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Preparation of Protein and Mineral Enriched Chapatti Using Hybrid Wheat, Chickpea and Barley

Sadaf Yaqoob[a]*, Shabbir Ahmad[a], Ambreen Naz[b], Muhammad Adil Rehman[c], Muhammad Siddique Raza[d], Kashif Razzaq[e] and Zulfiqar Ali[fg]

[a]Department of Food Science and Technology, MNS-University of Agriculture, Multan, Pakistan
[b]Department of Home Science, MNS-University of Agriculture, Multan, Pakistan
[c]Department of Food Science and Technology, The Islamia University of Bahawalpur, Punjab, Pakistan
[d]National Institute of Food Science and Technology, University of Agriculture, Faisalabad, Pakistan
[e]Department of Horticulture, MNS University of Agriculture, Multan, Pakistan
[f]Institute of Plant Breeding and Biotechnology, MNS University of Agriculture, Multan, Pakistan
[g]Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan

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Abstract. Nutritional profile of chapatti increased using other cereals and pulses. Hybrid wheat grown by crossing wheat varieties having high content of protein, Fe and Zn and used in combination with barley and chickpea. Therefore, current research was designed to check the effect of hybrid wheat on quality of chapatti in combination with chickpea and barley. So, different genotypes of hybrid wheat and one variety of barley and chickpea each were analyzed to assess physico-chemical properties, afterwards, hybrid wheat varieties milled into flour and mixed with barley and chickpea flour to prepare composite flour and to prepare chapatti at the end. Results showed TKW colour and protein contents ranged from 32.2-54.9 g, 15.3 to 20.4 and 10.55 to 19.50% respectively in hybrid wheats. NIR analysis revealed hardness of wheat genotypes varied from 66.34 to 86.9. Hybrid wheat varieties showed 2 to 6 min DDT and 24.7 to 38.3% wet glutin. In product, protein (18.79%), Fe (9.94 mg/100 g) and Zn (10.68 mg/100 g) of composite flour chapatti increased with the addition of chickpea and barley flour in hybrid wheat flour. Sensorial parameters changed non-significantly, while in case of taste and chewing ability C_1, C_2 and C_4, C_5 showed better results than other compositions. Based on nutritional attributes and sensorial characteristics it is concluded that chickpea and barley were used at 25% and 15% in composite flour along with hybrid wheat varieties like B8, AR5 × PBICR#16 and AR7-4 × 29IBWSN-245.

Keywords: hybrid wheat, nutrition improvement, rheology of flour, staple diet (chapatti), sensory evaluation

Introduction

Cereals are edible grains belong to the family, Gramineae. In different countries different kind of cereals are grown such as wheat (*Triticum aestivum)*, rice (*Oryza sativa*), corn (*Zea mays*), barley (*Hordeum vulgare*), oat (*Avena sativa*), millet (*Pennisetum glaucum*) and triticale (×*Triticosecale*). In Pakistan production of cereal is increasing day by day and in 2020 cereal production was almost 9.3 million tonnes (FAO, 2020). Among cereals, wheat (*Triticum aestivum* L.) shared a considerable proportion in total cereal production of the world. Production of wheat in Pakistan is 27.9 metric tonnes (GOP, 2022). Whole wheat grainis composed of 2-3% germ, 80-85% endosperm and 13-17% bran. Wheat grains contain moisture content (11-12%), carbohydrate (65-85%), protein (8-10%), ash and fat (2.10%), considerable content of the vitamin-B is also present in wheat. In Pakistan, wheat is consumed in the form of leavened and un-leavened bakery products (Kumar *et al*., 2011). Major portion of wheat flour (80%) is used in the form of chapatti (local name of the un-leavened flat bread) and 20% is consumed in the form of cookies, pastries, bread and cakes (leavened bakery products) (Ahmad *et al*., 2017).

Chapatti, an un-leavened bread consumed as a staple food in the Indian subcontinent and in the middle east. Nutritional value of the chapatti can be increased by using of composite flour technique to fulfill the nutritional requirements of the different peoples. A healthy human being needs 50 g protein, 18 mg/100 g iron and 08 mg/100 g zinc on daily basis. Lactating mothers need more protein, Fe and Zn than others *i.e.* 65 g protein, 24 mg/100 g iron and 12 mg/100 g zinc on daily basis (Ares Segura *et al*., 2016). Only wheat flour chapatti cannot fulfill the nutritional requirement

*Author for correspondence; E-mail: sadafch169@gmail.com

of people especially pregnant and lactating women and they must use different kind of medicines to fulfill their nutritional requirement. Few women cannot afford these medicines because they belong to poor family. So, the purpose of this study was to prepare flat bread with the blend of flour of different cereals, pulses and legumes like oat, millet, barley, lentils, chickpea, and grams to meet the requirements of these women.

Among the cereals, barley (*Hordeum vulgare* L.), known as groat originated from the Ethiopia and western Asia is a promising option. Barley contains 56 to 67% starch, 8.2 to 14.5% protein, 3 to 4% lipid and 2 to 3% ash and 6.32 to 93.7 mg/Kg iron and 16.8 to 30.3 mg/Kg zinc respectively (Guo *et al*., 2020). Barley grains have higher amount of the dietary fibers, low energy and higher quantity of minerals and vitamins than wheat. From pulses, chickpea (*Cicer arietinum* L.), also called Bengal gram or Garbanzo bean, is an old pulse. Chickpea contains 41-50% starch, 12.4-31.5% protein and 6% fat (Hirdyani, 2014). Content of iron and zinc in chickpea is 3.0 to 14.3 mg/100 g and 2.2 to 20 mg/100 g, respectively. Chickpea can also be used in combination with wheat to prepare nutritious bakery products as it contains higher amount of protein, iron and zinc (Ray *et al*., 2014).

Keeping in view the nutritional requirement of people especially lactating, pregnant women and to diversify the staple diet *i.e*., chapatti, current study was designed to prepare chapatti from flour of hybrid wheat, barley and chickpea.

Materials and Methods

Current research was conducted in Laboratories of Department of Food Science and Technology, central lab system of MNS-University of Agriculture Multan and in the Laboratory of Ghosia Flour Mill Lahore, Pakistan.

Procurement of materials. Hybrid wheat, husk-less barley and chickpea samples were obtained from Institute of Plant Breeding and Biotechnology, MNS-University of Agriculture Multan. Chemical and reagents were procured from Sigma-Aldrich Pvt. Ltd. (Castle Hill, Australia) and Merck-Millipore Pvt. Ltd., (Darmstadt, Germany).

