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Development and stability of candy in soursop mass

Desenvolvimento e estabilidade de doce em massa de graviola

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ABSTRACT

The objective of this work was to develop and characterize candies in soursop mass, replacing sucrose partially with glucose syrup, and to evaluate the stability during 90 days of storage under different temperatures. Two formulations of candies were prepared with sucrose substitution by glucose syrup, as well as a standard sample with sucrose alone. They were heated and concentrated to 71 °Brix for packaging in polyethylene packages. Afterwards, the candies were stored at 10 and 20 °C in a Biochemical Oxygen Demand (BOD) incubator and 28.1 °C (ambient temperature) for 90 days. During storage, the physical-chemical analyzes were performed: water content, total solids, pH, total titratable acidity, total soluble solids, water content and activity. Physical and chemical parameters changed during storage. It wasverified that the storage conditions caused reduction of the values of water content and water activity, besides increasing the values of total solids, total soluble solids and Ratio for all samples and storage conditions. The determining factor for the stability and preservation of product characteristics was the storage temperature; Being 10 ° C the ideal temperature for a better preservation of the candies in the standard formulation and 20 ° C for the added formulations of glucose syrup.

Keywords: Annona muricata L; Storage; Controlled atmosphere

RESUMO

Objetivou-se com este trabalho desenvolver e caracterizar doces em massa de graviola, substituindo a sacarose parcialmente por xarope de glicose, avaliando a estabilidade durante 90 dias de armazenamento sob diferentes temperaturas. Foram elaboradas 2 formulações de doces com substituição da sacarose por xarope de glicose, bem como uma amostra padrão somente com sacarose. Estas foram aquecidas e concentradas até 71 °Brix para o acondicionamento em embalagens de polietileno. Logo após, armazenou-se os doces à 10 e 20 ºC em incubadora de Demanda Bioquímica

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de Oxigênio (BOD) e 28,1 ºC (temperatura ambiente) durante 90 dias. Durante o armazenamento foram realizadas as análises físico-químicas: teor de umidade, sólidos totais, pH, acidez total titulável, sólidos solúveis totais, *ratio* e atividade de água. Os parâmetros físico-químicos sofreram alterações durante o armazenamento. Verificou-se que as condições de armazenamento provocaram redução dos valores de umidade e atividade de água, além de aumentar os valores de sólidos totais, sólidos solúveis totais e *ratio* para todas as amostras e condições de armazenamento. O fator determinante para a estabilidade e preservação das características dos produtos foi a temperatura de armazenamento; sendo 10 ºC a temperatura ideal para uma melhor conservação dos doces na formulação padrão e 20 ºC para as formulações adicionadas de xarope de glicose.
Keywords: Annona muricata L; Armazenamento; Atmosfera controlada

1 INTRODUCTION

Soursop (*Annona muricata* L.) comprises a berry-like fruit, which has the ellipsoid or ovoid shape. It has a juicy, slightly candy and acidic white pulp, surrounded by several black seeds (BRANDÃO, 2015), traditionally used in the production of juices and various types of candies.

Considering its consistency, the mass candy can be characterized as creamy / pasty or candy-cut candy, still being classified as simple candy (a type of pulp) or as candy mixed (more than one type of pulp) (MOURA *et al*., 2014). According to Brazilian legislation, the candy cut type comes from the appropriate processing of the edible parts of fruits and vegetables with sugars, being optional the use of acids, pectin, water, additives and other ingredients in order to obtain the final product characteristic (BRAZIL, 1978).

The search for a healthy life leads food industries increasingly to adapt to the reality of society, seeking to manufacture products that provide lower amounts of calories. This is what glucose syrup has been used in the preparation of jams and jellies. It has a lower molecular mass in relation to sucrose, which provides some advantages, such as the provision of a higher osmotic pressure that facilitates penetration into plant tissues and inhibits microbial attack, as well as fermentation processes (FONTES *et al*. 2012).

Currently, the literature does not have much research on mass candy of tropical fruits, mainly related to stability and composition. Among the few recently published papers on mass candy, Dias *et al*. (2011) with "mass candy of passion fruit albedo"; Godoy *et al*. (2014) with "mass candy of banana"; Campos *et al*. (2015) with "mass candy of passion fruit and acerola added of flour of passion fruit peel" and Oliveira *et al*. (2020) with "mass candy of banana and cajá".

