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Irradiation effect on lipid oxidation index on *okara*-based soybean flour

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ABSTRACT

Seasoned flour, also known as "farofa", is a low cost industrialized product easy to prepare, which may be enriched with nutrients in order to improve its nutritional value. Typically, it's made from maize or yuca tempered flour. However, soy seasoned flour (SSF), which is made from *okara* (inert-flavored-mass obtained as a residue from the soybean extract), is a viable alternative for nutritional enrichment in relation to the previous conventional tempered flour. This work aimed to reuse a by-product of processing of soybean *okara* to elaborate soy-seasoned flour and to analyze the possible effect of gamma irradiation at doses of 1 and 3 kGy, in the analysis of determination of lipid peroxidation. The preparation of SSF containing *okara*, dehydrated condiments and flavor uplifting proceeded at FATEC Marília. SSF samples were processed at "Centro de Energia Nuclear na Agricultura" (CENA), University of Piracicaba-SP, and irradiated with doses of 1 and 3 kGy in ^{60}Co source. The dose rate was 0.269/h. Analysis were performed to determine the peroxide index of control samples and irradiated in triplicate at 1, 15, 30 and 45 storage days according to the methodology for oils and fats with modifications. Using this peroxide methodology, it was not detected changes in oxidative quality in the samples, whatever was the storage period. The flour having as a parameter 29.92% of lipids. We conclude that this product have excellent nutritional attributes regards to the conventional flour, though we must apply a different methodology to detect any radiation damage on lipid compounds using doses up to 3kGy.

Keywords: *Okara*, Farofa, Ionizing radiation, Lipid oxidation, Peroxide.

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1. INTRODUCTION

The seasoned flour also called "farofa" is an industrialized product with low cost, easy preparation and can be enriched to provide food with higher nutritional and functional value. In this aspect, the *okara,* inert flavor mass purchased as residue from the production of soy extract, constitutes a viable alternative of nutritional enrichment related to seasoned corn and manioc flour, highlighting the high protein content in the soy flour base *okara* [1].

In this context, the irradiation technology presents a viable alternative for preserving food, to avoid food spoilage, insect infestation or foodborne diseases [2]. It consists in a kind of ionizing energy (gamma radiation, X-rays and electron-beam) applied as a treatment in food, packed or not. This technology presents an advantage, as it allows the reduction of the use of chemicals products. Irradiation technology involves the exposure of food to a specific dose of ionizing radiation [3, 4, 5].

The use of the ionizing irradiation process in lipid-rich food is linked to the breakdown of fatty acid chains present in the food constituents giving rise to the unique radical products formed solely by radiation in the oxidation of lipids [6]. The changes will depend on the composition of the food, the water content, the radiation dose, the temperature and the presence or absence of oxygen in the process [7, 8]. This research aimed to use the *okara* SSF as a way to reuse a by-product of soybean processing and analyzing the possible effect of gamma irradiation at doses of 1 and 3 kGy, in the analysis of determination of lipid peroxidation.

1.1. Lipid oxidation and irradiation.

Lipid oxidation is related as indicative of the nutritional quality of the food, and is considered the main cause of food spoilage during stocking, once stocking is an important phase of the production chain, as it guarantees quality and minimizes losses [9]. The incorrect stocking of high-lipid foods can cause the appearance of aldehydes, ketones, hydrocarbons, ethers, furans and lactones responsible for rancidity and undesirable taste, this interaction consists of a reaction with present oxygen [10, 11].

The use of antioxidant substances has an effect of isolating or preventing the formation of free radicals in food, with the purpose of delaying or preventing the appearance of oxidative alterations. They may be natural or synthetic. The natural ones are vegetable, artificial synthetics such as BHT (Butylhydroxytoluene), BHA (Butylhydroxyanisole), TBHQ (Terc-butylhydroquinone) and PG (Propylgalate), which are mostly used in the food industries because they have excellent stability and low cost [5, 12, 13]. However, the use of artificial antioxidants promotes toxicological effects in the organism, as we could see in animal studies the presence of toxicity in the kidneys, liver, in addition to the reduction of weight gain as a way to replace it and minimize / inhibit the appearance of lipid oxidation is employed the irradiation technology with low quantity [10, 14]. The low doses showed to be effective as in any other method of food conversation, since the use of high doses has the effect of compromising the lipid-rich foods, promoting side effects, resulting in small breaks in the chains, releasing sulphurous smell and unpleasant taste [15].This effect accelerates the lipid oxidation process in preserved foods [10, 16].

Ionizing radiation can act directly and indirectly. Direct action occurs when the radiation reaches a chemical bond of the constituent of the food directly. The indirect is from an ionization of another molecule, such as water, that can form free radicals that interacted with the food component [17]. The effects of ionizing radiation on lipid fraction consist in pathways strongly influenced by structure molecules, since they are the first excited when absorbed by radiation. The breakdowns of the triglyceride molecules will occur in the carbonyl group at position five occasionally, at all carbon-carbon bonds remaining in the fatty acid. In the case of saturated fats, it presents a link to oxygen compounds, causing a deficiency in electrons, directing the location of breaks for the next grouping carboxyl. Interactions of radiolysis reaction resulting in unsaturation of glycerides molecule can occur [5, 18].

