

Paste as a new product from Bamboo shoot (*Dendrocalamus asper*): physicochemical and microbiological properties

Pasta como um novo produto do broto de bambu (*Dendrocalamus asper*) propriedades físico-químicas e microbiológicas

Crema como nuevo producto del brote de bambú (*Dendrocalamus asper*) propiedades físicoquímicas y microbiológicas

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Abstract

There are 50 to 60 bamboo species, which the shoots are edible. This work aimed for the development and characterization of a new product from the *Dendrocalamus asper* specie, related to physicochemical, microbiological, texture and color characterization of a bamboo shoot paste. Cyanide was eliminated through preprocessing and the formula of the new product did not compromise bamboo shoots characteristics, as low-fat content food. The presence of phenolic compounds in the paste and antioxidant activity, even considering a product of high content of moisture, supports its consumption. As to the obtaining conditions, microbiological results indicate that consumption is safe, right after the paste production and during storage. The texture characteristics during storage, at room temperature and under cold, indicate the technical viability for this product, achieving stability, although it is still nonexistent in the market. Color changes in the final product, comparing to raw material, kept typical characteristics of bamboo shoot during storage, even considering browning reactions due to thermal treatment.

Keywords: Bamboo shoot; Innovation; Paste; Stability; Quality.

Resumo

São conhecidas cerca de 50 a 60 espécies de bambu com brotos comestíveis. Este trabalho tem o objetivo de desenvolver e caracterizar um novo produto da espécie *Dendrocalamus asper* quanto às propriedades físico-químicas, microbiológicas, textura e cor de uma pasta de broto de bambu. O cianeto foi eliminado no processamento e a formulação do novo produto não compromete as características do broto de bambu, como um alimento com baixo teor de gordura. A presença de compostos fenólicos e a atividade antioxidante na pasta, mesmo considerando um produto com alta umidade, justificam o seu consumo. De acordo com as condições de obtenção, os resultados da microbiologia indicam que o produto é seguro para consumo, na produção e durante a estocagem. As características de textura durante a estocagem em temperatura ambiente e sob refrigeração, indicam a viabilidade técnica de obtenção da pasta como um produto estável, ainda inexistente no mercado. As mudanças de cor no produto final, comparada a matéria prima, mantêm as características próprias do broto de bambu durante a estocagem, mesmo considerando as reações de escurecimento no tratamento térmico.

Palavras-chave: Broto de bambu; Inovação; Pasta; Estabilidade; Qualidade.

Resumen

Se conocen alrededor de 50 a 60 especies de bambú con brotes comestibles. Este trabajo tiene como objetivo desarrollar y caracterizar un nuevo producto de la especie *Dendrocalamus asper* en cuanto a las propiedades físicoquímicas, microbiológicas, de textura y color de una crema de brotes de bambú. El cianuro se eliminó en el procesamiento y la formulación del nuevo producto no compromete las características del brote de bambú, como alimento bajo en grasas. La presencia de compuestos fenólicos y la actividad antioxidante en la crema, aun

considerando un producto con alta humedad, justifican su consumo. Según las condiciones de obtención, los resultados de la microbiología indican que el producto es seguro para el consumo, en producción y durante el almacenamiento. Las características de textura durante el almacenamiento a temperatura ambiente y en refrigeración, indican la viabilidad técnica de obtener la crema como un producto estable, que aún no existe en el mercado. Los cambios de color en el producto final, en comparación con la materia prima, mantienen las características del brote de bambú durante el almacenamiento, incluso considerando las reacciones de pardeamiento en el tratamiento térmico.

Palabras clave: Brotes de bambú; Innovación; Crema; Estabilidad; Calidad.

1. Introduction

The consumption of bamboo shoots and leaves is common in countries like Korea, Japan and China. Shoot's products are also commercialized and consumed as a delicacy (Fszanz, 2004; Choudhury et al., 2012). The INBAR (International Network for Bamboo and Rattan) got involved with research and development of new products based on bamboo shoot. Although the use of bamboo is large, based on the energetic properties (Rusch et al., 2020a) and for composites for civil construction (Rusch et al., 2020b), the valorization of shoots needs to be expanded. The goal was to increase the consuming market, stimulating new uses and food security in scarce places (Hunter & Yang, 2002).

