



ISSN: 2230-9926

Available online at <http://www.journalijdr.com>

IJDR

International Journal of Development Research

Vol. 11, Issue, 10, pp. 51196-51202, October, 2021

<https://doi.org/10.37118/ijdr.22837.10.2021>



RESEARCH ARTICLE

OPEN ACCESS

NUTRITIONAL EVALUATION OF PLANT-BASED MEAT PRODUCTS COMMERCIALIZED IN BRAZIL

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ARTICLE INFO

Article History:

Received 07th August, 2021
Received in revised form
24th September, 2021
Accepted 18th October, 2021
Published online 30th October, 2021

Key Words:

Vegetarian, Processed products,
Imitating meats, Alternative meat,
Plant-based, Nutrition facts.

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ABSTRACT

This study had the objective to evaluate the nutrition profile, explore and identify the main types of plant-based products alternatives to meat, accessible for purchase in retail in Rio de Janeiro city, Brazil and/or in online platform (e-commerce). A transversal study was conducted with a systematic search of ingredient information of foods available in those platforms and in markets, supermarkets and specific stores of different counties in Rio de Janeiro, Brazil. Selected products were classified in six subgroups: hamburger, sausage, Italian sausage, plant-meats and mortadella. Then, analyzed according to the composition in protein, carbohydrates, fibers, fat, sodium and additives. There was a greater availability of products in the hamburger subgroup, followed by plant-meats. Products like mortadella showed the highest mean for calories and carbohydrates, mainly as a result of the added starch. Foods like sausage stood out due to the trans-fat and protein amounts detected in the majority of these products due to the soy addition. Hamburgers stood out by the saturated fat content. Overall, a growing variety of meat alternative products was noticed, but regarding the nutrition composition, most of them show great amounts of sodium, fat and additives. Thus, formulation adjustments in products should be required to reach a proper nutrition composition.

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Citation: Priscila Gotttroy Gois, Barbara Albernaz de Oliveira, Thaiane Ingrid Silva de Oliveira, Laura Buarque Goulart Coutinho, Alessandra da Silva Pereira, Ellen Mayra Menezes Ayres and Elaine Cristina De Souza Lima. "Nutritional evaluation of plant-based meat products commercialized in Brazil", *International Journal of Development Research*, 11, (10), 51196-51202.

INTRODUCTION

Increasing evidences show there is an epidemic of non-communicable chronic diseases that affect developed and developing countries and, that may be related to diet changes and life styles, associated to risk factors such as sedentarism, inappropriate food intake, stress, harmful alcohol consumption and tobacco use (Afshin *et al.*, 2019; Clara Nardini Souto, 2020; OMS, 2013). Diet changes are directly related to food patterns and cultures, that are influenced by different factors and associated mainly to social life, cultural and local economy of the place the person lives in (Martins and Faria, 2018; Monteiro *et al.*, 2013). Therefore, plant-based diets followers are growing in Brazil and worldwide. The prevalence of vegetarians in the world is around 0.2 to 4%. Asia is dominant where 19% of the population is vegetarians. In Africa and the Middle East, they correspond to 16%, followed by 8% in South and Central America, 6% in North America and 4% in Canada.

Europe shows the lower prevalence with a population of 5% of vegetarians, increasing year by year in a stable manner (Melina *et al.*, 2016; Statica, 2016). In Brazil, not alike, the vegetarian diet is raising the number of participants in the last few years. Research carried out by the Brazilian Institute of Public (IBOPE), from 2012 to 2018, have shown results that there was an increase of 75% of the individuals that declare themselves as vegetarians. In the latest year of the survey such percentage represented 14% of the population, and considering data from the Brazilian Institute of Geography and Statistics (IBGE) about the Brazilian population estimative, this number is equivalent to approximately 30 million of individuals (Ibope-Brasil, 2019). Coupled with changes on food patterns and cultures, there is the evolution of the food science technologies and the industries and companies' robotization/ mechanization. The processed products were disseminated all around the world, affecting different cultures and food patterns. Such products, usually, have high fat, sugar and sodium concentrations (Da Costa Louzada *et al.*, 2018; Monteiro *et al.*, 2019, 2013), what contributes to nutritional deficiencies

