INVESTIGATION OF THE PRESENCE OF BIOACTIVE, PHENOLIC AND MINERAL COMPOUNDS IN FOODS ANALOGOUS TO BARU ALMOND-BASED CHEESES FOR THE PUBLIC VEGAN

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In order to broaden the knowledge about the functional potential of the baru almond in new vegetable products, the present study sought to perform a chromatographic and spectrophotometric characterization of the presence of bioactive compounds, profile of phenolic compounds, physicochemical composition and minerals composition, sensorial profile and microbiological characteristics of foods analogous to the cheese based on baru almonds with different types of food condiments. Two vegetable food formulations analogous to baru almond based cheese were developed, differing only by the raw materials used for seasoning (AV1 - with pepperoni and oregano, and AV2 - with onion and garlic). Among the main results, ten types of phenolic compounds were found, with high levels of dietary fiber, lipids, calcium, iron and zinc. In addition, the microbiological and sensory characteristics were satisfactory. Thus, it is understood that it is possible to develop cheese type products using only vegetable ingredients, with base ingredients such as baru almonds.

KEYWORDS: VEGANISM; CERRADO; OIL SEEDS; CHEMICAL MOLECULES; HIGH PERFORMANCE LIQUID CHROMATOGRAPHY.

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1. INTRODUCTION

Since the beginning of the globalized digital era, people from all over the world have had a greater possibility and facility in the search for knowledge; the high incidence of information mainly influences the daily life of the youth of the 21st century, where new cultures, philosophies, techniques and ideologies are expanding, thus gaining new and curious followers. Young people today show a constant concern for the environment, social problems and especially for food, which in turn is increasingly beneficial for those who seeking health (France, 2017).

Among the new food ideologies is veganism, in which adherents advocate the idea that the food consumed should be free of animal ingredients, and consequently without the presence of milk, meat, eggs, gelatins, honey, leather, silk, and wool. The American Dietetic Association and Nutritionists of Canada recognize the benefits of the vegan diet for all individuals and throughout life. However, some specific nutrients may not be available, predisposing to the risk of developing deficiency diseases (Baena, 2015). The food industry, which follows the recent changes in the nutritional landscape, can be an effective vehicle for the development of products that are rich in the missing elements of this diet, thus increasing its product portfolio, acquiring new customers, increasing its profitability and developing products aimed to the needs.

Among the innovations in this segment are the development of analog cheese products, which are similar to traditional cheese in composition, appearance, characteristics and even in its intended use, however, without the use of milk and its composition, allowing its use by vegans. In these products, milk proteins and milk fat are partially or totally replaced by vegetable proteins (e.g. peanut protein, soy protein) and vegetable fats and oils (e.g. partially hydrogenated vegetable fat such as soy, palm, etc.). Cheese analogues can be formulated and produced according to the desired nutritional, functional and storage properties, thus prioritizing the needs of the consumer market (Zoidou et al., 2016; Marapana et al., 2017).

Besides the interest in new and increasingly specific diets, the need to preserve the Brazilian Cerrado, which is the target of human devastation, drives greater efforts to investigate the potential of native species. The Cerrado Biome occurs mainly in the Brazilian Central Plateau and occupies approximately 24% of the Brazilian territory. The Cerrado is recognized as the richest savannah in the world in terms of biodiversity (Instituto Brasileiro de Geografia e Estatistica- Educa, 2021). The baru almond (*Dipteryx alata* Vog.) is an oilseed native to this Biome and stands out due to its high nutrient density, high market value, and being part of a genetically abundant but understudied genetic heritage (Sano et al., 2014).

Previous studies with this almond show the presence of a number of health beneficial chemicals, such as dietary fiber (on average 15%), protein (approximately 30%), minerals (such as calcium, iron, magnesium, potassium and zinc) and bioactive compounds (antioxidants, phenolic compounds, monounsaturated fatty acids and tocopherols) (Sousa et al, 2011; Lemos et al., 2012; Fraguas et al., 2014; Sano et al., 2014; Faria et al., 2015; Siqueira et al., 2015; Lemos et al., 2016).

Analyzing the possibility of an efficient use of the baru kernel through its incorporation in new products for restrictive diets and the desire to identify and prove new functional properties of ready-to-eat products, detailed research is needed on technological alternatives for the development of healthy and biologically safe foods. Among the options, it is expected to be able to use baru almond, which is a nutritionally superior vegetable source to other raw materials commonly used in the development of alternative cheese-like foods (such as starch and cassava) - without the presence of dairy products - enabling consumption by vegans.

Therefore, in order to broaden the knowledge about the functional potential of the baru almond in new vegetable products, the present study sought to perform a chromatographic and spectrophotometric characterization of the presence of bioactive compounds, profile of phenolic compounds, physicochemical composition and mineral composition, the sensorial profile and

microbiological characteristics of foods analogous to the cheese based on baru almonds with different types of food condiments.

