POLISH JOURNAL OF FOOD AND NUTRITION SCIENCES
www.pan.olsztyn.pl/journal/
e-mail: joan@pan.olsztyn.pl
Pol. J. Food Nutr. Sci.
2007, Vol. 57, No. 4, pp. 487–496

# RHEOLOGICAL PROPERTIES AND QUALITY EVALUATION OF EGYPTIAN BALADY BREAD AND BISCUITS SUPPLEMENTED WITH FLOURS OF UNGERMINATED AND GERMINATED LEGUME SEEDS OR MUSHROOM

*Hesham A. Eissa, A.S. Hussein, B.E. Mostafa*

*Food Technology Department, National Research Centre, Cairo, Egypt*

Key words: biscuit, chick peas, colour, Egyptian balady bread, flours, germination, kidney peas, legumes, oyster mushroom, rheological properties, sensory attributes, wheat

Raw and germinated chick peas and kidney peas flours and mushroom flours as a partial substitute for wheat flour in Egyptian balady bread and biscuit production were evaluated. The rheological properties of flour dough and baking quality properties (physical, chemical, protein content, colour and sensory characteristics) of wheat flour, raw and germinated chick peas and kidney pea's flours or mushroom flours were examined in balady bread and biscuit. Wheat flour was partially replaced by raw and germinated chick peas and kidney pea's flours and mushroom flours in ratios of 5, 10, and 15%. Water absorption, dough development time (DDT) and dough weakening increased but mixing tolerance index (MTI) and dough stability decreased in the case of raw and germinated legumes flours, whereas the extent of decrease was relatively marginal in the case of mushroom flours at the level of 5 and 10%. Greater effects were observed on the mixing tolerance index values (MTI) in biscuit. It increased in the case of germinated legumes flour and mushroom flour, whereas the extent of decrease was relatively marginal in the case of raw legumes flour with increasing the level from 5% to15%. Baking properties, colour and sensory evaluation tests showed that 15% of wheat flour could be replaced with germinated legumes and mushroom flours and still providing good quality of Egyptian balady bread and biscuits. MTI as an indicator for staling test revealed that wheat bread was better than wheat-germinated legumes and mushroom flours bread regarding freshness.

## INTRODUCTION

In Egypt, the total yield of bread grains does not satisfy the needs of the country. The total production of wheat grains cover only about 55% of the total needs. The way to overcome this problem is to search for the native cereal sources or others which could be used with wheat flour bread making. Biscuits are convenient food products and the most popular bakery items consumed nearly by all levels of society in Egypt. Some of the reasons for such wide popularity are low cost among other processed foods (affordable cost), good nutritional quality and availability in different varieties, varied taste, easy availability and longer shelf-life. Most of bakery products are used as a source for incorporation of different nutritionally rich ingredients for their diversification [Gandhi *et al*., 2001; Hooda & Jood 2005; Sudha *et al*., 2007]. The enrichment of protein may be achieved through the incorporation of protein–rich non-wheat flours [Gandhi *et al*., 2001; Sharma & Chauhan, 2002]. Among them chick peas, kidney peas and Oyster mushroom have a great potential, due to their high and good quality-protein (24–35%), whereas legumes and mushrooms have better nutritional qualities (higher lysine and soluble dietary fiber and lower methionine than wheat) and better baking qualities than rye, but mushrooms have soluble and insoluble dietary fibre especially $\beta$-glucan [Fahmey *et al*., 1981; Ulloa *et al*., 1988; Varughese, *et al*.,1996; Petrovska *et al*., 2002]. Therefore, fortification with high protein legume flours could provide a good opportunity to improve the nutritional quality of protein consumed by many people. Also, fortification of wheat flour with non-wheat proteins increases protein quality by improving its amino acid profiles [Stark *et al*., 1975; Hoover, 1979].

Results according to Autio *et al*. [1998] reported that the germination–induced microstructural changes of cell walls in dough's were very extensive. The larger values of the area of visible cell walls of the germinated than for the native grains suggest that germination induces swelling of cell walls, but the smaller values suggest that germination causes fading of cell walls. However, the microstructure examination of dough section showed that germination caused two types of structural changes in the cell walls: (1) swelling and (2) fading of the blue fluorescence of cell walls. Moreover, doughs made from flours of germinated grains were always softer than dough's made from flours of native grains. Hence, development and consumption of such therapeutic bakery products would help to raise the nutritional status of the population. Information on incorporation of treated and untreated legumes (chick peas, kidney peas) and mushroom flour in bakery products and balady bread is scanty.

Thus, the present study was designed to evaluate the suit-

Author's address for correspondence: Dr. Hesham A. Eissa, Food Tech. Dept., National Research Center, Cairo, Egypt; tel.: (202) 202 6881; fax: (202) 337 0931; e-mail: hamin_essa@yahoo.com

ability of partial replacement of wheat flour using mushroom, ungerminated and germinated chick peas and kidney peas flours in Egyptian balady bread making and biscuit manufacture. Therefore, this study was aimed at evaluating the effects of raw and germinated chick peas and kidney peas flours and Oyster mushroom flours added as various ratios (5, 10 and 15%) on the rheological properties of dough and on the quality (physical, chemical, protein content, colour and sensory characteristics) of wheat balady bread and biscuits.

## MATERIAL AND METHODS

**Materials.** Wheat flours (72% and 82% extraction) were obtained from the North Cairo Flour Mills Company, Egypt. New cultivar of chick peas (*Cicer ariethinum*) and kidney peas (*Vigna sinensis*) were purchased from The Ministry of Agriculture in season 2005–2006 and kept at 3–4°C until needed for technological studies. Fresh Oyster mushroom (*Pleurotus. Sajor-Caju*, strain 290) cultivated on rice straw was purchased from the Center of Mushroom service (COMET)-Dokki, Cairo, Egypt and kept at 3–4°C for 2 days until needed for technological studies.

**Preparations of mushroom flour.** Oyster mushrooms were washed with cold water and blanched with steam for 7 min and dried in a thermostatically controlled oven with air fan to 60°C for 270 min and milled using a Laboratorial disc mill (Quadrumat Junior flour mill or Model Type No: 279002, ©Brabender ® OHG, Duisburg 1979, Germany) to pass through a 20 mesh/inch sieve, until using. However, steam blanching is necessary to remove the bitter taste from the mushrooms and to completely inactivatedthe polyphenoloxidase in mushroom [Deshpande & Tamhne, 1981; Paeaekkoenen & Kurbela, 1987].

**Preparations of legume flour.** The chick pea seeds and kidney pea seeds were soaked in distilled water for 9 h followed by boiling for 30 min. The chick peas seeds and kidney pea seeds were dehulled and dried in a thermostatically controlled oven with air fan at 60°C for 12 h, then ground using a Laboratorial disc mill (Quadrumat Junior flour mill or Model Type No: 279002, ©Brabender ® OHG, Duisburg 1979, Germany) to pass through a 20 mesh/inch sieve.

