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Preparation And Evaluation Of A Mixed Vegetable Drink Based On Coconut Milk, Amaranth, Quinoa And Acerola

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Abstract:
Allergic substances present in food pose a great risk to an individual's nutrition and health, depriving them of nutrients due to food restrictions. The vegetable drink made with coconut milk, amaranth, quinoa and acerola pulp (BVCAQA) could become a healthy and innovative drink, since the simplicity of the product's composition and the absence of additives allow it to be used as a nutritious, functional and hypoallergenic food. Formulations were made without the addition of acerola pulp (A) and with the addition of acerola pulp (B). The physical-chemical analyses followed the Adolfo Lutz Institute's physical-chemical methods for food analysis and the microbiological analyses followed the Manual of methods for microbiological analysis in food. In order to check whether there were any significant differences, the Analysis of Variance (ANOVA) was applied using the SISVAR program version 5.6. Principal Component Analysis (PCA) was carried out using the PAST software. The vegetable drink based on coconut milk, amaranth, quinoa and acerola pulp was produced naturally, without stabilizers, thickeners or industrial emulsifiers. There was a significant difference ($p<0.05$) between formulations A and B for the physicochemical parameter's soluble solids, pH and humidity. The acerola pulp is acidic and has a high moisture content. Its addition helps to reduce the pH and increase the moisture and soluble solids content of the vegetable drink. Its production could be a feasible technological possibility for small manufacturers. The hygienic and sanitary procedures used in the production of the vegetable drink contributed to its safety and the absence of microbiological contamination. The coconut, amaranth and quinoa drink flavored with acerola pulp could be a viable alternative for people looking for a balanced, nutritious diet or people who are lactose intolerant or allergic to animal milk and soy proteins.

Key Word: *Food allergy; Plant extract; Lactose intolerance; Public health.*

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I. Introduction

Adverse food reactions are undesirable or harmful effects that arise after consuming a food product and can be classified as food intolerance or food allergy [1]. Food allergy and intolerance are diseases that are often confused however, they differ in the response given by the body after ingestion or contact with the food [2] and [3]. Food allergy is defined as an adverse immunological reaction caused by a protein present in the food, which, when ingested, causes inflammatory processes [4]. Intolerance is the inability to digest, metabolize or absorb food or any of its nutrients, caused by the absence of a specific enzyme to process a given nutrient [5]. According to [6] and [3] 10% of children are affected by food allergies, and this illness can be related to urban lifestyles and genetic and environmental factors. In Brazil, 44% of the population has some kind of food intolerance [7]. It is the result of toxic, pharmacological, genetic, metabolic and psychogenic reactions generally caused by fructose, lactose, polymers of fructose and carbohydrates, condiments and food additives [5].

Lactose is a disaccharide present in mammalian milk and its derivatives, hydrolyzed by the enzyme lactase to produce two monosaccharides, glucose and galactose [8]. It plays an important role in providing energy, synthesizing various molecules, promoting the absorption of calcium, magnesium and retaining zinc [9]. Lactose is widely used in the production of various products such as mayonnaise, jam, ice cream and canned food. [10]. Lactose intolerance is the difficulty in digesting or absorbing lactose due to the inability of the enzyme lactase to hydrolyze this disaccharide [11]. The receptivity of milk and its derivatives in organisms with this enzyme deficiency can change depending on the level of intolerance [12]. Non-absorption of lactose is a disorder that occurs at all ages, with primary intolerance being the most common in adults who experience gas, diarrhea, abdominal pain and distension and flatulence as symptoms [13].

Vegetable milks, vegetable drinks or vegetable extracts are innovations developed by the food industry to meet the demands of people who are restricted to animal milk and its derivatives [14]. Plant extracts can be obtained from oleaginous plant matrices such as cereals, pseudo-cereals, legumes and fruits by maceration in an aqueous solution, filtration, homogenization and heat treatment of the plant base, with sensory and nutritional attributes and a composition that is very different from that of animal milk [15]. Extracts from cereals, oilseeds and legumes such as rice, soybeans, almonds and coconut are viable for sale [17].

The addition of fruit pulp to vegetable extract improves product acceptance by providing sensory and nutritional advantages [18] and [19] points out that the use of certain fruits can help to increase the nutritional value of new food products. However, there is a shortage of certain fruits being used as flavorings for dairy drinks [20].