2. MATERIAL AND METHODS

2.1 Material

The following raw materials were used in the preparation of the plant foods: Baru almond (local producer from the city of Barra do Garças – MT - 15°53'24"S latitude and 52°15'24"W longitude); Mineral water (Hidrobrás Águas Minerais do Brasil Ltda., Brumadinho - MG, Brazil); Manioc starch (Ingredion Brazil Ingr. Ind. Ltda., Mogi Guaçu - SP, Brazil); Extra virgin coconut oil (Copra Industria Alimentícia Ltda., Maceió - AL, Brazil); Himalayan pink salt (Pure Alimentos, Ijaci - MG, Brazil); Garlic, Onion, Peperoni pepper, Oregano (À Granel Lavras – MG, Brazil), Guar gum, xanthan gum, carrageen (Global food, São Paulo - SP, Brazil) and lactic acid (Corbion Food Ingredients, São Paulo - SP, Brazil). Table 1 describes information on the chemical composition of the ingredients.

TABLE 1. CHEMICAL COMPOSITION OF INGREDIENTS*

	Chemical Composition (%)				
Ingredients	Moisture	Protein	Lipids	Carbohydrate	Fiber
Water	100	0	0	0	0
Hydrated Baru almond	6.63	22.96	31.73	37.13	14.44
Cassava starch	17.8	0.5	0.3	81.1	0.6
Extra virgin coconut oil	0.1	0	70	0	0
Himalayan Pink Salt	0	0	0	0	0
Xanthan gum	0	3	0	2	30
Guar gum	0	3	0	2	30
Carrageenan	0	3	0	2	30
Oregano	9.42	13.46	6.40	48.77	15.65
Lactic acid	0	0	0	0	0
Pepper Pepperoni	10.75	13.46	14.28	49.7	34.8
Garlic powder	6.45	1.02	0.04	4.5	0.6
Onion Powder	5.39	10.41	1.04	79.12	15.2

* Chemical composition according to information on product labels

2.2 Development of formulations

Two cheese-like vegetable food formulations were developed, differing from each other by the use of different food condiments, such as: AV1 (flavored with pepperoni and oregano) and AV2 (flavored with onion and garlic) (Table 2). Both products had the same base formulation (composed of water, baru almond, cassava starch, extra virgin coconut oil, xanthan gums, guar and carrageenan, and lactic acid), differing only by the presence of condiments. A completely randomized design with three replicates and two treatments.

TABLE 2. FORMULATIONS AND INGREDIENTS PRESENT IN VEGETABLE FOODS ANALOGOUS TO BARU ALMOND CHEESE.

	Formulations[(1)] (%)	
Ingredients	AV1	AV2
Water	41.80	41.80
Hydrated Baru almond	36.24	36.24
Cassava starch	16.00	16.00
Extra virgin coconut oil	3.20	3.20
Himalayan Pink Salt	1.00	1.00
Xanthan gum	0.40	0.40
Guar gum	0.40	0.40
Carrageeenan	0.40	0.40
Oregano	0.25	0.00
Lactic acid	0.21	0.21
Pepper Pepperoni	0.10	0.00
Garlic powder	0.00	0.17
Onion Powder	0.00	0.17

[(1)]Formulations: AV1 (Vegetable food analogous to baru almond based cheese flavored with pepperoni and oregano) and AV2 (Vegetable food analogous to baru almond based cheese flavored with onion and garlic).

2.3 Product processing

The baru almonds (obtained raw) were sanitized, peeled manually and submerged in water at room temperature (18 °C) for 12 hours in order to inactivate possible antinutritional factors. Subsequently, the solid ingredients were weighed (MARK® Balance M3102), mixed manually and then solubilized in the liquid ingredients.Stirring, with the intention of homogenizing the mass, was carried out in blender (Philips Walita®, model Daily Collection) at speed 2 for 5 minutes. Afterwards, a brief manual homogenization and another 5 minutes of blending were carried out in the blender. Subsequently, the dough was heated in water bath at 80ºC for 3 minutes with constant manual mixing, obtaining at the end vegan foods. The products were then packed in rigid polypropylene containers previously sterilized and stored at 8°C for 24 hours in controlled temperature chambers (Eletrolab, model EL202) for cooling and complete stabilization of the gel. Then, the analytical determinations described below were performed in quadruplicate.

2.4 Determination of bioactive compounds

The content of total phenolic compounds was evaluated by *Folin Ciocalteu* and Fast Blue BB and antioxidant by free radical sequestration method DPPH• (2,2-diphenyl-1-picrylhydrazyl). The hydroalcoholic extracts were prepared according to the methodology adapted from Milardovic et al. (2006).

Total phenols were determined by the *Folin Ciocalteu* reagent method, using gallic acid as standard for the calibration curve. The absorbance was measured at 765 nm in a spectrophotometer (UV-Visible 50 Probe-Cary) and the results were expressed as mg gallic acid equivalent (GAE) 100 g^{-1} (Waterhouse, 2002).

The total phenolic compounds were also evaluated by the use of Fast Blue BB diazonic salt, using standard gallic acid for the calibration curve. The absorbance was measured at 420 nm in the spectrophotometer (UV-Visible 50 Probe-Cary) and the results were expressed as milligrams of gallic acid equivalent (GAE) per 100 g^{-1} (Palombini et al., 2016).

