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Research Article

Milling and Bread-Making Traits Associated with Grain Hardness in Ethiopian Bread Wheat Varieties Grown Under Bale Condition

Shure Soboka[1, *], Tilahun Bayissa[2], Wubishet Alemu[3]

[1]Oromia Agricultural Research Institute, Addis Ababa, Ethiopia
[2]Sinana Agricultural Research Center, Bale-Robe, Ethiopia
[3]Lions International Privet Limited Company, Addis Ababa, Ethiopa

Abstract

Many food processing industries utilizing bread wheat as a raw material are being established in the country. As a result, information on physico-chemical characteristics to match end use quality is very essential. In line with this, the current study was initiated with objectives to characterize physico-chemical properties in relation to bread making quality and to classify bread wheat cultivars as soft and hard wheat based on data generated. The grain of 44 Ethiopian improved bread wheat cultivars were collected from different agricultural research centers in the country and grown under rain fall condition at two locations (Ginnir and Sinana on station) during Bona (July-Jan., 2015/16 and 2016/17) growing season and analyzed for grain physical and flour chemical quality characteristics. The experiment was laid out in RCBD with three replications. Result of analysis of variance indicated that, there is significant variations in all quality parameters considered among cultivars. Grain physical characteristics, such as thousand kernel weight (TKW), percent vitreous kernel (%Vk), were showed highly significant difference ($P<0.01$) due to cultivars. Grain chemical quality as expressed by protein quantity (%P) and quality, percent gluten index (% Gl), Zeleny index (Zl), have also shown highly significant difference ($P<0.01$) due to genotypes. In addition, strong environmental variation was observed on measured quality characters. The present results indicated that there is huge genetic variation among Ethiopian wheat varieties for quality traits considered in this study.

Keywords

Milling Quality, Bread Wheat, Zeleny Index, Gluten

1. Introduction

Bread wheat (*Triticum aestivum* L.) is widely grown and the most important cereal crop used as staple food for about two billion people around the world [1]. In terms of per capital calories consumed, supply, and value of imports in Africa, wheat ranked number one among the crops [2]. Ethiopia is the leading wheat producer in the sub-Saharan Africa with a total production area of 1.79 million ha and total production of 5.34 million metric tones. In Ethiopia, wheat ranked fourth in total cultivated land area after teff, maize and sorghum and second both in total grain production and productivity after maize. Of

*Corresponding author: ibsasoboka2020@gmail.com (Shure Soboka)

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the current total wheat production area, 52.5% is located in Bale, Arsi and Shewa highlands [3]. Report by Central statistics authority of Ethiopian shows a slight increase in average wheat yield per hectare from year to year due to the use of improved seed, agronomic management and other pest protection practices. Since the introduction of wheat, more than 80 varieties of bread wheat have been released by different research centres from national as well as regional research institutes to search for widely adapted high-yielding and disease-resistant variety. As a result, more than 65 % of small holder as well as privet wheat farms were planted with improved cultivars.

The economic value of wheat is mainly determined by the class, which in part depends on composition of the grain. Physico-chemical properties of grain have a direct or indirect influence on the milling and baking qualities of wheat which mainly depends on genetic variation of the crop, its growing environment and management. The requirements of wheat grain quality are different for the major baked products such as bread, pastries and cookies and also within each of the types, are based on grain physical, flour chemical and dough rheological properties [4].

The physical characters include kernel hardness, vitreousness of kernel, thousand kernel weight and test weight. Higher vitreousness, indicates higher protein content, a harder kernel, coarser granulation, during milling higher yield of flour, superior product quality, and opportunity for premium price [5]. Test weight is known to be one of the simplest criteria used to determine the quality of grain and measure of grain bulk density. The higher the test weights the higher the quality, and the lower the test weight the lower it is. [6].

Thousand kernel weight is closely associated with test weight and is a good predictor of flour milling potential because it exhibits a strong linear relationship to the kernel weight. Generally considered as a guide to flour milling yield potential, test weight is a globally-used measurement of bulk density. It reflects the weight of kernels relative to their size and grain packing capacity [7].

Amount of wheat storage proteins as well as its quality is another most important chemical quality characteristics of bread wheat that influence bread-making property and strongly correlated with grain hardness [8]. Technologically, gluten is the most important wheat storage protein which changes with the total protein content, growing conditions and genetic disposition of variety and process of grain maturing [9]. The Zeleny sedimentation volume is also [10] used to obtain a semi-quantitative estimation of the amount and gluten strength and is the most rapid and reliable single small-scale tests and is mostly correlated to the protein content and the wheat hardness [11]. Hence, Zeleny sedimentation volume < 20 is property of wheat genotypes with low protein content, suitable for biscuit making 20-30 medium protein content, medium bread-making quality 30-40 high protein content, better bread-making quality > 40 very high protein content, very good bread-making quality.

Currently in Ethiopia, with the emerging and increase of agro-industries using wheat as a raw material, bread wheat with good quality grain for processing has become increasingly important. There is a high demand by both commercial and small-scale peasant farmers for wheat cultivars with higher grain yield and better end-use quality [4]. As a result, marketing of bread wheat is carried out as hard and soft bread wheat through physical observation of the grain to decide whether it is Vitreous or not even though wheat class breeding is not started yet. In terms of market value, hard bread wheat fetch more price than soft bread wheat class. On the other hand, quality reports are available for only few of the bread wheat cultivars released so far. Hence, it is important to characterize Ethiopian bread wheat varieties for their quality traits. Therefore, this study was initiated with the objective to identify Ethiopian bread wheat varieties with superior quality traits contributing to the bread making based on physico-chemical quality characteristics and classify those varieties as hard and soft wheat class based on quality traits [12].

