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Study of the process of getting the drops of papaya (carica papaya l.) Per basic spherification

Alessandra Almeida, Castro Pagani, Mariana Costa Oliveira, Anne Caroline Rocha Xavier, Alaiza Lima Barros Morais,Tatiana P. Nunes, Gabriel F. Silva

Abstract— Originally from tropical America, the papaya (Carica papaya L.) is a climacteric fruit widely produced in Brazil. This fruit is characterized by a relatively short shelf life, completing the ripening within a week under environmental conditions. Consumption is almost entirely done in natura, but is limited due to the inconvenience of the complicated peeling and consumption. The consumption could be expanded with the production of new products that allow longer shelf life. The gelling / spherification is a new method of food processing, which can be applied to the fruit pulp. The process consists of comprising a liquid trap into a film or controlled gelation, where the product can be presented in different forms (droplets, wires, cts). In light of the foregoing, the processing of new products with this much-appreciated fruit becomes interesting. When processing new products, some quality parameters have to be evaluated, such as physicochemical and nutritional parameters. This study aimed to obtain papaya droplets by basic spherification, checking physicochemical, microbiological and microscopic changes. From the papaya pulp, basic spherification process was held to obtain papaya droplets. The droplets were stored for 21 days inside of glass and polypropylene packages at 5±1 ° C. Microbiological results indicated that the samples were in accordance to the legislation until the 21st day in both packages. The presented physicochemical characteristics of papaya pulp were in accordance to the literature. It was observed a small decrease in protein, ° Brix, "ratio", vitamin C, total carotenoids, lycopene and beta-carotene in the droplets over time, in the two storage packages studied. It was possible to verify that the samples packed in polypropylene packages showed better preservation in total carotenoid, lycopene and beta-carotene. Regarding packaging, the samples when packed in polypropylene packages at ± 5 ° C presented less losses of nutrients in relation to the ones packed in glass for 21 days of storage. Thus, one may conclude that, the papaya droplets showed good physical and nutritional characteristics, making them viable for future commercialization.

Keywords: **Papaya, spherification, physical chemistry.**

I. INTRODUCTION

Originally from tropical America, the papaya (*Carica papaya L.*) has spread to several regions of the world [28]. It is one of the most common fruits in almost all countries of Tropical America. This fruit was known and consumed in the East since the early seventeenth century, being intensively cultivated in India, Sri Lanka, Malay Archipelago and in many other Asian countries. It also presents intense cultivation in the countries of South America, Central America and Caribbean, as well as in tropical Africa, Hawaii, Australia, Canary Islands (Spain) and Madeira (Portugal) [20]. In 2008, Brazil produced 1.9 million tons in 36.5 thousand hectares, with a production value estimated at R$ 1 billion [15]. Also in 2008, Brazil exported about 30 tons (7% less than in 2007), generating revenues of US$ 38.6 million [15]. As for domestic production, the main producers are the states of Bahia (902,000 tons), Espírito Santo (630,000 tons), Rio Grande do Norte (106,000 tons) and Ceará (100,000 tons). In relation to exports, the state of Espírito Santo accounts for 50% of the total [15]. The papaya is considered an excellent fruit, an important source of carotenoids, vitamin C and minerals; attributes of interest to the consumer, since the medical-scientific community has emphasized the importance of carotenoids in the diet, due to their antioxidant and anti-carcinogen properties [7]. The papaya is consumed as fresh fruit and is much appreciated for its sensory characteristics, especially color and aroma and also for its sweet flavor, lightly scented pulp and coloring varying from yellow to red [8]. The consumption of this fruit is almost entirely done *in natura*, but is limited due to the inconvenience of the complicated peeling and consumption [9]. Consumption could be expanded with the production of new products that allow its use in many different occasions and increase its shelf life, retaining the characteristics of the *in natura* product. The gelling / spherification is a new method of food processing, which can be applied to the fruit pulp. The process consists of comprising a liquid trap into a film or controlled gelation, where the product can be presented in different forms (droplets, wires, cts). The spherification is a technique of molecular gastronomy and its products are served in restaurants. No published scientific studies about this process were found, making it difficult to compare results obtained on this work with previous sources. Thus, studies aimed to obtain information about the process as a basis for future studies. Given the above, the objective of this work was to study the process of obtaining papaya droplets by basic spherification, checking the physicochemical, microbiological and microscopic changes. Also checking sensory acceptance, studying the behavior of aromas using the technique with the electronic nose as well as the viability and the time of storage of this product when packed in both glass and polypropylene packages and submitted to cold storage at 5±1 ° C.