**Germination of legumes.** The raw materials of chick peas and kidney peas were germinated in sterile Petri-dishes lined with wet filter papers for 48 h at 37°C, with frequent watering. The sprouts were rinsed in distilled water and dried at 55–60°C. The dried samples of raw and germinated chick peas and kidney peas were ground to fine powder in an electric grinder using a Laboratorial disc mill (Quadrumat Junior flour mill or Model Type No: 279002, ©Brabender ® OHG, Duisburg 1979, Germany) to pass through a 20 mesh/inch sieve and then stored in pouches bags for further use.

**Preparation of raw and germinated legumes flour or mushroom flour and wheat flour blends.** Raw and germinated legumes and mushroom were milled and sieved to obtain 72% extraction flour. Wheat flour of 72% or 82% extraction was well blended with raw and germinated legumes flour or mushroom flour to produce individual mixtures containing 0, 5, 10 and 15% replacement levels. All samples were stored in airtight containers and kept at 3–4°C until required.

**Balady bread making.** Balady bread making was done on an automatic commercial baking line according to Brown [1993] in the official baking house, north of Cairo city, Egypt.

Balady bread was prepared by mixing 100 g of wheat flour (82% extraction) / raw and germinated legumes and mushroom flour blends, 0.5 g of active dry yeast, 1.5 g of sodium chloride, 75–80 mL of water by hand for about 6 min to form the needed dough. The dough was left to ferment for 1 h at 30°C and 85% relative humidity, and was then divided into 125 g pieces. The pieces were arranged on a wooden board that had been sprinkled with a fine layer of bran and were left to ferment for about 45 min at the same temperature and relative humidity. The pieces of fermented dough were flattened to be about 20-cm in diameter. The flattened loaves were proofed at 30–35°C and 85% relative humidity for 15 min and then were baked at 400–500°C for 1–2 min.

The loaves were allowed to cool at room temperature for 2 h before being packed in polyethylene bags and stored at room temperature for further analysis.

**Biscuits making.** Test baking of biscuits was carried out for blends containing different levels of raw and germinated legumes flours or mushroom flours (0, 5, 10 and 15%). Biscuits were prepared according to the procedure described in A.A.C.C. [2000] with slight modifications. The ingredients included wheat flour or blends with raw or germinated legumes (chick peas and kidney peas) and mushroom flours were used as described by Sudha *et al.* [2007] and Hooda & Jood [2005]. The formula used was: 100 g of wheat flour (72% extraction), 57.77 g of sugar (cane, granular), 7.1 mL of water, 6 mL of fresh orange juice, 28.44 g of shortening, 0.93 g of salt (sodium chloride), 1.11 g of sodium bicarbonate and 14.66 g of dextrose. All ingredients (wheat flour control and wheat flour blends with raw and germinated legumes flours or mushroom flours) were mixed for 15 min using a mixer. The dough was then rolled between sheets of wax coated freezer paper to a uniform thickness of 9.mm and was cut using a circular mould to a diameter of 3.8 cm. Biscuits were baked at 205°C (400°F) for 9-10 min in a conventional air-fan electric oven. After baking, the biscuits were cooled to room temperature, packed in polyethylene pouches and sealed until analysis and testing.

**Dough characteristics.** Blends of 0, 5, 10 and 15% were prepared by substituting the wheat flour with raw and germinated legumes flours or mushroom flours. The effect of different flour levels on dough rheology was determined by Farinograph (Model Type No: 81010 (31, 50 and 63 rpm), ©Brabender® OHG, Duisburg, 1979, Germany) according to the standard methods [A.A.C.C., 2000]. Parameters measured were water absorption, dough development time, dough stability and mixing tolerance index (MTI). The elastic properties of dough with different levels of flours were measured using Extensograph (Model Type No: 81010 (31, 50 and 63 rpm), ©Brabender ® OHG, Duisburg, 1979, Germany) according to the standard [A.A.C.C. 2000] methods. The parameters studied were resistance to extension (R), extensibility (E), ratio figure (R/E) and energy (Area).

**Physical characteristics of biscuits.** Diameter (w) was measured by Boclase (HL 474938, STECO, Germany). Also, volume (v) and thickness (T) of biscuits were determined according to standard methods [A.A.C.C. 2000]. The spread ratio W/T was calculated. Percent spread ratio was calculated according to standard methods [A.A.C.C. 2000] by dividing the average value of diameter (w) by the average value of thickness (T) of biscuits.

**Analytical methods of protein determination.** Protein content of all samples was determined according to the macro Kjeldahl method [A.O.A.C., 2000].

**Colour determinations.** Objective evaluation of surface colour of biscuits and surface colour of crust of balady bread samples was measured. Hunter a*, b* and L* parameters were measured with a colour difference meter using a spectro-colourimeter (Tristimulus Colour Machine) with the CIE lab colour scale (Hunter, Lab Scan XE - Reston VA, USA) in the reflection mode. The instrument was standardized each time with white tile of Hunter Lab Colour Standard (LX No.16379): X= 72.26, Y= 81.94 and Z= 88.14 (L*= 92.46; a*= -0.86; b*= -0.16) [Sapers & Douglas, 1987].

The Hue (H)*, Chroma (C)* and Browning Index (BI) were calculated according to the method of [Palou *et al*., 1999] as follows:

$$H^* = \tan^{-1} [b^*/a^*] \quad (1)$$

$$C^* = \text{square root of } [a^{2*} + b^{2*}] \quad (2)$$

$$BI = [100 (x-0.31)]\ 10.72 \quad (3)$$

where:

$$X = (a^* + 1.75L^*) / (5.645L^* + a^* - 3.012b^*)$$

**Sensory characteristics.** The loaves of bread were allowed to cool on racks for about 1h before evaluation. Balady bread loaves were organoleptically evaluated for general appearance, surface colour of crust, taste, odour, roundness, crumb distribution, separation layer, upper layer thickness and lower layer thickness by 12 trained panelists according to El-Farra *et al*. [1982].

Sensory characteristics of biscuits were evaluated with some modifications, according to Zabik & Hoojjat [1984]. However, the sensory characteristics of biscuits were determined, using a taste panel, consisting of 12 judges. The panelists were asked to evaluate the products for surface colour, taste, odour, shape, texture and distribution of cell.

**Statistical analysis.** The results obtained were analysed statistically using SPSS statistical package (Version 9.05) according to Rattanathanalerk *et al*. [2005], analysis of variance (ANOVA), Duncan's multiple range test and least significant difference (LSD) was chosen to determine any significant difference among various treatments. Differences were found significant at $p<0.05$.

## RESULTS AND DISCUSSION

**Influence of raw and germinated legumes and mushroom flours on dough mixing properties (Farinograph) of biscuits made of flour with 72% extraction rate**

Incorporation of raw and germinated legumes and mushroom flours at 0%, 5%, 10% and 15% levels showed differences in dough mixing properties as measured by Farinograph. The results are indicated in Table 1.

