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Comparative Analysis for various Grain Quality Parameters in Bread Wheat Varieties

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ABSTRACT: The present studies were taken up to see the diversity and comparative analysis among the various thirteen bread wheat varieties based on their different grain quality aspects through advanced statistical approaches. The results revealed that protein content was at average with ranged from 11.12 to14.03%, starch content of 61.43 to 63.45% and for grain yield, ten varieties were noticed with statistically significantly at par in terms of varieties. In phenol test, GW451 variety was noticed with no development of pigmentation but all the varieties having good characteristics with low colour pigmentation value indicates a good chapatti colour. Later on, three cluster groups were generated based on different grain quality parameters where six varieties such as GW322, Lok1, GW173, GW451, HD2864 and HD2932 were generated in cluster I as more homogenous group, cluster II consist of four varieties of GW496, GW366, GW499 and HI1544 and lastly cluster III consist of GW11, MP3288 and DBW110. The results of PCA revealed that grain quality parameters exhibit a wide range of diversity among the wheat varieties.

Keywords: Bread wheat, gluten content, grain quality parameters, hardness, principle component analysis, protein content.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the main cereal crop in Indian situation and during 2020-21, India has made landmark with the total production of 109.52mt and the total average national productivity of 3464kg/ha (ICAR-IIWBR, 2021). Wheat grain can be processed into flour, semolina and other end products like bread, cookies, pastries, pasta, noodles, couscous, etc. and these foods provide about 20% calories and protein source in world's population. Wheat quality has traditionally been judged on functionality, mostly on gluten content and strength and to a lesser extent, on nutritional value (Marconi and Carcea 2001). Good chapatti qualities are more attracted to consumers and people are willing to pay more for better quality flour. Nowadays the importance of nutritious and nutraceutical food items became highly focussed and great concern by consumers. The essential requirement to attain good quality wheat could be the presence of various kinds of grain quality parameters in an optimum level. The grain quality of wheat is mainly determined by the genetic base, but it may also influence by agroclimatic conditions and management of cultural practices.

The flour gluten content is a useful indicator of flour quality, so the flour quality is influenced by the nature of the gluten and its various components. The sedimentation value of flour depends on the wheat protein composition and is mostly correlated to the protein content, the wheat hardness and the volume of pan and hearth loaves. A stronger correlation between loaf volume and Zeleny sedimentation volume compared to SDS sedimentation volume could be because of the protein content influencing both the volume and Zeleny value (Shewry and Tatham 2000).

Grain quality is defined by a range of physical and compositional properties. Whole grain quality encompasses the physical characteristics of grain, grain morphology, hardness, protein content, milling yield, test weight and dough handling characteristics are the characters commonly assessed for wheat quality. Therefore, multiple phenotypic characters of wheat such as grain, flour, dough and final products must be assessed to determine an overall quality and best end-use products (Battenfield *et al*., 2016). But, generally, the genotypic make up of a cultivar is the most important factor for determining wheat grain quality (Souza *et al*., 1993; Li *et al*., 2013).

At the present scenario of climate change, maintenance of grain quality of wheat has become a critical task for human nutrition, end-use functional properties, as well as commodity value. In wheat, physical properties of whole grain such as size and shape influence milling yield and screening losses, which determine the processing efficiency. Milling yield is defined by the amount of flour that can be extracted from grain and it's strongly dependent on the proportion of endosperm (75-

83%) (Hammermeister, 2008) and grain hardness (Hruskova and Svec 2009). Typically for small and shrivelled grains, the higher proportion of bran relative to endosperm produces a lower milling yield (Marshall *et al*., 1984). Since, test weight (kg/hl) reflects bulk density of grain so the higher test weight infers larger, higher quality grain, whereas lower test weights are associated with either small or pinched kernels or weather damaged grain with high water content.