2. Materials and Methods

2.1. Description of the Study Area and Experimental Design

This experiment was conducted at two districts of Bale Zone, Sinana district representing the highland areas while Ginnir district representing mid land areas. In the study, 44 (forty four) bread wheat varieties were collected from different research center and planted on the same plot of land during Bona (July-December) 2015/16 and 2016/17 cropping seasons under rain fed condition on plot area of 6 m^2 (6 rows with 0.2 m spacing between rows and 2.5 m length). Spacing between blocks and plots were 1.5 m and 1 m respectively. The experiment was laid out in RCBD with three replications. All agronomic and disease management practices were carried according to the recommendation of bread wheat at each location.

2.2. Data Collected

Agronomic data such as grain yield (GY) (kg ha^{-1}), and quality parameters including thousand kernel weight (TKW), Hectoliter weight (HLW), grain moisture content, grain protein content, percent gluten contents, Zylenel sedimentation volume and percent virtuousness kernel were determined at 12.5% moisture content based on standard protocols [7] using dockage free samples from each wheat variety. Vitreousness is considered to be related to the endosperm microstructure whereas hardness is suggested to influence the adhesion forces between starch granules and protein matrix [12].

2.3. Data Analysis

Statistical Analysis System (SAS) was used for the analysis of variance (ANOVA) using General Linear Model (GLM) procedure [13] SAS version 9.1. Mean separation was carried out using Least Significant Difference test (LSD) at P<0.05 and P<0.01 probability levels.

3. Results and Discussions

Statistically significant variation in all measured quality parameters (P≤0.01) was observed among Ethiopian bread wheat varieties grown under two districts of Bale. (Representative of both mid and highlands of Bale (Tables 1 and 2). Higher mean yield was recorded at Ginnir district as compared to that of Sinana. This is most probably due to the prevalence of conducive weather condition for wheat growth at Ginnir than at Sinana. The effect of growing environment on most of quality traits under this study was also observed particularly on grain vitrousness which accounts for about 97% at Ginnir and about 9.14% at Sinana on station. Thousand kernel weights has also shown significant variation at (P≤0.01) due to genotypic effect at both test locations. It varies from 48 g for variety Ogolcho to the smallest 32.57 g for the variety ET-13 at Ginnir whereas it varies from 46.79 g for variety Dinkinesh to 30.0 g for the variety Lakech at Sinana on station. Similar variation in Thousand kernel weight in bread wheat genotypes were reported by different authors in different bread wheat cultivars grown in different countries [14] in Pakistan, Ethiopia and Iran respectively. In general, the present study revealed existence of wide variation with respect to TKW among bread wheat varieties considered and this shows that there is huge possibility to exploit in improvement of this particular quality trait in breeding program. Similarly, [15] reported variability in bread wheat cultivars tested at Harameya and Kulumsa respectively with the values ranging from 33.2 g to 44.8 g. for the wheat genotypes tested at Haramaya and 32.0 g to 45.9 g for wheat genotypes tested at Kulumsa and hence these all reports are in agreement with the present study.

This significant difference (P <0.01) in TKW among wheat cultivars is mainly due to genetic variation. Thousand kernel weight is an important indicator for flour yield [16] and wheat cultivars can be classified according to their thousand grain weight as 15-25 g (very small), 26-35 g (small), 36-45 g (medium), 46-55 g (large) and over 55 g (very large) [17] (William *et al*., 1986). Accordingly, wheat cultivars in the current study fall in the range of medium to large grain weight category where 11% at Sinana and 16% of test varieties fall under small grain category at Ginnir.

Hectoliter weights is also another quality parameter which showed significant variation (P <0.01) due to test genotypes (Tables 1 and 2). Hectoliter weight (HLW) varied from 81.4 kg/hL for variety Galil to 86.40 kg/hL for variety Dinkinesh at Ginnir and 82.09 kg/hL for variety Dinkinesh to 89.27 kg/hL for variet Dinkinesh at Sinana on station. The hectoliter weight, which is dependents on both grain size and shape, is considered to be one of the most important physical criteria in all wheat grading systems. Flour yield and other quality parameters positively correlated with HLW. The results obtained in this experiment were in close agreement with the reports of [18] who reported that HLW of 130 hard red spring bread wheat grown at different locations of USA varied from 66.2 to 80.20 kg/hL, and 77.91 to 82.15 kg/hL- in 20 bread wheat cultivars of Ethiopia, respectively. It is also in consistent with the earlier findings of other researchers such as [19] who reported variations ranging from 68.30 to 81.00 kg/hl in different wheat varieties from different countries.

Protein is one of the primary quality components that influence most of wheat grain milling and baking quality characteristics. Protein quantity and quality determines wheat grain hardness, which intern determines its end use quality. Significant variation among the test cultivars was observed for grain protein content with the values ranging from 18.1% for variety K6295-4a to 13.37% for the variety Mekelle 04 at Sinana on station. Similarly, significant variation for grain protein content was 15.03% for variey Millinium to 11.23% for variety Kubsa at Ginnir district. The high protein percent at Sinana on station is most probably due to terminal water stress encountered which reduced starch accumulation. Gluten percent on the other hand varied from 35.30% to 24.47% at Ginnir and from 44.27% to 27.63% at Sinana on station. In the same way Zenly sedimentation volume which is an indicator of wheat flour gluten strength varies from 75 for variety Mararo to 52.10 for variety Dodota at Ginnir and 82 for variety Mararo to 55.27 for variety Kubsa at Sinana on station. Zeleny Index is a chemical parameter used in breeding and in rapid analysis to predict the overall baking quality of wheat. It is determined on the ground kernel or on the flour and it ranges from 0 to 80. Wheat having a Zeleny Index below 20 is generally regarded as unsuitable for baking. In general, the mean values of measured quality parameters are higher at Sinana on station as compared to Ginnir which indicate strong environmental influence in addition to genetic variation.

