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Standardisation and Rheological Characterization of Functional Beverage with Tropical Fruit, Pumpkin *(Cucurbita moschata),* Dietary Fiber of Pineapple *(Ananas comosus)* and Lactose-Free Skim Milk

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Abstract

The design, formulation and development of the new product or the improvement of traditional product, are conditioned of the knowledge of the physicochemical, bromatological and rheological characteristic and their components. **Objective:** The aim of this work is the development and standardization of beverage with functional characteristics, using tropical fruits, pumpkin *(Cucurbita moschata),* dietary fiber of pineapple *(Ananas comosus)* and lactose-free skim milk. **Methods/Analysis:** A standardization of beverage was doing evaluating the effect of pH, dietary fiber, xanthan gum, the amount of milk and pulps. The physicochemical, rheological, microbiological and sensorial evaluation was doing. **Findings:** The beverage presented a content 1.05±0.0424 of soluble dietary fiber, 3.05±0.0141 of insoluble and, 6.69±1.1463 of protein and vitamin A, C, B1, B2 y B3, ensuring a good nutritional contribution. Rheological characterization presented behavior of non-Newtonian pseudoplastic fluid adjusting to Ostwald de Waele model. The beverage had a good in general acceptance to the consumer. **Novelty/Improvement:** The final product presented a present a good acceptance in sensorial and a high nutritional composition, contributing to dietary protein, total dietary fiber and vitamins.

Keywords: Dietary Fiber of Pineapple *(Ananas comosus),* Functional Beverage, Microstructural, Rheology, Tropical Fruits

1. Introduction

The design of food product that provide nutritional value and beneficial effects in health show a highest interest in consumer[1]. The fruits are characterized for this amount in vitamins carbohydrates, carotenoids and minerals[2]. Milk is a food considers intrinsically functional or with natural functionality, due their high amount in calcium, unsaturated fatty acids (Oleic, C18:1 and linoleic C18:2), protein, carbohydrates and minerals[3].

Dietary fiber is a mix of carbohydrate, oligosaccharide and polysaccharide like cellulose, hemicellulose, peptic substances, gum and resistant starches[4]. It can be present in fruit, vegetable and have positive effects in health thanks to their properties. Pineapples shell has a 70.6% of dietary fiber, associate with a high content of myricet in, it is a principal polyphenol and can be responsible of antioxidant activity of this[5].

In the last few year, studies using dietaryfiber as agents which help to stabilize microstructure product in the time had been done, due the properties of increment the capacity of water retention, retention of oil, emulsification, and gels structures, so dietary fiber of fruit have better nutritional value of dietary fiber of cereal, because their amount of bioactive compounds like polyphenol and carotenoids.

The experiment design is an important tool to quantify the effects of variables on responses on process of production or to quantify the factors combinations to give a better quality in product formulation[6]. For this is necessary to

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find an optimized mixing of ingredients to generate a new product which the formulation with the characteristics of final product with high nutritional value and organoleptic properties remain desirable flavor and aroma[7].

The aim of this work is the development of beverage with pulp of Lulo *(Solanum quitoense)*, Passion fruit *(Passiflora edulis var. flavicarpa)*, Pineapple *(Ananas comosus)*, Mango *(Mangifera indica L.)*, Pumpkin *(Cucurbita moschata)*, dietary fiber of pineapple and lactose-free skim milk evaluating nutritional, rheological and sensorial characteristics.

2. Material and Methods

2.1 Materials

Pulp of Lulo *(Solanum quitoense)*, Passion fruit *(Passiflora edulis var. flavicarpa)*, Pineapple *(Ananas comosus)*, Mango *(Mangifera indica L.)*, Pumpkin *(Cucurbita moschata)* and lactose-free skim milk were used for formulation of functional beverage, were purchased in the central market of Cartagena of Indias city. Xanthan gum, ascorbic acid, sodium citrate and sodium benzoate supplied by Ingredients and functional products (IFP - Medellin), were used to prepare of functional beverage

2.2 Obtaining of Dietary Fiber of Pineapple *(Ananas comosus)*

Obtaining of dietary fiber of pineapple *(Ananas comosus)* was done using by products from the processing of the pulp and epidermis which were subjected to a size reduction, followed by washing with water in a ratio of 1:2 at a temperature of 60°C for 2 hours and dried in a flask under vacuum at 50 °C to constant weight. They were ground and sieved to obtain a particle size below 0.5 mm. Total Dietary Fiber (TDF) and Insoluble Dietary Fiber (IDF) were determined following AOAC 985.29 methods[8]. Soluble Dietary Fiber (SDF) was calculated by subtracting the IDF proportion from the TDF.