Studies on their functional properties are vast, comprehending shoots and leaves extracts (Park & John, 2010). Most of these include organic extracts, while bamboo shoot consumption does not occur on this form, but canned or even fresh, previously treated. Studies on the antioxidant activity of bamboo oil were also reported (Dubok et al., 2008; Wang et al., 2020).

Bamboo shoots are an alternative source of functional elements and have great nutritional value, presenting vitamins, amino acids and antioxidants, such as flavonoids, phenols and sterols, besides low content of fat and high content of fibers (Park & Jhon, 2009; Luo et al., 2012). Despite its health beneficial properties, bamboo shoot still needs a preprocessing stage to become edible, avoiding any risk to consumers due to the presence of cyanogenic compounds. The cyanide hydrogen, main toxicological compound found in bamboo shoots, can be eliminated through a simple process of cooking under boiling conditions.

Common products processed from bamboo shoot are fresh slices and canned, with several seasoning (Tamang & Sarkar, 1996; Kleinhenz & Midmore, 2002). However, there is a growing need to expand its varieties in the market. Traditional bamboo products may not be as pleasant as they were to new demanding consumers (Bhatt et al., 2005; Nirmala et al., 2011). Taking into consideration bamboo shoot potential as healthy food and its regular consumption in several countries, this paper analyses the physicochemical and microbiological characteristics of a new product as a paste developed from this raw material.

2. Methodology

Samples were collected in Rancho Queimado city, Santa Catarina State, Brazil, of *Dendrocalamus asper* specie which provides edible shoots. It was given preference to uniform sized shoots and transported in high-density polyethylene bags (HDPE), selecting the shoots without any defects for posterior analysis.

2.1 Preprocessing and paste elaboration of bamboo shoots

The cyanogenic glycosides elimination was according methodology of Ferreira et al. (1992), with modifications. Shoots were unpeeled until the removal of rigid fibers and cut into cubes of 1 to 1.5 centimeters. After the treatment, shoots were vacuum packed in HDPE bags and stored at -20 ± 2 °C. Paste was elaborated according to methodology developed by Watanabe (2016) from *Dendrocalamus asper* edible shoots. The paste was prepared from frozen shoots, by grinding in a

domestic blender, with the ingredients (salt - sodium chloride, citric acid and soy protein isolate), packaged and sterilized (121 °C for 15 minutes) in glass recipients of 30 g.

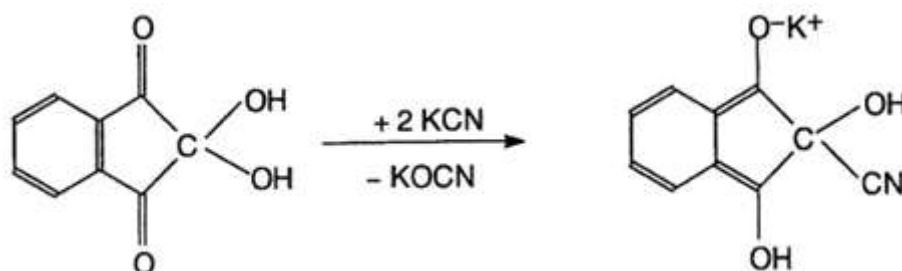
2.2 Storage conditions and sampling period

Pastes were stored at room temperature (22 ± 1 °C). Determinations of physicochemical and microbiological parameters were performed in triplicate and instrumental texture in quintuplicate, in the day of elaboration (initial month) and after 2 and 5 months of storage, under cold storage (4 ± 1 °C) and at room temperature. Centesimal composition was performed in triplicate, from preprocessed bamboo shoot and the paste, the day after product's elaboration and after 2 and 5 months of storage.

