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Characterization of peeled and unpeeled almond (*Prunus amygdalus*) flour after electron beam processing

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HIGHLIGHTS

- Examine physical chemical and sensory changes on irradiated almond.
- Increase the information on irradiation treatment at low doses.
- Contribute to broaden the use of this technology in the food.

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ABSTRACT

Flours of unpeeled and peeled almond seeds have been irradiated with ionising radiation at 1.5 kGy dose by means of 5 MeV energy electron beam. The effects of ionising radiation have been studied concerning microbiological parameters, such as total mesophilic counts, mould, yeast, enterobacters, coliform bacteria, as well as physicochemical parameters, free fatty acid, peroxide number, humidity, activity water, aflatoxin, pesticides, and sensory evaluation of attributes regarding only appearance, olfactory and rheological aspects in accordance with the prescription of Italian laws about the consumption of irradiated food. The results, compared with non-irradiated samples from the same supply, show a sharp decrease of pathogen loads while no significant variations of physicochemical parameters and sensory descriptors have been noticed. These results indicate that irradiation at 1.5 kGy dose, lower than values usually reported in literature, seems to be still a suitable sanitation treatment to extend the shelf-life of this kind of foodstuff while maintaining its nutritional, safe and sensory characteristics.

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1. Introduction

In the last years, many scientific evidences have shown beneficial effects of the oily dried fruit use (walnuts, hazelnuts, almonds, and pistachios) in a balanced diet thanks to the high nutritive value provided, besides of contribution of vegetal proteins, vitamin E, fibres, iron and calcium, also from contents in fat (46–76%) with a main fraction of mono- and poly-unsaturated fatty acids (Ryan et al., 2006) that may induce cardio-protective effects (Kelly and Sabate, 2006). Almonds quality may be substantially reduced if the product is subjected to insect damage during post harvest storage on the ground or pre harvest insect attack in the field (Schatzki and Ong, 2001). Furthermore, growth of some aflatoxigenic *Aspergillus* species and production of aflatoxin can make almonds unsuitable for consumption. In both cases, preservation strategies are necessary to prevent mycotoxin production or insect growth. The use of ionising radiation can be an efficient strategy, alternative to chemical one, in the post harvest applications (Kabak et al., 2006) which are allowed in food products up to a maximum dose of 10 kGy by many countries in the world (Lacroix and Quattara, 2000). Navaiz et al. (1992) have noticed on almonds, irradiated at 1.0, 1.5 and 2.0 kGy doses and stored for 6 months at a temperature of 5 °C, that the initial mould and yeast load, reduced to acceptable values, was maintained throughout the storage time. Other authors (Aziz and Mousa, 2004) report on *Aspergillus alutaceus*

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and *flavus* inhibition after 5 kGy dose irradiation and aflatoxin B1 (74.3–76.7%) and ocratoxin A (51.3–96.2%) detoxification with 6 kGy dose irradiation on chick-peas and peanuts.

Unsaturated fatty acid large content induces the formation of peroxides and free radicals that, by interacting with proteins and lipids, brings to oxidation products as aldehydes, esters, ketones and sulphured compounds (Sajilata and Singhal, 2006). A few works on irradiated oil of almond and shelled almonds (Sànchez-Bel et al., 2008, 2005) provided encouraging results on the absence of significant changes in the composition of fatty acids, lipid oxidation or appearance of rancidity with doses up to 7 kGy. It is very important to study the effect of ionising radiations on physicochemical and sensory properties of almonds as the consumer demands, besides nutritional quality, also a complete absence of off-odour and off-flavour. The radiation effect on both peeled and unpeeled almond flour has been evaluated in order to provide data to be the spurs for the adoption of such a technology in Italy.

2. Experimental

2.1. Samples

Almonds (*Prunus amygdalus*) to be treated with ionising radiation have been supplied by V. Besana S.p.A. Company based in S. Gennaro Vesuviano (Na, Italy) in form of fresh ground flour from peeled and unpeeled seeds, coming from different production sites. Each kind of flour has been divided into two parts. One has been irradiated and the other one has been used as a control sample. The control sample has been subjected to the same conditions of transport, storage and analysis of the irradiated flour.