Table 1*. Results of wheat grain quality characters for the experiment at Ginnir in 2015/16.*

SN	Variet	BM t/ha	GY kg/ha	TKW	HLW	% Vit	Gluten	%MC	%PC	%Z I
1	Hidase	7.80	3160.73^{d-l}	44.47^{bc}	84.13 $^{b-j}$	98.73 ^{a}	29.03^{c-l}	10.50	12.60 $^{e-q}$	63.10^{b-m}
2	Shorima	7.67	3283.00 $^{c-j}$	41.50^{c-g}	84.40^{b-i}	98.67 ^{a}	31.00^{a-h}	10.30	13.00^{c-k}	65.73^{b-i}
3	UTIQUE	8.20	3372.40^{c-j}	39.17^{f-l}	84.80^{b-g}	98.61 ^{a}	31.70^{a-e}	10.60	13.37^{b-j}	65.20^{b-j}

SN	Variet	BM t/ha	GY kg/ha	TKW	HLW	% Vit	Gluten	%MC	%PC	%Z I
4	Bika	8.93	2946.53^{f-l}	40.10^{e-j}	84.13^{b-j}	97.80^{ab}	31.60^{a-f}	10.33	13.40^{b-i}	70.27^{abc}
5	Alidoro	8.33	3301.20^{c-j}	44.10^{bc}	83.67^{e-k}	96.85^{abc}	31.27^{a-g}	10.73	12.97^{c-m}	55.43^{k-p}
6	Enkoy	7.60	2805.80^{g-l}	34.63^{n-q}	83.87^{c-k}	95.07^{abc}	32.33^{a-d}	10.63	13.43^{b-h}	60.00^{f-p}
7	Dereselign	7.87	2913.53^{f-l}	39.90^{e-k}	82.67^{j-m}	96.33^{abc}	29.83^{c-j}	10.43	12.80^{d-0}	63.90^{b-k}
8	Tay	9.13	3904.47^{a-e}	36.60^{l-o}	82.53^{klm}	99.73^{a}	27.03^{f-m}	10.63	12.60^{e-q}	58.40^{h-p}
9	Milennium	8.47	2710.53^{h-l}	34.17^{opq}	82.13^{lm}	100.00^{a}	35.30^{a}	10.50	15.03^{a}	68.80^{a-e}
10	Sofumer	8.80	3588.40^{a-h}	42.87^{bcd}	85.47^{ab}	100.00^{a}	29.83^{c-j}	10.50	12.77^{d-p}	62.00^{c-n}
11	K6290-Bulk	7.60	2610.53^{i-l}	38.23^{h-m}	82.13^{lm}	99.67^{a}	34.53^{ab}	10.40	14.47^{abc}	71.63^{ab}
12	M. walabu	9.40	3458.33^{b-i}	44.33^{bc}	85.00^{a-e}	97.57^{abc}	27.23^{e-m}	10.93	12.57^{e-q}	58.00^{h-p}
13	Dashen	8.47	3155.00^{d-l}	39.93^{e-k}	83.47^{f-l}	98.18^{ab}	26.20^{i-m}	11.50	11.93^{h-q}	58.07^{h-p}
14	Mekelle-03	9.33	3847.13^{a-f}	40.43^{d-i}	83.20^{h-l}	98.20^{ab}	27.60^{e-m}	10.57	12.53^{e-q}	53.23^{op}
15	K6295-4a	7.80	2943.40^{f-l}	33.63^{pq}	84.27^{b-i}	99.00^{a}	33.10^{abc}	10.70	13.97^{a-e}	63.00^{c-m}
16	Ogolcho	10.80	4469.80^{a}	48.00^{a}	84.00^{b-k}	100.00^{a}	27.17^{e-m}	10.40	11.87^{j-q}	60.27^{e-p}
17	Hoggana	7.00	2514.20^{jkl}	38.67^{h-l}	83.60^{e-l}	99.20^{a}	29.63^{c-j}	10.50	12.70^{e-q}	60.40^{e-p}
18	Gambo	10.07	4333.40^{ab}	47.67^{a}	84.93^{a-f}	99.87^{a}	26.60^{h-m}	10.73	11.70^{l-q}	59.73^{f-p}
19	Digelu	8.93	2698.73^{h-l}	38.07^{h-m}	84.80^{b-g}	95.67^{abc}	25.80^{i-m}	10.90	11.83^{k-q}	54.43^{m-p}
20	Danda	10.20	3688.67^{a-g}	46.10^{ab}	83.33^{g-l}	97.33^{abc}	27.00^{g-m}	10.53	11.90^{i-q}	60.53^{e-p}
21	Gasay	9.53	3478.67^{b-i}	42.03^{c-f}	85.20^{a-d}	95.33^{abc}	26.27^{i-m}	10.40	11.43^{n-q}	57.03^{j-p}
22	Jaferson	9.40	3731.13^{a-g}	38.63^{h-l}	84.13^{b-j}	92.57^{c}	28.73^{c-l}	10.60	12.40^{f-q}	57.10^{j-p}
23	Kingbird	8.00	3591.20^{a-h}	39.00^{h-l}	84.27^{b-i}	98.40^{a}	27.07^{f-m}	10.67	12.27^{g-q}	59.30^{g-p}
24	PAVON-76	8.47	3577.80^{a-h}	37.53^{i-n}	84.40^{b-i}	99.33^{a}	29.30^{c-k}	10.57	11.73^{l-q}	62.10^{c-n}
25	Simba	8.27	3227.33^{c-k}	44.43^{bc}	84.13^{b-j}	100.00^{a}	30.97^{a-h}	10.63	13.30^{b-k}	68.27^{a-f}
26	Sirbo	8.07	2308.20^{kl}	35.00^{n-q}	84.67^{b-h}	100.00^{a}	32.40^{a-d}	11.43	13.83^{a-e}	69.57^{a-d}
27	Qulqulluu	8.33	2739.80^{h-l}	35.43^{m-q}	82.93^{i-m}	99.63^{a}	31.47^{a-g}	11.07	13.47^{b-g}	63.77^{b-k}
28	Hulluka	8.93	3293.87^{c-j}	37.40^{j-n}	83.87^{c-k}	77.33^{e}	25.33^{j-m}	10.80	11.50^{m-q}	53.77^{nop}
29	Dinkinesh	8.33	2955.33^{f-l}	42.80^{bcd}	81.47^{m}	100.00^{a}	32.30^{a-d}	10.63	14.23^{a-d}	67.23^{a-g}
30	Mandoyu	9.73	3619.80^{a-h}	37.50^{i-n}	84.67^{b-h}	95.33^{abc}	28.67^{c-f}	10.37	11.93^{h-q}	61.27^{d-o}
31	Sula	7.60	3213.53^{c-l}	39.90^{e-k}	85.20^{a-d}	99.00^{a}	30.20^{b-i}	10.40	12.87^{d-n}	66.33^{b-h}
32	ET-13	9.27	2330.47^{kl}	32.57^{q}	84.80^{b-g}	96.00^{abc}	24.53^{lm}	11.00	11.67^{l-q}	54.70^{l-p}
33	Meraro	9.20	2284.27^{l}	33.80^{pq}	84.80^{b-g}	100.00^{a}	34.70^{ab}	10.63	14.60^{ab}	75.00^{a}
34	Mekelle -01	9.00	4019.20^{a-e}	43.33^{bcd}	85.33^{abc}	100.00^{a}	31.13^{a-h}	10.50	13.10^{b-k}	67.93^{a-f}
35	Bobicho	8.53	3292.73^{c-j}	38.13^{h-m}	83.47^{f-l}	95.67^{abc}	27.97^{d-m}	10.50	12.47^{e-q}	58.80^{g-p}
36	Tossa	7.73	3240.67^{c-k}	37.37^{j-n}	85.20^{a-d}	100.00^{a}	29.70^{c-j}	10.70	12.63^{e-q}	62.83^{c-m}
37	Galil	8.33	3095.53^{e-l}	39.97^{e-k}	86.40^{a}	98.67^{a}	29.80^{c-j}	10.50	12.40^{f-q}	62.77^{c-m}
38	Kubsa	8.07	3331.40^{c-j}	37.07^{k-o}	83.73^{d-k}	86.00^{d}	23.73^{m}	10.57	11.23^{q}	52.43^{p}
39	Abola	8.40	3167.73^{d-l}	34.27^{opq}	84.80^{b-g}	95.33^{abc}	28.37^{d-l}	10.50	12.43^{f-q}	61.83^{c-o}
40	Lakech	6.60	2820.87^{g-l}	36.27^{l-o}	85.07^{a-e}	98.00^{ab}	29.73^{c-j}	10.53	12.63^{e-q}	62.87^{c-m}
41	Mekelle 04	8.87	3983.40^{a-e}	44.33^{bc}	84.13^{b-j}	96.33^{abc}	25.03^{klm}	10.53	11.33^{npq}	57.33^{i-p}