TABLE 1. Effect of supplementation of wheat flour (72%) biscuit with different levels of raw and germinated legumes and mushroom flours on Farinograph reading.

| Samples | Water absorption (%) | Arrival time (min) | Dough development time (min) | Stability (min) | Mix Tolerance Index (BU) | Weakening (BU) |
|---|---|---|---|---|---|---|
| Control | 61.5 | 1.2 | 4 | 5.5 | 20 | 90 |
| 5% chick peas | 64 | 1.25 | 7 | 14 | 15 | 90 |
| 10% chick peas | 66 | 1.5 | 7 | 8 | 30 | 130 |
| 15% chick peas | 68 | 1.2 | 6 | 10 | 30 | 90 |
| 5% chick peas geminated | 64.5 | 1.2 | 3 | 10 | 20 | 110 |
| 10% chick peas geminated | 69 | 1.5 | 5 | 4.5 | 40 | 160 |
| 15% chick peas geminated | 70 | 2 | 4 | 8 | 40 | 160 |
| 5% mushroom | 66 | 1.5 | 4 | 6 | 30 | 160 |
| 10% mushroom | 68 | 1.5 | 5 | 6 | 50 | 110 |
| 15% mushroom | 68 | 1.5 | 4 | 8 | 60 | 100 |
| 5% kidney peas | 65 | 1.5 | 7.5 | 13 | 23 | 60 |
| 10% kidney peas | 68 | 1.8 | 7 | 8 | 20 | 60 |
| 15% kidney peas | 72 | 2 | 8 | 24 | 15 | 50 |
| 5% kidney peas germinated | 63 | 1.5 | 4 | 7 | 40 | 110 |
| 10% kidney peas germinated | 65 | 1 | 3 | 7 | 50 | 150 |
| 15% kidney peas germinated | 67 | 1 | 4 | 8 | 65 | 160 |

Addition of raw and germinated legumes and mushroom flours mainly increased the water absorption. By increasing the sample level from 5% to 15% the highest increase in water absorption was found with the addition of legumes flour samples (64–72%), for germinated legumes (63–70) and for mushroom flour (66–68%). The increase in the water absorption in the case of raw and germinated legumes flour was marginal. Similar effects on water absorption were observed by Sudha *et al*. [2007] when wheat bran or rice bran was added. Rosell *et al*. [2001] reported that the differences in water absorption are mainly caused by the greater number of hydroxyl groups which exist in the fiber structure and allow more water interactions through hydrogen bonding. The extent of increase in dough development time (DDT) was high in the case of raw and germinated legumes and mushroom flours. Dough stability which indicates the dough strength, decreased from 13 to 8 and 10 to 4.5 min in the case of raw and germinated legumes flours, respectively, whereas the extent of decrease was relatively marginal in the case of mushroom flours at the level of 5 and 10%. Greater effects were observed on the mixing tolerance index values (MTI). It increased in the case of germinated legumes flour and mushroom flour, whereas the extent of decrease was relatively marginal in the case of raw legumes flour with increasing the supplementation level from 5% to15%. Similar results were reported by Sudha *et al*. [2007] for the addition of wheat bran and rice bran blends. The results showed the weakening of dough with the increasing level from 5% to15% of germinated legumes flours, but adversely of the raw legumes and mushroom flours.

**Influence of raw and germinated legumes and mushroom flours on dough mixing properties (Farinograph) of balady bread made of flour with 82% extraction rate**

The effect of replacing wheat flour by raw and germinated legumes and mushroom flours at 0%, 5%, 10% and 15% levels on the Farinograph test is presented in Table 2. The raw and germinated legumes and mushroom dough developed readily with a low stability toward mixing, indicating deficient gluten quantity and quality. Water absorption, dough weakening and mixing tolerance index increased by increasing the level of germinated chick peas and mushroom flours, but decreased by increasing the level of raw and germinated kidney peas flour. Also, dough development time and stability increased by increasing the level of raw and germinated legumes, but decreased by increasing the level of mushroom flours. Greater effects were observed on the mixing tolerance index values (MTI). It increased in the case of germinated chick pea flour and mushroom flour, but decreased in germinated kidney pea flour whereas the extent of decrease or increase was relatively marginal in the case of raw chick and kidney pea flour with increasing the level from 5% to15%. Similar findings were observed by other authors [Rosell *et al*., 2001; Sudha *et al*., 2007; Ragaee *et al*., 2001; Doxastakis *et al*., 2002]. The increasing water absorption might be due to that raw and germinated legumes and mushroom flour containing more fiber, sugars and higher protein content, which retained more water.

**Influence of raw and germinated legumes and mushroom flours on the elastic properties of the dough (Extensograph) of balady bread**

The effect of incorporation of raw and germinated legumes flours and mushroom flours at varying levels on extensible properties is illustrated in Table 3. The resistance to extension values gradually increased for legumes flours addition with increasing levels of raw and germinated legumes flour, respectively, whereas it decreased for mushroom flour addition with increasing level of mushroom flour. This may likely be due to the interaction between polysaccharides and pro-

TABLE 2. Effect of supplementation of wheat flour (82%) balady bread with different levels of raw and germinated legumes and mushroom flours on Farinograph reading.

| Samples | Water absorption (%) | Arrival time (min) | Dough development time (min) | Stability (min) | Mix Tolerance Index (BU) | Weakening (BU) |
|---|---|---|---|---|---|---|
| Control | 57 | 2.5 | 6.5 | 10 | 40 | 80 |
| 5% chick peas | 60 | 1.5 | 10.5 | 18 | 30 | 80 |
| 10% chick peas | 63 | 1.75 | 7.25 | 10 | 30 | 85 |
| 15% chick peas | 64 | 2 | 10 | 19 | 20 | 90 |
| 5% chick peas geminated | 62 | 2 | 5 | 8.5 | 20 | 160 |
| 10% chick peas geminated | 62 | 3 | 7.5 | 9 | 40 | 170 |
| 15% chick peas geminated | 63 | 3 | 7.5 | 14 | 40 | 180 |
| 5% mushroom | 60 | 2.5 | 7 | 11 | 30 | 110 |
| 10% mushroom | 64 | 2 | 4.5 | 8 | 40 | 120 |
| 15% mushroom | 66 | 1.5 | 4 | 7 | 50 | 120 |
| 5% kidney peas | 65 | 2.5 | 5 | 19 | 15 | 40 |
| 10% kidney peas | 70 | 3.5 | 8 | 18 | 10 | 30 |
| 15% kidney peas | 73 | 3 | 6 | 22 | 10 | 20 |
| 5% kidney peas germinated | 60 | 4 | 6 | 12 | 30 | 70 |
| 10% kidney peas germinated | 64 | 4 | 7 | 22 | 25 | 50 |
| 15% kidney peas germinated | 67.5 | 5 | 9 | 25 | 15 | 20 |

TABLE 3. Extensograph properties of balady bread dough supplemented with different concentrations of raw and germinated legumes and mushroom flours.