Grain protein concentration is the net result of independent starch and protein accumulation in the grain (Vos, 1981). However, genetic factors also affect protein concentration of grain, through differences in both ways such as plant nitrogen accumulation and starch-nitrogen transfer efficiency during grain filling stage. Besides, grain protein concentration and composition is an important quality parameter which defines nutritional and end use properties of dough mixing and dough strength, development time, extensibility, breakdown along with loaf volume and ultimately affect the efficiency of bread making process and product quality. Protein content had a significant effect on the functional, pasting, colour and antioxidant properties (Punia *et al*., 2019). Hard wheat characterized by high protein (gluten) and hardness index are good for making bread and fine cakes. But, soft wheat lowers in protein content and hardness index are primarily used for cookies, crackers and breakfast foods. Therefore, the differences in hardness of grain and the type of end products are related to the gluten content (Marconi and Carcea, 2001). Moreover, the end use functionality of wheat is directly related to the protein content and composition of the grain (Du Cros, 1987). The protein content of 11.5% is minimum quality standard for adequate bread making and chapatti (Hogy and Fangmeier 2008). However, it has been estimated that globally 33% of applied nitrogen fertilization is recovered in harvested grain (Raun and Johnson 1999). Therefore, understanding the effects on gluten properties and end-use quality is important for wheat breeders, growers and end-use processors. Moreover, correlation is a method for determining the relationship between various plant traits and determining which component characters might be used in a breeding programme to boost yield (Kumar *et al*., 2022), as well as correlation coefficient provides the idea of quality activity and also evaluates the combination of varieties of plant characters. Correlation analysis can be an effective approach for determining the interdependencies among yield and its related component traits. Thus, correlation coefficient is a useful statistical tool in selecting higher yielding crop plants for the wheat breeders (Kumar *et al*., 2022). Therefore, the present investigations were carried out to find out the comparative analysis among the various bread wheat varieties based on their different aspects of grain quality and also to see the diversity through advanced statistical approaches.

MATERIALS AND METHODS

The thirteen bread wheat varieties were considered for the comparative studies based on the different physical and chemical grain quality parameters. These thirteen varieties consist of GW499, GW451, GW496, GW322, GW366, GW11, GW173, HI1544, DBW110, MP3288, HD2864, HD2932 and Lok1. The parentage details of these varieties are provided in Table 1.

Table 1: Details of parental crosses and pedigree for various bread wheat varieties.

Variety	Parentage
GW499	CLN3/PHR1007//GW336
GW451	GW324/4/CROC1/AE.SQUARROSA (205)//JUP/JY/3/SKAUZ/4/KAUZ /5/GW339
GW496	HD2285/CPAN1861
GW322	PBW173/GW196
GW366	DL802-3/GW232
GW11	LOK1/HW1042// LOK1
GW173	TW275 -7-6-10/LOK1
HI1544	HINDI162/BOBWHITE/CPAN2099
DBW110	KIRITATI/4/2*SERI 1B*2/3/KAUZ*2/BOW//KAUZ
MP3288	DOVE/BUC/DL788-2
HD2864	DL509-2/DL377-8
HD2932	KAUZ/STAR//HD 2643
Lok1	S308/S311

A. Physical and chemical analysis of wheat grain

The grain samples of each variety were analysed for different quality parameters at Wheat Quality Laboratory of Wheat Research Station, Sardarkrushinagar Dantiwada Agricultural University, Vijapur, Gujarat. These parameters includes protein content, wet gluten content, dry gluten content, gluten index, test weight, sedimentation value, starch content, moisture content, hardness index, thousand kernel weight, grain appearance score, grain diameter, grain yield and phenol colour test. Three characters of grain *viz*. size, shape and colour are taken into consideration for scoring of grain appearance. The test weight was measured using indigenous test weight instrument while 1000 grain weight was determined in electronic seed counter followed by weighing them and expressed the result in grams. The Infratec^{TM}1241 (FOSS) instrument determine protein content, starch content, sedimentation value, moisture content using near infrared transmittance technology under the wavelength range of 570-1050nm. The Glutomatic system (Perten) was used for determining the gluten content and gluten strength by gluten index (GI). A Perten SKCS4100 (Single Seed Kernel Characterization System) instrument was used to measure the hardness of kernel and grain diameter. Lastly, phenol colour test was examined for each of variety in 1% phenol solution and recorded the colour development.

Table 2: Characteristics of grain quality parameters of 13 different bread wheat varieties (2018-19 and 2019-20).