The antioxidant activity capacity was evaluated by the abduction method DPPH• (2.2-diphenyl-1-picrilhidrazil), read in spectrophotometer (UV-Visible 50 Probe–Cary) at 517 nm and the results were expressed as percentage of free radical (% SRL) (Milardovic et al., 1943).

2.5 Identification and quantification of phenolic compounds by HPLC-DAD / UV-Vis

The extracts for identification of phenolic compounds by chromatographic method were prepared following the methodology described by Ramaiya et al. (2013). For extraction, 2.5 g of sample was used, homogenized in 20 mL of 70% (v/v) HPLC grade methanol for 1 hour in an ultrasonic bath at room temperature (37 °C). The obtained extract was centrifuged at 1500 rpm for 15 minutes and filtered on filter paper with 14µm porosity. For sample injection, the extracts were filtered again using 0.45 µm porous membrane filters. A Shimadzu model high-performance liquid chromatograph (HPLC-DAD/UV-Vis) (Shimadzu Corporation, Kyoto, Japan) equipped with four high-pressure pumps (model LC-20AT) was used to quantify and identify phenolic compounds. Separations were performed using a Shimadzu Shim-pack ODS GVP-C18 (4.6 x 250 mm, 5 mm) connected to a pre-column (Shimadzu-pack ODS GVP-C18, 4.6 x 10 mm, 5µm). Phenolic compounds were detected at 280 nm and were identified by comparison of retention times with standards (catechin, vanillin, quercetin and gallic, chlorogenic, caffeic, ferruic, trans-kinnamic acids, *m*-coumaric, *p*-coumaric and *o*-cumaric). The results were expressed as mg phenolic compound in 100 g^{-1} of sample.

2.6 Physico-chemical composition

The centesimal composition (moisture, ash, lipids, crude protein and soluble and insoluble dietary fiber) was performed according to the methodology described by IAL (2008). The carbohydrate content was calculated by the difference in percentage of moisture, ashes, lipids and proteins. These determinations were calculated on a dry basis. The total caloric value (TCV) was obtained using traditional conversion factors of 4 Kcal/g for carbohydrate and protein, 9 Kcal/g for lipids (Brasil, 2003).

The water activity (Aw) of the developed products was determined by reading in Aqualab - CX-2 - Decagon digital hygrometer at 25 ºC. The pH was measured by the electrometric method using a TECNAL pH digital hygrometer (Tec 3MP). Total soluble solids (TSS) were obtained by direct reading in a refractometer and the values expressed in °Brix. The total titratable acidity (TTA) was determined by titration with 0.1 N NaOH and was expressed as % oleic acid (Instituto Adolfo Lutz, 2008).

2.7 Mineral composition

The mineral content was determined by the method of Sarruge; Haag (1974) and digestion with perchloric nitric acid at 50 °C was used for 10 to 15 minutes and at 100 °C until digestion of all the material. The determination was then made in an atomic absorption spectrophotometer (Perkim Elmer, 3110) reading at 248.3 nm. Calcium, iron and zinc levels were quantified. The results were expressed as mg.$100g^{-1}$ on a dry basis.

2.8 Microbiological analyzes

Analysis of total count of psychrophilic bacteria was performed by thedepth-coating method according to the American Public Health Association methodology (APHA, 2001). Standard agar culture medium was used for the count with incubation at 7 °C for 10 days in dilutions of 10^{-1}, 10^{-2} and 10^{-3}. The results were expressed in the presence or absence of UFC/g (Colony Training Unit).

The analysis of total and thermotolerant coliforms was performed according to Brazil (2003). Positive, gas-forming tubes were seeded in tubes containing *Escherichia coli* (EC), kept in a water bath at 44.5 °C for 24 to 48 hours to verify gas formation. The MLN (Most Likely Number) of fecal coliforms per gram of sample was calculated using the number of confirmed positive tubes.

2.9 Sensory analysis

For this test, the Ethics Committee of the Federal University of Lavras under number 1,716,605 approved the present study. The sensory analysis was performed with 400 providers, 200 daily and 200 vegetarian / vegan. The tasters were asked to rate the samples for acceptance of the flavor, appearance, texture, and impression attributes using the new structured point of the hedonic school, where 1 refers to extremely disliked and 9 refers to extremely liked. In addition, the tasters were also asked to indicate their intention to purchase the evaluated samples, for which they used the 5-point purchase intention scale, where 1 refers certainly not to buy and 5 refers certainly to buy. After receiving the evaluation forms duly completed by the tasters, we proceeded to content analysis for the interpretation and categorization of the data.

3. RESULTS AND DISCUSSION

3.1 Bioactive compounds

The results of the determinations of the presence of total phenolic compounds (by *Folin Ciocalteu* and Fast Blue BB methods) and of the antioxidant activity by the DPPH• free radical sequestration method of the baru cheese almond-based foods are described in Table 3. In reference to the averages obtained in the determination of total phenolic compounds by the *Folin Ciocalteu* method, the existence of these substances in the elaborated products is proven. It is detected that both formulations presented similar averages, demonstrating that the condiments used can also contribute in the presence of phenolic substances.

