooked to the end point of the jam (65 ° Brix). Diluted citric acid (1:2 in water) was added at the end point of process. Ingredients proportions, for each treatment, is shown in Table 1 (Box and Draper, 1987).

The products were packed in glass vials, each one with 250g of capacity, sterilized at 100°C/15 minutes (Granada et al., 2005), and sealed with metal caps. They were then filled with jam and have undergone heat treatment for 15 minutes in a water bath at 100°C, with subsequent cooling for 15 minutes in water at 10°C. Finally, they were stored at room temperature (25°C) until the time of analysis.

Experimental design

Complete randomized design (CRD) full factorial for a higher extraction yield, with three sources of variations, three levels in each, and three repetitions at the central point, totaling 11 treatments, as shown in Table 1 (Box and Draper, 1987).

The concentration of acid is represented as the amount of acid (g) per kg of added sugar, and pectin concentration calculated as the percentage of the total weight of the peel extract used.

In order to evaluate the effect of the variable and the interaction between them, a multiple linear model was estimated as shown in equation 1.

\[ Y = a + bx_1 + cx_2 + dx_3 + ex_1x_2 + fx_1x_3 + gx_2x_3 + \epsilon \] (1)

where \( a, b, c, d, e, f, g \) are the regression coefficients, \( Y \) is the response variable, \( x_1, x_2 \) and \( x_3 \) are independent coded variables (ratio of extract/sugar, citric acid concentration and pectin concentration) and \( \epsilon \) is the experimental error.

The coefficients \( e, f \) and \( g \) represent the significance of the interaction between the independent variables. The criterion for acceptance of the proposed model was based on the value of the determination coefficient (R²), the considered explanatory model for R values above 70%. The significance of the estimates for the coefficients were analyzed in order to determine which factor contributed to the best model fit in a 0.05 significance level.
Figure 1: Effect of pectin and extract/sugar concentration on total sugar content of jellies made with guava peels.

Ratings physical and physicochemical

Analyses of jellies were performed according to AOAC (2000), official methods, and data were expressed as mean ± standard deviations of at least triplicate determinations. The pH was determined in digital pH meter Tec-3MP (TECNAL, Piracicaba, Brazil); titratable acidity by titration (TTA) with 0.1N NaOH in the presence of phenolphthalein; total sugar (TS) by titration with Antrona reagent; and water activity (Aw) determined in unit 3TE Aqualab (Decagon Devices Inc., WA, USA).

The color of the jellies was measured using colorimeter Konica Minolta CR 400 (Minolta Corporation, Osaka, Japan), with direct reading of the CIELAB values: "L*" (brightness ranging from black (0) to white (100)) and "a*" (greenness (-) to red (+)).

Sensory analysis

The sensory acceptance test was adopted from methodology described by Stone and Sidel (2004), with evaluation of parameters: appearance, color, aroma, flavor, texture and global impression, from hedonic scale of nine points, where: (1) = disliked extremely, (5) = indifferent and (9) = liked extremely. The tests were conducted with 50 potential untrained consumers recruited from among the students and staff of both sexes, from the Federal University of Lavras (UFLA). Samples were presented randomly in disposable containers, identified by three digits. The experiment was carried out in individual booths under white light. Ethics Committee was not necessary for sensory analysis at the time of carrying out the work (2007).

Statistical analysis

The results of the physicochemical and physical analyzes were evaluated by response surface methodology employing the Statistica 5.0 software (StatSoft, Poland).

The results of sensory evaluation were submitted to nonparametric Kruskal Wallis test in order to verify if there was difference in the acceptance of 9 jellies formulations. Statistical analyses were performed with the help of R software, version 2.8.1 (2008). Means were considered significant at %.

RESULTS

Significant differences between means (P-value < 0.05) were observed only for total sugar (TS), influenced by all independent variables and the E/S x PC interaction, and total titratable acidity (TTA) values, influenced by citric acid concentration, from variance analysis at 5%.

Equation 2 represents the total sugar concentration in function to extract/sugar and pectin concentration. The acid concentration was kept at the central point, and obtained coefficient of determination (R²) equal to 75%.

Figure 1 shows the response surface generated by this model.
According to the described model, total sugar variation is mainly explained by the E/S ratio, pectin amount and the interaction between them. Model validation was obtained by estimates of these variables significance (P-value<0.05) when compared to the null model. Observing the values obtained in the analysis, it is noted that an increase in the concentration of pectin and decrease in E/S, or increase in the amount of added sugar, increase the percentage value of total sugar. The interaction between the factors E/S and pectin causes a decrease in the total concentration of sugar, which can be explained by the formation of stable fiber between pectin and sugar.

As expected, the acidity was affected only by the acid concentration, a result similar to that found by Nascimento et al. (2003), who developed formulations for fresh passion fruit albedo with the addition of acidifying agents. The model adjusted for TTA was not considered explanatory because the determination coefficient was less than 70%.

The other answers for pH, water activity (Aw) and color (L*, a*, b*), were not affected by the independent variables levels.

Results from sensorial evaluation are show in Table 2. The parameters that have the same letter are not statistically different between formulations. Treatment 9 represents the average of treatments 9, 10 and 11.