Variety	Protein (%)	Moisture (%)	Starch (%)	Wet Gluten (%)	Dry Gluten (%)	Sed. Value (ml)	Hardness Index	TGW (g)	Grain Dia. (mm)	Hectolitre Wt. (kg/hl)	Grain yield (Kg/ha)	Phenol Test (0-10)	Gluten Index
GW499	12.10	9.87	61.43^{abcd}	28.90	10.85	46.75	69.75^{abcd}	49.825^{ab}	3.07^{a}	79.20^{abcd}	4869.4^{abc}	6^{bc}	71.47^{cde}
GW496	11.37	9.90	63.05^{ab}	28.70	11.33	39.75	72.50^{abcd}	48.35^{abc}	3.08^{a}	82.57^{a}	4919.4^{abc}	0.75^{ef}	60.01^{e}
GW322	11.95	9.72	62.58^{abcd}	28.67	11.12	45.25	82.25^{a}	36.00^{d}	2.80^{ab}	75.57^{cd}	5228.3^{abc}	5.25^{c}	89.75^{a}
GW366	11.65	10.05	62.67^{abcd}	28.80	11.13	41.25	67.75^{bcd}	52.32^{a}	3.07^{a}	81.20^{ab}	5023.6^{abc}	6.25^{ab}	42.81^{e}
GW451	11.12	9.60	63.45^{a}	28.45	13.13	40.00	76.00^{ab}	43.37^{abcd}	2.95^{ab}	80.40^{abc}	4697.4^{abc}	0^{f}	76.79^{ab}
HI1544	11.37	9.95	62.27^{abcd}	28.60	11.67	41.00	80.00^{ab}	44.12^{abcd}	3.02^{ab}	80.15^{abc}	3509.9^{bc}	6.25^{ab}	63.91^{cde}
GW173	12.92	9.72	61.65^{abcd}	29.80	10.91	50.25	74.25^{abc}	42.75^{abcd}	2.88^{ab}	80.65^{abc}	6098.5^{a}	1^{e}	67.46^{cde}
GW11	13.60	9.60	60.62^{cd}	31.70	13.72	56.12	58.87^{d}	37.92^{cd}	2.75^{b}	74.30^{d}	5999.8^{a}	6.13^{ab}	68.62^{cde}
HD2864	11.70	9.62	63.02^{abc}	29.00	12.27	47.75	76.00^{ab}	36.75^{cd}	2.72^{b}	81.17^{ab}	5382.1^{abc}	2^{d}	87.72^{a}
Lok1	11.77	9.22	63.07^{ab}	29.15	11.25	46.50	61.13^{cd}	41.42^{abcd}	2.78^{ab}	75.67^{cd}	6137.3^{a}	6.25^{ab}	91.38^{a}
HD2932	12.20	9.12	62.70^{abcd}	29.05	13.27	50.25	70.13^{abcd}	36.07^{d}	2.82^{ab}	77.62^{abcd}	5705.3^{ab}	2.13^{d}	72.72^{bcd}
MP3288	14.03	9.87	60.35^{d}	31.47	13.19	55.37	76.38^{ab}	36.13^{d}	2.78^{ab}	77.91^{abcd}	3318.7^{c}	6.87^{a}	76.52^{bc}
DBW110	13.42	9.92	61.00^{bcd}	30.25	12.45	52.62	73.75^{abc}	38.32^{bcd}	2.80^{ab}	76.57^{bcd}	3200.0^{c}	6.75^{ab}	97.67^{a}
SEm	**1.09**	**0.32**	**0.79**	**0.99**	**0.92**	**5.39**	**4.67**	**3.83**	**0.10**	**1.78**	**739.86**	**0.27**	**4.07**
LSD	**NS**	**NS**	**2.42**	**NS**	**NS**	**NS**	**14.41**	**11.81**	**0.32**	**5.49**	**2279.70**	**0.81**	**12.55**
Yr. 2018-19	**12.92**	**9.55**	**61.50**	**30.69**	**11.71**	**51.15**	**73.42**	**41.52**	**2.88**	**78.36**	**4510.60**	**4.26**	**74.56**
Yr. 2019-20	**11.56**	**9.86**	**62.78**	**28.78**	**12.32**	**43.13**	**71.0**	**42.06**	**2.89**	**79.02**	**5349.42**	**4.28**	**74.18**
SEm	**0.43**	**0.13**	**0.31**	**0.39**	**0.36**	**2.11**	**1.83**	**1.50**	**0.04**	**0.70**	**290.19**	**0.11**	**1.59**
LSD	**1.32**	**0.39**	**0.95**	**1.21**	**NS**	**6.52**	**NS**	**NS**	**NS**	**NS**	**894.17**	**NS**	**NS**

