Effect of different ingredients contents on physical, physicochemical and sensory properties of the creamy banana marmalade cv. 'nanica' (*Musa cavendishii*)

Efeito dos diferentes teores de ingredientes nas propriedades físicas, físico-químicas e sensoriais de doce de banana cremoso cv. 'nanica' (*Musa cavendishii*)

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ABSTRACT
Banana is a highly perishable fruit, with a shelf life of 7 to 10 days, and the fruits being in excess or those in nonconformity to be consumed are used to produce marmalade; and it is an interesting economic alternative. This study evaluated the effect of different ingredients on the physical, physicochemical and sensory properties of creamy banana marmalade. An incomplete factorial design (2^{4-1}) with two levels of four factors (pulp/sugar ratio, pectin concentration, added amount of acid and sorbate concentration). The sensorial acceptance of marmalades was evaluated using a 9-point hedonic scale, and the purchase intention by employing a 5-point scale. The analyzed variables mostly affecting the parameters were the pulp/sugar ratio, the added amount of acid and the sorbate concentration, due to their reaction with the marmalade components. The formulation 2 was preferred by consumers because of the firmest texture and the intensified yellow color.
Keywords. fruit, fruit processing, *Musa cavendishii*.

RESUMO
A banana é uma fruta altamente perecível, com uma vida útil de 7 a 10 dias, e o uso do excedente da produção ou das frutas que estão fora dos padrões de consumo na forma de doce é uma interessante alternativa econômica. Os objetivos deste estudo foram avaliar o efeito de diferentes ingredientes sobre as características físicas, físico-químicas e sensoriais de doces de banana cremosos. Foi utilizado um delineamento fatorial incompleto (2^{4-1}) com dois níveis de quatro fatores (polpa/açúcar, concentração de pectina, quantidade de ácido adicionado e concentração de sorbato). Aceitação sensorial dos doces foi avaliada utilizando uma escala hedônica de 9 pontos, e a intenção de compra por meio de uma escala de 5 pontos. As variáveis analisadas que mais afetam os parâmetros foram a razão polpa/açúcar, pH e a concentração de sorbato, devido à sua reação com os componentes do doce. A formulação 2 foi a preferida devido à textura mais firme e cor mais amarelada.
Palavras-chave. fruta, processamento de fruta, *Musa cavendishii*.

INTRODUCTION

The banana is a fruit typical from tropical zones and Brazil is third in the world production. In Brazil, banana production is estimated at six million tons annually, this fruit have a fundamental role as a food, a provider of jobs in the rural environment and a generator of penny for the country. Besides, it constitutes in the highest *per capita* consumption, with amounts approaching 35 kg, reaching all layers of society, although it is second in the Brazilian consumer's fruit preference, after the orange[1].

Of the bananas that are picked in the field, 50% actually arrive in consumer hands. This fact is due to the losses caused by damage occurring during the planting phases until the harvest, the gathering of the bunches, packing in wood boxes, internal and external transport and in the handling of the fruits in the open-air markets and supermarkets. Therefore the processing of bananas becomes an alternative for the use of the extra fruits, since their shelf life is from 7 to 10 days under ambient conditions or the fruits used for *in natura* consumption are of sub-standard quality, making the decrease of post-harvest losses possible and representing a form of increasing the shelf life and aggregating value to the product. There are several products that can be obtained from the banana. Among them, are the pulp or *purée*, nectar, fruit in syrup, dehydrated products and several preserves, including jellies and marmalade[2].

Banana preserve is a quite popular form of preservation in Brazil and with commercialization possibility on the international market. The process is influenced by the fruit type, pectin concentration, pH, pulp/sugar ratio, among others thoroughly discussed in the literature[3-9].

However, due to microbial growth this product presents a limited shelf life, which can be prolonged with preservatives. On the other hand, the interaction between sorbate and other ingredients of the formulation could alter its quality.

The objectives of this study were to evaluate the effect of different ingredients on physical, physicochemical and sensory properties of creamy banana marmalade.

MATERIAL AND METHODS

The banana (*Musa cavendishii*) used for the production of the different formulations of the marmalades were bought in local supermarkets and selected according to their degree of maturation (yellow peels).

Commercial high methoxylation level pectins (VETEC), granulated sugar (CAETÉ brand), citric acid (VETEC), potassium sorbate PA (VETEC) and polypropylene packaging were used.

An incomplete factorial design was used (2^{4-1}), with 2 levels of 4 factors (pulp/sugar, pectin concentration, amount of citric acid added and sorbate concentration), as shown in Table 1[10].

The results were submitted to variance analysis for the determination of the effects on the physical, chemical and physicochemical responses. The STATISTICA 5.0 (STATSOFT, Tulsa, OK, USA) software was used.

The production of the marmalades followed methodology described by Rauch[11]. The banana bunches arrived at the reception area, where they were washed with common water for dirtiness removal and sanitized with chlorinated water (10 mg/kg of sodium hypochlorite). Soon afterwards they were selected according to the quality attribute (yellow peel). In sequence, the fruits were manually peeled and immediately introduced into a stainless steel pot containing antioxidant solution (0.5% ascorbic acid) and submitted to the blanching process for 10 minutes and then were depulped in an INCAPRI depulper, stored in polyethylene bags and refrigerated until their use.