enhancement, non-communicable chronic diseases and cancer developments (Zanini *et al.*, 2013). In developing countries such as Brazil, that consumption is increasing rapidly (Monteiro *et al.*, 2018). “Vegetarian” and “vegan” food products represent a specific marketing niche in expansion, moving a market that grows 40% per year, boosted by an increment in consumers’ concerns seeking a more sustainable, ethnic and healthy diet, besides those who split attention and want to decrease the consumption of food of animal origin (named as the “flexitarians”) (Carreiro, 2020; Révillion *et al.*, 2020). Global sales of vegan products achieved 2.22 billion dollars in 2015 and, in 2019, this value was 55 billion dollars, with expectations to achieve more than 60 billion dollars in 2023 (Conway, 2019). Google Trends data demonstrated an enhance of two to three times each year for the search on the topic “vegetarianism” compared to the previous year (the annual increase was between 150% to 250%), what may mean a rise in the consumer interest. This behavior should be kept or accelerated for the next few years (Ibope-Brasil, 2019). A plant-based diet plan with low processed foods intake is associated with a reduced cardiovascular disease (Kahleova *et al.*, 2018; Satija and Hu, 2018) and type 2 diabetes (McMacken and Shah, 2017; Satija *et al.*, 2016) risks. It also helps on weight control and diminishes the risk to develop obesity (Harland and Garton, 2016). Other positive implications of the reduced animal food consumption are: factors linked to sustainability and reduction of greenhouse gas emissions (Chai *et al.*, 2019; Springmann *et al.*, 2018). The vegetarian diet is seen mainly as healthy by the majority of the individuals and consequently as a possible way to prevent diseases associated to non-healthy food habits/behavior. However, this diet may become a risk when not planned by a professional from the nutrition field (Silveira *et al.*, 2017).

A big problem of this diet is the inappropriate use of processed products, because among those products there are “processed meats” that, in accordance to the Brazilian law, are defined as “any type of meat that has been transformed to salt, cure, fermentation, smoking or other processes in order to bring flavor out or to improve the shelf-life”, such as it occurs when processing bacon, Italian sausages and sausages, that are considered carcinogenic foods (Alves *et al.*, 2019; Bouvard *et al.*, 2015; Instituto Nacional do Câncer, 2018; Silva *et al.*, 2019). In the market for vegetarians, there is a variety of products destined to this public who are keen to consume ready-to-eat and gluten free foods. But they may also buy refined and artificial meat type foods. Plant protein products that imitate products of animal origin are also available, which supplies in majority the new consumers called “flexitarians”, who do not want to miss the sensory proprieties appreciated as an alternative to reduce the intake of meat (animal origin) (Melina *et al.*, 2016). The availability of food similar to meat, that are substituted by an industrial plant basis is in great ascent in the market (for instance, tofu, textured plant foods, like vegetarian sausages and hamburgers, and plant-based beverages, such as soy “milk”). Most of them are considered processed food that might be convenient to keep the commitment with the vegetarian way of eating cause. However, they can also limit the adequate nutrient intake since the greater part of them have a poor nutrition value and are sugar added or corn syrup with high fructose content, salt and chemical additives (Hoek *et al.*, 2011; Kumar *et al.*, 2017). Thus, due to the increasing number of vegetarians individuals and products for this public, many times with an unsatisfactory nutritional profile, the aim of this study was to evaluate the nutrition facts, explore and identify the main types of plant-based meat products for vegetarians, accessible in the Rio de Janeiro, Brazil’s market and/or in online platforms (e-commerce) in order to assemble the food exclusiveness and data base of the composition of products destined to vegetarians individuals.

MATERIAL AND METHODS

Study design: The study comprised a systemic review of the ingredient’s information in foods available online in the main Brazilian e-commerce platforms, searching in supermarkets, groceries and specific stores in Rio de Janeiro, Brazil.

Products selection and classification criteria: The products’ criteria established to select the ones to be evaluated were: (1) availability of these foods in supermarkets; (2) stores of specialized products in Rio de Janeiro or online; (3) no animal origin ingredients in the product’s composition. Selected products were classified in six subgroups of products: hamburger, sausages, Italian sausage, vegetable “meat”, mortadella and tofu. Mortadella is a processed meat product, typically produced in Brazil, obtained by an emulsion of butchery meat, added or not of lard (fat), with ingredients, packed into natural or synthetic casings, in different shapes/formats, and submitted to an adequate heat treatment (Brasil. Ministério da Agricultura Pecuária e Abastecimento. Secretaria de Defesa Agropecuária, 1988).

