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Effect of Production Location and Addition of Guar Gum on the Quality of a Sudanese Wheat Cultivar for Bread Making

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ABSTRACT: This study was carried out to investigate the effect of environment and addition of guar gum on the bread making quality of a Sudanese wheat cultivar. Results showed that wheat production location has a significant ($P \leq 0.05$) impact on the biochemical properties of wheat grains. The level of wet gluten of North Sudan wheat (29.3%) was significantly higher ($P \leq 0.05$) compared to that of Central Sudan wheat (25.6%). Falling number of North Sudan wheat flour (355 sec.) was close to the ideal range (250-300 sec.) compared to extremely higher level (490 sec.) recorded for Central Sudan wheat flour. Addition of guar gum as an improver at 1% significantly ($P \leq 0.05$) enhanced the water absorption, dough development time and dough stability in the wheat flour of both locations, however, North Sudan wheat flour remains superior ($P \leq 0.05$) in term of the dough properties compared to Central Sudan wheat flour. Surprisingly, addition of guar gum at 0.5% concentration to North Sudan wheat flour significantly ($P \leq 0.05$) improved the loaf bread volume (4.45 cm^3) compared to control (4.33 cm^3), whereas increasing the guar gum level to 1% slightly decreased the bread volume (4.22 cm^3). Contradictory, increasing the concentration of guar gum from 0.5 to 1% significantly enhanced the loaf bread volume (from 3.98 to 4.23 cm^3) of Central Sudan wheat flour compared to its control (3.90 cm^3). Furthermore, the bread of North Sudan wheat flour with 0.5% guar gum was superior ($P \leq 0.05$) in sensory characteristics such as flavor, taste and texture compared to that of Central Sudan wheat flour.

KEYWORDS: Debera, Dough properties, Guar gum, Loaf bread, Sudanese wheat.

1 INTRODUCTION

With an annual production of about 620 million tonnes, bread wheat (*Triticum aestivum* L.) is one of the world's most important crops [1]. Wheat is unique among cereals, because it contains gluten which has the characteristic of being elastic when mixed with water and retains the gas developed during dough fermentation. The quality of wheat flour for bread-making is generally evaluated by the amount of protein and quality of gluten [2]. The wheat flour containing large amount of protein and high quality of gluten is used for normal bread, whereas that of lower amount of protein is mostly used for confectionary or cakes [3]. Wheat produced in different parts of the world differs greatly in their intrinsic protein qualities and quantities, the quantity is influenced mainly by environmental factors, but the quality of protein is mainly a heritable characteristic [1]. Baking quality is determined by the physical properties of dough, its oxidative properties, the flour water absorption, bread volume, and the color of the bread crumb and crust. The baking properties of a dough sample depend on the flour's ability to form dough that, after mixing and during fermentation, has appropriate physical properties. The strength thus contributed to the dough is an important part of the bread making quality of the flour [4]. For several thousand years, bread has been one of the major constituents of the human diet, making the baking of yeast-leavened and sourdough breads is one of the oldest biotechnological processes. In wheat bread making, flour, water, salt, yeast and/or other micro-organisms are mixed into visco-elastic dough, which is fermented and baked [5]. Wheat flour is the major ingredient and consists mainly of starch (ca. 70–75%), water (ca. 14%) and proteins (ca. 10–12%). In addition, non-starch polysaccharides (ca. 2–3%), in particular arabinoxylans (AX), and lipids (ca. 2%) are important minor flour constituents relevant for bread production and quality [5]. During all steps of bread making, complex chemical, biochemical and physical transformations occur, which affect and are affected by the various flour constituents. In addition, many substances are nowadays used to influence the structural and physicochemical characteristics of the flour constituents in order to optimize their functionality in bread making [5]. In Sudan, wheat is a strategic field crop, since it constitutes the main staple food for most of the urban and rural population. Wheat cultivation in Sudan expanded recently and occupying the largest area in Sudanese irrigated schemes, and it is the second most important cereal crop after sorghum in the country [6]. The season with acceptable heat limits ranged between 90 and 110 days [7]. Wheat production was confined to the Northern Sudan, along the Nile banks (17-22N). However, after 1940s due to increasing demand for wheat consumption and scarcity of land, the growing area extended southward to the warmer Central and Eastern Sudan [8]. One of the main constraints of wheat production in Sudan is heat stress, which adversely affects plant growth and grain formation [9]. The consumption of wheat bread in Sudan is increasing in both rural and urban areas as a consequence of changing taste, convenience and consumer subsidies. However, bread can only be made from imported high gluten wheat which is not suitable for cultivation in the tropical areas for climatic reasons [10]. Sudanese wheat are generally of poor bread making quality, which is attributed to the low protein and gluten quantity and quality, in addition to low alpha amylase activity [11]. Improvement of wheat flour quality is very essential for production of good quality bread, and thus most of the quality problems can be solved with the suitable cultivation condition and uses of natural improver. Guar gum has been increasingly used as natural wheat flour improver because it is safe, cheap, and has the ability to improve dough properties and bread quality. Therefore, the aim of the present study was to investigate the effect of cultivation location of Sudanese wheat cultivar (locally known as Debera), as well as the addition of guar gum on the rheological and loaf bread making quality.