Amaranth is a pseudo-cereal with a considerable amount of protein, high levels of the essential amino acids lysine, tryptophan and the sulfur amino acids methionine and cystine, fiber and unsaturated fats [18]. The consumption of amaranth grains reduces cholesterol levels and corrects blood glucose levels and is recommended for celiac patients [21], [22] and [23]. It has antioxidant and antidepressant activity [24]. It also has water and oil absorption, gel-forming capacity and solubility as functional properties [26]. As for minerals, amaranth is a source of magnesium, zinc and iron [27]. Amaranth grains can be eaten fresh, cooked or as flour. They can be used as a partial or complete substitute for wheat flour in the preparation of bread dough, cereals and snacks, and can also be used in the form of protein concentrates and isolates [28]. The water-soluble extraction of amaranth is a process that requires soaking the grains in water, grinding, filtering and homogenizing [29]. The inclusion of amaranth as a constituent of food products will depend on the functional nature of its proteins, the composition of the products, processing, heat treatment and isolation circumstances [30] and [28].

Quinoa is a monocotyledonous pseudo-cereal of Andean origin that does not belong to the cereals (dicotyledons), but they are similar nutritionally. [31]. It is a grain little consumed by most Brazilians who are unaware of its nutritional advantages. It contains considerable amounts of proteins, vitamins, lipids, essential amino acids, fiber, flavonoids, polyphenols and phytosterols that provide numerous health benefits [32]. Quinoa is also rich in phosphorus and B vitamins and has higher iron and calcium levels than corn, rice, oats and wheat [33]. Quinoa has a high percentage of protein compared to traditional cereals and a high nutritional value [34]. It can be included in the diet of celiac patients, helping with child development and preventing chronic diseases due to the presence of the essential amino acid histamine [27]. Water-soluble quinoa extract must be produced by soaking the grains in water for a long time, then grinding, filtering and homogenizing [29]. Quinoa extract is made up of 5 to 10% quinoa, diluted fiber, vitamins and minerals, low in fat and moderate in protein, calories and carbohydrates [35].

Widely used in food preparation, coconut milk is considered to be a healthy drink that has several advantages that benefit the consumer's health and its nutritional composition [36]. Coconut milk or coconut extract is a vegetable drink made from coconut fat and water, with 3.8% protein and 25.2% saturated fatty acids [37]. It also contains calcium (Ca), iron (Fe), potassium (K), vitamins C and E [38]. Its composition includes the amino acids isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, tyrosine, valine and cystine [39]. [39]. The benefits produced by the use and consumption of coconut extract are a reduction in allergic levels related to its consumption, antioxidant activity, progression of the digestive process and toning of the skin [36]. It contains 33.3% of the calories, 50% of the fat, protein and carbohydrate content of bovine milk [35], making it an excellent option for those who want to reduce their carbohydrate intake [36]. So it may not be the best option for those with higher protein needs, but it would be suitable for those looking to reduce their carbohydrate intake. Around 90% of the calories in coconut milk come from saturated fat or medium-chain triglycerides [36]. In addition, virgin coconut oil, extracted from coconut milk, has high amounts of saturated and low molecular weight fatty acids [40] and can help reduce total cholesterol levels, triple cholesterol levels and increase serum HDL [41].

In view of the demand for lactose-free and allergy-causing foods, a mixed vegetable drink based on coconut milk, amaranth, quinoa and acerola was developed and evaluated as a nutritional drink option.

II. Material And Methods

The preparation of a vegetable drink based on coconut milk, amaranth, quinoa and acerola is an exploratory, experimental study with quantitative and qualitative results. The extraction of coconut milk, processing of amaranth, quinoa and development of the vegetable drink were carried out in the Industrial Kitchen and Food Laboratory of the Federal Institute of Education, Science and Technology of Tocantins - IFTO: campus Paraíso do Tocantins. The ingredients - acerola pulp, agar gum, fresh coconut, amaranth, quinoa, honey and probiotic milk culture - used in the extraction, preparation and processing of the plant-based drink were purchased from local businesses in the city of Paraíso do Tocantins.

