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Biscuits enriched with brown flaxseed (*Linum usitatissiumun* L.): nutritional value and acceptability

Camila Coutinho de Moura[1]
Nathalia Peter[1]
Bianca de Oliveira Schumacker[1]
Lúcia Rota Borges[1]
Elizabete Helbig[1]

[1] Departamento de Nutrição, Faculdade de Nutrição. Universidade Federal de Pelotas. Pelotas, RS, Brasil.

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Correspondence
Elizabete Helbig
E-mail: helbignt@gmail.com

Abstract

The incorporation of ingredients to bakery products has grown due to consumers' concern with their health. The search for a healthy diet is increasingly present in the population, due to increased prevalence of chronic noncommunicable diseases. As a result, food industry has developed products enriched in some way to contribute to the health of consumers, thus preventing the occurrence of diseases related to inadequate nutrition. The brown flaxseed (Linum usitatissimum L.) seed is a food ingredient with potential use due to its beneficial characteristics, adding nutritional value to food. This study aimed to formulate biscuits with different proportions of brown flaxseed bran and evaluate its physical and chemical composition, color and sensory characteristics. Biscuits were prepared by adding different concentrations of brown flaxseed bran, 5% (F5) and 20% (F20), related to control, prepared with wheat flour. These were assessed for their chemical composition, color, physical parameters and sensory acceptance. Biscuits prepared with added brown flaxseed bran had higher protein content, mineral residue, fiber and moisture, besides good acceptability compared with darker cookies made with wheat flour without flaxseed.

Keywords: *Linum usitatissimum*. Functional Food. Flaxseed. Nutritive Value

Introduction

The incorporation of substances with functional claims in foods has grown in recent years because of their beneficial properties for the human health.[1] As an example, we can highlight flaxseed (Linum usitatissimum L), an oilseed species in oval grain shape that can be found in the brown or gold colors. This grain can be consumed raw, crushed or added to food, and can be found in the form of whole grain, ground and as seed oil. Its aroma is similar to that of walnuts, and it has been added to products such as breads, cookies and cakes.[2,3] Brown flaxseed, originally from hot and humid climate, also cultivated in Brazil, adapts well to our climate.[4]

Over the past few years, the consumption of flaxseed has been noted to increase. This is due to a greater awareness on its benefits to the prevention of chronic noncommunicable diseases (NCDs), along with results from studies on the constituents of this grain. Of such constituents, we can highlight essential fatty acids, with α-linolenic acid (omega 3) found in the greatest amount, besides having fiber and protein. This grain is rich in lignans, phenolic acids, flavonoids, vitamins and minerals.[3,5]

Because it is rich in α-linolenic acid, evidence suggests that flaxseed has hypocholesterolemic effects, acting on the reduction of LDL (low density lipoprotein), and thereby it prevents cardiovascular diseases. Studies show that the consumption of flaxseed promotes increased HDL (high density lipoprotein) and its antioxidant properties work in the prevention of cancer and atherosclerosis.[6-8] Soluble fiber in flaxseed may help reduce cholesterol and control blood sugar, and its insoluble fiber may aid in digestion and reduce intestinal transit constipation, and therefore be useful in preventing cancer.[9]

Flaxseed bran is an outstanding antioxidant and immunostimulant, prevents degenerative and cardiovascular diseases, and shows excellent results in the treatment of pre-menstrual tension, menopause, and in reducing the risks of breast, prostate, and lung cancers.[10]

Based on available evidence regarding the nutritional benefits of flaxseed,[11] its consumption can be enhanced by incorporating it into food products, such as biscuits.

This study aims to develop a formulation of salty biscuits, adding brown flaxseed bran to wheat flour in different proportions, and assess its physical and chemical compositions, along with its sensory and color properties.

Methodology

Three types of biscuits were formulated for this research, C (Wheat Control), F5 (5% brown flaxseed bran) and F20 (20% brown flaxseed bran), as depicted on Table 1.

