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Assessing the suitability of wheat germplasm for biscuit preparation**

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A b s t r a c t. Wheat (*Triticum aestivum*) belonging to family *Poaceae* is the basic cereal consumed in many countries as a staple food and categorized based on protein, *i.e.* hard wheat (>10%) and soft wheat (7-10%). Hard wheat is used for bread production, while soft wheat is utilized in preparation of biscuits and cakes. The current study was planned to explore the potential of locally grown wheat germplasm for biscuits with special reference to physicochemical and sensory evaluation. For this purpose, wheat germplasm was inspected based on desired colour (medium brownish, light brownish, dark brownish, and yellowish), and selected genotypes were subjected to thousand kernel weight, NIR, and colour analysis. In the next stage, wheat was milled into straight grade flour and compositional (proximate, gluten, and mineral) as well as rheological analyses (farinograph and viscosity) were done. Further, biscuits prepared from flour were evaluated for quality characteristics like the spread factor, colour, hardness, and sensory profile. Based on the obtained results, it was determined that wheat germplasm with low protein levels (10.1±0.50, 9.20±0.34, 10.61±0.54, and 11.82±0.63, correspondingly) *i.e.* Line-3, Zincol, A-84, and A-21 was the best for preparing biscuits. The spread factor (59.767±3.39), hardness (3.41±0.37), colour (L^*=68.98±1.81, a^*=3.04±0.72 and b^*=30.31±0.85), and overall acceptability (8.05±1.16[ab]) had the best results for A-21. Therefore, it was suggested that germplasm A-21 must be grown as a variety to obtain straight grade flour that can be potentially utilized for biscuit preparation.

K e y w o r d s: soft wheat, straight grade flour, farinograph, near infrared analyzer, colour

1. INTRODUCTION

Common wheat is one of the important cereals belonging to the grass family *Gramineae* and species *aestivum*. Wheat is consumed as a national staple food in 43 countries; therefore, it ranks as world's 1st crop in terms of consumption (Morris, 2016; Sharifnasab *et al*., 2024). Although wheat is produced all over the world, most of it is produced in Argentina, Australia, India, and Canada, which account for 79% of global wheat production. Wheat is the main source of food for mankind with 67% consumed as food, 20% used for feed, and 7% as seed in the world (Erenstein *et al*., 2022). Likewise, wheat is also a staple food in Pakistan with 31.4 million ton production during 2023-24 and occupies a central position in the GDP of the country (GOP, 2023-24).

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Wheat grains exhibit differences in shape and can be long, oval, narrow, flattened, and spherical. They range from 5 to 9 mm in length and from 35 to 50 mg in weight. Wheat grains are composed of bran (12-16%), germ (3-4%), and endosperm (80-85%), and contribute to about 75-80% of carbohydrates and 10-18% of protein of total dry matter in the daily diet. In addition to carbohydrates and protein, wheat provides 1-2% fat and 2-10% minerals content (mainly iron, zinc, magnesium, and selenium) (Lončarić *et al*., 2021). The suitability of wheat grain is influenced by physical and compositional characteristics because they affect the functionality of flour. Among compositional parameters, protein contents in wheat drive its utilization in final products (Mamat and Hill, 2018).

The most important factor for classification of wheat is based on protein, which enhances milling, particle size, and yield of flour that defines its usage in making bread and non-bread products like cookies or biscuits (Sabanci *et al*., 2020). Hard and soft wheat are differentiated on the basis of kernel physiochemical properties, a basic genetic inherited character (Zarroug *et al*., 2015). Soft wheat flour of good quality has the capacity to produce biscuits with a high spread factor, diameter, minimum thickness, and soft texture (Karaduman *et al*., 2021).

Soft wheat flour has low protein (7-10%) and is used for preparation of cakes and biscuits (Zarroug *et al*., 2015). The proximate composition of soft wheat flour includes protein (<10%), crude fiber (0.51%), moisture content (10-13%), ash (1-1.5%), fat (1-3%), and carbohydrates (75-78%). Soft wheat flour is prepared from wheat by removing bran (brown surface coating) and germ (embryo), and its particle size is reduced into fine powder (Mamat and Hill, 2018). Wheat is milled into flour that is mainly used in leavened and un-leavened bakery products. All flours are not same in their particle size, *i.e.* soft wheat normally ground gives a smaller and finer particle size than hard wheat (Protonotariou *et al*., 2021). The flowability of flour is affected by its particle size, and a smaller size has high cohesive properties due to the high intermolecular forces among particles. Meanwhile, a higher surface area is responsible for high water absorption and needs high water content to produce dough of maximum consistency (Li *et al*., 2022).

There is a global interest in using wheat-based products, especially bakery goods, as the population expands. One common grain used in baked goods, such as breads, rolls, cookies, biscuits, and breakfast cereals, is wheat (David *et al*., 2015). Biscuits are high-energy, high-density products and the main source of carbohydrates, minerals, vitamins, and protein. A biscuit is defined as a small bakery product containing principal ingredients, *i.e.*, flour, sugar, and fat. It is different from other baked products like bread and cakes in terms of low moisture content that is 4% and has a long shelf life of about six months (Mamat and Hill, 2018). Preparation of biscuits with soft wheat requires a precise composition and water absorption. It is observed that there is an inverse relationship between biscuit diameter and protein content (Moiraghi *et al*., 2011; Tyuftin *et al*., 2021).

