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RESEARCH ARTICLE

Quality analysis of developed multigrain flour mixes

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ABSTRACT

The present research work on nutrient evaluation of multigrain flour mix was carried to standardize a simple, nutritional blends by utilizing wheat, foxtail millet, maize, Bengal gram and pumpkin seed with the objectives to develop and study the nutritional quality and sensory evaluation of a multigrain flour mix. Five blends were made Mix 1, Mix 2, Mix 3, Mix 4 and Mix 5 whole wheat, foxtail millet, maize, Bengal gram and pumpkin seed in the ratios (90:10), (80:10:10), (70:10:10:10) and (60:10:10:10:10), respectively. The formulated multigrain mixes were subjected to nutrient, physical, functional and sensory evaluation. The mixes were found to be more nutrient dense than the control. The colour and texture analyses of the mixes showed better results than the control. The Mix 3 contained the highest water absorption capacity and oil absorption capacity was highest in Mix 5. The acceptability trial was done on multigrain mix based chappatis and it was found that the Mix 5 was found acceptable (8.89 ± 0.60). Therefore, the formulations can be utilized for popularization, commercialization and development of such functional foods that would be beneficial to improve the general health status of populations..

Keywords: Functional analysis, multigrain mix, nutrient analysis, physical analysis, sensory evaluation

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INTRODUCTION

A healthy food is well balanced with respect to quality and quantity of ingredients from different food groups and not just concentrating on one food group, giving rise to a concept of multigrain foods (Shinde, 2017). Health effects of diets rich in whole grains and cereal fibres are well known and are associated with decrease risk of diabetes, myocardial infarction and certain cancers (Banu et al., 2010) due to the presence of phytochemicals, phenol compounds, carotenoids, vitamins, lignans, β glucan, inulin, resistant starch, sterols and phytate (Rui, 2007). In addition to whole grain benefits, multigrain blend concept helps to mix different whole grains to maximize their nutritious, functional and sensory properties (Mandge et al., 2014).

Wheat is considered good source of protein, minerals, B-group vitamins and dietary fibre i.e, an excellent health- building food. Wheat is a good source of thiamine and nicotinic acid (Kumar et al., 2011). The maize kernel is high in fat (33.3 %) in addition to enzymes, vitamin B complex, antioxidants such as vitamin E and polyunsaturated fatty acids (54.7 %) (Gwirtz and Casal, 2014). Millets are unique among the areas because of their richness in calcium, dietary fibre, polyphenols and protein (Devi et al., 2011). Foxtail millet (Setaria italica) is tasty, with a mildly sweet, nut-like flavor and contains a myriad of beneficial nutrients. This millet contains 12.3 per cent crude protein and 63-64 per cent carbohydrate 3.3 per cent minerals (Gopalan et al., 1991). It

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is considered to be one of the least allergenic and most digestible grain (Prashant et al., 2005; Xue et al., 2008). Bengal gram also called chickpea or gram (Cicer arietinum), is a major pulse crop in India and accounts for nearly 40 % of the total pulse production (FAO/WHO, 2008). Pulse is an important food crop due to the high protein and essential amino acid content. Pulses are 20-25 % protein by weight (Slavin, 2004). Oilseeds have long been used extensively as they are excellent source of protein (25.2-37%), vitamins and oil (37.8-45.4%) especially omega-6 fatty acids which have a number of biological application along with significant antioxidant activity in addition to anti-inflammatory and hypolipidemic activities (Barbara and Murkovic, 2004; Suresh and Das, 2003). Pumpkin seeds contain about 40 % of fat rich in unsaturated fatty acids (FA), lecithin and antioxidants as well as in cellulose and minerals particularly iron (Makni et al., 2010). Therefore an attempt has been made to formulate multigrain flour mixes by utilizing cereals, pulses, millets and oil seeds with objectives to study the nutritional, physical, functional and sensory qualities of the developed mixes.

MATERIALS AND METHODS

The ingredients for the development of multigrain flour mix were selected according to the guidelines given by ICMR for multigrain flours. Wheat grains (PBW621) were procured from Punjab Agricultural University, Ludhiana. Foxtail millets were procured from RARS, Gossaigaon. Bengal gram flour was bought from local markets of Jorhat. Pumpkin seeds were collected from local households and college hostels of Assam Agricultural University, Jorhat. All the ingredients were processed into flour according to standard methods and kept separately in airtight containers at refrigerated temperatures. Four different variations of multigrain flour mixes were developed using flours of whole wheat, foxtail millet, maize, Bengal gram and pumpkin seed at different level of incorporation and whole wheat (100 %) as control (Mix 1). Mix 2 was developed using whole wheat and foxtail millet (90:10), Mix 3 with whole wheat, foxtail millet and maize in the ratio 80:10:10, whereas Mix 4 was developed using whole wheat, foxtail millet, maize and Bengal gram (70:10:10:10) and Mix 5 with whole wheat, foxtail millet, maize flour, Bengal gram flour and pumpkin seed flour (60:10:10:10:10) respectively.

