Development of healthy multigrain biscuits from buckwheat-barley composite flours

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ABSTRACT

Multigrain biscuits were formulated by blending refined wheat flour with barley and buckwheat flours in the ratios of 100:0:0::WF:BF:BWF; 0:100:0::WF:BF:BWF; 80:20:0::WF:BF:BWF; 70:20:10::WF:BF:BWF; 60:20:20::WF:BF:BWF; 50:20:30::WF:BF:BWF; 40:20:40::WF:BF:BWF; 30:20:50::WF:BF:BWF. Incorporation of buckwheat flour led to increase in mean calcium, iron and zinc contents of the biscuits. Among the blends the highest mean calcium of 68.96 mg/100g, iron of 9.22 mg/100g, zinc of 5.28 mg/100g were observed in treatment T8 (30:20:50::WF:BF:BWF). In terms of taste and flavour scores, T8 (30:20:50::WF:BF:BWF) was also adjudged the best treatment for the development of multigrain biscuits, whereas highest colour score of 8.05, texture score of 7.96 and overall acceptability score of 7.95 were observed in T1 (100:0:0::WF:BF:BWF). Biscuits were stored for a period of 90 days during which there was a significant decline in mineral contents as well as sensory attributes. Economically, the blended biscuits were found to be cheaper as compared to commercially available multigrain biscuits.

Key words: Apricot, Barley, Buckwheat, Multigrain Biscuits, Pseudo-Cereal.

INTRODUCTION

Buckwheat (FagopyrumesculentumMoench) is highly nutritious pseudo-cereal known as a dietary source of protein with favourable amino acid composition and vitamins (Bonafaccia et al., 2003a), starch and dietary fiber (Skrabanja et al., 2004), essential minerals (Steadman et al., 2001) and trace elements (Bonafaccia et al., 2003b). Phenolic compounds are also found in abundance in buckwheat, including rutin, orientin, vitexin, quercetin, isovitexin, kaempferol-3-rutinoside, isoorientin, and catechins (Dietrych-Szostak and Oleszek, 1999). In comparison to most frequently used cereals, buckwheat has been reported to posses higher antioxidant activity, mainly due to high rutin content (Kreft et al., 2006) may inhibit lipid peroxidation. These functional components of buckwheat have health benefits like reducing high blood pressure, controlling blood sugar, lower blood cholesterol, prevents accumulation of fat, constipation (Kayashita et al., 1996), mammary carcinogenesis and colon carcinogenesis (Liu et al., 2001), strengthen capillary blood vessels (Watanabe, 1998) and suppresses gallstone formation and plasma cholesterol (Tomotake et al., 2000). In fact, most of buckwheat’s healthy effects are attributed to its high levels of phenolic compounds and antioxidant activity. Another functionality of buckwheat stems from its gluten-free characteristics making buckwheat suitable for the diet for celiac disease patients (Fessas et al., 2008). Several studies have been carried out to investigate incorporation of buckwheat flour in flour mixtures for gluten-free bread production (Alvarez-Jubete et al., 2010).

Barley (Hordeumvulgare L.) is considered as a functional grain because it contains β-glucan, B-complex vitamins, tocoetherols, tocopherols and has significant antioxidant potential (Sharma and Gujral, 2010a). Barley has higher amounts of phenolic compounds and antioxidant activity as compared to the more widely consumed cereals, wheat and rice (Sharma et al., 2012). Studies have shown that barley flour has high content of dietary fiber and high proportion of soluble fiber especially β-glucan. Health effects of β-glucans are suggested to lower plasma cholesterol, improving lipid metabolism, reducing glycemic index and boosting the immune system. Insoluble fiber is known for reduction in the risk of colon cancer (Potry, 1996). In barley most of the free phenolics are flavonols and tocopherols, whereas the bound phenolics are mainly phenolic acids (ferulic acid and p-coumaric acid) (Holtekjolen et al., 2006). It is therefore becoming an important cereal crop from nutritional and functional point of view. Numbers of experiments have shown that barley can be successfully incorporated in a vast array of products such as different types of bread, Asian noodles, bars, muffins, biscuits and cookies (Izydorczyk and Dexter, 2008).
Due to changing lifestyle, the people have started demanding ready to cook or ready to serve convenience foods. Among ready-to-eat snacks, biscuits possess several attractive features including wider consumption base, relatively longer shelf-life, more convenience and good eating quality (Hooda and Jood, 2005). Long shelf life of biscuits makes large scale production and distribution possible. The multigrain blends helps to mix different whole grains to maximize their nutritional, functional and sensory properties. Keeping in view, the tremendous benefits of the selected underutilized crops, i.e. buckwheat and barley, the present study was undertaken to assess the nutritional, nutraceutical and sensory attributes of the developed product.