2 MATERIALS AND METHODS

2.1 MATERIALS

Sudanese wheat cultivar (Debera) that was cultivated in two locations; North and Central Sudan was obtained from Seen Flour Mills, Khartoum North, Sudan. Guar gum was obtained from Weeta Flour Mills, Khartoum North, Sudan. Yeast was obtained from local market. All other chemicals are of analytical grade.

2.2 PREPARATION OF WHEAT FLOUR AND GUAR/WHEAT FLOUR BLENDS

The samples were cleaned and the physical characters such as, 1000 kernel weight, hectoliter weight were determined, then wheat grains were milled in Seen Flour Mill to white flour (74% extraction rate), and prepared for chemical analysis and bread making. The guar was blended with flour at three different levels: (0.5%, 1% and 1.5%).

2.3 CHEMICAL COMPOSITION

Moisture, ash, crude protein, crude fibre and fat contents were determined for wheat flour, guar and guar-wheat flour blends according to the AOAC method [12].

2.4 TOTAL MINERALS CONTENT

Minerals were determined from the samples by the dry ashing method that described by Chapman and Pratt [13]. About 2.0 g of samples was acid-digested with diacid mixture (HNO_3 /$HClO_4$, 5:1, v / v) in a digestion chamber. The digested samples were dissolved in double-distilled water and filtered (Whatman No. 42). The filtrate was made to 50 mL with double-distilled water and was used for determination of total minerals. Calcium and Magnesium were determined by a titration method [13]. Phosphorus was determined spectrophotometrically by using molybdovanadate method. Potassium and Sodium were determined according to the AOAC method [12] using EEL flame photometer.

2.5 GLUTEN QUANTITY AND QUALITY

Gluten quantity and quality of wheat flours with and without improvers were carried out according to the revised standard ICC method No. 155 and 158 [14] by using Glutomatic 2200 system (Perten Instruments AB, Huddinge, Sweden). Ten grams of the sample were mixed into dough with 5 ml distilled water in a test chamber with bottom sieve. The dough was then washed with 2% solution of sodium chloride. The gluten ball obtained was centrifuged at maximum speed by centrifuge (Type 2015) and quickly weighed. The percentage of wet gluten remaining on the sieve after centrifugation is defined as the gluten index. The total wet gluten was dried in heater (Glutork, 2020) to give the dry gluten. The weight of gluten was multiplied by ten to give the percentage of wet or dry gluten.

2.6 FALLING NUMBER

Alpha – amylase activity of wheat flours with and without improvers was determined according to Perten [15] as described previously [11].

2.7 SEDIMENTATION VALUE

Sedimentation value of wheat flours with and without improvers was carried out according to the official standard methods [16] that described previously [11].

2.8 FARINOGRAPH AND EXTENSOGRAPH CHARACTERISTICS

Brabender farinograph method was carried on wheat flours with and without improvers according to AACC method [16]. Titration curve was used for the assessment of the water absorption for each flour sample. A sample of 300 gram (14% moisture) was weighed and transferred into a clean mixer. The farinograph was switched on at 63 rpm for 1 min, then the distilled water was added from especial burette (the correct water absorption can be calculated from the deviation, 20 units deviation correspond to 0.5% water, if the consistency, is higher than 500 F. U. more water is needed and vice – versa). When the consistency is constant, the instrument was switched off and the water drawn from the burette indicates water absorption of the flour in percentage. The measuring mixer was thoroughly cleaned. A sample of 300 g was weighed, and then introduced into the mixer; the farinograph was switched on such as before. The water quantity, which is determined by the titration curve, was fed at once. When an appreciable drop on the curve was noticed, the instrument was run further 12 min before shutting off.

Extensograph method was used according to ICC method [17]. The extensograph and farinograph were set and operated at 30°C. The dough for extensograph was prepared as for the farinograph, but the amount of water used for mixing was 2% less due to the addition of 2% salt and the dough was mixed for 5 min only. Two pieces of dough (150 g each) were weighed, molded on the balling unit, rolled with dough roller into cylindrical test pieces, fixed in the dough holder, and stored in the rest cabinet for 45 min. The dough piece was placed on the balance arm of extensograph and stretched by stretching hook until it broke. During the period of stretching the behavior of the dough was recorded on a curve via extensograph. This test was performed at 45, 90, and 135 min intervals.

2.9 PREPARATION OF BREAD SAMPLES

Wheat flour and guar-wheat flour blends were baked according to Badi *et al*. [18]. About 250 g flour, water (according to farinograph water absorption), salt (1%), yeast (2%), sugar (2%) and oil (2%) were mixed to form a dough in mono-universal laboratory dough mixer for 5 min at medium speed. The dough was allowed to rest for 10 min at room temperature, then three pieces of 120 g dough were weighed, made into round ball and allowed to rest for another 15 min, then moulded, put into pan and placed in the fermentation cabinet for final proof for 1 h. Baking was done in an oven at 220°C with saturation of steam for 10-15 min. After the loaves were cooled, they were weighed (g) then the volumes measured in ml using volumeter by millet seed displacement method [19] and their specific volumes (v/w) were calculated. The loaves were sliced with an electrical knife, and then each loaf with its slice was photographed.

