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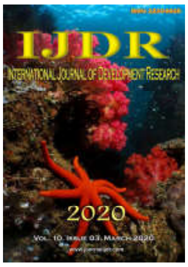

RESEARCH ARTICLE

OPEN ACCESS

SENSORY AND MICROBIOLOGICAL QUALITY OF GUAVA JAM WITH ADDED CONCENTRATED GRAPE JUICE

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ABSTRACT

The aim of this study was to evaluate the microbiological and sensorial quality of guava jam functionalized by the addition of concentrated grape juice. Two formulations were prepared: guava jam enriched by the addition of concentrated grape juice in the proportion of 30% (w/w) (SF), with sucrose, and guava jam enriched by the addition of concentrated grape with no added sugar (DF), in which sucrose was replaced by a commercial blend of sweeteners. Sensory analysis was performed with 120 untrained panelists using a 9-point Hedonic Scale Test, to evaluate attributes of color, aroma, flavor, texture and overall liking of samples, in addition to a Paired Test and a Purchase Intent Test. Both formulations were microbiologically safe and showed promissory sensory acceptance, although DF had less acceptance than SF, which was the panel's preferred sample. Furthermore, color acceptance was positively correlated with instrumental color intensity, evidencing the importance of this attribute in fruit jam development.

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INTRODUCTION

Guava (*Psidium guajava* L.) is one of the most popular tropical fruits due to its moderated sweet taste and mild characteristic aroma. In past years, it has drawn the attention of the scientific community by virtue of its extraordinary phenolic content and other bioactive components such as lycopene, so much that some author consider guava a 'superfruit' (Corrêa *et al*. 2014; Flores, Wu, Negrin and Kennelly 2015). With an annual production of almost 425,000 ton, Brazil is currently the third global guava producer. The red varieties 'Pedro Sato' and 'Paluma' are the most explored both for *in natura* consumption and industry processing (da Silva Lima, Ferreira, Vitali and Block 2019). Owing to the fruit high respiration rate and fast post-harvest ripening, the shelf-life of guava is actually short, leading to expressive losses during transportation, storage and retail (Murmu and Mishra 2018; Silva *et al*. 2018a). The industrial processing into shelf-stable products like jam and jellies is an alternative to exploit the guava surplus, mainly the huge amounts of overripe fruits out of commercial standard that are often discarded (Corrêa *et al*. 2011; Majerska, Michalska, and Figiel 2019). Fruit jam is a semi-solid food product obtained by cooking of fruits with sugar to increase the total soluble solids (TSS) content to >65% (Codex Stan-79 1981). Pectin and acids can be added in to meet a minimum pectin requirement of 1% and pH 3.0, as gel network is formed by pectin with specific TSS and pH (Shinwari and Rao 2018). A fruit jam of good technological quality should present bright color, distinctive flavor of the original fruit, intermediate consistency, and texture (not too runny, nor too hard) (Brandão *et al*. 2018). Owing to the increasing health concerns and augmented incidence of obesity, metabolic syndrome and diabetes worldwide, in recent decades there has been a significant rise in interest for low-calorie food consumption. The development of no added sugar fruit jams not only meets the general demand of consumers for healthy low-calorie food options, but also serves the public with restrictions on sugar consumption, such as diabetics (Majerska, Michalska and Figiel 2019). Low calorie food products can be formulated by adding combinations of non-caloric sweeteners, which are used for partial or full replacement of sucrose (Chung, Degner and McClements 2014). However, elimination of sucrose from food formulations is challenging. It impacts not only in sweetness, but also in the browning and crystallization processes, structure, viscosity, moisture, among other. Fruit jam containing alternative sweetener should present resembling textural and rheological characteristics, as well as sensory attributes such as color, aroma and flavor, to that of the conventional product (Belović, Torbica, Pajić-Lijaković, and Mastilović 2017). In a previous work of our group (Corrêa *et al*. 2014), we demonstrated that the incorporation of concentrated grape juice in the formulation of guava jam promoted an increment of more than two-fold in total phenolic content and of almost 20% in the antioxidant activity of the product compared to the standard guava jam. This novel functionalized food product displayed a non-Newtonian shear-thinning behavior at temperatures ranging from 25 to 55 ºC, and higher stability than the standard formulation when exposed to temperature variation. Bearing in mind all mentioned above, this study aimed to evaluate the sensory and microbiological quality of guava jams with added concentrated grape juice formulated with and without the addition of sucrose.