MATERIALS AND METHODS

Raw grains of buckwheat (*Fagopyrum esculentum*) and barley (*Hordeum vulgare*) and dried apricot (*Prunus armeniaca*) were procured from Leh, Ladakh, India. Refined wheat flour (*Triticum aestivum*), ghee (vegetable fat), sodium bicarbonate and cane sugar were purchased from local market of Jammu. Cane sugar was grounded into fine powder using grinder (Philips, Model: HL 1632, New Delhi, India). Aluminium laminated pouches used for packaging of multigrain biscuits were obtained from Vishwas Traders, Jammu.

The multigrain flours of wheat, barley and buckwheat were blended together in different ratios as per the treatments given below.

| Treatments | Wheat flour | Barley flour | Buckwheat flour |
|------------|-------------|--------------|----------------|
| T₁         | 100         | 0            | 0              |
| T₂         | 0           | 100          | 0              |
| T₃         | 80          | 20           | 0              |
| T₄         | 70          | 20           | 10             |
| T₅         | 60          | 20           | 20             |
| T₆         | 50          | 20           | 30             |
| T₇         | 40          | 20           | 40             |
| T₈         | 30          | 20           | 50             |

The process for preparation of biscuits was standardized using creaming method given by Whitley (1995). The ingredients used for the preparation of biscuits were flour (70 g), apricot powder (30 g), ghee (30 g), sugar (1.5 g), sodium bicarbonate (1.5 g) and water (30 ml).

Mineral matters were determined following procedure of Chapman and Pratt (1961) by dry ashing method using atomic absorption spectrophotometer. The samples were evaluated on the basis of color, texture/body, taste and overall acceptability by semi-trained panel of 9-10 judges using 9 point hedonic scale assigning scores 9-like extremely to 1-dislike extremely. A score of 5.5 and above was considered acceptable (Amerine *et al.* 1965). All the analyses were the means of three replicates. The cost of production of the product was determined by taking into consideration, the cost of raw materials, chemicals, packaging materials, etc. used in the preparation of the product. All the experiments were performed in triplicates. Data collected from aforesaid experiments was subjected to ANOVA (statistical analysis) with the help of factorial completely randomized design (Gomez and Gomez, 2010) and using the OP Stat software package.

RESULTS AND DISCUSSION

**Mineral contents**

Calcium: Calcium content of the multigrain biscuits was found to be increased from 41.99 to 68.96 mg/100g with the supplementation of refined wheat flour with composite flour of barley and buckwheat (Table 1). This might be due to the higher calcium contents in buckwheat and barley as compared to wheat flour. These findings are in accordance with results of Gupta *et al.* (2011a) who reported increase in calcium content in barley formulated cookies. Similarly, Yildiz and Bilgicli (2012) reported increase in calcium content of bread *Lavas* with the blending of whole buckwheat flour. Storage studies of multigrain biscuits revealed a significant (P≤0.05) decrease in its calcium content from 56.90 to 56.59 mg/100g with the storage of 90 days. The reason behind the decrease in calcium content might be due to their interaction with other components like protein and carbohydrates. Our findings are in conformity with the findings of Rubin *et al.* (1997) who studied the effect of micronutrient addition to cereal grain products.
Iron: There was a significant increase in iron content of multigrain biscuits upon the incorporation of barley-buckwheat composite flour which was noted to be ranged from 5.47 to 9.22 mg/100g (Table 2). Higher iron content of the composite flour might be the reason behind increasing trend in iron content of the blended biscuits. Arshad et al. (2014) reported increase in iron content with the incorporation of barley and oat flours in wheat flour while making multigrain cookies. During the storage of 90 days iron content decreased from 8.61 to 8.32 mg/100g which might be due to its interaction with other components. Misfa et al. (2000) reported decreasing trend in iron content in wheat atta fortified with elemental iron used for chapatti production.