2.10 SENSORY EVALUATION

The loaves were sliced with an electric knife and prepared for sensory evaluation, at same day, by the ranking test according to the procedure described by Land and Shepherd [20]. Ten semi-trained assessors were provided coded samples and asked to evaluate the general appearance, flavour, taste, texture and overall acceptability of bread slices. Sum of ranks were then statistically (P ≤ 0.05) interpreted according to the same ranking test described earlier.

2.11 STATISTICAL ANALYSIS

Data generated, except for sensory evaluations, was analyzed using Statistical Package for Social Sciences (SPSS). Mean (SD) were tested using one factor analysis of variance (ANOVA), and then separated using Duncan's Multiple Range Test (DMRT) according to Mead and Gurnow [21].

3 RESULTS AND DISCUSSION

3.1 PHYSICAL CHARACTERISTICS OF WHEAT GRAINS AND NUTRITIONAL COMPOSITION OF WHEAT FLOUR

The results on effect of cultivation location on the physical characteristics of wheat grains and the nutritional quality of wheat flour are presented in Table 1. Thousand kernels weight of Debera cultivar from North and Central Sudan was 34.8 and 31.2g, respectively. This result is within the range reported by Ahmed [22] and Mutwali [23] who found that the weight of 1000 kernels of different Sudanese cultivars ranged between 28 and 44 g, and 28.7 to 48.5, respectively. However, Makawi *et al*. [24] found that the weight of 1000 kernels of Sudanese cultivars Elnelain, Nepta and Argeen ranged between 31.70 to 34.80 g. Moreover, Zeleny [25] found that the thousand kernels weight for hard red spring and hard red winter wheat ranged from 20 to 32g, whereas soft white and durum wheat ranged from 30 to 40 g. Analysis of variance showed significant differences (P ≤ 0.05) in the kernel weight between the cultivar in the two locations. The cultivar of North Sudan has higher kernels weight compared to that of Central Sudan. This is reasonable since the environmental and growing conditions (soil, climate, water and nutrient levels) in the North Sudan are favorable for wheat cultivation compared to that of Central Sudan. Furthermore, the hectoliter weight of Debera cultivar from North and Central Sudan was 83.0 and 78.0 kg/hectoliter, respectively (Table 1). This result agreed with those of Mutwali [23] who stated that the hectoliter weight of 20 Sudanese wheat cultivars ranged between 76.6 and 85.25 kg/hectoliter. Williams *et al*. [26] reported that higher correlations occur between hectoliter weight (test weight) and flour yield. This is because hectoliter weight is related to grain density, rather than weight, and the denser kernels tend to contain more endosperm (flour). Statistical analysis of the results showed significant differences (P ≤ 0.05) in the hectoliter weight among debera cultivar in the two locations. Hectoliter weight of North Sudan cultivar is significantly (P ≤ 0.05) higher than that of the same cultivar when cultivated in Central Sudan. This result indicated that the differences in the environmental condition between the two locations significantly (P ≤ 0.05) affect the physical characteristics of wheat grains.

