Development of quick cooking multi-grain *dalia* utilizing sprouted grains

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Abstract Multi-grain *dalia* (MGD) formulations were prepared utilizing sprouted wheat and mixer of other three grains (barley, sorghum and pearl millet) in the ratio of 100:0 (MGD-A), 75:25 (MGD-B), 50:50 (MGD-C), 25:75 (MGD-D) and 0:100 (MGD-E), respectively. The mixer of barley, sorghum and pearl millet was prepared using 50, 25, 25 parts of these grains, respectively. The recovery of grits/ *dalia* (particle size 1.41 to 2 mm) from sprouted wheat and barley was 74.56 and 69.77 %, respectively while sorghum and pearl millet yield 47.94 and 49.39 % (particle size 0.954 to 1.41 mm), respectively. Sprouting brought a reduction of cooking time by about 50 % as compared to un-sprouted studied grains. Cooking time for different MGD formulations ranged from 3.91 to 4.42 min, which was slightly increased with increasing proportion of mixer of barley, sorghum and pearl millet ($p>0.05$). Rehydration ratio of MGD samples varied from 3.12 to 3.45 with minimum in MGD-E sample. Though protein content was decreased with increasing proportion of mixer of three grains in MGD samples but in vitro protein digestibility (58.68 to 62.75 %) was similar ($p>0.05$). The mean overall sensory acceptability scores for MGD samples ranged from 7.50 to 8.49 with ≥ 8.0 in samples having up to 75 % grits of mixer of three grains. In view of very good overall sensory acceptability, rich in crude fibre, calcium and iron content and

low cooking time, 25:75 parts of sprouted wheat and mixer of studied three grains, respectively may be considered for preparation of acceptable quality quick cooking multi-grain *dalia*.

Keywords Multi-grain · Sprouting · In vitro protein digestibility · Quick cooking · *Dalia*

As the health awareness of the consumers increased, there is a growing interest in the nutritional quality and additional health benefits of the products. The recent research development demonstrated the relationship between food consumption and incidence of diseases, which had changed the perception of consumers. Now people are accepting that “Health is a controllable gift”. Due to this multi-grain and whole grain concept is becoming popular. The cereals and millet like barley, sorghum and pearl millet, rich in functional ingredients are gaining popularity amongst those who are accustomed to softer cereals like wheat and rice because of the presence of dietary fibre, beneficial in various degenerative diseases. Whole grains are good sources of many phytochemicals, including phytoestrogens, phenolic compounds, antioxidants, phytic acid and sterols, water-soluble fiber (such as β -glucan and arabinoxylan), oligosaccharides (such as galacto- and fructo oligosaccharides), minerals, and essential amino acids, which make them important for preventing various degenerative diseases (Shah 2001; Dewettinck et al. 2008).

Multi-grain approach is a most common and convenient way of formulating the desired quality of formulations because of the supplementary affect of different nutrients from the combination of different grains making the end product more nutritious at the same time rich in other healthy constituents. Multi-grain flour is one of the common multi-grain based products getting popularity amongst obese, diabetic group and elderly population. Commonly used grain for preparation of multi-grain flour are wheat, maize, pearl millet,

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sorghum, *ragi*, soya flour, etc. Some of the multi-grain foods may include whole grain ingredients but the term multi-grain does not necessarily ensure that the food certainly contained whole grain ingredients. Multi-grain foods often have three to five different grains but can have up to twelve different grains. These foods are often provide a dense texture and rich flavor to the food products.