Moisture content, Crude protein, Crude fat, Crude fibre and Total mineral of the samples was determined following the A.O.A.C (2000) method. The carbohydrate content was determined by difference method (Gopalan et al., 2000). Energy value was determined by multiplying the percentage of crude protein, crude fat and carbohydrate by the calorific value of these three i.e., by the factor 4, 9 and 4 respectively and the estimation was recorded as Kcal per 100 g (Gopalan et al., 2000). Iron content was determined by Ranganna method (1986) by using spectrophotometer (Model No. 2513). Calcium content was determined by flame photometry using a systronic flame photometer (Model MM III) burner unit 121 at medium sensitivity according to the method of A.O.A.C, 2000.

Colour values of samples are determined by using hunter lab scan XE model (M/S Hunter associate laboratory Inc., Reston-V.A., USA) with a view angle of 2°. Colour values of the samples were determined by the hunter system L, a, b values.

Chappatis were packed in polypropylene pouches (two chappatis in each pouch for the study at different time interval), heat sealed and stored in an atmosphere maintained at temperature 25°C throughout the texture study. Shear force was evaluated using Texture Analyzer (Lloyd Instruments Ltd, Fareham, Hampshire, UK, Model LR-5K) according to the method described by Hemalatha et al. (2014) with slight modifications. The load cell of 1 KN was used and set for 26.0 mm deflection, and Warner blade speed was set at 100 mm/min.

Water and Oil absorption of the composite flours was determined subjectively by employing the method outlined by Gujral and Gaur (2002).

Standardization and development of multigrain flour mix based product

Multigrain flour mixes are usually consumed for its health beneficial effect and since mostly consumed in the form chappati, the product was restricted to chappati only. Chappatis were prepared by following the method as reported by previous researchers (Rao and Bharati, 1996; Kadam et al., 2012) with slight modifications. The chappati dough was prepared by mixing composite flour with the optimum amount of water. The dough was set aside to rest for around 15 minutes at room temperature (25 ± 1°C). The dough was divided into equal portions and rolled into a round sheet (12 cm in diameter and about 2 mm in thickness). The chappatis were baked on a pan at 210 ± 2°C. After baking, chappatis were cooled at room temperature.

Sensory evaluation of multigrain flour mix based product

Acceptability trials were conducted by a semi-trained panel consisting of 15 numbers of judges from the Department of Food Science and Nutrition. Scoring was done on nine point hedonic scale. The three most nutrient dense mixes viz., Mix 3, Mix 4 and Mix 5 were selected for the acceptability trial. For sensory evaluation, multigrain flour based chappati were developed according to the standard chappati formulation outlined by American Association of Cereal Chemists, AACC method (Anon, 1990). The chappati samples were evaluated in terms of colour, flavour, taste, texture and overall acceptance.

Statistical analysis

All the data of the experiment were statistically analysed by using mean, standard deviation and CRD in SPSS software.

RESULTS AND DISCUSSION

The developed multigrain mixes were analysed for the nutrient composition (Table 1). The moisture content of the mixes were statistically different at P ≤ 0.05 from each other with the highest in Mix 1. Differences of moisture content observed in the present study might be due to variation in the ingredients such as variety, geographical location, climatic conditions, time of harvesting, processing etc (Hylnka and Robinson, 1994 and Florkowski et al., 2009). The protein content of the mixes were significantly different at P ≤ 0.05. The highest increase in protein content of the multigrain mixes was observed in case of Bengal gram flour and pumpkin seed flour containing mixes at different level of incorporation. Similarly, Atuonwu and Akobundu (2010) reported that wheat flour substitution with pumpkin seed flour increased the protein content of the flour (10.05 - 12.81 g/100 g).

