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Evaluation of a functional beverage obtained by spray drying

INGENIERÍA DE ALIMENTOS

Evaluación de una bebida funcional obtenida mediante secado por aspersión

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Abstract

With this work, a functional and natural powder beverage was obtained based on natural ingredients with high protein content through the spray drying process. Two formulations of a functional beverage were sensorially evaluated, selecting only one of them, which was subjected to the following operating conditions: speed of the atomizer disk (30,000 RPM), air inlet temperature (145°C), and temperature air outlet (80°C). In addition to the above, the physicochemical and bromatological analysis was carried out both to the functional food in a liquid state and to that obtained in powder in order to compare its nutritional quality. The physicochemical and nutritional characteristics, in particular the protein content of the functional product in powder, were preserved, and once reconstituted in water it had a good sensory acceptance.

Keywords*: dehydration, functional beverage, protein content, sensory acceptance.*

Resumen

Con este trabajo se obtuvo una bebida funcional y natural en polvo a base de ingredientes naturales con alto contenido proteico mediante el proceso de secado por aspersión. Se evaluaron sensorialmente dos formulaciones de una bebida funcional, seleccionando solo una de ellas, la cual se sometió a las siguientes condiciones de operación: velocidad del disco atomizador (30,000 RPM), temperatura de entrada del aire (145 °C) y temperatura de salida del aire (80 °C). Aunado a lo anterior se realizó el análisis fisicoquímico y bromatológico tanto al alimento funcional en estado líquido como al obtenido en polvo con el fin de comparar su calidad nutricional. Las características fisicoquímicas y nutricionales, en particular el contenido proteico del producto funcional en polvo se conservó y una vez reconstituido en agua tuvo una buena aceptación sensorial.

Palabras clave: *aceptación sensorial, bebida funcional, contenido proteico, deshidratación.*

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1. Introduction

A functional drink corresponds to a food supplement that has a great variety of macronutrients (proteins, carbohydrates, lipids), where the function is to supply most of the metabolic energy to the body; additionally, they have vitamins, minerals, enzymes, and some essential amino acids that are used for the growth and construction of muscle fibers. These types of functional foods are found in different consistencies or formulations, basically they can be found in powder and liquid formulation, having a variability in terms of their useful life, due to the water activity that each one confers (1).

At present, protein supplements have become the main consumption of people, since there is a worldwide trend to consume healthy products, whether for athletes or the public, these are found in a large number of commercial chains such as they are supermarkets, health food stores, drugstores, etc., thus generating the greatest attention from various people who are looking for an alternative to the daily diet. Therefore, various technologists and researchers in the food industry have been developing new milk-based beverage formulations, such as shakes, powdered shakes, and dairy drinks (2). On the other hand, a controversy has been generated regarding the consumption of protein supplements due to the negative effects that can be generated, since the vast majority of proteins found on the market are made from synthetic compositions, adding a wide variety of additives such as preservatives, flavorings, colorants that help to give a greater stability and shelf life to the product.

Additionally, its high concentrations and impurities cause damage or side effects in our organs (3). Taking into account the aforementioned, the consumption of purely natural foods, low in substances or compositions that can generate adverse effects, is considered more appropriate and healthier, thus, the generation of functional drinks with a mixture of natural ingredients, generates greater reliability for the people who consume these supplementation products.

Some of the ingredients used in the formulation for the development of this project were: oatmeal, which contains a higher protein content compared to other cereals, which together with its carbohydrates, help repair muscles after physical training, "it also contains 6 of the 9 essential amino acids and has unique antioxidant compounds called avenanthramides which help prevent premature aging" (4,5), banana that is known for its contribution of potassium which is an essential compound for the heart, muscles, kidneys, and helps with the transport of oxygen to the brain, increases vitamin B12, increases vitamin C, increases energy, of In fact, it is a very good option before exercising (6), whey which is a high quality protein source that can be used effectively for the maintenance, restoration and synthesis of skeletal muscle proteins in response to resistance training in men and women, providing the body with the essential amino acids necessary for synthesis of the new fabric (7) and nonfat yogurt, which maintains healthy bones and improves blood clotting, muscle contraction, has a nutritional contribution of animal proteins and carbohydrates. The protein contribution of each of the components in the formulation of the functional drink is as follows in % m/m: whey 80, skim milk powder 34, precooked oatmeal 14.3, egg white 11, skim yogurt 3.8, banana 1.1, honey 0.4 and water 0 (8-10).