Physio-chemical analysis of raw materials. Thousand kernel weight (TKW) of hybrid wheat was measured by taking weight of thousand grains (Ahmad *et al*., 2017) and colour of hybrid wheat grains was analyzed by using chromameter (Adams *et al*., 2013). For TKW weight of thousand grains was noted while for colour analysis bunch of grains placed under the lens of the chromameter. Compositional analysis like moisture (method No. 44-15 A), protein (method No. 46-10), fat (method No.30-10), fibre (method No. 32-10), ash (method No. 08-01) of hybrid wheat, barley and chickpea flour were analyzed according to the methods described in AACC (2000). To determine the moisture content of the raw material, 3 to 5 g sample was placed in the hot air oven at 100±5 °C for 24 h and weight loss was calculated. Moisture free sample (5-10 g) taken in a thimble, placed in Soxhlet apparatus to extract fat from sample using petroleum ether as a solvent. Weight loss before and after placing in Soxhlet apparatus noted to calculate fat content. Moisture and fat free sample (2-3 g) was digested in 1.25% (250 mL) H_2SO_4 solution for 30 min, and residues collected after filtration and digested in 1.25% (250 mL) NaOH solution for 30 min. Residues collected after filtration, placed in muffle furnace at 550-650 °C for 5 to 6 h, fibre content was measured by taking weight loss in ignition. For ash determination sample (1-2 g) charred on flame and placed in muffle furnace at 550-650 °C for 5 to 6 h. Weight of residues after ignition in muffle furnace noted as ash content. To find the protein content, sample (1-2 g) digested in 30 mL H_2SO_4 along with digestion tablets in digester. Digested sample, diluted upto 250 mL using distilled water and 10 mL aliquot distilled in the presence of 40% NaOH (15 mL) and water (15 mL) using distillation apparatus. Distilled sample collected in 10 mL (4%) boric acid solution and titrated it against 0.1N H_2SO_4. Protein content calculated by following equation.

$$N\% = \frac{0.0014 \times \text{vol. of } 0.1N\ H_2SO_4 \text{ used} \times 250}{10 \times \text{weight of sample}} \times 100$$

$$\text{Protein } \% = (N\% \times 5.75)$$

For mineral (iron and zinc) contents of Hybrid wheat, barley and chickpea sample (1 g) was digested in HNO_3:$HClO_4$ (7:3) and diluted with distilled water (100 mL). Diluted digested samples were run on atomic absorption spectrophotometer for measuring Fe and Zn contents (AOAC, 2016). To measure wet and dry gluten content of hybrid wheat analyzed by washing the hybrid wheat dough under tap water until starches and dissolved pentosans removed and weight of viscoelastic material is termed as wet gluten. Viscoelastic material after washing was placed in hot air oven @ 100 °C for 24 h and termed as dry gluten (AACC, 2000).

Preparation of composite flour. Hybrid wheat verities, barley and chickpea was milled by Quadrumate senior mill (C.W. Brabender, Duisburg, Germany after cleaning at 12-13% moisture level (AACC, 2000). Then Hybrid wheat flour, chickpea flour and barley flour mixed in different ration like 60%, 25% and 15% respectively. Prepared composite flour was placed in airtight bags for further analysis and chapatti preparation.

Compositional analysis of composite flour. Moisture, protein (method 46-10), fibre (standard method No 32-10), ash (method No 08-01) and fat content (method number 30-25) of composite flour was measured by following the methods that are described in AACC (2000). Wet and dry gluten content of composite flour was determined according to the methods that are described in AACC (2000). Mineral (Iron and zinc) content was measured by following the guidelines that were explained in AOAC (2016). Procedures explained earlier in the section Physiochemical analysis of raw materials.

Rheology of composite flour. Rheology of composite flour was determined using E-Farinograph-TS according to the methods that are described in method 54-21 of AACC (2000). Farinograph measures water absorption (water required to run graph on 500BU), dough development time (time taken by the graph to touch the 500BU line), dough stability (time difference between the point from where graph reached 500BU and to point from where graph left the 500BU line) and dough weakening (difference in BU of curve from peak of graph to 12 min after the peak point). For determination of rheology of composite flour, weight of flour based on 14% moisture (300 g bowl) was taken in farinograph and water was added in it up till graph touched the 500BU line.

Preparation of chapatti. Composite flour chapatti was prepared by following the guidelines that was described by (Nasir *et al*., 2021). For chapatti preparation 250 g composite flour mixed with 75 mL water and 2 g salt. Then kneading of dough was done for 4-6 min. When the dough attained required consistency then it was placed for 30-40 min at room temperature. Afterwards, 120 g dough was taken, rolled and rounded by using the specific platform for preparation a desirable shape and thickness of chapatti. Thickness of chapatti was 2mm and diameter of chapatti was 15cm. At the end, chapatti was baked at the temperature of 210 °C on the preheated iron plate (griddle) for 60 to 80 sec 1-3 min from both sides. When chapatti was completely baked then it was placed in the wooden box and cooled for about 5 min. Then chapatti was stored in that box for further analysis.

Nutritional analysis of chapatti. Nutritional analysis of chapatti *i.e*., moisture (method No. 44-15 A), fat (method No.30-10), ash (process No. 08-01), protein (method No. 46-10) and fibre (method No. 32-10) were analyzed according to standard procedures described in AACC (2000). To measure the iron and zinc content of chapatti prepared from composite flour wet digestion method was used as per the detailed procedure explained in AOAC (2016).

Texture (hardness) of chapatti. Texture analyzer (TAXT Plus, Stable Micro Systems, UK) used to measure textural hardness of chapatti using needle probe. Needle probe was inserted into 5 to 10 g chapati sample (3 to 4 folds) at 2 mm/s speed. It was allowed to enter needle 10 mm deep in a sample and textural hardness of chapatti was expressed in grams (Shaikh *et al*., 2007).

Colour evaluation of chapatti. Colour analysis of all chapatti samples were made by using Chroma meter CR-400 Konica Minolta Sensing Singapore, as per the procedure described by Shaikh *et al*. (2007).

Sensory evaluation of chapatti. Sensorial attributes of chapatti prepared from composite flour was assessed using twenty panelists (untrained) from the MNS-University of Agriculture Multan including students and teachers. Sensory evaluation was done the basis of hedonic scale that ranging from 9 (extremely like) to 1 (dislike extremely) as per the guidelines explained by Lawless and Heymann (2010). Chapatti was evaluated for colour, aroma, pliability, mouth feel, texture, taste and overall acceptability.

