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Gamma radiation influence on technological characteristics of wheat flour

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ABSTRACT

This study aimed at determining the influence of gamma radiation on technological characteristics of wheat (*Triticum sativum*) flour and physical properties of pan breads made with this flour. The bread formulation included wheat flour, water, milk, salt, sugar, yeast and butter. The α -amylase activity of wheat flour irradiated with 1, 3 and 9 kGy in a Gammacell 220 (AECL), one day, five days and one month after irradiation was evaluated. Deformation force, height and weight of breads prepared with the irradiated flour were also determined. The enzymatic activity increased—reduction of falling number time—as radiation dose increased, their values being 397 s (0 kGy), 388 s (1 kGy), 343 s (3 kGy) and 293 s (9 kGy) respectively, remaining almost constant over the period of one month. Pan breads prepared with irradiated wheat flour showed increased weight. Texture analysis showed that bread made of irradiated flour presented an increase in maximum deformation force. The results indicate that wheat flour ionizing radiation processing may confer increased enzymatic activity on bread making and depending on the irradiation dose, an increase in weight, height and deformation force parameters of pan breads made of it.

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1. Introduction

Wheat is the leading source of cereal protein in human food, having higher protein content than either maize (corn) or rice. In terms of total production tonnages used for food, it is currently second to rice as the main human food crop, as maize is more extensively used as animal feed (Ronda and Roobs, 2011).

Bakery technology has the fermentation process, the unitary operations and the raw materials, as its main pillars. The raw materials determine the characteristics obtained by the end products. Wheat flour is the main ingredient in formulations and plays a key role, both on structuring the fermented dough and on determining the sensory characteristics of end products (Calvel, 1897; Suas, 2009).

Some studies appear in the literature concerning the application of ionizing radiation processing on different aspects of bakery technology. One of them published in recent years is a work described by Agúndez-Arvizu et al. (2006) on a typical Mexican bread. The aim of the present work was to determine the influence of gamma radiation on technological characteristics of wheat (*Triticum sativum*) flour and also on the physical properties of Brazilian pan breads made with this flour.

2. Experimental

2.1. Material

Wheat flour within the validity period of six months obtained locally were used, protein content 11% or 13%.

2.2. Irradiation

Wheat flour samples of 250 g each, packaged in polypropylene bags were subjected to irradiation in a ^{60}Co source, Gammacell 220 from Atomic Energy of Canada Ltd., at doses of 0, 1, 3 and 9 kGy, dose rate about 1.6 kGy/h, dose uniformity factor 1.13. Fricke dosimetry was previously made following ASTM E1026 standard practice for using the Fricke reference standard dosimetry system.

2.3. Enzymatic activity determination

The determination of the α -amylase activity, also known as Hagberg Falling Number, certified by ISO 3093 code AACC 56-81B, ICC 107, was developed in the Hagberg apparatus, according to the method described by Suas (2009) and expressed time in seconds. Seven grams samples were employed, being 16 samples for each dose and time after irradiation.

2.4. Bread making

Breads were made with the following formulation: wheat flour (60%), water (24%), milk (6%), salt (1%), sugar (2%), yeast (2%) and

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butter (6%). For the pan breads confection, the following sequence was employed: mixture of the ingredients for 8 min at 90 r/min; a first fermentation for 40 min at 25 °C; division of the dough in portions of 500 g; Resting time of 10 min at 25 °C; cylindrical shaping of the dough and their placing on rectangular pans (12 cm × 30 cm × 10 cm); final fermentation for 1 h and 20 min at 25 °C; baking at 160 °C in an air convection oven; cooling period of 45 min. Measurement of height (at the center of each bread) and weight were then performed on 4 unit of each one of the bread types prepared with flour irradiated with 0, 1, 3 and 9 kGy, respectively.

2.5. Texture analysis

The maximum deformation force was determined with a Extralab model TAXT2i Analyzer following the procedure recommended by the manufacturer, using two slices of bread, about 4 cm high and a 36 mm diameter aluminum cylindrical probe; a total of 48 slices were analyzed.

2.6. Statistical analysis

SigmaStat Version 1.0 for Windows 1994 from Jandel Corporation was employed, with sixteen repetitions for each sample. A nonparametric Kruskal–Wallis test was employed to determine the median and the first and third quartile, as well as the significant variations among the samples.

3. Results and discussion

According to Suas (2009), the optimal enzymatic activity varies according to the type of product desired. Higher values are recommended for breads that undergo prolonged fermentation periods and lower values for breads that undergo reduced periods of fermentation. For baking, falling number values between 200 and 300 s are recommended. In this range, there is an ideal α -amylase activity resulting in breads with appropriate volume. Enzymatic activities above 300 s result in breads with reduced volume. Calvel (1897) recommends that, if certain flour shows a value superior to 300 s, the addition of enzymatic improvers would be necessary in order to decrease this value.

Figs. 1 and 2 present the enzymatic activity of wheat flour with a protein content of 13% and 11%, respectively, irradiated at different doses versus time after irradiation.

It is shown that the 13% protein content flour, the samples irradiated at 3 and 9 kGy presented appropriate range values for bread making, as mentioned above. After the fifth day, the samples presented no further variations.

