



Functional soy food based on flaxseed and quinoa and enriched with iron and Vitamin B12

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ABSTRACT. A diet rich in food derived from vegetables reduces the risk of developing chronic and degenerative diseases and provides the essential nutrients for human consumption. Besides soybean, other foods of vegetal origin have been studied and incorporated in healthy formulations, such as quinoa and linseed. Current assay comprises a sensorial analysis of a product of vegetable origin, a soy product, based on quinoa and flaxseed, considered to be functional food, for its organoleptic characteristics acceptable by a sample group of 80 individuals. Several tests were conducted to reach an adequate formulation for the product, characterized by 11.1 g of protein content, 9.6 g of dietary fiber and low levels of lipids, since it had only 1.4 g. The resulting product revealed adequate microbiological conditions when subjected to microbiological analysis (coliforms at 45°C; coliforms at 35°C and *Staphylococcus aureus*). According to scores in the sensory analysis, it may be assumed that the product was accepted by the sample group. The favorable results indicate the possibility of consumers adhering to a processed diet rich in food derived from vegetables, with functional properties, to replace animal-derived food which is rich in saturated fats and low in fiber.

Keywords: functional food, dietary fiber, soy.

Alimento funcional de soja à base de quinoa e linhaça enriquecido com ferro e Vitamina B12

RESUMO. Uma dieta rica em vegetais reduz o risco de desenvolvimento de doenças crônicas e degenerativas, proporcionando os nutrientes essenciais para o consumo humano. Junto com a soja, outros alimentos de origem vegetal foram estudadas e incorporadas em formulações saudáveis, como quinoa e linhaça. O objetivo deste estudo foi analisar sensorialmente um produto de soja, à base de quinoa e linhaça, considerado alimento funcional, com características organolépticas aceitáveis para um grupo amostral de 80 pessoas. Vários testes foram realizados a fim de chegar à formulação de um produto adequado, caracterizado, em termos de vista físico-químico, com um teor de proteína de 11,1 g, fibra dietética 9,6 g e baixos níveis de lipídios, uma vez que teve apenas 1,4 g. O produto desenvolvido obteve condições microbiológicas adequadas quando submetidas a análises (coliformes a 45°C; coliformes a 35°C e *Staphylococcus aureus*). De acordo com dados da análise sensorial, pode-se concluir que o produto foi aceito pelos provadores. Os resultados favoráveis indicaram a possibilidade de o consumidor aderir a uma dieta rica em alimentos vegetais, processados e com propriedades funcionais para substituir alimentos de origem animal ricos em gorduras saturadas e pobre em fibras.

Palavras-chave: alimentos funcionais, fibras, soja.

Introduction

Several studies have been conducted to evaluate the relationship between health and food consumption. It is already a consensus that a diet rich in vegetal food, such as fruits, nuts, whole grains and legumes, decreases the risk of many chronic and degenerative diseases (FISBERG, 2004; MANHAN; ESCOTT-STUMP, 2005). Combined with regular physical exercises, a vegetal food-based diet may help adults to maintain the ideal weight. Food programs based on vegetal food may have a significant and

positive impact on aging, cardiovascular diseases and cancer (FRANCISCHI et al., 2010).

Many new products, mainly health-promoting vegetable-derived food are offered daily by the food industry under the label of functional foods. The food industry has great interests in developing new products whose functions go beyond the supply of basic nutrients and the satisfaction of consumers' taste (MARETI et al., 2010).

In fact, the introduction of functional food on the market and the improvement of already existing products have increased during the last decades due

to several factors related to health, lifestyle, level of information and market competitiveness (GRANATO et al., 2010; SIRÓ et al., 2008). The establishment of vegetable-based functional food is a challenging factor and should fulfill consumers' expectations for products with good sensorial and organoleptic characteristics (BATISTA FILHO; RISSIN, 2007), coupled to components that prevent diseases and improve general health.

Fiber-containing diets have been acknowledged for decades due to studies that related fiber consumption with the prevention of various gastro-intestinal diseases, common in Western people used to refined but poor fiber foods (STEELE et al., 2013). Owing to scientific and technologic progress, what was originally applied to diets for the improvement of the human body is currently researched to support scientifically these benefits in the search for functional food (VIZZOTTO et al., 2010).

Soy has been used in many products since its main protein replaces animal protein. The vegetarian consumers' food line has been growing up too, as more people choose that specific type of diet.