2.3 Cyanide determination

Analysis was conducted based on the colorimetric reaction between cyanide ion and 2,2-dihydroxy-1,3-indanedione (ninhydrin), in presence of sodium carbonate, according to Drochioiu (2002) and adapted by Surleva and Drochioiu (2013) (Figure 1). Extraction procedure was according Tsuge et al. (2001) using the micro diffusion technique in Conway Cell. Absorbance was read in UV-VIS spectrophotometer (Hitachi, U-1800, Tokyo, Japan) at 485 nm.

Figure 1. 2,2-dihydroxy-1,3-indanedione colorimetric reaction with cyanide.



Source: Drochioiu (2002).

2.4 Physicochemical and nutritional analysis

Physicochemical and nutritional analysis was according to AOAC (2005) for ash (942.05), moisture (925.10), proteins (920.87) and fat (945.39), total (985.29), soluble and insoluble fibers (991.42) determinations. The methodologies for quantification of minerals were: IN n° 20 for calcium; IAL (1985) for phosphorus and AOAC (2005) for iron (944.02) through a spectrophotometer (Micronal, AJX-3002PC); zinc and magnesium (AOAC, 2005) (985.35) through atomic absorption (Shimadzu Corp 02015, Kyoto, Japan). Reducing sugars were quantified according to Miller (1959), pH was determined with potentiometer (Quimis pHmeter, model Q-400, Brazil) and acidity by titulometry (AOAC, 2005).

2.5 Evaluation of the paste stability

The behavior of paste on storage was observed for a period of five months through texture, color and microbiological analysis.

Mesophilic microorganisms, yeasts and molds, heat-resistant molds, psychrophilic, *Staphylococcus aureus* and *Salmonella spp* were performed according to Silva et al. (2007), before and after heat treatment and in two months of storage.

Texture analysis was conducted under cold and at room temperature storage, utilizing a TA-XT plus texturometer (Stable Micro Systems Ltd., Surrey, United Kingdom) and a 25 mm of diameter lead. Texture profile was analyzed through

double penetration test, with 40 g of sample, in 1 mm s⁻¹ speed and 10 mm depth. Data was collected through Texture Expert Exceed 2.61 program (Stable Micro Systems Ltd., Surrey, United Kingdom) and response generated in a Strength (N) x Time (s) graph. Firmness, adhesivity, elasticity, cohesivity, gumminess and mastigability.

Color was measured with a colorimeter (Konica Minolta Chroma Meter CR-400, Osaka, Japan), which provided L*, a* and b* parameters. ΔE^* (total color difference) was also calculated according to Equation 1.

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2} \quad (1)$$

Analysis was performed in quadruplicate, before (A) and after (T0) heat treatment and during 2 and 5 months of storage.

2.6 Statistical analysis of the results

Data was submitted to analysis of variance (ANOVA) and the mean comparison test of Tukey, utilizing as minimum criteria of $p < 0.05$. This was performed through Assistat 7.7 beta software. In addition, the coefficient of Pearson correlation was calculated, when necessary, with Sigma Stat 3.5 software.

3. Results and Discussion

3.1 Cyanide elimination

Decontamination must be achieved to enable human consumption of bamboo shoots and preprocessing stage is responsible for it. According to JECFA (2001), the acute reference dose is 0,09 mg kg⁻¹ and the provisional maximum tolerable daily intake is 20 µg kg⁻¹ for cyanide.

Table 1 shows the cyanide content in raw shoots and treated after 30 and 60 minutes. After one hour, there was no cyanide detected in samples, taking into consideration the calibration curve concentration (from 0.01 to 1 µg kg⁻¹).

Table 1. Cyanide concentration (CN⁻) in bamboo shoots (*Dendrocalamus asper*) after harvest (control), after 30 and 60 minutes of boiling.

Time (minutes)	CN ⁻ (µg kg ⁻¹)
0	200.44 ± 0.24
30	48.40 ± 0.31
60	ND

ND: non detected. Source: Authors.

According these results, preprocessing removed cyanide from bamboo shoots for the secure production of the bamboo shoot paste, about cyanide contamination.

3.2 Centesimal composition

Analysis was performed of control (bamboo shoot after preprocessing stage), paste after ingredients addition and sterilization corresponding to zero time (T0) and after five months of storage (T5) (Table 2).