Wheat grains are a good source of minerals (especially magnesium) and B vitamins, and contain a number of molecules exhibiting interesting activities viz. vitamin E, antioxidant compounds (phenolic acids, carotenoids, etc.), and hormonally active compounds such as lignans (Slavin et al. 1999). A sufficient consumption of the whole grain products has a positive influence on the human cardiovascular system and is considered to protect against affliction from certain types of cancers (Jones 2006). Sorghum and pearl millet are staple foods for a large section of the people especially in dry land regions of India but nowadays coarse cereal and millets are gaining popularity amongst those who are accustomed to softer cereals like wheat and rice because of the presence of soluble and insoluble dietary fibre, beneficial in various degenerative diseases. Insoluble fraction of dietary fibre in cereal grains contains large proportion of cellulose, which has beneficial effects in the gastrointestinal tract (Riaz 1999). The soluble fractions, which consists mainly pectin, arabinoxylan and β -glucans has the ability to lower blood serum cholesterol, through its tendency to increase viscosity in the intestine. Earp et al. (1983) identified the mixed linked β -glucans in sorghum pericarp, aleurone and endosperm. These β -glucans are water-soluble and form viscous, sticky solutions. Klopfenstein and Hosney (1987) observed that rats fed bread prepared from white flour fortified with β -glucan (7 % by weight) had serum cholesterol significantly lower than those fed bread from unfortified flour. Several studies reported the possibility of utilization of sorghum and pearl millet for making diversified food products for human consumption (Mridula and Gupta 2008; Mridula et al. 2006, 2007, 2008). Although the grain colour particularly of pearl millet deteriorates the appearance and colour of the developed food products but the presence of complex carbohydrates and lower glycemic response of *bajra* (pearl millet) (Shukla et al. 1991) making it important for development of functional food products for health conscious consumers.

Sprouting or germination of cereals has been used for centuries for softening the kernel structure, improving its nutritive value, and reducing anti-nutritional factors (Bolbol et al. 2012). In fact, germination process is also one of the methods used to improve the functionality of oat seed protein (Kaukovirta-Norja et al. 2004). Several nutritive factors such as vitamins and bioavailability of trace elements and minerals are reported to increase during germination (Khattak et al. 2007, 2008). Studies indicated that germination process reduced the phytic acid and flatulence causing oligosaccharides

namely stachyose and raffinose, increased protein digestibility and improved sensory properties (Lintschinger et al. 1997). When grain once soaked followed by drying, porosity of grain increased that further facilitate the water absorption. Being porous in nature and with better digestibility of grain constituents, it is assumed that cooking time of grain may also be reduced. This property of sprouted and dried grains may be exploited for developing quick cooking products like, *dalia*. *Dalia* is a traditional breakfast cereal of north India, usually prepared from wheat. It is generally consumed by infants, young children, elderly people and health conscious consumers. In the era of health foods, this commonly consumed item may be made more nutritive utilizing the multi-grain and sprouting technique. With this background, this study was carried out to utilize selected sprouted grains for development of quick cooking multi-grain *dalia*, a traditional food of north India.

Materials and methods

Raw material Wheat (cv.PBW550), pearl millet (cv.PCB164) and barley (cv.PWRUB52), procured from PAU, Ludhiana while sorghum, procured from the local market were used for development of quick cooking multi-grain *dalia*. In order to sprout these selected grains, cleaned and graded wheat, barley, sorghum and pearl millet were soaked in water for 8 h at 30 °C; with seeds to water ratio 1:2. After soaking for desired period, water was drained and soaked grains were allowed to sprout at controlled temperature (35 ± 2 °C) and 95 % relative humidity. Wheat, sorghum and pearl millet were sprouted for 36 h while barley was sprouted for 48 h. Sprouting time for these selected grains was standardized in a separate experiment based on the nutritional quality, microbial load and sensory acceptability. The sprouted grain samples were then dried at 50 °C in a cabinet tray dryer to reduce the moisture content.

Preparation of multi-grain *dalia* Sprouted and dried wheat and barley were pearled for 2 min while sorghum was pearled for 1 min in a grain pearler (Make: CIAE (Central Institute of Agricultural Engineering), Bhopal, 100–300 kg/h) before milling to remove the rootlets of sprouted grains. Pearl millet was pearled in an abrasive rice polisher for 40 s. Pearled grains were then milled (sample size 3.0 kg) using multipurpose grain mill to prepare grits i.e. *dalia*. Similarly un-sprouted grains (unpearled) were also milled to get *dalia* for comparison of yield and cooking time of *dalia*. Milled products of all the selected grains were then subjected to sieve analysis using ASTM (American Society for Testing and Materials) sieves (No. 8, 10, 14, 20, 35, 45 and 100) to recover the different milling fractions. The wheat and barley grits passed through ASTM sieve no. 10 and 14 (particle size 1.41 to 2 mm) and