TABLE 3. MEAN VALUES OF TOTAL PHENOLIC COMPOUNDS (MEASURED BY *FOLIN CIOCALTEU* AND FAST BLUE BB METHODS) AND DPPH• OF PLANT FOODS ANALOGOUS TO BARU ALMOND CHEESE[(1)].

Analytical determinations	Formulations[(2)]	
	AV1	AV2
Total Phenolic Compounds GAE[(3)] - *Folin Ciocalteu* (mg.100g^{-1})	6.46±0.02	6.46±0.01
Total Phenolic Compounds GAE[(3)] - Fast Blue BB (mg.100g^{-1})	5.18±0.10	2.25±0.96
DPPH•[(4)] (% SRL)	29.14±0.90	10.42±0.25

[(1)]Mean ± standard deviation; [(2)]Formulations: AV1 (Vegetable food analogous to baru almond based flavored with pepperoni and oregano) and AV2 (Vegetable food analogous to baru almond based cheese flavored with onions and garlic); [(3)]Total Phenolic Compounds, GAE: Gallic Acid Equivalent; [(4)]SRL: Free radical sequestration.

On the other hand, a reduction in the presence of these elements was observed when evaluated by the Fast Blue BB method, demonstrating the difference between the two processes. This evidence is attributed to the fact that this procedure is specific and unique in the quantification of phenols, since the reagents used are not complexed with other substances, such as proteins,

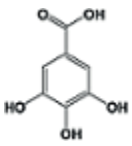
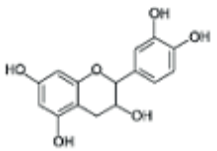
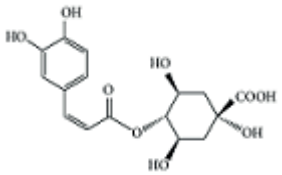
sugars and other reducing compounds, such as ascorbic acid (as in the *Folin Ciocalteu* method) (Campidelli et al., 2020). Therefore, it is verified that this method presents higher precision for the determination of these substances. It is also detected that formulation AV1 presented the highest averages, indicating that pepper and oregano may contribute more effectively to the presence of phenols (when this method is used).

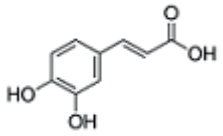
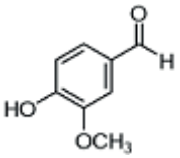
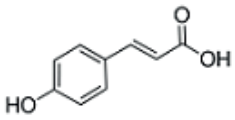
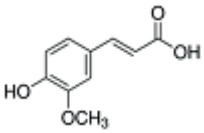
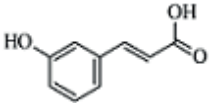
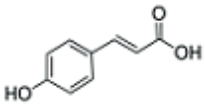
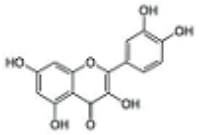
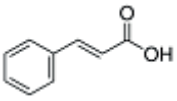
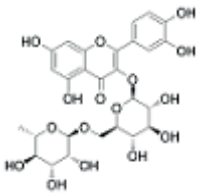
Regarding the average DPPH• levels of the developed products, AV1 showed a higher percentage of free radical sequestration reaching 29.14 % activity, whereas AV2 presented 10.42 % antioxidant activity. According to the classification established by Melo et al. (2008), DPPH radical scavenging capacity is considered strong when it reaches percentages above 70 %, moderate when it reaches percentages between 70 and 50 % and weak when it reaches values below 50 %. Thus, it can be considered that the developed vegan foods showed a weak ability to scavenge free radicals. This can be explained by the fact that these substances are thermally sensitive and since one of the steps in the manufacture of the products is massbaking, the heat may have effectively contributed to the reduction of these substances. Despite the result found, it can also be said that the products have antioxidant substances in large quantities. The above data contribute unprecedented results for the quantification of bioactive compounds in vegetal foods analogous to cheese, being able to grant functional properties to the developed products.

3.2 Identification of individual phenolic compounds by HPLC-DAD / UV-Vis

Ten phenolic compounds were detected in plant foods analogous to baru almond-based cheese, including flavonoids (catechin) and non-flavonoids (gallic acid, vanillin, *p*-coumaric acid, ferulic acid and trans-cinnamic acid). The results associated with the identification and quantification of these molecules are shown in Table 4.

TABLE 4. IDENTIFICATION AND QUANTIFICATION VIA HPLC-DAD/UV-VIS OF PHENOLIC COMPOUNDS PRESENT IN VEGETABLE FOODS ANALOGOUS TO BARU ALMOND CHEESE(1).