II. MATERIAL AND METHODS

This work was developed at the Laboratory of Plant Products Processing (Laboratório de Processamento de Produtos de Origem Vegetal (LPPOV)), Laboratory of Food Analysis (Laboratório de Análise de Alimentos (LAA)) and at

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the Laboratory of Microbiology (Laboratório de Microbiologia (LM)) of the Department of Food Technology (Departamento de Tecnologia de Alimentos (DTA)) in the Federal University of Sergipe (Universidade Federal de Sergipe), in São Cristóvão - SE.

A. Extraction of the pulp

Papaya samples (Carica papaya L.), of the Formosa species were obtained in local markets in the city of Aracaju-SE. The fruits of Formosa papaya were selected following the criteria hereinafter: ripe ripening stage (with 50% to 75% of yellow peel), size, free of infection and physical defects. Then a pre-wash was performed on samples of papaya with running water for removal of macroscopic impurities, after that the samples were sanitized by dipping them into an aqueous solution of organic chlorine (Sumaveg®) at 200 ppm for 15 minutes. After sanitization, the samples were rinsed for total removal of the aqueous organic chlorine (Sumaveg®). The papaya pulp was obtained with the use of an Itametal depulper (Fig. 1).

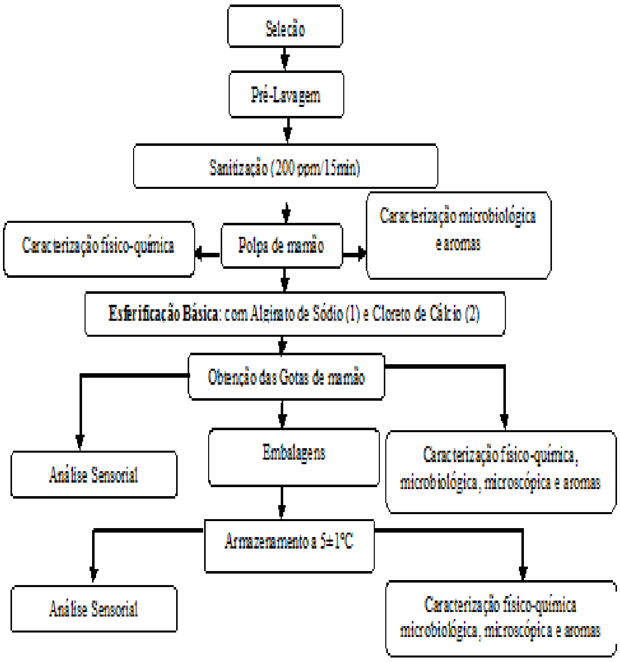

Fig. 1 Flowchart of the steps of obtaining drops of papaya process.

B. Spherification / Gelling

The papaya droplets were obtained through the process of basic spherification of the papaya pulp. The dripping methodology was used for the process of spherification. Two solutions were made. ***Solution (1):*** a solution composed by sodium alginate and papaya pulp (ratio 1: 100), in the preparation of this solution a RI1341 Philips homogenizer with 300 Watts of power was used. For ***solution (2):*** An aqueous solution was prepared at a concentration of 1% calcium chloride. The ***solution (1)*** was dripped with a syringe with a capacity of 20 mL on the ***solution (2).*** With a pierced instrument the droplets were drained and a new immersion of droplets was made in a container with water to remove any residue of the ***solution 2.*** After washing, the droplets were placed in glass and polypropylene 50-gram-packages and refrigerated at 5±1°C to be stored, characterized and subjected to sensory assess (Fig. 2).

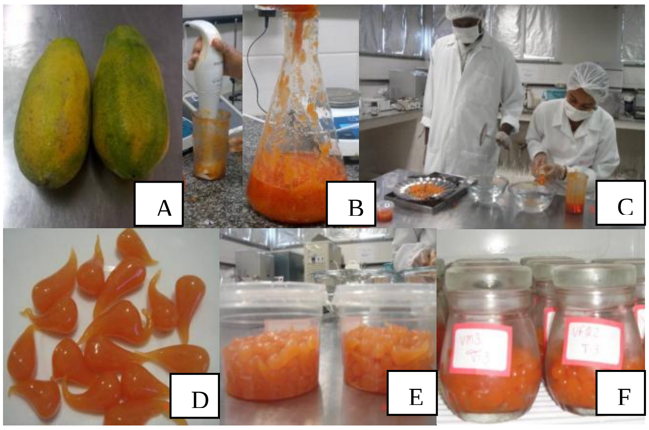

Fig 2 Steps in the processing of drops of papaya. (A) -Amostra papaya. (B) -Obtenção of papaya pulp. (C) -Polpa papaya with sodium alginate. (D) - to obtain pulp dripping drops. (E) and (F) - Drops of papaya in polypropylene containers and containers glass.

