INVESTIGATION OF THE PRESENCE OF BIOACTIVE, PHENOLIC AND MINERAL COMPOUNDS IN FOODS ANALOGOUS TO THE CHEESE BASED ON BARU ALMONDS FOR THE PUBLIC VEGAN

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ABSTRACT

In order to broaden the knowledge about the functional potential of baru almond in new vegan 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, of the sensorial profile and microbiological characteristics of foods analogous to the cheese based on baru almonds with different types of food condiments. Two formulations of vegetable food analogous to the 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 fibers, 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.

Key-Words: Veganism; Cerrado; Oilseeds; 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 influences mainly 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. Today's youngster shows constant concern for the environment, with social problems and especially with food, which in turn is increasingly beneficial to those who seek health (França, 2017).

Among the new alimentary ideologies is the veganism, in which the adepts defend the idea that the foods consumed must be exempt of ingredients of animal origin and consequently, without the presence of milk, meat, eggs, gelatines, honey, leather, silk and wool. The American Association of Dietetics 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 development of deficiency diseases (Baena, 2015). The food industry, which tracks 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 at needs.

Among the innovations in this segment are the development of analogue 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, protein and milk fat are partially or totally replaced by vegetable proteins (eg, peanut protein, soy protein) and vegetable fats and oils (eg partially hydrogenated vegetable fat such as soy, palm, etc.). The 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).

In addition to the interest in new and increasingly specific diets, the need for preservation of 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 Central Brazilian 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 oleaginous native of this Biome and stands out due to its high nutrient density, high market value and for being part of a genetically abundant genetic heritage, but little studied (Sano et al., 2014).

Previous studies with this almond show the presence of a number of beneficial health 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; Fragua 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 baru almond through its incorporation into new products for restrictive diets and the desire to identify and prove new functional properties of ready-to-eat products, a 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 the 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 baru almond in new vegan 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, of 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 to prepare the plant food: Baru almond (local producer of the city of Barra do Garças – MT - 15°53’24"S of latitude and 52°15’24"W of 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); Pink salt of the Himalayas (Pure Alimentos, Ijaci - MG, Brazil); Garlic powered, Onion powered, Peperoni pepper, Oregano powered (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*

Ingredients	Chemical Composition (%)				
	Moisture	Protein	Lipids	Carbohydrate	Fiber
Water	100	0	0	0	0
Baru almond moisturized	6.63	22.96	32.71	37.13	14.44
Cassava starch	17.8	0	0.3	81.1	0.6
Extra-virgin coconut oil	0.1	0	99.70	0	0
Pink Himalayan Salt	0	0	0	0	0
Xanthan gum	0	0	0	2	30
Guar gum	0	0	0	2	30
Carragena	0	3	0	2	30
Oregano	9.89	11.06	6.40	48.77	15.65
Lactic acid	0	0	0	0	0
Pepperoni pepper	10.75	13.46	14.28	49.7	34.8
Garlic powder	6.45	1.02	0.04	4.5	0.6
Powder onion	5.39	10.41	1.04	79.12	15.2

* Chemical composition according to information on product labels

2.2 Development of formulations

Two formulations of cheese-like plant food 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 the vegetable foods analogous to the almond cheese of baru.

	Formulations[1] (%)	
Ingredients	AV1	AV2
Water	41.80	41.80
Baru almond moisturized	36.24	36.24
Cassava starch	16.00	16.00
Extra-virgin coconut oil	3.20	3.20
Pink Himalayan Salt	1.00	1.00
Xanthan gum	0.40	0.40
Guar gum	0.40	0.40
Carragena	0.40	0.40
Oregano	0.35	0.00
Lactic acid	0.21	0.21
Pepperoni pepper	0.10	0.00
Garlic powder	0.00	0.17
Powder onion	0.00	0.17

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

2.3 Product processing

The baru (dehydrated) almonds were sanitized, peeled manually and submerged in water at room temperature (18 °C) for 12 hours, in order to inactivate possible antinutritional factors. Soon after, the solid ingredients were weighed (MARK® Balance M3102), mixed manually and then solubilized in the liquid ingredients. The 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 a further 5 minutes of blending were carried out in the blender. Subsequently, the dough was heated in water bath at 80 ºC 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 temperature-controlled chambers (Eletrolab, model EL202) for cooling and complete gel stabilization. Then, the analytical determinations described below were performed in quadruplicate.