SN	Variet	BM t/ha	GY kg/ha	TKW	HLW	% Vit	Gluten	%MC	%PC	%Z I
42	Honkolo	8.93	4142.47^{abc}	40.90^{d-h}	85.20^{a-d}	100.00^{a}	28.83^{c-l}	10.77	12.27^{g-q}	62.33^{c-n}
43	Kakaba	8.60	4034.60^{a-d}	40.80^{d-h}	84.93^{a-f}	82.00^{de}	23.47^{m}	10.33	11.27^{pq}	53.33^{op}
44	Dodota	7.53	3144.13^{d-l}	38.13^{h-m}	84.27^{b-i}	93.33^{c}	27.70^{e-m}	10.77	12.37^{f-q}	52.1\0^{p}
	Mean	8.55	3280.23	39.53	84.17	96.93	29.12	10.63	12.65	61.41
	CV	3.24	17.55	4.67	1.09	3.19	9.73	2.72	7.33	8.63
	F test	**	**	**	**	**	**	**	**	**
	LSD	0.98	934.25	3.00	1.49	5.01	4.60	0.47	1.51	8.60

In hard wheat, variation in loaf volume of bread can be attributed directly to differences in protein concentration [20]. The differences in protein content among different wheat cultivars could be related to wheat genetic difference [4]. The results of the present study is in agreement with the results reported by Soboka *et al.* [4] who reported significant difference in grain protein contents among twenty three Ethiopian bread wheat cultivars grown under Arsi condition and with arrange of 7.7% to 13.2%. Besides, the results of the present studies also in agreement with the report of [21] who found variation for this trait ranging from 9.71% to 15.42% among different bread wheat varieties.

The result of gluten content is also in close agreement with the findings of [4] who found variation ranging from 15.6 to 39.3% in wet gluten content in different wheat varieties. Similar report was also obtained by [22] who reported wet gluten in the range 19.47 to 30.37% in different wheat varieties done in Islamabad, Pakistan. This variation in wet gluten among the wheat cultivars considered in the present study may be attributed to the differences in genotypes and the environmental conditions such as temperature and rainfall.