Zinc: Zinc content of multigrain biscuits significantly increased from 2.60 to 5.28 mg/100g with the increase in the levels of composite flour in the wheat flour which might be due to higher zinc content of the former (Table 3). Hooda and Jood (2005) observed similar trend in fenugreek supplemented biscuits. Storage studies revealed that zinc content of the multigrain biscuits decreased significantly from 4.13 to 3.89 mg/100g, during storage period of 90 days. This might be due to its interaction with proteins and carbohydrates. Our results are in accordance with the findings of Sikandra and Boora (2009) while conducting nutritional evaluation of sorghum and chickpea incorporated value added products.

**Organoleptic evaluation:** Figures 1 to 4 depict the effect of buckwheat flour incorporation on the organoleptic characteristics of multigrain biscuits. With the increase in the level of buckwheat flour in the formulation, the sensory scores for colour, texture and overall acceptability of biscuits decreased (Chopra et al., 2014; Sedej et al., 2011b). The colour of buckwheat blended biscuits was darker and scored 6.39 at its higher incorporation as compared to that from wheat flour 8.05 because it had lower lightness and higher yellowness values. Yadav et al. (2010) found similar results by incorporating buckwheat flour to wheat flour at the level of 40 g/100 g. Texture score decreased from 7.96 to 6.15 and this was because of cracks formed with the addition of buckwheat flour. The use of non-glutenous composite flour (buckwheat flour) in biscuit preparation reduces the textural strength of cookies where such strength is dependent upon approximate levels of gluten development (Schober et al., 2003). There was increase in taste and flavour scores of multigrain biscuits with the incorporation of composite flour.

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**Table 1:** Effect of treatments and storage period on calcium content (mg/100g) of multigrain biscuits.

| Treatments | Storage period (days) | 0     | 30     | 60     | 90     | Mean  |
|------------|-----------------------|-------|--------|--------|--------|-------|
| T1 (100:0:0::WF:BF:BWF) | 42.12 | 42.06 | 42.00 | 41.80 | 41.99 |
| T2 (0:100:0::WF:BF:BWF) | 49.25 | 49.23 | 49.12 | 48.96 | 49.14 |
| T3 (80:20:0::WF:BF:BWF) | 43.52 | 43.49 | 43.43 | 43.23 | 43.41 |
| T4 (70:20:10::WF:BF:BWF) | 59.04 | 59.03 | 58.91 | 58.72 | 58.92 |
| T5 (60:20:20::WF:BF:BWF) | 61.55 | 61.51 | 61.42 | 61.25 | 61.43 |
| T6 (50:20:30::WF:BF:BWF) | 64.06 | 64.04 | 63.93 | 63.74 | 63.94 |
| T7 (40:20:40::WF:BF:BWF) | 66.61 | 66.54 | 66.44 | 66.28 | 66.46 |
| T8 (30:20:50::WF:BF:BWF) | 69.09 | 69.02 | 68.96 | 68.78 | 68.96 |
| Mean       | 56.90               | 56.86 | 56.77 | 56.59 |

