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Physical and functional properties of different cereals, pulses, millet and oil seeds

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ABSTRACT

The physical and functional properties of selected cereals, pulses, millets and oil seeds were studied. Physical properties of oat, barley, sorghum, chickpea, groundnut, flaxseed, finger millet, amaranth, maize, sesame seed ranged from 0.74 to 527.40 g Thousand seeds weight, 0.39 to 0.79 g bulk density, 0.002 to 0.45g/seed hydration capacity, 0.32 to 1.81 hydration index, 0.001 to 0.16 ml/seed swelling capacity and 0.13 to 0.56 swelling index. Water absorption capacity (2.36%) of sesame seed, gelation capacity (15.50%) of amaranth, emulsification capacity (52.56%) of flaxseed, swelling power (127.5%) of flaxseed, foam capacity (42.44%) of sesame seed and foam stability (99.29%) of finger millet was significantly higher. Finger Millet, amaranth and flaxseeds are high in mineral content. Oat and barley contain higher amount of dietary fiber. All these tested grains can be used for preparation of different types of nutritious products with better physical qualities.

KEYWORDS

Cereals, millets, oilseed, pulses, pseudo cereals

INTRODUCTION

The need for high protein and high fiber food with functional constituents is gaining popularity worldwide due to increasing health risks, as these help in tackling challenges of hunger, starvation and other persistent diseases (Mahajani, 2020). Cereal grains, pulses & oil seed like Oat, rice barley, sorghum, chickpea, groundnut, sesame seed, flaxseed, and amaranth are thought of to be one of the foremost vital sources of macromolecule, carbohydrates, vitamins, minerals and fiber for individuals all over the globe. More over, they are used as sources of indigestible carbohydrates that besides promoting many helpful physiological effects may by selection stimulate the expansion of lactobacilli and bifidobacteria gift within the colon, thereby acting as prebiotics (Kellow *et al.*, 2014). Cereals contain soluble fiber (such as 6-glucan and arabinoxylan), oligosaccharides (such as *galacto* and *fructo-oligosaccharides*) and resistant starch, and so are suggested to fulfill the prebiotic construct (Slavin, 2013; Andersson *et al.*, 2014) Interactive effects of the polyphenols and fiber on gut microbiota and associated benefits to colon health and against systemic inflammation. All the nutritious food products are generally prepared using cereal grains, pulses and oil seeds.

The major features of these substances are texture, structure, mouth feel, bulk, and plenty of other characteristics favored for unique finished food products, more people are willing to consume various whole grain foods, particularly foods such as whole grain bread and granola bars over other food items. (Combest and Warren, 2018). They not only provide nutrition, but also confer health promoting effects in food, such as anti-carcinogenic, anti-microbial, and antioxidant properties (Costabile *et al.*, 2008; Adebo and Gabriela, 2020). To develop products from all these grains pre processing is required like roasting, popping, puffing, rolling and flaking. For better pre processing like roasting, popping, puffing, rolling and flaking, better physical and functional properties are required (Mahajani, 2020).

MATERIALS AND METHODS

The present study was carried out in Center of Food Science and Technology, CCS Haryana Agricultural University, Hisar.

Procurement of material

Genotype of barley (BH-393,BH-946), Sorghum (HJ-541, HC-308), chickpea (HC-1, C-235) Oat (HJ-8, OS-6) and were procured from the Department of Genetics and Plant Breeding, College of Agriculture, CCS HAU, Hisar. Groundnut (GNH-4, GNH-804) was procured from the Regional Research Station, Bawal. Other ingredients like maize, finger millet, amaranth seeds, sesame seeds and were procured from local market, Hisar.

Preparation of sample

All grains like barley, chickpea, oat, sorghum and groundnut varieties were cleaned to remove extraneous grains, weeds, soil, dust and other foreign materials. Then grains were conditioned, dried and grounded to flour.

Physical Properties of cereal grains and legume

Oat, rice, barley, sorghum, chickpea, groundnut, sesame seed, flaxseed, and amaranth seeds were evaluated for the physical properties i.e. 1000 kernel weight, bulk density, hydration index and swelling index.

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1000 kernel weight

1000 kernel weight was measured by counting 100 randomly selected seeds. The seeds were weighed using an electronic balance having an accuracy of 0.001 g and weight was multiplied by 10 to give weight of 1000 kernels.

