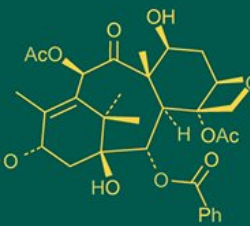
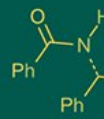


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Physical and functional characteristics of multi grains

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Abstract

Grains are a crucial part of the human diet and provide a significant source of energy, fiber, vitamins and minerals. Based on high arrival low cost rice, jowar, finger millet, horsegram, green gram and soyabean was selected and physical and functional so study was carried out to analyzed for physical, functional properties and proximate composition like moisture, fat, protein, ash, and crude fibre. Results revealed that thousand grain weight, thousand grain volume, length, breadth, length to breadth ratio and thickness exhibited significant differences ($p \leq 0.05$) among the grains while bulk density exhibited non-significant differences. The moisture content of the grains ranged from 7.87 percent to 12.85 percent. Soybean exhibited the highest protein content (40.29%) and fat content (19.52%). Ash content significantly from 0.65 percent to 4.60 percent and crude fibre ranged from 0.35 percent to 6.09 percent.

Keywords: Multigrains, nutrient, bulk density, hydration capacity, swelling capacity

Introduction

Grains form the largest section in human diet. It is also considered as a staple food. The consumption of cereals and legumes all over the world gives them an important position in international nutrition. Food grain production in India during 2024-25 was 357.73 million tonnes, which was higher by 25.43 million tonnes than the production during 2023-24, which was 332.30 million tonnes. (Ministry of agriculture and farmers welfare). Starchy endosperm consists of 15% fats and 13% proteins, such as globulins, albumins, glutenins, and gliadins. germ on one side of the kernel is enriched with 25% proteins and 8-13% lipids. The level of minerals is relatively high (4-5%). The bran known as the seed coat is enriched with minerals and vitamin B, it contains 53% of the cellulosic components (Khalid *et al.*, 2023) ^[4]. Cereal grains are low in total protein compared to legumes and oilseeds but many cereals offer humans an adequate amount of energy (Zorica *et al.*, 2022) ^[11]. Whereas Legume seeds are among the richest food sources of proteins about 20% in pea and up to 38-40% in soybean which is twice the dietary protein content of cereal grains (Rajni and Vikas, 2017) ^[6]. With large production and nutritional benefits grains with high arrival and low prices were selected and analysed to develop a functional food products.

Materials and methods

The study of grains physical, functional and nutritional analysis helps to chose the suitable processing method and development of food products.

Thousand grain weight (g)

Three sets of 1000 intact grains were selected randomly. The mean weight was expressed in g/1000 grains. Weight of selected grains was recorded in triplicates using electronic weighing balance and average was calculated (Mannurmath and Yenagi, 2014) ^[5].

Thousand grains volume (ml)

The volume of millet grains was measured by water displacement method. Thousand/ Hundred randomly selected grains were dropped in measuring cylinder containing known volume of water. The rise in volume was recorded in ml. The volume of millet was calculated by subtracting the initial volume from final volume (Mannurmath and Yenagi, 2014) ^[5].

Bulk density

Bulk density was calculated from weight and volume of grains as follows;

$$\text{Bulk density (g/ml)} = \frac{\text{Weight (g)}}{\text{Volume (ml)}}$$

Grain density was expressed as g per ml (Mannurmath and Yenagi, 2014) ^[5].

Thickness

The average thickness of randomly picked ten well developed grains were measured in mm with the help of digital vernier calipers having least count 0.01 mm (Yadav *et al.*, 2007) ^[10].

Length, breadth and L/B ratio

The average length and breadth of the randomly picked ten well developed grains were measured in (mm) with a help of

digital vernier calipers having least count 0.01 mm. The length/ breadth ratio was obtained by dividing the length of a single grain by the corresponding breadth to determine the size and shape (Yadav *et al.*, 2007) ^[10].

Functional properties of grains

Functional properties like hydration capacity, hydration index, swelling capacity, swelling index were assessed for grains.