2.4 Determination of bioactive compounds

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

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

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

The ability of antioxidant activity was evaluated by the method of kidnapping the DPPH• (2.2-diphenyl-1-picrilhidrazil), read in spectrophotometer (UV-Visible 50 Probe–Cary) the 517 nm and the results were expressed as percentage of the 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 the extraction, 2.5 g of sample were 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 extract obtained was centrifuged at 1500 rpm for 15 minutes and filtered on filter paper with 14µm porosity. For the injection of the samples, the extracts were again filtered using 0.45 µm porous membrane filters. A high-performance liquid chromatograph (HPLC-DAD/UV-Vis) model Shimadzu (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) attached to a pre-column (Shimadzu-pack ODS GVP-C18, 4.6 x 10 mm, 5µm). The phenolic compounds were detected at 280 nm and were identified by comparison of retention times with the standards (catechin, vanillin, quercetin and gallic acids,

chlorogenic, caffeic, ferrulic, trans-cinnamic, *m*-coumaric, *p*-coumaric and *o*-cumaric). The results were expressed as mg of 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 products developed was determined by reading in Aqualab - CX-2 - Decagon digital hygrometer at 25 °C. The pH was measured by the electrometric method using a digital pH meter (LUCA-3L (Tec-3MP). The total soluble solids (TSS) were obtained by direct reading in a refractometer and the values expressed in °Brix. Titratable total 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 the digestion with perchloric acid at 50 °C was used for 10 to 15 minutes and at 100 °C until the digestion of all the material. Next, the determination was made in an atomic absorption spectrophotometer (Perkim Elmer, 3110) with reading at 248.3nm. The levels of calcium, iron and zinc were quantified. The results were expressed as mg.100g^{-1} on a dry basis.

2.8 Microbiological analyzes

The analysis of total count of psychrophilic bacteria was performed by the plating method in depth according to the methodology of the American Public Health Association (APHA, 2001). Standard agar culture medium was used for counting with incubation at 7 °C for 10 days at 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 Brasil (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 the formation of gas. The MLN (Most Likely Number) of fecal coliforms per gram of sample was calculated by the number of confirmed positive tubes.

2.9 Sensory analysis

For the accomplishment of this test the Ethics Committee of the Federal University of Lavras under number 1.716.605 approved the present study. Sensory analysis was performed with 400 providers, 200 daily and 200 vegetarian / vegan. The tasters were asked to evaluate the samples for acceptance of the attributes of taste, appearance, texture and impression using the new point structured hedonic scale, where 1 refers to extremely disliked and 9 refers to extremely liked. In addition, tasters were also asked to indicate the purchase intention of the evaluated samples, for which they used the 5-point purchase intention scale, where 1 refers to certainly not buy and 5 refers to certainly buy. After receiving the assessment forms duly completed by the tasters, we proceeded to the 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 Folin Blue BB methods) and antioxidant activity by the DPPH• free radical sequestration method of the baru almond based cheese plant foods are described in Table 3. In reference to the averages obtained in the determination of total phenolic compounds by the method of *Folin Ciocalteu*, the existence of these substances in the elaborated products is proved. 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 the methods of *Folin Ciocalteu* and Fast Blue BB) 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, it was observed a reduction in the presence of these elements when evaluated by the Fast Blue BB method demonstrating differences 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 do not complex with other substances, such as proteins, sugars and other reducing compounds, such as ascorbic acid (as in method of *Folin Ciocalteu*) (Campidelli et al., 2020). Therefore, it is verified that this method presents greater precision for the determination of these substances. It is also detected that the AV1 formulation presented the highest averages, indicating that pepper and oregano can contribute more effectively to the presence of phenols (when this method is used).