Data collection: Labelling information data were collected from July 2019 to August 2020, including information from the ingredients’ list, nutrition facts and seals/labels for vegetarian products. The ingredients’ list evaluation consisted of identifying items that were responsible for the nutrient source: protein (textured soy protein; gluten; soy and/or legume extract/flour; chickpea; egg whey), carbohydrate (starch, cassava starch; wheat flour; other flours; sugar), lipids (vegetable oil; vegetable fat; palm fat), fibers (gum), sodium (salt; glutamate monosodium; soy sauce; others), besides additives (sweeteners, natural and artificial colorants and others). In the nutrition facts analysis, the amount of protein (g), total fat (g) and sodium (mg) of each selected product, as well as the energy value (kcal) per 100 grams of the product.

Data Analysis: The ingredients’ list data were analyzed by frequency (n) and percentages (%). In order to analyze the nutrition composition of the products, the mean per nutrient, micronutrient and energy value for each product class was calculated, and also shown their minimum and maximum content found in the different branded products of the same class. Excel Microsoft software sheets were used to transcribe and analyze data.

RESULTS

According to the selection criteria established, there were 56 vegetarian plant-based food products identified for vegetarians. As shown in Table 1, products were classified in 6 subgroups of products: hamburger (30%, n=17), sausage (11%, n=6), Italian sausage (9%, n=5), vegetable “meat” (27%, n=15), mortadella (7%, n=4) and tofu (16%, n=9). A greater availability of hamburger products was observed, followed by the alternative meats (Table 1). The nutrition facts and the energy value of the 56 food products of different brands consumed by vegetarians as meat replacers were compiled in Table 1. Mortadella products have shown the higher mean for energy value (208.16 Kcal/100g) and for carbohydrate total amounts (26.02 g/100g), whereas sausage products stood out for the trans fat content (0.0003 g/100g) and the Italian sausages demonstrated the highest mean of sodium (915.90 mg/100g) and fiber (7.19 g/100g). The outstanding subgroup for the protein amount was the sausages (16.04 g/100g) and for the total fat content, the tofu (8.20 g/100g); and saturated fat, the hamburgers (2.98 g/100g) (Table 1). The labelling information and nutrition facts identified in the food products evaluated are shown in Table 2. Also, the main ingredients responsible for the protein, carbohydrate, fibers, fat, sodium and additive amounts. Starches are the outstanding ingredient as carbohydrate source of the products. Therefore, 53.6% of the total analyzed products are starch added. Carbohydrate values varied from 2.88 to 26.02g/100g among the different types of products (Table 1). The lowest starch amount was in tofu (22%) and the highest in mortadella (100%) and Italian sausages (100%) (Table 2). A specific brand of mortadella was made of five different types of starch. In those last products (100%) there were the highest amount of carbohydrate (26.02%) with a variation of 22.4 to 32.8%. Only two tofu samples had starch in their ingredient list. Hamburgers (35.3%), 60% of the vegetable “meats” and 66.7% of the Italian sausages had starch, and corn starch was mostly used, probably due to its low price. Regarding the ingredient that provides fiber, 10.7% of all products were formulated with added fiber (Table 2), especially carrageenan,

Table 1. Mean values (minimum and maximum) of the nutrient and energy information of different branded plant-based meat products destined to vegetarian consumers (replacers) (n=56)

Foodproduct	samples (n)	Total energyvalue	Carbohydrate (g)	Protein (g)	Total fat(g)	Saturatedfat (g)	Transfat(g)	Fiber (g)	Sodium (mg)
Hamburger	17	199.67 (114.70 -296.20)	10.70 (4.80 - 38.50)	8.23 (4.0 - 21.60)	6.65 (0 - 22.50)	2.98 (0 - 5.25)	0	4.90 (0.90 - 9.40)	409.07 (0.40 - 861)
Sausage	6	173.08 (108.25-222.86)	9.93 (3.5 - 17.14)	16.04 (11.43 - 20.6)	7.47 (4 - 11.83)	0.89 (0 - 1.43)	0.0003 (0 - 0.002)	4.69 (2.57 - 6.25)	617.13 (358 - 780)
Italiansausage	5	151.77 (136.84 - 172)	7.78 (4.8 - 14)	12.72 (7.02 - 20.6)	7.58 (6.31 - 9.2)	0.77 (0.88 - 1)	0	7.19 (1.58 - 9.4)	915.90 (403.51 - 1132)
Vegetable "meat"	15	137.64 (34.8 - 308.33)	9.0 (0 - 51.67)	11.31 (1.83 - 26)	6.09 (0 - 15)	0.60 (0 - 2.42)	0	4.09 (0 - 7.6)	660.96 (190 - 2070)
Mortadella	4	208.16 (200 - 224)	26.02 (22.4 - 32.8)	12.43 (9.42 - 14.2)	6.32 (5.6 - 7.8)	0.91 (0.78 - 1.2)	0	1.13 (1 - 1.2)	375.35 (293.2 - 620.2)
Tofu	9	111.37 (50 - 173.7)	2.88 (0- 8.53)	8.40 (5 - 18)	8.2 (2.25 - 11.17)	1.29 (0 - 5)	0.0002 (0 - 0.002)	0.08 (0 - 0.76)	201.0 (7.5 - 500)