There was no significant difference between treatments 1, 3, 5, 7 and 9 for the appearance attributes, color and overall impression, usually with score between 6 and 7, indicating that the tasters little to moderately liked products, while jellies 2 and 6 have the lowest average values for these attributes, meaning that the tasters did not like thereof. In assessing the taste, 1, 3, 4, 5, 7 and 9 jellies obtained the highest scores, also in the range of liked little to like moderately, while the jelly 6 had lower score (indifferent to like slightly). For the texture attribute, preferably jellies were 1, 3, 5, 7, 8 and 9, holding the medium between 6 and 7, a factor which matches the preference found by Folegatti et al. (2003) for umbu jellies produced with higher pulp in relation extract/sugar, and jelly 6 had the lowest score. Evaluating the aroma, the panel found no differences between the tests 1, 5, 7 and 9, which enjoyed little moderately, and test 6 lower average received.

**DISCUSSION**

The physicochemical analyzes show that the pH after processing was lower in comparison to the interval 3.72 to 4.22 obtained by Lima et al. (2002) for guava in nature, which can be associated with the addition of citric acid to the formulation. However, the pH remained within the established value by Rauch (1965), cited by Cardoso (1994), equal 3.2, important point for gel formation and to prevent microbial growth. The titratable acidity remained within the range found for these same authors for fresh fruit, between 0.4% and 1.4% citric acid, and also within the range obtained by Cavalini et al. (2006) in guava variety Paluma equal 0.47% to 0.78% citric acid. The water activity (Aw) showed values close to that found by Sousa et al. (2003) (0.892) in osmotically dehydrated guava in vacuum sucrose solution at 65%, and also with the means found for sugar-free guava jam added of prebiotics (0.90) (Mesquita et al., 2013), though lower than the value of 0.99 reported by Sato et al. (2004) for the fresh fruit, due to the increase in sugar concentration during the cooking process.

It can be seen that the physicochemical properties measured were within the range of values to ensure good stability of the gel at room temperature, as shown in other studies (Policarpo et al., 2003; Lago et al., 2006; Mota, 2006).

The total sugar increased by reducing the ratio of extract/sugar and the pectin concentration increased due to the increase of sugar in the formulation. Addition of pectin in the formulation of jellies reduced the cooking time, browning reactions caused by high temperatures, and finally resulted in a greater amount of non-invert sugar (Jackix, 1980).

Although not differ significantly for the color parameters

\[
TS = 49.29 + 2.75x_1 - 2.11x_3 - 1.94x_1x_3 \quad (2)
\]

Table 2. Sensory parameters comparison of 9 guava peel jelly formulations by Kruskal Wallis test

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Appearance</th>
<th>Color</th>
<th>Aroma</th>
<th>Tasty</th>
<th>Texture</th>
<th>Global imp.*</th>
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<tr>
<td>1</td>
<td>a</td>
<td>ab</td>
<td>a</td>
<td>a</td>
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<tr>
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<td>f</td>
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<td>a</td>
<td>ab</td>
<td>ab</td>
<td>a</td>
<td>ab</td>
</tr>
</tbody>
</table>

*Global impression; same letter means that the averages evaluating are not statistically different from each other (P-value < 0.01).
(P-value > 0.05), it can be seen that the values of and underwent some changes to obtain lower values for brightness with the use of smaller proportions extract/sugar, probably due to the sugar browning reactions which results in slight browning (Miguel and Belloso, 2000). For the formulations with lower pectin values, it was also observed lower values for the parameter (red intensity), which may be due to the fact that the product has needly higher heating to achieve the desired concentration, resulting in degradation of lycopene, the main pigment of this fruit (Padula and Rodrigues, 1987).

Based on experimental design, it can be observed that the differences in scores between samples are mainly due to the concentration of extract/sugar, obtained higher scores for all attributes assays with higher amounts of extract (60/40 and 50/50) due to the contribution of the soluble constituents of the fruit itself, which enriches the jelly aroma and flavor. Similar trends were obtained by Lago et al. (2006) working with jambolan jelly, which presented more palatable to the proportion of 60/40 pulp/sugar. In jellies sensory evaluation umbu produced with proportion pulp/sugar equal 50/50 and 40/50, Folegatti et al. (2003) also had better sensory acceptance for treatments produced with higher pulp (50/50), which showed greater acceptance as the color, appearance and texture. According to the authors the color appeared less dark, which can be explained by the lower intensity of caramelization reactions of sucrose. Analyzing the jellies 2 and 6, which received the lowest scores for all sensory attributes, it is clear that besides the factor extract/sugar, the highest concentration of acid probably promoted hydrolysis of pectin, resulting in a less firm texture of jelly beyond more acidic taste (Jackix, 1988).

**CONCLUSION**

The variables significantly influenced the total sugar values and titratable acidity of the formulations, and the jellies produced with higher extract showed greater acceptance as the sensory attributes. The overall results, considering economic factor (non-use of pectin) indicate the use of balanced extract/sugar equal to 60/40 and 5.5 g/kg citric acid to optimizing production from jellies peel guava.

**Conflicts of interest**

The authors declare no conflicting interest on this manuscript.

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