Table 1. Formulation of biscuits made with wheat flour and biscuits enriched with brown flaxseed bran (*Linum usitatissiumun L.)*. Pelotas, RS, 2012.

Ingredients (grams)	Types of Biscuits		
	C	F5	F20
Wheat Flour	100	95	80
Flaxseed bran	0	5	20
Soy oil	16	18	24
Salt	3	3	3
Biological yeast	1.7	1.70	1.70
Baking soda	0.20	0.20	0.20
Dehydrated seasoning*	0.50	0.50	0.50
Water	60**	60**	60**

*Parsley, garlic, onion, oregano

**The percentage of ingredients (except water) was calculated in relation to wheat flour and brown flaxseed weight;

C = Control (wheat); F5 = 5% brown flaxseed bran; F20 = 20% brown flaxseed bran

Biscuits were crushed in a grinder for chemical analysis. Ash, moisture and crude protein contents were determined according to the Association of Official Analytical Chemists (AOAC).[12] Total Lipids were determined by the method described by Bligh & Dyer.[13] The amount of crude fiber was determined according with Angelucci et al.[14] Carbohydrates were calculated by finding the difference from the other components.The calorific value of biscuits was calculated based on the calorific value of the macronutrients, where 4 kcal.g^{-1} was used for carbohydrates and protein, and 9 kcal.g^{-1} for lipid. The determinations were performed in triplicate.

The physical analysis of biscuits were determined according to the method of 10-50D, from AOAC,[12] to determine the mass and diameter of the biscuits before and after heating, thickness and expansion factor. The specific volume was calculated by the ratio between baked biscuit apparent volume and weight, being expressed in g cm^{-1}. Biscuit texture profile was assessed in a texturometer (*texture analyzer* TA. XRplus, Stable Micro Systems).

Biscuit color was determined using a CR- 300 Minolta colorimeter, through a CIEL*a*b* system, in which the values of lightness (L*) range from 0 (black) to 100 (white), and the values of the chromaticity coordinates a* and b* range from - a* (green) to + a* (red), and from - b* (blue) to + b* (yellow).

For the sensory analysis, the test was conducted 24 hours after biscuit oven heating, with the participation of 60 untrained judges, consisting of teachers, students and employees of the Federal University of Pelotas, randomly approached, aged between 18 and 53 years old, who received the samples of 4.0 ± 0.5 g simultaneously, served and coded with three-digit numbers, in randomized complete block design. Participants were instructed to drink water after each tasting to clear their palate. Each judge received three biscuits, corresponding to each formulation, which were evaluated for sensory acceptability, using hedonic nine-point scale, ranging from " 1 " (extremely dislike) to " 9 " (extremely like), in accordance with the method described by Minim.[15]

For statistical analysis, the Tukey test was used. The level of significance was considered for values of $p < 0.05$.

The project was approved by the Ethics Committee of Research ESEF/UFPEL, and filed under 015 / 2012.

Results and discussion

The chemical composition of biscuits made with wheat flour enriched with brown flaxseed bran is shown on Table 2. F5 and F20 biscuits showed moisture content of 10.01% and 10.90 %, respectively, and moisture values are in accordance with those stipulated by CNNPA,[16] which must be less than 14 %. According to Teixeira et al.,[17] moisture must be controlled, since it interferes with the physical quality of the product, especially in the parameter that measures its hardness, because the lower the moisture content, the hardness the biscuit.

Biscuits fortified with brown flaxseed bran had higher protein, mineral residue and moisture content, compared with biscuits made with wheat flour without any addition of brown flaxseed bran (Table 2). As for fibers, it was observed that the best result was obtained for biscuits formulated with 20% brown flaxseed bran. Similar results were found by Oliveira et al.[18] in the preparation of bread using wheat flour mixed with flaxseed.