Hydration capacity (g/1000 grains)

Hydration capacity was measured by soaking weighed 1000 millets overnight in beaker with 100 ml of water. Next day, water was drained off and millets were dried using filter paper to remove superfluous water and weighed (Bhokre *et al.*, 2015) ^[12]. Hydration capacity was calculated as;

$$\text{Hydration capacity of seeds (g/1000 grains or g/100grains)} = \frac{\text{Weight after soaking (g)} - \text{Weight before soaking (g)}}{\text{Number of seeds (1000 grains)}}$$

Hydration index

Hydration index was calculated by using formula:

$$\text{Hydration index} = \frac{\text{Hydration capacity}}{\text{Weight of seeds}}$$

Swelling capacity (ml/ 1000 grains)

Thousand grains were counted and volume was noted by water displacement method. The grains were soaked overnight. Further, water was drained off next day and volume was noted (Bhokre *et al.*, 2015) ^[12]. Then, the swelling capacity was measured using formula:

$$\text{Swelling capacity} \left(\frac{\text{ml}}{1000 \text{ grains}} \right) = \frac{\text{Volume of seeds after soaking (ml)} - \text{Volume of seeds before soaking (ml)}}{\text{Number of seeds (1000 grains)}}$$

Swelling index

Swelling index was calculated using formula:

$$\text{Swelling index} = \frac{\text{Swelling capacity}}{\text{Volume of seeds}}$$

Tapped bulk density (g/ml)

A standard graduated cylinder of 100 ml capacity was taken

for the bulk density measurement. Initially, the empty measuring cylinder was weighed, and then 20 g of flour was added in the cylinder then tapped for 20-25 times to a vertical distance of 10 mm to pack the flour particles tightly and recorded the volume of weighed sample. The tapped bulk density (TBD) of flour was determined by following formula (Goula *et al.*, 2008) ^[3].

$$\text{Tapped bulk density (g/ml)} = \frac{\text{Weight of the sample at recorded volume (g)}}{\text{Volume of sample (ml)}}$$

Loose bulk density

Loose bulk densities of flours were determined by pouring flour sample into a 10 ml graduated measuring cylinder. Weight of the sample was measured when the sample volume reached 1 ml. The loose density was calculated by dividing weight with the volume of the obtained powder (Goula *et al.*, 2008) ^[3].

$$\text{Loose bulk density (g/ml)} = \frac{\text{Weight of flour at 1 ml}}{\text{Volume of the sample (1 ml)}}$$

Water absorption capacity

Water absorption capacity was assessed by the method of Sindhu and Khatkar (2016) ^[7]. Five grams of flour was weighed and added to the pre-weighed centrifuge tube (W_1) and stirred with a glass rod for 5 min. The contents were allowed to stand for 30 min and then centrifuged at 11000 rpm for 25 min. The free liquid was poured off. Inner sides of tube were wiped off with tissue paper. The centrifuge tube was weighed again (W_2). The water absorption capacity was calculated using the formula:

$$\text{Water absorption capacity, WAC (\%)} = \frac{W_2 - W_1}{5} \times 100$$

Oil absorption capacity

Oil absorption capacity was assessed by using Sindhu and Khatkar (2016) ^[7] method. One gram of flour was mixed with 10 ml of refined vegetable oil in pre-weighed centrifuge (W_1). The tubes were stirred for one min for complete dispersion of sample and the sample was centrifuged at 3000 rpm for 25 min. The separated oil was then removed and tubes were inverted on absorbent paper to drain off the remaining oil prior to reweighing (W_2). The oil absorption capacity was calculated using the formula:

$$\text{Oil absorption capacity, OAC (\%)} = \frac{W_2 - W_1}{5} \times 100$$

Proximate composition

Grains were analysed for proximate principles like moisture, protein, fat, ash and crude fibre (Anon, 2019) ^[2].

Results

The physical characteristic of rice, finger millet, jowar, greengram, horsegram and soybean was shown in Table 1. The physical properties of multigrain was analyzed, the results revealed significant differences in physical properties of selected grains. The thousand grain weight, thousand grain volume, length, breadth, length to breadth ratio and thickness exhibited significant differences ($p \leq 0.05$) among the grains while bulk density exhibited non-significant differences.

