ORIGINAL ARTICLE

Physical and organoleptic properties of protein plants for obtaining fully mixed alternative foods

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Propiedades físicas y organolépticas de plantas proteicas para la obtención de alimentos alternativos totalmente mezclados

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ABSTRACT: The growing need for raw materials for animal consumption constitutes a challenge for our country. That is why Cuba has engaged in the search for alternative foods based on the use of protein plants and other fiber and energy carriers. The present investigation was carried out at the Guayabal university farm. With the objective of proposing a technological process to obtain alternative foods completely mixed in the university farm "El Guayabal. The average values obtained in the results of the evaluation of the physical properties after the ingredients are crumbled for the formulation of a fully mixed food, average results of the Tithonia Diversifolia variety 16 with a humidity of 78% can be seen. Sugar cane c 85- 403 with humidity values of 77.99%. The King Grass variety OM-22 had a humidity of 69.68%. The percentage of dry matter of the samples varied between 21.8 and 30.32%.

Keywords: Fiber Carriers, Energy, Density, Humidity Dry Matter.

RESUMEN: La necesidad creciente de materias primas para consumo animal, constituye todo un reto para nuestro país. Es por ello que, Cuba se ha enfrascado en la búsqueda de alimentos alternativos basado en el uso de plantas proteicas y otras portadoras de fibra y energía. La presente investigación se realizó en la finca universitaria Guayabal con el objetivo de obtener propiedades físicas y organolépticas de plantas proteicas para la elaboración de alimentos alternativos totalmente mezclados en la finca universitaria "El Guayabal". Los valores promedios obtenidos en los resultados de la evaluación de las propiedades físicas luego de ser desmenuzados los ingredientes para la formulación de un alimento totalmente mezclado, se aprecian resultados promedio de la Tithonia Diversifolia variedad 16 con una humedad de 78%. La caña de azúcar c 85- 403 con valores de humedad de 77.99 %. El King Grass variedad OM-22 una humedad de 69.68 % El porcentaje de materia seca de las muestras varió entre 21.8 y 30.32%,

Palabras clave: portadoras de fibra, energía, densidad, humedad, materia seca.

INTRODUCTION

In 2011, Cuba spent more than 800 million dollars on the purchase of wheat, soybeans and corn, destined for animal feed, local media reported. The prices of these raw materials have continued to increase in the international market and, on the other hand, the agricultural productivity of soybeans and corn in the country registers lower levels than other regions of the world (Iraola et al., 2019).

At an international level, alternatives for animal feed constitute a matter of maximum relevance, since an increase of two billion people in the world population is predicted by 2050 (Rivera et al., 2015; Arango et al., 2016; Schultze et al., 2018; Santos et al., 2019). This will mean a significant increase in the demand for animal feed in a context of degraded lands and increased urbanization, which is why the search for new ways to increase livestock production is essential. Cuba as a country develops in the same context, hence the search for alternative foods based on the use of protein plants and other fiber and energy carriers.

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The investigation of physical organoleptic properties of protein silvers such as density, moisture loss, dry matter content and color index are of great interest for monitoring.

of the quality during their processing for the formation of food; also in the search for an adequate appearance and durability, and on the other hand, some of them constitute input data to simulation models for the calculation of cut resistance, as well as for the determination of productivity and power consumption during the design and selection of the system of machines that intervene in the technological process of production of this type of alternative food.

Among the protein plants of greatest interest as animal feed, the Cane (Saccharum officinarum L), the Tithonia (tithonia diversifolia) and the King Grass (pennisetum purpureum x p. typhoides) stand out (Castaño, 2012; Gallego et al., 2017). Based on this, knowledge of the properties of these three protein plants under regional conditions plays an indispensable role in obtaining an alternative food with high quality and use value in livestock farming. Consequently, with everything previously stated, the objective of obtaining physical and organoleptic properties of protein plants for the preparation of fully mixed alternative foods at the “El Guayabal” university farm

MATERIALS AND METHODS

For the determination of the main physical properties of the protein plants that are produced in the university farm ¨El Guayabal¨, belonging to the Agrarian University of Havana, an initial sample of 100 kg of Cane (saccharum officinarum L var. C85-403), Tithonia (tithonia diversifolia CM16) and King Grass (pennisetum purpureum x p. typhoides. OM-22), previously ground. This farm is located in the municipality of San José de Las Lajas, Mayabeque, Cuba, at kilometer 23 ½ of the National Highway (Figure 1).

