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Research Article

Physicochemical Characterization and Determination of the Useful Life of Dehydrated Creams of Barracuda (*Sphyraena ensis*) Flour with Pregelatinized Corn, Cassava and Yam Starch

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Abstract: The aim of this research was to characterize physicochemically dehydrated creams of fishmeal with pregelatinized corn, cassava and yam starch and determine their useful life. Three sources of Pregelatinized starch (corn (PCS), cassava (PCAS) and yam (PYS)) were evaluated varying in ratios of 20/40, 30/30 and 40/20 starch/fishmeal. It was determined the content of fat, protein, moisture, ash, pH and color parameters, which were compared with a commercial cream. In addition, the shelf life of the creams was established through the moisture gain by absorption isotherms, at a temperature of 35°C, varying the relative humidity between 34.78 and 91.66%. Very favorable nutritional levels were obtained in barracuda creams with fat and protein contents between 0.98-1.77% and 16.30-41.97%, respectively, with reference to the commercial cream. The percentage of moisture in the cream allowed to establish the useful life through isotherms of absorption, indicating that, with a percentage of compaction of 100, 20, 10 and 5%, the stability time of the cream is 33.39; 6.68; 3.34 and 1.67 months, respectively. Under the established conditions, creams with the minimum amount of barracuda flour, manage to overcome the nutritional contribution of commercial creams with a useful life of approximately 18 months with 50% of compaction.

Keywords: Conservation, fish, nutrition, protein, proximal analysis

INTRODUCTION

In Colombia, the fishing sector is being heavily influenced by the aquaculture practice, mainly of direct consumption species such as red and silver tilapia, trout, cachama and shallow water shrimp. However, studies have shown that there are other inland water species that bring greater benefits to human health and also have lower production costs. The barracuda (*Sphyraena ensis*) or beaked, as it is commonly known, is one of the marine species with greater commercial value, that abounds in the Pacific coast. According to previous studies, barracuda has a protein content of 19.52%, 2.18% ethereal extract, 1.21% ash and 77.13% water (Fonseca-Rodríguez and Chavarría-Solera, 2017); and is one of the species with the highest content of Eicosapentaenoic Acid (EPA) and Docosahexaenoic Acid (DHA), suggesting the possibility of considering not only blue or oily fish as a good source of omega 3 fatty acids (Castro-González *et al*., 2007; Suárez Ramirez, 2010; Esquivel *et al*., 2014).

In the food industry, foods that combine the nutritional contribution and practicality in its elaboration have been developed. This mainly involves the provision of elements such as fiber, vitamins and minerals, lipids, calories and proteins in the regular diet (Greensmith, 1998). Thus, for example, proteins play a fundamental role throughout a person's life cycle, causing their consumption to become necessary at any stage (Calderón Velez, 2006). For this reason, dehydrated creams have been cataloged as one of the food products of greatest demand in the world market (García *et al*., 2007), considering the modern society trend.

These foods use pregelatinized starch as one of its main ingredients so that its physicochemical and functional properties, among others, are altered in the proportion in which it is included in its formulation (Dapcevic Hadnađev *et al*., 2015). Thus, raw materials of amylaceous origin with high potential in the Colombian Caribbean Region such as cassava (*Manihotstuculenta* C.) and yam (*Dioscorearotundata*)

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have been considered, opting for alternatives of corn, the most used starch in the food industry worldwide. In this sense, the objective of this research was to characterize physicochemically dehydrated creams of barracuda flour with pregelatinized corn, cassava and yam starch and determine their useful life.

MATERIALS AND METHODS

Location: The development of this experiment was carried out at the facilities of the Pilot Plant of Unit Operations of the University of Sucre ("Los Pericos" Farm), located in Sampués, Sucre and at the Laboratory of Food Analysis of the Food Engineering program of the University of Córdoba (SedeBerástegui), municipality of Ciénaga de Oro, Córdoba.

Materials: The Pregelatinized Corn starch (PCS) was purchased from the company Surtiquímicos-Brenntag Colombia. The native starches of cassava and yam were purchased from the company Almidones de Sucre S.A.S and through a continuous process of bubbling (Pérez *et al*., 2015), respectively, which were modified following the methodology of Barragán-Viloria *et al*. (2016). The barracuda (*Sphyraena ensis*) meal was obtained at laboratory scale, from fish from the city of Sincelejo. The other ingredients, lactose-free milk powder, monosodium glutamate, salt and spices (onion, garlic, pepper and cumin) were obtained from local commerce in the city of Sincelejo.