The highest 1000-grain weight (164.42g) among the evaluated grains was observed in soybean, which was significantly ($p \leq 0.05$) higher compared to that of the other grains. In contrast, finger millet had the least 1000-grain weight (3.21g), which indicates its small seed size. Intermediate values were found in jowar (37.01g), horsegram (35.16g) and greengram (32.02g) while rice had relatively lower grain weight (10.68g). Soybean recorded the highest volume (145.01ml) followed by jowar (32.50ml), greengram (31.66ml) and horsegram (30.66ml) for 1000-grain volume, which was also on par. Finger millet recorded the least grain volume (2.50 ± 0.50 ml).

The bulk density of the grains was in the range of 1.02g/ml for greengram to 1.33g/ml for rice. However, these differences were not statistically significant (F -value = 3.41). Soybean showed the greatest length (8.23mm) in relation to the grain size, being significantly higher than the values for the other grains. Finger millet had the shortest grain length (1.93mm). Rice (5.32 mm) and greengram (5.63mm) showed moderate grain length and jowar (4.89mm) and horsegram (4.39 mm) were relatively smaller in size.

The breadth of the grains varied significantly, with soybean showing the highest value (6.33mm), followed by jowar (4.35mm), greengram (3.82mm), and horsegram (3.34 mm). Finger millet had the smallest breadth (1.64 mm). The length-to-breadth (L/B) ratio provides an indication of grain shape. Rice exhibited the highest L/B ratio (2.66), Finger millet had the lowest L/B ratio (1.18), suggesting a nearly spherical shape. Jowar (1.12), horsegram (1.31), soybean (1.30), and greengram (1.47). Similarly, significant differences were observed for grain thickness. Soybean had the highest thickness (4.96mm), followed by horsegram (3.30mm) and jowar (3.14mm). Rice exhibited the lowest thickness (1.60mm), closely followed by finger millet (1.61mm).

Table 1: Physical characteristics of selected grains

Grains	1000 grain weight (g)	1000 grain volume (ml)	Bulk density (g/ml)	Length (mm)	Breadth (mm)	L/B ratio	Thickness (mm)
Rice	10.68 $\pm$ 0.06 ^d	8.33 $\pm$ 0.58 ^c	1.33 $\pm$ 0.01 ^a	5.32 $\pm$ 0.98 ^b	1.99 $\pm$ 0.12 ^e	2.66 $\pm$ 0.40 ^a	1.60 $\pm$ 0.012 ^e
Finger millet	3.21 $\pm$ 0.65 ^e	2.50 $\pm$ 0.50 ^d	1.29 $\pm$ 0.18 ^{ab}	1.93 $\pm$ 0.12 ^e	1.64 $\pm$ 0.07 ^f	1.18 $\pm$ 0.06 ^c	1.61 $\pm$ 0.07 ^e
Jowar	37.01 $\pm$ 0.81 ^b	32.50 $\pm$ 0.50 ^b	1.14 $\pm$ 0.01 ^{ab}	4.89 $\pm$ 0.29 ^c	4.35 $\pm$ 0.18 ^b	1.12 $\pm$ 0.07 ^{cd}	3.14 $\pm$ 0.20 ^c
Greengram	32.02 $\pm$ 0.33 ^c	31.66 $\pm$ 2.89 ^b	1.02 $\pm$ 0.08 ^b	5.63 $\pm$ 0.24 ^b	3.82 $\pm$ 0.20 ^c	1.47 $\pm$ 0.09 ^b	2.18 $\pm$ 0.09 ^d
Horsegram	35.16 $\pm$ 1.39 ^b	30.66 $\pm$ 1.15 ^b	1.15 $\pm$ 0.08 ^{ab}	4.39 $\pm$ 0.29 ^d	3.34 $\pm$ 0.14 ^d	1.31 $\pm$ 0.07 ^c	3.30 $\pm$ 0.13 ^b
Soyabean	164.42 $\pm$ 1.23 ^a	145.01 $\pm$ 5.01 ^a	1.14 $\pm$ 0.04 ^{ab}	8.23 $\pm$ 0.25 ^a	6.33 $\pm$ 0.20 ^a	1.30 $\pm$ 0.04 ^c	4.96 $\pm$ 0.25 ^a
CD	1.57	4.33	0.18	0.41	0.14	0.16	0.14
SEm	0.51	1.40	0.06	0.14	0.05	0.06	0.05
F-value	13508.02**	1381.98**	3.41 ^{NS}	197.57**	1182.65**	105.35**	666.61**