		Formulations (2) (mg 100g^{-1})	
Phenolic Compound	Chemical Structure	AV1	AV2
Gallic Acid		81.43±0.69	85.80±1.16
Catechin		1.94±0.52	4.05±0.19
Chlorogenic Acid		5.08±0.52	4.52±1.40

Caffeic Acid		0.21±0.62	0.41±0.87
Vanillin		0.89±1.17	0.36±1.09
p-coumaric		0.06±0.01	0.04±0.23
Ferrulic Acid		0.11±0.23	0.06±0.20
m-coumaric		-	-
o-coumaric		-	-
Quercetin		7.99±0.40	6.72±0.09
Trans-Cinnamic Acid		1.31±0.25	1.48±0.19
Rutin		34.26±0.27	10.58±1.44

(1)Mean ± standard deviation; (2)Formulations: AV1 (Vegetable food analogous to baru almond based flavored with pepperoni and oregano) and AV2 (Vegetable food analogous to baru almond based cheese flavored with onions and garlic); - :Not identified.

Among the phenols identified by high-performance liquid chromatography, gallic acid, rutin and quercetin were the main phenols present in both formulations. A higher concentration of phenols was observed in AV1 and this can be explained by the presence of pepper and oregano. However, the main culprit for the high presence of these substances, in both formulations, was the baru kernel. This, in turn, is an oleaginous source of phenolic substances and according to Lemos et al. (2012) 100 grams of this kernel (raw and skinned) has 224.0, 87.2 and 45.4 mg.100g^{-1} respectively of gallic acid, catechin and ferulic acid. It is emphasized that the high presence of these substances in foods is desired because they are able to provide health benefits due to the wide spectrum of medicinal properties (Ozcan et al., 2014) they present and it is verified that plant foods analogous to baru almond cheese can be considered foods sources of phenolic compounds. These results may contribute unprecedented data on the development of cheese analogues.

3.3 Physico-chemical composition

Analyzes were performed to determine the centesimal composition of the two formulations in terms of moisture, fat, proteins, ash, carbohydrates, dietary fiber (insoluble and soluble) and total caloric value (TCV). Table 5 shows the results of the centesimal composition of the vegetable foods analogous to the baru almond-based cheese.

TABLE 5. CENTESIMAL COMPOSITION OF VEGETABLE FOODS ANALOGOUS TO BARU ALMOND BASED CHEESE[1].

Analytical determinations	Formulations[2]	
	AV1	AV2
Moisture (g.100g^{-1})	60.60±0.05	62.40±0.05
Lipids (g.100g^{-1})	10.90±0.03	8.90±0.08
Proteins (g.100g^{-1})	5.50±0.10	5.00±0.03
Carbohydrates[3] (g.100g^{-1})	18.90±0.13	19.00±0.06
Ashes (g.100g^{-1})	3.40±0.01	4.00±0.02
Insoluble fiber (g.100g^{-1})	15.27±0.09	17.83±0.15
Soluble fiber (g.100g^{-1})	5.17±0.20	6.57±0.01
TCV[4] (Kcal.100g^{-1})	183.00±0.70	177.00±0.34

[1]Mean ± Standard Deviation; [2]Formulations: AV1 (Vegetable food analogous to baru almond based flavored with pepperoni and oregano) and AV2 (Vegetable food analogous to baru almond based cheese flavored with onions and garlic); [3]Calculated from the difference to 100 of the sum of ash, lipids, protein and moisture; [4]Values determined using conversion factors determined in RDC nº. 40 (Brazil, 2001).

It was verified that the moisture had respective levels of 60.6 and 62.4 g.100g^{-1} for AV1 and AV2. This measurement is important because it reflects the solids content of the product, interfering with the stability of chemical, biochemical and microbiological reactions and the texture of the food. Zoidou et al. (2016) developed a cheese analog using olive oil and thyme and found 67.34 g.100g^{-1} of moisture in their product, a result higher than that found in this work. Whereas Santos et al. (2015), who developed cream cheese analogs based on aqueous soy extract, obtained 52.95 to 65.00 g.100g^{-1} of moisture, with the result of the present research being within the average range found by the authors.

As for the lipid content, it was detected that in the vegetable food analogous to the cheese based on baru almond flavored with pepper and oregano (AV1) the content found was higher than the one flavored with onion and garlic (AV2). When comparing the lipid results of this research with those obtained by Marapana et al. (2017), it was found that the cheese analog obtained by replacing the milk fat with vegetable fat (which has 26.30 g.100g.$^{-1}$ of lipids) shows an increase of 141.3 and 195.5% of the respective lipid value of AV1 and AV2. In foods with high lipid intake, a caution is recommended for daily consumption, since many of these products can be sources of saturated fats and which, according to Santos et al. (2013), has been shown to be associated with an increased risk of heart and arterial disease.

Regarding the protein content of the developed products, they represent approximately 10% of the Recommended Daily Intake (RDI), since it is 50 g.100g^{-1} for adult individuals (Brazil, 2005). When compared to the results of this research with tofu, which is a product made from soybean raw material and is the most widespread product as a vegetable substitute for cheese (also considered analogous to cheese), the levels found here AV1 and AV2 are respectively 16 and

24 % lower because it presents 6.6 g.100g^{-1} of protein. Therefore, it would be feasible to enhance the protein delivery by adding other amino acids sources, such as peas and/or soy protein isolates. Despite the reduction of tofu, the protein values of the developed products have an advantage over those obtained by Santos; Fritzen (2015), who obtained 3.34 g of soybean-based curd extract based on 65 % partially hydrogenated fat extract. 100 g^{-1} of protein and is 39.3 and 33.2 % lower than AV1 and AV2 respectively. The consumption of protein sources is justified by the main functions of these compounds in the human body, such as the defense of the body through the formation of antibodies, transport of substances through the blood, blood clotting, formation of hormones and muscle contraction (Silva et al., 2012). It is also worth mentioning that protein intake represents a significant nutritional deficiency among vegan consumers.