Bulk Density

Bulk density was determined according to the method described by Okaka and Potter (1977). 50 g sample was weighed and transferred to 100 ml graduated cylinder and tapped 20-30 times. The bulk density was calculated as weight per unit volume of sample.

Hydration index

Hydration capacity was determined according to the method described by Williams *et al.* (1983). Seeds weighing 10 g were counted and transferred to measuring cylinder. To this 25 ml water was added and cylinder was covered with aluminum foil and left overnight at room temperature. Next day, seeds were drained, superfluous water was removed with filter paper and swollen seeds were reweighed.

Hydration index was calculated using the following formula:

$$\text{Hydration Capacity (per seed)} = \frac{\text{Increase in weight of seeds}}{\text{Number of seeds}}$$

$$\text{Hydration index} = \frac{\text{Hydration capacity per seed}}{\text{Weight (g) of one seed}}$$

Swelling index

10 gram of sample seeds were counted and transferred to measuring cylinder and to this 25 ml of distilled water was added. Volume was noted and then it was kept as such for 24 hours at room temperature (20-30°C). The volume of soaked seeds was noted again. Swelling index was calculated using the formula

$$\text{Swelling Capacity (per seed)} = \frac{\text{Increase in volume of seeds}}{\text{Weight (g) of seeds}}$$

$$\text{Swelling index} = \frac{\text{Swelling capacity per seed}}{\text{Volume (ml) of one seed}}$$

Functional Properties

The cereal flour was assessed for the water absorption capacity, gelation capacity, emulsification capacity, swelling power, foam stability and pasting characteristics

Water absorption capacity

Water absorption capacity was determined by the method of Singh and Singh (1991). One-gram sample was mixed with 10 ml distilled water for 30 min. The contents then centrifuged at 3000 rpm for 20 min. and the volume of the supernatant was recorded. The results were expressed as ml/g sample.

Gelation Capacity

The gelation capacity was determined according to the method of Singh and Singh (1991). The sample suspension containing 8-15% (w/v) flour in 0.5% increment was prepared in 10 ml of distilled water. The test tubes were heated for 1 h in boiling water bath, rapidly cooling under running cold water. These test tubes were refrigerated for 3h at 5° C. The least gelation concentration was determined as that concentration at which the sample did not fall down or slip from an inverted test tube.

Emulsification capacity

The emulsion capacity was determined using the procedure described by Kinsella (1979). The flour sample 0.5 g was weighed and transferred to an Erlenmeyer flask. To this 5 ml. distilled water added and slurry was made in an Erlenmeyer flask stirring at 1000 rpm for 15 minutes with magnetic stirrer. Then 5 ml refined oil was added over a period of 5 min. stirring 1000 rpm, stirring as continued for an extra minute. The system was transferred into centrifuge tube treated in a water bath-maintained ad 85° C. The tube was finally centrifuges at 3500 rpm until the height of oil (separated from emulsion) was constant. Results were expressed as percentage of the emulsion after separating the upper layer from emulsion.

Swelling power

Swelling power of the flour was determined by the Subramanian *et al.* (1986). The flour sample (0.5g) was weighed and transferred into centrifuge tube, and 20 ml distilled water was added. The tube was placed in a heating block at 90° C for one hour. The tubes were periodically shaken. After cooling, the contents were centrifuged tube were wiped out by tissue paper for removal of excess moisture and then the weight of the tube with swelled sample was recorded.

$$\text{Swelling Power (\%)} = \frac{W_2}{W_1} \times 100$$

Where, W1 = Weight of Centrifuge tube +sample

W2 = weight of centrifuge tube + swelled sample

Foam Stability

The method described by Narayana and Narasinga Rao (1982), modified by Fagbemi and Oshodi (1991) was used to determined the foam capacity and foam stability. 2 gm flour sample was added to 50 ml distilled water at 30±2° C in a 100 ml measuring cylinder. The suspension was mixed properly and shaken to foam. The volume of foam after 30 sec. was recorded. The foam capacity was expressed as a percentage increase in volume. The foam volume was recorded 2 hr after whipping to determine foam stability as a percentage of the initial volume.