Note: Values are mean $\pm$ standard deviation of three replications, S.Em. - Standard error of mean, ** Significant at 1%, NS-Non significant, CD- Critical difference, Values with same superscript in the same column are not significantly different from each other

The hydration and swelling characteristics of rice, finger millet, jowar, greengram, horsegram, and soybean are presented in Table 2. Significant differences ($p \leq 0.01$) was observed among the grains for hydration capacity, hydration index, swelling capacity, and swelling index, as indicated by the highly significant F -values. The hydration capacity of grains varied considerably, ranging from 3.76g/1000 grains lowest in finger millet to 361.55g/1000 grains highest in soybean. Among the pulses, horsegram showed significantly higher hydration capacity (82.67g/1000 grains) compared to greengram (63.23g/1000 grains). Jowar recorded a moderate hydration capacity (55.19g/1000 grains), whereas rice and finger millet showed comparatively lower values of 14.37 and 3.76 g/1000 grains, respectively.

Horsegram exhibited the highest hydration index (23.57), followed by soybean (21.90) and greengram (19.75). In contrast, finger millet had the lowest hydration index (1.29), closely followed by rice (1.35) and jowar (1.47). The swelling capacity of the grains ranged from 55.45 ml/1000 grains in finger millet to 884.36 ml/1000 grains in soybean. Horsegram (586.96 ml/1000 grains) and greengram (574.47 ml/1000 grains) also exhibited high swelling capacity. Among cereals, jowar showed a higher swelling capacity (98.66 ml/1000 grains) compared to rice (63.44 ml/1000 grains) and finger millet (55.45ml/1000 grains). A

significant variation was also observed in the swelling index among the grains studied. Greengram recorded the highest swelling index (210.47), followed by horsegram (171.09) and soybean (62.09). Finger millet exhibited swelling index of 23.06, while rice and jowar showed relatively lower swelling indices of 7.48 and 3.01 respectively.

The functional property of flour was presented in Table 3. Statistical analysis revealed significant differences among the grain flours for all the evaluated parameters. The Loose Bulk Density (LBD) of the grain flours ranged from 0.41 to 0.51 g/ml. Horsegram flour exhibited the highest loose bulk density (0.51 g/ml), followed closely by rice flour (0.50 g/ml) and finger millet flour (0.48 g/ml). In contrast, greengram flour showed the lowest loose bulk density (0.41g/ml), while jowar and soybean flours recorded values of 0.42 and 0.44 g/ml, respectively. Similarly, Tapped Bulk Density (TBD) differed significantly among the grain flours, with values ranging from 0.60 to 0.73 g/ml. Rice flour exhibited the highest tapped bulk density (0.73 g/ml), indicating better packing ability upon compaction. Finger millet flour also showed relatively high tapped density (0.70 g/ml), followed by horsegram (0.69 g/ml) and greengram flour (0.68 g/ml). Soybean flour (0.62 g/ml) and jowar flour (0.60 g/ml) recorded comparatively lower values.