MATERIAL AND METHODS

Jam processing: The following ingredients were used for jam manufacture: mature pink guava fruits (*Psidium guajava*, Paluma cultivar), provided by Sitio Centenario (Mandaguaçu, PR, Brazil); commercial sucrose; Lowçucar® Cooking Sweetener (maltodextrin, stevioside, sodium cyclamate and sodium saccharin), kindly donated by the Lowçucar Company; mineral water; low and high methoxyl pectins (CPKelco, Limeira, SP, Brazil); citric acid and potassium sorbate (Sigma–Aldrich Co., Steinheim, Germany). The concentrated grape juice (*Vitis labrusca*) obtained from Isabel purple grapes was acquired at a local market of Maringa-PR; its composition is reported in our previous work (Corrêa *et al*. 2014). Two guava jams were prepared: guava jam enriched by the addition of concentrated grape juice in the proportion of 30% (w/w) (Standard Formulation - SF), with sucrose, and guava jam enriched by the addition of concentrated grape with no added sugar (Diet Formulation - DF), in which sucrose was replaced by a commercial mixture of sweeteners. The key ingredients used in each formula are displayed in Table 1. The guava fruits were cleaned with a sodium hypochlorite solution, peeled and then its cores were took out and discarded. The guava pulp was processed in a blender with enough mineral water to form paste. This content was transferred to a cooking pot with constant and controlled heating, and the paste was constantly homogenized. After 10 minutes of cooking process, pectin (high methoxylation pectin for SF and low methoxylation for DF) previously dissolved in warm mineral water, and sucrose/sweetener were added to the paste. The incorporation of the concentrated juice, in both formulations, was made only after the paste reached the soluble solids content of 55 °Brix, in order to minimize the degradation of antioxidants by the heat. Following, the other ingredients were added and the heating proceeded until the ending cooking point at 65 °Brix. Jams were hot-filled in previously sterilized glass jars and capped with metal lid.

Microbiological analysis: Prior to sensory analysis, 50g of each formulation (SF and DF) were sent to the Laboratory of Food Microbiology of the State University of Maringa and analyzed for *Salmonella* spp., mold and yeast, besides total and thermotolerant coliforms. Coliform populations were estimated using the three-tube most probable number (MPN) method. Aliquots of 1.0 mL of each dilution were added to tubes containing 10 mL of Lauril Sulfate Broth (Difco) and incubated at 35 ºC for 48 hours. A loopful of the contents from positive Lauril Sulfate Broth tubes was transferred to Brilliant Green Lactose Bile Broth (2%) (Difco) and incubated at 35 ºC for 48 hours, and to others containing *E. coli* broth (Difco) and incubated in a 45 ºC water bath with shaking for 48 hours (Murray *et al*. 2007). The positive tubes (with growth and gas production) and the negative tubes were quantified, and the MPN mL^{-1} for coliforms at 35 ºC and at 45 ºC was determined using the MPN table for three tubes. For isolation of *Salmonella* spp. Lactose Broth was incubated at 35 ºC for 24 hours. One mL of the pre-enrichment culture was transferred to Selenite Cystine Broth (Difco) and 0.1 mL to Rappaport Vassiliadis Broth (Oxoid, UK). These cultures were incubated at 35 °C for 24 hours and at 42 ºC for 48 hours, respectively. Each enrichment broth was sub-cultured on Hecktoen (Oxoid) and incubated at 35 ºC for 24 hours. Typical colonies were identified by biochemical and serological tests (Murray *et al*. 2007). For detection of moulds and yeasts, dilutions were spread onto the surface of DG18 agar (Difco). The plates were incubated at 25 ºC for up to five days and after this period the CFU $g^{-1}$was calculated.

