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RESEARCH PAPER

Characterization and Storage Studies of Instant Multigrain Porridge Made from Underutilised Crops of Ladakh

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ABSTRACT

Instant multigrain porridge mix was developed from buckwheat and barley grits along with apricot powder in the ratios of 100:0:0::BWG:BG:AP (Buckwheat Grits: Barley Grits: Apricot Powder), 0:100:0::BWG:BG:AP, 80:10:10::BWG:BG:AP, 70:20:10::BWG:BG:AP, 60:30:10::BWG:BG:AP and 50:40:10::BWG:BG:AP. Quality evaluation of multigrain porridge revealed that incorporation of barley grits and apricot powder to buckwheat grits in all the formulations increased mean values of crude protein, crude fiber, ash and antioxidant activity from 7.39 to 10.45 %, 2.02 to 2.39 %, 1.32 to 1.99 % and 40.69 to 48.02 %. However, there was a decrease in crude fat and carbohydrate from 2.56 to 1.72 % and 71.60 to 66.98 %, respectively. The developed porridge mix was stored in cotton bags for 150 days under ambient conditions (temperature: 28 ± 3°C and moisture content 12 ± 0.8%) to ascertain the changes in these parameters. Storage studies done at an interval of 30 days revealed that, there was a decrease in crude protein (9.81 to 7.15 %), crude fat (2.40 to 1.20 %), crude fibre (2.90 to 1.55 %), ash (1.98 to 1.55 %) and antioxidant activity (48.87 to 38.68 %), whereas, carbohydrate content increased from 68.80 to 70.72 %. Economics of the multigrain product revealed that porridge mix were economically profitable.

Keywords: Buckwheat, barley, apricot, pseudo-cereal, instant porridge mix, DPPH scavenging activity

Ladakh, a cold-arid, trans-Himalayan region of India, is known for many functional crops such as buckwheat, barley, seabuckthorn, apricot, walnut, turnip, pea, etc. (Hussain, 2018) Among these, buckwheat and barley despite being staple foods are now underutilized (Hussain *et al*. 2018a) because of the less knowledge of their functional properties among the local populace, preferences of younger generation for new food under the ages of modernization, availability of new crops like rice on subsidized rates under PDS, etc. These crops provide high quality protein, vitamins and minerals as well as antioxidants. The functional components of these crops have health benefits like reducing high blood pressure, controlling blood sugar, lower blood cholesterol, prevents accumulation of fat, constipation (Kayashita *et al*., 1996; Vinutha *et al*., 1998), mammary carcinogenesis and colon carcinogenesis (Liu *et al*., 2001; Potty, 1996), strengthen capillary blood vessels (Watanabe, 1998) and suppresses gall stone formation and plasma cholesterol (Tomotake *et al*., 2000). In fact, most of the health effects of these crops are attributed to their high levels of phenolic compounds and antioxidant activity (Sedej *et al*., 2011; Hussain and Kaul, 2018).

In recent years, a wide range of processed foods in ready to use/ready to eat forms have been developed

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and marketed which have potential to contribute nutrition as well as other health significant bioactive compounds. Rapid urbanization and changing lifestyle appears to offer ample opportunity for the development of instant mixes in Ladakh that are quicker and easier to prepare and have longer shelf life (Hussain *et al*. 2018b). Instant porridge is one of the ready to use breakfast foods which is now-a-days gaining much importance and popularity in Ladakh particularly in Leh and Kargil cities. The multigrain concept can provide breakfast foods with number of benefits associated with these grains (Mandge *et al*. 2011). The multigrain blends help to mix different whole grains to maximize their nutritional, functional and sensory properties which can further be enhanced by some processes such as malting, roasting, fortification, etc. Keeping in view, the above discussed points, underutilized crops of Ladakh like buckwheat and barley, were selected and the present investigation was undertaken to assess the nutritional and functional attributes of the multigrain porridge mix.