The Water Absorption Capacity (WAC) of the grain flours ranged from 2.22 to 2.98 ml/g. Rice flour demonstrated the highest WAC (2.98 ml/g), followed by jowar (2.81 ml/g) and finger millet flour (2.60 ml/g). Soybean flour exhibited WAC of 2.35 ml/g, whereas greengram and horsegram flours showed relatively lower values of 2.24 and 2.22 ml/g respectively. The Oil Absorption Capacity (OAC) values varied from 2.09 to 2.38 ml/g among the different grain flours. Jowar flour exhibited the highest OAC (2.38 ml/g). Horsegram flour showed an OAC of 2.23 ml/g, followed by greengram (2.14 ml/g) and finger millet flour (2.12 ml/g). Rice and soybean flours recorded the lowest OAC values (2.09 and 2.09 ml/g, respectively).

The proximate composition of rice, finger millet, jowar, greengram, horsegram, and soybean was presented in Table 4. Significant differences ($p \leq 0.01$) were observed among the grains. The moisture content of the grains ranged from 7.87 percent to 12.85 percent. Among the evaluated grains, rice exhibited the highest moisture content (12.85%), which was significantly higher than all other grains. In contrast, soybean recorded the lowest moisture content (7.87%), followed by greengram (8.31%). Jowar and horsegram had moisture contents of 9.22 percent and 9.79 percent respectively, while finger millet showed an intermediate value of 11.03 percent. Soybean exhibited the highest protein content (40.29%), significantly exceeding that of all other grains. Among the pulses, horsegram (27.59%) and greengram (25.24%) also demonstrated high protein contents. In comparison, jowar and finger millet contained moderate protein levels of 10.39 percent and 9.15 percent respectively, whereas rice had the lowest protein content (7.35 %).

The ash content which reflects the total mineral composition of the grains, varied significantly from 0.65 percent to 4.60 percent. Soybean recorded the highest ash content (4.60%) indicating a greater concentration of mineral constituents. This was followed by horsegram (3.78%) and greengram (3.25%). Finger millet contained 2.68 percent ash, while jowar and rice exhibited comparatively lower values of 1.59 percent and 0.65 percent, respectively. A significant difference was also evident in the fat content of the grains studied. Soybean showed a remarkably high fat content (19.52%), which was significantly greater than the values recorded for all other grains. The remaining grains exhibited relatively low-fat contents, ranging from 0.51 percent in rice to 1.89 percent in horsegram. Rice had the lowest fat content, followed by greengram (1.77%), jowar (1.84%), finger millet (1.87%), and horsegram (1.89%).

The crude fibre content differed significantly among the grains, ranging from 0.35 percent to 6.09 percent. Greengram exhibited the highest crude fibre content (6.09%), followed by soybean (5.44%) and horsegram (4.59%). Finger millet also contained appreciable fibre levels (3.51%), whereas jowar and rice had comparatively lower fibre contents of 1.64 percent and 0.35 percent respectively.

Discussion

Table 1 shows the significant variation of physical properties among grains. 1000 grain weight and volume was lowest in finger millet (3.21g and 2.50ml respectively) and highest in soyabean (164.42g and 145.01ml respectively). Grain dimensions like thickness, length, breadth and length to breadth ratio of multigrains showed that finger millet had

the lower grain dimension and soyabean highest grain dimension compared to other grains.

Functional characteristics are required to evaluate permeability of seed coat, hydration and swelling ability of grains Table 2 shows the significant differences ($p \leq 0.01$) were observed among the grains for hydration capacity, hydration index, swelling capacity, and swelling index, as indicated by the highly significant F-values. Substantial variability was seen in hydration and swelling behavior among cereals, millets, and legumes. Soybean exhibited the highest hydration capacity, which may be attributed to its larger seed size, porous structure, and higher protein content that facilitate greater water absorption. Variation in hydration and swelling capacity may be attributed to hardness of seed coat that hinders permeability of water inside the grain.