Regarding the mean levels of DPPH• of the products developed, AV1 showed a higher percentage of free radical sequestration reaching 29.14 % of activity, whereas AV2 presented 10.42 % of antioxidant activity. According to the classification established by Melo et al. (2008), the sequestration capacity of the DPPH radical is considered as strong when it reaches percentages above 70 %; considered as moderate, when it reaches percentages between 70 and 50 % and weak, when reaching values below 50 %. In this way, it can be considered that the developed vegan foods exhibited a weak capacity to sequester free radicals. This can be explained by the fact that these substances are thermally sensitive and as one of the steps in the manufacture of the products is the mass cooking, the heat may have contributed effectively to the reduction of these substances. Despite the result found, it can also be said that the products have antioxidant substances in high quantities. The aforementioned data contribute with unprecedented results for the

quantification of bioactive compounds in vegetal foods analogous to the cheese, being able to grant functional properties to the products developed.

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

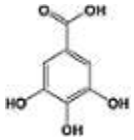
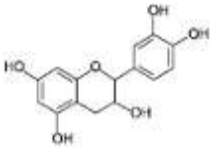
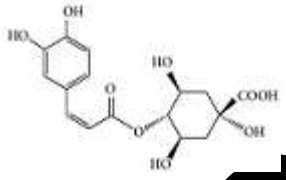
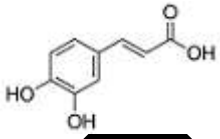
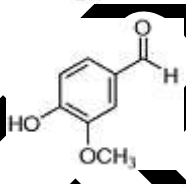
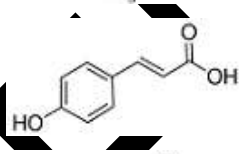
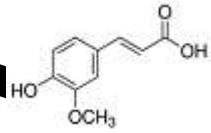
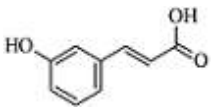
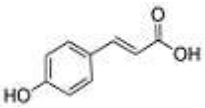
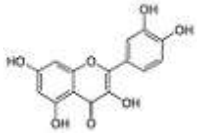
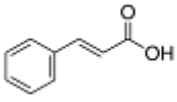
Ten phenolic compounds were detected in plant foods analogous to baru almond based cheese, among which flavonoids (catechin) and non-flavonoids (gallic acid, vanillin, *p*-coumaric acid, ferulic acid and trans-cinnamic acid). The results associated with the identification and quantification of these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

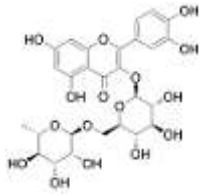
Among phenols identified by high performance liquid chromatography, gallic acid, rutin and quercetin were the major phenolics present in both formulations. It was observed a higher concentration of phenols in AV1 and this can be explained by the presence of pepper and oregano. However, the predominant responsible for the high presence of these substances, in both formulations, was the baru almond. This, in turn, is an oleaginous source of phenolic substances and according to Lemos et al. (2012) 100 grams of this almond (raw and with skin) has 224.0, 7.2 and 5.4 $mg.100g^{-1}$ 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 perform health benefits due to the wide spectrum of medicinal properties (Ozcan et al., 2014) that they present and it is verified that the vegetal foods analogous to the cheese of the baru almond can be considered foods sources of phenolic compounds. These results may contribute with unprecedented data on the development of cheese analogues.

3.3 Physico-chemical composition

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

Table 4. Identification and quantification via HPLC-DAD/UV-Vis of phenolic compounds present in the vegetal foods analogous to the almond cheese of baru[1].

Phenolic Compound	Chemical Structure	Formulations [2] (mg.100g^{-1})	
		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.

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	9.08
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})	±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 by RDC 360 (Brasil, 2003).