Coupled to soybean, other vegetal foods, such as quinoa and linseed, have been analyzed and incorporated in health formulations. Quinoa is a pseudo-cereal, gluten-free, a protein source, rich in lysine, an immunity-modulating amino acid (RIBEIRO et al., 2014). The ω -3 fatty acid in linseed helps child growth and development and reduces the risk factors of cardiovascular diseases, strokes, inflammation and immune disorders (BIGLIARDI; GALATI, 2013).

Based on recent literature and highlighting the formulation of new products based on human nutritional needs and health, current paper establishes and sensorially analyzes a quinoa- and linseed-based soy product, enriched with iron and B12 vitamin.

Material and methods

The product was prepared in June 2014 in the laboratory of the Food Technology Course at the Universidade Federal Tecnológica do Paraná, Ponta Grossa, Paraná State, Brazil. Several tests were performed for its preparation so that the product could be obtained, featuring good flavor, adequate sensory characteristics and differentiated nutritional characteristics.

Texturized soy protein, quinoa, linseed, carrageenan, mineral iron chelate, B12 vitamin

and seasonings (shoyo, onion, oregano and salt) were the ingredients used.

The sample included soy hamburger, previously fried in soy oil at high temperature, as prime material. Product was served with a mini-loaf of bread and lettuce.

Figure 1 presents the hamburger's production flowchart, adapted from UNIFRA, Santa Maria, Rio Grande do Sul State, Brazil.

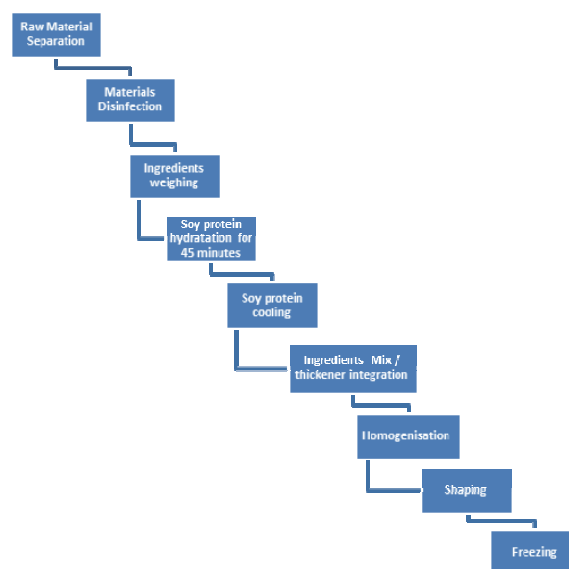


Figure 1. Production flowchart. Source: authors, 2014.

The proteins were determined by the microkjedahl method (IAL, 1985); food fiber by AOAC 991,43 method. (AOAC, 1995); total fats by the Soxlet method (IAL, 1985).

Analyses were conducted in the Physics and Chemistry Laboratory of the Food Engineering Course at the Universidade Estadual de Ponta Grossa, Ponta Grossa, Paraná State, Brazil.

Total energy, carbohydrate, iron and B12 vitamin rates were analyzed by data from table of food composition of UNICAMP, Brazil (TACO, 2010).

The microbiological pattern was analyzed according to current legislation (BRASIL, 2001) with total coliform at 35°C, fecal coliform at 45°C and *Staphylococcus aureus*, following method by Silva (1998).

Acceptability degree of attributes, such as color, appearance, flavor and texture, was assessed by a 9-point hedonic scale, following methodology quoted by Anzaldúa-Morales (1994), with "1 = I really disliked it" and "9 = I really liked it".

Eighty untrained individuals were randomly chosen to take part in the assay. They received

approximately 30 g of the product, briefly fried and served with bread and lettuce, in individual booths. Results were assessed by the average answer of the filled forms.

Results and discussion

Three assays were performed for the final formulation. The nutritional composition and the sensory aspects, such as flavor and texture, were appropriate for analyses.

Test One included 3 g of salt and thus a rather high sodium rate. Salt, an ingredient in the formulation, had to be replaced by a higher concentration of soy sauce (shoyo), with a lower concentration of sodium in its composition, which also gave a sort of color to the hamburger.

For Test Two, the composition, according to the TACO chart (2010), revealed a great amount of food fiber in the hamburger coupled to pastry without any adequate texture. The quantity of linseed was decreased and the carrageenan thickener was added to the mixture. The choice and amount of the thickener were determined according to current Brazilian legislation (BRASIL, 1998).