2. MATERIALS AND METHODS

2.1. Soya seasoned flour (SSF)

Obtaining the by-product of the *okara* soybean was performed following the methodology described by Viana, Bueno and Góes-Favoni (2011) [19], with modifications, in the processing

laboratory of "Faculdade Tecnologia de Alimentos" (FATEC/Marília). After obtaining the *okara*, it was dried in an air circulation oven (Marconi mod. 035) at 65°C for 4 hours. Then, preliminary tests were made; the SSF was prepared containing dehydrated *okara*, dehydrated seasonings and flavor enhancers. After cooling to room temperature, the SSF was packed in polypropylene bags lined with aluminum foil, each containing 500 g.

2.2. Gamma irradiation

SSF samples were submitted to irradiation treatment in the Radio Entomology and Food Irradiation Laboratory (LIARE) of the "Centro de Energia Nuclear na Agricultura" (CENA / USP) in Piracicaba-SP / Brazil. The doses applied were 1kGy, 3kGy; and control (non-irradiated) using Gamma cell 200 with ^{60}Co source, at a rate of 0.299 / hr.

2.3. Analysis of Peroxide Index

The analysis were performed at the laboratory of FATEC Marília / SP to determine the peroxide content in the control (non-irradiated) and irradiated (1 and 3 kGy) samples in triplicate at the time of 1, 15, 30, 45 days, according to the methodology described by Instituto Adolfo Lutz [20] with modifications for oils and fats as described by Broca; Devidé (2013) [21].

Initially, 5g of the sample were homogenized, in an erlenmeyer flask with a polished aluminum foil-covered; then, added 30 mL of acetic acid solution-chloroform (3:2), and later shaking on the shaker table (Marconi agitator mod. Ma 140) for 30 minutes. Then, added 0.5 mL flask of a saturated solution of potassium iodide to the Erlenmeyer and it was kept at rest under light, for 5 minutes. Added 30 mL of distilled water and the content was vacuum filtrated. Added 1 mL of starch solution 1% when filtered and titrated with sodium thiosulfate solution 0.01N with constant agitation. So, calculated the peroxide with the words below:

$$\frac{(A-B) \times N \times f \times 1000}{P} = \text{Peroxide index in meq by 1000g of the sample} \quad (1)$$

A = number in mL of Sodium Thiosulphate solution 0.1 (or 0.01 N) spent in titration sample.

B = number in mL of Sodium Thiosulphate solution 0.1 (or 0.01 N) spent in blank titration.

N = normality of the Sodium Thiosulphate solution.

f = factor of Sodium Thiosulphate solution.

P = number in grams of the sample.

3. RESULTS AND DISCUSSION

The observed results in irradiated samples of 1 and 3kGy and in the control samples, did not detect the presence of peroxide during the entire storage period (45 days), as shown in table 1. This demonstrates that there was no difference between treatments.

Table 1 - Peroxide content determined in the control (non-irradiated) SSF and irradiated with 1 and 3kGy on storage days 0, 15, 30 and 45.

	storage days			
Dose/Days	**0**	**15**	**30**	**45**
Controle	Not detected	Not detected	Not detected	Not detected
1 kGy	Not detected	Not detected	Not detected	Not detected
3 kGy	Not detected	Not detected	Not detected	Not detected

Source: Autor's data

In the SSF samples it was not possible to detect the peroxide index during the analyzes, a similar result also found by Silva *et. al.* (2010) [8] who observed the oxidative stability of wheat flour and corn meal after gamma irradiation at different doses (3, 4, 5 and 6 kGy), in samples of wheat flour stored for 3 months and corn meal for 6 months. However, in the same study, the results of the sensorial analysis revealed that wheat flour and corn meal were negatively affected in odor and color parameters, at all doses applied as well as during storage time.

The formation of characteristic flavors and odors is the result of the auto-oxidation of the unsaturated fats in the food. The interactions of ionizing radiation with some high lipid foods and the presence of water activity contribute to the oxidation process. In the previous work of the authors GÓES-FAVONI *et. al.* (2014) [1], a relatively high concentration of lipids was described (29.92%), but the irradiation did not significantly interfere in the concentration of these lipids and the moisture content was approximately 5.0%, an excellent parameter , essential for oxidative stability, since according to Brazilian legislation the maximum allowed moisture for flour is 15% [22; 23].

Broca & Devidé (2013) [21] evaluated the storage of temperate flours based on okara for 84 days and found no peroxide presence, concluding that the conditions that prevented lipid oxidation were storage under light shelter (aluminum foil packaging), absence of temperature variations and low exposure to oxygen, as well as the conditions used in this work (polypropylene bag packaging). According to Sousa (2013) [24], the absence of oxidative rancidity indicates that the packaging was efficient in its function of protecting the food, since it is sensitive to oxygen. Oxygen has a great effect on reducing the quality of a food, causing fat rancidification, which significantly changes its taste, acts on enzymatic browning, decreases nutritional value through the oxidation of vitamins, and promotes the proliferation of microorganisms.

Silva, et. al. (1999) [25] studied different methods to evaluate the degree of lipid oxidation and antioxidant capacity, showing the importance of the oxidation state of oils and fats, which were described in different methods (physical, chemical and physico-chemical), in counterpart none of these methods correlates perfectly with the organoleptic modifications produced in the course of oxidative reactions. The evaluation of the oxidative grade classifies the level of peroxides over time and the low level does not guarantee a good oxidative stability in the classical methods used for dosing peroxides.

4. CONCLUSION

It can be concluded that Okara is an excellent nutritional attribute in the SSF elaboration. Under the experimental conditions the irradiation process used in relation to the storage time of 45 days did not promote the oxidative deterioration of SSF due to the low humidity concentration of 5.0%. We suggest a methodology by CG-MS that analyzes oxidation and degradation of lipids.

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