



Protein Cereal Bars: Nutritional Enrichment and Physicochemical Analysis

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ABSTRACT

Cereal bars are nutritious foods that are easily accepted by consumer, well as practicality. This work aimed to develop protein cereal bar formulations and characterize it through nutritional chemical tests. Moisture, protein, mineral content were determined according to AOAC methodology. Total lipid content was determined by Bligh Dyer method, fibers were estimated theoretically using Unicamp food composition table, carbohydrate percentages were calculated by difference between 100, sum of other constituents. In centesimal composition tests were found in F1 and F2 cereal bar formulations, respectively: moisture (12.23, 12.47%), lipids (1.98, 5.04%), minerals (0.78, 1.23%), proteins (14.11, 15.20%), crude fiber (1.66, 5.65%), carbohydrates (62.24, 60.41%). Two cereal bars showed high protein content, low lipid content, good fiber content F2 formulation which would classify it as fiber source food. All these parameters prove that food has functional properties and its consumption can bring health benefits to population.

Key words: cereal bar, enrichment, protein, physicochemical analysis, legislation

INTRODUCTION

Current changes in food consumption as result of new demands generated by urban lifestyle make people need to restructure their lives according to time, financial resources, places available to eat and others. Industry, commerce, in turn, are always aware of these changes, offering alternatives, exploiting these market niches [1]. Health is major concern affecting people's lives, societies, its importance is becoming dominant in guiding consumer behavior, especially in age-independent food choices [2]. Many foods have contributed to development of various diseases such gastric cancer [3]. Today, by consuming food, people are not only looking for nutrition, but foods that can contribute to improving health in problems such obesity, diabetes, poor nutrition, meeting nutritional needs of elderly.

Products such cereal bars have been developed are widely consumed fast, nutritious, healthy, low calorie snack. These foods were introduced almost decade ago, when consumers were particularly interested in health, food, cereal bars contain nutrients such fiber, minerals. Today, cereal bars are consumed worldwide, including by people on diets, or with health problems or just quick snack [4-6].

Use of cereals such oats, wheat, rice flakes, barley or maize, oil seeds such linseed, chia in preparation of cereal bars promote both nutrient enrichment, increased fiber content. According to Mourão *et al.* (2009), addition of plum cashews, rice flakes, linseed, oatmeal bring functional value to cereal bars, promote increase in fiber content [7]. Nutritional value has been one of main aspects considered in elaboration of this product with high fiber content, low or fat-free, but with high micronutrient intake [8] vitamins, minerals.

According to National Health Surveillance Agency [9], dietary or functional foods are specially formulated with changes in nutrient content, suitable for use in different diets or for people with specific physiological and metabolic conditions. Cereal bars are characterized mixture of cereals agglutinated with dehydrated or candied fruit, honey or syrup and or with other ingredients at selection criteria [10]. According to Resolution RDC N°. 40 of march, 21/2001 of National Health Surveillance Agency [11], dietary fiber is any edible material that is not hydrolyzed by endogenous enzymes in human digestive tract, aiding functioning of intestine. Food and Drug Administration (FDA) has authorized these claims after an

extensive review of more than 37 clinical studies confirming effects of oat bran, oat bran in lowering cholesterol. This hypocholesterolemic effect is attributed almost exclusively to β -glucans present in oats. Foods with high soluble fiber content are cereals (oats, barley, maize, rye, *psillum*), fruits (bananas, apples), legumes (beans, peas), cauliflower, carrots [12], oilseeds (linseed, chia, Brazil nuts, almond, sunflower seed, sesame, macadamia). Studies have shown that consumers consider sensory characteristics as most important factor in food choice, although non-sensory attributes are also important, may affect taste perception [13]. Sensory attributes added to search for health benefits have enabled development of cereal bars with new food, nutritious, functional ingredients [14]. This work aimed to develop protein cereal bar formulations and characterize it through nutritional chemical tests.

EXPERIMENTAL SECTION

Cereal Bar Formulation

From cereal bar base formulation two formulations were developed: control formulation without addition of Linseed, oatmeal (F1 = 0%), formulation with replacement of rice flakes by Linseed, oatmeal (F2 = 19%). Formulations were prepared individually, with proportions of ingredients previously weighed in analytical balance, separated for preparation according to Table 1, Functional cereal bar was prepared shown in Figure 1.