Moisture of T0 and T5 did not present significant difference ($p \geq 0.05$), with values of 92.47 ± 0.04 g 100g⁻¹ and 92.56 ± 0.05 g 100g⁻¹, respectively. Control presented higher moisture due to the processing stage of heat treatment, which decreases water content by evaporation. This behavior has already been studied in pastes from other vegetables, as reported by

Andrade et al. (1989). Moisture content from raw bamboo shoots varied from 83.60 to 94.70 g 100g⁻¹ (Rana et al., 2011; Sood et al., 2013). As to ash content, all samples presented significant difference ($p < 0.05$). Authors reported values of 0.61 to 1.31 g 100g⁻¹ for raw shoots (Nongdam & Tikendra, 2014); although control had lower content, which can be due to entrainment of mineral compounds during preprocessing and boiling (Daiuto et al., 2015). Greater values in T0 and T5 are explained by the addition of ingredients for formulation of paste. Both differed significantly ($p < 0.05$) because of paste heterogeneity, once the macroscopic components interfere during sampling and analysis.

Fat content was equal to all samples, of 0.02 g 100g⁻¹. Exceptional cases are reported with amounts of 3.54 g 100g⁻¹, although usually are between 0.10 and 1.00 g 100g⁻¹ in raw shoots (Satya et al., 2010). Low fat content can be attributed to preprocessing conditions and origin of shoots.

Considering content of fat in other vegetable pastes like 8.30 and 14.77 g 100g⁻¹ (Xavier et al., 2014), results show that bamboo shoot paste is favorable for commercialization with the lowest fat content, encouraging its consumption as a healthy option.

Proteins were higher for T0 (2.82 g 100g⁻¹), but all samples presented significant difference ($p < 0.05$). Nongdam and Tikendra (2014) reported values between 0.60 to 3.69 g 100g⁻¹ in raw shoots, situating samples among those results. A lower value for control may be due to entrainment of some proteins during preprocessing. There was also the reincorporation of proteins by addition of ingredients, which would explain higher values for T0 and T5.

Insoluble portion of fiber presented higher values than the soluble one. After processing, fibers content did not suffer significant changes, which was also not influenced by ingredients addition. Authors report the same behavior for shoots under heat treatment (Zhang et al., 2011). Singh et al. (2011) reported values between 2 and 3 g 100g⁻¹ of total fibers in fermented bamboo shoots, consistent with evaluation of control. Other authors found it to be over 3 g 100g⁻¹ of insoluble fibers, which may vary depending on regional, climatic and species factors (Nakatsu et al., 2012).

Shoots are characterized by the presence of important minerals (Table 2). Sodium, potassium and phosphorus contents presented significant difference ($p < 0.05$) between all samples. Mineral results are consistent with ash contents, once control had lower values and T0 the highest ones. Control had lowest content of minerals because it lacked the addition on ingredients, which contributed to the formulation.

Sodium had higher content than other mineral, calcium was second highest and potassium the third. Increase in sodium content in T0 represents the addition of ingredients in paste, although other vegetable pastes in the market present much higher contents of 9,30 and 10,00 mg 100g⁻¹ (Ahmed & Shivhare, 2001; Pinedo et al., 2010).

There is a great disparity on minerals among shoots, depending of region and soil, even among the same species, making unviable to establish a content parameter (Nongdam & Tikendra, 2014).

Awol (2015) studied nutrients, minerals and bioactive components in bamboo shoots and found values of 19.16, 6324.10, 60.45, 13.59, 390.00 e 9.97 mg 100g⁻¹ for sodium, potassium, calcium, iron, magnesium and zinc, respectively.

The centesimal composition of bamboo shoot paste (Table 2), characterize this new product as a healthy product and alternative of easy consumption.

Table 2. Composition of bamboo shoot paste, shoot after preprocessing (control), shoot added of ingredients and sterilized at 121 °C for 15 min (T0) and after 5 months of storage (T5).

