**Contemporary Engineering Sciences, Vol. 11, 2018, no. 35, 1703 - 1712**
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**https://doi.org/10.12988/ces.2018.84146**

# Determination of the Physicochemical Characterization and Functional Properties of a Sweetened Sesame Paste

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## Abstract

The aim of this research was to determine the physicochemical characteristics and the functional properties of a sweetened sesame paste with the incorporation of bovine blood plasma. A multi-level 2x2x4 structure was used, a medium fraction, where the factors with their levels were: sesame paste (80% and 70%), syrup (20% and 30%) and blood plasma (0.75%, 1.0%, 1.25% and 1.5%), for eight experimental formulations with three repetitions for each treatment. The response variables were the physicochemical characteristics (pH, humidity, ash, protein, fat and fiber) and the functional properties (stability, water retention capacity, shatter capacity, stability and emulsifying capacity) of the sweetened paste. The treatments elaborated with 80% of sesame paste have the best physicochemical characteristics and functional properties, so they are considered optimal for use in the development of pastry products.

**Keywords:** sesame paste, blood plasma, proteins, stability

## 1. Introduction

Functional properties are physicochemical properties that allow it to contribute to the desired characteristics of a food. These can be classified into three large groups: Hydration properties dependent on the protein-water characteristics, properties dependent on protein-protein interactions and surface properties. The first group includes properties such as water absorption, succulence, swelling, adhesion, dispersibility, solubility and viscosity. The second group of properties intervenes in phenomena such as precipitation, gelation and formation of other different structures (fibers and protein pastes, for example). The third group of properties refers to the surface tension, emulsification and foaming characteristics of the proteins. These three groups are not totally independent; for example, gelation not only involves protein-protein interactions but also protein-water interactions; the viscosity and solubility depend on each other of the protein-water and protein-protein interactions [1, 2].

However, various studies on the functional properties of sesame (*Sesamum indicum* L.) and its products have been carried out, for example Cano-Medina et al., [3] evaluated the effects of oil concentration and pH on the emulsifying characteristics and foam concentrates of sesame protein (*Sesamum indicum* L.) (SESPC), concluding that this may have a potential use as a raw material in food industry. They also reported that at an extreme pH, SESPC continues to have important functional characteristics, such as emulsion stability, oil absorption capacity and foam formation. Similarly, Achouri and Boye [4] have isolated the sesame protein (SPI) and analyzed its functional properties, concluding that the sesame protein isolate possesses low protein solubility, water retention and fat binding capacities, but it has better emulsifying and foaming properties compared to the soy protein isolate. The objective of the present investigation was to characterize physicochemically and determine the functional properties of a sweetened sesame paste (*Sesamum indicum* L.). This work represents preliminary studies for the formulation of pastry products based on sesame paste and non-traditional raw materials.

## 2. Methodology

It was used sesame (S. indicum L.) variety seventy white of the mountainous region of Córdoba municipality, Bolívar (Colombia). Blood plasma of lyophilized bovine supplied by Tecnas S.A. (Medellin Colombia). The other inputs used in the formulation (salt, sugar and glucose) were obtained from supermarkets in the city of Cartagena de Indias, Colombia.

### *2.1 Technological development of sesame paste*

The methodology for the technologically elaboration of sesame paste reported previously was used [5, 6]. For the preparation of the pastae, 1000 grams of sesame seeds are bleached and dehusked; Then it was immersed in 6 liters of water (T = 18 ± 2 ° C) for 12 hours. The soaked seeds were squeezed and mechanically peeled using a dry cloth to rub and thus remove the peel from it. The seeds were then immersed for five minutes in a saline solution at 23% w / w (each 1000 grams in 8 liters of solution). In order to separate the cascades and other foreign elements, the immersion of the seeds in the saline solution was repeated three times; Then they were taken from the surface of the solution and washed with water five (5) times to remove the salt. Subsequently the seeds were squeezed to reduce the water content of the surface of the same and were used for the roasting process in this study. Two hundred and fifty grams of these moist dehusked seeds were toasted at temperatures of 140 ° C in a compact compact Challerger, series 02451 for 30 minutes with shaking. An ambient temperature was immediately balanced to prevent additional heating. The roasted seeds were ground in a mill for Corona brand grain, twice.

### 2.2 Syrup preparation

For the syrup preparation, sugar and water were used in a ratio of 1: 1 and the liquid glucose was added to 3% by total weight of the sugar. After having the syrup ready, and with the help of a homogenizer, the sesame paste and 50% plasma was mixed for 30 seconds at 2 rpm. The syrup was then slowly added at 2-4 rpm for 2 minutes and then the remaining 50% plasma was mixed for 3 minutes, achieving a good homogenization. It is important to note that the syrup must not be hot when added to the paste as it would facilitate the separation of the oil from it.