Test Three provided an adequate nutritional composition with a hamburger texture ready for consumption, featuring a firm and homogeneous consistency.



Figure 2. 80g of the prepared hamburger. Source: authors, 2014.

Table 2 shows the quantity of lipids, food fiber and protein determined in the physical and chemical analysis. Table 3 gives the vegetable-based

hamburger's nutritional composition, according to chemical and physical data, based on TACO chart (2005).

Table 1. 80g of the prepared hamburger formulation.

Ingredients	Quantity
Soy Protein	27.27g
Quinoa flakes	6.36g
Quinoa flour	11.82g
Linseed flour	5.45g
Soy sauce (Shoyo)	18.18g
Onion	6.9g
Carrageenan	4g
Chelate Iron	6mg
B12 Vitamin	0.5mcg

Table 2. Results of physical and chemical analyses.

Analysis	Results
Lipids (g%)	1.4
Food Fiber (g%)	9.6
Protein (g%)	11.1

The amount of calories in the hamburger was similar to that of commercial ones. However, the calorie rate of lipids was lower when compared to other products even vegetable-based ones. Several studies have shown that a lower consumption of total fat and animal fat is a relevant factor in the control of blood lipids (MARCONDELLI et al., 2008; MONTEIRO et al., 2014).

The different rates of carbohydrates were due to the variety and quantity of ingredients employed, with higher or lower concentration of the components. Soy and quinoa rates, either as flakes or flour, caused the high levels of carbohydrates since quinoa is rich in fibers and carbohydrates. Several studies showed that these foods are not merely a source of carbohydrates but also of phytochemicals which are highly important for the organism (BEHRENS; DA SILVA, 2010; NAVES, 2014; PIRES, 2006).

Table 3. Nutritional composition of prepared and commercial hamburgers.

	Prepared Hamburger (80g)	Commercial Vegetal Hamburger brand (80g)	Commercial Beef Hamburger (80g)
Energetic rate	162 kcal	188 kcal	190 kcal
Carbohydrates	29g	2.6g	2 g
Proteins	8.88g	16g	14 g
Total Fats	1.12g	13g	14 g
Food Fiber	7.68g	6g	0g
Sodium	818mg	775mg	820 mg
Iron	6mg	1.28mg	1.6 mg
B12 Vitamin	0.5mcg	*	*

*Rates were not informed on the food label.

It may be noted that the prepared hamburger had a lower protein rate than the beef hamburger,

which was already expected, since vegetal sources have been used in the preparation of the product. It is also known that soy protein has functional properties that minimize the risk of degenerative diseases (BEHRENS; DA SILVA, 2010; CAMPOS, 2014).

The hamburger also revealed high fiber rates due to the material used. Fiber sources from linseed, soy and quinoa present important functional properties in the reduction of cardiovascular diseases.

In the specific case of linseed, its omega-3 concentration also interferes positively in lipid metabolism (BEGUM, 2014; STEELE et al., 2013).

Enrichment by iron and B12 vitamin made the hamburger's composition similar to meat, naturally rich in these nutrients (TACO, 2010). Since this specific hamburger is prepared for the vegetarian consumer, it is an important source of iron and B12 vitamin. The above is highly relevant since many vegetarians are anemic due to the low intake of micronutrients (COZZOLINO, 2007).

Results with regard to microbiologic analysis on the microorganisms under analysis (total coliforms at 35°C; fecal coliforms at 45°C in the Most Probable Numbers and *Staphylococcus aureus* in Colony Formation Units) showed that rates were within the range established by Brazilian legislation. Results revealed that the vegetable-based hamburger is appropriate for consumption, according to current Brazilian legal standards (BRASIL, 2001).

Table 4. Microbiologic results.

Researched Microorganism	Test Result	Microbiologic Pattern according to RDC 12/2001
Coliforms at 45°C	4 NMP g ⁻¹	5 x 10 ³ NMP g ⁻¹
Coliforms at 35°C	240 NMP g ⁻¹	5 x 10 ³ NMP g ⁻¹
<i>Staphylococcus aureus</i>	< 102 UFC g ⁻¹	5 x 10 ³ UFC g ⁻¹

Source: report (2014).

Acceptance by 80 non-trained tasters was evaluated by the perception index resulting from the filling of the hedonic scale form.

Figure 3 shows the product's acceptance level after the 80 tasters filled the hedonic scale form: 49% liked the product a lot; 30% really liked it; 10% liked it; 5% slightly liked it; 4% were indifferent; 1% disliked it; and 1% really disliked it. Rates in other fields are not given since no one marked them.