It is obvious to produce soft wheat for low protein content; therefore, it is important to focus on the soft wheat composition and examine functional quality characteristics for its end use. Quality description, such as mixing time, water absorption of flour, and spread factor of biscuits, depends on the protein composition. Physical methods are mainly used to evaluate the properties of hard wheat used in bread making. However, most bakery products are made from soft wheat flour, which does not require proper mixing or development of dough as required for bread making (Wang *et al*., 2007; Karaduman *et al*., 2021). Worldwide, the classification of wheat is done based on the product *i.e.*, hard wheat with high protein is used for bread preparation, while soft wheat is used in biscuit and cake preparation. In Pakistan, unfortunately such classification does not exist. Mostly industries prepare biscuits or cookies from hard or medium hard wheat flour that affect the consistency and quality of their product. Therefore, this research was designed to identify wheat germplasm with a high yield and specific characteristics of soft wheat that could be used in biscuit preparation.

2. MATERIALS AND METHODS

2.1. Procurement of raw material

The wheat germplasm was procured from the Institute of Plant Breeding and Biotechnology (IPBB), MNS University of Agriculture, Multan (MNS-UAM). All necessary chemicals were procured from Emplura, Sigma Aldrich, and BDH Middle East LLC. The present research was conducted in the central lab system (CLS) of MNS-UAM, Volka Foods International Multan, and Data Foods Lahore, Pakistan.

2.2. Visual inspection of wheat grains

Thousand wheat germplasms were collected from IPBB MNS-University of Agriculture, Multan. The germplasm was selected based on visual parameters like appearance, grain size, colour, length, and width. Wheat grain with medium length and width were selected and further distributed into four main groups based on their colour, *i.e.*, dark, light, medium yellow, and yellowish. From each group, four high-yield germplasm were selected for quality analyses.

2.3. Physical characteristics

Thousand kernel weight (TKW) was determined by selecting 1000 clean, unbroken, and sound kernels, counted manually, and their weight was measured on a weighing balance (Ahmad *et al*., 2017). Moreover, to determine the colour of the grains, wheat grains from each germplasm were placed in a china dish and their upper surface was flattened. The sample was then placed under the lens of a Chroma Meter (CR400) to measure the L^*, a^*, and b^* value of the grains (Center, 2008). The NIR analysis of healthy wheat grains was done by scanning through a Perten instrument following the guidelines of AACC (2000). Parameters like protein, moisture, dry, and wet gluten, zeleny value, hardness, and damaged starch were determined through the NIR analysis (Zaresani *et al.*, 2024).

2.4. Milling of wheat

Wheat from each germplasm was tempered for 24 h at room temperature to achieve moisture at 14.5%.

Water required =

$$\left[\frac{100-(\text{original moisture \%})}{100-(\text{desirable moisture \%})}-1\right]\text{sample weight.} \quad (1)$$

After tempering, the samples were milled through Bastak 4000, which gave four milling fractions *i.e.* bran, reduction flour, shorts, and break flour (AACC, 2000). Break and reduction flour were blended to get straight grade flour.

2.5. Compositional analysis of ground flour

For the compositional analysis of the wheat flour, a sample (3-5 g) was taken in the pre-weighed china dish and placed in the oven at 100±5ºC for 24 h. Afterwards, the sample was cooled down in a desiccator and weight loss was noted as moisture content (method no. 44-15A, AACC, 2000). To determine the fat content, the moisture-free sample (5-7 g) was wrapped in a filter and placed in the Soxhlet apparatus. Petroleum ether was added to the receiving flask of the Soxhlet apparatus and heating was set so that 1 drop condensed in one second. At the end of the cycle (2-3), the fat-free wrapped sample was taken out and dried in a hot air oven at 50-60ºC to remove solvent residues. Weight loss was taken as the fat content of the sample according to method no. 30-10 of AACC (2000). The moisture- and fat-free sample (2-3 g) was digested in 250 mL of 1.25% H_2SO_4 at the simmering point for 30 minutes. After that, the sample was filtered and residues were washed with water to remove the acid content. The residues were digested in 250 mL of 1.25% NaOH at the simmering point for 30 min. Afterwards, the sample was filtered, and the residues were washed with water to remove the alkali content. At the end, the residues were collected, weighed in a pre-weighed china dish, and placed in a muffle furnace at 550-650ºC for 5-6 h. Weight loss before and after the muffle furnace was calculated as fiber content (method no. 32-10) in the sample (AACC, 2000). The protein content in the sample was determined using method 46-10 of AACC (2000). For this purpose, a 1-2 g sample was digested in 30 mL concentrated H_2SO_4 in the presence of 5 g of a digestion mixture (K_2SO_4: $FeSO_4$: $CuSO_4$) for 4 h. The digested sample was diluted to 250 mL using distilled water and a 10-mL aliquant was placed in the distillation flask. At the other end of the distillation chamber, 10 mL of a 4% boric acid solution with 1-2 drops of the methyl red indicator was added, and distillation started by adding 40% NaOH (20-25 mL) to the aliquant sample. After distillation, an ammonium borate solution was attained (yellow coloured) and titrated against 0.1 N H_2SO_4. The following formulas were used to calculate the protein content in the sample.