In the world there is a growing interest in consuming this type of supplements, due to the high willingness of people to practice exercises where muscle building and different cardiovascular activities are exercised, these are activities with an implication of aerobic metabolism and/or anaerobic (mainly lactic pathway), dependent on the glycolytic system, in which energy is obtained from muscle glycogen, through aerobic or anaerobic glycolysis [11].

Although, to date, it has not been possible to determine the amount of additional calories necessary for the formation of 1 kg of muscle tissue in humans, it is known when they should be consumed, so to test anabolism later of physical activity, protein hydrolysates show to be more effective than taking essential amino acids, but they must be combined with a quantity of sugars, recommending 1-1.5 g of carbohydrates (CH) and a portion of 3-4/1 (HC/P); in the same way, it is ideal that protein metabolism is just at the end of the training in the first 6 hours (and especially in the first 2 hours) since it is the moment when the cellular barriers for the entry of glucose are open [12,13]. Some research has managed to identify the effects on appetite, metabolism, and subsequent energy intake, when consuming different types of proteins such as animal-based (whey; WP), plant-based (soy; SP) and carbohydrates (CHO) [13]. Shakes with a high protein content are substances with a high concentration of macromolecules whose objective is to provide the body with the amount it needs to facilitate the creation of new muscle tissues [14].

Spray drying is broadly defined as the process by which a product or feed is converted from an initial liquid state to another pulverized one, obtaining almost instantaneously a dry solid using hot air as a means of supplying the heat necessary for drying [15-17]. Some investigations have been carried out in similar matrices, one of them was the evaluation of the spray drying conditions of a product based on whey and mango pulp, where the process was evaluated by means of a response surface analysis in a Vibrasec brand spray dryer, controlling the hot air inlet temperature between 120-160°C, outlet air temperature between 65-74°C, spray speed between 20,000-28,000 RPM and a maltodextrin concentration between 15% - 35% [18]. Another where they evaluated the physicochemical characteristics of the milk from a buffalo herd, followed by the standardization of the fat content, for which initial concentrations were established. Subsequently, they were subjected to a stage of concentration and spray drying, where process conditions (fat level, air temperature at the inlet, air temperature at the outlet and speed of the atomizer disk) and quality of the powder obtained were evaluated [6].

The objective of this study was to obtain a natural functional drink using the spray drying unit operation in order to preserve the protein content present in the original formulation and some quality characteristics of interest when the powder sample was reconstituted. This drying technique is widely used due to some benefits it offers to the final product, such as high solubility and providing encapsulation behavior for some compounds of interest.

2. Methodology

2.1 Formulation

For the realization of the functional drink, two commercial formulations were started, Table 1 shows the percentage composition, as a first measure each of the ingredients was weighed, then the powdered milk was diluted in 1/3 of the water. The whey was diluted in the previous mixture together with the oats and honey previously dissolved in the other third of water. Finally, the rest of the ingredients were homogenized together with the previous mixture and the remaining water for 5 minutes at a speed of 2,000 RPM in order to have a homogeneous drink without generating foam.

Table 1. *Ingredients and formulation of functional drinks*

Ingredients	Origin	Percentage composition (%)	
		Formulation No 1	Formulation No 2
Soluble soy isolate	* Tecnas S.A.	0	2
Dairy serum	* Tecnas S.A.	20	17
Skim milk powder	Commercial	3	3
Precooked oats	Commercial	2	1
Egg white	Commercial	8	5
Skim yogurt	Commercial	27	36
Banana	Commercial	4	4
Honey bee	Commercial	4	4
Water	Commercial	32	28

**Tecnas S.A.: Provider of comprehensive and innovative solutions in ingredients and additives for the food industry. Source: own elaboration.*

After obtaining the functional drinks, they were subjected to a sensory analysis where a group of consumers made up of 30 people between 20 and 45 years old evaluated the product that had the greatest acceptance through a preference test (each sample was labeled with codes of three random digits). This test was carried out in compliance with all the requirements set forth in the Colombian technical standard (NTC) 3925 [19].

2.2 Proximal analysis

The methods used for the proximal characterization of the functional drink and the powder sample are listed in Table 2.