On the other hand, the chemical composition of the wheat cultivar (Debera) from the Northern and Central Sudan is also differ and are presented in Table 1. The moisture content of wheat is important for both farmer and miller. The moisture content of tempered wheat flour (74% extraction) of Debera from North Sudan was 13.3% while that of Central Sudan was 12.3%. These results are similar to those of Mutwali [23] who reported a range of 10.21 to 13.13 for several Sudanese wheat cultivars grown in three different locations. Statistical analysis of the results showed significant differences (P ≤ 0.05) between the cultivar of the two locations, this may be attributed to the temperature variation between the two locations that is the Central Sudan is warmer than North Sudan. Differences in moisture content is expected even for wheat coming from a single field which can vary widely in moisture due to factors such as differences in soil fertility or stage of ripening of the grain. The ash content of the white wheat flour (74% extraction) is shown in Table 1. Ash content of Debera from North and Central Sudan was 0.54% and 0.55%, respectively. These results were well agreed with the data reported by Mutwali [23] who found that the ash content of 20 Sudanese wheat cultivars was ranged between 0.47 to 0.85%. Statistical analysis of the results showed significant differences (P ≤ 0.05) in the ash content of wheat flours (74% extraction rate) for the two locations. These results indicated that the production site of wheat had significant effect on the flour ash content. This could be attributed to differences in soil conditions, temperature, water and fertilizers between the two cultivation sites. Grain protein is of primary importance in determining the bread making quality of wheat. Variations in both protein content and composition significantly modify the flour quality for bread making. The protein content of white wheat flour (74%) of Debera cultivar from North and Central Sudan was 11.8% and 10.1%, respectively (Table 1). The results lies within the range obtained by Mutwali [23] who reported that the protein content of white flours of 20 different Sudanese cultivars grown in three different locations ranged between 9.59% to 14.06%. Analysis of variance showed significant differences (P ≤ 0.05) in the protein content among the white flours of Debera cultivars from North and Central Sudan, which indicated that cultivation site, had influenced the flour protein content. This variation may be due to the variation in growing condition such as amount of nitrogen and drying temperature in Central Sudan, which can partly denature grain protein and cause loss in protein [23]. Protein content and quality are of vital importance in flour milling. They are the characteristics that make wheat unique and are the main factors on which wheat is traded, where higher protein wheats commanding a higher price. As shown in Table 1. fat content of white wheat flour of Debera from North Sudan (1.07 %) was significantly (P ≤ 0.05) higher than that of Debera from Central Sudan (1.04%). These values were in agreement with those of Mutwali [23] who reported that the fat content of white flour of 20 Sudanese cultivars ranged between 0.91 and 1.74%. Similar findings were also reported by Ahmed [22] who stated that fat content of Sudanese wheat cultivars ranged between 0.85 and 1.73% for white wheat flour. Fiber content of the white wheat flour of Debera cultivar from North was 1.08%, whereas that of Debera from Central Sudan was 1.07% (Table 1). Analysis of variance showed insignificant differences (P ≥ 0.05) in the fiber content of white wheat flour of the Debera cultivar grown in the two locations. These results are higher than those of Ahmed [22] who reported that the fiber content of Sudanese wheat cultivars ranged between 0.30 and 0.48% for white flour. Mohamed [27] showed that the fiber content of the white flour of four Sudanese cultivars Debera, Elneelain, Condor and Sasaraib ranged between 0.40 and 0.48%. The carbohydrates content (Table 1) of Debera from North was 71.84%, while carbohydrates content of Debera from Central Sudan was 74.94%. The results obtained were agreed with Mohamed [27] who reported that carbohydrates content of four Sudanese wheat cultivars ranged between 72.2 and 80.1%. Analysis of variance showed significant differences (P ≤ 0.05) among the white wheat flour of the Debera cultivar grown in two different locations. Results in Table 1 also showed the macro elements content of Debera cultivar from North and Central Sudan. It is clear that the extraction (74%) affected positively in minerals content, in addition to the significant difference between the mineral content of Debera cultivar from North and Central Sudan. This result is in a good agreement with those of Mohamed [27] who reported that different locations of wheat cultivar have an effect on elements of sample. Kulp *et al*. [28] reported that, milling wheat into flour reduces the levels of many nutrients from their original levels in the wheat. It is well known that environmental conditions and genetic factors are very important, factors that influence variation in mineral element concentration in wheat flours.

Table 1. Physical characteristics of wheat grains, and nutritional composition of the flour (74% extraction) of Debera cultivar grown at different locations.

Parameter	Debera cultivar location	
	North Sudan	Central Sudan
Hectoliter weight (kg/hectoliter)	83.0±0.79[a]	78.0±0.26[b]
1000-kernels weight (g)	34.79±0.58[a]	31.20±0.30[b]
Moisture content (%)	13.3±0.10[a]	12.3±0.06[b]
Protein content (%) [Nx5.7]	10.8±0.06[a]	10.1±0.06[b]
Ash content (%)	0.54±0.01[a]	0.55±0.01[a]
Fat content (%)	1.07±0.02[a]	1.04±0.01[b]
Fiber content (%)	1.08±0.01[a]	1.07±0.01[b]
Carbohydrate content (%)	71.54±0.01[b]	74.94±0.01[a]
Phosphorus (mg/100 g)	0.39±0.01[a]	0.31±0.06[b]
Potassium (mg/100 g)	5.12±0.12[a]	4.50±0.30[b]
Sodium (mg/100 g)	10.30±0.10[a]	9.63±0.06[b]
Calcium (mg/100 g)	6.81±0.06[a]	5.32±0.06[b]
Magnesium (mg/100 g)	0.31±0.02[a]	0.29±0.01[a]

*Mean values having different superscript letter in the same raw differ significantly (*P* ≤ 0.05).