(g 100g ⁻¹)	Samples		
	Control	T0	T5
Moisture	96.21 ± 0.06 ^a	92.47 ± 0.04 ^b	92.56 ± 0.05 ^b
Ash	0.08 ± 0.01 ^c	1.03 ± 0.01 ^a	0.89 ± 0.01 ^b
Fat	0.02 ± 0.01 ^a	0.02 ± 0.00 ^a	0.02 ± 0.00 ^a
Protein	1.14 ± 0.04 ^c	2.82 ± 0.01 ^a	2.34 ± 0.02 ^b
Fibers	Soluble	0.39 ± 0.16 ^a	0.84 ± 0.08 ^a
	Insoluble	2.12 ± 0.12 ^a	1.89 ± 0.25 ^{ab}
Minerals (mg100g ⁻¹)			
Sodium	23.70 ± 0.00 ^c	335.87 ± 2.55 ^a	287.70 ± 0.10 ^b
Potassium	2.60 ± 0.00 ^c	19.50 ± 0.10 ^b	25.23 ± 1.07 ^a
Calcium	14.51 ± 0.37 ^b	36.06 ± 2.72 ^a	12.12 ± 0.86 ^b
Iron	0.61 ± 0.18 ^a	0.94 ± 0.23 ^a	0.78 ± 0.05 ^a
Phosphorus	0.09 ± 0.01 ^c	0.31 ± 0.03 ^a	0.22 ± 0.02 ^b
Magnesium	3.54 ± 0.19 ^a	3.50 ± 0.11 ^a	2.70 ± 0.03 ^b
Zinc	0.44 ± 0.03 ^{ab}	0.51 ± 0.05 ^a	0.39 ± 0.05 ^b

Mean ± Standard deviation (n=3).

Means followed by the same letter in the line do not differ statistically ($p < 0.05$), by Tukey test.

Source: Authors.

3.3 pH and acidity

During processing and storage, the product can be exposed to several factors that interfere with structure and nutritional composition. Related to those changes, pH is an important physicochemical evaluation parameter. With preprocessing stages and sterilization, risks of alterations were minimized, as inactivation of enzymes and microorganisms (Table 3). Control presented a significant difference ($p < 0.05$) of pH value (6.21 ± 0.01), while others presented 3.63, 3.68, 3.68 e 3.64 for A, T0, T2, and T5, respectively. There was no change in pH after sterilization, which demonstrated product stability additionally to the pH value away from the risk range for pathogenic microorganisms.

3.4 Reducing sugars

Reducing sugars (Table 3) has a great importance and can contribute significantly to a product's characteristics. These compounds participate actively in browning reactions through caramelization and Maillard, which are undesirable in the case of this product.

Acidity is a response to raw material composition, formulation and food conservation. Control presented 0.02 mL of NaOH mol L⁻¹ 100g⁻¹ and was significantly different ($p < 0.05$). Sood et al. (2013) found values of 0.28 1 mol L⁻¹ 100g⁻¹ for raw shoots, which demonstrates the low acidity of this material, and preprocessing could have contributed to lower value, due to loss of acids during boiling.

According to Kumbhare and Bhargava (2007), reducing sugars content in bamboo shoots can be near 1.14 g 100g⁻¹, although it decreases around 90% after boiling, which causes sugars degradation by heat. Control presented a value of 0.07 g 100g⁻¹, which is consistent with boiled shoots.

Table 3. Physicochemical properties of bamboo shoot paste, shoot after preprocessing (control), shoot added of ingredients before (A) and after sterilization (T0) at 121 °C for 15 min and after two (T2) and five (T5) months of storage.

Samples	pH	Acidity (mL of NaOH mol L ⁻¹ 100g ⁻¹)	Reducing sugars (g 100g ⁻¹)
Control	6.21 ± 0.01 ^a	0.02 ± 0.00 ^d	0.07 ± 0.00 ^c
A	3.63 ± 0.01 ^b	9.53 ± 0.00 ^b	0.40 ± 0.00 ^c
T0	3.68 ± 0.01 ^b	9.88 ± 0.12 ^a	2.55 ± 0.13 ^a
T2	3.68 ± 0.03 ^b	8.56 ± 0.01 ^c	2.75 ± 0.03 ^{ab}
T5	3.64 ± 0.01 ^b	8.68 ± 0.11 ^c	3.07 ± 0.04 ^b

Mean ± Standard deviation (n=3).

