LWT - Food Science and Technology 71 (2016) 175–183

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

# Physicochemical properties of whole wheat flour as affected by gamma irradiation

Naseer Ahmad Bhat, Idrees Ahmed Wani*, Afshan Mumtaz Hamdani, Adil Gani, F.A. Masoodi

*Department of Food Science & Technology, University of Kashmir, Srinagar, 190 006, India*

ARTICLE INFO

*Article history:*
Received 8 October 2015
Received in revised form
23 February 2016
Accepted 15 March 2016
Available online 17 March 2016

*Keywords:*
Wheat
flour
Gamma-irradiation
pasting
FTIR

ABSTRACT

Three wheat cultivars SW-1, SKW-355 and HS-240 were gamma irradiated at 2.5 and 5 kGy doses. The effect of gamma irradiation on physicochemical properties of whole wheat flour samples was investigated. Results revealed significant ($p \leq 0.05$) decrease in water absorption, oil absorption, swelling power and emulsion capacity of all the cultivars under study, whereas, water solubility index, emulsion stability, foaming capacity and stability were found to increase upon irradiation. Pasting properties in general were also found to decrease with irradiation. Structural analysis revealed a decrease in the intensities of O-H, C-H and O=C stretches and bending mode of water with increase in irradiation dose from 0 to 5 kGy for HS-240 and SW-1 whereas the reverse was true for SKW-355. Irradiation treatment decreased the Hunter color '*L*' and '*b*' values while as '*a*' values were increased with increase in irradiation dose.


## 1. Introduction

Wheat (*Triticum aestivum* L.) is one of the major sources of food for people in 43 different countries, accounting for 35% of the total world population that regularly consume wheat-based food (Zhang, Zhang, Xu, & Zhou, 2013). The total production of wheat in the world during 2014–2015 was 721 million tons (IGC, 2014–2015) while India recorded 95.9 million MT of wheat production during 2013–14 (FAO, 2014–15). In terms of consumption, it ranks second after rice as the main human food crop (Ronda & Roobs, 2011). The higher protein content in wheat compared to other cereals like maize and rice also makes it a leading source of cereal protein in human nutrition. The different parts i.e., endosperm containing mostly starch, bran containing mainly dietary fiber and germ containing lipids and proteins are concentrated at varying locations and proportion within a grain (Marquart, Jacobs, McIntosh, Reicks, & Poutanen, 2007). Endosperm and germ being the largest (81–84%) and smallest (2–3%) parts, respectively, are surrounded by the layers of bran which constitutes of 14–16% of the grain. Bran is a part rich in dietary fiber that is known for many health benefits in humans and is commonly eliminated during refining. The loss of germ and bran during conventional modern milling methods is also a cause of reduction in the total phenolics and flavanoids in wheat products (Li et al., 2015). Growing conditions of wheat influence the proximate composition in particular the external factors like climate and altitude. Starch content of wheat grown in higher altitudes is greater compared to that grown in lower altitudes. The dry and cold weather conditions generally seen at higher altitudes increases the yield and crude protein content in wheat (Petr, Capouchová, & Marešová, 2001).

Development of the products based on whole wheat flour is providing options to increase dietary fiber intake thus reducing glycemic and cholesterol indexes (Onyeneho & Hettiarachchy, 1992). The consumption of dietary fiber is also associated with reducing the risk of heart diseases, prevent colorectal cancer, bowl diseases, diabetes and diverticulitis (Topping & Clifton, 2001).

Whole wheat flour is generally sold in the market in the prepacked form. However, its shelf-life is restricted to 1–2 months because of insect infestation. In tropical countries, like India, high temperature and humid conditions result in insect infestation even in sealed pouches. The use of conventional methods of fumigation is not possible for sealed pouches because of the inability of fumigants to penetrate the same. Gamma irradiation is, therefore, considered to be an alternative method to prevent food spoilage, insect infestation and food borne illness as well as to increase the shelf-life of the product. Another important benefit of irradiation

* Corresponding author.
*E-mail address:* idwani07@gmail.com (I.A. Wani).

http://dx.doi.org/10.1016/j.lwt.2016.03.024
0023-6438/

treatment of such commodities is related to the possibility of reducing the use of highly toxic insecticides like phosphine and fumigants like methyl bromide. Food irradiation is, however, known to affect the physical, functional and pasting properties of the corresponding products (Falade & Kolawole, 2012).

Gamma-irradiation is responsible for inducing several changes in the carbohydrate and protein content of foods. It causes the physical modification of the starch. The free radicals developed during irradiation lead to the cleavage of glycosidic linkages converting large starch polysaccharides into smaller fragments (Wang, 2007). Studies also reveal the decrease in the total protein while a decrease in the soluble amino acid content upon irradiation (Maity et al., 2009). The objective of the present study was to evaluate the effect of gamma-irradiation on the physicochemical properties of three wheat cultivars that are grown on higher altitudes of J & K.