Table 2. *Results of wheat grain quality characters for the experiment at Sinana in 2015/16.*

SN	Variety	BM t/ha	Gy (kg/ha)	TKW	HLW	% Vit	Gluten	%MC	%P	ZI
1	Hidase	3.73^{b-f}	1593.17^{b-f}	44.13^{abc}	86.25^{a-i}	98.00	35.03^{i-q}	11.50^{a-f}	15.40^{e-m}	67.47^{e-n}
2	Shorima	3.47^{c-f}	1589.55^{b-f}	40.98^{b-h}	87.68^{a-f}	100.00	37.80^{b-k}	11.33^{c-f}	15.93^{b-k}	72.03^{c-i}
3	UTIQUE	5.50^{a-e}	2115.05^{a-e}	42.92^{a-d}	88.62^{abc}	98.33	37.83^{b-k}	11.27^{ef}	16.07^{b-i}	73.50^{b-g}
4	Bika	4.10^{b-f}	1488.01^{c-f}	39.78^{c-l}	87.96^{a-e}	100.00	40.43^{bc}	11.20^{ef}	16.93^{abc}	79.07^{abc}
5	Alidoro	5.33^{a-f}	1849.45^{b-f}	41.80^{a-f}	84.59^{c-j}	97.67	36.33^{e-o}	11.77^{a-d}	13.87^{no}	55.57st
6	Enkoy	5.60^{a-d}	2279.96^{a-d}	34.33^{m-q}	85.00^{c-j}	98.33	39.80^{b-f}	11.40^{b-f}	15.97^{b-j}	63.53^{l-s}
7	Dereselign	6.17^{ab}	2212.34^{a-d}	40.80^{b-i}	86.50^{a-i}	96.33	35.77^{g-q}	11.23^{ef}	15.47^{d-l}	65.43^{g-q}
8	Tay	5.93^{abc}	2785.19^{a}	40.96^{b-h}	85.09^{c-j}	99.67	34.83^{j-r}	11.37^{b-f}	15.43^{d-m}	65.33^{h-q}
9	Milennium	4.33^{b-f}	1953.09^{a-f}	35.49^{j-p}	83.15^{hij}	98.33	38.97^{b-i}	11.77^{a-d}	16.73^{b-e}	66.37^{f-q}
10	Sofumer	5.07^{a-f}	1699.92^{b-f}	42.10^{a-e}	84.30^{e-j}	99.67	34.23^{k-r}	11.90^{a}	14.93^{h-n}	63.93^{j-r}
11	K6290-Bulk	5.13^{a-f}	2038.79^{a-e}	38.69^{d-n}	83.82^{f-j}	99.67	39.60^{b-f}	11.50^{a-f}	16.77^{a-d}	71.67^{c-k}
12	M. walabu	5.07^{a-f}	1964.13^{a-f}	43.06^{a-d}	84.98^{c-j}	97.67	34.43^{k-r}	11.40^{b-f}	15.33^{f-m}	63.90^{j-r}
13	Dashen	7.06^{a}	2314.52^{abc}	38.68^{d-o}	86.53^{a-i}	98.33	32.60^{n-s}	11.40^{b-f}	14.73^{i-n}	65.83^{g-q}
14	Mekelle-03	4.60^{a-f}	2151.29^{a-d}	41.13^{b-g}	82.78^{ij}	96.67	33.77^{l-s}	11.80^{abc}	15.13^{h-n}	56.63^{rst}
15	K6295-4a	5.60^{a-d}	2061.06^{a-e}	33.42^{opq}	83.26^{g-j}	99.00	44.77^{a}	11.43^{a-f}	18.10^{a}	76.03^{a-d}
16	Ogolcho	4.83^{a-f}	2351.66^{abc}	42.62^{a-d}	85.98^{a-j}	93.33	34.70^{j-r}	11.50^{a-f}	15.30^{g-m}	69.03^{d-l}
17	Hoggana	4.47^{b-f}	1912.30^{b-f}	37.16^{e-o}	85.14^{b-j}	99.33	37.03^{b-l}	11.43^{a-f}	15.80^{b-k}	67.40^{e-n}

