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Formulation and Characterization of Buckwheat-Barley Supplemented Multigrain Biscuits

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Abstract

The current study was carried out on biscuits by incorporating barley flour (10%) and buckwheat flour (10%, 20%, 30%, 40% and 50%) into wheat flour. Biscuits were evaluated for physico-chemical, functional and sensory attributes. All the blended samples exhibited high fiber, fat, ash, carbohydrate and mineral contents when compared to those prepared from 100% wheat flour. Considering the taste, flavour, texture and overall acceptability, 10% buckwheat flour incorporated biscuit (70:20:10::WF:BF:BWF) was found to be at the top among the blends. The incorporation of buckwheat flour increased the DPPH scavenging potential hence increased the functional property of blended product.

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Introduction

Buckwheat (*Fagopyrum esculentum* Moench), a highly nutritious pseudo-cereal, is known for its high dietary fiber and starch,[1] protein with favourable amino acids and almost all vitamins,[2] essential minerals[3] and trace elements.[4] It is reported that buckwheat has higher antioxidant activity mainly due to the presence of phenolics such as quercetin, rutin, orientin, vitexin, isovitexin, isoorientin, catechins and kaempferol-3-rutinoside.[5] These components of buckwheat possess health benefits like reduction of high blood pressure, blood sugar control, lower blood cholesterol, prevention of fat accumulation, constipation,[6] colon carcinogenesis and mammary carcinogenesis,[7] strengthen capillary blood vessels[8] and suppresses plasma cholesterol and gallstone formation.[9] Another functional property of buckwheat is its gluten-free characteristics which make it promising diet for patients suffering from celiac disease.[10]

It is considered that barley (*Hordeum vulgare* L.) have functional property due to β-glucan, tocotrienols, tocopherols[11] and these components are known to have higher antioxidant activity and thus possible health benefits.[12,13] Barley flour has

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shown to have high content of dietary fiber especially β-glucan (soluble fibre). Health benefits of β-glucans have reported to lower plasma cholesterol, reducing glycemic index, improving lipid metabolism and boosting the immune system. Insoluble fiber present in it is known to reduce the chances of colon cancer.[14] It is therefore considered as important cereal crop with nutritional as well as functional properties. Keeping in view these benefits, increase in consumption of barley and its products is strongly recommended as food.

Keeping in view, the tremendous health benefits of the selected underutilized crops, i.e. buckwheat and barley, the present investigation was undertaken to assess the nutritional, nutraceutical and sensory attributes of the developed product i.e. biscuits. Development of multigrain bakery products from composite flour is the latest trend in the baking industry.

Materials and Methods

Raw Materials

Raw grains of buckwheat and barley and dried apricot were procured from Leh, Ladakh, India. Refined wheat flour, ghee (vegetable fat), sodium bicarbonate, cane sugar and aluminium laminated pouches were purchased from local market of Jammu. The current investigation was carried out in the Food Processing Laboratory of Division of Food Science and Technology, SKUAST-J, in the year 2017 and it took about one year to complete the study.

Development of Biscuits

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

T_1 (100:0:0::WF:BF:BWF),
T_2(0:100:0::WF:BF:BWF),
T_3 (80:20:0::WF:BF:BWF),
T4 (70:20:10::WF:BF:BWF),
T_5 (60:20:20::WF:BF:BWF),
T_6 (50:20:30::WF:BF:BWF),
T_7 (40:20:40::WF:BF:BWF) and
T_8 (30:20:50::WF:BF:BWF).

The process of biscuit making was standardized using creaming method given by Whitley.[15] The ingredients used for the preparation of biscuits were flour: 70g, apricot powder: 30g, ghee: 30g, sugar: 30g, sodium bicarbonate: 1.5g and water: 30ml. The fat was creamed with sugar and hot water. To this, all the other ingredients *viz*. composite flour, apricot powder and sodium bicarbonate were added, mixed and kneaded to form a dough and then rolled and cut into shape with the help of cutter and baked at 160 ºC till done. The biscuits were then cooled and packed.

Functional Properties

The bulk density and swelling capacity of the sample i.e. flour were determined as per the protocol given by Okaka and Potter.[16] The water and oil absorption capacities of samples were determined according to the protocol given by Soluski *et al*.[17] with slight modifications. For the determination of foaming capacity and foaming stability, the method described by Narayana and Rao[18] was followed.