C. Yield

The yield was obtained by weighing *in natura* fruits and then weighing these after pulping, after that, the ratio between the difference in this weighing and in the initial weight multiplied by 100 was calculated.

D. Moisture Content

The moisture content was determined by the method of direct drying in stove at 105 ° C in constant weight, following the method 012/IV [15]. The sample was weighed on an analytical balance (Tecnal) with accuracy of 10^{-4} kg.

E. Ashes or Minerals

The method of incineration in furnace according to the methodology described by the method 900.02 [1] was used. The weighing were made on an analytical balance (Tecnal) with accuracy of 10^{-4} kg to obtain constant weight.

F. PH

For determination of pH, the Potentiometric method following the methodology of the Adolfo Lutz Institute [15] was used (2005.017 / IV) .The pH was measured in a Tecnopon potentiometer, model MPA-210, calibrated with buffer solutions of pH 4 and 7 at 20°C. 5g of the sample were weighed, these had been diluted in 50 mL of water, the pH reading given by the apparatus was observed.

G. Soluble Solids (°Brix)

The determination of soluble solids was evaluated in an Abbé's bench refractometer (Biobrix) and the result was expressed in °Brix.

H. Acidity

The acidity content was determined by the method of titratable acidity determined by titration with 0.1M NaOH according to method number 22,058 [3] and expressed as citric acid percentage.

I. Ratio

The ratio between Brix and acidity (g citric acid/100g of pulp), called "ratio", was calculated from measurements of the soluble solids and acidity, as described above.

J. Vitamin C

The determination of vitamin C was performed according to the method number 43,065 [3] and modified by Benassi and Antunes [4]. In which the extraction solution of metaphosphoric acid is replaced by oxalic acid.

K. Proteins

The protein content present in the samples was determined by the Kjeldahl's method, following the method 036/IV [15].

L. Lipids

The lipid content was analyzed by the method of direct extraction in Soxhlet. As described by method 920.39 C [2].

M. Total carotenoids and β-carotene

The carotenoid contents were assessed following [17]. The contents were expressed in µg/g.

N. Lycopene

The determination of lycopene was carried out according to the method [24]. The contents were expressed in µg/g.

O. Color

Color readings were obtained using the 200b Minolta Color Meter colorimeter. In this color representation system, L*, ***a**** and ***b**** values describe the color uniformity in three-dimensional space, in which L* value corresponds to how bright and how dark is the analyzed product (0: black; 100: white). The (a*) values correspond to the green to red scale (negative a*, green; a* positive, red) and the (b*) values correspond to the blue to yellow scale (negative b*, blue; b* positive, yellow). The Hue angle (h^o) is the angle between a* and b*, indicating the saturation of the color of the object.

P. Preparation of samples for microbiological analysis

Each sample was first homogenized, and 25 mL of each sample were individually transferred to an Erlenmeyer flask containing 225 mL of sterile buffered peptone water, and it was followed by posterior homogenization (10^{-1} dilution); from this dilution, decimal dilution of 10^{-2} and 10^{-3} was performed.

Q. Count of yeasts and molds

The yeasts and molds count was performed on the surface by inoculating 1 mL of each prepared dilution on sterile Petri dishes containing 15 to 20 mL of culture medium of Potato Dextrose Ágar (PDA) suitably acidified with tartaric acid and solidified; the dishes were inverted and incubated at 25°C for 3 to 5 days in a greenhouse. Count of colonies was performed.

R. Microscopic analysis

Microscopic analysis was performed in common points of samples. In this analysis, a digital Dino-Lite Plus microscope, model AM313T, was used. Approach 20x ~ 230x.

S. Statistical Analysis

A completely randomized factorial design was used for the results of physicochemical analyses, following 2x4 (2 packages and 4 times), with three repetitions of each sample. Data were expressed as means. The t test, at 5% probability, for detection of differences in means between the papaya pulp and newly processed droplets was applied. The Tuckey´s test, at 5% probability, was used to detect differences in means between the packages and times. The Assistat software (Statistical Service), version 7.6 beta, 2011 was used.

III. RESULTS AND DISCUSSION

A. Physicochemical Analyses

The yield in papaya pulp was 75.95%, a big difference between the result obtained and the one submitted by Shinagawa (2009) [27] who obtained a yield of 95% while analyzing the performance of the *Formosa* papaya, this difference may be related the thickness of the pulp and peel as well as the amount of seeds from papayas. Table I shows the results of the physicochemical analysis of papaya pulp used in processing the droplets.

Table I - Physico-chemical characterization of papaya pulp used for processing drops and drops of papaya.