### 2.3 Experimental design and data analysis

A completely randomized experimental design was used, under a 2x2x4 multilevel factorial structure at half fraction to rule out the effects of similar treatments, where the factors with their respective levels were: sesame paste (PA) (80% and 70%) , syrup (A) (20% and 30%) and blood plasma (PB) (0.75%, 1.0%, 1.25% and 1.5%), for a total of 8 experimental formulations with three repetitions for each treatment. The variable responses were the physicochemical characteristics (pH, humidity, ash, protein, fat and fiber) and the functional properties (syneresis, water retention capacity, foaming capacity, foaming stability, emulsifying capacity and emulsifying stability) of the sugary paste. The formulations used are shown in Table 1. All measurements were made in triplicate, the result expressed represents an average with its respective standard deviation. The processing of the data was carried out using the statistical program STATPGRAPHICS Centurion Version XVI in Windows 10, in which the existence of differences of each of the parameters was statistically corroborated through an Analysis of Variances (ANOVA). When differences were found, Fisher's minimal difference difference (LSD) procedure was used to discriminate between means considering a level of significance of 5% ($\alpha = 0.05$).

**Table 1.** Formulations of sweetened sesame pastes

| Treatment | Sesame paste (%) | Syrup (%) | Plasma (%) |
|---|---|---|---|
| T1 | 70 | 30 | 0.75 |
| T2 | 70 | 30 | 1.00 |
| T3 | 70 | 30 | 1.25 |
| T4 | 70 | 30 | 1.50 |
| T5 | 80 | 20 | 0.75 |
| T6 | 80 | 20 | 1.00 |
| T7 | 80 | 20 | 1.25 |
| T8 | 80 | 20 | 1.50 |

### *2.4 Physical-chemical characterization*

Physicochemical characteristics linked to a greater or lesser extent to the functional properties were determined in order to establish a relationship between physicochemical characteristics and functional properties. The physicochemical characteristics evaluated according to A.O.A.C. [7] were pH (AOAC 10,041 / 84), acidity expressed in oleic acid (AOAC 942.15 / 90), humidity (AOAC 925.09), ash (AOAC 923.03), protein (AOAC 976.05), fat (AOAC 920.39), fiber (AOAC 962.09

### *2.5 Functional properties*

#### *2.5.1 Syneresis measurement*

The measurement was made after two days of refrigerated storage of the paste at 4 ° C. The paste were agitated for 2 min at 100 rpm on a shaking table (TECNAL brand, model TE-1401), then centrifuged by 15 minutes at a speed of 4000 rpm, in a compact centrifuge. The weight of the supernatant was obtained and the % syneresis was calculated by Equation (1):

$$\%Syneresis = \frac{(weight\ of\ the\ liquid\ separated\ from\ the\ paste)}{(total\ weight\ of\ paste)} x100 \tag{1}$$

The syneresis was calculated as the amount of liquid that separates from the product, due to the centrifugation in relation to the total mass of the paste that will be centrifuged [5, 8].

#### *2.5.2 Water retention capacity (CRA)*

The methodology used by Umaña et al., [9] was followed, for which 1 g of sample was weighed in a test tube, 10 mL of water were added and it was stirred for 5 min. Then it was centrifuged at 3000 rpm for 30 min, the supernatant was separated and the residue transferred in a crucible and weighed, obtaining the value of wet residue (RH). Then the residue was dried at 105 ° C ± 1 for 24 hours and weighed, obtaining the value of the dry residue (RS). The % CRA was calculated by Equation (2):

$$CRA = \frac{RH(g) - RS(g)}{RS(g)} \tag{2}$$

### *2.5.3 Foaming capacity (CES)*

The method of Coffmann and Garciaj [10] was chosen to determine the foaming capacity of the pastes analyzed. An amount of 1 g of paste was dispersed in 10 mL of distilled water and this suspension was vigorously shaken for 3 min in vortex. The volumes (mL) before (V1) and after (V2) the mixing were recorded. The foaming capacity (CES) was calculated according to Equation (3):

$$CES(\%) = \frac{(V_2 - V_1)}{V_1} * 100 \tag{3}$$

### *2.5.4 Foaming stability (EES)*

The foaming stability (EES) was determined by the volume difference measured when transferring the mixture to a measuring cylinder to determine the volume at 0 min and 60 min [11]. The foaming stability was calculated with Equation (4):

$$EES(\%) = \frac{EES_{60\,min}}{EES_{0\,min}} * 100 \tag{4}$$

### *2.5.5 Emulsifying capacity*

It was determined according to Yaumatsu et al., [12] methodology, in which 1 g of sample was mixed with 20 mL of distilled water, in a Tecnal brand shaker table (TE-1041) shaking at 200 rpm for 15 min. The pH was adjusted to 7 and the volume was brought to 25 mL with distilled water. Then equal parts (25 mL) of this solution were mixed with corn oil in a blender for 5 min and centrifuged at 1300 rpm in an Eppendorf brand centrifuge model N ° 5804. The emulsion was expressed in terms of percentage, as the height of the emulsified layer with respect to the total liquid.