Preparation of simples: The batch-type pregelatinization of the starches was performed from starch suspensions in water (50% w/v), simulating a complete mixing reactor, with a continuous stirring and heating system at 65°C (Cassava) and 81°C (yam) for 10 min at 300 rpm. As for the flour, the fish were washed and baked at 65°C for 15 min. Then, they were pulped and pressed at 2500 psi for 10 min. The cake obtained was dried at 65°C for 5 h in a forced ventilation oven. Finally, the samples were ground, sieved and packed in metalized plastic bags, to be used later. Samples of dehydrated creams (20 g) were prepared for each source of starch and each ratio of starch/flour. The ingredients in fixed proportions for each formulation were: Milk powder (15%), monosodium glutamate (1.5%), salt (6%), spices (16.5%) and stabilizing agent (1%) and were mixed at 250 rpm for 5 min.

Proximal analysis and physicochemical properties: The physicochemical tests performed on the dehydrated cream were determined according to the official methods described by the AOAC (2012) for ethereal extract, crude protein, moisture and ash. The pH was determined with a potentiometer (Metrohm 827 pHlab) and the color quantification was performed by means of a tri-stimulus colorimeter, Colorflex EZ 45 (HunterLab) with an opening diameter of 1.5 cm, the illuminate D65 was used as a reference system. The chromaticity coordinates "L" (luminosity), "a" (shades of red to green) and "b" (shades of yellow to blue) were measured using a Hunter-Lab scale. In this color system, corrected by CIELab, L* values vary from zero (black) to 100 (white), the values of a* vary from -a* (green) to +a* (red) and the values of b* vary from -b* (blue) to +b* (yellow) (Shenoy *et al*., 2014).

Determination of useful life: The shelf life estimate of dehydrated cream of barracuda cream was determined through absorption isotherms at a temperature of 35°C, the relative humidity ranging from 34.78 to 91.66%. Likewise, permeability of the packaging, water activity and critical humidity were established when a slight compaction was generated in the product simulating storage conditions at 35°C and 75% relative humidity.

Statistical analysis: An experimental design was used under a 3×3 factorial arrangement with three sources of starch and three starch/flour ratios, for a total of nine treatments, performed in triplicate. Statistical analysis of the data was performed using the statistical package R 3.2.1 free version using an Analysis of Variance (ANOVA) ($p \leq 0.05$). Results comparison was determined using Tukey's multiple range comparison test. The pregelatinized sources of starch were: corn, cassava and yam, in ratios that varied 20/40, 30/30 and 40/20 starch/flour. The analyzed variables were compared to a Commercial Cream (C.C) of Knorr brand seafood due to the absence on the market of fish creams.

RESULTS AND DISCUSSION

Proximal analysis: The results of the proximal analysis of the barracuda creams are shown in Table 1. It is observed that PYS provided the highest percentage of fat in the creams, mainly in the 20/40 starch/flour ratio. This may be related to the starch natural properties. Some studies report that yam (*Disocorearotundata*) starch has lower fat percentages than cassava starches (Alvis *et al*., 2008; Hernández-Medina *et al*., 2008). However, the behavior shown in the creams could be associated with the crystalline structure of the yam starch, which is stronger than in the cassava starch. Therefore, creams with PYS could retain more fat than PCAS and PCS (Moorthy, 2002; Vargas-Aguilar and Hernández-Villalobos, 2013). Regarding the protein content, statistically equal values were presented with PCS and PCAS. However, the highest values were found in the 20/40 starch/flour ratio, compared to the other ratios studied. Obviously, this may be related to the amount of barracuda flour in the cream formulation, therefore, as the higher flour content is presented, the higher percentage of protein it will have protein it will have.

Table 1: Proximal analysis of barracuda creams

Starch source	Starch/flour ratios 20/40	30/30	40/20
		Fat	
PCS	1.42±0.17abA	0.98±0.07bB	1.23±0.3aAB
PCAS	1.29±0.06bA	1.15±0.05bA	1.17±0.04aA
PYS	1.77±0.04aA	1.43±0.01aA	1.13±0.07aB
C.C.		2±0.02	
		Protein	
PCS	39.27±0.53bA	30.84±0.86aB	16.30±0.34aC
PCAS	38.21±0.59bA	30.49±1.12aB	17.17±0.85aC
PYS	41.97±2.39aA	31.06±1.24aB	17.87±0.33aC
C.C.		4.01±0.05	
		Humidity**	
PCS	6.48±0.50NS	6.66±0.35NS	7.24±0.25NS
PCAS	6.45±0.20NS	7.01±0.23NS	7.27±0.43NS
PYS	7.93±0.12NS	7.75±0.53NS	7.99±0.23NS
C.C.		4.42±0.21	
		Ash**	
PCS	11.36±0.13NS	10.95±0.14NS	10.84±0.07NS
PCAS	11.24±0.06NS	10.97±0.03NS	10.74±0.12NS
PYS	11.08±0.07NS	10.91±0.04NS	10.57±0.04NS
C.C.		9.63±0.153	