Sensory evaluation: This study was previously approved by the Research Ethics Committee of the State University of Maringa on December 3, 2010, protocol number 0453.0.093.000-10. After certifying the microbiological safety of the manufactured jams, sensory analysis was carried out in a standard and authorized sensory laboratory, equipped with 3 testing booths, under normal lighting conditions, according to the international standard ISO 8589 (2015). The panel consisted of 120 untrained assessors (71 females and 49 males), including students and employees of the State University of Maringa, Maringa, PR, Brazil. Samples of approximately 15g were randomly served to the panelists in plastic recipients identified with 3-digit codes. The sensory analysis form consisted of three tests: (1) an Acceptance Test, in which panelists evaluated attributes of color, aroma, flavor, texture and overall liking of samples, using a 9-point hedonic scale (1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = slightly dislike, 5 = neither like nor dislike, 6 = slightly like, 7 = like moderately, 8 = like very much, 9 = like extremely); (2) a Paired Preference Test, in which panelists chose their preferred sample; and finally, (3) a Purchase Intent Test to assess the possibility of panelists buying these products in the market within a scale that ranged from 5 - certainly would buy to 1 - certainly would not buy (Dutcosky 2011; Minim 2013).

Color evaluation: The color analysis was performed using a colorimeter (Hunter Lab – Miniscan EZ). The values are expressed as: L* (which represents luminosity intensity, 0 = dark and 100 = light), a* (where −a* represents direction to green and +a* direction to red), and b* (where −b* represents direction to blue and +b* direction to yellow) (Júnior 2019). In order to statistically study the correlation between the instrumental color and sensory acceptance in the guava jams, four jam samples were assessed: SF, DF, and two commercial jams acquired at commercial establishments of Maringa, Parana, Brazil, which were named CSF (Commercial Standard Formulation) and CDF (Commercial Diet Formulation).

Statistical analysis

Results were analyzed using the GraphPad Prism 5.0 Software. Assays were performed in triplicate for each sample, with results expressed as the mean values ± SD. The data were analyzed by ANOVA at 5% significance level.

RESULTS

According to the ANVISA - Brazilian Health Regulatory Agency (Resolution Nº 12 of January 2, 2001), which regulates sanitary microbiological standards for food and beverages, the maximum limit of mold and yeast in ready-to-eat jams is of 10^4 CFU g^{-1} of product. For SF and DF, mold and yeast were not found in concentrations superior to 1.0 x 10^2 CFU g^{-1} of jam (Table 2), thus within the limits advocated by the legislation.

Table 1. Key ingredients used in guava jam formulations

Product	Formulation
SF	200g of guava fruit 40g of sucrose 7g of pectin 120ml of concentrated grape juice
DF	200g of guava fruit 5g of cooking sweetener Lowçucar 10g of pectin 60mL of concentrated grape juice

Table 2. Microbiological characteristics of guava jams with added concentrated grape juice, standard (SF) and diet (DF) formulations

	SF	DF
Mold count (CFU g^{-1})	1x10^{2}	1x10^{2}
Yeast count (CFU g^{-1})	< 1x10^{2}	< 1x10^{2}
Coliform count at 35ºC (MPN g^{-1})	< 3	< 3
Coliform count at 45ºC (MPN g^{-1})	< 3	< 3
Salmonella spp. research	Absent	Absent

Table 3. Sensorial acceptance and purchase intent of guava jams with added concentrated grape juice

Attributes	SF	DF
Color	7.48 ± 0.77^{a}	6.84 ± 0.59^{b}
Aroma	7.45 ± 0.74^{a}	6.82 ± 0.76^{b}
Flavor	7.55 ± 0.92^{a}	6.85 ± 0.96^{b}
Texture	7.40 ± 0.84^{a}	6.77 ± 0.75^{b}
Overall liking	7.60 ± 0.31^{a}	6.88 ± 0.37^{b}
Purchase intent	4.55 ± 1.12a	3.13 ± 0.86^{b}

*Values followed by different letters on the same row differ significantly.