MATERIALS AND METHODS

Materials

Raw grains of buckwheat (*Fagopyrum esculentum*) and barley (*Hordeum vulgare*) and dried apricot (*Prunus armeniaca*) were procured from Leh, Ladakh, India. Fresh milk and cane sugar were purchased from local market of Jammu. Cane sugar was ground into fine powder using a grinder (Philips, Model: HL 1632, New Delhi, India). Aluminium laminated pouches used for packaging of instant multigrain porridge mix were obtained from Vishwas Traders, Jammu.

Preparation of instant multigrain porridge mix

Processing of grains

The processing was done according to the procedure given by Hussain and Kaul (2019). The grains were cleaned manually by removing the diseased grains and foreign materials, washed thoroughly under tap water to remove dust and then, dried in shade. The dried grains of buckwheat and barley were coarse ground in a laboratory mill (Philips, Model: HL 1632). The ground grains were sieved through ISI Mesh No. 20 (0.833 mm) for medium fractions (grits) and stored in air tight containers till further use. The washed, destoned and dried apricots were converted into powder and packet in air tight containers. The method of Kikafunda *et al*. (2010) was followed for developing multigrain porridge mix. Grits of buckwheat and barley and apricot powder were blended separately in different ratios with each other for making different formulations as F_1(100:0:0::BWG:BG:AP), F_2(0:100:0::BWG:BG:AP), F_3(80:10:10::BWG:BG:AP), F_4(70:20:10::BWG:BG:AP), F_5(60:30:10::BWG:BG:AP) and F_6(50:40:10::BWG:BG:AP).

Storage

The blended mixture of each treatment was packed in aluminium laminated pouches and stored for the shelf-life study of 150 days at ambient temperature (28 ± 3 ºC) and moisture content (12 ± 0.8%). The samples were analysed for various chemical constituents at an interval of 30 days following the standard procedures.

Analysis

The porridge mixes with formulations 100: 0:0::BWG:BG:AP, 0:100:0::BWG:BG:AP, 80: 10: 10::BWG:BG:AP, 70:20:10::BWG:BG:AP, 60: 30:10:: BWG:BG:AP and 50:40:10::BWG:BG:AP were analyzed after the storage at 30 days interval period.

Moisture, protein, ash and fat contents were measured according to AOAC methods (2002). The carbohydrate content was calculated by difference method by subtracting the sum of moisture, fat, protein and ash contents from 100. The antioxidant activity was determined by DPPH (1,1, diphenyl-2-picryihydrazyl) scavenging activity (Brand-Williams *et al*., 2002). All the experiments were performed in triplicates. Data collected from aforesaid experiments were 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

Proximate composition of raw materials

The data pertaining to the proximate composition of raw materials in Table 1, revealed that the moisture content of buckwheat was found to be 11.13 % which was closely related to the findings of Simurina *et al.* (2009) and Torbica *et al.* (2012) who reported the moisture content as 9.8 % and 11.30 %, respectively. The crude protein content of 8.32 % was recorded in buckwheat, which was supported by the findings of Baljeet *et al.* (2010) and Mann *et al.* (2012) with values of 8.73 % and 10.12 %, respectively. The crude fat of buckwheat was found to be 2.93 % which was in accordance with the results of Alvarez-Jubete *et al.* (2009) and Torbica *et al.* (2012) who reported the fat content of 2.1 % and 2.85 g/100g, respectively. The crude fibre content of buckwheat was recorded as 2.51 % which was nearly similar to the values of 2.70 % and 1.75 % reported by Simurina *et al.* (2009) and Chopra *et al.* (2014), respectively. The ash content of buckwheat was found to be 1.47 % which was supported by the results of Mann *et al.* (2012) and Chopra *et al.* (2014) who reported the ash content of 2.23 % and 1.38 % in buckwheat flour, respectively. Carbohydrate content of buckwheat was found to be 70.84 % which was closely related to the findings of Baljeet *et al.* (2010) who reported the value of the same as 75.84 % in buckwheat flour.

The moisture, crude protein, crude fat, crude fibre, ash and carbohydrate contents of barley were found to be as 12.04, 11.50, 1.52, 3.92, 2.20 and 67.10 %, respectively. A marginal difference was observed when the results were compared with the findings of Gupta *et al.* (2011) who reported moisture, protein, crude fat, ash and carbohydrate contents as 13.10, 8.20, 5.40, 1.45 and 69.70 % for barley flour.