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 food texture. Zoidou et al. (2016) developed a cheese analogue using olive oil and thyme and found 67.34 g.100g^{-1} of moisture in their product, a result superior to that found in this work. Already Santos et al. (2015), who developed analogues of cream cheese based on aqueous soy extract, obtained from 52.95 to 65.00 g.100g^{-1} of moisture, 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 vegetal food analogous to the cheese based on baru almond flavored with pepper and oregano (AV1) the contents found were higher than the 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 precaution is recommended for daily consumption, since many of these products can be sources of saturated fats and that 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 products developed, these represent approximately 10% of the Recommended Daily Intake (RDI), since it is 50 g.100g^{-1} for adult individuals (Brasil, 2005). When compared to the results of this research with tofu, which is a product made from vegetable raw material from soybean and is the most widespread product as a vegan substitute for cheese (also considered a cheese analog), the levels found here AV1 and AV2 are respectively 1[illegible] and [illegible] % lower because it presents 6.6 g.100g^{-1} protein. Therefore, it would be feasible to enhance protein delivery by adding other sources of amino acids, such as pea and soy protein isolates. Despite the reduction in tofu, the protein values of the developed products have an advantage over those obtained by Santos; Fritzen (2015), which obtained a 3.34 g of soybean based curd extract based on 65 % partially hydrogenated fat extract. 100 g^{-1} 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 organism, such as the defense of the organism through the formation of antibodies, transport of substances through the blood, blood coagulation, hormone formation and muscular contraction (Silva et al., 2014). 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 because of the presence of natural sugars, high levels of these nutrients become a viable option among the processed products. In addition, RDI was established at 300 g per day (Brasil, 2005), so the consumption of 100 g of vegetable food analogous to baru almond based cheese may represent 6.3% of this recommendation. Carbohydrate is the main source of calories in the diet and when ingested in adequate amounts and sufficient, serves as an immediate energy source, thus saving energy function proteins. It provides energy particularly to the

brain, which is the only organ dependent on nutrient (Melzer, 2011). Marapana et al. (2017) in the various formulations of cheeses analogues made with palm oil and maize, obtained results between 22.30 and 28.39 g.100.g^{-1} of carbohydrates in their products, all superior to 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 make inference 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 results lower than the ash content (0.81 g.100g^{-1}) indicating that the products developed in this research may be expressive sources of fixed mineral residue (which make inference the presence of minerals).

The total dietary fiber contents (soluble and insoluble fibers) found in formulated foods were 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 (Brasil, 2005), so the consumption of 100 g of vegan foods based on baru almonds correspond respectively to 68.13 and 81.33 % of this recommendation. Moreover, for a food to be considered high fiber content, it must contain at least 6 g of fiber per portion of food (Brasil, 1998). Considering that the portion of the processed products is 30 g, both fall under this attribute. The high fiber content comes from the baru and cassava starch, which have respectively 14.4 g.100g^{-1} (Carvalho et al., 2019) and 0.7 g.100g^{-1} (TACO, 2011). When compared to the vegan products available on the market, it is possible to demonstrate a high fiber presence on the part of the developed products, since AV1 has 100, 59.4 and 96.7 % and AV2 has 100, 66 and 96.7 % superiority in the presence of fibers available in C1, C2 and Nfu. According to these results, the daily consumption of the foods developed here should be enhanced, since the fibers are important agents that influence the intestinal flora modulating positively the microbiota preventing the appearance of diseases.

Regarding the caloric values found, AV1 and AV2 respectively have 183 and 177 Kcal.100g^{-1}. These values refer to the carbohydrate, lipid and protein contents. 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 in these parameters, thus allowing a greater consumption by those who wish to maintain the weight body.

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.[illegible]±0.01
AV2	0.97±0.10	5.62±0.02	7.00±0.0[illegible]	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 values of water activity (Aw) found in the products developed were high, but compatible with the formulations of the products. It has been found that the type of condiment does not cause change in this parameter. The free water is responsible in most cases of deterioration of food, so the determination of Aw is of utmost importance for its conservation and to establish the ideal packaging for the product. Santos; Fritzen (2015), when developing analogues of cream cheese based on aqueous soy bean extract, also found similar results for Aw (0.9[illegible] of the products.

As regards 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, protein, 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 pH ranges between 5.87 and 6.31 in their cheese analogues, values higher than those found in AV1 and AV2.

Regarding the parameters of total soluble solids, expressed as °Brix and total sugars, which represent the water-soluble compounds, these were considered low. It was

evidenced that the addition of the different condiments can contribute to the increase and reduction of this value, being the 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 breathing 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 the food (Anvisa, 2018). Results lower than those mentioned in this work were obtained by Fasoyiro (2005) when analyzing tofus produced with soybean coagulated with different concentrations of the dry flowers chalice of Roselle, with values ranging from 0.16 % to 0.41 %. 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 the calcium, iron and zinc contents 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 the almond cheese of baru[(1)].