FIGURE 1. El Guayabal Farm.

Sampling is done at random, checking the homogeneity of the product visually. The sample size by properties is determined from a pre-experiment according to Luyarati 1997), through expression (1) and is described below:

$$N_m = (\frac{t_s^2}{\Delta_a^2})\cdot\sigma^2 \quad (1)$$

Where:

t_s: coefficient that depends on the level of confidence and the number of samples, it is determined for a student's t distribution.

σ: typical or standard deviation.

Δ_a: maximum allowable error of the mean.

Mass: amount of matter that a body or material object has. Property independent of the position and state of movement of bodies that is closely related to other properties such as density and % moisture loss. Furthermore, an electronic scale is used to obtain it (Figure 2).

FIGURE 2. Electronic scale model LG-1001 from 0 to 1000 (g)/0.1 (g).

Density: The apparent density according to Díaz (2017) is the relationship between the mass of the material and the real volume occupied by the particle, excluding empty spaces. Apparent density is an important factor in the analysis of mass and heat transfers. These properties were also carried out in quality control, in the evaluation, calculation of the final product obtained. See expression 2.

$$Da = \frac{md}{V} \quad (2)$$

Where:

Da: apparent density. (g/cm^2);

md: sample mass, (g);

V: volume of the retaining cylinder, (cm^3).

It was determined by the Archimedes method, using a 100 ± 0.1 ml volumetric container, which was filled with 600 ml of distilled water; Then, 100 grams previously compressed in the shape of a cylinder were immersed until completely submerged. The volume of displaced water was recorded by direct reading on the scale of the container. The apparent density (ρa), in g/cm3, of the ingredients was determined as the relationship between the mass of each ingredient (g) and the volume of displaced water (cm^3) performing 5 repetitions per type of sample. (Figure 3)

FIGURE 3. Volumetric container of 100 ± 0.1 mL.

Moisture content: constitutes one of the fundamental properties that guarantees the stability and conservation of agricultural products, whether dehydrated or dried (Iraola et al., 2019; Riascos et al., 2020) expression (3)

$$\%H = \frac{m_a - m_s}{m_s} * 100 \quad (3)$$

Where:
H: humidity (%)
m_a: initial mass before drying the product (g)
m_c: mass after drying the product (g)

Samples of 100 grams of wet matter are taken and successively introduced into a microwave oven. A MIDEA model device is used, 230 voltage 50 Hz, 4.0 A intensity at the maximum power of 850 W, with a frequency of 2450 MHz. Each sample is subjected to 1 cycle of 5 minutes each at maximum power, in the presence of a 50 ml glass, containing distilled water. The glass of water is included to moisten the medium and prevent sample ignition. At the end of the first 5-min cycle, the sample is weighed and 2-minute cycles are carried out until the sample reaches a constant weight. (Crespo et al., 2007) (Figure 4). In addition, the variation of the mass and consequently the loss of humidity were monitored under natural drying conditions, indoors, in a ventilated warehouse, located on a plateau separated one meter from the ground, for this a total of 15 samples were used. (250 g each), five for each type of plant studied and were monitored for five days until weight stability was achieved during 3 consecutive measurements.

FIGURE 4. Midea brand microwave.

Dry Matter (DM): The estimation of % DM is of utmost importance to establish the amounts of nutrients that animals will consume. Ration calculations should be done in dry matter, in the same way as the comparison between nutrients offered and animal requirements (Stritzler et al., 2004). To determine this parameter, the following expression (4) is used.

$$\%MS = 100 - \%H \quad (4)$$

Where:
%MS: dry matter (%)
%H: humidity percentage.