Mineral content

Mineral content of the sample was determined by wet digestion method. One g flour was weighed and dispersed in a 150 ml conical flask. 25-30 ml diacid mixture (HNO_3:$HCLO_4$) in ratio 5:1 was added in flask and kept for overnight. Then the contents were digested by heating until clear white precipitates settled down at the bottom. The crystals left were dissolved by adding double distilled water. Then the contents were filtered through Whatman 42 filter paper. The filtrate was made to 50 ml volume by using double distilled water and used for the determination of trace minerals viz. iron, zinc, using Atomic Absorption Spectrophotometer (Lindsey and Norwell, 1969), in the Department of Soil Science, Haryana Agricultural University, and Hisar. Total calcium in acid digested sample was determined by the method of Chopra and Kanwar (1979).

Dietary Fiber

Total, soluble and insoluble dietary fiber constituents were determined by the enzymatic method given by Furda (1981).

RESULTS AND DISCUSSION

Physical properties of cereals, pulses, oilseeds and millets

Oat (HJ-8, OS-6), barley (BH-393, BH-946), sorghum (HJ-541, HC-308), chickpea (HC-1, C-235) groundnut (GNH-4, GNH-804), maize, finger millet, amaranth, flax seed & sesame seed were studied for physical properties. Thousand seeds weight, bulk density, hydration capacity, hydration index, swelling capacity and swelling index of cereals i.e. oat, barley, sorghum, chickpea, groundnut, flaxseed, finger millet, amaranth, maize, sesame seeds was observed Table 1.

Table 1: Physical properties of cereals, pulses, oil seed and millets

Sample	1000 kernel weight (g)	Bulk density (g/ml)	Hydration capacity (g/seed)	Hydration index(g/seed)	Swelling capacity (ml/seed)	Swelling Index (g/seed)
Oat HJ - 8	26.91±0.84	0.78±0.02	0.03±0.01	0.95±0.02	0.07±0.01	0.44±0.01
Oat OS - 6	28.29±0.29	0.73±0.02	0.02±0.02	0.82±0.01	0.03±0.01	0.40±0.01
Barley BH - 946	36.25±0.94	0.42±0.01	0.03±0.04	0.80±0.06	0.01±0.02	0.20±0.01
Barley BH - 393	30.58±0.13	0.58±.0.01	0.03±0.01	0.93±0.02	0.02±0.01	0.39±0.07
Sorghum HJ - 541	27.74±0.38	0.56±0.04	0.01±0.01	0.42±0.05	0.02±0.01	0.32±0.01
Sorghum HJ - 308	24.58±0.13	0.71±0.01	0.01±0.04	0.32±0.01	0.01±0.01	0.29±0.02
Chickpea HC - 1C-	115.23±0.35	0.63±0.03	0.14±0.01	1.16±0.09	0.10±0.01	0.24±0.01
Chickpea C- 235	133.86±1.02	0.39±0.04	0.12±0.05	1.20±0.01	0.11±0.02	0.29±0.01
Ground nut MH-4	467.39±1.21	0.54±0.01	0.32±0.06	0.71±0.04	0.13±0.02	0.14±0.01
Ground nut GNH - 804	527.40±0.57	0.50±0.04	0.33±0.01	0.59±0.01	0.16±0.04	0.13±0.01
Finger millet	02.47±0.05	0.79±0.02	0.002±0.73	0.99±0.01	0.001±0.02	0.26±0.01
Maize	242.10±0.57	0.60±0.01	0.30 ±0.29	0.59±0.01	0.15±0.01	0.13±0.01
Amaranth	0.74±0.01	0.73±0.03	0.45± 0.44	0.59±0.05	0.01±0.02	0.51±0.02
Fl ax seed	6.56±0.04	0.68±0.01	0.01±0.01	1.44±0.02	0.01±0.01	0.51±0.01
Sesame seed	3.10±0.15	0.66±0.03	0.006±0.01	1.81±0.01	0.006±0.05	0.56±0.02
CD at ± 5%	0.975	0.019	0.027	0.089	0.009	0.44

Value are mean ± SD of three observations

Thousand seeds weight of oat, barley, sorghum, chickpea, groundnut, flaxseed, finger millet, amaranth, maize, sesame seed ranged from 0.74 to 527.40 g. Thousand seed weight of groundnut varieties namely GNH-804 (527.40 g) and MH-4 (466.76g) was significantly higher (P<0.05) followed by maize, chickpea, Barley, Oat, Sorghum, flaxseed, sesame seed and finger millet, respectively. Thousand seed weight of amaranth was significantly lower (P<0.05) which is 0.74g as compared to other cereal, pulses, millet and oilseed. Similar results were found by Sangeeta and Grewal (2018). Similar value for thousand seed weight of flaxseed has been reported by Khan and Saini (2016). The results obtained for the thousand seed weight of corn and barley is in agreement with those reported by Makeri *et al.* (2013) and Abiose and Ikujenlola (2014).