Formulations [(2)]	Minerals (mg.100g^{-1})		
	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	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 is observed that the mineral present in greater quantity was calcium and these values supplement 10 % of RDI. This fact is of great importance, since the only source of calcium available to the human organism is that which comes from the diet. The benefits of

calcium supplementation may be limited when this mineral is in tablet form and an alternative approach would be to add calcium to a food product. Moreover, the fact that this public has food 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), which detected 90.04 mg.100g^{-1} of calcium in the analogue cheese developed.

The iron values of the elaborated products were also high and they provided 31 and 34 % of RDI for AVI and AV2, respectively. The onion and garlic contributed to an increase in the presence of this mineral, however, the formulations are expressive sources of this mineral. Probably, the high iron content comes mainly from the baru almond that has significant values of it (6.5 mg.100g^{-1}) (Campidelli et al., 2020).

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. The zinc content is relevant for health, since this mineral is efficient in reducing oxidative damage because it reduces the plasma levels of malondialdehyde and 8-hydroxy-2'-deoxyguanosine, which are important markers in the evaluation of lipid oxidation and of the oxidative damage to DNA, respectively (Marreiro et al., 2017).

As minerals cannot be synthesized by the body and the fact that drug capsules do not have high intestinal absorption, feeding becomes the most effective alternative for the supply of this deficiency, especially in relation to publics that have restrictive diets. Therefore, it can be said that vegetable 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 analyzes of the vegetal foods analogous to the baru almond cheese on the 1^{o} and 7^{o} day of storage are described in Table 8.

Microbiological tests were carried out to verify the presence of pathogenic microorganisms that is, causing diseases and food poisoning. According to Resolution RDC n^{o}. 12 of January 2001 of the National Agency of Sanitary Surveillance (Brasil, 2001),

which supervises and determines microbiological and sanitary standards for vegetable products based on almonds with addition of seasonings, the values for coliforms at 45 °C, must be less than 10 NMP/g. As regards the total count of psychrophilic bacteria, it has no counting pattern for this class of products. Thus, the microbiological results for the vegetal foods analogous to the cheese of baru almond, between the 1st and the 7º day of storage, for total and thermotolerant coliforms are within the established standards and for total count of psychrophilic bacteria are absent. Microbiological stability is one of the main indicators of sanitary conditions of food, so the samples examined are in satisfactory conditions and suitable for commercialization. Moreover, the low microorganism counts in the products demonstrate that the hygiene, processing and conservation techniques were adequate. Lower results were found by Santos; Fritzen (2015), who detected presence lower than 1 NMP/g for Coliforms at 45 °C after the product processing.

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	1º	Total and thermotolerant coliforms	< 3 NMP/g	< 3 NMP/g
		Total count of psychrophilic bacteria	Absent	Absent
	7º	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).

3.6 Sensory Evaluation

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

Table 9 summarizes the results obtained. There was no significant difference (P> 0.05) between the scores attributed by groups of omnivores or vegetarian / vegan for the products added with different condiments; however, there was a significant difference (P> 0.05) between the scores attributed in relation to the different groups of for processed products. The developed products obtained the highest marks of acceptance among the group of vegetarian / vegan consumers. Moreover, 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.

Table 9. Mean and standard deviation of the sensory acceptance scores of the products developed in relation to the sensorial attributes, for each group of consumers.

	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).

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

It was observed that AV1 obtained higher values for expectation and intention to buy, in relation to AV2, in the initial stage of the evaluation. However, in the next step, consumers attributed lower purchase-intent values to the AV1 and many said the product was worse than expected. For AV2 the results were positive. To 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 by the consumer after experimenting the same, that assimilated the image to that of the original cheese of animal origin and associated its sensorial attributes.

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	[illegible]00	44.00	2.00
	AV2	0.00	15.00	[illegible].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).

4. CONCLUSIONS

By evaluating the results obtained it was realized that it is possible to develop cheese-like products free from ingredients of animal origin. The vegetal foods analogous to the cheese of baru almond presented/displayed 10 types of phenolic compounds, being outstanding the gallic acid and the rutin, in addition, they showed high index of dietary fibers, lipids, calcium, iron, zinc and adequate characteristics microbiological conditions. However, the vegetable food analogous to the baru almond cheese which obtained the highest acceptance, expectation and purchase intention by the participants was seasoned with onion and garlic (AV2). The analyzes allowed the creation of an improvement scenario for 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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