Nitrogen =

$$\frac{\text{Volume of 0.1N } H_2SO_4 \text{ used} \times 0.0014 \times \text{Vol. of dilution (250)}}{\text{Weight of sample} \times 10} 100. \quad (2)$$

$$\text{Protein} = \text{Nitrogen percentage} \times 5.72. \quad (3)$$

The ash content in the sample was measured using method no. 08-01 of AACC (2000); accordingly, 1-2 g sample was taken in the pre-weighed crucible and charred on flame until white fumes appeared. Afterwards, the charred sample was placed in the muffle furnace at 550-650ºC for 5-6 h. At the end, the weight of residues was noted as the ash content. The NFE (Nitrogen Free Extract) of the wheat flour was estimated by subtracting compositional parameters (moisture, fat, ash, fiber, protein) from 100. The wet and dry gluten contents in the wheat flour were determined through the hand wash method as described in AACC (2000) method No. 38-10. A sample (25 g) was placed on a plate and dough was made using distilled water. The dough was placed in water for 30 min and, at the end, washed under tap water to remove soluble starches and pentosans. At the end, the remaining viscoelastic material was weighed as wet gluten. The viscoelastic dough was then dried in a hot air oven at 100ºC and noted as dry gluten.

The mineral content in the sample was measured using an atomic absorption spectrophotometer and a flame photometer according to method 3.014-016 of AOAC (2006). For this purpose, 2-3 g of flour from each germplasm was digested with a di-acid mixture of HNO_3 and $HClO_4$ at ratio 3:1 on a hot plate until fumes disappeared. Fe and Zn in the digested sample were measured with an atomic absorption spectrophotometer, while Na and K were determined using a flame photometer.

2.6. Rheological behaviour

The rheology of the dough was analyzed using a farinograph according to the protocol prescribed in AACC (2000), method number (54-21). Flour characteristics measured by the farinograph were water absorption, dough stability, dough development time, and dough weakness or softening. Water absorption was measured to attain the quantity of water for achieving 500±20 B.U. for the farinograph. For estimation of the rheological properties of the wheat flour, a 280-300 g sample adjusted per 14% moisture was added to the farinograph bowl and water was added so that the graph was adjusted to the 500 B.U. line. The sample was run for 20 min, and flour parameters were noted down.

2.7. Viscosity of flour

A Rapid Visco analyzer (Perten, USA) was used for measuring the Visco-elastic property of flour of wheat germplasm by following method No. 76-21 (AACC, 2000). For this purpose, a sample (3-4 g) was adjusted to 14% moisture and mixed with water (25 ml) in an aluminum canister. The canister was put in and slurry was equilibrated for 1 min at 50ºC, heated at 50 to 95ºC for 3 min 42 s, held at 95ºC for 2.5 min, and then cooled at 50ºC for 3 min 47 s and maintained at 50ºC for 2 min. For the first 10 s, the speed of the paddle was set at 960 rpm, and 160 rpm for the rest of the process.

2.8. Preparation of biscuits

Straight grade flour of different wheat germplasm was used for preparation of biscuits by following the recipe of AACC method No. 10-15D (AACC, 2000). Ingredients required for the preparation of biscuits were flour 200 g, sugar 100 g, shortenings 100 g, baking powder 1.5 g, and egg 40 g. At first, oil and sugar were mixed to get a whitish creamy texture, and then dry ingredients were added to prepare the dough. After making the dough in a mechanical mixer, it was sheeted on the sheeting tray in uniform thickness and then cut into circular shapes with the help of a cutter. The biscuit tray was labeled and placed in the baking oven with proper distance and baked at 165-180°C for 10-15 min until fully baked.

2.9. Physical analysis of biscuits

The hardness of the biscuits was measured by following the procedure developed by Shaikh *et al*. (2007). Accordingly, the texture analyzer (TAXT Plus connected with a computer) contained a cylinder probe of 2 mm, using a 5 kg load cell and HDP-90 (Heavy Duty Platform) with a holed plate. Similarly, the colour values of the biscuits were measured by a Chroma Meter according to Kara *et al*. (2005). The biscuits were placed under the photocell of the Chroma Meter, and values were taken in triplicate.

The spread factor of the biscuits was calculated by taking the ratio of the biscuit diameter and thickness, according to the procedure of AACC (2000) method No. 10-50D. For this purpose, thickness was measured by placing one biscuit over another and triplicate reading was recorded by repeating the process. Moreover, six biscuits were placed from edge to edge (horizontally) and rotated at the 90º angle for the width measurement in replication.

2.10. Sensory evaluation of biscuits

Biscuits prepared from each sample were subjected to sensory evaluation by the panel of eight members using a 9-point hedonic scale ranging from 1 to 9 with the least score of 1 (disliking extremely) and 9 being the highest score (liked extremely). Biscuits from each sample were presented on white plastic plates and water was provided with the biscuits to rinse the mouth during evaluation. The panelists were instructed to evaluate the coded biscuits for texture, colour, taste, flavour, crispness, and overall acceptability (Meilgaard *et al*., 2006).

2.11. Statistical analysis

All analyses were performed in triplicate and collected data was presented as mean ± standard deviation. Variation in the quality attributes of the wheat germplasm was determined using descriptive statistics, *i.e.* mean ± standard deviation, and graphs were constructed through Microsoft Excel 365. Significant differences among the quality attributes of the product were identified through one-way ANOVA (analysis of variance) under completely randomized design through Statistix 8.1 (Montgomery, 2017).