3.2 QUALITY PARAMETERS OF WHEAT FLOUR AND WHEAT FLOUR-GAUR BLENDS

The quality parameters (gluten quality and quantity, falling number and sedimentation values) of wheat flour and blends were shown in Table 2. Wet gluten content of control for Debera cultivar flour from North Sudan is 29.3%, whereas that of control for Debera cultivar flour from Central Sudan is 25.6%. These results are partially agreed with those of Mohamed [27] and Mutwali [23] who found that the wet gluten of Sudanese cultivars ranged between 26.2 to 31.9% and 28.6 to 46.9, respectively. Analysis of variance showed significant differences (P ≤ 0.05) in the wet gluten content of white wheat flour of the Debera cultivar grown in two different locations. In which the gluten content of Debera cultivar from North Sudan is significantly (P ≤ 0.05) higher than that from central Sudan. The low wet gluten in Central Sudan flour may be attributed to the warm weather in Central Sudan, which affects the moisture content of the grain, and this plays a vital factor in lowering the gluten quality and quantity. Addition of guar gum powder to the wheat flour caused a significant reduction (P ≤ 0.05) in wet gluten content. Results showed wet gluten values of 28.4, 26.6 and 24.0% for Debera cultivar from north Sudan supplemented with 0.5, 1 and 1.5% of guar gum powder, respectively, and 24.9, 23.4 and 20.2 % for Debera cultivar from central Sudan at 0.5, 1 and 1.5% of guar gum, respectively. There is a significant ($P \le 0.05$) reduction in the wet gluten content with increasing the percentage of guar gum powder in the blends. On the other hand, dry gluten content of control for Debera cultivar flour from North is 9.7%, while that of control for the same cultivar from Central Sudan is 8.5%. Partially similar results were obtained by Mutwali [23] who reported that the dry gluten content of Sudanese wheat cultivars grown in three different regions are ranged between 8.96 and 16.76 %. However, the results of dry gluten content in this study is lower than those of Makawi *et al*. [11] who reported a range of 10.3 to 11.6 for dry gluten content in some Sudanese wheat cultivars. Analysis of variance showed significant differences ($P \le 0.05$) in dry gluten content of wheat flour of the Debera cultivar grown in two different locations. Addition of guar gum powder was negatively ($P \le 0.05$) affected the dry gluten content. This result showed dry gluten values 9.5, 8.6 and 8.0% for Debera cultivar from North at 0.5, 1 and 1.5% of guar gum powder, respectively, and 8.3, 7.8 and 6.7% for Debera cultivar from Central Sudan at 0.5, 1.0 and 1.5% guar gum, respectively. The control of Debera cultivar flour from North showed 73.2 gluten index, whereas the result 70.2 gluten index obtained for Debera cultivar from Central Sudan (Table 2). This value agreed with those of Perten [15] who stated that the optimum range of gluten index for bread making is between 60 and 90. Also the results agreed with those of Mutwali [23] who reported a range of 36.4 to 92.8% for gluten index of 20 Sudanese wheat cultivars from three different locations. Addition of guar gum powder to wheat flour caused a significant increase ($P \le 0.05$) in gluten index. Guar gum positively ($P \le 0.05$) affected the gluten index due to it is ability to make a network of gluten more strong. Perten [15] stated that gluten index is an important indicator for gluten quality. Usually, there is a positive relationship between glutenin quantity and the gluten index percentage. But, there is a negative correlation with the gliadin quantity. Consequently, flour quality is influenced by the nature of the gluten and its various components. The result in Table 2 shows significant differences ($P \le 0.05$) among the blends in their sedimentation value. Debera flour from North showed 19.0 ml sedimentation value, while the that from Central Sudan gave 17.7 ml sedimentation value. This result was agreed with Elagib [29] who found that sedimentation values for Sudanese wheat cultivars ranged from 13.6 to 19.07 ml. While, Mutwali [23] reported a range of 19.0 to 40.3 ml for the sedimentation value of 20 Sudanese wheat cultivars grown at three different locations. Addition of guar gum at 0.5, 1.0 and 1.5% to Debera cultivar flour from North showed sedimentation values of 18.7, 19.8 and 21.0 ml respectively, whereas it gave sedimentation values of 18.3, 19.7 and 20.0 ml, respectively for wheat flour from Central Sudan. Analysis of variance revealed that addition of guar gum significantly ($P \le 0.05$) increased the sedimentation values of the wheat flours of both sites. The sedimentation test was based on the fact that gluten imbibes water and swells greatly when treated with dilute lactic acid under standard conditions. The amount of water imbibes and volume occupied by a weight of flour depends on the quality of gluten. Strong gluten swells the most and occupies the bigger volume [30]. Falling number of the flour for Debera cultivar from North Sudan was 355 sec, whereas that of the cultivar from Central Sudan gave a result as 490 sec (low alpha-amylase activity). Analysis of variance showed significant differences ($P \le 0.05$) in the falling number values of white wheat flour of the Debera cultivar grown in two different locations. Variation in falling number values might be due to the seasonality and storage conditions of wheat grains (moisture and temperature). The results of falling number in this study is lower the range obtained by Makawi *et al*. [11] who reported falling number of some Sudanese wheat flours between 471-833sec. Extremely higher falling numbers in the range of 508.0 to 974.7 sec were also reported by Mutwali [23] for 20 Sudanese wheat cultivars. This higher falling number may be attributed to dry harvest season which consequently affect the activity of alpha-amylase. Addition of guar gum powder at 0.5, 1.0 and 1.5 to Debera flour from North and Central Sudan negatively ($P \le 0.05$) affected the α-amylase activity and gave falling numbers of 380, 398, 422, 502, 535 and 556 sec, respectively. This may be due to the lowering activity of alpha-amylase enzyme by guar gum.

Table 2. Gluten quantity and quality, falling number and sedimentation value of flours and flour-guar blends.