| Samples | Dough energy ($cm^3$) | Dough extensibility (mm) | Dough resistance to extension (BU) | Proportion number (D=R/E) |
|---|---|---|---|---|
| Control | 54 | 125 | 240 | 1.92 |
| 5% chick peas | 43.5 | 120 | 280 | 2.33 |
| 10% chick peas | 55 | 110 | 340 | 3.09 |
| 15% chick peas | 78 | 95 | 780 | 8.21 |
| 5% chick peas geminated | 45 | 95 | 280 | 2.94 |
| 10% chick peas geminated | 67 | 105 | 500 | 4.76 |
| 15% chick peas geminated | 55 | 65 | 570 | 8.77 |
| 5% mushroom | 60 | 130 | 1090 | 8.38 |
| 10% mushroom | 74 | 110 | 705 | 6.41 |
| 15% mushroom | 84 | 100 | 690 | 6.9 |
| 5% kidney peas | 84 | 110 | 450 | 4.09 |
| 10% kidney peas | 66 | 88 | 770 | 8.75 |
| 15% kidney peas | 99 | 70 | 1000 | 14.29 |
| 5% kidney peas germinated | 25 | 45 | 270 | 6 |
| 10% kidney peas germinated | 66 | 50 | 940 | 18.8 |
| 15% kidney peas germinated | 77 | 50 | 1000 | 20 |

teins from wheat and mushroom flours as reported earlier by Jones & Erlander [1967]. The extensibility values were greatly reduced by the addition of raw and germinated legumes and mushroom flours. The ratio between dough resistance to extension and dough extensibility (D=R/E) increased with the increasing level of legumes (raw and germinated) and mushroom flours, indicating the dough becoming harder in the presence of legumes and mushroom flours.

The extent of increase in germinated legumes flour was marginal, indicating the dough becoming softer. The R/E ratio values increased to a greater extent in the case of germinated legumes from 1.92 for the control to 8.8–20 for 15% incorporation. It gradually increased from 2.3 to 14.3 and 2.94–20 for raw and germinated legumes, respectively. In the case of mushroom flour there was a marginal decrease in R/E values. Area under the curve decreased with the increase in the level of raw and germinated legumes and mushroom flours.

The raw and germinated legumes flours and mushroom flours extensogram indicated that the dough was softer and

TABLE 4. Physical characteristics (baking quality) of biscuit as affected by supplemented with different concentrations of raw and germinated legumes and mushroom flours.

| Samples | Weight (g) | Volume (cc) | Specific volume (cc/g) | Diameter (cm) | Thickness (cm) | Spread ratio | Spread ratio (±%) |
|---|---|---|---|---|---|---|---|
| Control | 30.50 | 250 | 8.2 | 6.67 | 1.37 | 4.87 | +11.87 |
| 5% chick peas | 28.44 | 271.7 | 9.6 | 6.67 | 1.73 | 3.86 | -11.64 |
| 10% chick peas | 30.02 | 253.3 | 8.5 | 6.64 | 1.67 | 3.98 | -2.96 |
| 15% chick peas | 34.73 | 251.6 | 7.3 | 6.9 | 1.5 | 4.60 | +5.25 |
| 5% chick peas geminated | 31.53 | 253.3 | 8.1 | 6.34 | 1.3 | 4.88 | +13.47 |
| 10% chick peas geminated | 34.41 | 256.6 | 7.5 | 6.77 | 1.6 | 4.23 | -3.42 |
| 15% chick peas geminated | 29.72 | 253.3 | 8.6 | 6.37 | 1.47 | 4.33 | 0.00 |
| 5% mushroom | 27.94 | 256.6 | 9.2 | 6.1 | 1.4 | 4.36 | +0.68 |
| 10% mushroom | 33.60 | 271.3 | 8.2 | 6.17 | 1.63 | 3.79 | -13.47 |
| 15% mushroom | 29.9953 | 263.3 | 8.8 | 6.17 | 1.37 | 4.50 | +3.42 |
| 5% kidney peas | 30.97 | 243.3 | 7.9 | 6.27 | 1.47 | 4.27 | -2.28 |
| 10% kidney peas | 31.30 | 260 | 8.3 | 6.37 | 1.83 | 3.49 | -20.55 |
| 15% kidney peas | 27.93 | 278.3 | 10 | 6.5 | 1.5 | 4.33 | -0.91 |
| 5% kidney peas germinated | 31.31 | 245 | 7.9 | 6.37 | 1.53 | 4.16 | -5.02 |
| 10% kidney peas germinated | 29.32 | 283.3 | 9.7 | 6.43 | 1.47 | 4.37 | +0.23 |
| 15% kidney peas germinated | 29.58 | 246.6 | 8.4 | 6.43 | 1.53 | 4.20 | -2.74 |

weaker than wheat flour dough (Table 3). Raw and germinated legumes flours and mushroom flours have less extensibility and highest dough energy than wheat flour dough. The substitution of wheat flour with raw and germinated legumes flours and mushroom flours at different levels minimized the extensibility. This decrement may be due to the deficiency of gliadin and glutenin in raw and germinated legumes and mushroom protein. The proportional number increased as the percentage of raw and germinated legumes flours and mushroom flours increased. These results are in agreement with those obtained by Jones & Erlander [1967] as well as by Naeem *et al*., [2002].

**Influence of raw and germinated legumes and mushroom flours on physical characteristics of biscuits**

Physical characteristics of biscuits, such as thickness, diameter and spread ratio, were affected by the increase in the level of raw and germinated of legumes flour and mushroom flour (Table 4). The changes in diameter and thickness are reflected in spread ratio which decreased consistently from 3.48 to 4.61 in raw legumes, 4.16–4.90 in germinated legumes and 3.79–4.53 in mushroom flour at 5–15% levels. These results indicated that the addition of raw and germinated legumes flour and mushroom flour adversely affected the thickness and diameter and thus, spread ratio of the supplemented biscuits. Cookies having higher spread ratios are considered most desirable [Kirssel & Prentice, 1979]. Other research workers also reported that the thickness of supplemented biscuits increased, whereas diameter and spread ratio of biscuits decreased with the increasing level of rice bran-fenugreek blends, fenugreek flour and different bran blends [Sharma & Chauhan, 2002; Hooda & Jood, 2005; Sudha *et al*., 2007].

Reduced spread ratios of raw and germinated legumes and especially of mushroom fortified biscuits were attributed to the fact that composite flours apparently form aggregates with increased numbers of hydrophilic sites available for competing for the limited free water in cookie dough [McWatters, 1978; Hooda & Jood, 2005]. Rapid partitioning of free water of these hydrophilic sites occurs during dough mixing and increases dough viscosity, thereby limiting cookie spread and top grain formation during baking.

**Influence of raw and germinated legumes and mushroom flours on protein content (mg/100 g) of balady bread and biscuits**

Table 5 shows that protein content increased with increasing raw and germinated legumes and mushroom flour in wheat flour. Control balady bread and biscuits had 5.67 and 9.18% protein content. In the case of supplemented biscuits, it ranged from 9.98 to 10.77% and from 9.18 to 10.70% in raw and germinated legumes flour based biscuits, but from 12.29 to 12.93% in mushroom flour based biscuits.