3. RESULTS AND DISCUSSION

3.1. Physical characteristics of wheat grain

The wheat germplasms were evaluated for physical parameters, *i.e.* Thousand Kernel Weight (TKW) and Colour (L^*, a^* and b^* values), which showed values from 23.24±1.26 g to 44.50±1.76 g for TKW and from 81.49 to 87.67, 1.17 to 2.25, and 8.12 to 12.74 for L^*, a^*, and b^*, respectively (Table 1, Fig. 1 a-d). The current results of TKW were supported by the results reported by Soomro *et al.* (2014) and Adams *et al*. (2013), who determined the values of TKW from 24.90 g to 46.00 g, colour L^* from 80.32 to 89.14, a^* from 2.16 to 2.10, and b^* from 8.01 to 13.14, respectively. TKW is an extensively applicable parameter for predicting flour yield after milling (Ghaffar *et al*., 2013). The variation in TKW is due to differences in cultivation in different agro-environmental conditions (Dziki and Laskowski, 2005).

3.2. Compositional analysis

The NIR analysis of the wheat grain showed zeleny, hardness and starch values from 20.94±1.11 to 35.8±1.65, 54.85±2.68 to 89.4±4.64%, and 61.06±3.11 to 67.47±3.23%, respectively (Table 1). In a previous research study, Ahmad *et al*. (2017) found that the zeleny value in different wheat ranged from 51.3 to 62.3. Likewise, some other researchers found hardness in the range from 62 to 87%. The range of starch in different wheat varieties was from 61.03 to 75.82% (Panhwar *et al*., 2014; Ghanghro *et al*., 2015). The variation in the zeleny value was due to the quality and quantity of gluten contents, which enhanced the variation in sedimentation and gave a high zeleny value. These changes might be due to genetic variations in wheat cultivars (Devi *et al*., 2022). Moreover, the difference in the wheat hardness may be due to some factors like wheat variety, growing area, and environment (Nucia *et al*., 2021).

a)
b)
c)
d)

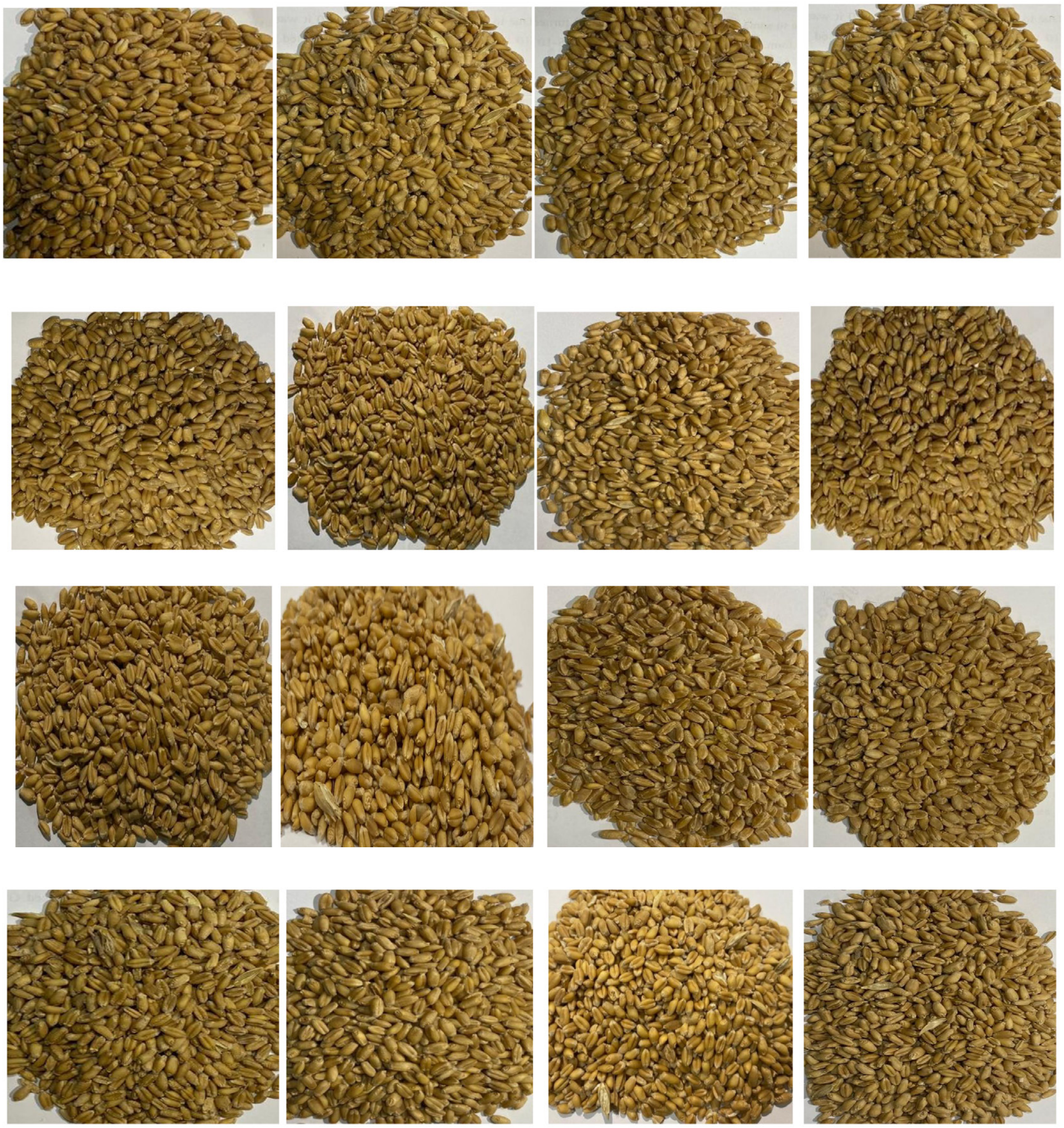

Fig. 1. Dark brownish (a), medium brownish (b), light brownish (c), and yellowish colour wheat germplasm.