Color Index (CI): The Color Index describes the color of the plant, allowing the freshness of the plant to be corroborated and on the other hand, when the product to be used in the formulations goes through prior drying processes, with the monitoring of this property it is possible to achieve a certain similarity with respect to conventional foods in terms of visual appearance. To determine the IC*, three parameters L*, a*, b* are used, following the lighting standard of the spectral scale, where L* describes the luminosity and a*, b*, evaluate the saturation that gives us the purity of the color and tone is the color itself, according to Francis and Clydesdale (1975). In this case, the change in IC is monitored during the drying process of the plants, for subsequent conformation to the alternative food, seeking the required moisture content and ensuring that the product maintains an adequate appearance and durability.

Axis (a) that goes from green to red measuring the purity of the color.

Axis (b) that goes from blue to yellow measuring the tone of the color itself.

The mathematical expression determined to calculate the Color Index (Francis and Clydesdale, 1975).

Other parameters related to the color index would be the a*/b* ratio, the tone ºh_ab, the saturation C_ab. Equations (5, 6 y 7).

$$IC = \frac{a \times 1\ 000}{L \times b} \quad (5)$$

Where:
a: zone of variation between green and red of the spectrum;
L: color intensity;
b: zone of variation between blue and yellow of the spectrum

$$°h_{ab} = artg\left(\frac{a}{b}\right) \quad (6)$$

$$C_{ab} = \left[(a)^2 + (b)^2\right]^{0.5} \quad (7)$$

It is obtained by the image capture method, according to Vignale et al. (2015). To obtain the digital images, the photography method is used using a CANON PowerShot A630 8.5 mega-pixel camera, located on a professional tripod elevated 1.40 m from the ground surface and three meters from the objective. After obtaining the images of each species, they are exported to the portable software ADOBE PHOTOSHOP Cs 3 in Spanish, where for each of them the numerical representation of the variables L, a and b is obtained to finally obtain the average value of them. The value of the IC* is determined according to the mathematical expression set out above. All data obtained is processed in Stargraphics Plus 5.1 Software and Microsoft Excel 2019.

RESULTS AND DISCUSSION

As shown in Table 1, the average values of the results of the evaluation of the physical properties of the protein plants studied and that are part of the ingredients for the formulation of a fully mixed food, an average moisture content was obtained for Tithonia Diversifolia variety 16 of 78%, for sugar cane c 85-403 of 77.99% and in the case of King Grass variety OM-22 69.68%. The percentage of dry matter of the samples varied between 21.8, 22.01 and 30.32%, for these varieties respectively. The values obtained are within the ranges established as zootechnical requirements for the use of these forages in different food formulations, both alternative feeds and silages (Castaño, 2012; Babiker et al., 2017; Laguna, 2018; Londoño et al., 2019; Navas, 2019; Navas et al., 2020). It is valid to point out the difference in humidity of raw materials is a property that directly influences the productivity and energy requirements of the animals. (Iraola et al., 2019).

TABLE 1. Average physical property results

Ingredients	Moisture %	DM %
Tithonia Diversifolia 16	78.2	21.8
Sugar cane C85-403	77.99	22.01
King Grass OM-22	69.68	30.32

Color

Table 2 shows the values obtained from the color coordinates by variety studied, the luminosity (L*) of the color of the protein plants of the categories of the visual scale were different from each other, with Tithonia Diversifolia variety 16 being less luminous with 40 by increasing the green color of the visual scale. Color saturation (C*ab) also decreased in the Cane with a value of 21.66 as the green color increased. At the same time the tone (ºh ab) of color corresponded to the green color represented on the scale. This result was similar to those obtained in the a*/b* relationship [variables a*(-a* green, +a* red) and b* (-b* blue, +b* yellow)].

The values of the variable b* decreased between each category, while the values of the variable a* remained relatively constant. This implied, on the visual color scale ranging from color A to VV, a reduction in yellow values (+b*) and a significant increase in green values (-a*). This coincides with what was observed in other species and explained the increase in chlorophylls. Pasquariello et al. (2015) reported the luminosity parameters (L* 37.5 to 43.3) in other species. Which denotes the fresh state in which the ingredients were. The color index of King Grass OM-22, Thitonia Diversifolia 16 and freshly milled Sugar Cane C85-403 was -52.08; -37.78 and -38.71, respectively.