Also, in the case of supplemented balady bread, it ranged from 6.06 to 6.30% and from 5.985 to 7.10% in raw and germinated legumes flour based balady bread, but from 7.50 to 10.61% in mushroom flour based balady bread. The increase in protein content of germinated legumes and mushroom flours supplemented balady bread and of mushroom flours supplemented biscuits might be the result of the appreciably higher protein content of germinated legumes flour and mushroom flour. These results are confirmed with the results of Hooda & Jood [2005] who reported higher protein content of biscuits prepared from blends of wheat-raw and germinated fenugreek flours. This was also consistent with findings of Sharma & Chauhan [2000] who also reported higher protein content of breads prepared from blends of wheat-fenugreek flours.

TABLE 5. Effect of supplementation of wheat flour balady bread and biscuit with different levels of raw and germinated legumes and mushroom flours on protein content (mg/100 g).

| Untreated and treated samples | Protein content (mg/100 g) | |
|---|---|---|
| | balady bread | biscuit |
| Control | 5.67 | 9.18 |
| 5% chick peas | 6.06 | 10.77 |
| 10% chick peas | 6.14 | 10.77 |
| 15% chick peas | 6.22 | 11.09 |
| 5% chick peas geminated | 5.99 | 9.98 |
| 10% chick peas geminated | 6.14 | 10.69 |
| 15% chick peas geminated | 6.46 | 11.65 |
| 5% mushroom | 7.50 | 12.29 |
| 10% mushroom | 8.38 | 12.77 |
| 15% mushroom | 10.61 | 12.93 |
| 5% kidney peas | 6.06 | 9.66 |
| 10% kidney peas | 6.14 | 9.81 |
| 15% kidney peas | 6.30 | 9.90 |
| 5% kidney peas germinated | 6.70 | 9.98 |
| 10% kidney peas germinated | 6.78 | 10.45 |
| 15% kidney peas germinated | 7.10 | 11.97 |

From the same Table 5, it could be noticed that total protein content in balady bread increased by about 1.0% with each increment of mushroom flour, while this was 0.4% with each increment of germinated legumes flour and only 0.2% with each increment of raw legumes flour. At the same time, total protein content in biscuits increased by about 0.7–1.5% with each increment of germinated legumes flour, while this was 0.3–0.7% with each increment of raw legumes flour and only 0.64% with each increment of mushroom flour. However, raw and germinated legumes and mushroom proteins could primarily be used in cereal products to improve nutritional properties.

**Colour characteristics**

Colour characteristic is a major criterion that affects the quality of the final product. The fortified flours blends showed a difference in colour in relation to the control (100% wheat flour). The slight improvement in colour was interpreted as an intense colour and it was dependant on the fortification level. Mean colour values of biscuit and balady bread of different treatments are recorded in Tables 6 and 7. It was not considered to be a real disadvantage since event the commercial control biscuits or bread varies in colour intensity according to the fortified biscuits or bread from which it is produced by addition of raw and germinated legumes flour and mushroom flour [Barron & Espinoza, 1993].

Tables 6 and 7 shows Hunter values of whiteness (L), redness (a) and Yellow (b) measured for crumb and crust colours. All fortified samples had slightly lower L values for

TABLE 6. Colour characteristics of biscuits (cookies) supplemented with raw and germinated legumes and mushroom flours.

| Samples | L* | a* | b* | C* | H* | BI |
|---|---|---|---|---|---|---|
| Control | 79.61 | 4.82 | 30.14 | 30.52 | 20.36 | 92.82 |
| 5% chick peas | 77.87 | 6.86 | 29.84 | 30.62 | 20.3 | 98.01 |
| 10% chick peas | 72.70 | 10.69 | 32.37 | 34.09 | 35.08 | 124.59 |
| 15% chick peas | 72.30 | 9.75 | 33.85 | 35.23 | 23.54 | 130.08 |
| 5% chick peas geminated | 77.03 | 4.59 | 31.18 | 31.51 | 23.6 | 100.15 |
| 10% chick peas geminated | 75.73 | 7.15 | 30.15 | 30.99 | 21.75 | 103.18 |
| 15% chick peas geminated | 77.80 | 6.24 | 32.09 | 32.69 | 23.07 | 105.32 |
| 5% mushroom | 72.59 | 7.22 | 28.78 | 29.67 | 21.95 | 103.41 |
| 10% mushroom | 67.87 | 8.45 | 30.01 | 31.18 | 22.24 | 120.51 |
| 15% mushroom | 64.85 | 8.24 | 29.80 | 30.92 | 21.9 | 126.29 |
| 5% kidney peas | 79.92 | 5.38 | 31.41 | 31.87 | 24.32 | 97.87 |
| 10% kidney peas | 76.717 | 5.97 | 34.72 | 35.24 | 24.65 | 117.14 |
| 15% kidney peas | 75.63 | 8.05 | 35.61 | 36.51 | 24.56 | 126.95 |
| 5% kidney peas germinated | 81.52 | 4.46 | 32.80 | 33.11 | 22.78 | 98.79 |
| 10% kidney peas germinated | 77.00 | 7.56 | 31.67 | 32.56 | 23.22 | 107.55 |
| 15% kidney peas germinated | 74.53 | 9.78 | 34.61 | 35.97 | 24.04 | 128.37 |

crust than the control and therefore a slightly darker crumb colour. All breads incorporating raw and germinated legumes flour and mushroom flour, especially germinated legumes flour, had lower crust L values than the control, indicating darker colour. There results are in coincidence and confirmed with these obtained by Kenny *et al*. [2000].

Increasing the percentage of added raw and germinated legumes flours and mushroom flours to wheat flours, the values of whiteness (L), redness (a), Yellow (b), chroma (C*), hue angle (H*) and browning index (BI) slightly increased in all fortified samples. Subjective evaluations confirmed that the raw legumes flour and mushroom flour biscuits and bread samples were darker, more red (a-values) and with higher browning index (BI) than with germinated legumes flour and control samples.

The results showed that the a-values (redness) and browning index (BI) increased in the fortified biscuit samples with the increasing level of raw and germinated legumes flour and mushroom flour from 5% to15% (Table 6), but decreased in the fortified balady bread samples with the increasing level of raw chick pea flour and germinated kidney pea flour from 5% to15% (Table 7). There results are consistent with these obtained by Ahmed [1999] and Kenny *et al*. [2000].