Table -1 Formulation of functional cereal bars with banana.

Ingredients (g)	Standard Formulation (F1)	Linseed and oatmeal formulation (F2)
Albumin	45	45
Rice flakes	80	---
Linseed	---	30
Honey	200	200
Flakes oatmeal	---	50
Sesame	30	30
Granola	50	50
Dehydrated Banana	50	50

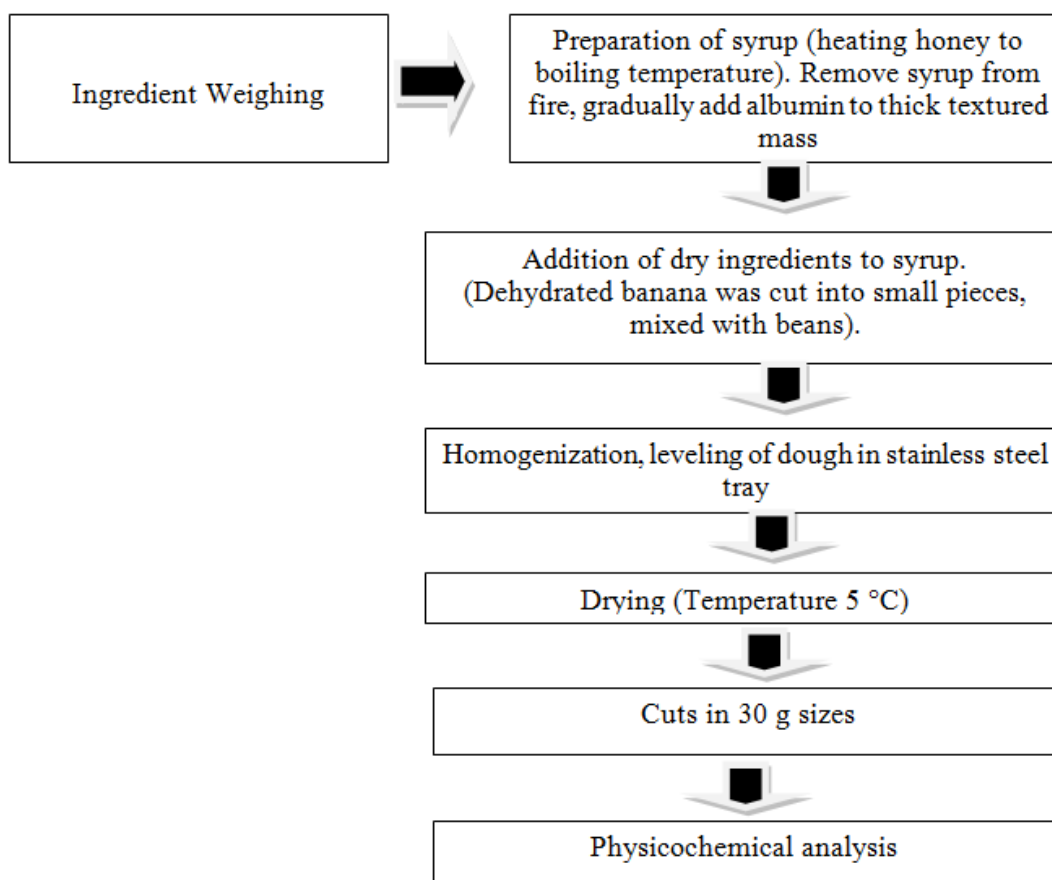


Fig. 1 Protein cereal bar elaboration flowchart

Nutritional analysis of cereal bar

Physicochemical analyzes of protein cereal bar were performed at Laboratory of General Chemistry, Analytical Chemistry of Federal University of Vale de São Francisco (UNIVASF). Tests were performed using official methodology of Association of Official Analytical Chemists [15]. Moisture was determined by drying in oven at 105 °C, ashes by incineration in muffle furnace at 550 °C until white mineral residue was obtained, crude protein was determined by Kjeldahl, fibers were indirectly quantified using Food Composition Table, Unicamp. [16], total lipids by Bligh & Dyer [17]. Carbohydrate content was calculated by difference between 100, sum of values obtained for moisture, protein, total lipids, fibers, ashes. All analyzes were performed in triplicate.