## 2. Materials and methods

### 2.1. Sample collection and preparation

Three certified wheat cultivars namely, SW–1, SKW–355 and HS–240 were collected from Sheri-Kashmir University of Agricultural Sciences & Technology, Kashmir (SKUAST-K), India. The grains were milled in a laboratory mill (Amar Industries, Amritsar, India) to obtain whole wheat flour after conditioning to moisture content of 14% (dw). It was then oven-dried at a temperature of 40 °C to a moisture content of 10.5% and packed in laminated pouches after sieving through 50 mesh for further analysis.

The flour samples (70 g/bag) at a moisture content of 10.5% were packed in two layers of polyethylene bags and were irradiated in a cobalt-60 ($^{60}$Co) source irradiator at room temperature (20 ± 2 °C). Samples were irradiated with absorbed doses of 0 (unirradiated), 2.5 and 5 kGy at the dose rate of 83 Gy/min. All the materials were kept at 20–40% relative humidity. To ensure that flour samples received the exact dose, the dosimeters were placed along with the samples. Aceric-cerous dosimeter was used to measure the absorbed dose of gamma irradiation by the samples. Irradiation was performed at Bhabha Atomic Research Center (BARC), Zakura, Srinagar, J &K, India. Irradiations were performed in duplicate.

### 2.2. Proximate composition

Moisture, protein, fat, crude fiber and ash contents of unirradiated whole wheat flour samples were determined according to the methods of AOAC (1990).

### 2.3. Apparent amylose content

Apparent amylose contents of the flour samples were determined according to the method of Williams, Kuzina, and Hlynka (1970). .

### 2.4. Bulk density

Bulk density was measured as a ratio of mass to volume (Wani, Sogi, Wani, & Gill, 2013).

### 2.5. Color

Color of the samples was determined using Color Flex Spectrocolorimeter (Hunter Lab Colorimeter D-25, Hunter Associates Laboratory, Ruston, USA) after being standardized using Hunter Lab color standards and their Hunter '*L*' (lightness), '*a*' (redness) and '*b*' (yellowness) values were measured. ΔE was calculated using the method of Caminiti et al. (2011).

### 2.6. Functional properties

#### 2.6.1. Water and oil absorption capacity

Sample (2.5 g on dry basis) was mixed with 20 mL distilled water or mustard oil in a centrifuge tube and then vortexed for 30 min at 25 °C. The slurry was then centrifuged at 5000 × g for 15 min (5810R, Eppendorf, Hamburg, Germany) and the supernatant was decanted. The weight of the residue was measured. The gain in weight was expressed as percentage of water/oil absorption capacity.

#### 2.6.2. Light transmittance

Light transmittance of whole wheat flour gels was determined by using the method of Wani et al. (2012).

#### 2.6.3. Swelling power

The swelling power was determined according to the method described by Wani et al. (2014).

#### 2.6.4. Water solubility index (WSI)

The WSI of whole wheat flour samples was determined according to AACC method 56–20 (AACC, 2000) with slight modifications. Flour sample (Mo) 0.20 g of whole-wheat flour sample (db) were dispersed in 20 mL deionised water and vortexed (Vortex-Genie, Scientific Industries, Inc., New York, USA) for 1 min. The samples were placed for 30 min in a water bath (50, 60, 70, 80 and 90 °C) and vortexed after every 5 min. This was followed by the centrifugation of the tubes at 5000 rpm for 15 min. The supernatant was collected in a preweighed petriplate ($W_1$). The residue from the water absorption sample was dried in a forced convection oven (NSW-143; Narang Scientific Works Pvt. Ltd., New Delhi, India) for 12 h at 110 °C and weighed ($W_2$).

WSI was calculated as:

$$\mathrm{WSI} = \frac{(W2 - W1)}{Mo}$$

#### 2.6.5. Emulsion capacity and stability

Emulsion capacity and stability was determined by the method of Martínez, Rosell, and Gómez (2014) with some modifications. Flour suspensions, 5% (w/v) at pH 3, 5 and 7 were mixed with commercial mustard oil (20 mL). The contents were homogenized for 1 min at maximum speed (WiseTis Homogenizer, Wisd Laboratory Instruments, Korea) to disperse the sample in the oil. The suspensions were then centrifuged at 800 g for 10 min. The emulsifying capacity (EC) was calculated as:

$$EC = \left(\frac{ev}{tv}\right) \times 100$$

Where, eν is the emulsion volume and tν is total volume.

Emulsion stability (ES) against high temperatures, were determined in the emulsions that were heated in a water bath at 80 °C for 30 min, and centrifuged at 800 g for 10 min. ES was calculated as:

$$EV = \left(\frac{fev}{iev}\right) \times 100$$

Where, *fev* is the final emulsion volume and *ie v* is initial emulsion volume.

#### 2.6.6. Foaming capacity & foam stability

Flour suspensions (5% w/v) at pH 3, 5, and 7 were homogenized