### *2.5.6 Emulsifying stability (EE)*

The previously formed emulsions were evaluated respect to time. Its stability was evaluated and presented in terms of%. The emulsion stability (EE) was calculated according to the methodology proposed by Ferreyra et al., [13].

## 3. Results

### *3.1 Physical-chemical characterization*

Table 2 summarizes the results of the triplicate measurements of each physicochemical characteristic evaluated. Differences are statistically significant ($p < 0.05$) in moisture content, protein, fiber, ash and fat. The formulations with higher content of sesame paste showed lower moisture content, this is because with a higher percentage of paste, the proportion of dry matter in the final product increases, maintaining a balance between moisture and dry matter in the treatments, such as reported by Julio et al., [14]. Likewise, the results indicated that the aggregate of plasma and sesame paste produced differences ($p < 0.05$) in the protein content of the products. The treatments that showed the highest percentage of protein were those that had the highest content of sesame paste, as stated by Montero et al., [15] in the manufacture of a sausage incorporating blood plasma and sesame paste, in which the treatment that contained greater addiction of sesame paste and blood plasma presented higher protein content than the other treatments, this possibly due to the fact that the sesame seed has a high nutritional value with a protein content between 17% to 23%. Similar results were obtained by Julio et al., [14] in which the addition of blood plasma and sesame paste increased the protein content of the product.

**Table 2.** Physicochemical characteristics of each treatment

| Property | Treatment | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 |
| pH | 6,13±0,07$^{a}$ | 6,10±0,01$^{a}$ | 6,12±0,08$^{a}$ | 6,12±0,09$^{a}$ | 6,08±0,03$^{a}$ | 6,09±0,07$^{a}$ | 6,13±0,10$^{a}$ | 6,17±0,04$^{a}$ |
| Acidity | 0,28±0,24$^{a}$ | 0,28±0,13$^{a}$ | 0,28±0,21$^{a}$ | 0,28±0,07$^{a}$ | 0,42±0,16$^{a}$ | 0,56±0,11$^{a}$ | 0,56±0,18$^{a}$ | 0,42±0,26$^{a}$ |
| Humidity | 20,93±0,27$^{cd}$ | 20,91±1,15$^{cd}$ | 22,24±1,25$^{d}$ | 21,31±0,58$^{cd}$ | 16,38±0,30$^{a}$ | 18,36±0,96$^{b}$ | 17,07±0,88$^{ab}$ | 20,42±0,78$^{c}$ |
| Ashes | 2,96±0,24$^{a}$ | 3,03±0,17$^{a}$ | 3,06±0,29$^{ab}$ | 3,00±0,11$^{a}$ | 3,25±0,02$^{ab}$ | 3,23±0,29$^{ab}$ | 3,25±0,28$^{ab}$ | 3,40±0,01$^{b}$ |
| Protein | 18,37±1,90$^{a}$ | 20,70±0,52$^{bcd}$ | 20,56±0,18$^{bc}$ | 20,01±1,00$^{ab}$ | 22,16±0,27$^{cde}$ | 19,08±1,48$^{ab}$ | 22,51±1,04$^{e}$ | 22,37±0,37$^{de}$ |
| Fat | 47,20±0,06$^{d}$ | 45,55±1,23$^{bc}$ | 46,87±1,02$^{cd}$ | 44,86±1,85$^{b}$ | 42,86±1,06$^{a}$ | 42,87±0,25$^{a}$ | 43,10±0,09$^{a}$ | 41,84±0,01$^{a}$ |
| Fiber | 2,92±0,01$^{ab}$ | 2,83±0,32$^{a}$ | 2,87±0,44$^{ab}$ | 2,95±0,13$^{ab}$ | 3,09±0,06$^{ab}$ | 2,94±0,05$^{ab}$ | 3,11±0,26$^{ab}$ | 3,37±0,53$^{b}$ |

Regarding the analysis of fat, the lowest values were presented by the formulations with the highest content of paste and plasma. This is because the percentage of fat was the main consequence of the amount of fiber that the sesame paste contributes, it means, as the fiber concentration increased the percentage of fat decreased. This phenomenon was found in the study of Julio et al., [14] who found lower values of fat in sausages with higher content of sesame paste and blood plasma in its formulation. similarly, Viana et al., [16] indicate that the incorporation of blood proteins, both plasma and globin, yields a ham paté with higher protein content and reduces between 20% and 30% of fat, thereby there is the possibility of obtaining light meat products, which in general, maintains the aroma, flavor and consistency of the unmodified products. Now, taking into account the fiber content of the sesame paste, it is understandable that the treatments with higher content of sesame paste have a higher fiber content [14].