Table 3: Correlation between all pairs of grain quality parameters of 13 wheat varieties.

	Protein	Moisture	Starch	Wet Gluten	Dry Gluten	Sed. Value	Hardness Index	TGW (g)	Grain Dia.	Hectoliter Weight	Grain Yield	Phenol Test	Gluten Index
Protein	1												
Moisture	-0.294*	1											
Starch	-0.918**	0.077	1										
Wet Gluten	0.918**	-0.166	-0.904**	1									
Dry Gluten	-0.013	-0.033	-0.005	0.176	1								
Sed. Value	0.949**	-0.450**	-0.853**	0.888**	0.066	1							
Hardness Index	-0.014	0.040	0.027	-0.213	-0.234	-0.081	1						
Grain weight	-0.321*	0.472**	0.187	-0.260	-0.315*	-0.447**	-0.323*	1					
Grain diameter	-0.367**	0.454**	0.201	-0.318*	-0.225	-0.477**	-0.149	0.885**	1				
Hectoliter weight	-0.521**	0.426**	0.474**	-0.504**	-0.097	-0.581**	0.205	0.580**	0.597**	1			
Grain Yield	-0.378**	-0.045	0.465**	-0.305*	0.042	-0.275*	-0.465**	0.084	-0.040	0.071	1		
Phenol Test	0.265	0.213	-0.412**	0.289*	-0.030	0.233	-0.187	-0.040	-0.126	-0.483**	-0.296*	1	
Gluten Index	0.177	-0.261	-0.078	0.120	0.070	0.283*	0.138	-0.594**	-0.576**	-0.517**	-0.112	0.096	1

** Correlation is significant at the 0.01 level (2-tailed)   * Correlation is significant at the 0.05 level (2-tailed)

Table 4: Cluster mean of different quality parameters of 13 bread wheat varieties.

Cluster No.	Protein (%)	Moisture (%)	Starch (%)	Wet Gluten (%)	Dry Gluten (%)	Sed. Value (ml)	Hardness Index	TGW (g)	Grain Dia. (mm)	Hectoliter weight (kg/hl)	Grain Yield (Kg/ha)	Phenol Test (0-10)	Gluten Index
Cluster1	11.62	9.94	62.36	28.75	11.23	42.19	72.50	48.65	3.04	80.78	4580.58	4.81	59.55
Cluster II	11.94	9.50	62.75	29.02	12.00	46.67	73.29	39.39	2.83	78.51	5541.48	2.58	80.97
Cluster III	13.64	9.80	60.66	31.14	13.11	54.71	69.67	37.46	2.78	76.26	4172.83	6.58	80.94

B. Statistical analysis

The data were analysed for correlation in between all pairs of grain quality parameters along with grain yield of 13 wheat varieties. Later, data were subjected to multivariate analysis by using R studio software. Then, results for different grain quality parameters of thirteen varieties were subjected to analyse with basic multivariate data reduction statistical technique such as principle component analysis (PCA). Cluster analysis was also generated to see the relation of varieties based on their grain quality data. Accordingly, Dendogram for all the thirteen varieties were constructed by following Squared Euclidean distance method (Sultana *et al*., 2018) and KMEANS analysis method was used to analyze the cluster distance among wheat varieties.