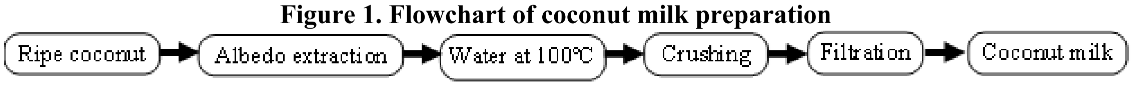
Sanitizing utensils.

All the utensils used will be sanitized in boiling water for 20 minutes. According to [42], using boiling water to sterilize utensils is an accessible and inexpensive procedure.

Preparation of coconut milk.

The preparation of coconut milk followed the methodology adapted from [11], using ripe coconut pulp and boiling water. Flowchart 1 shows the steps involved in preparing coconut milk.

Figure 1. Flowchart of coconut milk preparation



Source: Lima *et al.*, (2018)

Preparation of the pulps.

The acerola-flavored fruit pulps were purchased in 100-gram packages within the expiry date from local shops in the city of Paraíso do Tocantins and transported in thermal boxes at a temperature of 0 °C to the Industrial Kitchen of the IFTO Paraíso do Tocantins campus, where they will remain frozen at -18 °C until they are used in the process of making the vegetable drink. For incorporation into the drink, the acerola pulps were thawed at room temperature 25 °C, homogenized and added to the drink produced.

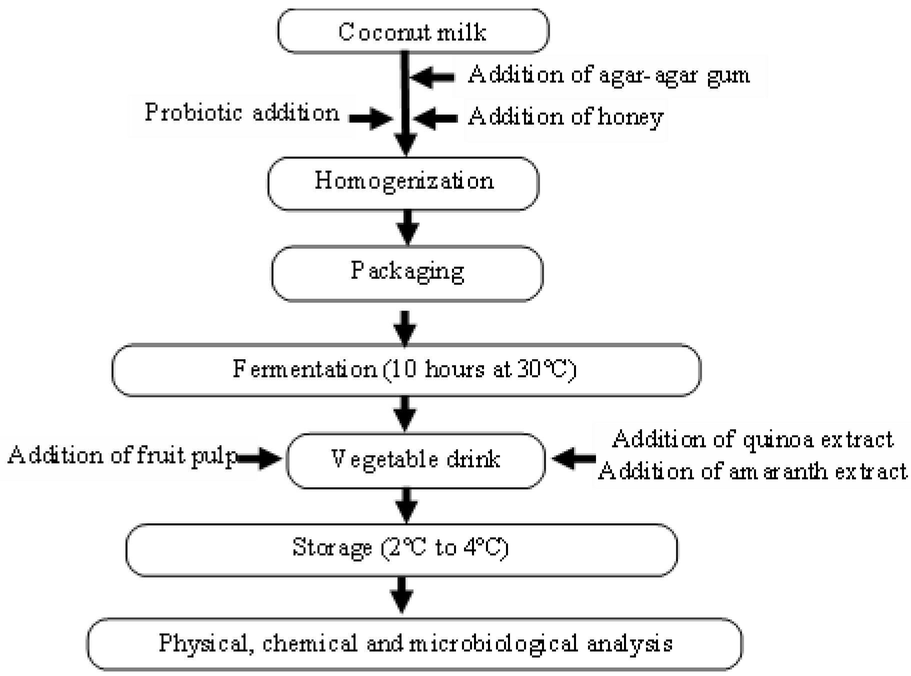
Preparation of the pseudostem extract (amaranth and quinoa).

The extracts were prepared according to the adapted methodology proposed [43]. The grains were boiled for 20 minutes in a 0.25% sodium bicarbonate solution. After cooking, the grains were washed and disintegrated with water at boiling temperature using an industrial disintegrator. The resulting dispersion was filtered and stored under refrigeration at 4 °C in glass jars with lids until it was incorporated into the vegetable drink produced.

Production of the vegetable drink with coconut milk, amaranth, quinoa and regional fruits.

The production of the coconut vegetable drink used the methodology adapted from [44]. Coconut milk, agar-agar gum and the probiotics Lactobacillus acidophilus, Bifidobacterium and Streptococcus thermophilus were used to make the drink. Flowchart 2 shows the production stages for yogurt with plant milk.