The results related to the proximate composition of the wheat germplasms are shown in Table 2. The maximum values for protein, moisture, fat, ash, fiber, and NFE were 14.62 % (F7 976R2), 12.68% (A-21), 2.77% (A-128), 1.86% (A-21), 0.93% (W-85), and 76.46 (B-8), respectively (Table 2). Moisture content is an excessively important parameter for quality evaluation and to analyze the wheat kernel texture (Pasha *et al*., 2006). The range of moisture content was between 11.78 and 14.00% in some Pakistani wheat cultivars (Khan *et al*., 2009). Jafri (2010) reported that proteolytic and lipolytic activities influenced by high moisture content resulted in nutrient loss, shorter storage duration, and low flour yield (Anjum *et al*., 2003).

Protein contents affect the functionality of grain, nutritional characteristics of wheat (Iqbal *et al*., 2015), and biscuit quality (Ahmedani *et al*., 2009). The range of protein content was 8.8-10.7% in soft wheat and 10.9-12.1% in hard wheat flour (Kim *et al*., 2004). High protein produced a full gluten matrix during dough mixing and gave a high loaf volume of the product. Wheat with low protein produced flour with less protein, resulting in low resistant dough having high extensibility. Weak or low protein flour is desired for production of biscuits with a high diameter, spread factor, and good texture than biscuits manufactured from hard wheat (Miller and Hoseney, 1997). Protein and moisture contents are important parameters for bakers and millers to choose appropriate wheat for products. Moreover, both genetic and agronomic factors of wheat produce high, low, and medium protein contents in kernel. It is also altered by planting density, application of fertilizers, and sowing period. The results of the proximate composition in the current study are in agreement with the findings of (Iqbal *et al*.,

Table 1. Physical characteristics of wheat germplasm

Varieties	TKW (g)	Colour value			Zeleny value	Hardness (%)	Starch (%)
		*L**	*a**	*b**			
Light brown wheat germplasm							
Line 3	28.66±0.74	85.02±4.17	1.05±0.05	8.78±0.43	25.16±1.40	68.16±3.81	65.87±3.69
Akbar	44.26±1.61	81.49±3.91	1.92±0.09	11.4±0.54	32.39±1.55	64.25±3.15	67.47±3.23
F7 976 R2	34.17±0.97	85.91±3.95	1.28±0.059	9.78±0.45	34.40±1.58	69.38±3.19	64.29±2.95
Eo F5 684 R2	34.19±0.96	84.9±3.99	1.65±0.078	10.66±0.50	31.5±1.70	70.23±3.79	63.56±3.43
Dark brownish wheat germplasm							
W-85	36.14±0.35	82.99±4.40	1.92±0.10	11.08±0.58	20.94±1.11	89.4±4.64	65.69±3.48
A-84	41.14±0.30	84.61±4.31	2.25±0.11	12.74±0.65	22.82±1.16	88.86±4.53	61.06±3.11
Eo F6 1024 R3	25.44±0.24	84.37±3.96	1.54±0.072	9.43±0.44	32.43±1.59	54.85±2.68	61.38±3.00
F7 970 R2	23.24±1.26	85.9±4.46	1.41±0.073	9.35±0.48	32.34±1.68	62.42±3.24	62.16±3.23
Medium brownish wheat germplasm							
B-7	38.78±1.32	82.92±3.98	1.59±0.076	10.18±0.49	32.36±1.55	82.59±3.96	65.82±3.22
A-128	39.42±1.24	87.32±4.62	1.17±0.062	9.59±0.50	21.00±1.11	59.27±3.14	62.82±3.33
Line 2	42.78±0.52	87.67±4.29	1.29±0.063	9.35±0.46	25.90±1.295	71.60±3.94	63.40±3.17
F6 660 R2	37.71±1.45	85.34±4.01	1.59±0075	10.4±0.48	34.66±1.44	76.00±3.57	63.25±2.97
Yellowish colour wheat germplasm							
Zincol	40.42±0.36	82.72±3.80	1.92±0.088	11.08±0.49	35.8±1.65	85.32±3.92	66.27±3.05
A-21	44.50±1.76	87.57±4.72	1.11±0.060	8.12±0.51	34.24±1.85	75.76±3.94	63.13±3.40
EoF6 660 R2	35.60±0.49	84.78±3.81	1.74±0.078	10.04±0.43	30.66±1.56	67.71±3.05	63.46±2.85
B-8	39.08±1.08	83.17±4.57	1.51±0.083	9.74±0.53	34.56±1.90	72.4±3.47	64.07±3.52

2015; Choudhary *et al*., 2013; Masih *et al*., 2014; David *et al*., 2015), who estimated the values for moisture, protein, fat, ash, fiber, and NFE to range from 8.9 to 10.88, 8.35 to 13.68, 1.19 to 1.45, 0.50 to 0.70, 0.42 to 051, and 72.25 to 78.60%, respectively.