In Figure 5 it is possible to describe the variation of the mass of Sugar Cane variety C85-403, Tithonia Diversifolia 16 and King Grass OM-22 using the microwave oven. It can be seen that the mass tends to decrease over time in all cases, logical for a drying process. A very similar and stable behavior is seen in this process for sugar cane and Tithonia, with drying completed in 15 min, which is due to the similarity of the milled product (stem + foliage). In the case of King Grass, it stabilizes the dough variation much faster than the previous varieties, its drying is completed in 11 minutes and it has a slightly lower dough variation. A strong relationship is corroborated between the variables studied, expressed in coefficients of determination R2≥0.92 shown in a polynomial adjustment of the relationship of one variable with respect to the other.

Figure 6 shows the percentage of moisture loss of the varieties exposed to dehydration conditions in the laboratory and in a shaded room, resulting in a slightly higher moisture loss when the drying process was carried out using a microwave oven. In none of the three species were significant differences found in moisture loss, however, among the three varieties studied, the variation in mass and consequently the moisture loss by both methods turned out to be lower in King Grass and when it was dried the product.

TABLE 2. Results of colorimetric parameters

Colorimetric parameters	Kin Grass OM-22	Tithonia 16	Sugar cane C85-403
L	49	40	70
hab	-1.0274	-0.6503	-0.834
Cab	23.61	22.38	21.66
a/b	-0.6005	-0.516	0.397
IC	-52.08	-37.78	-38.71

Source: own elaboration

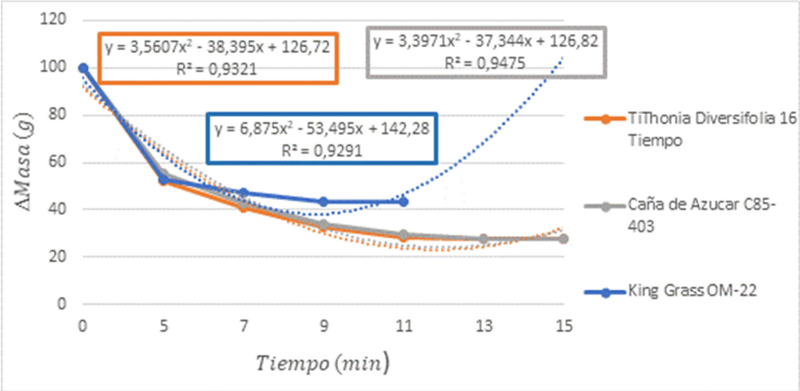

FIGURE 5. Behavior of the mass of the protein plants studied during the drying process using microwaves.

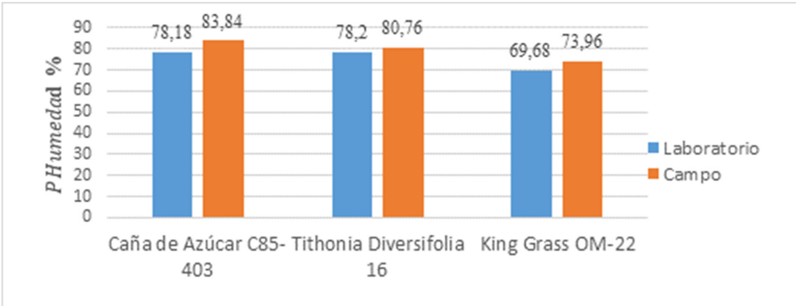

FIGURE 6. Moisture loss graph in Sugarcane C85-403 variety, Tithonia Diversifolia variety 16 and King Grass OM-22.

CONCLUSIONS

- The moisture content of Tithonia Diversifolia variety 16 is 78%, of sugar cane c 85-403 is 77.99% and in the case of King Grass variety OM-22 69.68%, while the matter content dry was 21.8, 22.01 and 30.32%, for these varieties respectively.
- The color index of King Grass OM-22, Thitonia Diversifolia 16 and freshly milled Sugar Cane C85-403 was -52.08; -37.78 and -38.71, respectively.
- The moisture loss values ranged from 69.68 to 83.84% in the three varieties studied and in both methods, being slightly lower when drying King Grass with a microwave oven.

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