Means followed by the same letter in the column do not differ statistically ($p < 0.05$), by Tukey test.

Source: Authors.

T0 had the highest content of reducing sugars ($2.55 \pm 0.13 \text{ g } 100\text{g}^{-1}$). This increase is due to sterilization, which enhances the content of reducing groups by carbohydrate hydrolysis. There was a slight increase during storage due to hydrolysis of oligo and polysaccharides in shoots and ingredients of formulation. That is favored by the low value of pH in samples (3.64 to 3.68).

Physicochemical characteristics of the paste indicate that, although pH is close to neutrality in control, there was great contribution to reducing its value with the formulation and addition of ingredients, and represents lower risk for food. On the other hand, there was a contribution with sterilization, as to pH and acidity, during storage. Reducing sugars did not present any significant changes at the end of 5 months of storage and maintaining the expected for bamboo shoot products, found in literature.

3.5 Microbiology

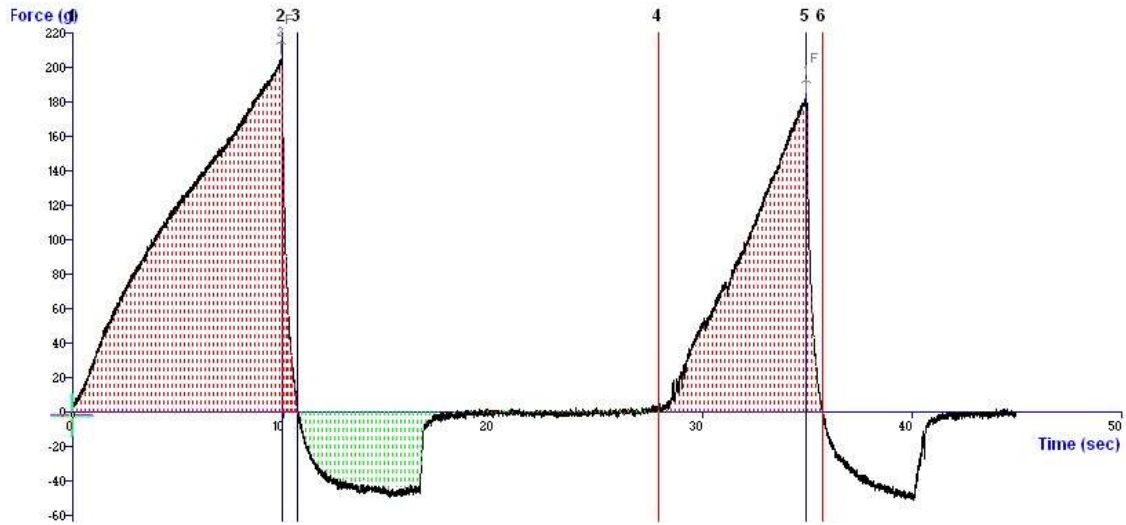
In order to certify product's safety, microbiology was performed. Coliforms at 45 °C presented count of $< 10 \text{ UFC g}^{-1}$ before and after sterilization. In the analysis of *Salmonella spp.*, it was verified the absence in 25 g of sample. Results indicate that bamboo shoot paste is fit for human consumption. However, psychrophilic microorganisms and *S. aureus* were analyzed to evaluate preparation of paste and the possibility of storage in cold. Both presented negative results for paste before and after sterilization.

Bamboo shoot paste had $6.5 \times 10^1 \text{ UFC g}^{-1}$ for mesophilic microorganisms before processing (A). In T0 and T2 that was no longer observed, with $< 10 \text{ UFC g}^{-1}$. As to yeast and molds, all samples were $< 10 \text{ UFC g}^{-1}$. By the second month of storage, it was performed heat-resistant spore analysis, to verify spore presence that could have resisted to sterilization, and their absence was confirmed.