The moisture, crude protein, crude fat, crude fibre, ash and carbohydrate contents of apricot powder were found to be 13.04, 1.53, 1.76, 2.09, 2.62 and 67.05 %, respectively. These values are in parallel with that of Hussain *et al*. (2010) who reported moisture, protein, crude fat, and ash contents as 13.70, 1.20, 1.47 and 3.90% in *Travet* cultivar of dried apricot. The nutrients such as protein, fiber and ash were comparatively higher in barley and fat and carbohydrate were lower than buckwheat thus could be a healthy additive for porridge making. Also addition of apricot could make the products more nutritious.

Nutritional composition of multigrain porridge mix

Crude protein

According to the results presented in Table 2, the incorporation of barley grits led to the increase in mean protein content of porridge mix significantly from 7.39 % to 10.45 % having maximum in F_6 and minimum in F_1, respectively. The increase in protein content of the multigrain porridge is clearly attributed to the high protein content of barley than that of buckwheat. Pelembe *et al*. (2002) reported increase in protein content of the extrudates with increase in the amount of cowpea in the sorghum-cowpea instant porridge. Similar increase in protein content with the increase in walnut powder in complementary food formulated from sorghum, walnut and ginger was reported by Adebayo-Oyetoro *et al*. (2013). As in evident from the data, that during 150 days of

Table 1: Proximate composition of raw materials

Parameters	Raw materials		
	Buckwheat	**Barley**	**Apricot powder**
Moisture (%)	11.13 ± 1.4	12.04 ± 0.6	13.04 ± 2.2
Crude protein (%)	08.32 ± 2.4	11.50 ± 0.4	01.53 ± 0.8
Crude fat (%)	02.93 ± 0.7	01.52 ± 1.6	01.76 ± 3.4
Crude fibre (%)	02.51 ± 2.5	03.92 ± 1.7	02.09 ± 1.3
Ash (%)	01.47 ± 1.2	02.20 ± 0.6	02.62 ± 2.9
Carbohydrates (%)	70.84 ± 1.8	67.10 ± 0.5	67.05 ± 3.1

Table 2: Effect of formulations and storage period on crude protein (%) of multigrain porridge mix

Formulations	Storage period (days)						
	0	30	60	90	120	150	Mean
F_1 (100:0:0::BWG:BG:AP)	08.29	08.14	07.96	07.55	06.84	05.61	**07.39**
F_2 (0:100:0::BWG:BG:AP)	11.47	11.34	11.12	10.72	10.00	08.83	**10.58**
F_3 (80:10:10::BWG:BG:AP)	08.41	08.28	08.05	07.66	06.96	05.76	**07.52**
F_4 (70:20:10::BWG:BG:AP)	09.34	09.25	08.99	08.59	07.90	06.69	**08.46**
F_5 (60:30:10::BWG:BG:AP)	10.23	10.12	09.90	09.48	08.78	07.60	**09.35**
F_6 (50:40:10::BWG:BG:AP)	11.14	11.03	10.79	10.40	09.69	08.47	**10.45**
Mean	09.81	09.69	09.46	09.07	08.36	07.15	

Effects CD ($p \leq 0.05$); Formulation 0.02; Storage 0.01; Formulation x Storage N.S.

Table 3: Effect of formulations and storage period on crude fat (%) of multigrain porridge mix

Formulations	Storage period (days)						
	0	30	60	90	120	150	Mean
F_1 (100:0:0::BWG:BG:AP)	2.96	2.92	2.82	2.59	2.29	1.81	**2.56**
F_2 (0:100:0::BWG:BG:AP)	1.59	1.50	1.40	1.20	0.88	0.38	**1.15**
F_3 (80:10:10::BWG:BG:AP)	2.85	2.78	2.66	2.45	2.14	1.62	**2.41**
F_4 (70:20:10::BWG:BG:AP)	2.56	2.50	2.36	2.17	1.88	1.38	**2.14**
F_5 (60:30:10::BWG:BG:AP)	2.29	2.22	2.10	1.89	1.58	1.10	**1.86**
F_6 (50:40:10::BWG:BG:AP)	2.15	2.09	1.96	1.74	1.44	0.95	**1.72**
Mean	**2.40**	**2.33**	**2.21**	2.00	1.70	1.20	