In relation to the presence of carbohydrates, 18.9 and 19.0 g.100g^{-1} of carbohydrates were quantified in AV1 and AV2, respectively, and due to the presence of natural sugars, high levels of these nutrients become a viable option among processed products. In addition, the RDI has been established at 300 g per day (Brazil, 2005), so the consumption of 100 g of vegetable food analogous to the baru almond based cheese may represent 6.3% of this recommendation. Carbohydrates are the main source of calories in the diet and when ingested in adequate and sufficient amounts , they serve as an immediate source of energy, thus saving energy function proteins. It provides energy particularly to the brain, which is the only organ dependent on the nutrient (Melzer, 2011). Marapana et al. (2017) in various formulations of analogues cheeses made with palm oil and maize, obtained results between 22.30 and 28.39 g.100.g^{-1} of carbohydrates in their products, all higher than those developed here.

For ash, values of 3.4 and 4.0 g.100g^{-1} were found in AV1 and AV2, respectively. The ash content refers to the fixed mineral residue that can infer the presence of minerals in the developed products. As the vegan public is generally deficient in mineral content, consuming foods with high levels of ash may become a suitable option in nutritional terms. Zoidou et al. (2016), found lower results for ash content (0.81 g.100g^{-1}) indicating that the products developed in this investigation may be expressive sources of fixed mineral residue (which infer the presence of minerals).

The total dietary fiber contents (soluble and insoluble fiber) found in the formulated foods was 20.44 and 24.4 g.100g^{-1} for AV1 and AV2, respectively. According to the Brazilian Resolution, the RDI for fiber consumption is 30 g per day (Brazil, 2005), so the consumption of 100 g of vegan foods based on baru almonds correspond to 68.13 and 81.33 % of this recommendation, respectively. In addition, for a food to be considered high in fiber, it must contain at least 6 g of fiber per food serving (Brazil, 1998). Considering that the portion of the processed products is 30 g, both are covered by this attribute. The high fiber content comes from the starch of the baru and cassava, which have, respectively 14,44 g.100g^{-1} (Campidelli et al., 2019) and 0.7 g.100g^{-1} (TACO, 2011). When compared to vegan products available in the market, it is possible to demonstrate a high presence of fiber by the developed products, since AV1 has 100, 59.4 and 96.1% and AV2 has 100, 66 and 96.7% superiority in the presence of fiber available in C1, C2 and tofu. According to these results, the daily consumption of the foods developed here should be increased, since fibers are important agents that positively influence the intestinal flora modulating the microbiota preventing the onset of diseases.

Regarding the caloric values found, AV1 and AV2 have 183 and 177 Kcal.100g^{-1} respectively. These values refer to the contents of carbohydrate, lipid and protein . When comparing these results with commercial vegan products (C1 and C2), which have respectively 280 and 253.3 Kcal.100g.$^{-1}$, it is detected that the developed ones have a reduction of these parameters, thus allowing a greater consumption by those who wish to maintain the body weight.

The results for Aw, pH, TSS and TTA of the baru almond based vegetable foods are described in Table 6.

TABLE 6. VALUES OF AW (WATER ACTIVITY), PH, TSS (TOTAL SOLUBLE SOLIDS) AND TITRATABLE TOTAL ACIDITY (TTA) OF THE VEGETAL FOODS ANALOGOUS TO THE BARU ALMOND CHEESE[1].

Formulations[2]	Aw	pH	TSS[3]	TTA[4]
AV1	0.97±0.09	5.63±0.01	6.00±0.07	0.58±0.01
AV2	0.97±0.10	5.62±0.02	7.00±0.05	0.58±0.01

[1]Mean ± Standard Deviation; [2]Formulations: AV1 (Vegetable food analogous to baru almond based flavored with pepperoni and oregano) and AV2 (Vegetable food analogous to baru almond based cheese flavored with onions and garlic); [3]Expressed in ºBrix; [4]Expressed in% oleic acid.

The water activity (Aw) values found in the developed products were high, but compatible with the formulation of the products. It was found that the type of seasoning does not cause changes in this parameter. Free water is responsible in most cases for the deterioration of foods, so the determination of Aw is of utmost importance for their preservation and to establish the ideal packaging for the product. Santos; Fritzen (2015), in developing acream cheese analog based on aqueous soy extract, also found similar results for Aw (0.98) of its products.