*Means with different letters in columns (Lower case, comparison between source of starch) and rows (Capital letters, comparison between starch/flour ratio) indicate significant statistical differences (p≤0.05), according to the Tukey test.
** NS: Not significant

Table 2: Physicochemical analysis of barracuda creams

Starch source	Starch/flour ratio 20/40	30/30	40/20
		pH	
PCS	6.34±0.006bB	6.36±0.01bA	6.35±0.007bAB
PAS	6.38±0.01aC	6.39±0.01aB	6.42±0.005aA
PYS	6.36±0.01aC	6.38±0.005aB	6.42±0.003aA
C.C.		6.17±0.03	
		a*	
PCS	0.48±0.02bA	0.08±0.02cB	-0.03±0.03cC
PAS	0.55±0.04aA	0.31±0.02aB	0.26±0.01aC
PYS	0.36±0.03cA	0.22±0.01bB	0.11±0.03bC
		b*	
PCS	15.72±0.04aA	14.38±0.08aB	12.90±0.12abC
PAS	15.11±0.04bA	14.08±0.18bB	12.81±0.05bC
PYS	15.68±0.07aA	14.52±0.04aB	13.12±0.08aC
		L*	
PCS	83.02±0.13cC	84.40±0.07bB	86.17±0.21bA
PAS	83.38±0.34bC	84.43±0.1bB	85.97±0.02bA
PYS	84.52±0.04aC	85.80±0.13aB	86.85±0.07aA

*Means with different letters in columns (Lower case, comparison between Starch source) and rows (Capital letters, comparison between starch/flour ratio) indicate significant statistical differences (p≤0.05), according to the Tukey test.

Some investigations report fat contents above those obtained in barracuda flour creams and lower protein contents. Pacheco de Delahae (2001), García *et al*. (2007) and Praderes *et al*. (2010) carried out studies on dehydrated creams of banana meal, arracacha flour and gelatinized ahuyama flour, respectively, reaching values for fat between 3.15%-9.65% and for protein between 6.5% and 11% 5%. This evidences that the nutritional content of the dehydrated creams obtained exceeds in the contribution of proteins to commercial creams, which is around 4%, as those made from vegetable flours. In addition, the fat content is lower and the source of the fish is fat with a high content of unsaturated fatty acids.

On the other hand, there were no statistical differences (p≥0.05) in the moisture content of the creams. However, the values were within the allowed limits by NTC 4482 (1998) for soups and creams, which should not be greater than 8% w/w. This parameter is important, considering that this is a product that is marketed in powder, therefore, it must guarantee the quality of it, avoiding the caking that begins to manifest with humidities above 10%. In this way, investigations report moisture contents between 4.4% and 6.61% for dehydrated creams of bean, peas, lentils and quinchoncho (Martínez and Marcelo, 2002; Limones Acosta and García Arreita, 2011; Macías Garcia and Vinces Bravo, 2011).

As for the ash content, no statistically significant differences (p≥0.05) in the interaction of the evaluated factors were found. According to the results obtained by Pacheco de Delahae (2001) and García *et al*. (2007), the dehydrated creams showed ash values between 6.2%-10.4% and 6.22%-6.77%, respectively. These values are below those reported in this study, as reported by Praderes *et al*. (2010) (5.9%).

Physicochemical properties: The physicochemical analysis of barracuda creams report is shown in Table 2. The pH results obtained in this study showed significant statistical differences (p≤0.05) in all evaluated starch/flour ratios, the pH values with PCS were different from the values obtained with PCAS and PYS, the latter were the one that showed the highest values. Similarly, for all sources of starch there were differences between the ratios studied, with the ratio 20/40 starch/flour registered lower values of pH. pH is one of the most important stability parameters as an indicator of the sedimentation process in food dispersions through repulsive forces. In addition, it allows to establish the convenience in the consumption of a consumer. The acidity or alkalinity levels of the food, help qualify the pertinence from the medical and physical point of view. This may suggest that barracuda creams are in a range suitable for human consumption and represent a reference in the stability of the dispersions (Fitzpatrick *et al*., 2016).