Statistical analysis. All the experiments were conducted in triplicate and resultant data were statistically analyzed using statistix 8.1. Statistical technique (mean ± standard deviation) was applied on the data obtained from analysis of raw material. One way ANOVA under CRD was used to determined significant difference among treatments used in composite flour and chapatti preparation (Montgomery, 2017).

Results and Discussion

Physical parameters of hybrid wheat. Mean values of TKW (thousand kernel weight) of twenty hybrid wheat genotypes given in Table 1 revealed that TKW values of hybrid wheat varied between 32.2 to 54.9 g. In these analyses higher value seen in variety AR7-4 × 29IBWSN-245 (54.9 g) and lowest value seen in variety A13 (32.2 g). Results of current study resemble with the results of Khan *et al*. (2015) who calculated that thousand kernel weight in wheat varieties are ranged from 42.3 to 52.1 g and 35.0 to 49.95 g respectively. On the other hand, colour values of hybrid wheat genotypes were found as 53.1±2.8 (l*) in B8, 7.2±0.388 (a*) in A13 and 20.4±1.059 (b*) in AR5 × PBICR#16. Current results are in agreement with the study of Wrigley *et al*. (2015) who noted color range of wheat grains as 87.8 to 87.4 (l*), 2.8 to 3.0 (a*), 28.7 to 30.6 (b*) respectively. Variation in physico-chemical parameters is due to hybrid varieties, growing and environmental conditions.

Compositional analysis of hybrid wheat, barley and chickpea flour. Moisture, ash, fat, protein, fibre and NFE (nitrogen free extract) of hybrid wheat flour were 9.71±0.532 (%), 1.99±0.100 (%), 1.98±0.089 (%), 16.37±0.77 (%), 2.2±0.1 (%) and 74.107±0.370 (%) presented in Table 1. Present measures are in agreement with the findings of (Iqbal *et al*., 2015; Mueen-ud-din,

Table 1. Mean ± S.D. of physico-chemical analysis of various hybrid wheat varieties

Variety	TKW (g)	Colour (l*)	Colour (a*)	Colour (b*)	Moisture	Fat	Protein	Crude fibre	Ash	NFE
A13	32.2±1.576	44.3±2.1	7.2±0.388	18.8±0.0881	9.51±0.520	1.58±0.086	11.66±0.61	1.92±0.078	1.91±0.090	3.46±0.367
A23	47.6±2.522	42.6±2.3	6.2±0.334	16.4±0.771	9.01±0.493	1.45±0.075	14.27±0.70	1.78±0.095	1.94±0.091	71.58±0.357
A84	46.3±2.361	48.6±2.3	6.8±0.368	18.7±0.877	8.51±0.469	1.91±0.103	12.09±0.57	1.91±0.097	1.93±0.098	73.63±0.368
Akbar	46.9±2.346	51.7±2.7	5.3±0.288	19.2±0.904	8.51±0.465	1.57±0.084	12.00±0.62	1.87±0.099	1.98±0.097	74.11±0.370
AR1-6 × Galaxy-13	50.0±2.502	46.3±2.2	5.6±0.298	17.7±0.954	9.71±0.535	1.91±0.105	11.96±0.56	1.96±0.089	1.68±0.089	72.75±0.363
AR5 × PBICR#16	48.5±2.424	36.1±1.8	6.6±0.325	15.4±0.741	9.71±0.532	1.89±0.088	13.07±0.65	1.89±0.085	1.01±0.054	72.46±0.362
AR5 × PBICR#16	48.0±2.546	48.7±2.4	6.1±0.297	20.4±1.059	9.71±0.533	1.47±0.074	11.38±0.60	1.97±0.099	1.96±0.092	73.52±0.367
AR5 × PBICR#16	42.9±2.186	45.6±2.1	6.2±0.330	17.7±0.831	9.41±0.516	1.67±0.083	16.37±0.77	2.2±0.089	1.99±0.100	68.38±0.341
AR5 × Suntop	41.2±2.142	45.7±2.3	6.1±0.286	18.4±0.862	8.91±0.490	1.88±0.092	12.64±0.63	1.85±0.097	1.96±0.092	72.76±0.363
AR7-4 × 29IBW SN-245	42.9±2.274	48.6±2.3	5.1±0.230	17.9±0.930	9.11±0.501	1.5±0.825	12.37±0.61	1.98±0.088	1.95±0.103	73.09±0.365
AR7-4 × 29IBW SN-245	54.9±2.908	36.1±1.7	6.8±0.354	15.3±0.717	9.01±0.492	1.78±0.087	15.00±0.78	1.95±0.096	1.89±0.089	70.42±0.352
AR7-4 × 79: zwb14	34.4±1.823	46.5±2.5	5.83±0.309	17.8±0.941	8.98±0.493	1.98±0.089	11.72±0.59	2±0.095	1.75±0.082	73.56±0.367
B8	35.6±1.887	53.1±2.8	5.9±0.320	19.0±0.892	8.51±0.469	1.69±0.077	15.32±0.72	1.79±0.086	1.84±0.090	70.83±0.354
Bhakar-Star	43.5±2.177	48.7±2.3	5.6±0.304	17.0±0.797	8.21±0.453	1.72±0.092	12.93±0.69	1.93±0.087	1.9±0.099	73.28±0.366
Galaxy-13	39.7±1.945	42.8±2.0	5.9±0.320	18.9±0.890	9.61±0.525	1.79±0.096	12.77±0.64	1.9±0.098	1.1±0.052	72.88±0.364
Line 2	38.2±2.027	51.4±2.6	6.6±0.354	20.0±0.939	8.31±0.456	2±0.108	11.87±0.58	1.94±0.099	1.89±0.095	73.99±0.369
R26 3-1 × Zincol	38.5±1.808	46.6±2.2	5.4±0.269	17.8±0.799	7.41±0.407	1.87±0.095	12.38±0.58	2.1±0.098	1.88±0.098	74.36±0.371
R26 3-1 × Zincol	40.6±1.950	46.7±2.3	6.0±0.326	18.3±0.858	8.41±0.464	1.56±0.074	10.72±0.50	1.83±0.096	1.8±0.085	75.65±0.378
Suntop	32.9±1.743	44.8±2.1	6.0±0.321	17.3±0.815	6.91±0.381	1.66±0.089	10.55±0.55	1.8±0.094	1.95±0.096	77.11±0.385
Zincol	49.1±2.604	43.7±2.3	6.4±0.346	17.7±0.830	8.31±0.457	1.83±0.098	11.36±0.56	1.88±0.092	1.05±0.056	75.56±0.377
Barley	-	-	-	-	11.09±0.543	1.67±0.082	16.4±0.804	4.45±0.218	1.05±0.051	65.34±3.254
Chickpea	-	-	-	-	6.96±0.362	4.56±0.237	19.5±1.014	5.09±0.265	2.05±0.106	61.84±2.145