Debera cultivar (Location)	Guar gum level (%)	Gluten quantity and quality			Falling number (sec)	Sedimentation value (cm^3)
		Wet gluten (%)	Dry gluten (%)	Gluten index (%)		
North Sudan	0.0	29.3 ± 0.00^{a}	9.7 ± 0.00^{a}	73.2 ± 0.00^{e}	355 ± 1.53^{h}	19.0 ± 0.00^{bcd}
	0.5	28.4 ± 0.21^{b}	9.5 ± 0.07^{b}	78.2 ± 0.21^{c}	380 ± 0.58^{g}	18.7 ± 0.58^{cde}
	1.0	26.6 ± 0.14^{c}	8.6 ± 0.07^{c}	80.7 ± 0.42^{b}	398 ± 2.08^{f}	19.8 ± 0.58^{bc}
	1.5	24.0 ± 0.14^{f}	8.0 ± 0.70^{e}	84.7 ± 0.35^{a}	422 ± 1.73^{e}	21.0 ± 0.00^{a}
Central Sudan	0.0	25.6 ± 0.21^{d}	8.5 ± 0.00^{d}	70.2 ± 0.00^{f}	490 ± 1.53^{d}	17.7 ± 0.58^{e}
	0.5	24.9 ± 0.35^{e}	8.3 ± 0.14^{d}	73.2 ± 0.14^{e}	502 ± 1.00^{c}	18.3 ± 0.58^{de}
	1.0	23.4 ± 0.35^{g}	7.8 ± 0.14^{e}	76.3 ± 0.42^{d}	535 ± 4.51^{b}	19.7 ± 0.58^{bc}
	1.5	20.2 ± 0.42^{h}	6.7 ± 0.14^{f}	80.1 ± 0.57^{b}	556 ± 6.66^{a}	20.0 ± 0.00^{b}

*Mean values having different superscript letter in the same column differ significantly ($P \le 0.05$).

3.3 FARINOGRAPH CHARACTERISTICS

The farinograph characteristics of Debera cultivar from North and Central Sudan and the blends were shown in Table 3. The water absorption of bread flour of Debera cultivar from North and Central Sudan was 61.2 and 60.3 farinograph unit, respectively. These results were within the range 57 to 62% obtained by Mutwali [23] for Sudanese wheat cultivars grown in three different locations. Similar observation of water absorption was recently reported for Iranian wheat that used for the preparation of leavened flat bread locally known as Barbari [31]. Water absorption of the Debera cultivar flour of North Sudan was higher than that of Central Sudan. This indicated that the production site had affected the water absorption of Debera wheat flour. For North Sudan cultivar, addition of guar gum powder in the ratios 0.5, 1.0 and 1.5% was shown to increase the water absorption of the blends to 61.9, 63.1 and 65.0, respectively. For Central Sudan cultivar, addition of guar gum powder in ratios 0.5, 1.0 and 1.5% was also shown to increase the water absorption of the blend to 60.8, 62.2 and 64.1%, respectively. These results are in agreement with the fact that addition of different gums increased the water absorption of wheat flour [32]. The water absorption of wheat flour dough is governed in practice, by the protein content and quality and by the extent to which the starch is damaged mechanically [33]. Generally high farinograph water absorption of flour is considered an indication of good baking performance. The reason could be that high protein content causes good baking performance and high water absorption [34], [35]. The development time of control Debera flour from North Sudan was 4.3 min, which is higher than development time of control Debera flour from Central Sudan, which was 3.5 min. These results agreed with the findings of Mutwali [23] who reported that dough development time of Sudanese wheat cultivar in the range of 1.68-5.16 min. It seems that North Sudan cultivar has good bread making quality compared to that of Central Sudan, because long development time is good indicator of the quality of the flour for bread making [36]. Addition of guar gum powder in ratios of 0.5, 1.0 and 1.5% concomitantly decreased the development time of wheat flour of the two locations. These results agreed with Rao *et al*. [32] who reported that addition of guar gum decreased the dough development time. Dough stability of Debera cultivar from North and Central Sudan was 4.9 and 5.4 min, respectively. These results agreed with the findings of Mutwali [23] who reported that dough stability of Sudanese wheat cultivar in the range of 2.0-6.2 min. The weak flour gives dough with low elasticity and stability, while the strong flour gives elastic dough with high stability. But the additives can improve these properties. The dough stability time with 0.5, 1.0 and 1.5% guar gum were 5.4, 5.7, and 4.8 min, respectively, compared with control Debera flour from North Sudan, which is 4.9 min. In case of flour from Central Sudan cultivar, dough stability was 5.7, 6.3 and 5.1 min for ratios 0.5, 1.0 and 1.5% guar gum, respectively. Ellis and Apling [37] reported that, addition of guar gum improved dough stability. The dough stability time of wheat flour was increased by addition of guar gum powder at 0.5 and 1.0%, while the ratio 1.5% decreased the dough stability time of wheat flour. This negative result may be due to the fact that increment of ratio of guar gum powder makes the dough very viscose and thus affect the dough strength.

Table 3. Farinograph characteristics of Debera flour containing different levels of guar gum as improver.