Likewise, the moisture content of powdered products has been reported to be closely related to interactions between the particles, which are normally reinforced by forming bridges that are dependent on the pH and content of hydroxyl groups in the food; that is, pH of food dispersions closes to neutrality, as in the case of dehydrated creams, may be associated with moisture content, which in this case was higher in creams with PYS (Opaliński *et al*., 2016).

On the other hand, significant statistical differences were found (p≤0.05) on the evaluated color parameters a*, b* and L*. It is evidenced that for all the starch/flour ratios there were differences between the

Table 3: Estimation of the useful life according to the modeling and percentage of compacted mass

Storage conditions	% Compaction relative to the total mass	Stability time	
		Months	Years
35°C	100	33.39	2.78
	20	6.68	0.56
	10	3.34	0.28
	5	1.67	0.14

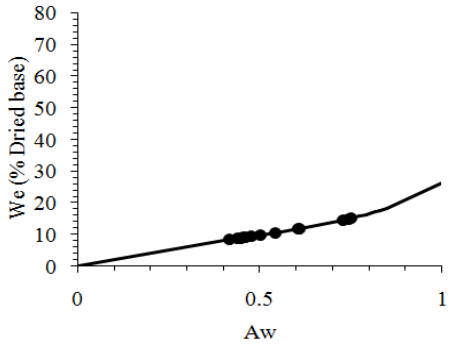

Fig. 1: Sorption isotherm for dehydrated barracuda cream

sources of starch in chromaticity values a*; being the treatments with PCAS the ones that presented higher values, related to red shades (+a*). Differences were found between the starch/flour ratios for each source of starch, obtaining the highest values for the 20/40 starch/flour ratio. The blue-yellow chromaticity parameter (b*) showed the lowest values in the creams with PCAS for all starch/flour ratios, while the creams with PCS and PYS showed similar behavior. In addition, the same trend was evidenced, the higher b* values were obtained in the 20/40 starch/flour ratio, showing yellow shades.

In regards to the luminosity component (L*), the creams presented significant differences ($p \leq 0.05$), considering values between 83.02 and 86.85, which indicates a high degree of luminosity, which can be basically related to the starch/flour ratios that were used. It was evidenced that the ratios with higher starch content (40/20), showed the highest values for the L* component on each of the sources of starch evaluated. Praderes *et al*. (2010) and García *et al*. (2007) performed studies with instant soups of ahuyama and arracacha, respectively, obtaining similar results to the barracuda creams in the b* chromaticity, whereas the values of a* were higher and the values of L* lower than the ones obtained experimentally.

Determination of useful life: The shelf life analysis of dehydrated fish cream was directly associated with the moisture content. The permeability of the metallized package under which the study was made, allowed to define the useful life of the cream evaluating the moisture gain. Initially, the experimental results showed that the moisture content (dry basis) was 8.03% and the Aw at 25°C was 0.41; when the sample reached the point of failure, the critical humidity was defined as 10.38% and the critical Aw was 0.574 (Fig. 1).

These parameters, added to the storage conditions and all the variables that were taken into account to determine the shelf life of the cream, allowed to estimate that with a compaction percentage of 100, 20, 10 and 5% the shelf life of the cream is 33.39; 6.68; 3.34 and 1.67 months, respectively (Table 3). This indicates that the greater the compaction percentage relative to the total mass, the longer the product will take to reach critical conditions, therefore, its stability and useful life will be greater. This phenomenon is attributed to the attraction between the particles, conditioned by humidity and temperature, which under extreme conditions can lead to loss of stability and structural form of the particles, leading to the formation of a cake and the melting of the material (Caparino *et al*., 2017). Some studies have reported similar results, suggesting that under conditions of humidity and temperature close to those used in this research, a shelf life of about 2 years of dehydrated soups can be achieved (Limones Acosta and García Arreita, 2011).

CONCLUSION

Dehydrated creams formulated with 40/20 starch/flour ratios achieved higher protein percentages and lower fat percentages than commercial creams made from fishmeal and other creams made from vegetable flours.

The moisture content of the dehydrated creams possible to estimate a useful life of approximately 18 months with a percentage of 50% compaction, thus providing improved stability to creams.

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CONFLICT OF INTEREST

Authors should disclose all financial/relevant interest that may have influenced the development of the manuscript.

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