2009; Ikhtiar and Alam, 2007) who reported 8.3 to 9.6% moisture, 12.10 to 16.57% protein, 1.58-2.1% ash, 1.95% to 2.96% fat and 0.40- 2.14% fibre in different wheat verities. On the other hand, moisture, ash, fat, protein and fibre content of barley flour were 11.09± 0.543 (%), 1.05±0.051 (%), 1.67±0.082 (%), 16.4±0.804 (%), 4.45±0.218 (%) respectively, while for chickpea flour values were 6.96±0.362 (%), 2.05±0.101 (%), 4.56±0.237 (%), 19.5±1.014 (%) and 5.09±0.265 (%) respectively. Current findings of barley moisture (10.7 to 11.1%), protein (12.8-13.01%), ash (2.05-2.40%), fat (1.65 to 3.35%) and fibre (4.98 to 5.09%) are similar with the values reported by Obadi *et al*. (2021) and Collar and Angioloni (2014) who mentioned barley moisture, protein, ash, fat and fibre in the range of 10.7 to 11.1%, 13.66 to 11.60% , 2.05 to 2.40%, 1.5 to 1.95% and 2.68 to 2.96% respectively. Results of protein, ash, fibre and fat content of chickpea resembled with the study of (Raza *et al*., 2019; Xu *et al*., 2014) who reported moisture, protein, ash, fat and fibre content in chickpea as 10.35 to 10.48%, 23.1 to 23.64%, 2.67 to 3.40%, 1.65 to 3.35% and 5.9 to 6.7% respectively. Variation in compositional analysis of raw material (hybrid wheat, barley and chickpea) form the previous findings might be due to the variation in climate, genetic makeup and growing practices.

Mineral analysis of hybrid wheat, barley and chickpea. Iron content in hybrid wheat genotypes, barley and chickpea was noted as 3.39 to 15.34 mg/100 g, 6.8 to 7.2 mg/100 g and 13.11 to 14.01 mg/100 g respectively (Table 3). On the other hand, zinc content in hybrid wheat genotypes, barley and chickpea was calculated 5.58 to 10.92 mg/100 g, 7.62 to 8.05 mg/100 g and 8.65 to 8.88 mg/100 g respectively (Table 3). Results of analysis of current study are in favour with the study of (Amjad *et al*., 2010; Mueen-ud-Din *et al*., 2009) who reported 44 mg/100 g of the content of iron and Zn content varies between 0.8 to 2.8 mg/100 g in wheat (variety AS, 2000) flour. The current results showed that hybrid wheat varieties have more Fe and Zn than common wheat varieties secondly per yield production of hybrid wheat is more than commo wheat varieties.

Wet and dry gluten content of hybrid wheat. In the current findings highest value of dry gluten content observed as 12.8% in AR5 × PBICR#16 and lowest value was observed as 8.3% in Suntop similarly lowest wet gluten content was noted in AR7-4 × 79: zwb14 as 24.7% and highest wet gluten content was noted in AR5 × PBICR#16 as 38.3%. The current results are in line with the findings of the Wrigley *et al*. (2015) who reported the dry and wet gluten content in the range of 9.5-10.3% and 20.9- 24.01% in different wheat varieties. Gluten contents play a role in deciding the usage of wheat in bakery products and hybrid wheat have having more then 10% dry gluten would use in bread preparation and its potential use in pasta would be figured out.

Rheological study of hybrid wheat flour. According to current study water absorption (%), dough development time (min), dough stability (min) and dough weakening (BU) of hybrid wheat was 55.3 to 59.4%, 0.5 to 4.1 min, 2.4 to 12.6 min and 85 to 160 BU respectively (Table 3). Result of current study are in agreement with the findings of Zhang *et al*. (2012) who found 53.9 to 72.5% water absorption in wheat varieties. Similarly, Mohammed *et al*. (2012) reported that dough development time of wheat verities varied between 0.5 to 4.1 min. Current results regarding dough weakening are in contradiction with the results of Amir *et al*. (2015) who found weakening of dough in different wheat varieties ranged as 46.67 to 141.67BU. Falling number and quality of protein of hybrid wheat vary the rheology of hybrid wheat flour than other wheat varieties. Hybrid wheat having more gluten resulted in high dough stability and less dough weakening. Stronger dough could tolerate extensive mixing process used in bread and pasta preparation.

Compositional analysis of composite flour. According to descriptive statistical analysis, mean values of moisture, protein, fat, ash and fibre content in composite flour ranged from 9.4 to 10.3%, 13.16 to 18.79%, 2.39 to 2.52%, 1.56 to 2.17% and 3.01 to 3.26% respectively (Table 4). Current findings of moisture, protein, fat, ash and fibre contents in composite flour resembled with the findings of Pande *et al*. (2017) who found that moisture, protein, fat, ash and fibre content in composite flour (wheat, maize, barley, sorghum, Amaranthus, Bengal gram, Horse gram, soybean, finger millet and pearl millet flour) as 9.02 to 9.35%, 13.44 to 14.83%, 1.75 to 2.85%, 1.28 to 1.79% and 1.78 to 2.25% respectively. An increase in protein content in composite flour is due to the use of chickpea flour and hybrid wheat flour. Inclusion of chickpea and barley resulted in high protein of composite flour regardless the partial removal of hybrid wheat flour (high in protein as compared to common wheat). Similarly, fiber content and ash content of composite flour increased that might be due to chickpea and barley. As for as mineral contents are concerned, current results revealed that Iron (Fe)

Table 2. Compositional analysis (mean ± S.D.) of hybrid wheat varieties assessed through NIR