Physical Parameters of Biscuits

Diameter and thickness of biscuits were checked out by using Vernier Caliper. Spread ratio was estimated according to AACC method[19] by dividing the diameter by thickness of biscuits in terms of their average values, whereas, weight loss of biscuits was calculated by using digital weighing balance.

Chemical and Sensory Properties

Moisture, protein, ash and fat contents were determined according to AOAC methods.[20] The calculation of carbohydrate content was done by difference method by subtracting the sum of moisture, fat, protein and ash contents from 100. Mineral matters were determined following procedure of Chapman and Pratt[21] by dry ashing method using AAS (atomic absorption spectrophotometer). The antioxidant activity was measured in terms of DPPH (1,1, diphenyl-2-picryihydrazyl) scavenging activity.[22] Color was analysed using a Hunter Color Lab. Non-enzymatic browning index (NEB) of the biscuit samples was determined as previously given by Sharma and Gujral.[23] The samples were evaluated on the basis of color, texture/body, taste and overall acceptability by semi-trained panel of 9-10 judges by the use of 9 point hedonic scale assigning scores 9 for 'like extremely' to 1 for 'dislike extremely'. 5.5 score and above were considered acceptable.[24] Results were expressed as mean of triplicate observations.

Statistical Analysis

All the experiments were performed in triplicates. Data collected from current investigation was subjected to ANOVA with the help of two-way factorial completely randomized design[25] and using the OP Stat software package.

Results and Discussion

Functional Properties of the Raw Materials

The functional properties of the raw materials (flours) play an important role in manufacturing of food products. The functional properties of the raw materials *viz.* buckwheat flour, barley flour and refined wheat flour, used for the development of multigrain biscuits are presented in Table 1. The bulk densities of buckwheat flour and barley flour were 0.80 g/ml and 0.78 g/ml, respectively, which are significantly higher than that of the refined wheat flour (0.75 g/ml). The water absorption capacity of buckwheat flour and barley flour was found to be significantly ($p \leq 0.05$) lower than that of refined wheat flour. It might be because of the lower amount of hydrophilic compounds in these flours. The oil absorption capacity of buckwheat flour and barley flour was significantly higher than that of refined wheat flour. The swelling capacities of buckwheat flour, barley flour and refined wheat flour were 13.05 ml, 13.67 ml and 16.74 ml, respectively. The

Table 1: Functional properties of raw materials

Parameters	Raw materials			
	Buckwheat flour	**Barley flour**	**Refined wheat flour**	**C.D. ($p \leq 0.05$)**
Bulk density (g/ml)	0.8	0.78	0.75	N.S.
Water absorption capacity (%)	135.48	132.73	153.83	0.05
Oil absorption capacity (%)	181.86	180.52	172.64	0.04
Swelling capacity (ml)	13.05	13.67	16.74	0.05
Foaming capacity (%)	16.57	14.72	11.59	0.04
Foam stability (%)	91.93	93.48	96.73	0.05

Table 2: Treatments effect on physical parameters of multigrain biscuits

Treatments	Diameter (cm)	Thickness (cm)	Spread ratio (D/T)	Weight (g)	Bake loss (%)
T_1 (100:0:0::WF:BF:BWF)	6.32	0.78	8.1	10.68	11.39
T_2 (0:100:0::WF:BF:BWF)	5.95	0.82	7.25	11.3	5.05
T_3 (80:20:0::WF:BF:BWF)	6.29	0.78	8.06	10.75	10.53
T_4 (70:20:10::WF:BF:BWF)	6.27	0.79	7.93	10.84	10
T_5 (60:20:20::WF:BF:BWF)	6.23	0.8	7.78	11.03	9.24
T_6 (50:20:30::WF:BF:BWF)	6.17	0.81	7.61	11.35	8.49
T_7 (40:20:40::WF:BF:BWF)	6.1	0.83	7.34	11.74	8.06
T_8 (30:20:50::WF:BF:BWF)	6.02	0.85	7.08	12.13	7.31
Mean	**6.16**	**0.8**	**7.64**	**11.22**	**8.75**
C.D. ($p \leq 0.05$)	**0.04**				

WF: wheat flour BF: barley flour BWF: buck wheat flour

foaming capacity of buckwheat flour and barley flour was higher than that of refined wheat flour. Foaming capacity depends upon the arrangement of protein molecules. Flexible proteins possess good foaming capacity but highly complex globular ones have comparatively lower foaming ability.