Table 1: Nutrient analysis of multigrain flour mixes (per 100g)

Nutrients	Mix 1	Mix 2	Mix 3	Mix 4	Mix 5	$CD_{0.05}$
Moisture (g)	12.20 ± 0.20^{bc}	12.10 ± 0.12^{bc}	10.10 ± 0.10^{a}	8.45 ± 0.35^{b}	5.45 ± 0.15^{c}	0.40
Protein (g)	12.10 ± 0.10^{c}	12.12 ± 0.15^{c}	12.20 ± 0.19^{c}	13.03 ± 0.21^{b}	14.04 ± 0.20^{a}	0.39
Fat (g)	1.70 ± 0.01^{ab}	1.87 ± 0.02^{b}	1.90 ± 0.02^{b}	1.92 ± 0.05^{c}	2.67 ± 0.04^{a}	0.07
Crude fibre (g)	1.90 ± 0.02^{c}	2.10 ± 0.07^{d}	2.26 ± 0.01^{b}	2.28 ± 0.08^{b}	2.58 ± 0.010^{b}	0.13
Total mineral (g)	1.08 ± 0.04^{a}	1.26 ± 0.01^{a}	1.49 ± 0.02^{c}	1.77 ± 0.01^{b}	1.84 ± 0.03^{b}	0.03
Carbohydrate (g)	71.02 ± 1.05^{c}	70.55 ± 1.54^{b}	72.05 ± 1.98^{c}	72.55 ± 1.54^{c}	73.42 ± 2.63^{a}	0.12
Energy (kcal)	347.78 ± 3.91^{a}	347.51 ± 2.10^{a}	354.10 ± 3.05^{b}	359.60 ± 3.90^{b}	373.87 ± 2.50^{c}	3.54
Iron (mg)	4.90 ± 0.20^{b}	4.69 ± 0.05^{d}	4.71 ± 0.04^{bc}	5.17 ± 0.08^{b}	5.81 ± 0.05^{a}	0.29
Calcium (mg)	48.00 ± 0.02^{d}	49.20 ± 0.01^{c}	50.00 ± 0.01^{c}	52.02 ± 0.01^{b}	67.00 ± 0.03^{a}	0.22

Values are mean±SE of 3 replications, Means within row separated by Duncan's multiple range test P ≤ 0.05
Means followed by the same letter shown in superscript(s) are not significantly different

The fat content of the mixes increased gradually and the highest increase was observed in pumpkin seed flour incorporated mix i.e., Mix 5. Itagi et al. (2012) revealed that the fat content of the multigrain composite mixes varied from 9 - 13 g/100 g, highest in Mix 1 and lowest in Mix 4 which could be due to the presence of full fat ground nut content in the former and defatted soya flour in the latter. Thus it implied that the increase in fat content in the present study might be due to the incorporation of pumpkin seed. The highest fibre content was found in Mix 5. This increase might be due to the presence of pumpkin seed flour as the grains were used along with the seed coat. The results obtained were in order with the findings of Indrani et al. (2011), which revealed that the presence of crude fibre content contained between 2.5 to 4.7 g/100 g which could be due to the seed coats oil seeds used in the formulation. Another study by Banu et al. (2012) indicated that the addition of oilseed flour contributed substantially to the increased fibre content of the flour.

The highest mineral content was found in Mix 5 followed by Mix 4, Mix 3, Mix 2 and Mix1 respectively. The significant difference was found at $P \leq 0.05$ within the group. The total mineral content of the multigrain mixes in the present study is also consistent with the findings of Mandge et al. (2014) in which the total mineral content of multigrain porridge mix ranged between 1.00 to 1.92 g/100 g, respectively. The significant increase in the total mineral content of Mix 5 might be from the contribution of pumpkin seed coat. This could be due to the fact that total mineral is mostly concentrated in the outer layer such as pericarp, aleurone layer and germ of the seed which is usually lost considerably during processing (Dendy et al., 1995).

The carbohydrate content of the developed mixes was highest in Mix 5. However, with the incorporation of maize, Bengal gram and pumpkin seeds, a significant increase in the carbohydrate content was observed which could be accounted due to increased concentration of carbohydrate of maize in dry weight basis. Similarly, Shrinag (2015) revealed that the cereal-pulse based composite mixes for chapati had the carbohydrate content of 55.86 - 62.38 g/100 g respectively, and the increased in the carbohydrate resulted from the addition of maize, soybean and chickpea. The energy content of the mixes varied from 347.78 to 373.87 kcal/100 g with significant difference at $P \leq 0.05$ between the developed mixes. Highest energy was found in case of Mix 5 incorporated with pumpkin seed flour which was found rich in fat and carbohydrate content. Radhika et al. (2010) revealed that the energy content of the atta mix ranged from 1012.5 to 1142.2 kcal/100 g and the increase in calorie of the mixes resulted due to the increased incorporation of wheat and Bengal gram.