In table 3 horsegram showed the highest loose bulk density ($0.51 \pm 0.01 \text{ g ml}^{-1}$) whereas greengram ($0.41 \pm 0.01 \text{ g ml}^{-1}$) exhibited the lowest value. Bulk density is influenced by particle size, shape, porosity, and chemical composition of the grains. The higher tapped density of was seen in rice indicates better particle compaction compared with jowar and soybean. Tapped bulk density reflects the extent to which particles rearrange under mechanical vibration and is an important parameter for designing storage bins and packaging systems. Water absorption capacity is the capacity of the flour to be associated with water molecules under limited condition (Alfaony *et al.*, 2017) [1]. Difference in the water absorption capacity may be probably due to the variation in the starch granules, inherent differences in amorphous and crystalline areas among starch and also due to protein content. Fat absorption capacity has been attributed to the physical entrapment of oil and it is important, since fat acts as flavour retainer and increase the mouth feel of foods. Sreerama *et al.* (2008) [9] revealed that the enhanced ability of flour to absorb and retain water and oil may help to improve binding of the structure, enhance flavour retention, improve mouth feel and reduce moisture and fat losses of food products.

The proximate composition of the selected cereal grains and legumes revealed significant ($p \leq 0.01$) variations in moisture, protein, ash, fat, and crude fibre contents, indicating substantial nutritional diversity among the grains (table 4). These differences are expected because cereals and legumes differ considerably in their chemical composition and botanical characteristics. The moisture content ranged from 7.87 to 12.85%. Rice recorded the highest moisture content whereas soybean had the lowest moisture content. Protein content differed markedly among the grains, ranging from 7.35 to 40.29%. Soybean contained the highest protein rice had the lowest protein content, Singh *et al.* (2004) [8].

Summary and Conclusion

The high arrival and low-price grains varied significantly each other in physical, functional and proximate composition. Physical properties may affect the handling, processing characteristics, storage requirements and quality of the final products. Knowledge of these physical properties is fundamental to the design of appropriate processing equipment and optimal optimization of grain utilization in the development of food products. Hence multigrain mix can be developed from these grains.

Table 2: Functional properties of selected grains

Grains	Hydration capacity (g/1000 grain)	Hydration index	Swelling capacity (ml/1000 grains)	Swelling index
Rice	14.37±0.05 ^e	1.35±0.00 ^d	63.44±0.71 ^e	7.48±0.54 ^d
Finger millet	3.76±0.37 ^f	1.29±0.16 ^d	55.45±0.70 ^e	23.06±6.23 ^d
Jowar	55.19±1.24 ^d	1.47±0.00 ^d	98.66±0.35 ^d	3.01±0.04 ^e
Greengram	63.23±0.71 ^c	19.75±0.07 ^c	574.47±7.06 ^c	210.47±24.49 ^a
Horsegram	82.67±3.16 ^b	23.57±0.67 ^a	586.96±3.53 ^b	171.09±33.55 ^b
Soyabean	361.55±2.52 ^a	21.90±0.11 ^b	884.36±7.07 ^a	62.09±2.04 ^c
CD	4.30	0.70	10.64	42.01
SEm	1.24	0.20	3.08	12.14
F-value	11464.13**	3036.47**	13106.19**	54.37**

Note: Values are mean ±standard deviation of three replications, S.Em.-Standard error of mean, ** significant at 1%, NS-Non significant, CD- Critical difference, Values with same superscript in the same column are not significantly different from each other

Table 3: Physical and functional properties of multigrain flours

Grains	Loose bulk density (g/ml)	Tapped bulk density (g/ml)	Water absorption capacity (ml/g)	Oil absorption capacity (ml/g)
Rice	0.50±0.02 ^a	0.73±0.01 ^a	2.98±0.45 ^a	2.09±0.03 ^a
Finger millet	0.48±0.01 ^a	0.70±0.01 ^a	2.60±0.39 ^a	2.12±0.01 ^a
Jowar	0.42±0.02 ^b	0.60±0.04 ^b	2.81±0.38 ^a	2.38±0.29 ^a
Greengram	0.41±0.01 ^b	0.68±0.01 ^a	2.24±0.08 ^a	2.14±0.08 ^a
Horsegram	0.51±0.01 ^a	0.69±0.02 ^a	2.22±0.09 ^a	2.23±0.07 ^a
Soyabean	0.44±0.01 ^b	0.62±0.01 ^b	2.35±0.48 ^a	2.09±0.04 ^a
CD	0.08	0.08	0.86	0.30
SEm	0.02	0.02	0.25	0.09
F-value	17.68**	12.83**	1.61**	1.68**