Soursop is integrated as a seasonal raw material and is unusual for the consumer market for the production of such candy, since the industrial production of these is mainly related to fruits such as guava, banana and cashew. In view of the above, the objective of this work is the development and characterization of soursop pastry with partial replacement of sucrose by glucose syrup, stored at different temperatures (10, 20 °C and 28.1°C) during the period of 90 days, in order to understand and establish their behaviors and the best form of storage.

2 MATERIAL AND METHODS

The research was developed at the Federal Institute of Education, Science and Technology of Rio Grande do Norte (IFRN), Pau dos Ferros campus, in the Fruit Processing and Food Analysis laboratories. For the preparation of candies, the following ingredients were used: soursop pulp, crystal sugar (sucrose), glucose syrup and commercial high-methoxylation pectin, purchased at the retail market in the city of Pau dos Ferros-RN, in which the concentration of the glucose syrup varied according to the formulations described in Table 1.

Table 1 - Formulations of the mass candies of soursop

Ingredients	**Standard formulation**		**Formulation 1**		**Formulation 2**	
	(g)	**%**	**(g)**	**%**	**(g)**	**%**
Soursop pulp	500	49.26	500	49.26	500	49.26
Crystal Sugar	500	49.26	400	39.41	300	29.56
Glucose syrup	-	-	100	9.85	200	19.70
Pectin	15	1.48	15	1.48	15	1.48

The dry ingredients (crystal sugar and pectin) were initially weighed and blended into stainless steel pans. Thereafter, the wet ingredients (soursop pulp and glucose syrup) were added and homogenized according to each formulation. It is recommended to firstly mix the pectin with the sugar (dry ingredients) so that there is no formation of lumps at the direct contact of the pectin with the wet ingredients, mainly the pulp.

Subsequently, the blends were brought to the blender with constant homogenization and the total soluble solids content was verified until reaching the value of 71 ° Brix for the packaging in 100 ml polyethylene plastic pots, by cooling them in trays with water.

The candies were stored during the 90 days period, at the ambient temperature of the city of Pau dos Ferros-RN (annual average of 28.1 °C) and under controlled conditions in incubator type BOD (Biochemical Oxygen Demand) at temperatures of 10 and 20 °C. During storage, the samples were submitted to the same physical-chemical analyzes at "zero time" and at every 30 days.

The physico-chemical determinations were performed, in triplicates, for the parameters: water content and total solids (in oven at 105 °C / 24 h), pH (potentiometry), total titratable acidity - ATT (by titration), total soluble solids - SST (refractoriness), Ratio (SST/ATT), according to Adolfo Lutz Institute (IAL, 2008) and water activity (Aw), through the Aqualab CX-2 Decagon equipment at 30 °C.

The treatment of the data followed in a 3 x 3 x 4 factorial scheme, being 3 formulations, 3 storage temperatures and 4 storage times. The data were treated using the Assistat software version 7.7 beta (SILVA; AZEVEDO, 2016), through Analysis of Variance (ANOVA), and by comparing the means by the Tukey test at 5% level of significance ($p < 0.05$).

3 Results and Discussion

For the water content analysis (Table 2), it was observed that in all conditions studied there was a reduction in the values with storage time. The candies stored at ambient temperature showed a greater reduction of the water content, which is possibly caused by the high temperature of the place that favors greater evaporation of the free water.

This can be verified by the standard sample, which, when submitted to ambient temperature during its total storage period, obtained a reduction of water content of approximately 57.46%, while the same formulation submitted to temperatures of 10°C and 20°C, presented drops of Approximately 25.04 and 30.23%, respectively.

Table 2 - Results of water content and total solids of soursop candies during storage of 90 days in different storage conditions