Flowchart 2: Stages in the production of vegetable fermented milk with coconut milk, amaranth, quinoa and regional fruits.



Source: Adapted de Brandão *et al.* (2021)

Vegetable drink formulation design

Two (2) formulations were prepared, one with the fermented beverage without the addition of acerola pulp (FSAPA) and the other with the fermented beverage with the addition of acerola pulp (FCAA). Table 1 shows the proportions of the ingredients used for the formulations evaluated in this study. Both were subjected to physico chemical characterization and their microbiological parameters were analyzed.

Table 1. Finished vegetable drink preparations

Ingredients (%)	FSAPA	FCAPA
Amaranth Extract	5,00	5,00
Quinoa extract	5,00	5,00
Agar-agar gum	1,50	1,50
Coconut milk	78,00	78,00
Honey	10,0	10,0
Acerola pulp	--------------	25,00
Probiotics	0,5	0,5

Source: Authors (2024)

The drink was pasteurized at 75 °C for 15 minutes, filled into glass jars with metal lids, previously sterilized in an autoclave at 121 °C for 30 minutes, and kept refrigerated at a temperature of 4 ± 1 °C.

Physical-chemical analysis.

The physical-chemical characteristics were carried out in the Food Analysis Laboratory of the IFTO: Paraíso do Tocantins campus, using the physical-chemical methods for food analysis of the Adolfo Lutz Institute [46], Official Methods of Analysis of the Analytical Chemistry Association [47]. The analysis in triplicate were: Carbohydrates: difference in the total weight of the sample [47]; Ash by the residue incineration method [46]; Total fats by the Soxhlet method [46]; Hydrogen potential (pH): direct reading on a digital potentiometer [46]; Proteins by the Kdjedahl method [46]; Soluble solids: digital refractometer [47] and Moisture by the oven drying method at 105°C for 4 hours [46].

Microbiological analysis.

The determination of molds and yeasts, coliforms at 45 °C and Salmonella sp. were carried out according to the methodology of [48] and the results were compared with the Normative Instruction - IN Nº 161, of July 1, 2022 of the National Health Surveillance Agency - ANVISA [49].

Statistical analysis

In order to check whether there was a significant difference between the results, ANOVA analysis of variance will be applied and Tukey's test will be applied between the means of the response variables at a 5% significance level. All the statistical analyses were carried out using the SISVAR program version 5.6 [50]. Principal Component Analysis (PCA) will assess the interrelationship between the data and the treatments, with the aim of grouping the physicochemical variables according to similarity. It will address the generation, selection and interpretation of the components investigated and determine the variables with the greatest influence on the formation of each component. The PCA analysis was carried out using the PAST software [51].

III. Result And Discussion

The average results of the physical-chemical parameters for total carbohydrates, ash, lipids, hydrogenionic potential (pH), proteins, soluble solids and moisture analyzed in the two formulations, without the addition of acerola pulp (A) and with the addition of acerola pulp (B), are shown in Table 2.

Table 2. Physico-chemical analysis of the vegetable drink formulations.

Physical-chemical parameters	FSAPA	FCAPA
Total carbohydrates (%)	$3.93^{A}\pm0.49$	$4.06^{A}\pm 0.02$
Ash (%)	$0.40^{A}\pm 0.02$	$0.44^{A}\pm 0.01$
Lipids (%)	$5.98^{A}\pm0.02$	$5.95^{A}\pm 0.03$
Hydrogen potential (pH)	$4.40^{A}\pm0.01$	$3.80^{B}\pm 0.06$
Proteins (%)	$1.29^{A}\pm0.03$	$1.39^{A}\pm 0.03$
Soluble solids (%)	$9.14^{A}\pm 0.03$	$9.64^{B}\pm 0.01$
Moisture (%)	$88.07^{A}\pm 0.55$	$89.7^{B}\pm 0.51$

Source: Authors (2024)

There was a significant difference ($p<0.05$) between formulations A and B for the physicochemical parameters Brix, pH and moisture. The acerola pulp is acidic and has a high moisture content. Its addition helps to reduce the pH and increase the moisture and soluble solids content of the vegetable drink. Carrying out research into the preparation and characterization of a fermented drink based on coconut extract with caja pulp, [52] also found significant differences ($p<0.05$) for the physical-chemical parameters pH, soluble solids and humidity.