The mean values regarding wet and dry gluten in the different wheat germplasms ranged from 25.83 to 30.34% and from 8.77 to 9.83%, respectively (Table 2). The maximum value of wet and dry gluten was observed in Eo F6 1024R3, while lowest was seen in Akbar. Similar results of wet and dry gluten were shown by Buriro *et al*. (2012) and Soomro *et al.* (2014), who reported 23.35 to 39.60% and 7.55 to 15.87% of wet and dry gluten, respectively. Gluten refers to proteinaceous viscoelastic and cohesiveness of products, and these properties are observed by isolation of starch from wheat flour (Pasha *et al*., 2007). In wheat grain, 80% of total protein consist of gluten and glutenin together, as shown by Rosin (2009). Mixing properties, dough extensibility, and elasticity mainly depend on gluten strength and the composition and quality of protein. Kumar *et al*. (2013) published that dough strength directly affects the texture of the final product, and dough prepared for bread will have a different level of gluten than dough for biscuits (Kumar *et al*., 2013). A low level of gluten is required for biscuit preparation to improve its technological function and gluten development, which produces starch granules responsible for starch quality (Fustier *et al*., 2007). The bread making quality, flour quality, and rheological properties mainly depend on the gluten content. Any modification in the chemical concentration and composition of wheat protein effectively alter dough rheology and flour characteristics (Gulzar *et al*., 2010).

The values of minerals (iron and zinc) in the different wheat germplasms exhibited high variation ranging from 0.49 to 7.7 ppm (iron) and from 0.09 to 0.92 ppm (zinc), as given in Table 2. Similar findings were reported by Amjad *et al.* (2010), who found iron content between 1.48 and 2.13 ppm, while zinc content measured by Akhter *et al.* (2012) was from 0.06 to 0.3 ppm in different wheat varieties. The mineral concentration in wheat may vary due to genetic, agricultural, soil, and climatic conditions.

3.3. Rheological behaviour

The rheological characteristics of the wheat flour were determined through viscosity and farinographic studies, which are presented in Table 3. The viscosity of the wheat flour was measured in terms of pasting temperature (PaT), ranging from 65.22±2.46˚C (A-21) to 66.54±0.68ºC (W-85), peak time (PT) from 3.60±0.44 to 5.73±0.96 min (A-84), peak viscosity (PV) from 1050.67±4.47 (Line 3)

Table 2. Compositional attributes of wheat germplasm

Wheat germplasm	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fiber (%)	NFE (%)	Wet gluten (%)	Dry gluten (%)	Fe (ppm)	Zn (ppm)
Line 3	9.74±0.23	10.3±0.50	1.37±0.15	1.50±0.40	0.83±0.11	76.26± 3.66	28.63±1.40	9.44±0.52	0.5±0.02	0.92±0.05
Akbar	9.20±0.20	10.4±0.49	1.63±0.15	1.62±0.39	0.55±0.28	76.59±3.52	25.83±1.24	8.77±0.46	1.74±0.09	0.1±0.03
F7 976 R2	11.52±0.65	14.62±0.67	1.47±0.38	1.54±0.36	0.63±0.13	70.23±3.30	27.46±1.26	9.07±0.43	5.23±0.25	0.09±0.04
Eo F5 684 R2	11.11±1.12	13.38±0.63	1.63±0.50	1.61±0.16	0.68±0.21	71.59±3.79	28.41±1.33	9.34±0.50	7.21±0.39	0.99±0.06
W-85	9.22±0.21	11.7±0.62	2.50±0.40	1.84±0.14	0.93±0.06	73.81±3.76	28.82±1.53	9.58±0.51	0.7±0.03	0.9±0.48
A-84	11.70±0.82	10.61±0.54	2.20±0.46	1.60±0.43	0.80±0.06	73.09±3.44	28.42±1.44	9.4±0.47	2.79±0.14	0.86±0.04
Eo F6 1024 R3	11.28±0.10	13.8±0.65	2.67±0.15	1.37±0.28	0.70±0.16	70.19±3.65	30.34±1.42	9.83±0.48	4.65±0.23	0.62±0.03
F7 970 R2	10.97±0.82	13.96±0.73	1.50±0.10	1.74±0.1	0.83±0.17	71.00±3.41	29±1.50	9.54±0.49	5.67±0.29	0.72±0.04
B-7	9.33±0.32	11.09±0.53	2.50±0.20	1.52±0.17	0.80±0.24	74.77±3.96	29.2±31.40	9.77±0.52	0.38±0.02	0.89±0.05
A-128	12.20±0.20	11.48±0.61	2.77±0.15	1.40±0.15	0.60±0.12	71.56±3.51	27.03±1.43	8.99±0.48	7.7±0.41	0.85±0.41
Line 2	12.29±0.52	12.09±0.59	2.50±0.27	1.68±0.22	0.83±0.13	70.61±3.32	27.75±1.36	9.21±0.45	1.74±0.08	0.91±0.08
F6 660 R2	11.32±0.90	13.89±0.65	1.37±0.25	1.60±0.32	0.59±0.16	71.23±3.28	29.14±1.37	9.57±0.45	0.49±0.02	0.38±0.02
Zincol	9.20±0.34	12.82±0.59	3.43±0.31	1.46±0.32	0.68±0.15	72.42±3.91	28.93±1.33	9.63±0.44	0.49±0.03	0.86±0.03
A-21	12.68±0.11	11.82±0.63	1.68±0.07	1.86±0.61	0.64±0.30	71.31±3.21	27.81±1.50	9.14±0.49	2.71±0.15	0.64±0.15
EoF6 660 R2	10.95±0.71	13.2±0.59	1.60±0.16	1.74±0.20	0.78±021	71.73±3.94	28.1±1.26	9.27±0.42	3.47±0.16	0.68±0.16
B-8	9.50±0.53	10.0±0.55	1.76±0.09	1.44±0.24	0.84±0.18	76.46±4.21	29.14±1.60	9.65±0.53	0.62±0.03	0.86±0.03