The treatments were concentrated in open pan until 73 °Brix. All the ingredients were added at the beginning of the process, only the citric acid was put in the end of the process.

Table 1. Incomplete factorial design for production of marmalades

Treatments	Pulp/sugar (g/g)		Pectin Concentration (%)		Amount of citric acid added (mL)		Sorbate Concentration (%)	
	x_1	X_1	x_2	X_2	x_3	X_3	x_4	X_4
1	-1	40/60	-1	0	-1	3.0	-1	0
2	+1	60/40	+1	1%	-1	3.0	-1	0
3	+1	60/40	-1	0	+1	3.5	-1	0
4	-1	40/60	+1	1%	+1	3.5	-1	0
5	+1	60/40	-1	0	-1	3.0	+1	0.1%
6	-1	40/60	+1	1%	-1	3.0	+1	0.1%
7	-1	40/60	-1	0	+1	3.5	+1	0.1%
8	+1	60/40	+1	1%	+1	3.5	+1	0.1%

x_1- coded variable corresponding to pulp/sugar; x_2- coded variable corresponding to pectin concentration; x_3- coded variable corresponding to amount of citric acid added; x_4- coded variable corresponding to sorbate concentration

The marmalades were packaged hot, in polypropylene pots, inverted, cooled and refrigerated until being analyzed.

The marmalades were analyzed as to reducing (RS) and non-reducing (NRS) sugar levels by the Somogyi-Nelson method. The total titratable acidity (TTA) was expressed in equivalents of malic acid per 100g of sample. All analysis was according to the official AOAC methods[12] in triplicate.

The water activity was measured through an Aqualab Model series 3 TE (Decagon Device, Pullman, USA) apparatus, previously calibrated with standard solution (the samples were analyzed at room temperature, in 3 cm x 1 cm flasks). Color measurement was determined using a colorimeter Konica Minolta CR 400 (Konica Minolta, Ramsey, NJ) with direct reading of Luminosity ((L) – Variation of black (0) to white (100), Intensity (a) – variation of green (-) to red (+) and Intensity (b) – Variation of blue (-) to yellow (+). Color measurements were taken in triplicate in three different places on the pots marmalades. The texture profile analyses (TPA) occurred under the following conditions: pre-test speed 5.0 mm/s, test speed 2.0 mm/s and post-test speed 2.0 mm/s with a compression distance of 10.0 mm by a 6.0 mm cylindrical aluminum probe. The texturometer from Stable Micro Systems Model TA - XT2i (Goldaming, England) was used. The parameters analyzed were: hardness (HAR), fracturability (FRA) and adhesiveness (ADH). For each preserve 6 measurements were taken.

The acceptance of the marmalades was evaluated by 30 potential consumers, members of the UFLA community (students, teachers and employees) and the appraised attributes (appearance, smell, texture, color, flavor) were judged through a structured 9 point hedonic scale (1 = I extremely disliked to 9 = I extremely liked). The samples were presented in plastic cups, coded with three algorism removed from a table of random numbers, and conducted in individual cabins in the Sensorial Analysis Laboratory of the Food Science Department (UFLA), under white light and at room temperature[13]. The results were submitted to the variance analysis (ANAVA) and the differences among the averages compared by the Tukey test to 5% of probability, by the STATISTICA 5.0 (STATSOFT, Tulsa, OK, USA).

RESULTS AND DISCUSSION

The Table 2 presents the result of the influence of the effects on the respective analyses.

Table 2. Estimate of the effects of the variables on the chemical and physicochemical analyses of the creamy banana marmalade

Factor	ATT	NRS	RS	AW
Mean	0.66	20.02	6.48	0.71
X_1	0.17	1.6	0.85	0.04
X_2	-0.11	2.37	-0.54	-0.05
X_3	-0.24	-5.21	-0.69	-0.06
X_4	0.14	-10.78	-0.08	-0.09

It is observed that in general, the variable that most affected all the analyzed characteristics was the amount of citric acid added (X_3), whose increase reduced the non-reducing sugars (NRS), through the hydrolysis to reducing sugars (RS), since the addition of citric acid lowers the pH.

Similar results were found by Policarpo et al.[14], analyzing formulations of umbu pulp marmalades, and for Besbes et al.[15], studying mango jellies formulated with different peel levels in substitution of the pulp.

It is also observed that there was a reduction of the non-reducing sugars by the sorbate addition (X4), suggesting a reaction of the reducing sugars with the sorbate[16]. According Alexandre et al.[17], the addition of sorbate inhibits the reducing sugars. The increase of the pectin addition (X_2) and of the pulp/sugar ratio (X_1) resulted in an increase of the non-reducing sugars, signifying a higher protection against hydrolysis of these sugars during the cooking.

The increase of the pulp/sugar ratio (X_1) and potassium sorbate addition (X_4) have caused a positive effect on the percentage of ATT (total titratable acidity). The effect of X_1 on ATT may have been due to the acidity of the bananas, as perceived by Menezes et al.[18] in their studies with guava preserves, where the acidity was higher for treatments with higher pulp/sugar ratio. In relation to sorbate concentration Evageliou et al.[19] say that the use of potassium sorbate increased ATT by combining this with the acids in the product.