Effects CD ($p \leq 0.05$); Formulation 0.02; Storage 0.01; Formulation x Storage N.S.

storage period, the protein content of porridge mix decreased from the initial levels of 9.81 % to 7.15 %. This observation could be due to hydrolysis of protein molecules during storage. These findings are in line with that of Butt *et al*. (2008) and Leelavati *et al*. (1984) while storing wheat flour. Upadhyay (1994) also observed similar results in *suji* stored in different packaging materials.

Crude fat

Table 3 delineates the effect of treatment and storage periods on crude fat content of multigrain porridge mix. The lowest mean fat content of 1.15 % was recorded in formulation F_2 followed by formulations F_6 and F_5 having fat contents of 1.72 % and 1.86 %, respectively. The highest mean fat content of 2.56 % was recorded in control F_1 (100:0:0::BWG:BG:AP). Kawka *et al*. (1999) reported increase in crude fat content of bread with the substitution of barley flakes in wheat flour and Hussain and Kaul (2018) also reported same trend in buckwheat-barley incorporated biscuits. These reports well support our findings regarding increase in fat content with the increase in proportion of barley in multigrain porridge mix. Storage was found to have noteworthy effect on the fat content of multigrain porridge. The mean percent crude fat of the product at the beginning of storage was 2.40 % which decreased significantly to 1.20 % as the storage approaches five months. The decline is likely to be due to the lipolytic activity of enzymes, i.e. lipase and lipoxidase (Haridas *et al*., 1983 and Leelavathi *et al*., 1984). The findings of the present investigation are in consonance with that of Murugkar and Jha (2011) and Shahzadi *et al*. (2005) who also reported decrease in fat content in sprouted soybean flour packed in different packaging materials and in flour blended with various legume flours.

Crude fibre

The crude fiber content of multigrain porridge mix is given in Table 4, which illustrates the effect of treatments and storage periods on its crude fibre content and revealed that the mean crude fiber increased from 2.02 to 2.39 % with the supplementation of buckwheat with barley in the porridge which could be due to the higher concentration of crude fibre in barley as compared to the buckwheat. Earlier other workers, (Hussein *et al*., 2013) reported similar results in balady bread made from wheat flour supplemented with barley flour. So the findings of above authors confirm the present study. With the advancement of storage period (150 days), the mean fibre content decreased significantly from 2.90 to 1.55%. The decrease in crude fibre might be due to the degradation of hemicelluloses and other structural polysaccharides during storage. Heat and moisture solubilizers also degrade pectic substances leading to the decrease in crude fibre content as reported by Sharon and Usha (2006) in bread fruit flour. This observation is agreed with other scientific findings of Singh *et al*. (2006) in pearl millet cake and Butt *et al*. (2003) in wheat flour.

Ash

The ash content represents the quantity of total minerals. The ash content of multigrain porridge mix (of six samples) is determined from the data in Table 5. The porridge mix prepared from 100 % barley grits (F_2) was found to have highest mean ash content of 2.08 %. The ash content increased with the incorporation of barley grits. In 1987, Bhatty reported that barley usually contains visible specks of bran and subsequently appears darker and is higher in ash content than typical wheat flour. The results also corroborated those of Kawka *et al*. (1999) who reported an increase in ash content of bread with

Table 4: Effect of formulations and storage period on crude fiber (%) of multigrain porridge mix