2.3 Standardization of Functional Beverage

Mixes of 28%w/w Lulo *(Solanum quitoense)*, 20%w/w Passion fruit *(Passiflora edulis var. flavicarpa)*, 25%w/w Pineapple *(Ananas comosus)*, 25%w/w mango *(Mangifera indica L.)*, y 2%w/w Pumpkin *(Cucurbita moschata)*, were done using natural pulp. The experimental design surface center response of two blocks in central points and two center points on each block were conducted in order to evaluate the experimental variables, dietary fiber pineapple *(Ananas comosus)*, xanthan gum and pH of preparation was performed evaluating each at three levels, ratio pulp mixture, lactose-free skim milk was kept constant (4:6), obtaining 14 experiments (Table 1). The process was performed in a stirred batch reactor (100 g), using a pallets impeller geometry and applying a rotational speed of 60 rpm for 30 minutes, pre-mixture the different pulps with sugar, dietary fiber pineapple *(Ananas comosus)* was performed by adjusting the pH. Thereafter was added slowly lactose-free skim milk and sodium benzoate was carried out about 15 minutes in a homogenizer type rotor stator IKA Ultra Turrax T10at rotational speed 20500rpm, and then stored at 4 °C.

Table 1. Formulation with experimental design surface center response

Sample code	pH	Fiber	Xanthan Gum
1	4.70	0.8	0.14
2	4.20	0.8	0.18
3	4.20	0.4	0.14
4	4.45	0.6	0.16
5	4.00	0.4	0.16
6	4.00	0.4	0.18
7	4.00	0.6	0.16
8	4.45	0.6	0.13
9	4.50	0.8	0.16
10	4.10	0.4	0.18
11	4.45	0.6	0.18
12	4.45	0.6	0.16
13	4.80	0.6	0.16
14	4.45	0.3	0.16

2.4 Physicochemical Characterization

The determination of the physicochemical characteristics of the stable beverage was analyzed in triplicate using the methods described by Association of Official Analytical Chemists (AOAC, 1998). Soluble solids expressed as °Brix will be determined with a digital refract meter HI 96801 (AOAC 931.12), treatable acidity (acidity %) is expressed as grams of citric acid/100 ml pulp, using a factor 0.070, using with NaOH 0.1N (AOAC 942.15), the pH was determined by direct reading pH-meter HANNA HI9126 (AOAC 943.02). The crude protein was determinate using AOAC 991.20, crude fat AOAC 920.39, total dietary fiber, insoluble fiber and soluble fiber AOAC 985.29, vitamin A

(AOAC 992.06), C (AOAC 967.21), B1 (AOAC 942.23), B2 (AOAC 940.33), and B3 (AOAC 985.34), to determine the nutritional contribution.

2.5 Rheological Characterization

Rheological characterization for each sample was carried out in controlled-stress (ARES, Rheometric Scientific, UK) rheomether, using coaxial cylinder geometry. Viscous flow test were determined at 25ºC in a shear rate range of 10^{-2}-$10^{2}s^{-1}$, were taken 3 minutes at each shear rate order to obtaining the steady state regime.

2.6 Microbiological analysis

Microbiological quality of the final product was evaluated, taking into account the parameters established for refreshment by the Colombian Technical Standard 3549[9], MPN coliforms/cm^3, MPN coliform fecal/cm^3, yeast and mold count, CFU/cm^3, at 2 and 15 days after processing.

2.7 Sensory Evaluation

Sensory analysis was performed in accordance with the Technical Guide Colombian 165, the organoleptic parameters were evaluated as the color, odor, flavor and texture, using a scale from 0 to 5 (0 the lowest quality and 5 the best quality). Order to assess the formulation having the best features of acceptance by the panelists.

3. Results and Discussion

3.1 Obtaining Dietary Fiber of Pineapple *(Ananas comosus)*

A concentration of total dietary fiber values of 78.88± 4.520 were obtaining byproducts, with percentages of 3.95 ± 1.33 as soluble part and 75.240 ± 2.986 was obtained as insoluble, expressed in w/w percentage. Insoluble fiber content provides intestinal functions due to main ingredients are rich in polysaccharide celluloses, peptic, arabinoses, xylose and hemicelluloses substances. The content of soluble fiber helps water retention as well as its ability to increase the time required for the absorption of nutrients. Moreover, technologically act as thickening agents, gelling and stabilizing foams and emulsions, such as film forming[10]. Becoming a desired for added food ingredient, providing the body functional and technological characteristics of the product.