SN	Variety	BM t/ha	Gy (kg/ha)	TKW	HLW	% Vit	Gluten	%MC	%P	ZI
18	Gambo	5.73^{a-d}	1528.27^{c-f}	42.56^{a-d}	88.43^{a-d}	99.67	33.53^{l-s}	11.23^{ef}	14.90^{h-n}	67.13^{e-o}
19	Digelu	4.47^{b-f}	1102.97^{f}	34.51^{m-q}	86.71^{a-i}	99.67	32.40^{o-s}	11.67^{a-e}	14.63^{j-o}	58.77^{q-t}
20	Danda	5.50^{a-e}	1860.56^{b-f}	45.11^{ab}	86.06^{a-j}	100.00	32.70^{m-s}	11.43^{a-f}	14.80^{i-n}	63.67^{k-r}
21	Gasay	5.47^{a-e}	1703.56^{b-f}	38.08^{d-o}	87.88^{a-f}	98.67	33.80^{l-s}	11.40^{b-f}	14.60^{k-o}	65.47^{g-q}
22	Jaferson	4.77^{a-f}	1893.59^{b-f}	34.70^{l-q}	88.24^{a-e}	99.67	38.63^{b-j}	11.47^{a-f}	16.20^{b-h}	68.30^{d-m}
23	Kingbird	4.93^{a-f}	1820.69^{b-f}	35.88^{g-p}	84.85^{c-j}	98.67	36.60^{c-m}	11.53^{a-f}	15.87^{b-k}	67.90^{e-n}
24	PAVON-76	5.40^{a-e}	2451.27^{ab}	39.21^{c-m}	85.22^{a-j}	97.67	31.07^{rst}	11.83^{ab}	14.10^{mno}	60.03^{n-t}
25	Simba	4.47^{b-f}	1890.10^{b-f}	40.02^{b-k}	86.46^{a-i}	98.33	36.47^{d-n}	11.53^{a-f}	15.93^{b-k}	74.37^{a-f}
26	Sirbo	3.93^{b-f}	1267.46^{ef}	35.62^{i-p}	89.27^{a}	99.00	40.63^{b}	11.33^{c-f}	16.97^{ab}	81.13^{ab}
27	Qulqulluu	4.60^{a-f}	1755.64^{b-f}	33.47^{n-q}	84.40^{d-j}	96.00	40.00^{b-f}	11.30^{def}	16.77^{a-d}	71.80^{c-j}
28	Hulluka	4.33^{b-f}	1537.60^{c-f}	36.62^{f-o}	85.59^{a-j}	94.67	35.63^{h-q}	11.33^{c-f}	15.47^{d-l}	64.77^{i-q}
29	Dinkinesh	3.50^{c-f}	1600.65^{b-f}	46.79^{a}	82.09^{j}	98.67	36.17^{f-p}	11.63^{a-f}	16.20^{b-h}	65.07^{i-q}
30	Mandoyu	4.70^{a-f}	2336.91^{abc}	36.01^{g-p}	87.53^{a-f}	98.67	35.10^{i-q}	11.33^{c-f}	15.17^{g-n}	65.87^{g-q}
31	Sula	3.00^{ef}	1640.04^{b-f}	39.03^{c-m}	83.37^{g-j}	100.00	39.17^{b-h}	11.83^{ab}	16.50^{b-g}	72.80^{c-i}
32	ET-13	2.87^{f}	1419.53^{def}	35.83^{h-p}	88.08^{a-e}	99.00	33.90^{k-s}	11.17^{f}	14.87^{h-n}	66.93^{e-o}
33	Meraro	2.87^{f}	1156.21^{f}	31.20^{pq}	85.78^{a-j}	99.00	40.40^{bcd}	11.83^{ab}	17.00^{ab}	82.07^{a}
34	Mekelle -01	5.40^{a-e}	1930.25^{a-f}	42.21^{a-e}	88.49^{a-d}	99.67	36.83^{b-l}	11.43^{a-f}	15.60^{c-l}	73.33^{b-h}
35	Bobicho	3.40^{d-f}	1775.00^{b-f}	38.81^{d-m}	87.20^{a-h}	94.33	33.3^{l-s}	11.30^{def}	14.90^{h-n}	62.63^{l-t}
36	Tossa	5.10^{a-f}	2098.92^{a-e}	34.81^{k-q}	89.24^{ab}	98.67	34.93^{j-r}	11.30^{def}	15.17^{g-n}	67.47^{e-n}
37	Galil	3.27^{d-f}	1731.75^{b-f}	36.31^{g-p}	83.18^{hij}	99.33	40.23^{b-e}	11.77^{a-d}	16.67^{b-f}	74.53^{a-e}
38	Kubsa	4.20^{b-f}	1488.41^{c-f}	36.26^{g-p}	84.69^{c-j}	99.33	32.07^{q-s}	11.50^{a-f}	14.37^{l-o}	59.07^{o-t}
39	Abola	5.33^{a-f}	1961.59^{a-f}	35.00^{k-q}	87.30^{a-g}	99.67	33.33^{l-s}	11.57^{a-f}	14.77^{i-n}	68.00^{d-n}
40	Lakech	4.17^{b-f}	1491.94^{c-f}	30.00^{q}	85.32^{a-j}	99.67	32.83^{m-s}	11.23^{ef}	14.73^{i-n}	60.53^{m-t}
41	Mekelle 04	4.20^{b-f}	2168.97^{a-d}	42.24^{a-e}	85.98^{a-j}	97.33	27.63^{t}	11.63^{a-f}	13.37^{o}	56.50^{rst}
42	Honkolo	3.87^{b-f}	2210.30^{a-d}	38.92^{c-m}	87.83^{a-f}	99.00	32.37^{p-s}	11.23^{ef}	14.33^{l-o}	64.83^{i-q}
43	Kakaba	3.87^{b-f}	1660.21^{b-f}	40.59^{b-j}	87.73^{a-f}	98.00	30.23st	11.27^{ef}	14.30^{l-o}	55.27^{t}
44	Dodota	3.60^{c-f}	1710.23^{b-f}	37.87^{d-o}	85.45^{a-j}	99.33	35.43^{h-q}	11.53^{a-f}	15.37^{f-m}	58.87^{p-s}
	Mean	*5.35*	*1853.46*	*38.54*	*86.00*	*99.14*	*35.76*	*11.47*	*15.49*	*66.81*
	%CV	*33.56*	*28.79*	*8.42*	*2.95*	*4.29*	*6.80*	*2.67*	*5.32*	*7.44*
	F test	**	**	**	**	**	**	**	**	**
	LSD	*2.51*	*865.74*	*5.26*	*4.12*	*3.42*	*3.95*	*0.50*	*1.34*	*8.07*

Combined analysis of variance over year and location has shown statistically significant ($P \leq 0.05$) variation for the measured quality characters due to bread wheat varieties. The vitreousness kernel values (Table 3) ranged from 99.25 to 92.17% which is very high for all test verities. Higher vitreousness indicates higher protein content, a harder kernel, coarser granulation, during milling, higher flour yield, superior product quality and opportunity for premium price [5]. The gluten, protein and zanely sedimentation volume content of the test varieties also varied from 40.47 to 26.99, 16.46 to 13.17 and 81.60 to 54.99 respectively which revealed that the wheat genotypes were highly influenced by growing year and locations to express high quality character and fall under best to good bread-making quality class. In general bread wheat variety Mararo scored the highest quality characters while Makalle 04 with the lowest quality even though all the varieties fall under best to good bread making quality. Higher and significant quality values are also obtained at Ginnir in both years which most probably due to higher temperature and shorter maturity period which positively affects protein quality.