RESULTS AND DISCUSSION

A. Physical and chemical analysis of wheat grain

The physical and chemical characteristics of grain samples of thirteen bread wheat varieties are provided in Table 3. The protein content was found to be in the range of 11.12 to14.03% but among the thirteen varieties there were non-significant differences for protein content. Six varieties such as GW499, GW173, GW11, HD2932, MP3288 and DBW110 were recorded having protein content of above 12%. Similarly, the results of moisture content, wet gluten, dry gluten and sedimentation value were non-significant differences among the thirteen bread wheat varieties. The moisture content of all the samples of bread wheat varieties were observed ranging from 9.22 to 10.05%. The result of starch content has depicted that 9 varieties has significantly at par ranging from 61.43 to 63.45% followed by varieties DBW110, GW11 and MP3288 with starch content ranged from 60.35 to 61.00% as shown in Table 3. Wheat varieties GW322 have maximum hardness index (82.25) followed by HI1544 (80.00) while the minimum was reported in GW11 (58.87) and Lok1 (61.13).

For 1000 grain weight, seven varieties GW499, GW496, GW366, GW451, GW173, HI1544 and Lok1 were statistically at par as provides in Table 3. The result of grain diameter has indicated that all the eleven varieties are statistically at par except two varieties GW11 and HD2864 having least grain diameter of 2.75 and 2.72mm respectively. For gluten index, five varieties GW322, GW451, HD2864, Lok1 and DBW110 recorded with gluten index ranging from 76.79 to 97.97. For grain yield, all the ten varieties were noticed with statistically significantly at par in terms of varieties and years but three varieties HI1544, MP3288 and DBW110 were recorded with least yield ranging from 3200 to 3509kg/ha as provided in Table 3.

In phenol test, GW451 variety was noticed with no development of pigmentation at all so recorded as zero score as shown in Fig. 4. Four varieties *i.e.* GW496, GW173, HD2864, and HD2932 were recorded having score of 1-2. While, seven varieties *i.e.* GW11, GW366, GW322, GW499, Lok1, DBW110 and HI1544 were recorded with score ranged from 5-6 score. But, MP3288 variety was recorded with maximum pigmentation with 7 score. Hence, the result of phenol colour test has depicted that all the varieties having good characteristics with low colour pigmentation value indicates a good chapatti colour.

B. Statistical analysis

The diversity among the various bread wheat varieties based on the different grain quality parameters was assessed using Dendogram generated by *R studio* software. The result has depicted that three cluster groups were generated among them where six varieties such as GW322, Lok1, GW173, GW451, HD2864 and HD2932 were generated in cluster I as more homogenous group, cluster II consist of four varieties such as GW496, GW366, GW499 and HI1544 and lastly cluster III consist of GW11, MP3288 and DBW110 as provided in Table 6 and Dendogram in Fig. 1. Among the three clusters groups by the KMEANS method of analysis for cluster height, the maximum cluster distance was found between cluster II and III (1369.69) and cluster I and II exhibited cluster distance of 961.21 followed by cluster I and III (408.71) as depicted in Table 7. The details of cluster height among the group are also graphically plotted in Dendogram plot (Fig. 1).

Based on various grain quality parameters the Principle Component Analysis (PCA) was analyzed by using *R studio* software. Based on these grain quality parameters the results of PCA revealed a wide range of diversity among the wheat varieties. The Eigen value representing the variance of the principle components and the cumulative percent of the Eigen value indicating percentage contribution to the total variance attributable to each principle component are provided in Fig 3. The PC was used to determine the extent of variation among the varieties. Scree plot explained the percentage variance associated with each principal component obtained by drawing graph between Eigen values and principal component numbers (Fig. 2).

Three characters of grain *viz.* size, shape and colour are taken into consideration for scoring. Bold grains with attractive shape, amber golden colour and luster of the grain are the main criteria for scoring. It's score are recorded from 0-10 scale so, the maximum score 10 is awarded for excellent quality (Ram *et al*., 2018). Thousand grain weight is a useful measure of grain size since it is a function of kernel size and density. It is an important scale in seed quality that influences seed germination, seed vigour, seedling establishment and yield. The electronic counter was used for counting 1000 grain followed by weighing them and expressed the result in grams. Generally bread wheat recorded with a wide range of variability from 22 to 45g of 1000 grain weight (Ram *et al*., 2018).