Parameters	Papaya Pulp	Drops of papaya.
moisture (%)	$88,45\pm0,01^b$	$89,41 \pm0,50^a$
Ash (%)	$0,44\pm0,028^b$	$0, 63 \pm0,00^a$
Ph	$4,84\pm0,01^a$	$4,66\pm 0,03^b$
Total acidity (g citric acid / 100 g)	$0,088\pm0,0^a$	$0,088\pm0,00^a$
Ascorbic acid (mg / 100g)	$47,38\pm3,58^a$	$36,99\pm0,02^b$
Soluble Solids (Brix)	$10,33\pm0,14^a$	$9,92\pm 0,14^b$
Ratio	$117,86\pm1,75^a$	$112,56\pm1,54^b$
Proteins (%)	$0,55\pm0,01^a$	$0, 54\pm0, 01^a$
Lipids (%)	$0,39\pm0,22^b$	$0,78\pm0,07^a$
Total carotenoids (mg / g)	$39,35\pm1,49^a$	$36,82\pm0,19^b$
Beta-Carotene (mg / g)	$11,17\pm0,96^a$	$9,50\pm 0,0^b$

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Lycopene (mg / g)	26,49±0,02[a]	26,49±0,0[a]
Color		
L*	23,33±2,74[a]	17,87 ±1,40[b]
*A**	+12,37±0,38[b]	+15,13 ±1,47[a]
*B**	+12,40±3,41[a]	+17,23 ±3,35[a]
H°	48,7±0,92[a]	45,10 ± 0,87[b]

* Data in table are on a wet basis.

As for the moisture content, the value obtained for the pulp was 88.45%, which is in agreement with the value reported by other authors, such as Shinagawa (2009) [27], El-Aquar and Murr (2003) [9] and Grizzoto *et al*., (2005) [10] that, while studying the *Formosa* papaya pulp, found contents of 90.46%, 87.73% and 90.2% respectively. When comparing the pulp with the droplet, there is a significant difference in relation to the moisture content that can be explained by the fact that the droplets passed by water immersion in the processing. Regarding the ash content the value was 0,4433 which was close to that found by Shinagawa (2009) [27] who, while analyzing the pulp of papaya, found levels of 0.41. The ash content of the pulp was lower than the ash content of the droplet, which probably occurred due to the alginate skin that when formed in the droplets incorporated ash content. The pH found in this study was 4.84, and was consistent with that one found by Lima *et al*. (2009) [18], El-Aquar and Murr (2003) [9] who found values from 5.06 to 5.10 and 5.75 respectively. It was observed that the pulp had a greater value than the droplet, which can be explained by the acid character of the sodium alginate. Miguel (2008) [19], when studying minimally processed melons found that the melons coated with sodium alginate showed lower pH compared to the control._The acidity value was 0.088g of citric acid/100g, which is in the range of the one found by Souza *et al*. (2005) [29] who, while analyzing the minimally processed *Formosa* papaya, obtained a value of 0.058g of citric acid/100g. When comparing the pulp to the droplets we found that there was no difference between the levels of acidity. The value found in this study for the °Brix was 10.33 which is in the range of values obtained by other authors, such as, Souza *et al*. (2005) [29] who, when analyzing minimally processed *Formosa* papaya, found 11.67 °Brix and Lima *et al*. (2009) [18] who, while analyzing the *Formosa* papaya sold in Mossoró-RN, noted the following values of soluble solids: 12.86 °Brix, 13.42 °Brix and 12.64 °Brix. According to Souza *et al*. (2005) [29] the high sugar content is related to the low acidity and indicates the papaya pulp mild flavor. The pulp showed higher Brix than the droplet. According to Trigo (2010) [30], who evaluated the quality of minimally processed *Formosa* papaya using eatable coatings, the immersion of the fruit in film forming solution can leach soluble solids of the fruit. The ascorbic acid content of the papaya pulp evaluated in this study was 47.38 mg / 100g, close to that obtained by Rocha *et al*. (2007) [26] who, while analyzing vitamin C content in *Formosa* papaya, found a value of 46.92mg/100g. It was found that the pulp had higher ascorbic acid content than the droplet, probably due to losses occurred during processing. Regarding the protein content, the value obtained was 0.55%, higher than that found by Shinagawa (2009) who found a protein content in *Formosa* papaya pulp of 0.05g / 100g. As for the protein content there was no significant difference in the contents of pulp and droplets. The value of lipid content was 0.39%, lower than that found by Shinagawa (2009) [27] who found a lipid content of 0.49g/100g. The lipid content of the droplet was higher than the content of the pulp, the alginate coating likely contributed to this increase. The total carotenoids content was 39.35 µg/g, it is in agreement with El-Aquar and Murr (2003) [9] who obtained 37.02 µg /g of total carotenoids in *in-natura Formosa* papaya. Kimura *et al*. (1991) [16], while studying papaya, found total carotenoid contents in the range from 27.8 to 37.8 µg of carotenoids/g per sample. The total carotenoids content was higher in the pulp compared to the droplet; this decrease may have been caused by processing. Regarding beta-carotene, Grizzoto et al. (2005) [11], while analyzing papaya pulp, found a value of 3.64 µg of beta-carotene/g per sample, lower than that reported in this paper that was 11.17 µg/g. The carotene content in the pulp was higher when compared to the droplet; the decrease may have been caused by processing. According to Rodriguez-Amaya *et al*., (2008) [25], the lycopene content of papaya is equal to 23 ± 8 µg lycopene/g of papaya, which shows that the value shown in Table 5 (26.49 µg /g) is consistent with the literature. When comparing lycopene content of papaya pulp to the droplets content there was no significant difference. The results of color parameters (a* = +12.37; b* = +12.40; L* = 23.33; h° = 48.7) showed that the pulp color was dark orange. Rai and Chauhan (2008) [23], while analyzing *in-natura* papaya, found values of a* = + 9.15; b*= +23.47, L* = 37.51. Comparing the parameters of pulp color (a * = +12.37; b*= +12.40 *; L * = 23.33; h° = 48.7) to the color parameters of droplet (a * = + 15.13; b* = +17.23, L* = 17.87; h° = 45.10) it was also observed that the droplets had a darker color than the pulp. The moisture of the papaya droplets (Table II) showed significant difference in relation to storage time, this has increased by 3.32% in glass package and 3.25% in polypropylene package after 21 days of storage. It was found that the moisture content of the droplets stored in two types of package had similar behavior over time. Among the packages, there was significant difference only on day 14, when the glass package presented moisture content slightly lower than that observed in polypropylene package. The increased moisture can be explained by the fact that during the droplets obtaining process an immersion is carried out in water, which may have been absorbed by the droplets.