3.6 Instrumental texture

Texture behavior is presented in Figure 2, which illustrates texture profile simulating chew (Szczeniak, 1975). Table 4 shows the results of texture parameters obtained from paste analyzed in two temperatures: room and cold storage. This test was performed to evaluation of the behavior in case of cold storage after opening the package and stored in a refrigerated environment.

Figure 2. Texture profile (force in Newton x time in seconds) generated by TA-XTplus texture analyzer for bamboo shoot paste.



Source: Authors.

Firmness (Table 4) parameter had an increase after sterilization and did not suffer significant change ($p \geq 0.05$) after two months of storage, at room temperature. While in cold storage, it suffered an increase, being more resistant to deformation, although having a decrease to 1.78 N (T2) afterwards. Authors report an abrupt decrease in firmness with samples that suffered heat treatment, caused by decomposition of pectin substances, in the cellular walls of vegetable tissue (Zheng *et al.*, 2013), also in the low pH of paste.

No samples presented significant difference ($p \geq 0.05$) in cohesivity, even in different temperatures. That represents a cohesive product during processing and storage that does not suffer rearrangement of macromolecules and water expulsion.

As to adhesivity, sample A stored at room temperature had a decrease from 2.59 to 1.73 N s, by the second month of storage, also decreasing its property to adhere in tooth after chewing. The same behavior was observed at cold storage.

Elasticity showed an increase at both temperatures. At room temperature, mastigability presented a significant increase ($p < 0.05$) from 3.25 N (A) to 4.22 N (T0), but did not suffer changes after two months. Gumminess showed a significant increase ($p < 0.05$) after sterilization. In cold storage, both presented the same behavior, having an increase after sterilization. At lower temperatures, fibers in bamboo shoot paste become more rigid, therefore being more resistant to disintegration. Besides, heat treatment resulted in water retention to formulation ingredients, especially protein ones, what proves texture of paste.

Table 4. Instrumental texture of bamboo shoot paste before (A) and after (T0) sterilization at 121 °C for 15 min, in two (T2) months of storage, analyzed at room temperature (22 ± 1 °C) and under cold storage (4 ± 1 °C).

Texture	Samples	Room temperature*	Cold storage*
Firmness (N)	A	1.39 ± 0.06^{aB}	1.40 ± 0.02^{aC}
	T0	1.69 ± 0.06^{bA}	1.97 ± 0.16^{aA}
	T2	1.62 ± 0.08^{bA}	1.78 ± 0.04^{aB}
Cohesivity (dimensionless)	A	1.76 ± 0.08^{aA}	1.74 ± 0.15^{aA}
	T0	1.76 ± 0.09^{aA}	1.77 ± 0.07^{aA}
	T2	1.82 ± 0.08^{aA}	1.82 ± 0.04^{aA}
Adhesivity (Ns)	A	2.59 ± 0.27^{aA}	2.94 ± 0.29^{aA}
	T0	2.12 ± 0.21^{bB}	2.47 ± 0.12^{aB}
	T2	1.73 ± 0.31^{aB}	1.92 ± 0.10^{aC}
Elasticity (dimensionless)	A	1.33 ± 0.09^{aB}	1.30 ± 0.14^{aB}
	T0	1.42 ± 0.10^{aAB}	1.37 ± 0.05^{aAB}
	T2	1.56 ± 0.11^{aA}	1.53 ± 0.05^{aA}
Masticability (N)	A	3.25 ± 0.40^{aB}	3.18 ± 0.69^{aB}
	T0	4.22 ± 0.48^{aA}	4.78 ± 0.68^{aA}
	T2	4.62 ± 0.52^{aA}	4.97 ± 0.19^{aA}
Gumminess (N)	A	2.44 ± 0.17^{aB}	2.44 ± 0.25^{aB}
	T0	2.98 ± 0.16^{bA}	3.49 ± 0.41^{aA}
	T2	2.95 ± 0.17^{bA}	3.25 ± 0.10^{aA}

Mean \pm Standard deviation (n=4)

Lower case letters compare means, in the same line, for the same time at different temperatures of storage, and capital letters, in the same column, between the same temperatures of storage for different times. Different letters differ significantly ($p < 0.05$), according to Tukey test.