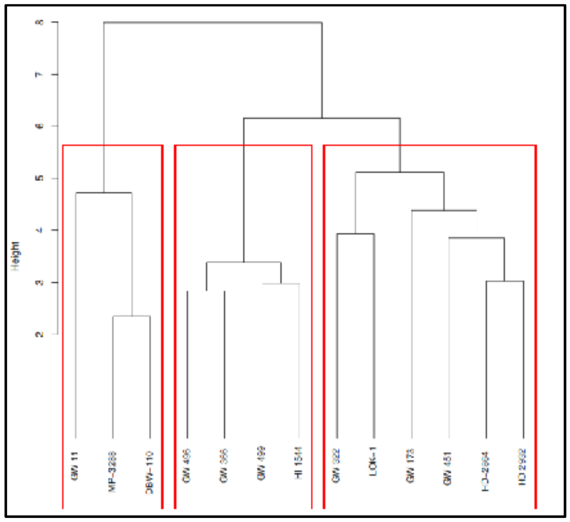

Fig. 1. Dendogram showing cluster pattern distance among the different 13 bread wheat varieties based on their grain quality parameters.

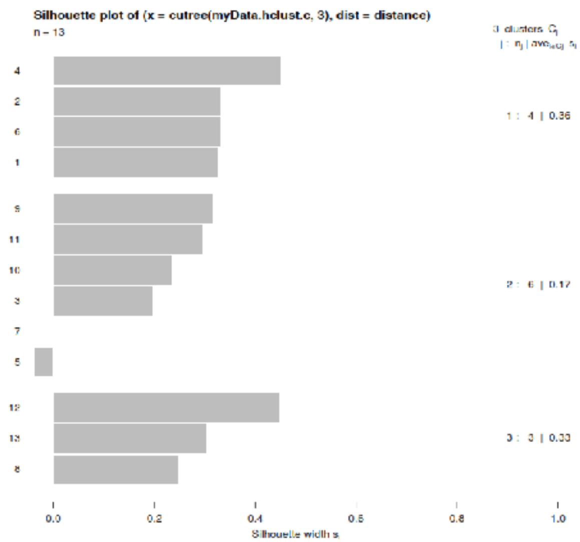

Fig. 2. Scree plot showing Eigen values in response to component for estimated variables.

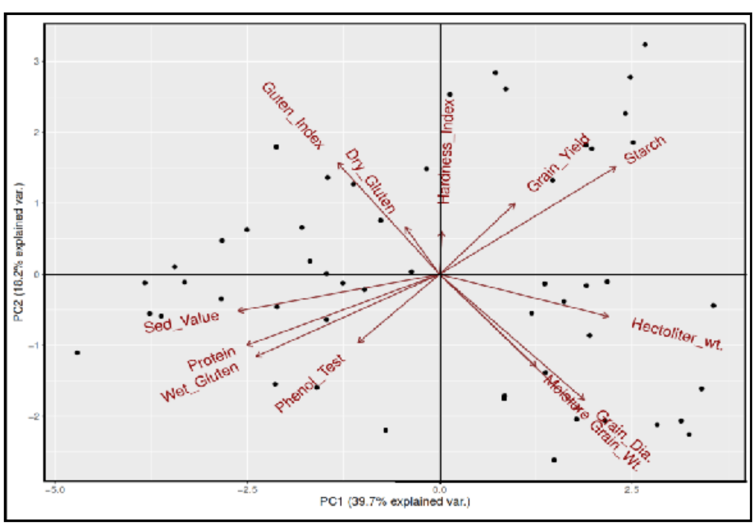

Fig. 3. PCA plot for different grain quality parameters of 13 bread wheat varieties.

Another parameter *i.e.* hectoliter weight is a specific volume of grain and is an indication of the bulk density of the grain. It generally determines plumpness of the grain and also known as hectoliter weight (kg/hl). It indicates a rough index for the flour recovery. Immature and shrivelled grains are usually low in hectoliter weight and poor floor yield. The result of hectoliter weight with >78kg/hl are considered as best (Ram *et al*., 2018).