Caloric value per 100g of food was determined by multiplying amounts of carbohydrates, proteins, lipids found by 4, 4, 9, respectively, at end, result of three multiplications was added. Caloric value (Kcal) = [(HC * 4) + (PTN * 4) + (LIP * 9)] [18].

Statistical Analysis

Statistical analysis was performed by One-way ANOVA, using STATISTICA® 7.0 program, values considered significant with $p > 0.05$. All determinations were performed in triplicate ($N = 3$), data were expressed as mean \pm standard deviation. Graphics were made using Microsoft Office Excel program. Results were compared using Tukey test to identify significant differences between test results, with significance level of 95% for each parameter evaluated.

RESULTS AND DISCUSSION

Centesimal Composition

Food industry is increasingly investing in fortified foods, using fruits, cereals to increase nutritional value. Main aspects considered elaboration of cereal bars are; choosing cereal, selecting appropriate carbohydrate (to maintain balance between taste, shelf life), multi-nutrient enrichment, processing stability. Nutritional value has also been considered, with high fiber, low or fat-free, but high energy size products being preferred [19, 20]. Table 2 describes values obtained in physicochemical characterization of functional cereal bars.

Table -2 Centesimal composition of dry protein banana protein bar

Centesimal composition (g/100g ⁻¹)	Cereal Bar Control (F1)	Oatmeal and Linseed cereal bar (F2)
Moisture	12.23c \pm 0.02	12.47c \pm 0.03
Proteins	14.11s \pm 0.06	15.20d \pm 0.10
Lipids	1.98p \pm 0.01	5.04e \pm 0.01
Ashes	0.78k \pm 0.01	1.23e \pm 0.20
Raw fiber	1.66 h \pm 0.01	5.65 b \pm 0.01
Carbohydrates	69.24T \pm 0.01	60.41a \pm 0.01
Caloric value (Kcal 100g ⁻¹)	361	378

* Average \pm standard deviation of triplicate analysis. Values that present same letter, in same line, do not present significant differences ($p < 0.05$) by Tukey Test at 95% confidence.

Moisture

According to resolution N°. 272 of September 22, 2005, moisture content of dried or dehydrated fruit products should be up to 25% [21]. Resolution N°. 263/2005 [22], cereal-based products must have a maximum moisture limit of 15%, therefore, it was observed that both formulations met moisture levels provided for in both laws. High moisture content in food masks content of lipids, proteins, other constituents, has greater potential for development of spoilage microorganisms.

In addition, crunchiness is characteristic sensory attribute of cereal bars that is synonymous with freshness, product quality, its loss characterized by softening is causes rejection of consumption [23-25] when analyzing hydrolyzed collagen enriched cereal bars found moisture values of 12.01%. Values within legislation little higher than those found this study.

Proteins

Banana cereal bar formulations presented satisfactory protein content, in standard formulation (F1) content of 14.11 g 100g⁻¹ found, F2 formulation found 15.20 g 100g⁻¹. BRITO *et al.* [26] in developing cereal bar incorporated with dehydrated fruit, fruit peels found 2.40 g 100g⁻¹ protein. BOEIRA *et al.* [23] when developing protein-enriched cereal bars found protein content of 12.87 g 100g⁻¹. It is noteworthy that textured soy protein blend was incorporated goal was to obtain a highly protein product. Values found in this study were higher than those found by both researchers showing that addition of albumin, other contributors contributed to protein enrichment of formulations.

Lipids

In banana cereal bar formulations lipid content ranging from 1.98 g 100g⁻¹ for F1 formulation, 5.04 g 100g⁻¹ for F1 formulation were found. Arévalo-Pinedo *et al.* [19] when developing cereal bar based on babassu flour found in their

formulations lipid values from 10.96 to 9.52 g 100g⁻¹ which would characterize as very greasy product. However, Morett & Fett. [27] explained that coconut, babassu fat are rich in low molecular weight saturated fatty acids, therefore easily digestible by human body. Marchelle & Novelo. [28] developing a salty cereal bar found 13.65 g 100g⁻¹ lipids. Although characteristics of fat used in product development is relevant factor, it is noteworthy that those looking for this product prefer those with low fat content.