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Table II -Teor humidity (%) in drops of papaya stored at 5 ± 1 ° C for 21 days in glass and polypropylene.

Packaging	Time (Days)			
	0	7	14	21
Glass	89,41 ±0,50^{aB}	92,38± 0,03^{aA}	91,82± 0,85^{bA}	92,27± 0,12^{aA}
Polypropylene	89,41±0 ,50 ^{aB}	92,32± 0,03^{aA}	92,62± 2,78^{aA}	92,56± 0,12^{aA}

** Means followed by the same letter, lowercase and uppercase in the column on the line, do not differ by Tukey test at 5% probability.*

As for the ash content (Table III) the average relative values found for the packages showed significant difference on day 7 and day 21. While in storage times it was possible to be observed that there was significant difference during storage. There was an 1.56% increase in the ash content of the glass package and 10.14% in the polypropylene package at the end of storage.

Table III. Levels of ash (%) in drops of papaya stored at 5 ± 1 ° C for 21 days in glass and polypropylene.

Packaging	**Time (Days)**			
	0	7	14	21
Glass	0,634±0 ,01^{aA}	0,5824± 0,01^{bB}	0,6657± 0,03 ^{aA}	0,6442± 0,01^{bA}
Polypropylene	0,634±0 ,01 ^{aBB}	0,6707± 0,01^{aAB}	0,6477± 0,03^{aAB}	0,6986± 0,01^{aA}

** Means followed by the same letter, lowercase and uppercase in the column on the line, do not differ by Tukey test at*

No such accented oscillations were observed in pH. From day 7 on, it was observed a decrease in the pH value, with subsequent increase in the 14th day of storage in the glass package, which had reached at the end of the storage values close to those found in the processing day (Table IV). This behavior was also verified by Groppo (2007) [12] while studying the minimally processed orange, treated with sodium alginate and stored at 5 °C. Regarding droplets stored in polypropylene packages and glass packages, these last showed no significant differences with the storage period.

Table IV. Values of pH drops papaya stored at 5 ± 1 ° C for 21 days in glass and polypropylene.

Packaging	**Time (Days)**			
	0	7	14	21
Glass	4,66± 0,03^{aAB}	4,58± 0,02^{aAB}	4,71± 0,24^{aA}	4,50± 0,03^{aB}
Polypropylene	4,66± 0,03^{aA}	4,60± 0,00^{aA}	4,65± 0,05^{aA}	4,65± 0,02^{aA}

** Means followed by the same letter, lowercase and uppercase in the column on the line, do not differ by Tukey test at 5% probability.*

For soluble solids content, there was no significant difference between the storage period of the droplets and, only on the last day significant difference between the packages studied was verified (Table V). It was possible to observe a 21.88% decrease in soluble solids content over time in samples packed in glass packages and a 26.11% decrease in the samples packed in polypropylene from the initial content. This decrease can be explained by the fact that during the process of production of droplets an immersion is carried out in water, which could be leaching the soluble solids content.