*Temperature: room (23 ± 2 °C), cold storage (4 ± 2 °C).

Source: Authors.

It can be observed that parameters of cohesivity, adhesivity, elasticity and masticability did not present significant difference ($p \geq 0.05$), after two months of storage (T2), between samples at room temperature and cold storage. Therefore, there would be no concerns in keeping the product at room temperature.

3.7 Instrumental color

Bamboo shoot presents light yellow and homogeneous color from top to bottom. Intensification of color is common during heat treatments, through caramelization and Maillard reactions, and instrumental color analysis can be a parameter to assure the paste's quality. Table 5 presents mean values of chromatic coordinate L*.

There was a decrease in control of L* parameter of 4.68 in formulated and non-sterilized paste. This did not present significant difference ($p \geq 0.05$) after sterilization, but presented a decrease after two and five months of storage. Lower values indicate browning in sample, as 100 represents a tendency to white and 0 to black.

Table 5. Value L* (luminosity) and ΔE^* (color difference) of bamboo shoot paste, shoot after preprocessing (control) added of ingredients before (A) and after sterilization (T0) at 121 °C for 15 min and after two (T2) and five (T5) months of storage.

Samples	L*	ΔE^*		
Control	75.75 ^a	-	-	-
A	71.07 ^b	4.79 ¹	-	-
T0	71.10 ^b	5.70	4.21 ²	-
T2	69.36 ^c	7.05	4.23	1.78 ³
T5	68.96 ^c	7.95	5.42	2.35

Means followed by the same letter, in the line, differ statically ($p < 0.05$) by Tukey test.

¹ ΔE^* comparing with control

² ΔE^* comparing with sample A

³ ΔE^* comparing with sample T2

Source: Authors.

Difference of color showed higher variation, when comparing control to others, presenting 7.95 of difference from T5. However, sterilized paste (T0) presented color difference of 2.35 after five months of storage, a lower value.

Zheng et al. (2013) studied bleaching of bamboo shoots and observed initial L* values of 82.41, decreasing to 62.81 after 15 minutes of processing. Even after five months (T5), sample presented lighter color of 68.96.

Pattern of browning is illustrated in L*. As to a* parameter, it shows an increase, during storage, leaning to 0, what comprehends a tendency to red color, consequence of the possible formation of browning compounds due to caramelization and Maillard reactions, during heat treatment. Parameter b* is positive, although low, which results in a color approximate to yellow and confirms natural paste color when submitted to storage. Therefore, during processing, has a higher tendency of browning after formulation (A), although still presenting small changes after sterilization and reaching stabilization during storage. In experiments with bamboo shoot drying, Bal et al. (2011) noticed initial values of a* (0.86) and b* (21.83), suffering changes to 8.88 and 14.21, respectively. These values comprehend those found in the paste of bamboo shoot, with slight variations.

4. Conclusion

Bamboo shoot was submitted to preprocessing, the formulated paste presented viable characteristics and cyanide was not detected. The stability of acidity and pH value below 4.5, besides sterilization, assured the product's safety during storage, with microorganisms' absence in 5 months of study.

Bamboo shoot paste presented low fat content and kept the presence of soluble and insoluble fibers, besides having proteins incorporated to composition. Paste also presented mineral content close to raw material, with higher sodium amount. Despite this fact, it is still considered low when compared to other vegetable pastes.

Texture characteristics during storage indicate that bamboo shoot paste presents technical viability, as it does not suffer significant changes at different storage temperatures. Changes in color have not shown significant appearance, keeping the yellow light color.

The paste of bamboo shoot was considered a product able for consumption, with properties that enables new possibilities of application and development of other products based on this raw material. In addition, future research works are indicated in order to verify the preference and purchase intention of consumers for this new product obtained from the species *Dendrocalumus asper* and other shoots of edible bamboo species, always considering the need to prove the elimination of the cyanogenic compounds from this raw material.

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