Variety name	Moisture (%)	Protein (%)	Wet gluten (%)	Dry gluten (%)	Zeleny	Starch	Hardness
A13	9.2±0.506	12.67±0.65	33.09±1.555	11.69±0.619	27.67±1.46651	64.89±3.179	77.6±4.112
A23	9.5±0.4655	15.6±0.81	35.34±1.660	11.75±0.622	26.31±1.39443	65.89±3.228	76.3±4.043
A84	8.9±0.4361	12.45±0.64	35.81±1.683	9.96±0.527	24.88±1.31864	64.4±3.155	79.1±4.192
Akbar	10.7±0.5243	11.34±0.58	34.76±1.633	11.76±0.623	31.5±1.6695	61.89±3.032	66.34±3.516
AR1-6 × Galaxy-13	11±0.583	11.9±0.61	32.89±1.545	8.59±0.455	29±1.537	63.47±3.110	73.9±3.916
AR5 × PBICR#16	8±0.392	13.22±0.68	33.54±1.576	8.63±0.457	27±1.431	63.8±3.126	81.45±4.316
AR5 × PBICR#16	8.7±0.4263	11.2±0.58	29.35±1.379	9.08±0.481	25.57±1.355	64.25±3.148	84.6±4.483
AR5 × PBICR#16	10.4±0.5096	11.6±0.60	34.22±1.608	8.6±0.455	26±1.378	59.87±2.933	70.4±3.731
AR5 × Suntop	10.6±0.5194	13.45±0.69	27.21±1.278	8.85±0.469	21±1.113	64.45±3.158	66.8±3.540
AR7-4 × 29IBWSN-245	9.8±0.4802	14.82±0.77	33.78±1.587	12.63±0.669	25±1.325	65.42±3.205	69.3±3.672
AR7-4 × 29IBWSN-245	11.3±0.5537	13.1±0.68	34.56±1.624	9.29±0.492	23±1.219	63.52±3.112	75.7±4.012
AR7-4 × 79:zwb14	10.9±0.5341	12.87±0.66	33.68±1.582	11.41±0.604	32±1.696	64.05±3.138	86.9±4.605
B8	8.2±0.4018	14.2±0.73	31.15±1.464	13.23±0.701	22±1.166	62.9±3.082	68.5±3.630
Bhakar-Star	10.1±0.5252	15.01±0.78	31.89±1.498	11.87±0.629	24.87±1.31811	59.45±2.913	75.5±4.001
Galaxy-13	10.4±0.5096	13.65±0.70	34.65±1.628	13.56±0.718	22.21±1.17713	63.08±3.090	76.1±4.033
Line 2	10.2±0.4998	14.56±0.75	36.81±1.730	11.1±0.588	28.67±1.51951	60.65±2.971	73.6±3.900
R26 3-1 × Zincol	10.2±0.4998	12.33±0.64	32.51±1.527	8.25±0.437	33±1.749	63.85±3.128	70.31±3.726
R26 3-1 × Zincol	10.1±0.4545	13.67±0.71	28.98±1.362	11.34±0.601	30±1.59	64.73±3.171	67.3±3.566
Suntop	10.3±0.5047	11.89±0.61	33.87±1.591	13.45±0.712	25.47±1.34991	60.54±2.966	84.3±4.467
Zincol	10.2±0.561	12.87±0.66	35.81±1.683	12.98±0.687	22.56±1.19568	65.11±3.190	69.9±3.704

Table 3. Rheological and mineral analysis of hybrid wheat varieties depicted as mean ± S.D

Variety name	Water absorption (%)	Dough development time (min)	Dough stability (min)	Dough weakening (BU)	Iron (mg/100 g)	Zinc (mg/100 g)	Wet gluten (%)	Dry gluten (%)
A13	57.3±2.865	3.5±0.168	5.5±0.2695	105±5.4600	3.39±0.179	6.960±0.327	27.3±14.280	9.13±0.426
A23	57.6±2.88	3±0.144	3.5±0.1715	98±5.0960	15.34±0.751	7.771±0.388	33.4±13.567	11.12±0.566
A84	58.6±2.93	6±0.288	9.5±0.4655	160±8.3200	7.70±0.408	6.568±0.327	28.3±16.497	9.43±0.461
Akbar	56.8±2.84	3.5±0.168	5.5±0.2695	125±6.5000	7.37±0.368	6.007±0.317	28.1±17.318	9.43±0.439
AR1-6 × Galaxy-13	58.4±2.92	2.5±0.12	6±0.294	99±5.1480	5.30±0.264	6.709±0.314	28.0±6.481	9.36±0.493
AR5 × PBICR#16	55.3±2.765	3±0.144	4.5±0.2205	96±4.9920	7.87±0.377	8.424±0.403	30.6±3.588	10.22±0.488
AR5 × PBICR#16	58.5±2.925	4±0.192	5.5±0.2695	133±6.9160	4.39±0.228	10.022±0.470	26.6±4.276	8.94±0.451
AR5 × PBICR#16	57.5±3.021	3.5±0.324	6.5±0.574	128±7.215	8.35±0.392	7.910±0.395	38.3±9.027	12.84±0.637
AR5 × Suntop	59.3±2.965	4±0.192	5±0.245	134±6.9680	6.24±0.311	7.602±0.357	29.6±10.447	9.93±0.502
AR7-4 × 29IBWSN-245	58.9±2.945	4±0.192	5.5±0.2695	87±4.5240	7.99±0.423	10.923±0.578	28.9±2.358	9.65±0.510
AR7-4 × 29IBWSN-245	56.6±2.83	2.5±0.12	6±0.294	92±4.7840	6.36±0.337	7.729±0.362	35.1±8.647	11.00±0.583
AR7-4 × 79:zwb14	55.7±2.785	2.5±0.12	5±0.245	88±4.5760	6.89±0.323	9.302±0.437	27.4±1.452	9.13±0.429
B8	56.5±2.825	5±0.24	7±0.343	141±7.3320	11.70±0.620	7.060±0.373	35.8±12.897	11.95±0.596
Bhakar-Star	55.8±2.79	4.5±0.216	6±0.294	143±7.4360	6.87±0.894	5.589±0.273	30.2±21.601	10.1±0.472
Galaxy-13	59.4±2.97	2.5±0.12	7.5±0.3675	86±4.4720	9.98±0.469	6.862±0.322	29.9±20.492	10.06±0.527
Line 2	56.4±2.82	2.5±0.12	16.5±0.8085	89±4.6280	4.74±0.222	6.325±0.303	27.8±15.387	9.34±0.444
R26 3-1 × Zincol	57.6±2.88	2±0.096	3±0.147	85±4.4200	6.02±0.294	8.668±0.458	28.9±5.475	9.64±0.510
R26 3-1 × Zincol	57.5±2.875	3±0.144	3.5±0.1715	131±6.8120	8.10±0.380	7.015±0.343	25.1±11.327	8.68±0.401
Suntop	56.7±2.835	5.5±0.264	3±0.147	123±6.3960	6.52±0.345	5.936±0.290	24.7±18.306	8.34±0.429
Zincol	56±2.8	4±0.192	11.5±0.5635	123±6.3960	12.50±0.625	6.486±0.336	26.6±19.407	8.94±0.442
Barley	-	-	-	-	6.8±0.333	7.62±0.374	-	-
Chickpea	-	-	-	-	13.11±0.681	8.65±0.450	-	-

Table 4. Rheological analysis of composite flour and composition analysis of composite flour and chapatti prepared from various concentrations of hybrid wheat, chickpea and barley (values were showed as mean ± S.D.)