The increased nutritional value in these studies is due to the composition of flaxseed bran, 34.82 % dietary fiber, 28 % protein and 0.37 % lipid, this in low amount because in our study defatted bran was used. Thus, brown flaxseed bran has higher values than wheat flour: 6.87% fiber, 13.44% protein and 1.73% lipid, in accordance with Heinemann et al.[19]

F20 biscuits had higher fiber content, with significant difference compared to control and F5 (Table 2). Similar values were found by Borges et al.,[20] which evaluated wholemeal bread enriched with flaxseed bran through its physical, chemical and sensory characterization.

Percentages of protein and ash increased with the addition of flaxseed bran, with significant difference (Table 2). The greatest amount of mineral residue was also found by Hussain et al.[9] when adding flaxseed bran to *cookies*, and by Maciel, [21] when adding flaxseed bran to crackers. Such results are due to the presence of minerals in flaxseed, as it has higher ash content compared with special purpose wheat flour, with values of 18.5g/100g and 0.8g/100g, respectively.

For carbohydrates, F5 and F20 did not differ from each other ($p \geq 0.05$), but differed significantly when compared to control (Table 2).

Table 2. Chemical composition of biscuits made with wheat flour and bran brown flaxseed in different proportions (dry basis). Pelotas, RS, 2012.

Composition	Types of Biscuits		
	C	F 5	F 20
Protein	9.29±0.20^{c}	10.44±0.07^{b}	12.04±0.10^{a}
Ether extract	3.76±0.43^{a}	2.70±0.50^{a}	3.67±0.22^{a}
Mineral residue	0.40±0.113^{c}	3.16±0.11^{b}	3.73±0.05^{a}
Carbohydrate	87.79±2.30^{a}	83.70±0.43^{b}	80.55±0.26^{b}
Total fiber	1.09±0.37^{b}	0.76±0.08^{b}	1.96±0.22^{a}
Moisture	9.75±0.03^{a}	10.01±0.21^{a}	10.90±0.04^{a}
Calorific value (kcal.100g-1)	422.16^{a}	400.86^{a}	403.39^{a}

*Different letters on the same row, for the same nutrient, indicate significant difference by Tukey's test ($p<0.05$).
**C= control (wheat); F5= 5% flaxseed bran; F20= 20% flaxseed bran

Table 3 shows the color parameters of biscuits, represented by the values of L* (lightness), a* and b* (chromaticity). All biscuits formulated with flaxseed bran exhibited lower values of L* and b* than those of wheat flour biscuits, ie., darker color. The coloring of biscuits is particularly related to the formulation ingredients: biscuits with higher fiber content often have darker coloring. Similar results were reported by Alpaslan & Hayta,[22] when using flaxseed flour in bread processing.

Table 3. Color parameters of biscuits made with wheat flour and bran brown flaxseed in different proportions. Pelotas, RS, 2012.

Color parameters	Types of Biscuits		
	C	F5	F20
L*	67.57±2.85[a]	59.32±1.47[b]	42.56±2.13[c]
a*	1.29±0.13[c]	2.97±0.25[b]	5.96±0.48[a]
b*	23.79±0.95[a]	21.01±1.80[b]	16.75±1.35[c]

*Means followed by different letters in the columns differ through Tukey's test ($p<0.05$).
**C= control (wheat); F5= 5% flaxseed bran; F20= 20% flaxseed bran

Table 4 shows the physical parameters, in which weight before and after oven heating did not show any significant difference among samples. The expansion factor was greater for control and for 5% brown flaxseed bran enriched biscuits compared with 20% brown flaxseed bran enriched biscuits (Table 4). The expansion factor is related to the ability of ingredients to absorb water, generally biscuits high in fiber have decreased expansion factor,[23] which occurred in our study.