Regarding the hardness of grain, it is used as grading factor to determine wheat types and to define end product quality. The SKCS 4100 (Single Seed Kernel Characterization System) determine kernel hardness and expressed as an index of -20 to 120. Based on the hardness index, the grains with HI<45 are classified as soft, 45 to 75 as medium hard and >75 as hard (Ram *et al*., 2018).

Moreover, the moisture content denotes the quantity of water unit per mass of grain and expressed on a percentage basis. Moisture content of 12% is commonly used as a conversion factor for protein content and other tests where the results are affected by moisture content (Ram *et al*., 2018). It indicated that low moisture content of less than 12% in wheat samples are suitable for storage and less prone to microbial attack.

Besides, protein content is a key specification for wheat and related to processing properties like water absorption and gluten strength. Protein content of grain being primary criteria in determining the bread making quality of wheat. Moreover, variations in both the protein content and composition significantly modify the flour quality for bread making. The protein requirements are >12.0%, 10-12% and <10% for making good quality bread, chapatti and biscuit respectively (Ram *et al*., 2018). According to result of Makawi *et al.* (2013), the protein content of wheat flour were reported in the ranged from 9.5 to 12.9%, while the lowest value (9.5%) was observed in Elnelain cultivar and the highest value (12.9%) in Nepta, while Argeen cultivar recorded with 11.3% of protein showing significant difference as compared with the Australian wheat cultivar (12.6%).

Differences in heritability estimates were identified for six traits (test weight, thousand kernel weight, protein content, plant height, days to anthesis, spikes m^2) under different management systems *viz.* conventional and organic farming. The protein content was found to be lower at the organic farming, so varieties with high quality protein and better nitrogen uptake were recommended for organic farming in order to compensate the relatively low protein content in wheat grain (Osman *et al*., 2012). Similarly, result of near-infrared hyperspectral imaging has classified western Canadian wheat into different eight commercial groups (Mahesh *et al.*, 2008). Variation in protein content among wheat varieties is due to differences in their genetic makeup as well as differences in environmental and production conditions prevailed during growth stages (Randhawa, 2002).

Regarding the gluten content and gluten index, gluten is the functional component of protein and determines many of the dough and processing characteristics of wheat flour. It is responsible for the elasticity and extensibility characteristics of flour dough. Wet gluten reflects protein content and flour specification required by end users in the food industry (Ram *et al*., 2018). Curic *et al.* (2001) reported the range of dry gluten from 8.44 to 11.77% in flour of different wheat varieties and Lin *et al.* (2003) found the range of dry gluten from 7.0 to 16.7%. As dry gluten contains no water, it can be directly correlated with crude protein, which is a direct indicator of flour strength and bread baking potentialities (Anjum and Walker 2000). Though, wheat based foods are not suitable for people with having wheat intolerance, especially coeliac disease (Sollid, 2000; Wieser and Koehler, 2008; Koehler *et al*., 2016). The protein and gluten content basically determine the bread making quality of the flour (Rakszegi *et al*., 2016). Although, it is difficult to make good quality bread wheat if gluten is to be excluded but various strategies such as adding of additives for increasing rheological properties which ultimately decrease gluten content, gluten proteolysis, genetically modified wheat breeding, sourdough fermentation, frozen storage, and partial baking have been employed to produce gluten free bread (Gallagher *et al.*, 2003; Arendt and Dal Bello, 2008; Casper and Atwell, 2014).

Another parameter which is sedimentation value which provides information on the protein quantity and quality of the wheat and flour. It sedimentation test is used as a screening tool in wheat breeding as well in milling applications. The required sedimentation value of >60ml, 30-60ml and <30ml are good for making quality bread, chapatti and biscuit respectively (Ram *et al*., 2018). Mutwali (2011) reported the sedimentation value in the range of 19.0 to 40.3ml in 20 Sudanese wheat cultivars grown at three different locations. The result of Pasha *et al*. (2007) reported that Zeleny sedimentation value were ranged from 50.67 to 80.34ml and the wet gluten content were ranged from 13.82 to 43.13% where highest was reported in Pavon and SA42 variety, while the lowest wet gluten was found in Durum97 and Wadanak85 wheat varieties. Further, Hruskova and Famera (2003) evaluated 318 wheat samples for Zeleny sedimentation value through NIR technique and reported the value in range from 17 to 66ml.