Khan et al. (2005) in their study of soy flour supplementation on mineral and phytate contents of unleavened flat bread (chapatis) found that the soya supplemented flour contained higher amount of iron as compared to the control (wheat flour). Ragaee et al. (2006) reported that the barley and millet flours exhibit higher mineral content compared to commercial hard and soft wheat. The increase in the calcium content of Mix 5 might be due to the calcium contribution from the Bengal gram and pumpkin seed as these two ingredients has the highest calcium content among all the ingredients. The lower values found for the Mix 2, Mix 3 and Mix 4 were still higher compared to control (wheat flour). Similar observations was also made by Iqbal et al. (2006) in which the calcium content of the composite flour increased (76-97 mg/100 g) with the increased incorporation of chickpea and cowpea.

Colour

The Hunter colour meter was used to study the variation in chromatic compounds of the selected mixes (Table 2). Lightness of the multigrain mixes i.e., L* value in the scale 0 (black) to 100 (white) decreased from 84.70 to 83.71 in Mix 3 and Mix 5, respectively which could be due to increased incorporation of maize, Bengal gram and pumpkin seeds, whereas the values were at par in Mix 3 and Mix 4 respectively. The decrease in the lightness of the mixes might be due to the addition of legume and oilseed flour. Redness value (a*) was obtained between 2.11 (Mix 5) and 2.36 (Mix 3) in the scale of -100 (redness) to +100 (greenness). In the scale of -100 (blueness) to +100 (yellowness), yellowness (b*) was found to be highest (14.68 ± 0.15) followed by Mix 4 (14.45 ± 0.13) and Mix 3 (13.77 ± 0.11), respectively. Significant changes in the colour may be due to the addition of various ingredients, however the difference between the values are non-significant. Pande et al. (2017) reported similar observations that with increase in the percentage of grain flours, the dark coloured spots become more which may be attributed to the lesser L* value of the flours.

Table 2: Colour of multigrain flour mixes

Flour	L* (lightness)	a*(redness)	b*(yellowness)
Mix 3	84.70 ± 0.15^{a}	2.36 ± 0.02^{a}	13.77 ± 0.11^{c}
Mix 4	84.55 ± 0.18^{b}	2.32 ± 0.03^{b}	14.45 ± 0.13^{b}
Mix 5	83.71 ± 0.12^{c}	2.11 ± 0.02^{c}	14.68 ± 0.15^{a}
$CD_{0.05}$	0.32	0.45	0.77

Values are mean±SE of 3 replications Means within column separated by Duncan's multiple range test P ≤ 0.05
Means followed by the same letter shown in superscript(s) are significantly not different

Texture profile analysis

Textures of the multigrain based chapatis were studied by the shear force required to tear the chapatis (Table 3). Each chapatis was cut into 3 pieces of 3 cm each and the shear test was conducted for a total of 9 pieces and the average value of force in Newton was recorded. Tests were carried out at intervals of every 3 hours.

Table 3: Texture profile analysis of multigrain mix based chapatis

Sample	Texture (shear force N)		
	0h	3h	6h
Mix 3	14.4 ± 0.3^{a}	13.6 ± 0.1^{b}	10.6 ± 0.3^{c}
Mix 4	12.3 ± 0.3^{a}	11.4 ± 0.2^{b}	9.8 ± 0.1^{c}
Mix 5	10.1 ± 0.2^{a}	7.5 ± 0.1^{b}	5.2 ± 0.2^{c}

Values are mean ± SE of 3 replications Means within column separated by Duncan's multiple range test P ≤ 0.05
Means followed by the same letter shown in superscript(s) are significantly not different

In Mix 3 and Mix 4, gradual decrease in the shear force was observed while significant decrease in case of Mix 5. The decrease in the shear force could be attributed due to the dryness and hardening of the chapatis which increased with time. There was gradual decrease in the shear force at 3 and 6 hours respectively compared to the fresh chapatis. However, decrease in the shear force was more at the time interval of 6 hours. As the non-wheat flour present increased in the multigrain mix, the shear force of the chapatis decreased. The shear force of the prepared chapatti was affected by water absorption capacity. Rao et al. (1996) had reported a decrease in the shear force required to tear the chapatis as the time interval increased and the brittleness of the chapatis increased.