Bulk density of chickpea, barley, groundnut, maize, sesame seed, flaxseed, sorghum, oat, amaranth, finger millet ranged from 0.39 to 0.79 g. Bulk density of finger millet was significantly (P<0.05) higher (0.79g/ml) followed by oat, amaranth, sorghum , flax seed, sesame seed, chickpea, maize, barley and groundnut, respectively. Similar results for oat bulk density was observed by Takhellambam and chimmad (2015) and Kaur and Singh (2017) Bulk density of cereal grains and flaxseed varied from 0.50 to 0.83 g/ml. Makeri *et al.* (2013) documented higher bulk density (1.10-1.16 g/ml) of barley cultivars than obtained in present study. Sharma and Prasad (2013) reported higher value for bulk density of different linseed varieties ranging from 1006 to 1198 kg/m^3 than recorded in present study.

Hydration capacity of chickpea, barley, groundnut, maize, sesame seed, flaxseed, sorghum, oat, amaranth, finger millet ranged from 0.002 to 0.45. Hydration capacity of amaranth was significantly (P<0.05) higher (0.45g/seed) than other cereals. Hydration index of sesame seed, flaxseed, chickpea, barley, groundnut, maize sorghum, oat, amaranth, finger millet ranged from 0.32 to 181. Hydration index of sesame seed was significantly (P<0.05) higher (1.81) followed by flaxseed (1.44) and chickpea HC-1 (1.16) and C-235(1.20). Swelling capacity of groundnut, maize, sorghum, flaxseed, sesame seed, oat, amaranth, barley, finger millet ranged from 0.001 to 0.16 ml/seed. Swelling capacity of groundnut varieties namely GNH-804 (0.16 ml/seed) and MH-4 (0.13 ml/seed) was significantly higher (P<0.05) followed by maize, chickpea, Oat, barley, sorghum, flaxseed, amaranth, finger millet, sesame seed respectively. Nutan (2015) observed the similar results for the hydration and swelling capacity of cereal grains, but the results obtained for the hydration and swelling index of cereal grains are conflicting with those reported by Guria (2006). Swelling index of groundnut, maize, sorghum, flaxseed, sesame seed, oat, amaranth, barley, finger millet ranged from 0.13 to 0.56. Swelling index of sesame seed was significantly (P<0.05) higher than other cereals. Swelling index of maize was significantly (P<0.05) lower (0.13) than other cereals.

Functional properties of cereals, pulses, oilseeds and millets
Data regarding water absorption capacity, gelation capacity, emulsification capacity, swelling power, foam capacity and foam stability of groundnut, maize, sorghum, flaxseed, sesame seed, oat, amaranth, barley, finger millet have been presented in Table 2.

followed by finger millet, groundnut and chickpea. The percentage gelation capacity was lowest in case of sorghum (1.16%). Similar results for Oat, barley, flaxseed and maize of gelation capacity was observed by Chaudhary *et al.* (2018).

Emulsification capacity of groundnut, maize, sorghum, flaxseed, sesame seed, oat, amaranth, barley, finger millet ranged from 0.05 to 52.56 %. Their of Emulsification capacity was observed highest in flaxseed followed by sesame seed, groundnut, chickpea, sorghum oat and barley. Emulsification capacity of amaranth was lowest than other cereals. Swelling power of groundnut, maize, sorghum, flaxseed, sesame seed, oat, amaranth, barley, finger millet ranged from 5.52 to 119.2 %. Swelling power was highest in flaxseed (127.5%) followed by chickpea, sesame seed and sorghum.