With regard to the pH, it was considered mildly acidic in both formulations, moreover, it was detected that the condiments contribute in a similar way to the acidity of the product. This chemical characteristic, combined with the presence of water, proteins, lipids and mineral salts, makes the product susceptible to microbial development, requiring care during processing and storage in order to ensure the sensorial and microbiological quality of the products. Marapana et al. (2017) in their studies found in their cheese analogues pH values between 5.87 and 6.31, values higher than those found in AV1 and AV2.

As for the total soluble solid parameters, expressed in °Brix and total sugars, which represent the water-soluble compounds, these were considered low. It was shown that the addition of different seasonings can contribute to the increase and reduction of this value, being onion and garlic responsible for increasing the sweetness attributes of the products developed.

The titratable acidity of the plant foods analogous to the baru almond cheese obtained similar means, indicating that the type of condiment does not influence this parameter. According to the authors Chitarra; Chitarra (2005), the acidity of a food is given by the presence of organic acids that serve as substrates for respiration and the variation of this parameter can influence the quality characteristics. Moreover, it is important to know the acidity of a food, since it is related to several characteristics of the final product, being applied in analyzes of deterioration and stability of food (Anvisa, 2018). Lower results than those mentioned in this work were obtained by Fasoyiro (2014), when analyzing tofu produced with soy coagulated with different concentrations of the calyx of dried Roselle flowers, with values ranging from 0.16 % to 0.42 %. The same author reports that the acidity values of tofu are dependent on the coagulant used.

3.4 Mineral composition

The determination of the mineral composition for calcium, iron and zinc present in the vegetal foods similar to the baru almond cheese, as well as the RDI of the minerals are shown in Table 7.

TABLE 7. MINERAL CONTENT OF THE VEGETABLE FOODS ANALOGOUS TO BARU ALMOND CHEESE[1].

	Minerals (mg.100g^{-1})		
Formulations [2]	Calcium	Iron	Zinc
AV1	100.00±0.01	4.40±0.07	2.10±0.01
AV2	101.00±0.02	4.80±0.05	2.10±0.01
RDI[3] (mg.100g^{-1})	1000	14	7

[1]Mean ± Standard Deviation; [2]Formulations: AV1 (Vegetable food analogous to baru almond based flavored with pepperoni and oregano) and AV2 (Vegetable food analogous to baru almond based cheese flavored with onions and garlic); [3]RDI: Recommended Daily Intake.

It can be seen that the mineral present in the greatest quantity was calcium, and these values supplement 10 % of the RDI. This is of great importance since the only source of calcium available to the human body is from the diet. The benefits of calcium supplementation may be limited when this mineral is in pill form and an alternative approach would be to add calcium to a food product. In addition, the fact that this public has dietary restriction regarding the consumption of dairy products and derivatives, may contribute negatively to the presence of this mineral in the body of these individuals. The results obtained are similar to those found by Zoidou et al. (2016), who detected 90.04 mg.100g^{-1} of calcium in the analogue cheese developed.

The iron values of the elaborated products were also high and provided 31 and 34 % of RDI for AVI and AV2, respectively. Onion and garlic contributed to an increased presence of this mineral, however, the formulations are expressive sources of this mineral. Probably, the high iron content comes mainly from the baru almond which has significant values (6.5 mg.100g^{-1}) (Campidelli et al., 2019).

The average value found for the zinc mineral was also considered high in both products, supplying 30 % of the RDI. The baru almond is also the source of this mineral, since it has 6,5 mg.100g^{-1} (Fernandes et al., 2010). And it is probably the biggest contributor to its presence in the developed products. Zinc content is relevant to health, since this mineral is efficient in reducing oxidative damage by reducing plasma levels of malondialdehyde and 8-hydroxy-2'-deoxyguanosine, which are important markers in the evaluation of lipid oxidation and oxidative damage to DNA, respectively (Marreiro et al., 2017).

Since minerals cannot be synthesized by the body and the fact that drug capsules do not have high intestinal absorption, food becomes the most effective alternative for supplying this deficiency, especially in relation to audiences who have restrictive diets. Therefore, it can be said that plant foods analogous to baru almond-based cheese can fill some of the nutritional deficiency faced by this public.

3.5 Microbiological analysis

The result of the microbiological analyses of the vegetal foods analogous to the baru almond cheese on the 1st and 7th day of storage are described in Table 8.

TABLE 8. MICROBIOLOGICAL ANALYZES OF TOTAL AND THERMOTOLERANT COLIFORMS AND COUNTING OF PSYCHROPHILIC BACTERIA IN PLANT FOODS SIMILAR TO BARU ALMOND CHEESE.

			Formulations[1]	
			AV1	AV2
Storage Days	1	Total and thermotolerant coliforms	< 3 NMP/g	< 3 NMP/g
		Total count of psychrophilic bacteria	Absent	Absent
	7	Total and thermotolerant coliforms	< 3 NMP/g	< 3 NMP/g
		Total count of psychrophilic bacteria	Absent	Absent

[1]Formulations: AV1 (Vegetable food analogous to baru almond based flavored with pepperoni and oregano) and AV2 (Vegetable food analogous to baru almond based cheese flavored with onion and garlic).