Table V. Content of soluble solids (° Brix) in drops of papaya stored at 5 ± 1 ° C for 21 days in glass and polypropylene.

Packaging	**Time (Days)**			
	0	7	14	21
Glass	9,92± 0,14^{aA}	9,37± 0,20^{aB}	8,17± 0,14^{aC}	7,75± 0,00^{Ad}
Polypropylene	9,92± 0,14^{aA}	9,07± 0,06^{bB}	8,17± 0,14^{aC}	7,33± 0,29^{bD}

** Means followed by the same letter, lowercase and uppercase in the column on the line, do not differ by Tukey test at 5% probability.*

For the content of titratable acidity (TA) an increase was observed over time, occurring a significant difference at the end of storage. It was observed that in the glass package there was an increase of 89.44% and an increase of 117.93% in polypropylene package in relation to the initial content. Being found a significant difference between the packages, as the polypropylene package had a higher acidity in relation to the glass package (Table VI).

Table VI. Levels of total acidity (g citric acid / 100g) in drops papaya stored at 5 ± 1 ° C for 21 days in glass containers and polypropylene.

Packaging	**Time (Days)**			
	0	7	14	21
Glass	0,0881±0 ,001^{aD}	0,1174± 0,014^{aC}	0,1505±0 ,001^{aB}	0,1669± 0,006^{bA}
Polypropylene	0,0881±0 ,001^{aD}	0,1260±0 ,001^{aC}	0,1420± 0,008^{aB}	0,1920±0 , 001 ^{aA}

** Means followed by the same letter, lowercase and uppercase in the column on the line, do not differ by Tukey test at 5% probability.*

According to the results of the "ratio", there was a significant difference between the days of storage and between the packages, the difference only occurred on the seventh day of storage. The results indicated that the sweetness of the pulp was decreased by the passage of time, causing a loss in relation to the initial content of 58.72% in droplets stored in glass package and a loss of 66.06% in the polypropylene package (Table VII).

Table VII. Mean values of 'ratio' (soluble solids / titratable acidity) of drops of papaya stored at 5 ± 1 ° C for 21 days in glass and polypropylene.

Packaging	**Time (Days)**			
	0	7	14	21
Glass	112,56±1 ,54^{aA}	80,79± 12,59^{aB}	54,25± 0,86^{aC}	46,46± 1,58^{aC}
Polypropylene	112,56±1 ,54^{aA}	71,98± 0,48^{bB}	57,64± 4,04^{aC}	38,20± 1,49^{aD}

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With regard to the content of vitamin C, it was found that losses occurred during the storage period in both types of packages. The droplets stored in glass package showed less reduction, 49.93%, while the polypropylene package reduction was of 66.80% (Table VIII). Droplets stored in glass packaging showed better preservation of vitamin C, the best conservation may have been favored by the lower permeability to oxygen of this type of package.

Table VIII. Vitamin C content (mg / 100gramas) in drops papaya stored at 5 ± 1 ° C for 21 days in glass containers and polypropylene.

Packaging	Time (Days)			
	0	7	14	21
Glass	36,99± $0,02^{aA}$	36,13± $0,15^{aB}$	24,72± $0,06^{aC}$	18,52± $0,13^{aD}$
Polypropylene	36,99± $0,02^{aA}$	36,14± $0,21^{aB}$	18,59± $0,03^{bC}$	12,28± $0,09^{bD}$

** Means followed by the same letter, lowercase and uppercase in the column on the line, do not differ by Tukey test at 5% probability.*

Regarding the total carotenoid contents, in this research, it was found no significant difference, neither in the storage time nor between packages until the 7th day. On the 14th day there was a significant difference in time, when the reduction of the total carotenoids was observed. It was noticed that the papaya droplets stored in polypropylene package showed lower total carotenoid, a loss of 6.93%, and the ones stored in glass package showed a loss of 9.94% (Table IX).

Table IX. Content of total carotenoids (mg / g) drops papaya stored at 5 ± 1 ° C for 21 days in glass and polypropylene.

Packaging	Time (Days)			
	0	7	14	21
Glass	36,82± $0,19^{aA}$	36,47± $0,32^{aA}$	35,04± $0,0^{aB}$	33,16± $0,14^{bC}$
Polypropylene	36,82± $0,19^{aA}$	36,50± $0,0^{aA}$	34,99± $0,35^{aB}$	34,27± $0,0^{aC}$

** Means followed by the same letter, lowercase and uppercase in the column on the line, do not differ by Tukey test at 5% probability.*

According to Table X, it can be seen that there was a reduction in the content of beta-carotene with the storage time, in which the polypropylene package was more effective on the conservation of this carotenoid. The droplets stored in glass package showed a loss of 29.69% and the ones stored in polypropylene a loss of 5.26%, compared to the initial content.