Table 3. Rheological behaviour of wheat germplasm

Wheat germplasm	Viscosity				Farinograph			
	Pasting temperature (°C)	Peak time (min)	Peak viscosity (cP)	Breakdown viscosity (cP)	Water absorption (%)	Dough development time (min)	Dough Stability (min)	Weakening (BU)
Line 3	65.69±1.25	3.70±0.40	1050.67±4.47	679.67±20.55	55.6±2.61	2.5±0.12	7±0.38	65.8 ±3.29
Akbar	65.55±1.15	3.60±0.44	1873.33±115.0	666.33±86.66	55.4±2.83	4±0.22	6±0.27	98.6±4.83
W-85	66.54±0.68	4.50±0.79	1449.33±190.2	584.00±62.39	61.1±3.24	3±0.14	4.5±0.22	108±5.08
A-84	65.50±0.53	5.73±0.96	1532.00±146.46	638.00±90.07	57.8±3.12	4.5±0.23	8.5±0.46	86.4±4.15
B-7	65.78±1.21	5.37±0.64	1809.00±58.97	611.33±32.01	57.2±3.03	5.5±0.30	5±0.28	79.6±4.21
A-128	65.24±2.63	5.47±1.15	1635.67±168.84	668.00±32.19	56.1±2.52	3.5±0.19	17±0.80	126±6.80
Line 2	65.58±1.49	5.24±1.34	1582.33±80.09	692.00±9.0	55.3±2.60	4.5±0.24	21±1.10	134±6,57
Zincol	66.02±3.12	5.00±0.96	1558.33±264.30	669.00±23.58	57.2±3.09	3.5±0.19	8±0.43	74±3,52
A-21	65.22±2.46	5.10±1.11	1677.33±251.81	651.67±21.78	54.1±2.49	3±0.14	5.5±0.29	96±4.98
B-8	65.95±0.68	5.30±0.61	1769.33±189.32	645.00±55.0	57.3±3.15	2.5±0.14	11.5±0.62	119±7.13

to 1873.33±115.0 cP, and breakdown viscosity (BV) from 584.00±62.39 cP (W-85) to 692.00±9.0 cP (Line 2). Rheology is an important instrument to evaluate the quality of flour for cereal scientist (Hadnađev *et al*., 2011). Cereal technologists apply a series of test throughout the processing chain to evaluate the mechanical features of grain, molecular and compositional structure of cereals, and functionality of cereals during processing and to analyze the quality of end products. Important parameters estimated in rheometry are viscosity, plasticity, and elasticity, which express the behaviour and characteristics of dough and products.

In the farinographic study, the wheat varieties showed water absorption (WA), dough development time (DDT), dough stability (DS), and softening of dough (SoD) in the range from 54.1±2.49 to 61.1±3.24%, 2.5±0.12 to 5.5±0.30 min, 4.5±0.22 to 17±0.80 min, and 65.8 ±3.29 to 134±7.37 BU, respectively (Table 3). SoD showed a negative correlation, while WA, DDT, and DS were positively correlated with flour quality.

It has been observed that the water absorption of wheat germplasm exhibits high genetic diversity. Wheat flour having lower water absorption tends to be more suitable for biscuit preparation. However, it was noted that high water absorption was due to high DS and protein. Some factors, like the quality of protein, pentosan contents, damaged starch, particle size, and starch portions are used for determining the level of water absorption (Vizitiu and Danciu, 2011). It was also observed in this study that stronger wheat flour gives a low level of weakening in contrast to soft wheat varieties.

3.4. Physical analysis of biscuits

Biscuits prepared from different wheat germplasms were used to measure hardness and colour using the texture analyzer and the Chroma Meter, respectively, while the spread factor was calculated by the ratio of diameter and thickness measured with a vernier caliper (Table 4). Biscuits prepared from different wheat germplasms did not show significant variation in terms of their hardness, colour, and spread factor. Six biscuits were used for measuring their thickness and diameter, which ranged from 25.867±0.63 to 30.32±1.03 cm and from 5.0333±0.39 to 6.2033±0.45 cm, respectively. In turn, the spread factor and hardness values ranged from 50.333±4.69 to 62.033±2.27 and from 28.32±0.79-3.47±0.28 kg, respectively. The results showed that the wheat germplasm selected for biscuit preparation had similar behaviour during baking. The variation in the spread factor directly depends on the variation in the diameter and thickness of biscuits, which were enhanced by the protein content and ingredients used for making the biscuits. In term of hardness, the variation was due to the bran