Most people from the sampling group informed an acceptance index. Due to the above, it may be stated that the vegetable-based hamburger supplied

consumers' taste requirements, very much like a beef hamburger. Due to its biodiversity and the natural resources available, Brazil has an important capacity to innovate functional foods, as the above assay has shown. (TEIXEIRA et al., 2010).

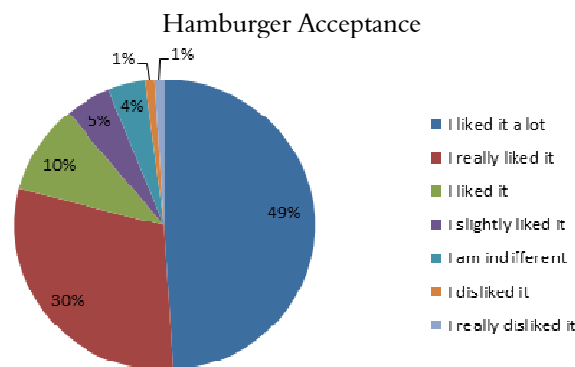


Figure 3. Acceptance of the prepared hamburger.

The definition of functional food established by Ordinance n.18 of the 30th April 1999, published by the Health Surveillance Agency of the Ministry of Health, says that any food or ingredient that alleges functional or health propriety must be safe for consumption, without the need of medical prescription, provides basic nutritional functions in daily diet coupled to good metabolic and physiological effects for people's health (BRASIL, 1999). Legislation on functional food provides information on the consumer's organism. The label should mention the ingredients involved, nutrition information, nutritional allegations, nutrient's function in specified processes and a declaration of its effects on health. It is therefore important that the product be assessed as safe food and associated with illnesses through scientific studies and analyses (VIZZOTTO et al., 2010).

There are actually several types of food with functional properties, particularly which include in their composition dietary fibers, oligosaccharides, proteins and peptides, vitamins, antioxidants, minerals, polyunsaturated fatty acids (PUFAs); isoflavones and other flavonoids, lactic acid bacteria and others (LAMARAO; FIALHO, 2009).

With the exception of soy, vegetable-based foods are rich in proteins, albeit incomplete, since they do not have all the essential amino acids in adequate quantities for human beings. In fact, humans require a combination of foods that complement each other in amino acid quantities with proteins combined to high biologic rates (BRASIL, 2008).

Increasing The growing concern for a health-promoting diet puts soy within the preference list of more and more Brazilians. Owing to scientific

evidence on the functional products, consumers are more aware on the relationship between health and nutrition. In fact, they prefer prevention to treatments which is evidenced by decrease in medical expenses, healthy aging, better life style and the neutralization of damage-causing environment (CARDOZO; OLIVEIRA; 2011).

Further, quinoa (*Chenopodium quinoa*, Willd), one of the ingredients used, is a plant native to the Andes region. It has a promising economic value since it may be used as a potential ingredient for animals and humans. Due to its high nutritional quality, it has been focused upon by several researchers worldwide. The plant is resistant to pests and develops under adverse conditions of altitude, moisture and in soils with low mineral salts. In other words, it may survive where many other cereals fail (STEELE et al., 2013).

Bolivia is the largest quinoa's producer, with 46% of world production, followed by Peru, with 42%, and by the United States, with 6.3%. The demand for quinoa has been rising in all countries, especially by naturalists who prefer gluten-free alternative foods. Its nutritional rates are balanced and may complement protein-lacking human diet by replacing the protein derived from livestock with the advantages of corn and soy, when used separately (FRANCISCHI et al., 2010).

Cereals represent the basis of human diet and it contributes towards one half of human energy and protein ingestion. Proteins participate in the building and maintenance of tissues, enzymes, hormones, antibodies, energy supply and the regulation of the metabolic processes. Besides nitrogen, amino acids supply sulfur compounds to the organism and, as lipoproteins, the proteins participate in the transportation of triacylglycerol, cholesterol, phospholipids and soluble vitamins. They also contribute towards homeostasis by keeping an osmotic balance between the organism's several fluids. Due to their structure, proteins are capable of combining themselves with acid or base compounds and thus keep the acid-base equilibrium between blood and the organism's different tissues (SBUZZI, 2013; PIRES, 2006; MOREIRA, et al., 2010).