Candies (Fator 1)	Time in days (Factor 3)	Water content (%)			Candies (Fator 1)	Time in days (Factor 3)	Total solids (%)		
		Storage conditions (Factor 2)					Storage conditions (Factor 2)		
		10 °C	20 °C	Ambient (28.1 °C)			10 °C	20 °C	Ambient (28.1 °C)
Pattern	0	24.64^{aA}	24.64^{aA}	24.64^{aA}	Pattern	0	75.36^{fA}	75.36^{fA}	75.36^{fA}
	30	21.14^{bA}	21.74^{bcofA}	19.45^{bB}		30	78.86^{eB}	78.26^{bcofB}	80.55^{eA}
	60	18.64^{defB}	20.39^{eA}	12.75^{eC}		60	81.36^{abcB}	79.61^{bC}	87.25^{bA}
	90	18.47^{efA}	17.19^{fA}	10.48^{fB}		90	81.53^{abB}	82.81^{aB}	89.52^{aA}
9.85 %	0	23.56^{aA}	23.56^{abA}	23.56^{aA}	9.85 %	0	76.44^{fA}	76.44^{efA}	76.44^{fA}
	30	19.66^{bcdeB}	21.98^{bcdeA}	19.14^{bcB}		30	80.34^{bcdeA}	78.02^{bcdeB}	80.86^{deA}
	60	20.43^{bcdA}	20.83^{cdeA}	13.15^{deB}		60	79.57^{cdeB}	79.17^{bcdB}	86.85^{bcA}
	90	17.69^{fB}	20.54^{deA}	12.35^{eC}		90	82.31^{aB}	79.46^{bcC}	87.65^{bA}
19.70 %	0	24.58^{aA}	24.58^{aA}	24.58^{aA}	19.70 %	0	75.42^{fA}	75.42^{fA}	75.42^{fA}
	30	20.75^{bcB}	22.64^{bcA}	17.42^{cC}		30	79.25^{deB}	77.36^{deC}	82.58^{dA}
	60	20.07^{bcdeB}	22.29^{bcdA}	14.77^{dC}		60	79.93^{bcdeB}	77.71^{cdeC}	85.23^{cA}
	90	18.94^{cdefB}	21.78^{bcdeA}	14.12^{deC}		90	81.06^{abcdB}	78.22^{bcdeC}	85.88^{bcA}

Water content MG = 18.40; CV= 0.83%; DMS columns= 1.83; DMS lines= 1.30; Factor Fcal 1=24.55**; Factor Fcal 2=479.33**; Factor Fcal 3= 648.09**; Int. Fcal F1 x F2= 4.20**; Int. Fcal. F1 x F3 = 14.66**; Int. Fcal F2 x F3= 79.82**; Int. Fcal F1 x F2 x F3 =4.75**; Treatments Fcal =102.65**. Total Solids: MG= 80.08%; CV= 0.83%; DMS columns= 1.83; DMS lines= 1.30; Factor Fcal 1= 24.55**; Factor Fcal 2= 479.33**; Factor Fcal 3= 648.09**; Int. Fcal F1 x F2= 4.20**; Int. Fcal. F1 x F3= 14.66**; Int. Fcal F2 x F3= 79.82**; Int. Fcal F1 x F2 x F3= 4.75**; Treatments Fcal = 102.65**. MG - General average; CV - Coefficient of variation; DMS - Minimum significant difference; ** significant at the 1% probability level. Averages followed by the same lowercase letter in the column and uppercase in the row do not differ statistically from one another. The Turkey test was applied at a 5% probability level.

Another aspect to be emphasize about the pattern candy stored at ambient temperature was the presented of oscillations throughout the storage period, a behavior also found by Martins *et al*. (2011), who studied the stability of banana candies in bulk. On the other hand, Santana Neto *et al*. (2014), when studying banana candy added with functional components, obtained water content values close to and higher than the present research, varying between 19.06 and 35.36%. Jesus *et al*. (2019) found almost double in water content values (41.63 to 46.49%) when studying candy in banana biomass paste and cajá pulp, consequently due to the shorter time (3 minutes) of concentration of the candies during processing.

Regarding the total solids contents (Table 2), the three formulations submitted to the temperature of 10 °C did not present significant differences ($p<0.05$), when compared with each other in their respective periods of storage. That is, the pattern candy sample stored at a controlled temperature of 10 °C and in the period of 30 days of storage did not show significant difference ($p<0,05$)of the others in the same storage conditions, and so on.

Total solids, as well as total soluble solids (Table 3), increased throughout storage, showing a higher concentration of solids, mainly sugars. Considering that the storage conditions are predominant factors for the conservation of the sensorial characteristics of the product, the samples stored at ambient temperature presented a greater loss of water, culminating in a higher concentration of the total solids for this condition.