### *3.2 Functional properties*

Table 3 shows the functional properties analyzed for sweetened sesame pastes with different blood plasma formulations. It is evidenced that statistically significant differences were detected ($p < 0.05$) in all evaluated properties. As regards syneresis, these differences are possibly due to the fact that the moisture content varied according to the formulation used, the formulations with the highest humidity being the least stable and therefore with the short shelflife. Additionally, a higher percentage of proteins in paste formulated with higher content of sesame paste, due to the moisture retention capacity of these, contribute to a lower syneresis [5, 6]. In terms of emulsifying capacity and stability, these depend on two different sets of molecular properties. While the emulsifying capacity is affected by the speed of adsorption, flexibility and hydrophobicity, the stability depends on the rheological properties of the protein film. The protein in most foods is made up of mixtures of different molecular species; therefore, its emulsifying properties are determined by the interaction between the protein components in the interface, and these at the same time by the physicochemical differences found [2]. In this order, the treatments with higher content of sesame paste and blood plasma showed the best characteristics of emulsifying capacity and stability, possibly because the plasmic proteins have favorable characteristics for their use in the food industry, highlighting their participation as emulsifying agent, foaming agent and binder and its ability to form gels and increase the profitability of the product [15, 17]. The above, evidences the fact that in the treatments with higher content of sesame paste and blood plasma, better characteristics in terms of capacity and foaming stability are also detected.

**Table 3**. Summary of functional properties of each treatment

| Property | Treatment | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 |
| Syneresis | 9,62±0,09$^{a}$ | 8,60±0,13$^{b}$ | 7,07±0,08$^{c}$ | 7,62±0,23$^{d}$ | 6,83±0,23$^{c}$ | 6,62±0,33$^{c}$ | 6,12±0,64$^{e}$ | 5,88±0,05$^{f}$ |
| Water retention capacity | 1,61±0,09$^{a}$ | 1,72±0,04$^{ab}$ | 1,76±0,10$^{ab}$ | 1,98±0,16$^{bc}$ | 2,04±0,23$^{c}$ | 2,31±0,10$^{d}$ | 2,61±0,19$^{e}$ | 2,97±0,21$^{f}$ |
| Foaming capacity | 4,50±0,71$^{a}$ | 6,50±0,71$^{b}$ | 7,0±1,41$^{bc}$ | 8,00±0,10$^{bcd}$ | 8,50±0,71$^{cde}$ | 8,90±0,20$^{de}$ | 9,50±0,71$^{de}$ | 9,98±1,41$^{e}$ |
| Foaming stability | 96,56±1,04$^{a}$ | 97,59±0,65$^{ab}$ | 98,37±1,62$^{ab}$ | 98,46±1,01$^{ab}$ | 98,56±1,02$^{ab}$ | 98,7±1,01$^{b}$ | 99,27±0,36$^{b}$ | 99,59±0,65$^{b}$ |

**Table 3**. (Continued): Summary of functional properties of each treatment

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Emulsifying capacity | 7,23±0,46$^{a}$ | 8,03±0,13$^{a}$ | 13,29±1,47$^{b}$ | 15,43±1,76$^{c}$ | 15,35±0,49$^{c}$ | 16,40±1,62$^{c}$ | 16,80±0,21$^{c}$ | 20,51±1,19$^{d}$ |
| Emulsifying stability | 87,25±1,06$^{a}$ | 90,30±1,24$^{ab}$ | 90,50±1,54$^{ab}$ | 91,01±1,14$^{ab}$ | 92,70±1,08$^{bc}$ | 93,00±1,83$^{bc}$ | 94,50±1,70$^{bc}$ | 97,25±1,34$^{c}$ |

A similar situation arose in the water retention capacity, since the treatments with higher content of paste and plasma showed better characteristics, which can be explained by the gelling property of the plasma, because the gel that forms traps fat and wáter [18] and the fiber content provided by sesame paste (4.58%), which is hydrated during the manufacturing process [5], helping to retain of water. As stated by Julio et al., [14], whose products with blood plasma and sesame paste in their formulation had a higher yield and lower water loss.

## 4. Conclusions

From the above it can be inferred that the use of sesame paste and bovine blood plasma improve the functional properties and physicochemical characteristics of sugary pasta, being the treatments made with 80% of sesame paste and those with a higher content of plasma the best, so they are optimal for use in the development of pastry products.

**Acknowledgments.** The authors thank the Administrative Department of Science, Technology and Innovation (COLCIENCIAS) for the financing of the project 110766441920 through 664 announcement.

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**Received: April 17, 2018; Published: May 24, 2018**