It's important to note that quinoa seeds, leaves and inflorescences are high quality protein sources which may be compared to milk casein. Quinoa's nutritional quality is important due to its sulfur amino acids and lysine amino acid, contrastingly to cereal proteins that are low in lysine (BIGLIARDI; GALATI, 2013).

With regard to the quantity of proteins, quinoa contains 23%, while wheat and barley contain respectively 21.8 and 17%. Quinoa has 46% fiber

against wheat and corn (or barley) respectively with 24 and 15% (FRANCISCHI et al., 2010).

Linseed (*Linum usitatissimum* L.) is another ingredient used in the preparation of the vegetable hamburger. It is a plant commercially cultivated in several countries, especially in Canada with approximately 40% of world production (SBUZZI, 2013; BATISTA FILHO; RISSIN, 2007). Linseed has a high rate of a soluble mucilaginous fiber with positive impacts on hypercholesterolemia and hyperglycemia in humans.

The rising demand for vegetal protein has intensified studies of linseed as a food source for humans (ANNUNZIATA; VECCHIO, 2013). The grain is composed of 30 - 40% lipids, 20 - 30% protein and 20 - 28% total food fiber, coupled to vitamins A, B, D, E and the minerals potassium, phosphorus, magnesium, calcium and others) (ALMEIDA et al., 2009). In fact, the lipid fraction of linseed is rich in polyunsaturated fatty acids (73%), with moderate amounts of monounsaturated fatty acids (18%) and low saturated fatty acids (9%). Linoleic acid accounts for approximately 16% of total fatty acids, while α -linolenic acid represents nearly 57%, exceeding any vegetable-based oil (TARLEY et al., 2004).

Linseed is also rich in phenolic acids, with antioxidant activity, and lignin, a substance whose chemical structure is very similar to estrogen and to its activity as hormone. Due to such characteristics, it is employed to decrease the symptoms of menopause when estrogen levels are at their lowest (DLISHCHEKENIAN, V. R.2011). Linseed consumption has increased significantly because of its benefits. It is actually considered a functional food since, besides its basic nutritional functions, it produces metabolic and physiologic effects which are beneficial to health (SBUZZI, 2013).

The hamburger produced in current study may be considered a fortified food. According to ANVISA (National Health Surveillance Agency), a fortified food is a food to which nutrients are added to upgrade its nutrition rates, quantitatively replacing the nutrients during the processing of the food or supplementing nutrients at levels beyond its normal content (BRASIL, 2008).

Food enriching is a highly effective method to prevent several micronutrients deficiency, especially iron and B12 vitamin nutritional deficiency. Current technology is prepared to fortify industrialized food and, in the future, the bio-fortification of the seeds with iron and B12 vitamin, without any alterations in the food's properties (ZANCUL, 2004). It is important to note that Brazilian legislation

determines that the added nutrients are biologically available since the main goal of fortified food is to minimize nutritional deficiency.

Bio-availability began to be studied for pharmacological ends only. However, it may vary according to the metabolism's absorption and extension ratio of the ingested substance prior to affecting the target organ. It was only in the 1980s that bio-availability started to be used in the nutrition field (RIBEIRO et al., 2014).

The bio-availability of a nutrient must not be confused with the food's content. In fact, processed foods may have lost part of their contents, according to their stability. However, bio-availability of the remaining amount may or may not be altered. Consequently, the nutrient's stability and bio-availability are distinct (ANNUNZIATA; VECCHIO, 2013).

Therefore, the hamburger prepared in current study may be a contribution to human diet. In fact, it provides higher protein yield and replaces beef with a product derived from vegetables. A product that meets the consumer's needs and tastes may thus be prepared and industrialized.

Conclusion

The assay's main goal, or rather, the preparation of a specific vegetal hamburger was achieved. A vegetable-based product, a functional food based on quinoa and linseed and enriched with iron and B12 vitamin, was prepared.

The product has high protein levels and may replace beef due to its texturized soy protein with differentiated nutritional characteristics and attractive flavor, observed in the sensory analysis.

Microbiologic, physical and chemical analysis shows that it is fit for human consumption and within the range of current Brazilian food legislation.

Results show that consumers may adopt a diet rich in vegetal food with functional properties to replace animal food, rich in saturated fats and poor in food fibers. The former actually supplies nutritional needs, with sensory characteristics for good acceptance.

According to the above favorable results, further studies may be undertaken which may focus on shelf life and new types of flavors, but always emphasizing vegetable-based products, especial needs and beneficent properties for the human organism.

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