2.3 Colorimetry

The measurement was carried out with a Konica Minolta CM5 colorimeter measuring CIE-L*a*b*color space; with this, the tone coordinates (H - Eq. 1), chroma (C - Eq. 2) and the color change (ΔE - Eq. 3) were determined. [20].

$$H = (a^2 + b^2)^{0.5} \quad (1)$$

$$C = arctg\left(\frac{b}{a}\right) \quad (2)$$

$$\Delta E = ((\Delta a)^2 + (\Delta b)^2 + (\Delta L)^2)^{0.5} \quad (3)$$

Where: *(a)* indicates the deviation from red to green, *(b)* indicates the deviation from blue to yellow, *(L)* brightness y *(Δ)* the difference between the coordinates of the liquid sample and the reconstituted powder sample.

Table 2. *Methods for proximal characterization*

Parameter	Unit	Method
Moisture content	(%)	930.15/90 of AOAC
Acidity	(%)	962.12 of AOAC
Soluble solids	(%)	942.12 of AOAC
Ashes	(%)	942.05 of AOAC
Protein	(%)	920.123 of AOAC
Fat	(%)	920.39 of AOAC
Crude fiber	(%)	962.09 of AOAC
Total carbohydrates	(%)	Clegg Antronhe
Sodium	(mg/100g)	985.35 of AOAC
Iron	(mg/100g)	985.35 of AOAC
Calcium	(mg/100g)	985.35 of AOAC
Potassium	(mg/100g)	985.35 of AOAC
Magnesium	(mg/100g)	985.35 of AOAC
Phosphorus	(mg/100g)	985.35 of AOAC
Vitamin C	(mg/100g)	NTC 440

Source: own elaboration.

2.4 Viscosity

The viscosity was analyzed by means of a BROOKFIELD GDV2 T viscometer with an LV-

0.1 No 61 needle, taking into account that the upper limit value was set at 0.7 Pa.s, this analysis was performed on the functional drink [21].

2.5 Spray drying process conditions

The spray drying process was carried out in a reference equipment "PSALAB" Vibrasec SAS, the operating conditions for the spray drying process were controlled based on reported literature, speed of the atomizer disk (30,000 RPM), inlet temperature of the air (145°C) and air outlet temperature (80°C) [22]. All the analyzes stated in the proximal characterization (section 2.2) and colorimetry (section 2.3) were performed on the final product obtained, plus the following measurements:

2.6 Process performance (RP)

It was calculated using Eq. 4:

$$RP = \frac{Tsf}{Tsi} * 100 \qquad (4)$$

Where: (Tsf) Total final solids and (Tsi) Total initial solids, both calculated on a dry basis.

2.7 Water activity (Aw)

It was measured using an AQUALAB PAWKIT portable 25°C dew point hygrometer.

2.8 Morphological characterization

A morphological characterization was performed by SEM (for its acronym in English) at a magnitude of 1,000 X. The samples were fixed to a conductive double-glued copper tape, which will be covered with a layer of carbon. The tape was covered with a layer of gold and was observed in a scanning electron microscope (JEOL JSM 7,600F, Akishima, Japan), operating under ultra-vacuum conditions [23].

2.9 Sensory evaluation of the reconstituted functional drink

The reconstitution of the powdered product was done in water until the amount of initial solids was reached and a profile test of the final product was carried out and a comparison with the liquid functional drink sample under initial conditions.

2.10 Statistic analysis

The analyzes of the evaluated variables were carried out using the Statgraphics Centurión XVI.I software. Each variable was measured in triplicate and an analysis of variance was analyzed and when significant differences ($p < 0.05$) were found, they were compared using a multiple range test.

3. Results

Regarding the affective test applied to each of the formulations, it was found that 22 of the 30 people showed a preference for formulation No. 1 [5], which exceeded the minimum limit that generates significant differences, accepting the hypothesis that, if there is a preference for either of the two samples, which indicates that said formulation is accepted.

Regarding viscosity, the result obtained for the functional drink was 0.0316 ± 0.0015 Pa.s, with a speed of 12 RPM, 63.1% of torque and a density of 1.024 g/cm3. The viscosity value was below the limit of 0.7 Pa.s, thus guaranteeing a good fluidity of the sample through the diaphragm pump towards the drying chamber. Some studies have shown how the use of protein isolates and pectin from fruits such as blueberries, favor solubility, thus contributing to the reduction of the viscosity of the drink [24]. Other research mentions how viscosity is closely related to the mouthfeel of milk-based drinks [25], reason for which this physical parameter becomes a quality indicator for the purpose of this research.