Sample name	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
Composite flour								
Moisture (%)	10±0.52	10.1±0.494	10.2±0.530	9.8±0.509	9.7±0.475	9.4±0.488	10.3±0.463	10.1±0.505
Protein (%)	15.43±0.756^{cd}	13.16±0.644^{d}	15.72±0.770^{bc}	17.09±0.837^{abc}	18.79±0.920^{a}	16.8±0.823^{abc}	17.79±0.871^{ab}	7.09±0.837^{abc}
Fat (%)	2.4045±0.117	2.2905±0.112	2.4645±0.120	2.5125±0.123	2.5245±0.123	2.5185±0.123	2.4585±0.120	2.3925±0.117
Ash (%)	1.67±0.088^{bc}	1.49±0.067^{c}	2.17±0.097^{a}	1.56±0.078^{bc}	1.59±0.071^{bc}	1.67±0.075^{bc}	1.76±0.079^{b}	1.56±0.070^{bc}
Fiber (%)	3.014±0.156	3.128±0.147	3.08±0.139	3.2±0.1760	3.074±0.1598	3.05±0.153	3.11±0.162	3.26±0.173
Wet gluten (%)	21.48±1.15992^{a}	17.34±0.93636^{c}	17.94±0.96876^{c}	17.34±0.93636^{c}	18.36±0.99144b^{c}	17.76±0.95904^{c}	21.06±1.13724^{ab}	22.98±1.241
Dry gluten (%)	3.967±0.19436^{ab}	3.2±0.1568^{e}	3.33±0.15^{e}	3.2±0.1664^{e}	3.4±0.1802^{e}	3.3±0.1617^{e}	3.67±0.179^{bc}	4.27±0.209
Water absorption (%)	60.2±2.9498	56.4±2.7639	57.4±2.8126	59±2.891	64.9±3.1801	60.2±2.9498	61.3±3.0037	58.3±2.8567
Dough development time (min)	9±0.405^{b}	3±0.135^{f}	7.8±0.351^{c}	4±0.18^{e}	10±0.45^{a}	7±0.315^{cd}	2.5±0.1125^{f}	6.5±0.2925^{d}
Dough stability (min)	20±0.06b	6±0.318f	10.5±0.5565c	7±0.371ef	24±0.272a	9.5±0.5035cd	4±0.212g	8±0.424^{de}
Dough weakening time (BU)	185±8.88	89±4.2720	105±5.040	96±4.6080	197±9.456	98±4.704	82±3.9360	92±4.4160
Iron (mg/100 g)	9.945±0.527^{a}	7.719±0.409^{cd}	8.913±0.472^{ab}	6.537±0.346^{e}	7.647±0.405^{ced}	6.669±0.353^{de}	6.741±0.357^{de}	7.935±0.420^{bc}
Zinc (mg/100 g)	8.365±0.393^{b}	10.681±0.502^{a}	8.245±0.387^{b}	9.325±0.438^{b}	9.181±0.431^{b}	8.689±0.408^{b}	8.761±0.411^{b}	8.875±0.417^{b}
Chapatti								
Moisture (%)	35.51±1.456	34.25±1.576	33.58±1.478	33.41±1.637	32.87±1.413	35.78±1.467	34.19±1.573	33.38±1.469
Protein (%)	14.85±0.609^{bc}	12.91±0.594^{c}	15.41±0.678^{b}	16.54±0.810^{ab}	18.45±0.793^{a}	16.45±0.674^{ab}	17.65±0.812^{a}	16.78±0.738^{ab}
Fat (%)	2.35±0.026	2.24±0.085	2.37±0.085	2.32±0.096	2.37±0.103	2.41±0.065	2.27±0.075	2.32±0.103
Ash (%)	1.58±0.065^{a}	1.47±0.068^{ab}	1.48±0.065^{ab}	1.36±0.067^{b}	1.39±0.060^{b}	1.54±0.063^{ab}	1.61±0.074^{a}	1.47±0.065^{ab}
Fiber (%)	2.78±0.114	2.85±0.131	2.91±0.128	2.89±0.142	2.93±0.126	2.94±0.121	3.06±0.141	3.12±0.137
Colour (l*)	47.52±2.424	46.87±2.625	48.12±2.598	46.25±2.729	45.85±2.430	48.14±2.455	47.92±2.684	46.28±2.499
Colour (a*)	2.47±0.126^{c}	2.59±0.145^{bc}	2.74±0.148^{abc}	2.81±0.166^{abc}	2.64±0.140^{bc}	3.11±0.159^{a}	2.98±0.167^{ab}	2.87±0.155^{abc}
Colour (b*)	20.58±1.050	20.78±1.164	21.12±1.140	22.45±1.325	22.58±1.197	22.87±1.166	21.14±1.184	22.47±1.213
Iron (mg/100)	8.85±0.363^{a}	7.65±0.352^{bc}	8.54±0.376^{ab}	6.37±0.312^{d}	6.78±0.292^{cd}	5.94±0.244^{d}	6.68±0.307^{d}	7.79±0.343^{b}
Zinc (mg/100)	8.11±0.333^{c}	9.87±0.454^{a}	8.11±0.357^{c}	9.18±0.450^{abc}	9.27±0.399^{ab}	8.58±0.352^{bc}	8.71±0.401^{bc}	8.69±0.382^{bc}
Hardness	24.58±1.008^{g}	25.12±1.156^{g}	25.68±1.130^{g}	26.05±1.276^{g}	24.85±1.069^{g}	25.49±1.045^{g}	24.98±1.149^{gg}	25.36±1.116^{g}