Table 2. Ingredients responsible for protein, carbohydrate, fibers, fat, sodium and aditives amounts of different branded plant-based meat products destined to vegetarian consumers(replacers) (n=56)

	Ingredients	Hamburger	Sausage	Italian sausage	Vegetable "meat"	Mortadella	Tofu	Total(n)
		n=17	n=6	n=5	n=15	n=4	n=9	56
Proteinproducts	Texturedsoyprotein	59	67	40	80	0	22	50
	Gluten	29	83	40	53	100	0	46
	Soyextract/flour	41	83	40	67	0	89	57
	legume	6	17	60	7	0	0	11
	Chickpea	24	17	0	0	0	0	9
	Eggwhey	6	33	80	7	0	11	16
Products high in carbohydrate	starch	35	67	100	60	100	22	54
	Wheatflour	29	17	0	0	0	0	11
	Other flours*	29	0	0	7	0	0	11
	sugar	12	50	20	13	0	0	14
Fibers	gums	0	17	80	0	0	11	11
Products high in fat	Vegetableoil	41	100	100	60	100	11	57
	Palmfat	18	0	0	7	0	22	11
	Vegetablefat	6	0	0	0	0	0	2
Productshigh in sodium	Sodium	71	100	80	73	100	44	73
	Glutamatemonosodium	0	0	0	0	0	0	0
	Soysauce (shoyo)	18	33	20	27	0	11	20
	others**	6	0	60	7	100	0	16
Additives	sweetners	6	50	80	7	0	22	20
	Other additives	6	17	80	20	100	67	34
	Artificialcolorant	35	50	20	33	100	0	34
	natural colorant	6	0	40	0	0	0	5

*rice flour, oat flakes or flour, quinoa flakes or flour, unknown frying flour, corn flour.**unknownseasonings, sodiungalinate, sodiumpropionate, sodiumbenzoate.

xanthan and locust bean gums. The lowest mean was observed in tofu (0.08 g/100g) and the highest in Italian sausage products (7.19 g/100g). In general, products have soy added to their formulation in order to increase the protein concentration. In 50% of the products there were textured soy protein (TSP) and 57.1% had soy or soy flour or soy extract. The highest mean was seen in sausage products (16.04%) and the lowest mean for hamburgers (8.23%). The greater variation in proteins was also noted in hamburgers and such variation occurs due to TSP use. So that the product with the lowest protein level was produced with fresh peas. That highest protein level in sausages is explained by the TSP addition (66.7%), gluten (83.3%) and soy/soy flour (83.3%). All mortadellas were processed containing gluten. Regarding the Italian sausages, only 40% of them had TSP as ingredient, but 60% had legume and 80% egg whey in its ingredients' list. Mean values for total fat varied from 6.09 to 8.2 g/100g.

The highest amount was seen in tofu and the lowest in the vegetable "meats". However, the hamburgers were the products with the highest content of saturated fat, because 6% of them had vegetable fat in their composition. More than half (57.1%) of all products has vegetable oil in their formulation, especially the soy oil, whereas 10.7% have palm fat (Table 2). Sodium levels had an important variation among the different types of products and within the same subgroup. The highest sodium amount was observed in vegetable "meats" (2070 mg/100g) and the lowest in hamburgers (0.40 mg/100g). The greater variation within the same product was seen in the vegetable "meats" (190 – 2070 mg/100g), and the Italian sausage products had the highest means 915.90 mg/100g (Table 1). These sodium values are resulted from the salt addition (73.2% of the products have salt in their formulation) from the refined, marine or low-sodium salt, besides the soy sauce addition in 19.2% of the products. Other compounds that add sodium such as the sodium caseinate and alginate are evident in 60% of the Italian sausages. In mortadellas, 100% has sodium benzoate in their ingredients' list (Table 2). Some products (19.6%) have sweeteners in their formulation, often seen in sausages (50%) and in the Italian sausages (80%). In relation to colorants and other additives, 33.9% of the products have those substances. All mortadellas, for instance, have some of these chemical compounds. Many products do not have the additive description, especially colorants and aromas, that show only the "natural" or "artificial" information.