Formulations	Storage period (days)						
	0	30	60	90	120	150	Mean
F_1 (100:0:0::BWG:BG:AP)	2.50	2.45	2.34	2.07	1.67	1.14	**2.02**
F_2 (0:100:0::BWG:BG:AP)	3.94	3.90	3.77	3.52	3.14	2.57	**3.47**
F_3 (80:10:10::BWG:BG:AP)	2.64	2.58	2.44	2.20	1.80	1.27	**2.15**
F_4 (70:20:10::BWG:BG:AP)	2.71	2.66	2.54	2.28	1.91	1.39	**2.24**
F_5 (60:30:10::BWG:BG:AP)	2.78	2.74	2.61	2.36	1.98	1.43	**2.31**
F_6 (50:40:10::BWG:BG:AP)	2.86	2.82	2.69	2.44	2.06	1.51	**2.39**
Mean	**2.90**	**2.85**	**2.73**	**2.47**	**2.09**	**1.55**	

Effects CD ($p \leq 0.05$); Formulation 0.02; Storage 0.01; Formulation x Storage N.S.

Table 5: Effect of formulations and storage period on ash (%) of multigrain porridge mix

Formulations	Storage period (days)						
	0	30	60	90	120	150	Mean
F_1 (100:0:0::BWG:BG:AP)	1.49	1.48	1.42	1.32	1.21	1.04	**1.32**
F_2 (0:100:0::BWG:BG:AP)	2.22	2.22	2.18	2.08	1.98	1.80	**2.08**
F_3 (80:10:10::BWG:BG:AP)	1.93	1.91	1.86	1.77	1.65	1.50	**1.77**
F_4 (70:20:10::BWG:BG:AP)	2.03	2.01	1.96	1.87	1.75	1.58	**1.86**
F_5 (60:30:10::BWG:BG:AP)	2.11	2.08	2.02	1.94	1.81	1.65	**1.93**
F_6 (50:40:10::BWG:BG:AP)	2.15	2.13	2.08	1.99	1.87	1.73	**1.99**
Mean	**1.98**	**1.97**	**1.92**	**1.82**	**1.71**	**1.55**	

Effects CD ($p \leq 0.05$); Formulation 0.02; Storage 0.01; Formulation x Storage N.S.

the substitution of barley flakes in wheat flour. The ash content of 100 % buckwheat porridge mix (F_1) was 1.32 %. The order of the mean ash contents of the blends was found to be as follows; $F_3 < F_4 < F_5 < F_6$. Upon storage of 150 days, the mean ash content decreased significantly from 1.98 to 1.55 % because the minerals might chelate with other components resulted in less availability. Similar decrease in ash content during 60 days of storage was reported by of Butt *et al*. (2004) while studying the effect of moisture and packaging and shelf-life of wheat flour. These findings are consistent with the results of previous study on maize based traditional weaning foods (Afoakwa *et al*., 2006) and wheat flour (Butt *et al*., 2004).

Carbohydrate

The treatments significantly ($p \leq 0.05$) influenced the carbohydrate content of multigrain porridge mix (Table 6). With increase in the proportion of barley in the product, the mean carbohydrate content decreased significantly ($P \leq 0.05$) from 71.60 % (in 0 % BG) to 66.98 % (in 40 % BG) porridge mixes. The decline in carbohydrate content is attributed to its lower concentration in barley as compared to buckwheat. The results are at par with that of Hussein *et al*. (2013) in balady bread made from wheat flour supplemented with barley flour. The mean carbohydrate content of porridge mix increased significantly from 68.80 % to 70.72 % during 150 days of storage period which might be due to the breakdown of complex polysaccharides into simple sugars. Similar trend was also observed by Sarojini *et al*. (1996) in rajmah flour and by Varshney *et al*. (2008) in defated peanut cereal biscuits.

Antioxidant activity

The antioxidant activity (DPPH radical scavenging activity) of the multigrain porridge mix (Table 7) after 30 minutes reaction differed significantly (P ≤

Table 6: Effect of formulations and storage period on carbohydrate (%) of multigrain porridge mix