Table 2: Functional Properties of various cereals, pulses, oil seed and millets

Sample	Water absorption Capacity (ml/g)	Gelation capacity (%)	Emulsification capacity (ml/100ml)	Swelling power (%)	Foam capacity (%)	Foam stability (%)
Oat HJ - 8	1.77±0.03	7.27±0.01	36.02±1.27	110.2±0.20	20.66±1.15	92.27±2.65
Oat OS - 6	1.56±0.01	6.72±0.02	43.13±1.69	113.5±0.49	12.66±1.15	92.31±0.06
Barley BH - 946	0.78±0.03	7.83±0.07	41.07±0.56	112.6±0.40	24.66±10.2	78.33±1.50
Barley BH - 393	1.02±0.02	8.66±0.28	45.09±1.69	109.9±0.20	29.41±3.39	84.38±0.27
Sorghum HJ - 541	0.98±0.00	1.16±0.28	43.27±0.41	110.6±0.56	16.33±1.13	91.17±0.93
Sorghum HJ - 308	0.95±0.01	1.83±0.28	37.21±0.74	116.0±0.23	17.33±2.30	88.63±0.90
Chickpea HC-1 C	0.96±0.03	9.16±0.28	45.84±1.17	119.2±0.17	26.98±1.31	93.62±0.58
Chickpea 235	0.94±0.01	8.83±0.28	47.08±0.72	111.5±0.03	32.21±2.03	92.81±0.34
Groundnut MH - 4	0.98±0.02	10.00±0.50	50.17±1.64	30.50±0.49	16.33±1.13	92.19±0.09
Groundnut GNH - 804	0.96±0.01	10.16±0.28	49.33±1.15	37.20±0.28	13.81±0.15	91.42±1.03
Finger millet	1.10±0.06	11.01±0.21	20.11±0.85	5.52±0.10	2.80±0.72	99.53±0.41
Maize	1.52±0.01	8.00±0.01	20.25±1.56	110.2±0.17	13.33±0.57	91.47±0.03
Amaranth	2.10±1.56	15.50±0.60	0.05±0.01	8.42±0.02	21.53±1.12	82.78±0.29
Flax seed	1.86±0.04	8.00±0.05	52.56±0.05	127.5±0.23	09.20±0.40	52.47±0.32
Sesame seed	2.36±0.02	6.67±0.11	50.71±0.24	117.0±0.13	42.44±1.43	79.59±0.71
CD at ± 5%	0.034	0.328	0.664	0.549	0.678	1.559

Value are mean ± SD of three observation

Water absorption capacity of groundnut, maize, sorghum, flaxseed, sesame seed, oat, amaranth, barley, finger millet ranged from 0.94 to 2.36%. Sesame seed showed highest water absorption capacity followed by flaxseed, maize, amaranth and finger millet. Water absorption capacity of chickpea was lowest. Similar results were observed by Mehta (2018). Similar results for oat varities was observed by Sandhu *et al*. (2015). Higher value for water absorption capacity (2.85 to 3.35) was for Oat varities by Choi *et al*. (2012). Higher water absorption capacity was found to be higher for finger millet flour by Shrestha and Shrivastva (2015). Similar water absorption capacity was observed by Khan and Dutta (2018). For sorghum water absorption capacity was in accordance with Udachan *et al*. (2015)

Gelation capacity of groundnut, maize, sorghum, flaxseed, sesame seed, oat, amaranth, barley, finger millet ranged from 1.16 to 15.50 %. Gelation capacity of amaranth was highest

Foam capacity of groundnut, maize, sorghum, flaxseed, sesame seed, oat, amaranth, barley, finger millet ranged from 9.20 to 42.44 %. Foam capacity was observed highest in sesame seed followed by chickpea, barley, amaranth oat and sorghum. Foam stability of groundnut, maize, sorghum, flaxseed, sesame seed, oat, amaranth, barley, finger millet ranged from 52.60 to 99.29 %.

Foam stability was highest in finger millet followed by chickpea, oat, groundnut and maize. Water absorption capacity (2.36%), gelation capacity (15.50%), emulsification capacity (52.56%), swelling power (127.5%), foam capacity (42.44%) and foam stability (99.29%) was significantly (P<0.05) higher than the water absorption capacity (2.36%) of cereals.