Physical Attributes of Biscuits

The effect of treatments on physical parameters of the multigrain biscuits, prepared from the flours of buckwheat, barley and refined wheat shown in Table 2, reflects that the diameter of buckwheat blended biscuits was observed, significantly ($p \leq 0.05$) lower as compared to that of wheat biscuits. The thickness of biscuits ranged from 0.78 to 0.85 cm which increased when buckwheat flour is incorporated. It might be because of the decrease in diameter of the biscuits. The changes in diameter and thickness affect the spread ratio of biscuit. The spread ratio of control (wheat) biscuits was 8.10 and it decreased when buckwheat flour is added. This could be attributed to the fact that the composite

Table 3: Treatments effect on proximate composition (%) of multigrain biscuits

Treatments	Moisture content	Crude protein	Crude fiber	Crude fat	Ash	Carbohydrate
T_1 (100:0:0::WF:BF:BWF)	3.42	7.22	1.67	20.82	1.32	73.06
T_2 (0:100:0::WF:BF:BWF)	2.56	7.34	3.29	21.21	1.17	70.79
T_3 (80:20:0::WF:BF:BWF)	3.24	7.26	1.81	20.9	1.26	72.87
T_4 (70:20:10::WF:BF:BWF)	3.16	7.06	1.94	21.03	1.33	72.94
T_5 (60:20:20::WF:BF:BWF)	3.1	6.97	2.01	21.67	1.42	73.06
T_6 (50:20:30::WF:BF:BWF)	3.06	6.73	2.15	22.73	1.56	73.19
T_7 (40:20:40::WF:BF:BWF)	3.03	6.41	2.33	23.12	1.67	73.34
T_8 (30:20:50::WF:BF:BWF)	3	5.34	3.69	23.65	1.82	73.47
Mean	**3.07**	**6.79**	**2.36**	**21.89**	**1.44**	**72.84**
C.D. ($p \leq 0.05$)	0.02					

Table 4: Treatments effect on antioxidant (%) and mineral contents (mg/100g) of multigrain biscuits

Treatments	Antioxidant activity	Calcium	Iron	Zinc
T_1 (100:0:0::WF:BF:BWF)	34.62	42.12	5.61	2.71
T_2 (0:100:0::WF:BF:BWF)	46.81	49.25	12.31	5.63
T_3 (80:20:0::WF:BF:BWF)	36.4	43.52	6.94	3.24
T_4 (70:20:10::WF:BF:BWF)	38.34	59.04	8.3	3.82
T_5 (60:20:20::WF:BF:BWF)	41.4	61.55	8.54	3.96
T_6 (50:20:30::WF:BF:BWF)	43.87	64.06	8.82	4.1
T_7 (40:20:40::WF:BF:BWF)	46.5	66.61	9.08	4.24
T_8 (30:20:50::WF:BF:BWF)	48.93	69.09	9.34	5.38
Mean	**42.1**	**56.9**	**8.61**	**4.13**
C.D. ($p \leq 0.05$)	0.02			

WF: wheat flour BF: barley flour BWF: buckwheat flour

flours present form aggregates with the increase in hydrophilic sites which compete for the limited free water present in biscuit dough.[27] Also the increased level of fiber and β-glucan absorb more water which resulted into harder dough consequently less spread ratio.[28] Sharma and Gujral[26] also observed reduction in spread ratio in barley blended cookies. The weight of biscuits increased with the increases in buckwheat flour in the blends and it ranged from 10.68 to 12.13 g. This was probably due to the oil retention capacity of buckwheat flour during baking. Decrease in Bake loss decreased with the supplementation of wheat flour with buckwheat flour may be attributed to the ability of fibers present in latter to retain more water as compared to former.