Note: Values are mean ±standard deviation of three replications, S.Em.-Standard error of mean, ** significant at 1%, NS-Non significant, CD- Critical difference, Values with same superscript in the same column are not significantly different from each other

Table 4: Proximate composition of multigrain flours (g %)

Grains	Moisture	Protein	Ash	Fat	Crude fibre
Rice	12.85±0.09 ^a	7.35±0.21 ^f	0.65±0.02 ^f	0.51±0.01 ^f	0.35±0.21 ^f
Finger millet	11.03±0.29 ^b	9.15±0.35 ^e	2.68±0.04 ^e	1.87±0.06 ^e	3.51±0.08 ^d
Jowar	9.22±0.04 ^c	10.39±0.03 ^d	1.59±0.03 ^d	1.84±0.04 ^d	1.64±0.01 ^e
Greengram	8.31±0.05 ^d	25.24±0.52 ^c	3.25±0.02 ^c	1.77±0.01 ^c	6.09±0.02 ^a
Horsegram	9.79±0.06 ^e	27.59±0.04 ^b	3.78±0.04 ^b	1.89±0.05 ^b	4.59±0.05 ^c
Soyabean	7.87±0.06 ^f	40.29±1.13 ^a	4.60±0.01 ^a	19.52±0.05 ^a	5.44±0.06 ^b
CD	0.32	1.31	0.08	0.10	0.23
SEm	0.09	0.38	0.02	0.03	0.07
F-value	388.16**	1205.11**	5084.88**	6257.92**	1084.34**

Note: Values are mean ±standard deviation of three replications, S.Em.-Standard error of mean, ** significant at 1%, NS-Non significant, CD- Critical difference, Values with same superscript in the same column are not significantly different from each other

References

- Alfaugarni GA, Ibrahim OS, Ali MM. Physico-chemical characteristics of starches from different cereal grains. *Am J Food Sci Technol*. 2017;5(4):125-134.
- Association of Official Analytical Chemists. Official methods of analysis. 21st ed. Washington, DC: Association of Official Analytical Chemists; 2019.
- Goula AM, Karapantsios TD, Achilias DS, Adamopoulos KG. Water sorption isotherms and glass transition temperature of spray dried tomato pulp. *J Food Eng*. 2008;85:73-83.
- Khalid A, Hameed A, Tahir MF. Wheat quality: a review on chemical composition, nutritional attributes, grain anatomy, types, classification, and function of seed storage proteins in bread making quality. *Front Nutr*. 2023;10:1053196.
- Mannuramath M, Yenagi N. Evaluation of little millet cultivars for physical, nutritional and processing qualities. *Acad Law Serials*. 2014;10(2):131-140.
- Kamboj R, Nanda V. Proximate composition, nutritional profile and health benefits of legumes: A review. *Legume Res*. 2017;41(3):325-332.
- Sindhu R, Khatkar BS. Physicochemical and functional properties of starch and flour of tartary buckwheat. *Int J Eng Res Technol*. 2016;6:315-320.
- Singh U. Functional properties of grain legume flours. *J Food Sci Technol*. 2004;38:191-199.
- Sreerama YN, Sasikala VB, Pratapa VM. Nutritional implications and flour functionality of popped/expanded horse gram. *Food Chem*. 2008;108(3):891-899.
- Yadav RB, Khatkar BS, Yadav BS. Morphological, physicochemical and cooking properties of some Indian

- rice (*Oryza sativa* L.) cultivars. J Agric Technol. 2007;3:203-210.
11. Tomičić ZM, Pezo LL, Spasevski NJ, Lazarević JM, Čabarkapa IS, Tomičić RM. Diversity of amino acids composition in cereals. Food Feed Res. 2022;49(1):11-22.
 12. Bhokre CK, Joshi AA, Rodge AB. Determination of physico-chemical and functional properties of different genotypes of horse gram. Asian J Dairy Food Res. 2015;34(4):307-313. doi:10.18805/ajdfr.v34i4.6884.