retained on subsequent sieve, were considered as *dalia*. During feasibility trials, sorghum and pearl millet grits of 1.41 to 2 mm size showed higher cooking time than that of wheat and barley grits of same size; while the cooking time for smaller sized sorghum and pearl millet grits (0.954 to 1.41 mm) showed comparatively lower and near to the cooking time required for wheat and barley grits. Hence for sorghum and pearl millet, the grits passed through ASTM sieve no. 14 and 20 (particle size 0.954 to 1.41 mm), were considered as *dalia* for preparing quick cooking multi-grain *dalia* (MGD). The prepared grits i.e. *dalia* were mixed in different proportion (Table 1), packed and stored for further quality analysis. Thus five different multi-grain *dalia* (MGD) samples in duplicate were prepared from sprouted wheat and mixer of other three grains (barley, sorghum and pearl millet) in the ratio of 100:0 (MGD-A), 75:25 (MGD-B), 50:50 (MGD-C), 25:75 (MGD-D) and 0:100 (MGD-E), respectively. The mixer of barley, sorghum and pearl millet was prepared using 50, 25, 25 parts of these grains, respectively.

In view of good sensory acceptability, MGD-D sample was considered for shelf life study at room temperature. Freshly prepared MGD-D sample (250 g) was packed in commercially available Low density polyethylene (LDPE; thickness 65 μ) and kept at room temperature for 90 days period during August and October, 2012. Stored samples were evaluated for alcoholic acidity, microbial load and sensory characteristics at 30 days interval.

Bulk density of MGD samples was determined following the standard method, by filling a 250 mL cylinder with *dalia* sample from a set height, tapping three times, followed by weighing the contents (Singh et al. 2012).

Instrumental colour quality (L, a and b values) of MGD samples was determined by using Hunter Colorimeter (model no. 45/0 L, made in U.S.A.). h° (hue angle) and C^* (chroma) were computed by using the following formula.

$$h^\circ = \tan^{-1} \left(\frac{b}{a} \right), C = [a^2 + b^2]^{1/2}$$

where b=b values, a=a values

Proximate composition and microbial load Moisture, protein (using the factor $6.5 \times N$), fat, minerals, crude fibre,

calcium and iron in MGD samples were determined as per standard methods (AOAC 2000). Total carbohydrate value was obtained by difference. Total calories were calculated by multiplying protein, carbohydrates and fat content by 4, 4 and 9, respectively. In vitro protein digestibility of samples was determined by Akesson and Stachman (1964) method. All the chemicals used for estimation of proximate composition were of AR grade. Alcoholic acidity in the samples was determined as per the method suggested by Thapar et al. (1988). Microbial load (viable bacterial count and yeast and mould counts) were determined following pour plating method (Cruickshank et al. 1975).

Cooking time of MGD samples was determined as per the method suggested by Narasimha and Desikachar (1978) for pigeon pea dhal with little modification. Twenty g MGD sample was put into 150 mL of distilled water in the beaker at a temperature of 90–95 °C. Determination of cooking time was done using a stop watch. The beaker was covered to avoid leakage of steam while cooking. After 2 min of the initial boiling of beaker content, a few *grits* were drawn from the beaker with the help of a sample spatula at every 30s interval and pressed in between two clean glass plates to check if the grits are cooked to the centre core. Cooking time was recorded when 100 % of the grits were completely cooked and no longer had hard uncooked centre. The sample was then further allowed to simmer for 30 s more to ensure that all the grits are completely cooked and been well gelatinized.

Solid loss of multi-grain *dalia* in cooking water was determined by the cooking of *dalia* samples for the desired period followed by removing the cooked grits from the cooking water using a muslin cloth. The cooking water containing the dissolved solids was evaporated on a hot plate at about 70–80 °C, followed by drying in a hot air oven at 105 °C till the constant weight. The solid loss was calculated with reference to the raw MGD samples taken for cooking and expressed as percentage.

Rehydration ratio was determined by cooking 20 g of MGD samples in 150 mL of distilled water for desired cooking time followed by removing the cooked grits from cooking water by using a muslin cloth. Free moisture from cooked grits was further removed by spreading them

Table 1 Proportion of grits in multigrain *dalia* formulations

Grits from sprouted grains	% grits in formulations				
	MGD-A	MGD-B	MGD-C	MGD-D	MGD-E
Wheat ^a	100	75	50	25	0
Barley ^a	–	12.5	25	37.5	50
Sorghum [#]	–	6.25	12.5	18.75	25
Pearl millet [#]	–	6.25	12.5	18.75	25

^a particle size 1.41 to 2 mm;
[#] particle size 0.954 to 1.41 mm;
 MGD-multi grain *dalia*