Proximate Composition of Multigrain Biscuits

The minimum and maximum moisture content of 2.56 and 3.42% was recorded in T_2 and T_1 respectively. With the incorporation of the buckwheat-barley flours, there was reduction in moisture content and which might be due to low levels of protein content in these flours (Table 3). Mustafa *et al.*[29] reported a decrease in moisture content of baked products with decrease in protein content. Jan *et al.*[30] also has shown that the moisture content of cookies made from the blends decreased with the increase in the ratio of buckwheat flour. The crude protein of multigrain biscuits ranged from 5.34 to 7.34%. With supplementation of composite flour of barley and buckwheat, the protein content of multigrain biscuits decreased significantly at 5% level of significance. The decrease in protein content might be the result of the lower protein contents of the composite flour as well as due to dilution of gluten content of wheat flour in biscuits. Baljeet et al. 31 reported decrease in protein content in biscuits incorporated with buckwheat flour from 7.20 ± 0.05% (control) to 5.60 ± 0.06% (40 % BWF). With the incorporation of both barley and buckwheat flours in multigrain biscuits, the crude fat content increased significantly from 20.82 to 23.65%. While studying the assessment of quality of gluten free crackers, Sedej *et al.*[32] reported that the composition of fat of the wholegrain buckwheat crackers was significantly higher as compared to wholegrain wheat crackers. The increase in fat content was probably due to the ability of oil retention of buckwheat flour during baking. Highest crude fiber content of 3.69% was recorded in treatment T8 followed by 3.29% in T_2 and 2.33 in T7 and the lowest of 1.67% was recorded in T_1. The increase in fibre content in biscuits could be justified by the fact that there was higher fiber content in barley and buckwheat flours as compared to wheat flour. Baljeet *et al.*[31] have also shown increase in crude fiber in biscuits with the incorporation of buckwheat flour. The ash content represents the total mineral content in food. All the blends varied significantly in ash content resulting from differences among individual treatment ratios.

Table 5: Treatments effect on colour and non enzymatic browning of multigrain biscuits

Treatments	L*	a*	b*	NEB
T_1 (100:0:0::WF:BF:BWF)	69.53	6.03	38.46	0.007
T_2 (0:100:0::WF:BF:BWF)	53.19	7.93	25.43	0.021
T_3 (80:20:0::WF:BF:BWF)	65.76	6.15	34.03	0.01
T_4 (70:20:10::WF:BF:BWF)	63.03	6.47	32.19	0.011
T_5 (60:20:20::WF:BF:BWF)	60.78	6.89	30.32	0.013
T_6 (50:20:30::WF:BF:BWF)	60.12	7.09	29.66	0.015
T_7 (40:20:40::WF:BF:BWF)	57.45	7.56	28.89	0.017
T_8 (30:20:50::WF:BF:BWF)	56.44	7.72	28.68	0.018
Mean	**60.78**	**6.98**	**30.95**	**0.014**
C.D. ($p \leq 0.05$)	0.04			

WF: wheat flour BF: barley flour BWF: buckwheat flour

The ash content of multigrain biscuits increased from 1.17% in T_2 to 1.82% in T_8. The increase in ash content might be because of high minerals in barley and buckwheat flour when compared with the wheat flour. Similar trends were reported by Yildiz and Bilgicli[33] while studying effects of buckwheat flour (whole) on physico-chemical properties of Lavas. The incorporation of composite flour in multigrain biscuits significantly ($P \leq 0.05$) increased carbohydrate content. The increase in carbohydrate content in biscuits was probably because of its higher amount in composite flour than wheat flour. Jan et al. 30 found similar trend in biscuits incorporated with buckwheat flour. The highest carbohydrate content of 73.47% was recorded in treatment T_8 whereas the lowest carbohydrate content of 70.79% was observed in treatment T_2.

Antioxidant Activity (DPPH Scavenging Potential)

The inhibition potential of DPPH (2,2-diphenyl-1-picrylhydrazyl) radicals was higher in blended biscuits as compared to wheat flour biscuits due to the presence of higher phenolic compounds in buckwheat flour. Thus the scavenging activity was found to be increased with increase in incorporated flour contents in the biscuits (Table 4). This was probably because of higher antioxidant activity of barley and buckwheat flours.[32,33] These might react with peroxy radicals (free radicals) which are the major contributors of the auto-oxidation of fat. Further increase in antioxidant activity of buckwheat incorporated biscuits can be attributed to maximum production of melanoidins which is supported by higher non enzymatic browning values of the same. Earlier Sharma and Gujral[26] observed increase in the DPPH radical scavenging activity with the increase in the addition of barley in cookies ranging from 10.8 ± 1.3 (100% wheat flour) to 17.9 ± 0.5 (100% whole barley flour) due to higher phenolic content in barley.

Minerals (Ca, Fe and Zn) Contents

There was significant increase in the mineral contents particularly calcium, iron and zinc with increased incorporation of buckwheat flour in wheat flour (Table 4). Calcium content increased from 42.12 to 69.09 mg/100g, iron 5.61 to 12.31mg/100g and zinc 2.71 to 5.63 mg/100g. Yildiz and Bilgicli34 reported increase in calcium and iron content of bread Lavas with the blending of whole buckwheat flour. This was because of the higher content of these minerals in buckwheat flour in contrast to the other raw materials used.