$\mathbf{C_1}$ = 60% Hybrid wheat (B8)+ 25% chickpea+15% barley; $\mathbf{C_2}$ = 60% Hybrid wheat (BAR7-4 × 29IBWSN-245)+ 25% chickpea+15% barley; $\mathbf{C_3}$ = 60% Hybrid wheat (Galaxy-13)+ 25% chickpea+15% barley; $\mathbf{C_4}$ = 60% Hybrid wheat (R26 3-1 × Zincol) + 25% chickpea+15% barley; $\mathbf{C_5}$ = 60% Hybrid wheat (AR5 × PBICR#16)+ 25% chickpea+15% barley; $\mathbf{C_6}$ = 60% Hybrid wheat (AR5 × Suntop) + 25% chickpea+15% barley; $\mathbf{C_7}$ = 60% Hybrid wheat (AR7-4 × 29IBWSN-245)+ 25% chickpea+15% barley; $\mathbf{C_8}$ = 60% Hybrid wheat (AR5 × PBICR#16)+ 25% chickpea+15% barley; *Value sharing same letters in a row are non-significant to each other, while value sharing different letter in a row are significantly different to each other.

content of composite flour varied between 6.53 to 9.94 mg/100 g with highest value *i.e*., 9.945 mg/100 g was seen in C_1 and lowest value *i.e*., 6.53 mg/100 g was calculated in C_4 that can be verified from Table 4. Findings of current study are in contradiction with the findings of Pande *et al*. (2017) who found 3.71 to 4.5 mg/100 g iron and 2.71 to 3.89 mg/100 g zinc content in composite flours (wheat, maize, barley, sorghum, Amaranthus, Bengal gram, Horse gram, soybean, finger millet and pearl millet flour). Mainly Fe content was contributed by the hybrid wheat as per our focus Fe and Zn enriched hybrid wheat varieties were selected to prepare composite flour.

Gluten contents unveil clear understanding about texture of the dough and quality of the end bakery product (chapatti). According to current findings wet gluten content of composite flour ranged from 17.34 to 22.98% with highest value was calculated in C_8 as 22.98% and lowest value was in C_2 and C_4 as 17.34% as can be viewed in Table 4. On the other hand, dry gluten content of composite flour was calculated as 3.2 to 4.2%. Results of current findings are similar with the results of Amir *et al*. (2015) who found 22.64 to 32.72% wet gluten content in composite flour (Maize, Sorghum and wheat flour) but results of dry gluten are in contradiction with the findings of Amir *et al*. (2015) who calculated the 7.2 to 12.0% wet gluten content in composite flour. Apart from the higher gluten hybrid wheat varieties, gluten content of composite flour doesn't increase much, that might be due to power stretchability of protein (glutenin and gliadin). The gluten content is directly correlated to the grain protein, which is strongly influenced by the addition of chickpea and barley that lack gluten. Secondly, chickpea starch absorbs more water as compared to wheat flour components (starch and protein) hence play a vital role in hindering gluten development. Protein content highly influenced the gluten content of the flour. Climate and genotype are the main factors that greatly influenced the quality and quantity of gluten Violeta *et al*. (2010).

Rheology of composite flour. In this study water absorption, dough development time, dough stability and dough weakening of the composite flour noted as 56.4 to 64.9%, 2.5 to 10 min, 4 to 20 min and 82 to 197BU respectively (Table 4). Current findings are in line with the study of (Amir *et al*., 2015; Amjad *et al*., 2010) who found 58.7 to 66.0% (water absorption), 1.50 to 5.83 min (Dough Development time), 3.5 to 6 min (Dough stability) and 46.67 to 141.67 BU (Dough weakening) in composite flour of seven different wheat varieties. Variations in water absorption due to less gluten content in composite flour (Hybrid wheat, barley, and chickpea flour). Dough development time basically describe the quality of protein. A good protein quality flour takes more time in dough development as compared to weak protein quality flour. Variation in dough development time in this study might be due to quality difference of protein of composite flour Aydoðan *et al*. (2015).

Time of dough stability is an extensive behavior of the quality of gluten and protein content of flour. According to current study variations in dough stability time of composite flour dough are due to difference in cultivars and growing conditions. Genotype play a vital role in the stability time of dough Ji-chun *et al*. (2007).

Compositional analysis of chapatti. Chapatti prepared from composite flour analyzed to measure composition, colour, texture and sensory attributes. Mean values of total moisture of chapatti ranged from 32.87% to 35.51% with the high value seen in chapatti is prepared from flour of "C_2" and lowest content of moisture in "C_3". Mean values of protein contents chapatti (prepared from composite flour) varied between 12.91 to 18.45% with highest value was observed in "C_5" and lowest value in "C_2". Accordingly, fat content of chapatti (prepared from composite flour of hybrid wheat, barley and chickpea) ranged from 2.24 to 2.41%. Similarly, lowest value (1.36%) of ash content of chapatti and highest value (1.67%) was observed in chapatti C_4 and C_7 respectively. Likewise, highest value of fiber 3.12% was observed in C_8, while lowest value 2.78% in C_1 (Table 4).

Current finding of moisture, protein, fat, ash and fiber content of composite flour chapatti are in line with the study of (Tangariya *et al*., 2018; Cheng and Bhat, 2015) who calculated 25-32% moisture, 11.4-15.5% protein, 1.31-1.42% fat, 1.43-1.60% ash and 2.27-3.01% fibre in chapatti prepared from composite flour of jering (*Pithecellobium jiringa* Jack) legume and wheat. Protein content in composite flour chapatti was high than the chapatti of whole wheat flour but gluten quality is not better due to usage of pulse (chickpea) however, protein composition is better as protein of chickpea and barley are good source of lysine Pathania *et al*. (2017).

As for as mineral contents are concerned, higher content of iron seen in C_1 is 8.85 mg/100 g and lower content was observed in C_4 is 6.37 mg/100 g as shown in

Table 4. Present study results are in line with the research of Kadam *et al*. (2012) who reported 5.92-12.11 mg/100 g iron and 6.91 mg/100 g to 8.67 mg/100 g zinc content in composite flour (wheat, chickpea and soya bean flour) chapatti. The increase in mineral content of composite flour chapatti is due to incorporation of other grains flour like chickpea and barley. Hybrid wheat flour used in preparation of composite flour chapatti, has higher content iron and zinc than other wheat flour.