3.2 Formulation and Standardization of Functional Beverage

Table 2, can observe the results of physicochemical parameters of pH, soluble solids expressed in Brix degrees and acidity (expressed like percent of citric acid) in samples obtained from the different pulps produced. The passion fruit present the highest value of soluble solids, 13.35 ± 0.212, and acidity, 9.75 ± 0.010 and pumpkin the lowest 1.3 ± 0.020 of soluble solids and 0.28 ± 0.001 % acidity, and the mixtures are presented pH 3.46, soluble solid 5.5º Brix and acidity of 6.44 % critic acid, respectively. The results obtained during homogenization of milk, pulps and fiber was the stabilization of beverages with sample code 2, 3, 4, 7, 8, 9, 12 and 13, therefore proceeded to carry out the characterization after 70 hours of processing.

Table 2. Physicochemical characteristics of pulps the tropical fruits

Tropical fruit	Soluble solids (ºBrix)	pH	Acidity (% citric acid)
Lulo *(Solanum quitoense)*	7.15 ± 0.070	3.26 ± 0.160	6.37 ± 0.0039
Passion fruit *(Passiflora edulis var. flavicarpa)*	13.35 ± 0.212	3.10 ± 0.013	9.75 ± 0.0098
Pineapple *(Ananas comosus)*	8.20 ± 0.989	3.82 ± 0.173	1.75 ±0.0165
Mango *(Mangifera indica L.)*	0.60 ± 0.707	3.23 ± 0.201	1.54 ± 0.059
Pumpkin *(Cucurbita moschata)*	1.30 ± 0.020	0.22 ± 0.006	0.28 ± 0.001

Among the variables studied is observed that pH is the parameter determining the stability of the beverage, due that in the same processing conditions of fiber and xanthan gum, varying pH values of the samples showed a significant difference, i.e., that products with pH values above 2 independently of the concentrations of gum and fiber, presented improved physical stability for 15 days.

3.3 Physicochemical Analysis

Physicochemical analyzes were performed in beverage with sample code 4, evaluating the nutritional contribution of the mixture of tropical fruit and lactose-free skim milk, obtaining the values shown in Table 3. The beverages standardized presents values of 6.70 ± 1.146

considering a good source of protein and vitamins with values of 15.99 ± 0.0141 of vitamin A, 71 ± 1.4142 of C, 0.06 ± 0.0141 of B1, 0.025 ± 0.007 of B2 and 0.085 ± 0.0070 of B3 expressed as mg of vitamin per 100g sample. Fat contribution is zero for this it's not considered as a lipid source, total dietary fiber values of 4.2% w/w being soluble fiber and 1.05 %w/w and 3.05 %w/w of insoluble fiber, and can be considered for beneficial health effects, due epidemiological studies suggest that diets high in soluble and insoluble dietary fiber associated with increased satiety and the volume of the fecal mass, thus promoting the function of the digestive system[11].

Table 3. Nutritional characteristics of the beverage

pH	4.69 ± 0.01
ºBrix	17 ± 0.436
Acidity (% ac. Citric)	4.07 ± 0.005
Fat	0.000
Protein	6.69 ± 1.146
Vitamin A, mg/100g	15.99 ± 0.0141
Vitamin C, mg/100g	71 ± 1.414
Vitamin B1, mg/100g	0.06 ± 0.014
Vitamin B2, mg/100g	0.025 ± 0.007
Vitamin B3, mg/100g	0.085 ± 0.0070
Soluble fiber %	1.05 ± 0.0424
Insoluble fiber %	3.05 ± 0.0141

3.4 Rheological Characterization

The viscosities of beverage shows a decrease in function of pH ranging under processing, showing a decrease by increasing the shear rate for all the samples as shown in Figure 1 which is characteristic of non-Newtonian fluids type shear thinning[12]

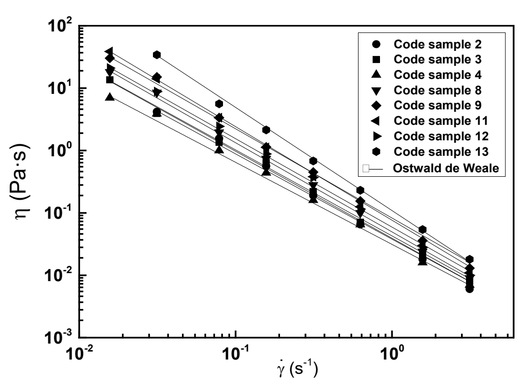

Figure 1. Viscous flow curves for the different formulations studied.