Debera cultivar location	Guar gum level (%)	Water absorption corrected to14%	Water absorption corrected to 500 FU	Dough Stability (min)	Dough development time (min)
North Sudan	0.0	59.2	61.2	4.9	4.3
	0.5	59.9	61.9	5.4	3.7
	1.0	60.8	63.1	5.7	2.9
	1.5	62.7	65.0	4.8	2.4
Central Sudan	0.0	59.0	60.3	5.4	3.5
	0.5	59.6	60.8	5.7	2.5
	1.0	61.1	62.2	6.3	2.2
	1.5	63.0	64.1	5.1	2.0

FU: Farinograph unit

3.4 EXTENSOGRAPH CHARACTERISTICS

The extensograph measures the stretching properties of wheat flour dough for determining the flour quality and for checking flour treatment with additives like ascorbic acid, proteinase or emulsifiers. The extensograph characteristics of wheat flour and blends are shown in Table 4. Debera flour with guar gum exhibited an increase in the energy and resistance at 45, 90 and 135 min, compared to the control flour. This effect is in agreement with study of Rao *et al*. [32] who reported an increase in resistance to extension by addition of guar gum to wheat flour. From the present results, using guar gum powder in ratios of 0.5, 1.0 and 1.5% showed higher ($P \leq 0.05$) values of energy at 45, 90 and 135 min of Debera flour from

North Sudan than the values of Debera flour from Central Sudan. The ratio 1.5% of guar gum showed significant decrease (P ≤ 0.05) in energy results compared with other ratios of guar gum. There were significant differences among locations, indicating that site of production had affected the flour extension properties. Similar observation has recently been reported for several Sudanese wheat cultivars grown in three different locations [23]. The results also showed that as the fermentation time increased the resistance values of the flour blends and the control increased. Whereas addition of guar gum powder to wheat flour showed slight decrease in extensibility at 45, 90 and135 min compared with control wheat flour. These results agreed with those of Rao *et al*. [32] who reported a decrease in extensibility with addition of surfactant gels to wheat flour. This negative effect may be due to the dilution of gluten content specially gliadin, which is responsible for extensibility. It is well known that the increase in protein content is associated with an increase in mixing time, mixograph peak resistance, and resistance to extension, extensibility and loaf volume. Ellis and Apling [37] mentioned that, the guar gum can improve the energy of weak dough and increase the resistance to extension.

Table 4. Extensograph characteristics of Debera flour containing different levels of guar gum as improver.

Cultivar location	Guar gum level (%)	Energy $(cm)^2$			Resistance (cm)			Extensibility (mm)			R/E		
		45 min	60 min	135 min	45 min	60 min	135 min	45 min	60 min	135 min	45 min	60 min	135 min
North	0.0	59	61	58	224	260	283	146	138	127	2.0	2.5	2.7
	0.5	75	81	86	276	348	320	148	136	149	2.3	3.2	2.8
	1.0	73	75	85	314	436	468	134	112	116	3.7	4.3	4.7
	1.0	72	79	73	342	408	427	126	122	110	3.1	3.7	4.3
Central	0.0	61	65	62	277	408	494	131	112	95	2.6	3.0	3.4
	0.5	60	70	68	286	357	394	126	120	112	3.1	3.5	4.0
	1.0	70	71	74	318	358	406	132	120	118	3.4	3.7	4.2
	1.5	63	56	64	318	369	448	121	103	104	2.9	3.8	4.0

*Each value is the mean of triplicate samples.

3.5 BREAD MAKING QUALITY

The main factor, which places wheat in the front position among the world crops, is its bread-making quality. So, wheat food products are an essential part of balanced diet, because they provide good nutritional value for their caloric values. Wheat is used for several purposes, but the traditional staple food is bread, which is produced in many forms by different processes. The effect of addition at ratios 0.5, 1.0 and 1.5% of guar gum powder on the baking characteristics of Debera flour from North Sudan and Debera flour from Central Sudan is shown in Tables 5, and Figures 1 and 2. Control loaf bread volume of Debera flour from North is 465 cc, addition of guar gum gave a significant difference (P≤0.05) in bread volume. The loaf bread of 0.5% guar gum gave the highest value; even more than control it gave 480.0 sec, while the ratios 1.0 and 1.5% guar gum gave the result of 450.0 and 435.0 cc, respectively. Whereas the control loaf bread volume of Debera flour from Central Sudan is 408 cc, the ratio 1.0% guar gum gave the highest value, it was 462 cc, while the ratios 0.5 and 1.5% guar gum gave the lowest values, which were 422.0 and 418.0 cc, respectively. Specific volume of control bread of Debera flour from North was 4.33 cc/g. The highest value of specific volume gave at ratio 0.5% guar gum as 4.45 cc/g, whereas the ratios 1.0 and 1.5% gave results 4.22 and 4.12 cc/g, respectively. While the specific volume of control loaf bread of Debera flour from Central Sudan was 3.90 cc/g, addition of guar gum affected positively at ratios 0.5 and 1.0% gave results of 3.98 and 4.23 cc/g, respectively. While guar gum at ratio 1.5% negatively affected the loaf specific volume and the result was 3.82 cc/g. These results are supported by those obtained by Elagib [29] who reported similar loaf volumes of some Sudanese wheat cultivars. From the present results, it is clear that the specific volume of the loaf bread was affected by the addition of improvers and by wheat quality as indicated by the amount of protein content, gluten quantity and quality and sedimentation value. Cauvain and Chamberlain [38] stated that, loaf volume increase is attributed to improved gas retention and to extending the period of dough expansion during the baking stage. Perten [15] stated that, quality factors such as loaf volume and water absorption are related to gluten quality and quantity. Higher gluten quantity values generally give a greater bread volume. Basically, strong flours must be used for making good bread.