There is no Brazilian legislation that defines the physical-chemical parameters for evaluating a vegetable drink based on coconut, amaranth, quinoa and acerola. The results of this research were compared with those found in the literature. In the case of a coconut milk fermented yoghurt with fruit, the results of a study carried out by the authors [11] obtained carbohydrate contents ranging from 3.23 to 6.36 (g/100 g), showing a significant difference between them ($p<0.01$) and lower than the values found in this study.

In relation to the ash content, the research carried out showed results lower than the 0.52% found by [43] in the Brazil nut drink, 0.60 and 0.90% found by [53] when characterizing yoghurt using coconut milk, and close to that presented by [11] in the development of a coconut-based drink and a fermented coconut drink with acerola, reaching values of 0.40 to 0.41%.

In view of the percentage of lipids, [54] observed in drinks based on real quinoa and coconut milk in the traditional versions that sample A had 2.29% and sample C had 2.01% lipids, values which were lower than those found in this study. The results found in [11] of 6.83% lipids for fermented coconut milk without added acerola pulp and 5.94% lipids for fermented coconut drinks with added acerola pulp were respectively higher than the FSAPA formulation and close to the FCAPA formulation.

With reference to pH determination, [11] found variations of 3.76 to 4.30 for the hydrogenic potential, these values are found by the authors are close to the hydrogenic potentials found in the FSAPA and FCAPA formulation of the vegetable drink made from coconut milk and amaranth, quinoa. [43] observed a pH of 6.35 in the nut drink and 7.14 in the whole soy drink. [55] obtained 6.78 for a soy extract-based drink and 4.04 for a soy drink flavored with pineapple and coconut. According to [56], pH can interfere with the organoleptic characteristics of the product, as well as visual aspects and viscosity. The pH value of FSAPA is close to that found by [57] in their drink fermented with cajá-mango pulp, with a pH of 4.31.

The protein content found in FSAPA (1.29%) and FCAPA (1.39%) was respectively lower than that found by [11] in coconut milk ferment (1.61%) and coconut milk ferment with added acerola pulp (1.48%). The research carried out showed higher protein content values for FSAPA and FCAPA than those found by [54] and [55].

The soluble solids levels in this study were 9.14% (FSAPA) and 9.64% (FCAPA), which were higher than those found by [54] in a drink based on real quinoa and coconut milk and lower than the soy-based drink flavored with pineapple and coconut found by [55]. Work carried out by [52] showed results for soluble solids equal to 7.80% for the fermented drink without caja pulp and 14.80% for the fermented drink with caja pulp. This value was, respectively, lower than that found in this research for FSAPA and higher than that found for FCAPA. According to [56], the soluble solids of a food indicate the percentage of sugars present, which leads to a higher percentage of sugars with a higher ° Brix result.

The moisture content showed results of 88.07% for FSAPA and 89.7% for FCAPA. These results are close to those found by [11] in coconut milk ferment (87.9%) and coconut milk ferment with added acerola pulp (88.6%). The results for moisture content were higher than those found by [53], who found 80.60% moisture for a coconut-based drink, and [57] when characterizing a drink fermented with caja-mango pulp, with 61.26% moisture.

The results of the microbiological analysis of the mixed vegetable drinks based on coconut milk, amaranth, quinoa and acerola pulp are shown in Table 3.

Table 3. Microbiological analysis of vegetable drinks without the addition (A) and with the addition (B) of acerola pulp.

Formulation	*Escherichia coli* (NMP.mL^{-1})	*Salmonella spp*. (25 mL)
A	< 3	Absence
B	< 3	Absence

Source: Authors (2024)

Due to the absence of Brazilian legislation for vegetable drinks based on coconut milk, amaranth, quinoa and acerola pulp, the results were compared with microbiological parameters of juices and other "in natura" or reconstituted drinks recommended in IN No. 161 /2022 [34]. According to the values shown in table 3, the vegetable drink based on coconut milk, amaranth, quinoa and acerola pulp was suitable for the food safety and consumption conditions required by legislation, not posing any risks to consumer health. Microbiological research on a vegetable drink based on coconut milk and regional fruits carried out by [11] also found a result that complied with the legislation and did not pose any risks to consumer health. The hygienic and sanitary procedures used in the production of the vegetable drink contributed to safety and the absence of microbiological contamination. Formulations of the fermented product based on coconut extract without and with the addition of cajá pulp prepared by [52] showed low counts for total coliforms, molds and yeasts, being suitable for human consumption, showing that the implementation of good practices in the handling of fermented foods was safe.