As the strain rate increases, the interaction between the particles are deformed or destroyed resulting in the reduction of flocs size and a decrease in viscosity[13]. Due to the behavior of the emulsions, various models can be used to fit the experimental data, where the viscosity is represented as a function of strain rate, that the obtained product is represented by a potential drop, so adjusted to model Ostwald de Waele, which is expressed by the eq. (1).

$$\eta = k_s \dot{\gamma}^{(n-1)} \quad (1)$$

Where η apparent viscosity, *Ks*, consistence index, nflux index, and shear rate.

Model fitting Ostwald de Waele experimental data can be compared in Figure 1 with continuous line, which corresponds to the fit of the equation to the viscosity data, showing good fit, with value between 0.98011 $<R^2<$0.99986. Evaluation parameters showed a significant variation with respect to pH, as the pH increased elaboration, ratings increased consistency and flow (Table 4), denoting an increase in shear thinning.

Table 4. Ostwald de Waele parameters for the different sample codes at 25ºC

Code sample	*Ks*	*n*	R^2
Code sample 2	0.038	–0.367	0.992
Code sample 3	0.031	–0.315	0.980
Code sample 4	0.043	–0.379	0.991
Code sample 8	0.050	–0.429	0.992
Code sample 9	0.083	–0.430	0.986
Code sample 11	0.076	–0.499	1.000
Code sample 12	0.059	–0.417	0.998
Code sample 13	0.109	–0.653	0.997

3.5 Microbiological Evaluation

The results of microbiological analysis are shown in Table 5, presenting lower values than required by the NTC 3549, where were established values of: 9 MPN/cm^3 for total coliform values, <3 MPN/cm^3 for fecal coliforms and 100CFU/cm^3 for molds and yeasts count for fruit beverage with a high quality 30-day of life. The microbiological stability of beverages corroborate results required by the standard values until 15 days after processing, indicating that the food is microbiologically safe. Since coliforms have been considered traditionally as indicators of quality control of water intended for human consumption, also the absence of fecal coliform, classifies it as a food that is not high risk for consumers.

Table 5. Microbiological characteristics of beverages

	MPN totals coliforms/ cm³	MPNfecal coliforms/ cm³	Yeast and mold count, CFU/cm³
Lactose-free skim milk	0	0	10
Beverage after 2 days of elaboration	0	0	12
Beverage after 15 days of elaboration	2	0	25
Values of reference foods for direct consumption	9	<3	100

3.6 Sensory Evaluation

Based on assess the acceptance of the finished product, were taken random samples to determine the taste, color, odor and texture. Beverages had a good acceptance with an evaluation of ± 4 of 95 % of the panelists in the parameters of taste, odor and color. Instead, to the texture obtained an evaluation of mean value of acceptance ±3.5 to 70% of the panelists, this was due to the perception of small solid particles, by referring to high content of insoluble fiber in suspension in the final product. Finally, it can be deduced that in general, the beverage obtained had a good acceptance to the consumer.

4. Conclusion

Tropical fruits used in the development of this research presented important properties for the design of new food products of high demand for consumers, as are beverages. Moreover, is emphasized harnessing local and regional level of the raw material for exploitation in the design of healthy products for society, as well as with international projection?

Standardized beverages stabilized at pH values above 2, for a while (>) greater than 15 days after their preparation, stored at 4°C. The beverages presented the rheological characteristic behavior of non-Newtonianpseudo plastic fluid, represented by the model potential of Ostwald de Waele were adjusted (R^2> 0.9801). The pH standardization process of beverages showed a direct correlation with increased viscosity parameters. Microbiological products maintained their physicochemical properties and nutritional characteristics.

The final product presented a nutritional composition, contributing to dietary protein with significant values of 6.70 ± 1.146, total dietary fiber values of 4.2%, and 1.05 ± 0.042% of soluble fiber and 3.05 ± 0.014 for insoluble fiber and containing substantial vitamins like A, C, B1, B2 and B3. The beverage obtained presents a good acceptance in the parameters of taste, odor and color. Instead, obtained an evaluation of mean value of acceptance texture parameter due to the perception of solid particles, which should be a more severe process of particle size reduction.

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