The functional properties of cereal grains and flaxseed are in agreement with those reported by means of previous studies in accordance to Adebowale *et al*. (2012), Adebayo *et al*. (2013), Chandra and Samsher (2013), Shad *et al*. (2013), Inglett *et al*. (2013) and Jagannadham *et al*. (2014).

Table 3 shows mineral content available in Oat, barley, sorghum, chickpea, groundnut, finger millet, maize and other grains ranges for Calcium 10.87 to 895.96 mg/100gm. The higher amount of calcium was found in sesame seed (895.96 mg/100gm), followed by amaranth (278.57), chickpea HC-1 (148.21), where as lower amount of ca was in maize. Iron content in amaranth was significantly higher (13.58 mg/100gm) than other grains. Sesame seed and finger millet contain iron content is almost similar amount followed by sorghum HC-308 (7.35 mg/100gm). Significantly lower amount of Iron content was found in maize. Similar result for Oat varieties HJ-8, OS-6 by Mehta (2018), Narwal and Dahiya (2015), Sangwan *et al*. (2014).

Table 3: Mineral content: calcium, iron and zinc contents (mg /100g) of various cereals, pulses, oil seeds and millets

Sample	Calcium	Iron	Zinc
Oat HJ-8	53.37±1.07	4.65±0.05	4.10±1.19
Oat OS-6	51.19±1.28	4.12±0.16	3.99±0.75
Barley BH-946	23.74±0.41	3.92±0.08	2.18±0.01
Barley BH-393	25.10±0.38	4.25±0.33	2.45±0.02
Sorghum HJ-541	21.41±1.35	6.67±0.01	4.12±0.16
Sorghum HJ-308	32.88±1.14	7.35±0.04	3.78±0.07
Chickpea HC-1 C-	148.21±1.33	5.00±0.12	3.57±1.02
Chickpea 235	143.29±0.79	6.01±0.05	3.83±1.05
Ground nut MH-4	55.42±0.79	3.48±0.03	3.20±0.20
Ground nut GNH-804	52.08±0.83	3.56±0.15	3.56±0.52
Finger millet	345.3±0.90	9.32±0.69	5.25±5.56
Maize	10.87±1.04	2.30±0.17	0.52±0.03
Amaranth	278.57±1.38	13.58±0.54	5.49±0.28
Flax seed	242.82±3.25	2.79±0.19	4.50±0.36
Sesame seed	895.96±6.42	9.34±0.36	6.60±0.06
Rice (puffed)	14.73±0.36	4.56±0.24	1.43±0.12
CD at ± 5%	3.74	0.428	0.886

Value are mean + SD of three observation

Dietary fiber of cereals, pulses, oil seeds & millets

Data regarding dietary fiber of cereals, pulses, oil seeds and millets have been presented in Table 4. As shown in table barley BH-946 contain higher amount of total insoluble fibers 16.82 mg/100g where as lower amount of total insoluble fiber 1.76 mg/100g in puffed rice. Oat OS-6 contains 13.20 mg/100g total insoluble fiber higher than oat HJ-8 which is 12.10 mg/100g. Among chickpea, sorghum and groundnut verities C-235 (12.70), HJ-541 (9.65) and GNH-804 (10.27) exhibit higher amount of total insoluble fiber.

Sorghum HJ-308 exhibit least amount of soluble fiber ((1.26 mg/100g), whereas significantly higher soluble fiber was for amaranth (24.3 mg/100g) followed by flaxseed, sesame seed, maize and finger millet (22.2, 13.8, 9.32 and 7.002 mg/100g). Other grains contain total soluble fiber Oat HJ-8 (3.21), OS-6 (3.42), Barley BH-946 (2.40), BH-393 (3.44), Chickpea HC-1 (2.25), C-235 (2.52), Groundnut MH-4 (1.79) and GNH-804 (1.98) respectively.