Table 3. *Effect of variety on some grain milling and bread making quality characters combined over location and year.*

Varieties	Vit. (%)	Gluten (%)	Moisture (%)	Proteins (%)	Z Index (ml)
Hidase	98.35 ±1.38[abc]	33.22 ±4.38[e-i]	11.13 ±0.44 [a-d]	14.57 ±1.60 [a-h]	68.84 ±8.24 [c-k]
Shorima	98.00 ±2.12 [a-e]	35.51 ±6.05[a-h]	11.04 ±0.51 [a-d]	15.09 ±2.13 [a-h]	70.21 ±11.92 [b-k]
UTIQUE	98.24 ±1.56[a-d]	34.65 ±6.01[b-i]	10.36 ±2.60[bcd]	14.93 ±1.84 [a-h]	69.61 ±12.00 [b-k]
Bika	97.28 ±1.85 [a-g]	33.98 ±7.10[c-i]	10.93 ±0.45 [a-d]	14.76 ±2.16 [a-h]	71.46 ±13.03 [b-g]
Alidoro	97.30 ±2.24[a-g]	34.76 ±4.94[b-i]	11.22 ±043 [ab]	14.18 ±1.69 [c-h]	61.33 ±7.70[i-m]
Enkoy	97.68 ±2.36[a-f]	36.68 ±6.34[a-f]	11.03 ±0.58 [a-d]	15.01 ±1.87 [a-h]	66.76 ±9.18[c-l]
Dereselign	97.50 ±1.88 [a-f]	33.03 ±4.26 [e-i]	10.95 ±0.39 [a-d]	14.37 ±1.39 [c-h]	66.07 ±8.17 [c-l]
Tay	98.84 ±1.12[ab]	33.73 ±5.94 [c-i]	11.12 ±0.36 [a-d]	14.83 ±1.87 [a-h]	67.58 ±11.18 [c-k]
Milennium	98.58 ±1.08[abc]	35.84 ±6.56[a-g]	11.17 ±0.53[abc]	15.48 ±1.93 [a-f]	66.63 ±11.19 [c-l]
Sofumer	99.08 ±1.51[a]	33.62 ±4.02 [c-i]	11.24 ±0.68[ba]	14.49 ±1.45 [b-h]	67.33 ±7.30 [c-k]
K6290-Bulk	98.17 ±2.37[a-e]	37.55 ±8.43[a-e]	11.17 ±0.57[abc]	16.08 ±2.98[abc]	72.97 ±14.77[a-e]
M. walabu	98.14 ±1.72 [a-e]	33.07 ±4.94 [e-i]	11.21 ±0.30 [ba]	14.66 ±1.68 [a-h]	66.01 ±8.89 [c-l]
Dashen	96.80 ±2.62 [a-g]	33.41 ±7.87 [c-i]	11.32 ±0.40[a]	14.74 ±2.71 [a-h]	68.63 ±16.52 [c-k]
Mekelle-03	96.88 ±1.68 [a-g]	31.16 ±4.27 [g-j]	11.18 ±0.60 [abc]	13.99 ±1.42 [d-h]	57.66 ±9.33[lm]
K6295-4a	98.33 ±1.83[abc]	40.47 ±10.04[a]	11.14 ±0.42 [abc]	15.88 ±5.03[a-d]	74.04 ±15.88[abc]
Ogolcho	98.00 ±4.51 [a-e]	30.73 ±8.28[hij]	11.16 ±0.56 [abc]	14.08 ±1.75 [d-h]	66.09 ±8.06 [c-l]
Hoggana	98.47 ±1.41[abc]	34.62 ±6.69[b-i]	11.18 ±0.50 [abc]	14.91 ±2.27 [a-h]	65.96 ±10.93 [c-l]
Gambo	96.22 ±6.72 [a-g]	33.90 ±7.15[c-i]	11.13 ±0.38 [a-d]	14.62 ±2.50 [a-h]	68.94 ±12.63 [c-k]
Digelu	98.17 ±2.29 [b-e]	32.09 ±7.32 [f-i]	11.33 ±0.57[a]	14.15 ±2.29 [c-h]	63.81 ±13.78 [f-m]
Danda	96.00 ±4.47 [c-g]	33.29 ±5.42 [d-i]	11.21 ±0.53 [ba]	13.28 ±4.28 [gh]	65.13 ±14.07[c-l]
Gasay	96.00 ±3.28 [c-g]	33.73 ±5.65[c-i]	11.03 ±0.53 [a-d]	14.33 ±2.00 [c-h]	67.41 ±9.80 [c-k]
Jaferson	95.06 ±5.91[fg]	33.60 ±5.11[c-i]	11.19 ±0.47 [ba]	13.43 ±3.91[gh]	61.38 ±9.39[h-m]
Kingbird	98.60 ±1.14[abc]	34.12 ±6.20[c-i]	11.19 ±0.21 [ba]	14.13 ±3.68 [c-h]	68.84 ±11.45 [c-k]
PAVON-76	97.92 ±1.68 [a-e]	32.04 ±5.43 [f-i]	11.18 ±0.53 [abc]	13.83 ±2.02 [e-h]	65.21 ±10.78 [c-l]
Simba	97.92 ±1.73 [a-e]	34.97 ±6.54[b-i]	11.18 ±0.46 [abc]	15.22 ±2.36 [a-f]	72.73 ±12.34[a-f]
Sirbo	96.75 ±4.45 [a-g]	38.34 ±6.02[abc]	11.34 ±0.28[a]	16.34 ±2.13[ab]	78.64 ±13.25[ab]
Qulqulluu	98.07 ±3.42 [a-e]	38.23 ±6.58[a-d]	11.21 ±0.44 [ba]	16.04 ±2.32[abc]	73.51 ±10.88[a-d]
Hulluka	92.17 ±9.63[h]	31.66 ±6.41 [g-j]	11.13 ±0.09 [a-d]	13.85 ±2.18 [e-h]	63.68 ±10.88[f-m]
Dinkinesh	98.50 ±1.09[abc]	35.74 ±5.59[a-f]	10.38 ±8.96[bcd]	15.73 ±2.22[a-e]	69.60 ±9.07 [b-k]
Mandoyu	96.67 ±2.19 [a-g]	33.28 ±5.80 [d-i]	11.00 ±0.62 [a-d]	13.34 ±3.89 [gh]	66.88 ±10.78 [c-k]
Sula	98.75 ±1.54[abc]	34.18 ±4.55[c-i]	11.21 ±0.70 [ba]	14.65 ±1.66 [a-h]	69.67 ±6.93 [b-k]
ET-13	98.25 ±1.76[a-d]	34.49 ±9.54[c-i]	10.43 ±2.89 [d]	15.01 ±3.15 [a-h]	70.44 ±17.39 [b-i]
Meraro	99.25 ±1.22[a]	39.29 ±6.05[ab]	11.23 ±0.51 [ba]	16.46 ±2.12[a]	81.60 ±11.02[a]
Mekelle -01	97.75 ±2.67 [a-f]	32.94 ±4.78 [e-i]	11.08 ±0.57 [a-d]	14.23 ±1.37 [c-h]	68.08 ±11.18 [c-k]