**Sensory evaluation**

*Sensory characteristics of biscuits*

The effects of legumes and mushroom supplementation on the sensory characteristics of biscuits are presented in Table 8. With the increase in the level of legumes (raw

TABLE 7. Colour characteristics of balady bread supplemented with raw and germinated legumes and mushroom flours.

| Samples | L* | a* | b* | C* | H* | BI |
|---|---|---|---|---|---|---|
| Control | 55.62 | 6.80 | 20.23 | 21.34 | 19.48 | 97.27 |
| 5% chick peas | 52.04 | 7.43 | 20.42 | 21.73 | 19.46 | 108.19 |
| 10% chick peas | 51.70 | 6.72 | 19.20 | 20.34 | 19.03 | 100.47 |
| 15% chick peas | 52.85 | 5.88 | 19.25 | 20.12 | 21.45 | 95.90 |
| 5% chick peas geminated | 58.86 | 5.44 | 19.34 | 20.09 | 18.05 | 83.70 |
| 10% chick peas geminated | 56.08 | 5.40 | 18.72 | 19.48 | 20 | 85.57 |
| 15% chick peas geminated | 56.63 | 6.58 | 20.21 | 21.25 | 20.1 | 94.55 |
| 5% mushroom | 57.78 | 7.25 | 20.99 | 22.20 | 21.11 | 97.60 |
| 10% mushroom | 55.37 | 8.86 | 22.43 | 24.11 | 24.7 | 114.2 |
| 15% mushroom | 47.65 | 9.34 | 20.13 | 22.19 | 21.1 | 124.29 |
| 5% kidney peas | 52.74 | 6.39 | 23.60 | 24.44 | 25.58 | 121.64 |
| 10% kidney peas | 55.21 | 7.23 | 19.79 | 21.06 | 19.29 | 97.00 |
| 15% kidney peas | 54.17 | 7.74 | 20.96 | 22.34 | 21.85 | 106.64 |
| 5% kidney peas germinated | 49.06 | 9.46 | 21.39 | 23.39 | 24.23 | 127.97 |
| 10% kidney peas germinated | 48.27 | 8.78 | 20.70 | 22.48 | 22.68 | 124.31 |
| 15% kidney peas germinated | 53.76 | 8.21 | 21.88 | 23.36 | 22.8 | 113.78 |

TABLE 8. Statistical analysis of sensory evaluation of biscuit as affected by different levels of raw and germinated legumes and mushroom flours (mean values).

| Samples | Shape | Surface colour | Taste | Odour | Texture | Distribution of cell |
|---|---|---|---|---|---|---|
| Control | $7.9^{A}$ | $8.0^{A}$ | $7.6^{AB}$ | $7.9^{A}$ | $7.3^{A}$ | $7.7^{AB}$ |
| 5% chick peas | $7.6^{ABC}$ | $7.6^{ABC}$ | $7.5^{AB}$ | $8.0^{A}$ | $7.1^{A}$ | $7.6^{AB}$ |
| 10% chick peas | $7.9^{A}$ | $8.3^{A}$ | $7.9^{A}$ | $8.1^{A}$ | $7.2^{A}$ | $7.9^{AB}$ |
| 15% chick peas | $6.5^{BC}$ | $6.7^{BCD}$ | $7.9^{A}$ | $8.2^{A}$ | $6.4^{A}$ | $7.5^{AB}$ |
| 5% chick peas geminated | $6.5^{BC}$ | $6.5^{CD}$ | $7.5^{AB}$ | $7.3^{AB}$ | $6.5^{A}$ | $7.6^{AB}$ |
| 10% chick peas geminated | $7.7^{AB}$ | $7.4^{ABCD}$ | $7.5^{AB}$ | $7.9^{A}$ | $7.3^{A}$ | $7.9^{AB}$ |
| 15% chick peas geminated | $7.4^{ABC}$ | $7.1^{ABCD}$ | $7.2^{ABC}$ | $7.7^{A}$ | $6.9^{A}$ | $7.3^{AB}$ |
| 5% mushroom | $6.9^{ABC}$ | $7.1^{ABCD}$ | $6.0^{CD}$ | $6.1^{C}$ | $6.6^{A}$ | $5.9^{C}$ |
| 10% mushroom | $6.4^{BC}$ | $6.1^{D}$ | $6.5^{BCD}$ | $6.3^{BC}$ | $7.0^{A}$ | $6.9^{BC}$ |
| 15% mushroom | $6.3^{C}$ | $6.1^{D}$ | $5.4^{D}$ | $5.9^{C}$ | $6.7^{A}$ | $6.9^{BC}$ |
| 5% kidney peas | $7.9^{A}$ | $7.6^{ABC}$ | $7.9^{A}$ | $7.7^{A}$ | $7.5^{A}$ | $7.8^{AB}$ |
| 10% kidney peas | $7.0^{ABC}$ | $6.3^{CD}$ | $7.2^{ABC}$ | $7.7^{A}$ | $6.6^{A}$ | $6.9^{BC}$ |
| 15% kidney peas | $6.8^{AB}$ | $6.5^{CD}$ | $7.0^{ABC}$ | $7.6^{A}$ | $6.5^{A}$ | $6.8^{BC}$ |
| 5% kidney peas germinated | $7.1^{ABC}$ | $6.7^{BCD}$ | $7.8^{A}$ | $7.7^{A}$ | $7.7^{A}$ | $8.1^{A}$ |
| 10% kidney peas germinated | $7.7^{AB}$ | $8.0^{AB}$ | $7.0^{ABC}$ | $7.5^{A}$ | $7.6^{A}$ | $7.8^{AB}$ |
| 15% kidney peas germinated | $7.7^{AB}$ | $7.3^{ABCD}$ | $7.7^{AB}$ | $7.7^{A}$ | $7.0^{A}$ | $7.3^{AB}$ |
| LSD** | 1.530184 | 1.921501 | 1.564211 | 1.353010 | NS* | 1.487346 |

* Non-significant; ** Least Significant Difference

and germinated) and mushroom in the formulation, the sensory scores for shape, colour, texture and odour of biscuits decreased and increased sharply. Replacement of flour with 5% and 10% legumes flour (raw and germinated) and mushroom flour impaired the taste of biscuits (control samples had 7.6 score), which decreased significantly from 7.5–7.9 (raw legumes), 7.5–7.8 (germinated legumes) and 6.0–5.4 (mushroom) up to 15% levels, respectively, which might be due to the bitter taste of raw and germinated legumes flour.

The control samples had maximum shape and colour acceptability, whereas biscuits containing 15% addition of raw and germinated legumes flour and mushroom flour were found to be shape and colour unacceptable to the panelists in terms of shape and colour. The shape and colour acceptability score for control was 7.9 and 8.0 on a 10-point hedonic scale. Biscuits made from blends containing 5% level of raw legumes and 10% level of germinated legumes flours did not differ significantly ($p<0.05$) from the control. At 15% levels of substitution, the shape and colour acceptability was rated as poor. The germinated legumes flour-supplemented biscuits performed better than the other legumes and mushroom–supplemented biscuits. Similar observations were also reported with supplementation of rice bran-fenugreek blends flour [Sharma & Chauhan, 2002] and fenugreek flour [Hooda & Jood, 2005] with wheat flour.

Biscuits made from blends containing 5% level of raw legumes and 10% level of germinated legumes flours did not differ significantly ($p<0.05$) from the control. At 15% levels of substitution, the shape and colour acceptability was rated as poor. The raw and germinated legumes flour-supplemented biscuits with 5 and 10% performed better in distribution of cell than the control and the other legumes and mushroom--supplemented biscuits.

From the sensory acceptability rating, it was concluded that legumes and mushroom flour could be incorporated up to 10% level in the formation of biscuits without affecting their sensory quality.