The sample was subjected to the spray drying process, with a process yield of 62.5 ± 2.0% and a water activity of 0.3 ± 0.01 [26] reporting 70% yields in the theophylline spray drying process with different cow's milk with variable fat content, a performance that is not far from the result obtained in this study and that could be compared when dealing with dairy beverages. Some research reports that the particle size and water activity of powdered samples decrease with decreasing the ratio of whey protein to casein [27]. On the other hand, in some investigations [28] they have been used as an encapsulating material through spray drying, where they performed the microencapsulation of Lactobacillus Plantarum. Other researchers [29] studied the microencapsulation of citron extract with acacia gum, modified starch, whey protein and maltodextrin by spray drying. Regarding the proximal characterization, Table 3 shows the various differences between the functional drink and the powder sample. With regard to the moisture content and dry matter, logical results are displayed according to the nature of each preparation.

Table 3. *Results of the proximal characterization*

Parameter	Unit	Functional Drink	Powder sample
Moisture content	%	66.9 ± 0.6^{a}	6.8 ± 0.0^{b}
Dry Matter	%	33.1 ± 0.6^{a}	93.3 ± 0.0^{b}
Nitrogen	%	2.5 ± 0.2^{a}	7.0 ± 0.2^{b}
Ashes	%	1.6 ± 0.1^{a}	2.7 ± 0.8^{b}
Protein	%	15.7 ± 1.2^{a}	44.8 ± 1.0^{b}
Fat	%	1.9 ± 0.3^{a}	7.3 ± 0.3^{b}
Crude fiber	%	1.0 ± 0.2^{a}	1.6 ± 0.3^{b}
Total Carbohydrates	%	13.9 ± 2.0^{a}	38.4 ± 2.5^{b}
Sodium	mg/100g	135.2 ± 14.0^{a}	231.7 ± 11.6^{b}
Iron	mg/100g	0.6 ± 0.3^{a}	2.5 ± 0.4^{b}
Calcium	mg/100g	262.6 ± 6.0^{a}	496.2 ± 4.9^{b}
Potassium	mg/100g	264.4 ± 0.7^{a}	873.5 ± 0.9^{b}
Magnesium	mg/100g	0.5 ± 0.1^{a}	1.0 ± 0.0^{b}
Phosphorus	mg/100g	78.2 ± 8.5^{a}	179.4 ± 1.2^{b}
Vitamin C	mg/100g	40.5 ± 0.7^{a}	0.0 ± 0.0^{b}

**Average of three measurements ± standard deviation reported on a dry basis. In the columns of not sharing the same letter they are significantly different (p <0.05). Source: own elaboration.*

Table 4. *Chromatic coordinates CIE-L*a*b* and ΔE*

Coordinates	Functional Drink	Powder sample
L*	69.7 ± 0.2 [a]	72.7 ± 0.3 [b]
a*	4.5 ± 0.1 [a]	5.2 ± 0.1 [b]
b*	18.2 ± 0.4 [a]	20.1 ± 0.2 [b]
H	18.7 ± 0.4 [a]	24.2 ± 0.3 [b]
C	76.2 ± 0.1 [a]	78.1 ± 0.1 [b]
ΔE	3.6	

**Average of three measurements ± standard deviation. In the columns of not sharing the same letter they are significantly different (p <0.05). Source: own elaboration.*

In general terms, in the powder sample, a high value in its composition of protein, carbohydrates and minerals stands out, offering a greater nutritional contribution, in addition to providing an alternative in the preservation of the product. However, the vitamin C content was affected in the powdered sample for the selected drying conditions. Some studies, such as, for example, in the manufacture of powdered milk beverages by spray drying with theophylline, report moisture percentages between 4.1% and 10.3% [30], range in which the percentage of humidity obtained in this investigation is found. On the other hand, [31] report small changes in the amount of Calcium in milk protein concentrates subjected to the spray drying process. In contrast to the above quotes [32], they conclude that the inlet air temperature in the spray drying process has significant effects on the physicochemical properties, especially on Jamun fruit juice.

Regarding the colorimetric analysis, Table 4 shows the CIE-L*a*b* chromatic coordinates and the color difference between the two samples. The color change is between 2 and 4, which is considered a normal tolerance threshold, according to ISO 12647-2 (2004) [33].