Fig. 1 Recovery of grits during sieve analysis of un-sprouted and sprouted wheat (a), barley (b), sorghum (c) and pearl millets (d) after milling

on a filter paper. The rehydrated sample was weighed and the rehydration ratio was computed using the following formula (Prasert and Suwannaporn 2009).

$$\text{Rehydration ratio} = \frac{\text{weight of rehydrated MGD sample}}{\text{weight of uncooked MGD sample (g)}}$$

Sensory characteristics Sensory characteristics of cooked MGD samples were evaluated for different sensory attributes by a group of nine panelists. Cooking of *dalia* was done taking 400 mL of liquid portion (200 mL cow milk and 200 mL distilled water) and 25 g sugar per 50 g of MGD sample, followed by cooking for desired period. Fifty mL of freshly prepared each MGD sample at 40 °C was served to the each

panel for sensory evaluation. Sensory attributes like appearance and colour, sensory texture/ body, odour, flavour and taste, and overall acceptability of MGD samples were assessed using nine point hedonic scale. Hedonic scale was in the sequence as extremely- 9, like very much- 8, like moderately- 7, like slightly- 6, neither like nor dislike- 5, dislike slightly- 4, dislike moderately- 3, dislike very much- 2, dislike extremely- 1 (BIS 1971).

Statistical analysis Data pertaining to three replicates of each parameter except colour quality ($n=8$) and sensory characteristics ($n=9$) were analyzed for analysis of variance using LSD (least significant difference) of AgRes software statistical package. Mean and standard deviation were computed using Microsoft Excel 2003.

Table 2 Selected physical properties and peak viscosity of multi-grain *dalia*

MGD samples	Selected physical properties			
	Peak viscosity, cP	Bulk density, g/mm ³	True density, g/mm ³	Porosity, %
MGD-A	83.67±0.58 ^a	0.692±0.002 ^c	1.333±0.056	48.07±2.12 ^a
MGD-B	61.33±2.89 ^b	0.703±0.004 ^b	1.304±0.040	46.07±1.44 ^{ab}
MGD-C	59.33±0.58 ^b	0.705±0.004 ^b	1.303±0.046	45.97±1.85 ^{ab}
MGD-D	59.67±0.58 ^b	0.707±0.002 ^b	1.277±0.034	44.59±1.55 ^{bc}
MGD-E	59.00±1.00 ^b	0.738±0.002 ^a	1.274±0.021	42.15±0.90 ^c
F value	166.08 ^{**}	118.56 ^{**}	0.974 ^{ns}	5.41 ^{**}
CD	2.62	0.005	0.075	2.96

All values are mean±SD ($n=3$), values with different superscript are statistically different; ^{ns} $p>0.05$, ^{**} $p<0.01$; MGD-multi grain *dalia*

Table 3 Instrumental colour quality of multi-grain *dalia*

MGD samples	L	a	b	Hue	Chroma
MGD-A	75.85±0.99 ^{ab}	4.55±0.31 ^a	16.41±0.55 ^a	74.53±0.81 ^d	17.03±0.81 ^a
MGD-B	76.23±0.91 ^a	3.72±0.20 ^b	14.96±0.58 ^b	76.04±0.79 ^c	15.42±0.60 ^b
MGD-C	75.90±1.37 ^{ab}	3.30±0.15 ^c	14.74±0.69 ^b	77.37±0.67 ^b	15.10±0.92 ^b
MGD-D	74.98±0.72 ^{bc}	2.85±0.26 ^d	13.38±0.32 ^c	78.00±1.13 ^b	13.68±0.66 ^c
MGD-E	74.60±0.39 ^c	2.35±0.16 ^c	12.51±0.33 ^d	79.34±0.73 ^a	12.73±0.33 ^d
F value	4.40 ^{**}	110.66 ^{**}	68.69 ^{**}	59.10 ^{**}	76.89 ^{**}
CD (0.05)	1.04	0.251	0.573	0.757	0.595

All values are mean±SD ($n=8$); values with different superscript are statistically different; ^{**} $p<0.01$; MGD-multi grain *dalia*