DISCUSSION

All assessed products are considered processed foods and their nutrition profile show harmful characteristics to health, with a higher energy density, free sugars, sodium and saturated fat. Increasing evidences demonstrate that processed food consumption are associated to the enhancement of non-communicable diseases risks, of cardiovascular risk factors (such as, dyslipidemias, high blood pressure), adverse effects over health as obesity and metabolic syndrome and poor quality diets (Luiten *et al.*, 2016). The starch is the ingredient that provides the basic nutrient in regard to carbohydrates. According to the Brazilian National Sanitary Surveillance Agency, the starch is a product extracted from the eatable parts of the plant (seeds), being abundant in cereal, roots and tubercules beans. Most of the processed products that has starch carry also important technological proprieties due to this nutrient (Brasil, 2005a; Walter *et al.*, 2005). When available, it impacts on food consistency and texture, for example (Denardin and Silva, 2009). The starch can also be used as a fat replacer in low-calorie foods, and traditionally, as a stabilizer and/or emulsifier in processed foods matrixes (Bello-Pérez La, 2006). Among the starches used, stands out the corn starch due to its low price, therefore, they are used to improve technology proprieties and as a caloric ingredient in food systems, explored as stabilizers, texture agents, water or fat binder (Silva *et al.*, 2008). Regarding the ingredients that confer fiber into products, it was noticed that carrageenan gum, xanthan gum and locust bean gum. The xanthan gum (produced in industries) and locust bean gum are fat replacers, while carrageenan gum (extracted from an Irish seaweed) and locust bean (extracted from carob plant)

have the functional purpose of stabilizers and thickener (Canella-Rawls, 2019). Besides the xanthan gum having a higher cost than the starch and some other hydrocolloids, it has been used due to its unique rheologic proprieties (Li and Nie, 2016). Although we know that it is possible to obtain proteins and aminoacids in a proper way in a balanced vegetarian diet, individuals that adopt such diet there is still a great concern towards the protein daily requirements. Therefore, it is important for consumer to be aware, since there is an association between alternative meat products (hamburgers, etc) with protein source. The replacement of animal protein by vegetable proteins has been driven by the sustainability warranty on food protein sources. The high protein intake among vegetarians can be assigned to a highly traditional intake of vegetable foods sourced in proteins, such as legumes, whole grains, nuts, seeds and milk replacers (Mariotti and Gardner, 2019). The requirements must clearly advise to healthy substitutes (for instance, vegetable-based proteins source, fruit, vegetables and whole grains) by animal origin products, because some replacers may limit the diet quality and mitigate healthy benefits (such as, refined grains and other processed foods) (Parker and Vadiveloo, 2019). In vegetarian products, it is possible to guess that the most important plant input are usually soy, coconut, seeds, bean and nuts, using the prerogative of having eco-friendly sustainable methods and lower prices compared to animal protein sources (González *et al.*, 2015). The food Market for such public is in deep expansion, not only because there are more and more people adherence to the practice, but also a healthy diet is a necessity for a piece of the population that have food constraints. The company is concerned about growing, even more the range of products to attend vegan and vegetarian public (Carreiro, 2020; Ibope-Brasil, 2019).