All samples kept at a temperature of 10 °C throughout the storage period did not show significant differences between them during the same reference time. Regarding the samples submitted to the temperature of 20 °C, it was observed that both the formulation 9.85% and the 19.70%, during the periods of 30, 60 and 90 days of storage, did not differ statistically among themselves ($p<0.05$). Silva *et al*. (2011), when studying candies elaborated with umbu pulp, obtained values of total solids lower than those mentioned in the present research, which is justified by the fact that the candies have a water content higher than those studied in the present research.

During the storage period, all the conditions under study showed an increase in the concentration of total soluble solids (° Brix), as can be seen in Table 3. Such behavior caused changes in the sensorial characteristics of candies, especially for the ones that were submitted to the ambient temperature, like: change in the coloration (darker) and more rigid texture, caused by the loss of water and consequent concentration of the solids. A similar result was observed by Martins *et al*. (2011), which showed a tendency to increase the solubility of solids content of the silver bananas studied, over time of storage in all applied treatments.

All samples corresponded to that recommended by Brazilian legislation (BRAZIL, 1978) which establishes a minimum value of 65 °Brix for this type of candy. Although there were reductions in the values of total soluble solids at some moments of storage.

In relation to the storage conditions in which the samples were submitted, all of them showed a higher concentration of the soluble solids at ambient temperature. Regarding the controlled temperatures, it was observed that the substitution of sucrose for glucose syrup causes a higher concentration of solids, especially in the formulation with 19.70% of glucose syrup.

The three samples maintained at ambient temperature showed significant differences between them ($p<0.05$) in the entire storage period, as well as when compared to the other storage conditions evaluated for periods of 30, 60 and 90 days. This happened because the ambient temperature is higher than the others studied, causing a higher rate of water evaporation of the product and, consequently, in the concentration of the total soluble solids.

Table 3 - Results of total soluble solids and ratio of soursop candies during storage of 90 days in different storage conditions

Candies (Factor 1)	Time in days (Factor 3)	Total soluble solids (°Brix)			Candies (Fator 1)	Time in days (Fator 3)	Ratio (SST/ATT)		
		Storage conditions (Factor 2)					Storage conditions (Factor 2)		
		10 °C	20 °C	Ambient (28.1 °C)			10 °C	20 °C	Ambient (28.1 °C)
Pattern	0	71.50^{gA}	71.50^{fA}	71.50^{lA}	Pattern	0	139.56^{bA}	139.56^{bcA}	139.56^{bcA}
	30	75.50^{bB}	72.50^{eC}	78.00^{iA}		30	191.56^{aA}	182.67^{aAB}	164.00^{bB}
	60	73.50^{fC}	74.50^{dB}	80.00^{fA}		60	148.43^{bA}	152.65^{abcA}	157.88^{bA}
	90	74.50^{eB}	74.50^{dB}	83.50^{bA}		90	151.47^{bA}	156.51^{abcA}	157.71^{bA}
9.85 %	0	71.50^{gB}	71.50^{fB}	72.50^{jA}	9.85 %	0	139.56^{bA}	139.56^{bcA}	139.56^{bcA}
	30	76.50^{aB}	74.50^{dC}	79.00^{hA}		30	192.93^{aA}	161.54^{abcB}	208.58^{aA}
	60	75.00^{cC}	76.00^{bB}	80.50^{eA}		60	137.72^{bA}	137.21^{bcA}	146.54^{bcA}
	90	75.00^{dC}	75.50^{cB}	83.00^{cA}		90	146.62^{bA}	150.24^{bcA}	147.13^{bcA}
19.70 %	0	71.50^{gA}	71.50^{fA}	71.00^{mB}	19.70 %	0	139.56^{bA}	139.56^{bcA}	139.56^{cA}
	30	76.50^{aB}	74.50^{dC}	79.50^{gA}		30	200.91^{aA}	164.95^{abB}	203.99^{aA}
	60	76.50^{aB}	76.50^{aB}	82.50^{dA}		60	134.31^{bA}	131.59^{cA}	137.80^{bcA}
	90	76.50^{aB}	75.50^{cC}	84.00^{aA}		90	140.41^{bA}	140.42^{bcA}	139.77^{bcA}