Ashes

Formulations presented mineral contents ranging from 0.78 g 100g⁻¹ (F1) to 1.23 g 100g⁻¹ (F2). Estévez *et al.* [29] prepared cereal bars containing wheat germ, oats, nuts that had ash content of 2.2 g 100g⁻¹. Freitas & Moretti. [30] their studies of development of functional cereal bar found ash content of 2.2 g 100g⁻¹. Paiva *et al.* [31] found in composition of cereal bars values from 1.16 to 2.06 g 100g⁻¹ ash. Marchelle & Novelo [28] when developing salty cereal bar found ash content of 5.09%. It can be observed that depending on constituents incorporated in cereal bar, these values may be higher or lower when compared to this study.

Raw Fiber

More and more people are seeking foods high in dietary fiber they recognize their health benefits such increased satiety, weight reduction, full cholesterol, LDL cholesterol, control of dyslipidemia, reduced risk of cancer, cardiovascular disease, type 2 diabetes. Formula F1 had fiber content of 1.66 g 100g⁻¹, formulation F2 5.65 g 100g⁻¹ of fibers. Commercialized cereal bars have amount of 4% or 4 g 100g⁻¹ crude fiber [32]. This means that F2 cereal bar has higher fiber content than commercial bars, this result is due to use of cereals, oilseeds that already have good fiber content. BRITO *et al.* [26] in developing cereal bar incorporated with dehydrated fruit, fruit peels found 2.95 g 100g⁻¹ of raw fiber. Current recommendations for dietary fiber intake vary according to age, sex, energy intake, with appropriate recommendation being around 14 g of fiber per 1,000 kcal ingested [33, 34]. Resolution n°. 27/1998, of National Health Surveillance Agency [35], regulates exclusively complementary nutritional information of foods that are produced, packaged, marketed, ready for consumer. Solid foods with 3.0% dietary fiber are considered fiber source and if it has quantity $\geq 6.00\%$ should be given high fiber attribute. Thus formulation F2 could be labeled fiber source product.

Total carbohydrates and caloric value

Formula F1 had carbohydrate content of 69.24 g. 100g⁻¹ with a caloric value of 361 kcal 100 g⁻¹, formulation F2 carbohydrate content of 60.41, caloric value of 378 kcal 100g⁻¹. These values were expected honey was added to formulations, this contributes to increase in carbohydrate content, caloric value. It is noteworthy that honey is very nutritious food, has been researched due to its pharmacological properties, health benefits [36]. Guimarães & Silva [37], when developing five cereal bar formulations with addition of murici pass fruit, found carbohydrate levels ranging from 75.25 to 77.12 g 100g⁻¹ with energy value ranging from 349.51 to 358, 77kcal 100g⁻¹. Gutkoski *et al.* [8] in developing high fiber oatmeal cereal bars found carbohydrate values ranging from 45.32 to 58.94 g. 100g⁻¹, total caloric value of cereal bars decreased with increasing fiber content, ranging from 285 to 325 kcal 100.g⁻¹. Cereal bar formulations could fit light classification. Term light is used food industry to characterize foods that present minimum 25% reduction in some nutrient or total caloric value compared to conventional food. In order to reduce calories, it is necessary to reduce content of some energy nutrient, which may be carbohydrates, lipids or proteins [21, 8]. Commercial cereal bars have between 360, 449 kcal 100g⁻¹, which allows cereal bars developed in this study to be framed light food due to reduced lipid content.

CONCLUSION

Results allow us to conclude that Linseed, oatmeal can be used as ingredient for preparation of cereal bars because they have adequate texture, taste, appearance, contribute to reduction of lipids. Which albumin addition favors increase in protein content. That two cereal bars have functional profile due to protein increase, reduced lipid content. F2 formulation with Linseed, oatmeal added satisfactory fiber content, can be considered based on legislation fiber source food.

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Conflict of Interest -Authors declare that they have no conflict of interest, this article does not contain any studies with human participants or animals.

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