An affective test was also carried out on the reconstituted drink, comparing it with the initial functional drink, three-digit random codes were used, and it was found that 18 of the 30 people preferred the latter sample [5]. Thus, concluding that neither of the two samples generates significant differences. Therefore, the sensory acceptance of the functional drink reconstituted in water is given with respect to the original functional drink, conferring similar flavors, additionally having really positive effects in terms of its nutritional contribution, mainly its protein content. Figure 1 shows the sensory attributes of the two samples.

It can be seen that the attributes of viscosity, appearance, odor and characteristic color presented a higher degree of intensity in the sample of the liquid functional drink. While the attributes of acidity, sweet, bitter, granularity and smoothness presented a similar degree of intensity between the two samples. The variation in the degree of intensity in the attributes of viscosity, appearance, odor and characteristic color could be presented because no wall material was used in the formulation, which helps to protect against oxidation phenomena, losses of volatile substances and allow controlled release of other compounds of interest [34, 35].

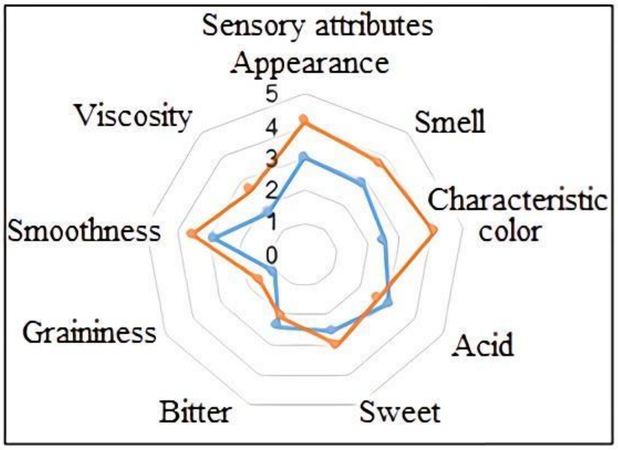

Figure 1. *Sensory attributes of the liquid functional drink (blue line) and reconstituted (orange line).* *Source: own elaboration.*

Figure 2 shows in a global way that the particles of the powder sample obtained by the spray drying process have a spherical shape, with an average diameter size of 27.1 ± 7.5 µm. Rupture and roughness are also evidenced in some of the capsules formed during the spraying process, a phenomenon that was also reported [36] in the study of the influence of the drying conditions and the composition of whey protein (WP), maltodextrin (MD) and their mixtures on the morphology of the particles during spray drying on a pilot scale, these authors also attribute it to said phenomenon the increase in density.

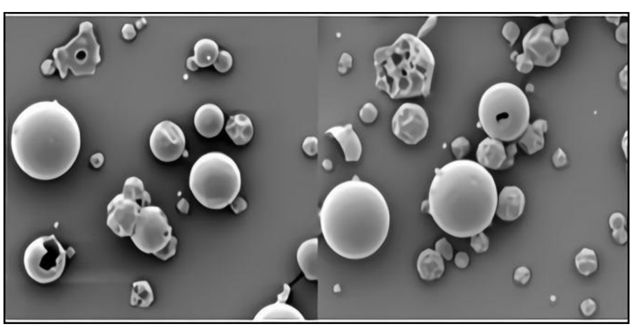

Figure 2. *Scanning electron micrographs (SEM-1,000X) of the powder sample.* *Source: own elaboration.*

Other authors [37] report a direct effect of the drying temperature on the morphology of the particles obtained from a milk protein concentrate, since a higher drying air temperature led to a rapid elimination of water, generating contraction of the particles that In turn, it resulted in smaller sizes and more irregular shapes, which is why the size and shape distribution of the particles in the powder sample could be explained, since the temperature used in this experiment is within the range used by these authors. Other research reports that drying process conditions significantly affect effective performance, adhesion of solids to the dryer walls, moisture content, water activity, solubility, bulk density, particle size, and morphology [38]. Some authors, like [31], report morphological changes in spray dried Jamun juice powder, concluding that at high temperatures (155 ° C-160 ° C) the particles show a certain degree of contraction compared to the particles produced at lower temperatures (140 ° C -145 ° C)

4. Conclusions

It is concluded that during the spray drying process of the functional drink, the characteristic protein content of this type of products was preserved, likewise, the liquid functional drink and the reconstituted drink did not show significant differences according to the sensory evaluation. It is recommended to work with the help or incorporation of some encapsulating material that helps reduce the gaps between some parameters evaluated, such as, for example, color, odor, appearance, viscosity and vitamin C content in order to obtain a final product that is as close to the initial.

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