Table 4: Dietary fiber of cereals, pulses, oil seed and millets

Sample	Total insoluble fiber	Total soluble fiber
Oat HJ-8	12.10±0.05	3.21±0.02
Oat OS-6	13.20±0.01	3.42±0.10
Barley BH-946	16.82±0.01	2.40±0.05
Barley BH-393	11.09±0.03	3.44±0.01
Sorghum HJ-541	09.65±0.02	1.67±0.17
Sorghum HJ-308	06.57±0.13	1.26±0.05
Chickpea HC-1 C-	09.99±0.18	2.25±0.05
Chickpea 235	12.70±1.22	2.52±0.02
Ground nut MH-4	08.58±0.04	1.79±0.02
Ground nut GNH-804	10.27±0.38	1.98±0.10
Finger millet	05.12±0.38	7.02±0.09
Maize	07.56±0.06	9.32±0.04
Amaranth	09.35±0.15	24.3±0.02
Flax seed	09.56±0.33	22.2±0.05
Sesame seed	10.02±0.15	13.8±0.01
Rice (puffed)	01.76±0.26	2.56±0.03
CD at ± 5%	0.446	0.229

Value are mean ± SD of three observations

As shown in Table 4 barley BH-946 contain higher amount of total insoluble fibers 16.82 mg/100g where as lower amount of total insoluble fiber 1.76 mg/100g in puffed rice. Oat OS-6 contains 13.20 mg/100g total insoluble fiber higher than oat HJ-8 which is 12.10 mg/100g. Among chickpea, sorghum and groundnut varities C-235 (12.70), HJ-541 (9.65) and GNH-804 (10.27) exhibit higher amount of total insoluble fiber.

Sorghum HJ-308 exhibit least amount of soluble fiber ((1.26 mg/100g), whereas significantly higher soluble fiber was for amaranth (24.3 mg/100g) followed by flaxseed, sesame seed, maize and finger millet (22.2, 13.8, 9.32 and 7.002 mg/100g). Other grains contain total soluble fiber Oat HJ-8 (3.21), OS-6 (3.42), Barley BH-946 (2.40), BH-393 (3.44), Chickpea HC-1 (2.25), C-235 (2.52), Groundnut MH-4 (1.79) and GNH-804 (1.98) respectively.

As in oat verities oat HJ-8 and OS-6 , Chaudhary (2017) reported the total dietary fiber in oat OS-6, HJ-8 similar to results. Mehta (2018) reported lower value for total soluble and total insoluble dietary fiber. Twelve percent total dietary fiber was found in oat grain flour by Usman *et al*. (2010). Sterna *et al*. (2016) reported 10 percent dietary fiber, similar results were found by Chappalwar *et al*. (2013); Maboodurrahman and Birari (2013). Kilci and Gocmen (2012) reported significantly lower dietary fiber content of oat flour Total insoluble dietary fiber of oat, barley, sorghum, groundnut, maize, finger millet, amaranth and sesame seed. Payne (2000) reported the higher dietary fiber of flaxseed (24.5 and 28 g/100g). Kurek *et al*. (2018) reported dietary fiber in significant lower amount of amaranth flour total dietary fiber (11.15), insoluble dietary fiber (6.59) & soluble dietary fiber (4.56).

CONCLUSION

This research concluded that oat, barley, sorghum, chickpea, groundnut, flaxseed, finger millet, amaranth, maize and sesame seed passes desirable purposeful physical and functional properties, Mineral and dietary fiber content. Thousand seed weight of amaranth was significantly lower ($P<0.05$) which is 0.74g as whereas groundnut varieties namely GNH-804 (527.40 g) and MH-4 (466.76g). Bulk density was of grains ranged from 0.39 to 0.79 g. Hydration capacity of oat chickpea, barley, groundnut, maize, sesame seed, flaxseed, sorghum, oat, amaranth, finger millet ranged from 0.002 to 0.45. whereas hydration index ranges 0.50 to 1.81, Swelling index ranges 0.13 to 0.56. Water absorption capacity (2.36%) sesame seed, gelation capacity (15.50%) amaranth, emulsification capacity (52.56%) flaxseed, swelling power (127.5%) flaxseed, foam capacity (42.44%) sesame seed and foam stability (99.29%) finger millet was significantly higher. Finger Millet, amaranth and flaxseeds are high in mineral content. Oat and barley contain higher amount of dietary fiber, also chickpea C-235 similarly exhibit higher amount of dietary fiber. Among varities Oat HJ-8, barley BH-393, Sorghum HJ-541, Chickpea HC-1, Groundnut GNH-804, and other grains can be easily used for popping, roasting, puffing, flaking or other thermal treatment of pre-processed product for development of variety of food products because of better physical and functional properties. Hence, a form of innovative healthful products can be prepared to fit the consumer wishes and additionally to gain nutrients security.

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