Color Analysis

The lightness (L*) as well as yellowness (b*) of the biscuits decreased, when there was an increase in the buckwheat flour in the blends (Table 5). While as, it was observed that there was increase in redness (a*) with increase in buckwheat flour content in the biscuits. Lin *et al.*[35] observed similar results in case of buckwheat (15% level) incorporated wheat bread. It could be because of the browning reaction that was caused by Maillard reaction and sugar caramelization during baking. The browning

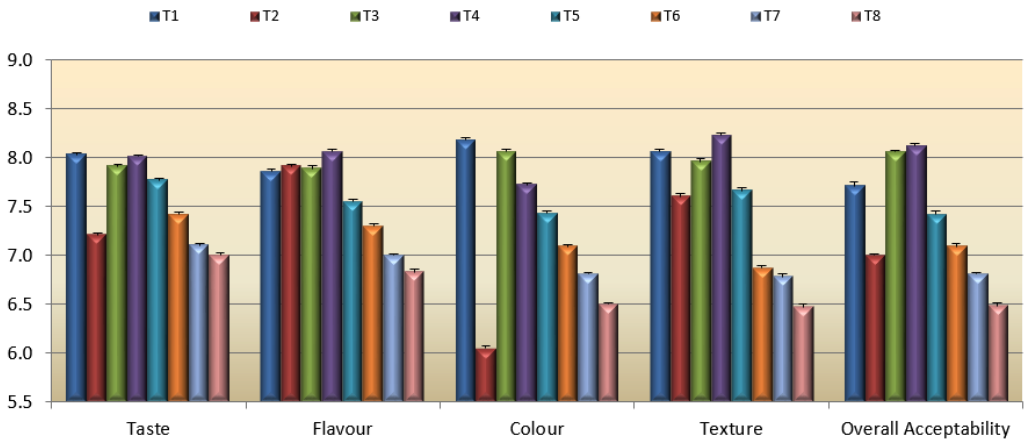

Fig. 1: Sensory parameters of multigrain biscuits due to incorporation of composite flours

reactions are affected by several factors such as temperature, water activity, sugars, pH and ratio and type of amino compounds.[35]

Non Enzymatic Browning Index

Significant ($P \leq 0.05$) effect was found on non-enzymatic browning index of biscuits with the supplementation of wheat flour with buckwheat flour (Table 5). This might be due to the protein and sugar dilution of the wheat flour upon blending of whole buckwheat flour. Non-enzymatic browning index of refined wheat biscuits was observed to be 0.007. Baking of biscuits led to the increase in non-enzymatic browning index with the increase buckwheat flour incorporation. Ramirez-Jimenez *et al.*[36] also found a noteworthy increase in browning index upon baking of bread. Browning was associated with Maillard reaction which occurred during baking of biscuits. It has been widely accepted that Maillard browning is affected by several factors which further led to the increase in intensity of brown pigment. The reason for browning might also be due to sugar caramelization, as formulated biscuits have higher in sugar content.

Organoleptic Evaluation

Figure 1, depicts the effect of addition of buckwheat flour on organoleptic attributes of multigrain biscuits. When the level of buckwheat flour increased in the formulation there was a decrease in sensory/ organoleptic scores for taste, colour, flavour, texture and overall acceptability of biscuits.[37,38] The score of taste and flavour got reduced significantly from 8.03 to 7 and 7.86 to 6.83, respectively which was possibly due to presence of flavonoid compounds (quercetin, rutin and protocatechuic acid) having bitter taste in buckwheat flour. Texture score decreased from 8.06 to 6.47 which were due to the cracks formed on account of blending of buckwheat flour. The use of buckwheat flour in biscuit preparation reduced its textural strength which depends upon development of approximate levels of gluten.[39] The color of buckwheat blended biscuits was darker and scored 6.50 at its highest incorporation as compared to that from wheat flour (8.18) because it had lower lightness and higher yellowness values. Similar results were also found by Yadav *et al.*[27] while incorporating buckwheat flour to wheat flour at 40 g/100 g level. Biscuits prepared from treatment T_4 were rated as best by the panelists in terms of overall acceptability with a score of 8.12 which decreased up to 6.48 in treatment T_8.

Conclusion

The concept of multigrain products would provide the maximum nutrients as well as health benefits for the malnourished section of population of developing countries like India. Further food products like biscuits can be utilised during catastrophic situations like flood and earthquake owing to its high nutritive value, portability and maximum shelf life.

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Conflict of Interest

The authors declare no conflict of interest.

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