The specific volume ranged from 1.1 to 1.28 $cm^3.g^{-1}$, and the lowest value was found for the F20 sample (Table 4). Note that there was no significant difference between the formulations with added bran and control, and similar results were reported by Oliveira et al.[18]

Texture result analysis showed lower value of firmness to the F5 sample compared to C and F20 (Table 4). Biscuit firmness is related to the force applied to cause a change or disruption on the sample, and can be related to human mastication. The maximum force measured for bakery products depends on several factors, such as the quality of flour, mass moisture, conservation and amount of fats, sugars, emulsifiers, enzymes, among other.[24] Oliveira et al.[18] in their study on the preparation of bread using wheat and flaxseed mixed flour have found less firmness for control bread compared with flaxseed bread. And for the "crispness" variable, C and F20 differ ($p \geq 0.05$), however, F5 showed no significant difference from the other at the level of 5 % (Table 4).

Table 4. Physical assessments of biscuits made with wheat flour and bran brown flaxseed in different proportions. Pelotas, RS, 2012.

Physical parameters	Types of Biscuits		
	C	F5	F20
MA (g)	170.40±8.3[a]	169.33±11.44[a]	171.45±19.07[a]
MD (g)	113.40±6.4[a]	111.54±7.5[a]	116.89±14.6[a]
FE (g)	4,04±0,37[, b]	3.98±0.41[b]	5.60±0.66[a]
VE (cm3. g-1)	1.28±0.08[a]	1.24±0.35[a]	1.1±0.2[a]
CRC	38.94±0.28[a]	38.30±1.02[a,b]	37.73±0.54[b]
FMZ	11463.5±522.4[a]	8500.26±625.08[b]	11357.51±1009.1[a]

*Means followed by different letters in the columns differ through Tukey's test ($p<0.05$). MA: mass before oven; MD: mass after oven; FE: expansion factor; VE: specific volume; CRC: crispness; FMZ firmness.

**C= control (wheat); F5= 5% flaxseed bran; F20= 20% flaxseed bran

Results for "flavor", "texture", "color", "look", "aroma" and "overall impression", and their standard deviations, are presented in Table 5. Significant difference was observed ($p < 0.05$) in the categories "flavor" and "overall impression". For flavor, all means showed good degree of acceptance. F5 sample obtained the highest value of acceptance (6.65) , with no significant difference compared to F20. However, biscuits formulated with wheat flour showed lower acceptance rate (Table 5), with significant difference ($p < 0.05$). Similar results were reported by Maciel et al.,[11] in a study for crackers with addition of flaxseed bran.

Regarding "overall impression" significant difference was found for: 5% brown flaxseed bran biscuit has outperformed the other formulations, but the F20 formulation did not differ significantly ($p < 0.05$) from control (Table 5).

Table 5. Sensory attributes of biscuits made with wheat flour and bran brown flaxseed in different proportions. Pelotas. RS. 2012.

Sensory attributes	Types of Biscuits		
	C	F5	F20
Flavor	5.92±1.80^{b}	6.65±1.75^{a}	6.05±2.11^{a,b}
Texture	5.18±2.06^{a}	6.12±1.89^{a}	5.63±2.25^{a}
Overall impression	6.20±1.57^{a,b}	6.80±1.42^{a}	6.08±1.96^{b}
Color	6.63±1.57^{a}	6.72±1.56^{a}	5.98±2.14^{a}
Look	6.82±1.46^{a}	6.72±1.02^{a}	6.02±1.46^{a}
Aroma	6.67±1.16^{a}	6.47±1.47^{a}	6.08±1.76^{a}

*Different letters on the same column, for the same nutrient, indicate significant difference by Tukey's test ($p<0.05$).

**C= control (wheat); F5= 5% flaxseed bran; F20= 20% flaxseed bran

Results obtained in the sensory analysis showed that biscuits with added flaxseed bran can be commercially feasible, since they have good acceptability and increased nutritional quality. This ingredient can, according to Borges et al., [20] Maciel et al.[11] and Oliveira et al.,[18] improve the palatability of biscuits, making it more accepted by consumers, similar to what has been found in this present study.

Conclusion

The addition of flaxseed bran to wheat flour has enriched biscuit formulation, increasing its nutritional value, the content of protein, fiber and minerals. The formulation with the addition of 5% flaxseed bran was the most accepted of all, proving to be viable and more nutritious for daily feeding.

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