Formulations	Storage period (days)						
	0	30	60	90	120	150	Mean
F_1 (100:0:0::BWG:BG:AP)	70.89	71.00	71.22	71.60	72.09	72.81	**71.60**
F_2 (0:100:0::BWG:BG:AP)	67.16	67.27	67.50	67.89	68.35	69.03	**67.86**
F_3 (80:10:10::BWG:BG:AP)	70.40	70.54	70.80	71.12	71.60	72.35	**71.13**
F_4 (70:20:10::BWG:BG:AP)	69.54	69.64	69.89	70.24	70.74	71.44	**70.24**
F_5 (60:30:10::BWG:BG:AP)	68.57	68.71	68.97	69.31	69.83	70.51	**69.31**
F_6 (50:40:10::BWG:BG:AP)	66.26	66.35	66.60	66.98	67.49	68.20	**66.98**
Mean	68.80	68.91	69.16	69.52	70.01	70.72	

Effects CD (p ≤ 0.05); Formulation 0.02; Storage 0.01; Formulation x Storage 0.03.

Table 7: Effect of formulations and storage period on antioxidant activity (%) of multigrain porridge mix

Formulations	Storage period (days)						
	0	30	60	90	120	150	Mean
F_1 (100:0:0::BWG:BG:AP)	44.57	43.92	42.84	40.73	37.74	34.36	**40.69**
F_2 (0:100:0::BWG:BG:AP)	49.25	48.59	47.56	45.4	42.40	39.07	**45.37**
F_3 (80:10:10::BWG:BG:AP)	47.16	46.51	45.45	43.34	40.33	36.98	**43.29**
F_4 (70:20:10::BWG:BG:AP)	49.16	48.5	47.44	45.31	42.33	38.97	**45.28**
F_5 (60:30:10::BWG:BG:AP)	51.22	50.54	49.53	47.39	44.42	41.02	**47.35**
F_6 (50:40:10::BWG:BG:AP)	51.90	51.23	50.19	48.05	45.09	41.70	**48.02**
Mean	48.87	48.21	47.16	45.03	42.05	38.68	

Effects CD (p ≤ 0.05); Formulation 0.02; Storage 0.01; Formulation x Storage N.S.

Table 8: Cost production of multigrain porridge mix

Ingredients	Rate @ (₹)	Multigrain porridge (50:40:10::BWG:BG:AP)	
		Quantity	Amount (₹)
Buckwheat	53/Kg	1260 g	66.78
Barley	20/Kg	360 g	7.2
Apricot	360/Kg	180 g	64.8
Laminate pouches	1/pouch	18	18
Total cost of ingredients			156.78
Overhead charges (including labour & fuel, machinery depreciation)	@ 20 %		31.35
Profit	@ 15 %		23.51
Value Added Tax (VAT)	@ 13.50 %		21.16
Grand total			232.8
Sale price/pouch (100 g)			12.88

0.05) with different treatments. Formulation F_6 was exceptionally high in quenching DPPH at 48.02 % and F_1 had the lowest DPPH scavenging capacity (40.69 %) among the blends. Increase in barley proportion in the product led to the increase in DPPH scavenging activity and it is attributed to its possession of maximum quantity of radical inhibitors or scavengers with possibility to act as primary antioxidants. They might react with free radicals, particularly with the peroxy radicals, which are the major propagators of the auto-oxidation chain of fat, thereby terminating the chain reaction (Sharma and Gujral, 2014). In previous studies, Sharma and Gujral (2014) reported increase in the DPPH radical scavenging activity with the increase in barley supplementation in cookies. With the advancement of storage period, the mean scavenging activity of porridge mix declined significantly from 48.87 to 47.16 % and to 38.68 % after 60 and 150 days, respectively. The reason might be due to the degradation of polyphenols which are responsible for the antioxidant activity. Our results are in accordance with the findings of Reddy *et al*. (2005) and Hussain *et al*. (2018a) in biscuits.

Cost of production

Economics calculations of prepared multigrain porridge mix are presented in Table 8. The cost of production of porridge mix F_6 (50:40:10::BWG:BG:AP) 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 porridge mix comes to ₹ 12.88/100g, which is cheaper as compared to commercially available porridge.

CONCLUSION

Based on the results and observations, it can be concluded that multigrain porridge become more nutritious with the incorporation of buckwheat grits and apricot powder. This type of convenient food can go a long way in supplying the required quantities of dietary fiber and other nutrients to various segments of population. The product can be stored for 150 days with not much loss of nutrients and is also economical.

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