Coliform counts (at 35 ºC and 45 ºC) were less than 3 NMP g^{-1}for both samples, whereas *Salmonella* spp. was absent (Table 2), which evidenced the microbiological safety and enabled the sensory evaluation of the jams by panelists. Table 3 shows the means and standard deviation of sensory acceptance of the two guava jam formulations. Overall, both samples pleased the panelists, as the acceptability score were between 6 = slightly like and 8 = like very much. SF presented higher acceptability than DF for all sensory characteristics. Texture was the attribute that least pleased the panel, especially for DF. The average score for purchase intent attributed to SF revealed that panelists 'would probably buy' this product if it was marketed, whereas would 'maybe buy or maybe not' the DF (Table 3). Regarding the Paired Preference Test, of the 120 panelists 86 preferred SF while 34 chose DF. In this Two-Tailed Difference Test, the sample with the highest vote was considered, and the respective number of responses was compared to data in Table – Tests Comparison Paired-Difference (Meilgard *et al.* 1991), confirming that SF was the favorite sample.

Table 4. Chromatic characteristics of guava jams

	L*	a*	b*
SF	40.39 ± 0.03	17.51 ± 0.08	12.78 ± 0.03
DF	39.73 ± 0.03	20.09 ± 0.02	12.51 ± 0.01
CSF	35.05 ± 0.03	15.20 ± 0.03	9.95 ± 0.02
CDF	41.46 ± 0.03	21.50 ± 0.04	13.90 ± 0.08

SF - Standard Formulation; D - Diet Formulation; CSF - Commercial Standard Formulation; CDF - Commercial Diet Formulation.

Table 4 displays the results obtained in the instrumental analysis of color, which was carried out for SF, DF, CSF (Commercial Standard Formulation) and CDF (Commercial Diet Formulation). As shown in Table 4, guava jams formulated with sucrose (SF and CFS) presented the highest luminosity intensity (L *) values. Regarding a* parameter, the no added sugar jams (DF and CDF) were the most reddish among assessed samples (Table 4). Furthermore, no considerable differences were observed for parameter b* between guava jams with added concentrated grape juice (SF and DF). Since red is the color that characterizes traditional guava jams, to investigated the correlation of the instrumental color with the sensory acceptance of this product, we only considered parameter a* that indicates the axis of the chromaticity of the green (-) to red (+).

Table 5. Values of the sensory and instrumental color (a*) of guava jams

	Sensory color	Instrumental color
SF	6.12	15.20
DF	8.32	21.5
CSF	6.84	17.51
CDF	7.51	20.09

SF - Standard Formulation; D - Diet Formulation; CSF - Commercial Standard Formulation; CDF - Commercial Diet Formulation.

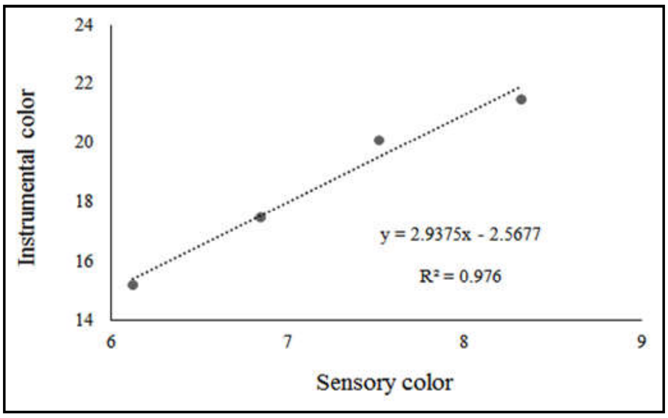

Figure 1. Correlation between sensory color (acceptance scores) and instrumental color (a* values) of the guava jams

Table 5 displays the average scores obtained for the attribute of color in the Acceptance Test as well as the instrumental color data represented by the parameter a* for each sample, whereas Figure 1 shows the correlation between these values. The sensory color was positively correlated with instrumental color intensity (R^2=0.9769).