Total soluble solids: MG= 75.76 °Brix; CV= 0.20%; DMS columns= 0.004; DMS lines= 0.003; Factor Fcal 1= 6771450.79**; Factor Fcal 2= 114259145**; Factor Fcal 3= 106353369**; Int. Fcal F1 x F2= 244764.04**; Int. Fcal. F1 x F3= 1505796.30**; Int. Fcal F2 x F3= 18098794**; Int. Fcal F1 x F2 x F3= 290844.24**; Crashes Fcal = 19520515**. Ratio: MG= 153.29; CV= 7.62%; DMS columns= 32.10; DMS lines= 22.83; Factor Fcal 1= 3.43*; Factor Fcal 2= 2.55^{ns}; Factor Fcal 3= 96.28**; Int. Fcal F1 x F2= 1.52^{ns}; Int. Fcal. F1 x F3= 2.92*; Int. Fcal F2 x F3= 4.26**; Int. Fcal F1 x F2 x F3= 2.19*; Crashes Fcal = 10.75**. SST - Total soluble solids; ATT - Titratable total acidity; MG - General average; CV - Coefficient of variation; DMS - Minimum significant difference; ** significant at the 1% probability level; * Significant at the 5% probability level; Ns not significant. Averages followed by the same lowercase letter in the column and uppercase in the row do not differ statistically from one another. The Tukey test was applied at a 5% probability level.

Regarding the Ratio (Table 3), specifically in the period of 60 and 90 days, statistical similarities ($p<0.05$) were observed for all formulations in all storage conditions. Thus, only in the period of 30 days a significant difference ($p<0.05$) was obtained, being the treatments with 9.85 and 19.70% of glucose stored at 20 °C and for the pattern formulation the sample stored at 20 °C is similar to the others elaborated with glucose, while the stored at ambient temperature and 10 ° C differed from each other ($p<0.05$).

It was also noted by the statistical similarities that the time factor of storage influenced more strongly in the values of Ratio in comparison to the factor storage temperature. This influence stands out in the values presented during 30 days of storage, at temperatures 20 °C and at ambient, provoking greater variations in the values.

Since the Ratio represents the sweetness sensation of the sample that is transmitted by the balancing of the sugars present and the total acidity of the product, in which, the greater its value, the greater the sensation of sweetness of the product. All the samples studied for all the storage conditions had the sensation of sweetness intensified with the storage, when compared to the initial and final values of the 90 days of storage.

Oliveira Neto *et al*. (2018), when preparing mariola-type candy pastry from the use of banana peel, obtained values that varied between 126.31 to 158.71 for the Ratio parameter. These inferior results to the present work can be justified by the use of the peel to replace the fruit pulp itself, so that a lesser sensation of sweetness is expected.

The pH of the candies (Table 4) decreased abruptly in the first 30 days of storage in all storage conditions, but in the other storage periods (60 and 90 days) there was an increase in values, but remained below the initial values (Time 0).

This fact may be related to the dissociation of pH molecules and acids, which are inversely proportional. That is, the higher the pH, the lower the concentration of acids in the product, a fact that happened in the storage periods of 60 and 90 days that may have lost acids.It is observed was verified that the behavior of the candy with substitution of 19.70% of the sucrose by glucose presented statistical similarities ($p<0.05$) in all the storage conditions for all the periods of storage. Thus being the values obtained of these in the ambient temperature, 10 and 20 °C, not differ statistically ($p<0.05$) in the study time.

Differently, the candy with substitution of 9.85% of sucrose by glucose presented statistical differences ($p<0.05$) in the ambient temperature of the others in the period of 30 days. The fact that the candies have been processed from the soursop pulp and not from the fruit explains the low results obtained for the pH, since the process of production of pulps in the processing industry often includes a stage of acidification of the pulp to avoid oxidation and better preservation thereof, in addition to the process comprises concentration of the pulp.

The values obtained in the period of 30 days of storage in all storage conditions are lower than those found by Silva *et al*. (2016), in which they found pH values in the range of 3.94 and 4.43 for formulations of creamy juçara fruit sweets with banana and pineapple. Higher pH values are presented by Jesus *et al*. (2019), who found values between 3.56 and 4.14 when studying banana and cajá candy.