Colour (l*, a* and b* values) analysis of chapatti. Mean values of the color (l*, a* and b* values) of chapatti were ranged from 45.85-48.14%, 2.47-3.11% and 20.58-22.87% respectively. According to previous study l*, a* and b* values of chapatti were 41.29-62.61%, 3.45- 8.58% and 11.38-15.63% respectively (Cheng and Bhat, 2015). By increment in the baking time of dough, the temperature and browning process of the different kind of bakery products resulted reduction in l* and b* values of the final product and increase in a* value Lara *et al*. (2011). Variations in color can be due to maillard reaction (which occur in amino acids and reducing sugars during baking) affected by different composition of amino acids and reducing sugars. Variation in color value l* indicate the greater level of substitution in chapatti flour (Cheng and Bhat, 2015).

Textural hardness of Chapatti. Textural properties of chapatti determined through hardness using TAXT Plus instrument. The addition of barley and chickpea flour with in wheat flour, the hardness of chapatti increased. According to current study, mean values of textural hardness of chapatti were 24.58 g(C_1), 25.12 g(C_2), 25.68 g(C_3), 26.05 g(C_4), 24.85 g(C_5), 25.49 g(C_6), 24.98 g(C_7) and 25.36 g(C_8). Results of current study are in line with the results of Scheuer *et al*. (2016) who found 8.40 to 29.86 g texture hardness of chapatti. So, this study revealed that chapatti prepared from composite flour has better nutritional profile apart from texture which varies. Variation in textural hardness of chapatti was due to the addition of barley and chickpea flour. Lack of gluten strength due to addition of other flours and difference in amylose and amylopectin in starches of barley and chickpea plays an important role in disturbing/varying texture of chapatti. Secondly, these starches compete in water absorption with protein (albumin and globulin) and provide thick, pasty texture to the product.

Sensory analysis of chapatti. Sensory characterization plays an important role in making composition successful and sustainable. Mean value of colour observed was 6.90(C_1), 7.20(C_2), 7.10(C_3), 7.30(C_4), 7.00(C_5), 6.90(C_6), 7.30(C_7), 7.00(C_8) and mean values for taste of composite flour chapatti were 7.10, 6.90, 6.80, 6.80, 6.50, 6.60, 6.80 and 6.60 for C_1, C_2, C_3, C_4, C_5, C_6, C_7 and C_8 respectively. According to current study mean value of chewing ability ranged between 6.40 and 7.00. The highest value was calculated in C_4 and C_5 was 7.00 and lowest value was calculated in C_1 was 6.40. Likewise, mean values for flavour ranged from 6.50 to 7.20 and values for folding ability range from 6.60 to 7-10 in composite flour chapatti. Results of current studies agree with the previous studies on sensory analysis of chapatti (prepared from *Pithecellobium jiringa* Jack, legume and wheat). Those studies reported values for sensory characteristics as 3.33-5.47 (colour), 6.50-7.10 (taste), 3.02-8.27 (chewing ability), 7.17-7.97(flavour) and 7-10(folding ability) (Sharma *et al*., 2020; Cheng

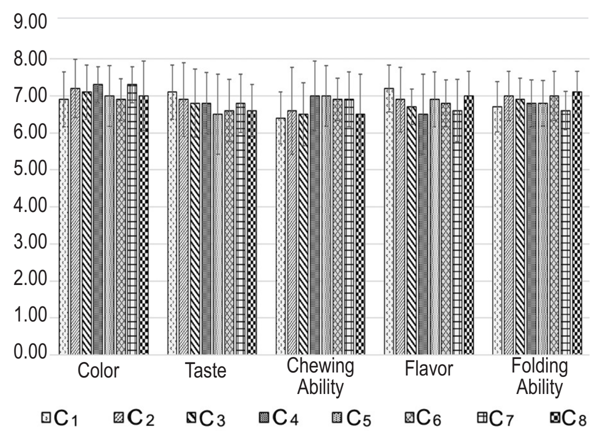

Fig. 1. Sensory characteristics of chapatti prepared from composite flour of hybrid wheat, chickpea and barley.
C_1 = 60% Hybrid wheat (B8)+ 25% chickpea+15% barley; **C_2** = 60% Hybrid wheat (BAR7-4 × 29IBWSN-245)+ 25% chickpea+15% barley; **C_3** = 60% Hybrid wheat (Galaxy-13)+ 25% chickpea+15% barley; **C_4** = 60% Hybrid wheat (R26 3-1 × Zincol) + 25% chickpea+15% barley; **C_5** = 60% Hybrid wheat (AR5 × PBICR#16)+ 25% chickpea+15% barley; **C_6** = 60% Hybrid wheat (AR5 × Suntop) + 25% chickpea +15% barley; **C_7** = 60% Hybrid wheat (AR7-4 × 29IBWSN-245)+ 25% chickpea+15% barley; **C_8** = 60% Hybrid wheat (AR5 × PBICR#16)+ 25% chickpea+15% barley.

and Bhat, 2015; Lara *et al*., 2011). Variations in chapatti sensory attributes are due to incorporation of barley and chickpea flour Inam *et al*. (2010). Current findings support the results of previous study of Bindra and Manju (2019) which found that overall sensory characteristics of chapatti affected due to Millard reaction. Cooking method and temperature also highly influenced the sensory properties and quality of chapatti. Main problem occurred during substitution of wheat flour with other flours are hard texture chapatti, darker in colour and decreased chewability. Purpose of hybrid wheat selection was to counter these problems to some extent as it has higher protein and results revealed that chapatti prepared from hybrid wheat produce good results as compared to chapatti prepared from normal wheat composite flour. It showed potential of hybrid wheat being used in chapatti preparation along with flour of chickpea and barley with minimum compromised on quality and good nutritional product.

Conclusion

Based on the findings of the research conducted, it is suggested to incorporate hybrid wheat varieties that are high in protein, iron and zinc into staple food preparations, along with 25% chickpea and 15% barley flour. Recommended hybrid wheat genotypes are "B8", "AR5 × PBICR#16" and "AR7-4 × 29IBWSN-245" are best to be used in chapatti preparation. according to nutritional analysis of composite flour chapatti, it can be concluded that C_7 and C_5 have higher protein content. Iron content is higher in C_1 and C_3 and content of zinc is higher in C_2 and C_5. According to sensory results C_2, C_1, C_4 and C8 show better results in case of Colour, taste, chewing ability, flavour and folding ability. According to results of textural hardness C_1 is better among all samples. Based on nutritional attributes and sensorial characteristics it is concluded that chickpea and barley were used at 25% and 15% in composite flour along with hybrid wheat. As for as hybrid wheat genotypes are concerned B8, AR5 × PBICR#16 and AR7-4 × 29IBWSN-245 are best to be used in chapatti preparation.

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Conflict of Interest. The authors declare that they have no conflict of interest.

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