Varieties	Vit. (%)	Gluten (%)	Moisture (%)	Proteins (%)	Z Index (ml)
Bobicho	96.67±3.55 a-g	32.60±4.71 f-i	11.03±0.59 a-d	14.33±1.59 c-h	64.83±10.36d-l
Tossa	99.00±0.74a	33.21±3.84 e-i	11.13±0.35 a-d	14.36±1.43 c-h	67.04±6.96 c-k
Galil	99.00±0.74a	35.58±6.14 a-h	11.16±0.63abc	14.93±2.13 a-h	70.52±9.32 b-j
Kubsa	95.50±7.56 d-g	30.43±5.80ij	11.14±0.55abc	13.75±1.94 fgh	63.07±11.68g-m
Abola	95.42±4.80 e-g	32.33±4.75 f-i	10.27±2.78 cd	14.54±2.01 a-h	68.80±10.15 c-k
Lakech	98.42±1.56abc	30.61±3.29ij	11.13±0.44a-d	13.42±1.21gh	60.63±6.09 klm
Mekelle 04	97.25±2.22 a-g	26.99±8.82j	11.13±0.59 a-d	13.17±1.51 h	54.99±17.24m
Honkolo	98.92±0.79ab	32.85±6.66 e-i	10.34±2.80 bcd	13.35±4.39 gh	67.40±12.88 c-k
Kakaba	94.67±8.24gh	31.56±6.42g-j	10.23±2.76d	14.22±2.22 c-h	64.12±13.45e-l
Dodota	97.00±3.19 a-g	33.26±5.42 d-i	11.16±0.50abc	14.46±1.72 b-h	61.25±9.21j-m
Mean	97.48±3.59	33.90±6.45	11.04±1.13	14.57±2.47	67.39±11.94
CV	3.54	18.37	2.29	16.72	16.91
F test	**	**	**	**	**
LSD	2.76	4.99	0.91	1.95	9.14

Combined over location, non-significant but higher grain protein quantity and significantly ($P \leq 0.05$) higher protein qualities (gluten and zanely index) were observed at Ginnir (table 4), which most probably due to lower altitude, higher temperature and shorter crop maturity period which hinders starch accumulation and accelerate protein storage.

***Table 4**. Some wheat quality parameters as affected by growing Environment.*

Environment	Vitriousness (%)	Gluten (%)	Moisture (%)	Protein (%)	Zaleny Index
Ginnir	97.65±4.13	34.78±7.26a	10.74±10.74b	14.66±2.73	71.01±13.56a
Sinana	97.32±2.94	33.02±5.39b	11.34±11.34a	14.48±2.19	63.78±8.71b
G. Mean	97.48±3.59	33.90±6.45	11.04±11.04	14.57±2.47	67.39±11.94
CV	3.68	18.88	9.86	16.98	16.91
F test	ns	**	**	ns	**
LSD	0.61	1.09	0.19	0.42	1.95

4. Conclusion

It has been known that the grain properties predetermine both the milling and final end-use quality of bread wheat. The result of the present study confirmed the existence of considerable variation among the test varieties with respect to some physical and other grain quality characters due to genetic and environmental variations. In addition to genetic variation, strong environmental influence was also observed in all measured quality characters. Higher grain protein quantity and qualities were observed at Sinana on station which is due to the terminal moisture stress encountered during growing season. On the other hand better vitreous grain was obtained at Ginnir site as the environment is mid altitude having short maturity period with higher mean daily temperature and suitable for wheat varieties to express genetically inherent hardness. Generally, most bread wheat varieties tested under this study fall under good to best bread making quality based on qualities traits analyzed. However, the experiment should be repeated over seasons and locations to have a clear quality classification of Ethiopian bread wheat varieties.

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Conflicts of Interest

The authors declare that there is no conflict of interest.

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