With respect to the sensory evaluation, the organoleptic characteristics of biscuit samples made from wheat flour and different levels of raw and germinated legumes flour and mushroom flour are summarized in Table 8. There was a highly significant difference in all sensory properties of biscuits except texture score between the control sample and those blends which contained raw and germinated legumes flour and mushroom flour up to 15% level. Biscuits prepared with raw and germinated legumes flour and mushroom flour at any level addition received significantly higher scores for colour, taste, shape, odour and distribution of cell with the highest acceptability. The results obtained indicated that raw and germinated legumes flour could constitute a good alternative for biscuits manufacture.

*Sensory characteristics of balady bread*

Panelists liked all tested balady breads (Table 9). The general appearance, distribution of crumb, crust colour, odour, roundness, separation layer, taste, upper and lower thickness of the breads containing raw and germinated legumes flour and mushroom flour up to 15% were ranked higher than the control bread. The sensory evaluation data demonstrated that wheat flour could be replaced up to 10% using raw and germinated legumes flour and mushroom flour without drastically affecting bread quality [Pena & Amaya, 1993; Doxastakis *et al*., 2002; Naeem *et al*., 2002].

There was a highly significant difference in all sensory properties of balady bread score between the control sample and those blends which contained raw and germinated legumes flour and mushroom flour up to 15% level. Balady bread prepared with raw and germinated legumes flour and

TABLE 9. Statistical analysis of sensory evaluation of balady bread as affected by different levels of raw and germinated legumes and mushroom flours (mean values).

| Samples | Appearance | Color of Crust | Taste | Odour | Roundness | Crumb distribution | Separation Layer | Upper Layer Thickness | Lower Layer Thickness |
|---|---|---|---|---|---|---|---|---|---|
| Control | 5.67$^{BC}$ | 5.5$^{DEF}$ | 5.42$^{BC}$ | 4.75$^{D}$ | 4.58$^{DE}$ | 6.0$^{ABC}$ | 5.50$^{ABC}$ | 4.92$^{ABCDE}$ | 5.50$^{ABCD}$ |
| 5% chick peas | 4.75$^{CD}$ | 4.67$^{EF}$ | 3.67$^{DE}$ | 4.50$^{D}$ | 4.75C$^{DE}$ | 3.58$^{E}$ | 4.67$^{CD}$ | 4.33$^{CDE}$ | 4.08$^{DEF}$ |
| 10% chick peas | 3.25$^{E}$ | 2.42$^{G}$ | 2.67$^{E}$ | 2.83$^{E}$ | 3.83$^{E}$ | 3.42$^{E}$ | 3.42$^{D}$ | 3.17$^{E}$ | 3.17$^{F}$ |
| 15% chick peas | 7.00$^{AB}$ | 7.17$^{ABC}$ | 6.5$^{AB}$ | 7.08$^{AB}$ | 6.83$^{A}$ | 5.75$^{BCD}$ | 5.83$^{ABC}$ | 5.25$^{ABCD}$ | 5.17$^{ABCDE}$ |
| 5% chick peas geminated | 6.58$^{AB}$ | 6.42$^{BCD}$ | 6.42$^{AB}$ | 6.00$^{ABCD}$ | 6.50$^{A}$ | 5.92$^{ABC}$ | 6.58$^{AB}$ | 5.33$^{ABCD}$ | 5.25$^{ABCD}$ |
| 10% chick peas geminated | 6.00$^{BC}$ | 5.83$^{CDE}$ | 5.33$^{BC}$ | 5.33$^{CD}$ | 6.08$^{ABC}$ | 5.50$^{CD}$ | 4.83$^{CD}$ | 4.83$^{ABCDE}$ | 4.0$^{DEF}$ |
| 15% chick peas geminated | 7.58$^{A}$ | 7.67$^{AB}$ | 7.58$^{A}$ | 7.08$^{AB}$ | 6.92$^{A}$ | 7.08$^{AB}$ | 6.67$^{AB}$ | 6.58$^{A}$ | 6.42$^{A}$ |
| 5% mushroom | 7.75$^{A}$ | 7.67$^{AB}$ | 6.08$^{AB}$ | 6.67$^{ABC}$ | 7.25$^{A}$ | 5.92$^{ABC}$ | 6.67$^{AB}$ | 5.83$^{ABC}$ | 5.83$^{ABC}$ |
| 10% mushroom | 6.00$^{BC}$ | 5.5$^{DEF}$ | 5.33$^{BC}$ | 6.50$^{ABC}$ | 6.08$^{ABC}$ | 4.75$^{CDE}$ | 5.42$^{BC}$ | 4.00$^{DE}$ | 4.42$^{BCDEF}$ |
| 15% mushroom | 6.58$^{AB}$ | 6.33$^{BCD}$ | 5.00$^{BCD}$ | 5.92$^{ABCD}$ | 6.00$^{ABCD}$ | 5.17$^{CD}$ | 5.42$^{BC}$ | 4.50$^{BCDE}$ | 4.42$^{BCDEF}$ |
| 5% kidney peas | 6.42$^{AB}$ | 6.33$^{BCD}$ | 6.67$^{AB}$ | 6.00$^{ABCD}$ | 6.92$^{A}$ | 5.92$^{ABC}$ | 6.67$^{AB}$ | 5.33$^{ABCD}$ | 5.83$^{ABC}$ |
| 10% kidney peas | 4.17$^{DE}$ | 4.17$^{F}$ | 4.42$^{CD}$ | 4.42$^{DE}$ | 5.00$^{BCDE}$ | 3.67$^{E}$ | 3.50$^{D}$ | 3.25$^{E}$ | 3.17$^{F}$ |
| 15% kidney peas | - | - | - | - | - | - | - | - | - |
| 5% kidney peas germinated | 7.92$^{A}$ | 7.67$^{AB}$ | 7.08$^{A}$ | 7.25$^{A}$ | 7.33$^{A}$ | 7.25$^{A}$ | 7.33$^{A}$ | 6.25$^{AB}$ | 6.08$^{AB}$ |
| 10% kidney peas germinated | 5.83$^{BC}$ | 8.1$^{A}$ | 5.42$^{BC}$ | 5.58$^{BCD}$ | 6.25$^{AB}$ | 4.42$^{DE}$ | 4.67$^{CD}$ | 4.50$^{BCDE}$ | 4.25$^{CDEF}$ |
| 15% kidney peas germinated | - | - | - | - | - | - | - | - | - |
| LSD** | 1.35691 | 1.39319 | 1.59113 | 1.63128 | 1.490803 | 1.401202 | 1.65311 | 1.76295 | 1.71241 |

** Least Significant Difference

mushroom flour at any level addition received significantly higher scores for appearance, distribution of crumb, crust colour, odour, roundness, separation layer, upper and lower thickness and taste with the highest acceptability. The results obtained indicated that raw and germinated legumes flour could constitute a good alternative for balady bread manufacture.