DISCUSSION

Regarding the microbiological assay results (Table 2), Brandão *et al*. (2018), who evaluated the microbiological quality of dietetic functional mixed cerrado fruit jam during storage, also detected mold and yeasts values below the limit established by law. Likewise, coliform counts (at 35 ºC and 45 ºC) less than 3 NMP g^{-1} and absence of *Salmonella* spp. were reported by Souza *et al*. (2016) in their work on tamarind (*Tamarindus indica* L.) jelly, by de Souza *et al*. (2018) when analyzing a mixed jelly of umbu (*Spondias tuberosa* Arr. C.) and mangaba (*Hancornia speciosa* G.), and also by Lemos *et al*. (2018) when evaluating carrot jam added with acid lime (*Citrus latifolia* Tanaka) juice. The acceptability scores displayed by both guava jams, for all attributes assessed, were very favorable (Table 3). Guimarães, Alves and Querido (2019), for instance, verified less expressive results when studying conventional and 'light' blueberry jellies, with average scores of 6.67 for color, 5.65 for flavor and 5.32 for texture. The lower score verified for DF concerning texture (Table 3) could be explained in part by the longer cooking time required for diet/light jellies to achieve the minimum soluble solids content required by law. Moreover, from the technological point of view, the importance of sugar in the formulation of jams and jellies goes beyond its sweetening function, as it influences the balance of the gel (pectin-water), supply total soluble solids (TSS) and take part in caramelization and/or Maillard reaction (Di Monaco, Miele, Cabisidan, and Cavella 2018). Hence, the substitution of sucrose with sweeteners can impair the gelation process in jams, leading to loss of quality.

With respect to the results obtainde in the Purchase Intent Test, Silva *et al*. (2018b) verified similar scores when assessing the acceptability of bocaiuva (*Acrocomia aculeata* (Jacq.) Lodd. ex Mart) jellies. Furthermore, De Avila and Storck (2014) in their study on the sensory acceptance of physalis (*Physalis peruviana* L.) jellies also observed a preference for the product made with sugar (standard formulation) over the jelly made with xylitol (diet formulation). In the process of developing new products, determining product acceptance and/or preference is a key factor (de Souza *et al*. 2016). The data set obtained by the sensory analysis of the guava jams with added concentrated grape juice indicates the need for reformulation of DF, including testing with other sweeteners or sweetener blends, so that this product can compete in the market. Cyclamate, one of the components of the blend used in the manufacture of DF, can be heated without decomposition and has the ability to enhance fruity flavors. However, this sweetener presented lower acceptability than sucrose, sucralose, aspartame, and neotame when tested for pitanga (*Eugenia uniflora* L.) nectar formulation (Freitas, Dutra and Bolini 2016). Likewise, sodium saccharin and stevioside, the other constituents of the sweetener blend, can generate bitter aftertastes in some food products (Miele *et al*., 2017). In the past decade, natural sweeteners are gaining interest from consumers and companies (Carocho, Morales and Ferreira 2017). These compounds can improve fruit products attractiveness buy the enhancement of color, flavor, and phenolic profile, not only during preparation but also through storage (Kopjar *et al*. 2016). Vilela *et al*. (2015), when investigating the sucrose replacement by the sweeteners fructose, sorbitol, and fructooligosaccharides in strawberry, raspberry, and cherry jams, verified very promissory results regarding technological quality and acceptability. Rubio-Arraez *et al*. (2018) reported that the low glycaemic index sweeteners tagatose and isomaltulose, added in equal proportion in the formulation of watermelon jelly achieved a similar sensorial acceptance score to the commercial one (elaborated with sucrose). Contrasting with the trend observed in our color analysis (Table 4), Reissig *et al*. (2016), when analyzing the color of conventional and no added sugars red strawberry guava (*Psidium cattleianum* Sabine) jellies, verified that the conventional product had the lowest lightness value compared to those elaborated with aspartame, saccharin and cyclamate, acessulfame and sucralose. Pineli *et al*. (2015) and Reissing *et al*. (2016) reported lower values of lightness for red strawberry guava jellies (L* average value of 33.66) and strawberry jams (L* average value of 21.28), respectively, when compared to ours. The positively correlation found between instrumental color intensity (R^2=0.9769) and sensory color (Figure 1) evidences the influence of the intensity of the reddish color in the acceptability of guava jam. Pineli *et al*. (2015) verified that color was positively correlated to overall liking acceptance attribute of strawberry jams.

Conclusion

This work demonstrated that guava jams enriched through the addition of concentrated grape juice, formulated either with sucrose (SF) or sweeteners (DF), are products with promising microbiological and sensory quality that could meet current consumer's demand for high nutritional value foodstuff, being also an option to reduce guava fruit losses. Finally, considering that the sensory color of the studied jams was positively correlated with instrumental color intensity, this attribute should be observed in the potential reformulation of DF as well as in the development of new guava-based products.

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