Table 4. Physical characteristics of biscuits prepared from wheat germplasm

Treatments	Diameter (cm)	Thickness (cm)	Spread factor	Hardness (kg)	Colour *L**	Colour *a**	Colour *b**
T_0	30.84±0.36	6.20±0.49	49.90±3.50^{c}	2.92±0.22	66.14±3.37	2.51±1.44	31.87±0.95
Line 3	25.867±0.63	5.63±0.91	56.33±7.65^{b}	3.47±0.28	68.62±2.71	2.87±0.49	31.63±2.73
Akbar	26.747±1.02	5.76±0.84	57.57±8.61^{b}	3.40±0.29	71.10±4.05	3.08±0.54	33.76±1.16
w-85	26.217±0.38	5.89±0.69	58.93±5.54^{ab}	2.96±0.13	69.83±5.45	2.88±0.20	32.23±2.14
A-84	28.317±0.56	5.83±0.58	58.30±4.97^{ab}	3.37±0.46	71.16±5.19	2.32±0.71	29.73±1.45
B-7	27.973±0.80	6.20±0.45	62.03±2.27^{a}	28.32±0.79	74.20±1.77	28.32±0.59	32.54±1.84
A-128	30.32±1.03	5.03±0.39	50.33±4.69^{c}	3.13±0.23	70.03±4.61	3.42±0.10	33.03±2.26
Line 2	30.3±0.35	5.37±0.50	53.70±4.75^{bc}	3.12±0.12	67.27±1.72	3.30±0.35	32.04±0.25
Zincol	27.407±0.41	5.56±0.99	55.60±9.02^{b}	3.26±0.42	69.64±4.21	2.41±0.41	30.56±0.81
A-21	30.37±0.40	5.98±0.33	59.77±3.39^{a}	3.41±0.37	68.98±1.81	3.04±0.72	30.31±0.85
B-8	27.313±0.80	5.11±0.58	51.10±7.48^{c}	3.24±0.08	75.28±2.80	3.39±0.49	31.78±1.62

T_0 – Control, biscuits prepared from straight grade flour. Values in the same column marked with different letter differ significantly ($p < 0.05$).

Table 5. Sensory evaluation of biscuits prepared from wheat germplasm

Treatments	Colour	Flavour	Taste	Texture	Overall acceptability
T_0	6.42±1.7^{ab}	6.28±2.16	6.87±1.88	6.47±2.17^{ab}	6.94±1.70^{ab}
Line 3	6.94±0.9^{ab}	6.92±1.22	6.94±1.62	6.95±1.61^{ab}	7.15±1.51^{ab}
Akbar	5.98±1.3^{b}	6.08±1.88	5.991.83±	6.28±1.87^{ab}	6.18±1.83^{b}
W-85	6.64±1.75^{ab}	5.89±1.84	6.44±1.95	6.72±2.02^{ab}	6.78±1.93^{ab}
A-84	7.21±1.2^{ab}	7.18±1.65	7.18±1.35	7.06±1.66^{ab}	7.29±1.59^{ab}
B-7	6.31±1.5^{ab}	6.56±1.87	6.19±1.69	5.92±2.0^{b}	6.17±1.89^{b}
A-128	6.85±1.9^{ab}	6.18±1.93	6.17±178	6.67±1.91^{ab}	6.85±1.88^{ab}
Line 2	6.93±1.3^{ab}	7.13±1.71	7.01±1.42	6.81±1.69^{ab}	7.24±1.61^{ab}
Zincol	7.11±1.3^{ab}	7.00±1.33	7.28±1.35	7.25±1.6^{b}	7.39±1.46^{ab}
A-21	7.68±0.8^{a}	7.15±1.05	7.47±1.06	7.91±1.1^{a}	8.05±1.16^{ab}
B-8	6.13±1.6^{ab}	6.23±1.91	6.25±1.96	5.86±2.0^{b}	5.89±1.91^{b}

Explanation as in Table 4.

contents in the wheat flour *i.e.*, lower values of hardness were due to lower bran contents, while high bran contents may give rise to soft biscuits (Sozer *et al*., 2014).

3.5. Sensory evaluation of biscuits

The results of the sensory evaluation showed that biscuits prepared from various soft wheat germplasms differed non-significantly ($p > 0.05$) in terms of flavour and taste but significantly in terms of colour, texture, and overall acceptability (Table 5). The scores related to flavour and taste ranged from 5.89 to 7.18 and from 5.99 to 7.18, respectively. Likewise, the values for colour and texture ranged from 5.98 to 6.42 and from 5.86 to 7.25, respectively. However, in terms of overall acceptability, biscuits prepared from A-21 showed the highest score (8.05), while B-8 achieved the lowest score (5.89). Moreover, the colour of biscuits may vary due to Maillard reaction and water absorption from air (Gemede, 2023). Likewise, the fluctuation in the flavour, taste, and texture of biscuits may be due to the quality of wheat flour, wheat genotype, and water absorption, which cause oxidation of fat (Sharif *et al*., 2003; Saeed *et al*., 2012). Furthermore, gradual changes in the overall acceptability of biscuits might be due to moisture absorption, free fatty acids, and peroxide value (Sharif *et al*., 2003; Lou *et al*., 2021).

4. CONCLUSIONS

It was concluded that thousand kernel weight is an important parameter for millers. A-21 had the highest value of thousand kernel weight (44.50±1.76), which showed suitability of the germplasm for high yield of straight grade flour. Under these observations, germplasms Line 3, Akbar, A-84, and B-8 should be considered as soft wheat, whereas others are considered hard wheat germplasms. Protein and gluten showed a strong relationship with the rheology and texture of the product. High protein wheat gave strong dough extensibility, which was suitable to obtain a high bread loaf. Wheat with low protein content gave low dough resistance to achieve the desired diameter and texture of biscuits. In terms of farinographic analysis, water absorption showed a positive relationship with protein and gluten in the wheat flour. High water absorption (W-85=61.1±3.24) value in wheat is not suitable for biscuit preparation, as high water absorption was related to low peak viscosity, breakdown viscosity, and dough development time. The hardness of biscuits prepared from different wheat germplasms showed non-significant results, which indicated the absence of variation. The results of physical and compositional product analyses and sensory evaluation showed that low-protein wheat flour gave good results regarding biscuit texture without any treatment necessary for lowering the gluten quantity.

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