Among the analyzed products, the soy was the ingredient mostly used to provide proteins. The texturized soy protein stood out as a soy subproduct elaborated from the defatted soy flour by a high temperature process and with the purpose to resemble meats of animal origin (Brasil Anvisa, 2005). Soy proteins can be used as emulsifiers, depending of the pH value and temperature, but similar to other legume proteins (Sharma and Barone, 2019). Another protein ingredient used in vegetarian products is the gluten, that is constituted by the junction of two proteins, the gliadin and glutenin, that can be found in wheat, oat, rye and barley grains (Singh and Whelan, 2011). The gluten (setian) has a texture similar to the meat, what may turn it ideal to vegetarian meals that imitate meat products. The soy protein and the wheat gluten are the dominant ingredients in Alternative Meats (Anwar, Dina; Ghadir, 2019). The tofu is among the products with higher protein content and are well-known as "soy cheese" and indeed they indicate some similarity regarding their composition and appearance compared to a traditional Brazilian cheese named "minas cheese". Humidity correspond to approximately 84% and 8% of proteins, with a caloric value of 76 kcal/100 g, in accordance to the USDA (Anwar and Ghadir, 2019). Tofu is being more and more used, replacing dairy products and also meat products as ingredients in dishes due to its high protein bioavailability and low cost when compared to the animal category version (Dey A., 2017). It is a nutritious meat replacer, that when consumed regularly, may bring health benefits because it acts significantly reducing the total cholesterol, triglycerides and low density lipoprotein (Jubayer *et al.*, 2014).

According to Anwar, Dina; Ghadir (2019), tofu demonstrated to be a good source of essential aminoacids regarding the protein quality with a high content, showing an alternative to meat. Vegetable fat addition to vegetarian products were noticed. The vegetable fat is a product mainly made of glicerids fat acids of vegetable origin. The food industry uses the hydronization in order to produce hydrogenated vegetable fat or to extend oils' due to date. (Silva *et al.*, 2015). In emulsions of embedded products they are featured by the high level of constituents division, and by the emulsifying of the fat, turning it invisible and improving the flavor and the texture of the final product (Guerreiro, 2016). The palm fat that is used in some food products with marketing appeal of healthiness is not considered sustainable. The forest protection and the animal life in the cultivation area are some of the questions that raise, requiring farming practices to be

more appropriate (FIB - Food Ingredients Brasil, 2014; Gesteiro *et al.*, 2019). Nevertheless, the global increase of total fat (animal + vegetal) is a current concern. The sodium level varied a lot among the different types of products and in the same products, being considered high in the vegetarian products analyzed. The exceeded consumption of sodium is a considerable cause of heart diseases, stroke and avoidable renal diseases. There are progressive evidences that suggests that the high sodium consumption enlarges stomach cancer risk, osteoporosis and obesity (Brown *et al.*, 2009; He *et al.*, 2010). An ingredient that is frequently used in products was the soy sauce, that has a sodium amount that varies from 12 to 18% in their composition. The World Health Organization (WHO) limits the daily sodium consumption to 2000 mg, which is equivalent to 5g of salt per day, however, the new guidelines decreased this goal to less than 2 g of salt, since they may cause harm such as hypertension and cardiovascular diseases (Brasil, 2012). Therefore, according to the analyzed results all products assessed are in agreement with the recommendation, as long as not eaten in excess. It is important to evaluate the daily total intake, considering the maximum value of sodium in vegetable products, since they may exceed 2000mg in 100g of product.

The mostly used additive that promotes a great amount of sodium was sodium benzoate, a product that is widely in countries such as Brazil, but in some countries there are restrictions like in France, where they only allow its use in curdled milk, and in Italy and Portugal they are prohibited in drinks (Paredes-Serrano *et al.*, 2016). According to the Brazilian law of the Health Ministry (Brasil, 1997), additive is any ingredient added intentionally to food with the aim of modifying its physical, chemical, biological or sensory characteristics, during its processing, preparation, treatment, packaging, storage, transportation or manipulation, without the purpose of nutrition to improve the shelf-life conditions and to offer safe foods, thus, attend the consumer market expectation (Brasil, 1997). The use of food additives has been exploited. Many of them are used in processed foods in order to improve the sensory characteristics or extend those food shelf-lives (Albuquerque *et al.*, 2012). Among the colorants, the artificial ones, that are usually associated to the food allergies and hyperactivity, especially in children (Schumann *et al.*, 2008). Another additive are the sweeteners, which are substances with a high power to sweeten, when compared to sucrose, used as a replacer of such sugar in diet foods and beverages aiming at calorie value reduction, outstandingly sorbitol and maltodextrin (Cardello *et al.*, 2001).

CONCLUSION

This research shows that there is an ascending variety of vegetarian food products as possible alternatives towards traditional meat products. The majority of the products showed a high amount of sodium and fat, besides soy addition with the purpose to increase protein value. It is important to give attention to labels, especially because exceeding quantities are harmful to human health. That way the precepts of an adequate and healthy vegetarian diet is not being met but generating nutrient deficit. So, the named vegetarian food product is not a synonym of nutritive and healthy.

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