Water absorption capacity

From the Table 4 it was found that Mix 3 had the lowest WAC which might be due to the comparatively high content of carbohydrate against the protein content of the other flours. An important factor affecting water absorption capacity is the protein content of the flour. Water absorption capacity of the flour increased as the non-wheat protein rich components viz., Bengal gram, maize and pumpkin seeds. An important factor affecting water absorption capacity is the protein content of the flour.

Similarly, according to Ghavidel and Prakash (2006) carbohydrate composition may also be a factor influencing the water absorption capacity of the flours. It is known that polysaccharides, which are hydrophilic in nature greatly, affect water absorption capacity.

Table 4: Functional properties of multigrain flour mixes

Parameters	Mix 3	Mix 4	Mix 5	$CD_{0.05}$
Water absorption capacity (WAC) (%)	94.63 ± 0.54^{c}	94.86 ± 0.60^{c}	101.46 ± 0.69^{a}	1.72
Oil absorption capacity (OAC) (%)	130.66 ± 0.80^{c}	136.40 ± 0.83^{a}	143.33 ± 0.88^{b}	1.01

Values are mean ± SE of 3 replications Means within column separated by Duncan's multiple range test P ≤ 0.05
Means followed by the same letter shown in superscript(s) are significantly not different

Oil absorption capacity

The increased oil absorption capacity of Mix 4 might be due the addition of Bengal gram flour. Peters et al. (2003), in their studies on plantain and chickpea flour blend, have reported a high oil absorption capacity of blends. Mix 5 had the highest oil absorption capacity which might be due to the high protein content resulting from the presence of pumpkin seed powder which is considered as a potential source of protein. This may be due to the fact that binding of the lipid depends on the surface availability of hydrophobic amino acids (Shahzadi et al., 2005).

Sensory evaluation of multigrain flour mix based product(s)

The developed multigrain mixes were prepared in the form of chapati from the three most nutrient dense mixes viz., Mix3, Mix 4 and Mix. The mean scores of sensory attributes of multigrain flour mix based chapatis are given in Table 5.

Table 5: Sensory evaluation of multigrain flour mix based chapatis

Sample	Sensory attributes					
	Colour	Appearance	Texture	Taste	Flavour	Overall acceptability
Mix 3	8.10 ± 0.02^{b}	7.53 ± 0.12^{cb}	7.50 ± 0.05^{bc}	7.23 ± 0.11^{bc}	8.00 ± 0.02^{c}	8.01 ± 0.69^{c}
Mix 4	8.12 ± 0.08^{b}	7.75 ± 0.10^{b}	8.21 ± 0.18^{b}	7.70 ± 0.13^{b}	8.54 ± 0.03^{ab}	8.56 ± 0.51^{b}
Mix 5	8.50 ± 0.01^{a}	7.91 ± 0.31^{a}	8.53 ± 0.15^{b}	8.42 ± 0.15^{a}	8.61 ± 0.02^{a}	8.89 ± 0.60 ^{a}
CD at 5%	0.27	0.33	1.03	1.20	0.22	0.31

Each value is an average of fifteen determinations Means within column separated by Duncan's multiple range test P ≤ 0.05
Means followed by the same letter shown in superscript(s) are significantly not different.

The acceptance scores were assigned for various sensory parameters viz., colour, appearance, texture, taste, flavour and overall acceptability. No significant difference between the mixes in context to colour was observed. The mean score for appearance of the Mix 5 based chapatis had the highest score followed by Mix 4 and Mix 3 with no significant difference P ≤ 0.05. The highest score in context to texture was that of Mix 5 followed by Mix 4 and Mix 3. The textural effect of Mix 5 might be due to increased protein and fat content of the formulation. The data depicted in Table 2 revealed that the mean score were above the acceptance limit with lowest score of Mix 3 against the highest in Mix 5. The flavour of multigrain Mix 5 based chapatis obtained the maximum mean score followed by Mix 4 and Mix 3. However, Mix 4 and Mix 5 were statistically at par with each other and Mix 3 was found to be significantly superior. Similarly, Singh et al. (2016) reported that the addition of different proportions of pumpkin seeds increased the taste and flavour of the prepared product (biscuits).

CONCLUSION

In the present investigation, different kinds of composite flours were made from wheat, maize, foxtail millet, Bengal gram and pumpkin seed. The multigrain mixes developed were nutritionally superior in terms of protein, fibre, total mineral, crude fat and iron contents. This study also focussed on the utilization of underutilized nutritious ingredients such as maize, foxtail millet and pumpkin seeds and which could be popularized among masses. Development of such functional foods would be beneficial to improve the nutritional status of vulnerable groups.

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