Results and discussion

Milling of sprouted and un-sprouted studied grains, to obtain *dalia* of desired size was done at moisture content of 6.0 to 6.50 % (w.b.). Sieve analysis of sprouted and un-sprouted grain fractions (Fig. 1) indicated that sprouting brought an impact on the recovery of grain fractions i.e. percent of material retained on different sieves ($p<0.0$). Affect of spouting on the grain hardness and a slight variation in the moisture content of studied grains may be reasons of variation in the recovery of grits on different sizes. Recovery of wheat and barley grits on sieve number 14 (passed through 10 no. sieve) was higher than that of sorghum and pearl millet, might be due to the difference in the grain size. The particle size of wheat *dalia* generally being marketed was found in the range of 1.41 to 2 mm. In the present study, recovery of *dalia* (1.41 to 2 mm particle size) from un-sprouted wheat and barley was 77.26 and 78.9 %, respectively as against 74.56 and 69.77 %, respectively from sprouted grains. In case of sorghum and pearl millet, the recovery of *dalia* (0.954 to 1.41 mm size) from un-sprouted and sprouted grains was 47.46 and 55.33 %, and 47.94 and 49.39 %, respectively. The bigger size grits of these un-sprouted and sprouted grains may be utilized for making multi-grain flour while that of smaller grits may be used for making *utpam*, *upma* and other products. The smaller grits of sprouted grains would be quite useful in making quick cooking mixes for *utpam*, *upma*, etc.

Bulk density is an important functional property of flour and should be given due consideration while making weaning foods for young children. Germination has been reported to be a useful method for the preparation of low bulk weaning foods (Desikachar 1980). Hussain and Unddin (2012) had also reported lower bulk density of wheat, germinated for 48–72 h, which varied from 0.49 to 0.57 (g/mL). In the present study, true density of different MGD formulations was statistically similar but bulk density and porosity were affected with the proportion of grits of studied grains in different MGD formulations. These properties were found significantly lower in case of MGD-A; and increased with decreasing level of wheat grits in the MGD formulations (Table 2). This might be due to the variation in the grain type, proportion of grits of studied grains and also the size of grits which varied sample to sample. Peak viscosity of different MGD formulations varied between 83.67 and 59.0 with minimum in MGD-E and maximum in case of MGD-A sample. Variation in the proportion of grits of different grains in MGD formulations may be a reason of difference in the peak viscosity of samples.

Instrumental colour quality was also found significantly affected with the proportion of the grits of different grains in MGD formulations (Table 3). Though, there was a variation in the L, *a* and *b* values of different MGD samples but no specific trend was observed amongst different MGD samples. As *a* and *b* values were affected due to the level of grits of studied grains, h° and C^* were also changed accordingly. A linear

Table 4 Cooking quality of multi-grain *dalia*

MGD samples	Cooking time, min	Hydration ratio	Solid loss in cooking water, %
MGD-A	3.91±0.30	3.45±0.01 ^a	14.29±0.23 ^c
MGD-B	4.08±0.08	3.48±0.10 ^a	16.15±0.29 ^d
MGD-C	4.19±0.05	3.36±0.12 ^{ab}	18.52±0.29 ^c
MGD-D	4.29±0.15	3.28±0.07 ^b	21.07±0.95 ^b
MGD-E	4.42±0.10	3.12±0.07 ^c	22.39±0.30 ^a
F value	0.45 ^{ns}	8.84 ^{**}	139.08 ^{**}
CD	2.98	0.154	0.896

All values are mean±SD ($n=3$); values with different superscript are statistically different; ^{ns} $p>0.05$, ^{**} $p<0.01$; MGD-multi grain *dalia*

increase was observed in hue values ($p<0.01$) of MGD samples, which were found increased with decreasing proportion of wheat grits in the formulations. While a reverse trend was observed for chroma of MGD samples with minimum for MGD-E and maximum for MGD-A sample, which was with wheat grits only.