Microbiological tests were carried out to verify the presence of pathogenic microorganisms, that is, causing diseases and food poisoning. According to the Resolution RDC nº. 12 of January 2001 of the Agência Nacional de Vigilância Sanitária (Brazil, 2001), which supervises and determines microbiological and sanitary standards for almond-based vegetable products with the addition of condiments, the values for coliforms at 45 °C, must be lower than 10 NMP/g. Regarding the total count of psychrophilic bacteria, there is no standard count for this class of products. Thus, the microbiological results for the vegetable foods analogous to the baru almond cheese, between the 1st and the 7th day of storage, for total and thermotolerant coliforms are within the established standards and for the total count of psychrophilic bacteria they are absent. Microbiological stability is one of the main indicators of the sanitary conditions of food, and the samples examined were in satisfactory conditions and suitable for commercialization. Moreover, the low count of microorganism in the products demonstrate that the hygiene, processing and conservation techniques were adequate. Lower results were found by Santos; Fritzen (2015), who detected a presence of lessr than 1 NMP/g for Coliforms at 45 °C after the product processing.

3.6 Sensory Evaluation

Consumers were asked to taste two samples of the developed products and to respond to a questionnaire that containing an acceptance test regarding taste, appearance, texture and overall impression and purchase intention (after experimentation) (Table 9).

TABLE 9. MEAN AND STANDARD DEVIATION OF THE SENSORY ACCEPTANCE SCORES OF THE DEVELOPED PRODUCTS IN RELATION TO THE SENSORIAL ATTRIBUTES, FOR EACH CONSUMER GROUP.

	Omnivores				Vegetarian/vegan			
Formulations[1]	Appearance	Flavor	Texture	Overall impression	Appearance	Flavor	Texture	Overall impression
AV1	5.20±1.90	4.90±2.10	5.20±2.00	5.10±2.00	6.40±1.90	6.20±2.10	6.20±2.00	6.40±1.00
AV2	5.00±2.00	5.50±2.20	5.40±2.10	5.50±2.00	6.20±2.00	6.70±2.20	6.10±2.10	6.50±2.00

[1]AV1 (Vegetable food analogous to baru almond based flavored with pepperoni and oregano) and AV2 (Vegetable food analogous to baru almond based cheese flavored with onion and garlic).

Table 9 summarizes the results obtained. There was no significant difference (P> 0.05) between the scores assigned by omnivore or vegetarian /vegan groups for the products added with different seasonings; however, there was a significant difference (P> 0.05) between the scores assigned in relation to the different groups of for processed products. The developed products obtained the highest acceptance mark among the vegetarian/vegan consumer group. Furthermore, the lower scores attributed by vegan consumers regarding the introduction of products without animal ingredients and comparison with the original product (of animal origin) can be related to the sensory attributes.

It is possible to observe in Table 10 the results regarding the purchase intentions of the two consumer groups after consumption of the elaborated products. Note that the purchase intention of both processed products was higher among vegetarian / vegan consumers. The plant food analogous to baru almond cheese most liked by the participants was seasoned with onion and garlic (AV2).

TABLE 10. COMPARISON OF THE PURCHASE INTENTION BETWEEN THE TWO GROUPS OF CONSUMERS (IN%) IN RELATION TO THE SENSORIAL ATTRIBUTES OF THE VEGETAL FOODS ANALOGOUS TO THE CHEESE BASED ON BARU ALMOND.

		Purchase intent scale (%)				
Consumer Group	Formulations[1]	I would not buy with certainty	Probably would not buy	I have doubt if I would buy	I would probably buy	Would buy with certainty
Omnivores	AV1	24.00	16.00	31.00	25.00	4.00
	AV2	16.00	23.00	16.00	37.00	8.00
Vegetarian/ vegan	AV1	5.00	15.00	34.00	44.00	2.00
	AV2	0.00	15.00	22.00	46.00	17.00

[1]AV1 (Vegetable food analogous to baru almond based flavored with pepperoni and oregano) and AV2 (Vegetable food analogous to baru almond based cheese flavored with onions and garlic).

It was observed that AV1 obtained higher values for expectation and purchase intention, in relation to AV2, in the initial stage of the evaluation. However, in the next step, consumers attributed lower purchase intention values to AV1 and many said the product was worse than expected. For AV2, the results were positive. At this point it is possible to infer that the expectation generated by the presentation of the label characterizing the product as “Vegetable cheese” prejudiced the perception of the consumer after trying it, who assimilated the image to that of the original cheese of animal origin and associated its sensorial attributes.

4. CONCLUSIONS

By evaluating the results obtained, ones realizes that it is possible to develop cheese-like products without ingredients of animal origin. The vegetal foods analogous to the baru almond cheese presented 10 types of phenolic compounds, w gallic acid and rutin standing out, in addition, they showed high levels of dietary fiber, lipids, calcium, iron, zinc and adequate microbiological characteristics. However, the vegetable food analogous to baru almond cheese that obtained the highest acceptance, expectation and purchase intention from the participants was seasoned with onion and garlic (AV2). The analyzes allowed the creation of a scenario for the improvement of vegan products with the addition of baru seeds, in order to broaden knowledge about its nutritional and sensory characteristics.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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