PCA principal component analysis was applied to better interpret the data and observe similarities or differences between formulations A and B based on their physicochemical characteristics presented in table 2.

In this way, PCA projected the data into two most significant main components with their respective eigenvalues, explained variance and accumulated variance (table 4).

Table 4. Principal components (PC), eigenvalues and percentage of variance explained

PC	Eigenvalue %	% variance explained
1	1.99995	99.998
2	4.63E-02	0.002

Source: Authors (2024)

Based on the results obtained by principal component analysis, the respective eigenvalues and percentages of variance, shown in Table 4, indicate that PC1 was responsible for 99.998% and PC2 for 0.002% of the variations in the data. The sum of principal components I and II adequately presented the variability between the samples [58].

The weights of the principal components CP1 and CP2 for the physical-chemical variables total carbohydrates, ash, lipids, pH, proteins and moisture are shown in Table 5.

Table 5 - Highest values in bold of the components for the variables analyzed

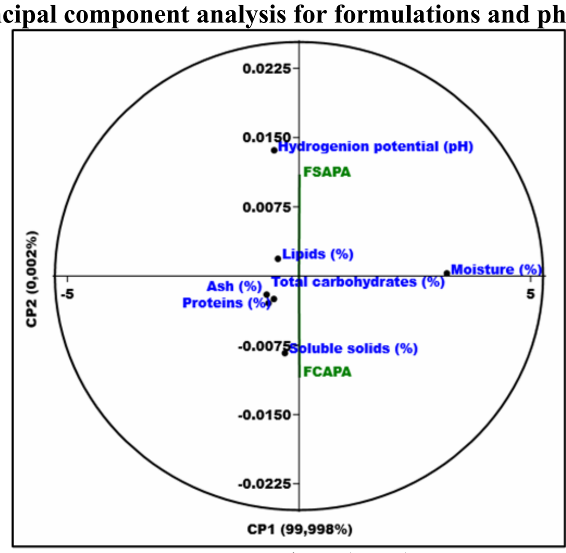
Physical chemical parameters	CP1	CP2
Total carbohydrates (%)	-0.54136	**-0.00248**
Ash (%)	-0.69864	**-0.00200**
Lipids (%)	-0.45465	**0.00186**
pH	-0.53659	**0.01362**
Proteins (%)	-0.65817	**-0.00294**
Soluble Solids (°Brix)	-0.30406	**-0.00834**
Moisture (%)	**3.19350**	0.00029

Source: Authors (2024)

According to the data shown in Table 5, the first principal component (CP1) has a higher weight for the variables total carbohydrates, ash, lipids, pH, proteins and soluble solids and the principal component (CP2) has a higher weight for the variable moisture.

The graph with the main components (CP1) and (CP2), presented in Figure 1, displays their respective weights, allowing the visualization of the main groupings in the set of variables.

Figure 1. Graph of the principal component analysis for formulations and physical-chemical parameters.



Source: Authors (2024)

Figure 1 shows that the FSAPA formulations are related to the main component CP1 and the FCAPA formulations are related to the main component CP2. The FCAPA formulation had a higher carbohydrate, ash, protein, soluble solids and moisture content. The FSAPA formulation had higher values for lipids and hydrogen potential.

IV. Conclusion

The vegetable drink produced with coconut milk, amaranth and acerola had a relevant nutritional value, an excellent lipid composition, a low carbohydrate content, a good source of protein and complied with the food safety and consumption conditions required by legislation, posing no risk to consumer health. It can add positively to the industry of non-alcoholic fermented products that are lactose-free and have functional properties, as well as having adequate physicochemical and microbiological characteristics, making it a consumption option for lactose-intolerant and non-lactose-intolerant individuals looking for a balanced food.

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