Table X. Carotene content (mg / g) drops papaya stored at 5 ± 1 ° C for 21 days in glass containers and polypropylene.

Packaging	Time (Days)			
	0	7	14	21
Glass	9,50± $0,0^{aA}$	9,47± $0,13^{aA}$	7,66± $0,50^{bB}$	6,68± $0,40^{bC}$
Polypropylene	9,50± $0,0^{aA}$	9,33± $0,02^{aA}$	9,25± $0,33^{aA}$	9,00± $0,41^{aA}$

** Means followed by the same letter, lowercase and uppercase in the column on the line, do not differ by Tukey test at 5% probability.*

During storage it was observed that there was significant difference between the packages and between the storage periods regarding the content of lycopene. It was noticed the reduction of the contents of lycopene over time, in which the droplets stored in polypropylene package showed lower losses of this carotenoid with a percentage of 6.11% and in glass package this reduction was higher, 10.04% of loss (Table XI).

Table XI. lycopene content (mg / g) drops papaya stored at 5 ± 1 ° C for 21 days in glass containers and polypropylene.

Packaging	Time (Days)			
	0	7	14	21
Glass	26,50± $0,0^{aA}$	24,25± $0,11^{bB}$	24,23± $0,54^{bB}$	23,84± $0,07^{bB}$
Polypropylene	26,50 ±$0,0^{aA}$	26,01± $1,05^{aAB}$	25,42± $0,0^{aAB}$	24,88± $0,0^{aB}$

** Means followed by the same letter, lowercase and uppercase in the column on the line, do not differ by Tukey test at 5% probability.*

The better conservation of the total carotenoids, beta-carotene and lycopene in polypropylene package might be explained because this type of package offers a better protection to light incidence for being more opaque than the glass container. The parameter of L color indicates the brightness and varies from 0% (black) to 100% (white). There was a significant difference between the packages and storage time (Table XII). The color showed a decrease in the amount of light over time which indicates the darkening of the droplet. This decrease was of 35.09% in glass package and of 36.21% in polypropylene package. This darker color may be related to the coloration of sodium alginate, which has a slightly brown color. The enzymatic browning reaction, oxidation or light incidence may have contributed to the darkening of the droplets.

Table XII. color parameter L * of drops papaya stored at 5 ± 1 ° C for 21 days in glass containers and polypropylene.

Packaging	Time (Days)			
	0	7	14	21
Glass	17,87± $1,40^{aA}$	16,77± $0,90^{aA}$	11,67± $0,67^{bB}$	11,60± $0,0^{aB}$
Polypropylene	17,87± $1,40^{aA}$	13,93± $1,33^{bB}$	13,80± $0,0^{aB}$	11,40± $0,0^{aC}$

** Means followed by the same letter, lowercase and uppercase in the column on the line, do not differ by Tukey test at 5% probability.*

The a* color varies from red (+ a) to green (-a). There was no significant difference between the packages. However it was observed a decrease by the passage of time, which shows that there was a reduction in red. In the glass package there was a reduction of 36.09%, while in the polypropylene package the loss was of 45.14% at the end of storage. This

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decrease may be related to the degradation of the total carotenoid content, which has been demonstrated in this study (Table XIII).

Table XIII. Parameters * color of droplets papaya stored at 5 ± 1 ° C for 21 days in glass containers and polypropylene.

Packaging	Time (Days)			
	0	7	14	21
Glass containers	+15,13 ±1,47aA	+12,07 ± 0,58aAB	+9,63 ±1,48aB	+9,67 ±1,69aB
Polypropylene	+15,13 ±1,47aA	+10,10 ± 2,45aB	+9,90 ±0,35aB	+8,30 ±2,46aB

** Means followed by the same letter, lowercase and uppercase in the column on the line, do not differ by Tukey test at 5% probability.*

The parameter b* refers to the color variation between yellow (+ b) and blue (-b). There was no significant difference between the packages. However it was observed a decrease over the storage period, indicating a decrease in yellow color. In glass package reduction was of 22.98%, and of 25.89% in polypropylene package (Table XIV). This decrease may be related to the degradation of beta-carotene content observed in this study.

Table XIV. color parameter b * of drops papaya stored at 5 ± 1 ° C for 21 days in glass containers and polypropylene.