Starch constitutes 60-70% of the mass of wheat flour. In general, soft wheat has less protein and more starch than hard wheat. The wheat starch is the predominant carbohydrate source for human diets, also an important substrate for producing alcoholic beverages and fuel ethanol by fermentation and the raw material for many industries (Guragain *et al*., 2016). Starch are synthesized and accumulated during the grain filling process (Yang *et al*., 2004), which is the major factor influencing grain yield and quality of wheat (Emes *et al*., 2003; Hurkman *et al*., 2003). For testing of varietal purity qualitatively, phenol colour test is generally performed since it correlates to the darkening of whole meal dough and negatively correlated to the chapatti quality. Dark colour indicates high polyphenol oxidase activities which are not suitable for good chapatti quality (Ram *et al*., 2018). So, wheat varieties having good characteristics with low colour pigmentation value indicate a good chapatti colour.

Table 5: Membership of 13 bread wheat varieties under 3 different clusters based on their grain quality parameters.

Cluster No.	Number of variety	Percentages	Varieties
I	6	46.15	GW322, Lok1, GW173, GW451, HD2864, HD2932
II	4	30.77	GW496, GW366, GW499, HI1544
III	3	23.08	GW11, MP3288, DBW110

Table 6: Mean inter cluster distance values of 13 varieties wheat by KMEAN method.

Cluster	II	III
I	961.21	408.71
II	---	1369.69

Fig.4. Performance of 13 different bread wheat varieties in Phenol test.

Correlations and principal component analysis also revealed interesting insights into relationships among various quality parameters studied. The study has importance as the protein content is the basis for usage of wheat for the formulation of various products (Punia *et al*., 2019). Moreover, the application of principle component analysis (PCA) which are generally used for basic multivariate data reduction in order to ascertain the relationships between two or more characters by linear transformation of original variables to a new group also known as principle component. This method made it possible to fully assess the correlations in between various components of grain quality traits and this method is generally used for the analysis of object diversity and allows their grouping according to the similarity hierarchy (Gregorczyk *et al*., 2008). Multivariate methods such as principle component analysis have proven to be useful for evaluating and classifying germplasm when a large number of accession are assessed for several characteristics of agronomic importance. In particular it identifies the principal directions in which the data varies (Singh *et al*., 2018). Principal component analysis also categorized the varieties on the basis of their chapatti making quality. The wheat varieties with chapatti score >90 (C306, GW322, GW381, GW173, GW190, HD2687, and Lok1), chapatti score <70 (WH291, WH157, C591, HD2189, and UAS 410) and chapatti score 70-90 (HD2329, Raj3765, WH1021, NIAW34, and Raj3077) were grouped separately (Panghal *et al*., 2019). But, as earlier report indicated that the protein characteristics, the proportion of gluten and end-use qualities were influenced by year and cultivar (Rozbicki *et al*. 2015; Triboi *et al*. 2000). The principle component analysis was made for visualizing the differences and similarities among the various quality attributes of different wheat varieties. Later, Eigen value was obtained from the PC, which was used to determine the relative discriminative power of the axes and their associated characters (Alice *et al*., 2018). Therefore, the present findings could able to generate valuable information for the various quality aspects of wheat varieties.

CONCLUSION AND FUTURE SCOPE

From the above findings, it can be concluded that protein content was at average with ranged from 11.12 to14.03%, starch content of 61.43 to 63.45% and for grain yield, all the ten varieties were noticed with statistically significantly at par in terms of varieties. Later on, three cluster groups were generated based on different grain quality parameters where six varieties such as GW322, Lok1, GW173, GW451, HD2864 and HD2932 were generated in cluster I as more homogenous group, cluster II consist of four varieties of GW496, GW366, GW499, HI1544 and lastly cluster III consist of three varieties, GW11, MP3288 and DBW110. The results of PCA revealed that grain quality parameters exhibit a wide range of diversity among the wheat varieties. Thus, the present experimental study will help to understand the utility of wide range of diversity among the wheat varieties and selection of best superior varieties based on these quality parameters.

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