It can be observed that the 11% protein content flour showed a decrease in the falling number as irradiation dose increased. Just the sample irradiated at 9 kGy is within the proper range for

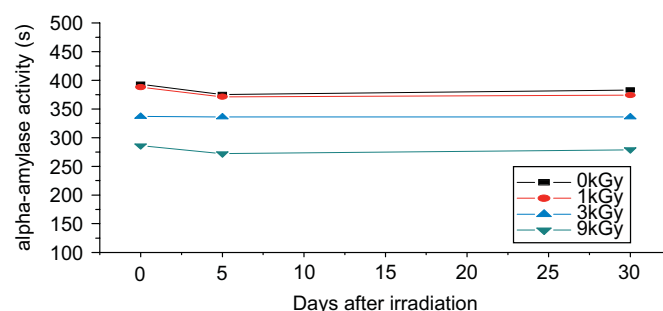


Fig. 2. Enzymatic activity of wheat flour (11% protein content) irradiated at different doses versus time after irradiation.

Table 1

Physical properties of breads made of irradiated wheat flour.

Dose (kGy)	Weight (g)	Height (cm)	Deformation force (N)
0	422 [422; 422] ^b	11 [9.5; 11.0] ^a	1.49 [1.21; 1.57] ^d
1	436 [436; 438] ^a	10 [9.5; 11.0] ^a	3.92 [3.91; 4.03] ^a
3	436 [428; 430] ^a	11 [9.0; 11.5] ^a	2.09 [2.02; 2.1] ^c
9	436 [434; 436] ^a	12 [10.5; 12.0] ^a	2.94 [2.0; 3.26] ^b

Medians and quartiles [25%; 75%]. Values on the same column with different superscripts differ significantly ($P < 0.05$).

bread making, unlike the non irradiated samples and the ones irradiated at 1 and 3 kGy, which showed higher values for falling number. From the fifth day on, there were no significant variation for the samples, whether they were irradiated or not. The data shows that when irradiation dose was increased, there was an increase in the enzymatic activity or falling number reduction expressed in seconds, for both wheat flours. In both cases, using a dose of 9 kGy there would be no need of addition of enzymatic improvers, rich in α and β -amylase, for bread confection.

Measurement of changes in weight, height and maximum deformation force of breads made with irradiated wheat flour are reported in Table 1.

The weight of breads made of irradiated wheat flour was higher than the weight of those made of unirradiated flour. The bread weight is directly related to the amount of moisture the dough can hold. According to Mulla et al. (2010) damaged starch could be evidenced by its water absorption capability. Damaged starch can absorb 2–4 times its weight in water when compared to an undamaged starch, which can absorb up to 0.4 times (Dubat, 2004). Chung and Liu (2009) described the generation of damaged starch as a result of irradiation on food rich in starch. According to Hayes et al. (1995), irradiated wheat flour could be capable of retaining more water after bread baking when compared to those which were not irradiated because of a lower content of damaged starch.

Table 1 shows that there was a slight increase in height, although not significant, for breads made of the highest radiation dose applied. The height of the bread is directly related to the amount of fermentable sugars present in the wheat flour used as a substrate for the action of the yeasts (Calvel, 1897). Then, irradiation could be responsible for the degradation of starch and, consequently, the release of higher amount of fermentable sugar (Dhital et al., 2010) that would give rise to greater pore size in the core and greater height.

The maximum deformation force of breads made of irradiated flour had higher values when compared with those made of unirradiated flour. This behavior may be due to increased extensibility generated by the modification of gluten structure. There are references in the literature that molecular weight and structure of gluten polymers are closely linked to their rheological

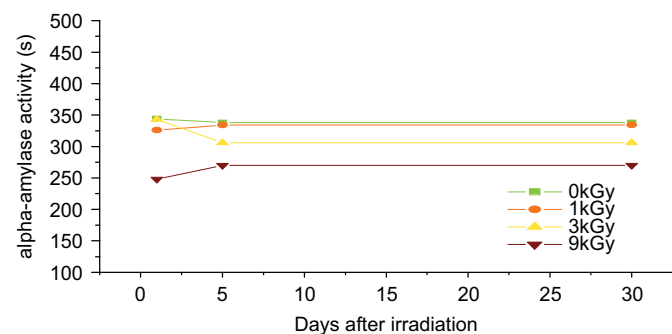


Fig. 1. Enzymatic activity (falling number in seconds) of wheat flour, protein content of 13%, irradiated at different doses versus time after irradiation.

behaviors and, ultimately, their performance in the end product (Gelinas and McKinnon 2004; Sivam et al., 2010).

4. Conclusion

Present results showed that ionizing radiation at the doses applied in this study, 1, 3 and 9 kGy, generated changes in the characteristics of the assayed flours. The enzymatic activity was not adversely affected by radiation. When radiation dose was increased, there was an increase in enzymatic activity—less time of falling number—apparently as a result of the breakdown of starch chains. This fact is beneficial for bread baking purposes. Irradiated wheat flour also induced changes in some physical properties of pan breads made of it.

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