Packaging	Time (Days)			
	0	7	14	21
Glass containers	+17,23 ±3,35aA	+15,80± 0,98aA	+13,60 ±0,0aA	+13,27± 0,1aA
Polypropylene	+17,23 ±3,35aA	+12,67± 2,14aA	+13,00±0 ,0aA	+12,77 ±2,80aA

** Means followed by the same letter, lowercase and uppercase in the column on the line, do not differ by Tukey test at 5% probability.*

The Hue angle color parameter showed a significant difference between the packages only on the 14th day, when glass package showed a lower value in relation to polypropylene package. And, by the passage of the time, there was no significant difference at all periods for the glass package, whereas in the polypropylene package this difference occurred until the 14th day. It was observed that there was an increase in this parameter over time. When droplets packed in glass package increased by 22.39% and the polypropylene packaged increased by 21.44% (Table XV).

Table XV. Parameter Color Hue angle of drops of papaya stored at 5 ± 1 ° C for 21 days in glass and polypropylene.

Packaging	Time (Days)			
	0	7	14	21
Glass	17,87± 1,40aA	16,77± 0,90aA	11,67± 0,67bB	11,60± 0,0aB
Polypropylene	17,87± 1,40aA	13,93± 1,33bB	13,80± 0,0aB	11,40± 0,0aC

** Means followed by the same letter, lowercase and uppercase in the column on the line, do not differ by Tukey test at 5% probability.*

B. Microbiological Analysis

It can be seen from Table 16 that all samples until the seventh day showed themselves up in accordance with the requirements of the Brazilian legislation, according to RDC number 12, (BRAZIL, 2001). At day 21 samples stored in polypropylene packages were on the limit required by law. After this time it was possible to visually observe the presence of yeasts and molds in the samples in both packages (table XVI).

Table XVI. Results obtained in the microbiological analysis of drops of papaya.

Packaging	Time (Days)			
	0	7	21	Limite RDC
Glass	$3,2x10^2$	$4,7\ x10^2$	$3,7x10^3$	$5,0\ x10^3$
Polypropylene	$3,2x10^2$	$4,2\ x10^2$	$5,2\ x10^3$	$5,0\ x10^3$

* RDC Resolution N012 of 02/01/2001 (BRAZIL, 2001)[5].

It was found that the droplets stored in glass packages showed the longer shelf life, which can be explained by this type of package having lower permeability to oxygen. The presence of fungi in a high number is undesirable because of the microbiological quality, as they are capable of producing large variety of enzymes, which cause spoilage of fruit. In addition, many molds can produce toxic metabolics when they are developing in food (Pinheiro *et al*., 2005) [21].

IV. CONCLUSION

The results show that in some parameters of the physicochemical analyses of the droplets of freshly processed papaya significant difference was presented when compared to the *in natura* papaya pulp. The packing of the papaya droplets in polypropylene package proved to be the most suitable for better conservation in total carotenoid, lycopene and beta-carotene while glass package best sustained vitamin C contents. Droplets stored in glass packages had better microbiological results. The shelf life under these conditions was about 21 days at 5 °C. This study showed the viability of spherification of papaya pulp, since the droplets obtained in this process have nutritional characteristics similar to the ones of the papaya pulp.

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AUTHOR'S PROFILE

Alessandra Almeida Castro Pagani: Laboratório de Análise de Alimentos - LAA, Departamento de Tecnologia Alimentos –DTA,Universidade Federal de Sergipe, UFS, Cidade Universitária Prof. "José Aloísio de Campos", Av. Marechal Rondon, s/n, São Cristóvão – SE.

Mariana Costa Oliveira: Laboratório de Análise de Alimentos - LAA, Departamento de Tecnologia Alimentos –DTA,Universidade Federal de Sergipe, UFS, Cidade Universitária Prof. "José Aloísio de Campos", Av. Marechal Rondon, s/n, São Cristóvão – SE.

Anne Caroline Rocha Xavier: Laboratório de Análise de Alimentos - LAA, Departamento de Tecnologia Alimentos –DTA,Universidade Federal de Sergipe, UFS, Cidade Universitária Prof. "José Aloísio de Campos", Av. Marechal Rondon, s/n, São Cristóvão – SE.

Alaiza Lima Barros Morais: Laboratório de Análise de Alimentos - LAA, Departamento de Tecnologia Alimentos –DTA,Universidade Federal de Sergipe, UFS, Cidade Universitária Prof. "José Aloísio de Campos", Av. Marechal Rondon, s/n, São Cristóvão – SE.

Tatiana Pacheco Nunes: Laboratório de Análise de Alimentos - LAA, Departamento de Tecnologia Alimentos –DTA,Universidade Federal de Sergipe, UFS, Cidade Universitária Prof. "José Aloísio de Campos", Av. Marechal Rondon, s/n, São Cristóvão – SE.

Gabriel Francisco Silva: Laboratório de Análise de Alimentos - LAA, Departamento de Tecnologia Alimentos –DTA,Universidade Federal de Sergipe, UFS, Cidade Universitária Prof. "José Aloísio de Campos", Av. Marechal Rondon, s/n, São Cristóvão – SE.