## CONCLUSIONS

The results obtained indicated that raw and germinated legumes (chick peas and kidney peas) flour and mushroom flour may be blended with wheat flour at levels as high as 15% without adversely affecting baking performance of balady bread, but with some adverse effects on biscuits. However, the addition of raw and germinated legumes and mushroom flours as a source of protein to wheat flour affected the rheological, colour and sensory characteristics of balady bread and biscuits in various ways. Balady bread and biscuits containing germinated chick peas and kidney peas flour (15%) and mushroom flour (15%) were high in protein and acceptable. The protein composition of these samples showed that protein, which plays a very important role in improving rheological, technological and sensory properties of baking products, could be used for enriching the protein content of balady bread and biscuits. These studies have shown the potential for developing protein-rich balady bread and biscuits.

## REFERENCES


1. A.A.C.C., Approved Method of the AACC. 10th ed., American Association of Cereal Chemists, INC. st., Paul, 2000, Minnesota, USA.
2. A.O.A.C., Official Methods of Analysis of the Association of Official Analytical Chemists, 17th ed., Association of Official Analytical Chemists, 2000, Arlington, Virginia, USA.
3. Ahmed Z.S., Effect of hydrocolloids in Egyptian balady bread. II. Baking quality. J. Agric. Sci. Mansoura Univ., 1999, 24, 3535–3544.
4. Autio K., Fabritius M., Kinnunen A., Effect of germination and water content on the microstructure and rheological properties of two rye doughs. Cereal Chem., 1998, 75, 10–14.
5. Barron J., Espinoza A., Fortification of maize tortilla with alkali-treated Chickpea flour. Int. J. Food Sci. Technol., 1993, 28, 505–511.
6. Brown, J., Advances in breadmaking technology. 1993, *in*: Advances in Baking Technology (eds. B.S. Kamel, C.E. Stauffer). Chapter 3. Blackie Academic & Professional, London-NewYork-Tokyo, pp. 38–87.
7. Deshpande A., Tamhne D., Studies on dehydration of mushrooms. J. Food Sci. Tech. – India, 1981, 18, 96–101.
8. Doxastakis G., Zafiriadis I., Irakli M., Marlani H., Tananaki C., Lupine, Soya and triticale addition to wheat flour doughs and their effect on rheological properties. Food Chem., 2002, 77, 219–227.
9. EL-Farra A.A., Khorshid, A.M., Mansour S.M., Elias A.N., Studies on the possibility of supplementation of balady bread with various commercial soy-products. 1982, *in*: Materials of the 1st Egyptian Conference on Bread Research, pp. 9–23.
10. Fahmey A., Noaman M., Ammar K., Zein R., Chemical and technological studies on baby foods. II – Amino acids composition. Egypt. J. Food Sci., 1981, 9, 59–74.
11. Gandhi A., Kotwaliwale N., Kawalkar J., Srivastava D., Parihar V., Raghu Nadh P., Effect of incorporation of defatted soy flour on the quality of sweet biscuits. J. Food Sci. Technol., 2001, 38, 502–503.
12. Hooda S., Jood S., Organoleptic and nutritional evaluation of wheat biscuits supplemented with untreated and treated fenugreek flour. Food Chem., 2005, 90, 427–435.
13. Hoover W., Use of soy proteins in baked foods. J. Am. Oil Chem. Soc., 1979, 56, 301–305.

14. Jones R., Erlander S., Interactions between wheat proteins and dextrans. Cereal Chem., 1967, 44, 447–453.
15. Kenny S., Karina W., Catherine S., Elke A., Incorporation of dairy ingredients into wheat bread: effects on dough rheology and bread quality. Eur. Food Res. Technol., 2000, 210, 391–396.
16. Kirssel L., Prentice M., Protein and fibre enrichment of cookie flour with brewer's spent grains. Cereal Chem., 1979, 50, 261–265.
17. McWatters K., Cookie baking properties of defatted peanut, soybean and field pea flours in baking powder biscuits. Cereal Chem., 1978, 55, 853–863.
18. Naeem H.A., Darvey N.L., Gras P.W., MacRitchie F., Mixing properties, baking potential, and functionality changes in storage protein during dough development of triticale-wheat flour blends. Cereal Chem., 2002, 79, 332–339.
19. Paeaekkoenen K., Kurbela R., Effect of drying method on the water sorption of blanched Northern milk cap mushrooms (*Lactarius trivialis*) at different temperatures. Lebens. Wiss. Technol., 1987, 20, 158–161.
20. Palou E., Lopez-Malo A., Barbosa-Canovas G., Chanes-Welti J., Swanson W., Polyphenoloxidase and colour of blanched and high hydrostatic pressure treated banana puree. J. Food Sci., 1999, 64, 42–45.
21. Pena R.J., Amaya A., Milling and bread making properties of wheat-triticale grain blends. J. Sci. Food Agric., 1993, 60, 483–487.
22. Petrovska B., Kulevanova S., Stefov V., Infrared analysis of Macedonian mushroom dietary fibre. Nahrung / Food., 2002, 46, 238–239.
23. Ragaee S.M., Campbell G.L., Scoles G.J., Macleod J.G., Tyler R.T., Studies on rye (Secale cereal L.) lines exhibiting a range of extract viscosities. . Rheological and baking characteristics of rye and rye/wheat blends and feeding value for chicks of wholemeals and breads. J. Agric. Food Chem., 2001, 49, 2446–2453.
24. Rattanathanalerk, M., Naphaporn,C., Walaiporn, S., Effect of thermal processing on the quality loss of pineapple juice. J. Food Eng., 2005, 66, 259–265.
25. Rosell, C., Rojas J., Benedito B., Influence of hydrocolloids on dough rheology and bread quality. Food Hydrocoll., 2001, 15, 75–81.
26. Sapers G., Douglas F., Measurement of enzymatic browning at cut surfaces and in juice of raw apple and pear fruits. J. Food Sci., 1987, 52, 1258–1262, 1285.
27. Sharma H., Chauhan G., Physicochemical and rheological quality characteristics of fenugreek supplemented wheat flour. J. Food Sci. Technol., 2000, 37, 87–90.
28. Sharma H., Chauhan G., Effects of stabilized rice bran-fenugreek blends on the quality of breads and cookies. J. Food Sci. Technol., 2002, 39, 225–233.
29. Stark A., Satterlee L., Kendrick J., Computer blending and laboratory evaluation of added food proteins for specific functional and nutritional properties. Food Prod. Devel., 1975, 9, 38–42.
30. Sudha, M., Vetrimani R., Leelavathi K., Influence of fibre from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. Food Chem., 2007, 100, 1365–1370.
31. Ulloa J., Valencia M., Garcia Z., Protein concentrates from chickpea: Nutritive value of a protein concentrate from chickpea obtained by ultrafiltration. J. Food Sci., 1988, 53, 1396–1398.
32. Varughese G., Pfeiffer W.H., Pena R.J., Triticale: A successful alternative crop. I. Cereal Foods World, 1996, 41, 474–482.
33. Zabik M.E., Hoojjat P., Sugar-shap cookies prepared with wheat-navybean sesame seed flour blends. Cereal Chem., 1984, 61, 41–44.