Cooking time of *dalia* (1.41 to 2 mm size) of all the studied un-sprouted grains was 8.2, 8.12, 8.43 and 8.18 min for wheat, barley, sorghum and pearl millet, respectively. Cooking time of sprouted wheat and barley *dalia* (1.41 to 2 mm size) was 3.86 and 4.18 min, respectively while that for sprouted sorghum and pearl millet grits (0.954 to 1.41 mm), it was 4.34 and 4.47 min, respectively. The lower cooking time for sprouted *dalia* indicated that sprouting was influential in reducing the cooking time of by more than 50 %. Due to lower cooking time for *dalia* from sprouted grains, *dalia* developed using different proportions of sprouted grains may be considered as quick cooking multi-grain *dalia*. The lower cooking time of sprouted *dalia* may be due to lower grain hardness, comparatively porous grain structure and breakdown of grain constituent to smaller component during sprouting that in turns resulted in lower cooking time. Processing of grain causes micro structural changes in cell and tissue structures, proteins, cell wall components, starch and fat droplets. Autio *et al.* (1998) reported that the germination-induced micro-structural 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 and thus affect the overall grain quality. Cooking time for different MGD formulations varied between 3.91 and 4.42 min with minimum for MGD-A with wheat grits only while maximum for MGD-E sample which was devoid of wheat grits (Table 4). Though, a slight variation was observed in the cooking time for different MGD samples but the difference was statistically similar ($p>0.05$). This showed that multi-grain *dalia* from sprouted grains may be as acceptable as *dalia* from wheat grain as for cooking time is concern.

Rehydration ratio (water uptake by grits during cooking) of different MGD samples varied from 3.12 to 3.45 with minimum in MGD-E sample and maximum in MGD-A sample ($p<0.01$). A reverse trend was observed for solid loss of MGD samples in the cooking water. Results indicated that with higher cooking time, rehydration ratio was lower while solid loss was higher, which was obvious (Table 4). The variation in the cooking quality of different MGD samples might be due to grain quality, grit size and proportion of different grits in the MGD samples. Though solid loss of different MGD samples varied significantly but it won't affect the nutritional quality of the end product because cooking water is not being drained off during the normal existing practices of cooking of MGD samples.

Table 5 Nutritional quality of multi-grain *dalia*

MGD Samples	Moisture, % w.b.	Protein, %	Fat, %	Crude fibre, %	Minerals, %	Carbohydrates, %	Calories, kcal/ 100 g	In vitro protein digestibility, %	Calcium, mg/ 100 g	Iron, mg/ 100 g
MGD-A	6.28±0.02	10.26±0.18 ^a	1.70±0.06 ^e	3.23±0.16 ^a	1.29±0.006 ^a	77.24±0.26 ^{ab}	365.26±0.93	62.75±1.00	45.33±1.15 ^b	1.18±0.11 ^c
MGD-B	6.32±0.04	9.68±0.14 ^b	1.79±0.02 ^d	3.46±0.06 ^{ab}	1.22±0.008 ^b	77.53±0.18 ^a	364.96±0.45	62.58±1.99	52.00±2.0 ^{ab}	1.80±0.19 ^b
MGD-C	6.20±0.22	9.45±0.06 ^{bc}	1.89±0.02 ^c	3.66±0.15 ^b	1.21±0.001 ^b	77.59±0.11 ^a	365.19±0.21	61.96±2.83	54.67±7.57 ^a	2.55±0.19 ^a
MGD-D	6.39±0.12	9.53±0.11 ^{bc}	1.98±0.04 ^b	3.91±0.12 ^a	1.12±0.011 ^c	77.07±0.13 ^b	364.25±1.02	61.51±1.15	56.00±4.00 ^a	2.61±0.43 ^a
MGD-E	6.46±0.07	9.32±0.22 ^c	2.11±0.03 ^a	4.06±0.15 ^a	1.07±0.025 ^d	76.99±0.37 ^b	364.16±0.70	58.68±1.75	58.67±2.31 ^a	2.68±0.11 ^a
F value	2.09 ^{ns}	16.84 ^{**}	63.29 ^{**}	18.16 ^{**}	140.77 ^{**}	4.19 [*]	1.54 ^{ns}	2.35 ^{ns}	4.60 [*]	22.70 ^{**}
CD (0.05)	0.213	0.282	0.063	0.246	0.023	0.415	1.325	3.39	7.46	0.433

All values are mean±SD ($n=3$); values with different superscript are statistically different; ^{ns} $p>0.05$, ^{*} $p<0.05$, ^{**} $p<0.01$; MGD-multi grain *dalia*