**Effects** | C.D. (p<0.05) |
| Treatment | 0.02 |
| Storage | 0.01 |
| Treatment x Storage | NS |

**Table 2:** Effect of treatments and storage period on iron content (mg/100g) of multigrain biscuits

| Treatments | Storage period (days) | 0     | 30     | 60     | 90     | Mean  |
|------------|-----------------------|-------|--------|--------|--------|-------|
| T1 (100:0:0::WF:BF:BWF) | 05.61 | 05.55 | 05.45 | 05.29 | 05.47 |
| T2 (0:100:0::WF:BF:BWF) | 12.31 | 12.26 | 12.17 | 12.03 | 12.19 |
| T3 (80:20:0::WF:BF:BWF) | 06.94 | 06.90 | 06.77 | 06.66 | 06.81 |
| T4 (70:20:10::WF:BF:BWF) | 08.30 | 08.23 | 08.13 | 08.03 | 08.17 |
| T5 (60:20:20::WF:BF:BWF) | 08.54 | 08.47 | 08.40 | 08.22 | 08.40 |
| T6 (50:20:30::WF:BF:BWF) | 08.82 | 08.77 | 08.68 | 08.50 | 08.69 |
| T7 (40:20:40::WF:BF:BWF) | 09.08 | 09.04 | 08.93 | 08.80 | 08.96 |
| T8 (30:20:50::WF:BF:BWF) | 09.34 | 09.29 | 09.19 | 09.06 | 09.22 |
| Mean       | 08.61               | 08.56 | 08.46 | 08.32 |

**Effects** | C.D. (p<0.05) |
| Treatment | 0.02 |
| Storage | 0.01 |
| Treatment x Storage | NS |
Table 3: Effect of treatments and storage period on zinc content (mg/100g) of multigrain biscuits

| Treatments | Storage period (days) |
|------------|-----------------------|
|            | 0    | 30   | 60   | 90   | Mean |
| T₁ (100:0:0::WF:BF:BWF) | 2.71 | 2.67 | 2.59 | 2.46 | 2.60 |
| T₂ (0:100:0::WF:BF:BWF) | 5.63 | 5.62 | 5.51 | 5.38 | 5.53 |
| T₃ (80:20:0::WF:BF:BWF) | 3.24 | 3.20 | 3.12 | 3.03 | 3.14 |
| T₄ (70:20:10::WF:BF:BWF) | 3.82 | 3.81 | 3.70 | 3.56 | 3.72 |
| T₅ (60:20:20::WF:BF:BWF) | 3.96 | 3.91 | 3.8  | 3.70 | 3.84 |
| T₆ (50:20:30::WF:BF:BWF) | 4.10 | 4.07 | 3.98 | 3.86 | 4.00 |
| T₇ (40:20:40::WF:BF:BWF) | 4.24 | 4.21 | 4.12 | 4.00 | 4.14 |
| T₈ (30:20:50::WF:BF:BWF) | 5.38 | 5.36 | 5.26 | 5.13 | 5.28 |
| Mean       | 4.13 | 4.10 | 4.01 | 3.89 |      |

Effects: C.D. (p<0.05)
- Treatment: 0.02
- Storage: 0.01
- Treatment x Storage: NS

Fig 1: Effect of treatments and storage period on taste of multigrain biscuits.

Fig 2: Effect of treatments and storage period on colour of multigrain biscuits.

Fig 3: Effect of treatments and storage period on flavour of multigrain biscuits.

Fig 4: Effect of treatments and storage period on texture of multigrain biscuits.
Table 4: Cost production of multigrain biscuits

| Ingredients            | Rate @ (Rs.) | Quantity | Amount (Rs.) |
|------------------------|--------------|----------|--------------|
| Wheat                  | 17/Kg        | 840 g    | 14.28        |
| Buckwheat              | 53/Kg        | 120 g    | 6.36         |
| Barley                 | 20/Kg        | 240 g    | 4.80         |
| Apricot                | 360/Kg       | 360 g    | 129.60       |
| Sugar                  | 40/Kg        | 360 g    | 14.40        |
| Vegetable fat          | 120/Kg       | 360 g    | 43.20        |
| Laminate pouches       | 1/pouch      | 12       | 12           |
| Total cost of ingredients |             |          | 224.64       |
| Overhead charges (including labour & fuel, machinery depreciation) @ 20% | | | 44.92 |
| Profit @ 15%           |              |          | 33.69        |
| Value Added Tax (VAT) @ 13.50% |          |          | 30.32        |
| Grand total            |              |          | 333.57       |
| Sale price/pouch (100 g) |            |          | 16.67        |

**Cost of production:** The cost of production of multigrain biscuits $T_1 (70:20:10::WF:BF:BWF)$ is based upon the fixed and variable cost of all ingredients used and some other factors viz. processing charges, packaging materials and labels used. The cost of production of biscuits comes 16.67/100g, which is cheaper as compared to commercially available multigrain biscuits in the market (Table 4).

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