Table 4 - Results of pH and total titratable acidity of soursop candies during storage of 90 days in different storage conditions

Candies (Factor 1)	Time in days (Fator 3)	pH			Candies (Factor 1)	Time in days (Fator 3)	Total titratable acidity (%)		
		Storage (Factor 2)					Storage (Factor 2)		
		10 °C	20 °C	Ambient (28.1 °C)			10 °C	20 °C	Ambient (28.1 °C)
Pattern	0	3.35^{aA}	3.35^{aA}	3.35^{aA}	Pattern	0	0.51^{aA}	0.51^{abcA}	0.51^{bcA}
	30	1.40^{fA}	1.37^{dA}	1.43^{eA}		30	0.40^{bB}	0.40^{dB}	0.48^{cdA}
	60	2.17^{deA}	2.14^{cA}	2.18^{cdA}		60	0.50^{aA}	0.49^{bcA}	0.51^{bcA}
	90	2.37^{bA}	2.31^{bAB}	2.28^{bB}		90	0.49^{aA}	0.48^{bcdA}	0.53^{abcA}
9.85 %	0	3.35^{aA}	3.35^{aA}	3.35^{aA}	9.85 %	0	0.51^{aA}	0.51^{abcA}	0.51^{bcA}
	30	1.28^{gB}	1.24^{eB}	1.37^{eA}		30	0.40^{bAB}	0.46^{cdA}	0.38^{eB}
	60	2.14^{eA}	2.16^{cA}	2.10^{dA}		60	0.54^{aA}	0.55^{abA}	0.55^{abcA}
	90	2.36^{bcA}	2.28^{bB}	2.29^{bAB}		90	0.51^{aAB}	0.51^{abcB}	0.57^{abA}
19.70 %	0	3.35^{aA}	3.35^{aA}	3.35^{aA}	19.70 %	0	0.51^{aB}	0.51^{abcB}	0.51^{bcA}
	30	1.24^{gA}	1.22^{eA}	1.23^{fA}		30	0.38^{bB}	0.45^{cdA}	0.39^{deAB}
	60	2.13^{eA}	2.09^{cA}	2.11^{dA}		60	0.57^{aA}	0.58^{aA}	0.60^{aA}
	90	2.26^{cdA}	2.27^{bA}	2.24^{bcA}		90	0.55^{aAB}	0.54^{abcB}	0.60^{aA}

pH: MG= 2.27; CV= 1.63%; DMS columns= 0.10; DMS lines= 0.07; Factor Fcal 1= 30.18**; Factor Fcal 2= 3.88*; Factor Fcal 3= 13865.56**; Int. Fcal F1 x F2= 0.29^{ns}; Int Fcal.. F1 x F3= 9.92**; Int. Fcal F2 x F3= 3.41**; Int. Fcal F1 x F2 x F3= 1.92*; Treatments Fcal = 1193.40**. Total titratable acidity: MG= 0.50%; CV= 6.19%; DMS colunas= 0.09; DMS linhas= 0.06; Fcal Fator 1= 14.08**; Factor Fcal 2= 9.25**; Factor Fcal 3= 95.92**; Int. Fcal F1 x F2= 1.22^{ns}; Int. Fcal. F1 x F3= 4.57**; Int. Fcal F2 x F3= 3.07**; Int. Fcal F1 x F2 x F3= 1.95*; Treatments Fcal = 11.67**. SST - Total soluble solids; ATT - Total titratable acidity; MG - General average; CV - Coefficient of variation; DMS - Minimum significant difference; ** significant at the 1% probability level; * Significant at the 5% probability level; Ns - not significant. Averages followed by the same lowercase letter in the column and uppercase in the row do not differ statistically from one another. The Tukey test was applied at a 5% probability level.

It is worth noting that Brazilian legislation does not regulate the pH values of candies in bulk, however it is known that it is a fundamental element for the conservation of foods.

The pH should not exceed the range of 4.5, since from this value there is a favorable growth of pathogenic bacteria such as *Clostridium botulinum* (MOURA *et al*., 2014). Therefore, all samples remained below this parameter known and defended by the literature, not obtaining values higher than 3.5. In contrast, molds and yeasts are able to tolerate very acidic conditions becoming the main agents of deterioration of candies.

The results obtained for the acidity analysis (Table 4) show that the higher the sucrose substitution by glucose in the candies the higher the total titratable acidity of the samples. The acidity of the candies decreased during the first 30 days of storage in all storage conditions, increased during the period with oscillations between 60 and 90 days.

It was noticed that in the period of 60 days the formulations did not suffer interferences of the storage conditions, since there was no statistical difference ($p<0.05$) between the samples. In addition, all samples in the 30-day storage period at 10 °C did not differ statistically from each other ($p<0.05$), but differed from those stored at other periods and conditions.