2.2. Ionisation radiation treatment

Irradiation has been performed, at 1.5 kGy dose, by means of 5 MeV electron accelerator of the Physics Department of University of Messina (Auditore et al., 2004). This accelerator is a research tool, designed in collaboration with the ENEA Accelerators Group (Frascati, Rome); it has auto focusing accelerating structure, able to deliver an extremely collimated electron beam with 4 mm^2 surface spot.

An accurate measurement of the irradiation dose per unit electron current has been performed, at different distances from the electron beam exit window, by means of Gafchromic films. This allows us to measure the total dose provided to a given sample as a function of the total electron charge collected by a charge integrator, coupled with a toroidal ferrite, which continuously monitors the beam electron current stability.

The uncertainty of the dose measurement is primarily affected by the beam energy stability, which is better than 2%.

The dose rates for selected beam parameters were measured with alanine reference dosimeters from the accredited Risø High Dose Reference Laboratory. Doses given to samples were determined by selecting appropriate beam parameters.

The treatment channel allows to put samples to be irradiated at a maximum distance of nearly 80 cm from the electron output window. The electron beam, once outside the accelerating structure, broadens in such a way to keep a uniform distribution on a circular surface with a diameter almost one tenth of the distance from the output window. This situation, on one hand avoids complicated structures to yield uniform electron distribution, on the other one limit the dimensions of the samples to irradiate.

Flour samples, about 1 kg in weight for each type, have been shared in Petri capsules (6 cm diameter and 1 cm height) and individually irradiated. Flour (25 g) has been inserted in the capsules without any compression to avoid anomalous density increases that could have conditioned the dose distribution in the irradiated samples. Forty Petri capsules were irradiated. The Petri capsule dimensions represent the best compromise between a minimum fractionation sample and the total irradiation time.

Furthermore, the capsule thickness has been properly chosen as to stay in the build up region of the dose–depth curve, thus allowing to minimise the uncertainty in the dose–depth uniformity.

Table 1
Analysed microbiological and physicochemical parameters.

Microbiological parameters (ufc/g)	Physicochemical parameters
Total mesophilic counts	Free fatty acid (% oleic acid)
Mould/yeast	Rancidity (qualitative, test of Kreiss)
Enterobacters	Number of peroxide (Meq O_2/kg mg)
Coliform bacteria—otal	Humidity (%)
Escherichia coli ß-glucuronidase (+)	Activity water
Coagulase positive staphylococci	Pesticides (mg/kg)
Salmonella spp	Aflatoxin (B1+B2+G1+G2) (μg/kg)
Listeria monocytogenes.	

2.3. Analytical determinations

Besana S.p.A. Company has determined in triple microbiological and physicochemical parameters forming its own analysis protocol, before and after ionising radiation treatment; microbiological and physicochemical parameters analysed and their relative methods are reported in the Table 1.

2.4. Sensory analysis on not irradiated samples

A measurement of possible change in the sensory characters, due to the radiation effect, has been done by the sensory profile method (UNI 10957, 2003).

The sensory profile was constructed by using a 12 judges trained panel (UNI EN ISO 8586, 2008), consisting of students of the DISPA.[1] In a few preliminary meetings, by using commercial and Besana samples, the judges have generated a list of descriptors based on the percentage of citations referring to appearance, olfactory, gustative and mouthfeel attributes. The final set consisted of 15 descriptors for peeled samples and 20 descriptors for unpeeled samples; the descriptors for both samples are reported in Table 2. The different descriptors were quantified using a nine point intensity scale where the digit 1 indicates the descriptor absence while the digit 9 the full intensity. Evaluations have been lead in single boxes at the DISPA sensory analysis laboratory. The order of presentation was randomized between judges and sessions. Water was provided for rinsing between samples. All data were acquired by a direct computerised registration system (FIZZ Byosistemes. ver. 2.00 M, Couternon, France).

The obtained profile allowed to quantify the sample characteristics separately and in perception order.

The difference in number and typology of the descriptors accounts for the relevant almonds dissimilarity. The peel in the unpeeled almonds accounts for the presence, for instance, of the woody attributes which are absent on the contrary in the peeled almond.

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