Table 6 Sensory characteristics of multi-grain *dalia*

MGD Samples	Appearance & colour	Sensory texture/ body	Odour	Flavour & taste	Overall acceptability
MGD-A	8.42±0.47 ^a	8.33±0.49 ^a	8.25±0.45 ^a	8.42±0.51 ^a	8.25±0.62 ^{ab}
MGD-B	7.83±0.54 ^{bc}	8.25±0.58 ^a	8.04±0.45 ^a	8.38±0.43 ^{ab}	8.24±0.50 ^{ab}
MGD-C	8.08±0.42 ^{ab}	8.33±0.44 ^a	8.25±0.58 ^a	8.33±0.49 ^{ab}	8.49±0.48 ^a
MGD-D	7.50±0.48 ^c	7.67±0.49 ^b	8.08±0.47 ^a	7.96±0.54 ^{bc}	8.00±0.56 ^b
MGD-E	7.04±0.40 ^d	7.75±0.45 ^b	7.50±0.52 ^b	7.63±0.57 ^c	7.50±0.56 ^c
F value	15.81 ^{**}	5.33 ^{**}	4.60 ^{**}	5.34 ^{**}	5.64 ^{**}
CD (0.05)	0.378	0.405	0.408	0.419	0.448

All values are mean±SD ($n=9$); values with different superscript are statistically different; ^{**} $p<0.01$; MGD-multi grain *dalia*

Nutritional quality of different MGD samples is presented in Table 5. Protein, fat, crude fibre and minerals content of all MGD samples varied between 9.23 to 10.26 %, 1.7 to 2.11 %, 3.23 to 4.06 % and 1.29 to 1.07 %, respectively (Table 5). Though there was a variation in protein, fat, and carbohydrates content of different MGD samples but the total calories in all the samples were found at par. In vitro protein digestibility of all the MGD samples varied between 58.68 and 62.75 % with minimum in MGD-E sample and maximum in MGD-A with wheat grits only but the difference was statistically similar. Though with decreasing proportion of wheat grit, minerals content decreased but calcium and iron content was found increased with addition of grits of other grains in MGD formulations.

Mean sensory scores for all the sensory attributes of all MGD samples were more than 7, showed that all the samples were well accepted by the panelist for all the sensory characteristics (Table 6). The mean sensory scores for overall acceptability scores for MGD-B to MGD-D samples were ≥ 8 i.e. in the hedonic category of liked very much with minimum for MGD-E sample. MGD-D sample with overall acceptability score 8 indicated that acceptable quality quick cooking multi-grain *dalia* may be developed utilizing MGD-D formulation.

No significant increase in moisture content was observed during 90 days storage period, which was 6.54 % at the end of the study as compared to 6.39 in fresh sample. Alcoholic acidity is basically determined to assess the changes caused, in the grain and grain-based product, due to deterioration in the fats and proteins present in them. Alcoholic acidity of freshly prepared MGD-D sample was 0.16 ± 0.011 which was slightly increased (0.18 ± 0.13 %) during 90 days storage period. A slight increased for alcoholic acidity were also observed during the storage of bengal gram and bengal and barley based *sattu* (Mridula *et al.* 2009, 2010). Some increase in the total bacterial and yeasts and moulds count was observed from 4.8×10^3 and 1.0×10^3 cfu/g to 5.6×10^3 and 1.0×10^3 cfu/ g, respectively at the end of the study but were well within the acceptable limits of total bacterial counts of 5.0×10^4 cfu/ g (Deshpande *et al.* 2004). This sample was also with

good overall acceptability score (7.94) at the end of 90 days of storage period.

Conclusion

Multi-grain *dalia* was prepared from different proportion of sprouted wheat, barley, sorghum and pearl millet grits. Proportion of grits of different sprouted grains influenced the overall quality of different MGD samples significantly. Yield of *dalia* (particle size 1.41 to 2 mm) from sprouted wheat and barley was 74.56 and 69.77 %, respectively while for sprouted sorghum and pearl millet, it was 47.94 and 49.39 % (particle size 0.954 to 1.41 mm), respectively. Cooking time of sprouted grains was lower than the un-sprouted studied grains by about more than 50 %. Being lower in cooking time, multi-grain *dalia* developed using different proportions of sprouted grains may be considered as quick cooking multi-grain *dalia*. In view of very good overall sensory acceptability scores, rich in crude fibre, calcium and iron content and low cooking time, MGD-D i.e. sample with 25:37.5:18.75:18.75 parts of sprouted wheat, barley, sorghum and pearl millet, respectively may be considered for preparation of acceptable quality quick cooking multi-grain *dalia*, which also stored well for 90 days at room temperature.

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