According to Lago *et al*. (2006), the titratable acidity should not exceed 0.80%, with a minimum of 0.30%, in order to avoid pectin hydrolysis or crystals formation in the candies; therefore the samples studied are within this period. Superior results were found by Dias *et al*. (2011), in which they prepared passion fruit albedo mass candy with glucose syrup and studied storage in different types of packaging with values ranging from 0.64 to 0.86%.

For water activity (Table 5), as observed for water content, there was a reduction in values in all storage conditions. This is due to the loss of water free of candies and consequent concentration of solids, which causes the reduction of aw values and consequent reduction of the possibility of developing microorganisms.

Table 5 - Results of water activity (aw) of soursop candies during storage of 90 days in different storage conditions

Candies (Factor 1)	Time in days (Factor 3)	Storage (Factor 2)		
		10 °C	20 °C	Ambient (28.1 °C)
Pattern	0 days	0.663^{aA}	0.663^{aA}	0.663^{aA}
	30 days	0.660^{aA}	0.660^{aA}	0.667^{aA}
	60 days	0.550^{bcA}	0.533^{bB}	0.550^{cdA}
	90 days	0.547^{bcA}	0.523^{bB}	0.517^{deB}
9.85 %	0 days	0.663^{aA}	0.663^{aA}	0.663^{aA}
	30 days	0.617^{abB}	0.660^{aA}	0.617^{abcB}
	60 days	0.527^{cdC}	0.537^{bB}	0.587^{bcdA}
	90 days	0.507^{cdB}	0.517^{bA}	0.473^{eC}
19.70 %	0 days	0.663^{aA}	0.663^{aA}	0.663^{abA}
	30 days	0.630^{aB}	0.653^{aA}	0.587^{bcdC}
	60 days	0.547^{bcB}	0.527^{bC}	0.567^{cdA}
	90 days	0.467^{dB}	0.523^{bA}	0.467^{eB}

MG= 0.589; CV= 4.44%; DMS columns= 0.072; DMS lines= 0.051; Factor Fcal 1= 6.188**; Factor Fcal 2= 1.79^{ns}; Factor Fcal 3= 168.81**; Int. Fcal F1 x F2= 1.76^{ns}; Int. Fcal. F1 x F3= 1.88^{ns}; Int. Fcal F2 x F3= 31.70**; Int. Fcal F1 x F2 x F3= 1.43^{ns}; Treatments Fcal = 21.37**. MG - General average; CV - Coefficient of variation; DMS - Minimum significant difference; ** significant at the 1% probability level; * Significant at the 5% probability level; Ns not significant. Averages followed by the same lowercase letter in the column and uppercase in the row do not differ statistically from one another. The Tukey test was applied at the 5% probability level.

A greater reduction in water activity is highlighted in samples that present partial substitution of sucrose by glucose in most samples. As a result, glucose binds more strongly to the other components of candy, which does not happen with sucrose. The drop in values is positive for the stability of candies, as it hinders the proliferation of pathogenic microorganisms, giving greater safety for the consumer.

The sample with 9.85% glucose in the period of 60 and 90 days differed statistically ($p<0.05$) from each other for all storage conditions. The same happened to the sample 19.70% of glucose for the periods of 30 and 60 days. However, the pattern sample stored in the 30-day period showed a significant similarity ($p<0.05$) in all temperatures studied.

Aw values in the range of 0.3 to 0.7 tend to develop maximum browning in foods of plant origin, due to the Maillard reaction. This feature may or may not be desirable depending on the purpose of the product (MENEZES *et al*., 2009). This explains the change in color suffered by candies during the storage period, especially those who were subjected to ambient temperature that was well above the others.

Differently from the result obtained by Martins *et al*. (2011), in which they found oscillations of aw when analyzing candy mass of silver banana, the soursop candies presented just a decrease for this parameter.

4 CONCLUSIONS

The formulations of mass candies of soursop were influenced by time, storage conditions and partial substitution of sucrose by glucose syrup.

The storage temperature determined better stability / preservation of the characteristics at 10 °C in the pattern formulation and 20 ° C for the formulations with addition of glucose syrup when undergoing less changes in the aspects analyzed.

Storage was the factor that most significantly influenced the composition of the sweets during the study, followed by the type of sweets and finally the storage temperature.

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