The increase of the pectin concentration (X_2) and amount of citric acid added (X_3) reduced the ATT. This is probably because of the interaction of H+ ions with the pectin networks[19].

The increase in pulp/sugar ratio (X_1) has effect increase water activity, show effect negative on water activity (AW) in the product. It is probably because the increase in pulp, and consequently decrease the amount of sugar will lead to increased free water content in the product. According to Menezes et al.[18], since the increase of pectin concentration (X_2), amount of citric acid added (X_3) and potassium sorbate concentration (X_4) have decrease effect on AW. According to Löfgren e Hermansson[20] for the formation of the gel in jams, jellies and preserves the sugar binds to water and pectin micelles, which are linked to acid, making the water be free in three-dimensional networks thus diminish the water activity.

In Table 3, it is noted, by the size of the effects, that the variables that affected the texture parameters were the pulp/sugar ratio (X_1), pectin concentration (X_2), sorbate concentration (X_4). The increase of the pulp/sugar ratio (X_1) increased the hardness (HAR) and fracturability (FRA) and the pectin addition (X_2) increased the adhesiveness (ADH) and reduced the hardness and fracturability. The sorbate addition (X_4) reduced the hardness and fracturability. Other properties were little altered.

In relation to the results in the literature, the depressive effect of the pectin on the hardness is not the expected, because the increase of its concentration elevates the hardness[18,14], but it might have been hydrolyzed during the cooking therefore not exercising this function[19].

The Table 4 presents the effects of the color parameters (L*, a*, b*) of the treatments. Its shows that the highest registered effect was for the amount of citric acid added (X_3), whose increase tends to lighten the product. The sorbate addition (X_4) causes darkening as seen by the negative effect value of L*. The parameters a* and b* are influenced by the increase of the pulp/sugar (X_1), whose increase elevates these parameters, especially b*, indicator of the yellow color. The pectin (X_2) increase reduces the parameters a* and b*. The increase of the pectin concentration causes a certain decrease in the color parameters, as verified in some other works[18,20,21].

The results of the averages obtained by the sensorial analysis are presented in Table 5. It is observed that there was significant difference among the treatments 2 (60/40 pulp/sugar ratio, 1,0% pectin concentration, 3,0 mL citric acid and 0% sorbate concentration) and 5 (60/40 pulp/sugar ratio, 0% pectin concentration, 3,0 mL citric acid and 0,1% sorbate concentration) only for the flavor attribute. The treatment 5 obtained the lowest score (indifferent - I slightly liked). The treatment 2 obtained the highest score (I moderately liked - I liked a lot, with average of score of 7.16). These differences can be attributed to the sorbate concentration, considerably lower for treatment 2 due to the probable reaction of sorbate resulting in a darker product.

In relation to color attribute, there was no significant difference between treatments. This indicates that even if the independent variables affect the parameters, color (L*, a*, b*) (Table 4) does not influence on consumer acceptability.

Table 3. Estimate of the effects of the variables on the texture analysis of creamy banana marmalade

Factor	ADH (g*s)	HAR (g)	FRA (g)
Mean	-152.02	147.39	118.96
X_1	-119	145.7	141.5
X_2	142.1	-30.5	-92
X_3	32.6	-73.5	-39.3
X_4	78.2	-134.5	-120.4

Table 4. Estimate of the effects of the variables on the color analysis of creamy banana marmalade

Factor	L*	a*	b*
Mean	0.83	-0.33	0.73
X_1	1.49	1.18	4.9
X_2	0.14	-1.6	-2
X_3	3.19	-1.1	0
X_4	-1.5	0.21	0

Table 5. Sensorial characteristics of creamy banana marmalade

Treatments	Appearance	Smell	Texture	Color	Flavor
1	6.52 a	6.19 a	6.23 a	6.71 a	6.71 ab
2	7.06 a	7.00 a	7.13 a	7.00 a	7.16 a
3	6.84 a	6.52 a	6.23 a	6.61 a	6.68 ab
4	6.68 a	5.77 a	6.52 a	6.81 a	6.09 ab
5	6.42 a	6.16 a	6.48 a	6.68 a	5.58 b
6	6.55 a	6.03 a	6.32 a	6.94 a	6.19 ab
7	6.87 a	6.32 a	6.77 a	6.94 a	6.74 ab
8	6.26 a	6.19 a	5.90 a	6.13 a	6.68 ab
CV	24.51	29.19	27.72	24.4	29.3

CV = Coefficient of Variation

CONCLUSIONS

It is concluded that the variables that most affects the analyzed parameters are the pulp/sugar ratio, amount of citric acid added and sorbate concentration, since these react with the components of the marmalades. In this research, as a consequence of these alterations, the treatment 2 (pulp/sugar = 60/40; pectin concentration = 1%; amount of citric acid added = 3.0 mL; sorbate concentration = 0) was the favorite to the firmer texture and more yellow color. These results indicate that these variables should be researched at other levels to reach optimization.

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