Table 5. Physical characteristics of loaf breads made from debera wheat cultivars and with guar gum as improver.

Cultivar Location	Guar gum (%)	Loaf Weight (g)	Loaf Volume (cm^3)	Loaf Specific volume (cm^3/g)
North Sudan	0.0	107.3 ± 0.12^{bc}	465 ± 5.00^{ab}	4.33 ± 0.05^{ab}
	0.5	107.9 ± 0.59^{ab}	480 ± 5.00^{b}	4.45 ± 0.02^{a}
	1.0	106.6 ± 2.00^{bc}	450 ± 18.03^{abc}	4.22 ± 0.12^{bcd}
	1.5	109.2 ± 0.26^{a}	435 ± 31.22^{bcd}	4.12 ± 0.10^{cde}
Central Sudan	0.0	104.6 ± 0.70^{de}	$408. \pm 17.56^{d}$	3.90 ± 0.17^{e}
	0.5	105.8 ± 0.78^{cd}	422 ± 10.41^{cd}	3.98 ± 0.11^{e}
	1.0	109.1 ± 0.53^{a}	462 ± 2.89^{ab}	4.23 ± 0.05^{bc}
	1.5	103.9 ± 0.40^{e}	418 ± 20.21^{d}	3.82 ± 0.18^{de}

*Mean values having different superscript letter in each column differ significantly at ($P \leq 0.05$).

Fig. 1. Loaf bread prepared from North Sudan Debera cultivar flour with guar gum as improver at concentration of (A) 0.0%, (B) 0.5%, (C) 1.0%, and (D) 1.5%.

Fig. 2. Loaf bread prepared from Central Sudan Debera cultivar flour with guar gum as improver at concentration of (A-G) 0.0%, (B-G) 0.5%, (C-G) 1.0%, and (D-G) 1.5%

3.6 SENSORY EVALUATION

Table 6. shows the effect of guar gum powder on the organoleptic quality (general appearance, flavor, taste, texture and overall preference) of bread made of Debera flour from North Sudan and Central Sudan. The Evaluation of general appearance of bread made from Debera flour from North, ranged between 23 to 38, and the ratio 0.5% guar gum gave the best result. Whereas the general appearance of bread prepared from Debera flour from central Sudan ranged between 18 to 41. The ratio 1% guar gum gave the better bread. The flavour and taste affected as the same, and it is clear in this study addition of guar gum not bad, except in high level 1.5%. Compared with control flour, addition of guar gum improved the bread made from Debera flour, especially at ratio 0.5% that gave a better result for bread prepared from north Sudan cultivar and the ratio 1% gave the best value for bread prepared from Central Sudan cultivar. This positive effect in a good agreement with Cawley [39] who stated that bread with guar had a soft texture, better softness and improved shelf life. From these results it is clear that the Panelists prefer the bread prepared from Debera flour of North Sudan with ratio of 0.5% guar gum. When the ratio of added guar gum elevated to 1% the bread made from Debera cultivar of Central Sudan is preferred compared to that of North Sudan with the same amount of guar gum.

Table 6. Sensory evaluation (%) of loaf bread made from the debera wheat cultivar flours with guar gum as improver.

Cultivar Location	Guar gum (%)	General Appearance	Flavor	Taste	Texture	Performance
North Sudan	0.0	38^{c}	15^{a}	26^{b}	26^{b}	23^{b}
	0.5	23^{b}	15^{a}	18^{a}	18^{a}	17^{a}
	1.0	32^{b}	23^{b}	22^{b}	27^{b}	25^{b}
	1.5	36^{b}	40^{c}	38^{c}	30^{b}	47^{c}
Central Sudan	0.0	32^{b}	27^{b}	23^{b}	35^{b}	36^{b}
	0.5	21^{b}	21^{b}	22^{b}	24^{b}	21^{b}
	1.0	18^{b}	27^{b}	24^{b}	16^{a}	15^{a}
	1.5	41^{c}	37^{b}	39^{b}	28^{c}	36^{b}

*Means values having different superscript letter in the same column differ significantly ($P \leq 0.05$).

4 Conclusions

The study revealed that the wheat variety Debera is capable of producing high quality loaf bread if natural improver such as guar gum is applied. The quality of the wheat produced in the Northern Sudan is better than that produced in the Central Sudan due to differences in the climatic factors, length of the season, soil and temperature especially as the low temperature is suitable for improving the chemical characteristics and the nutritive value of the wheat and affecting the rheological characteristics of the dough. The guar gum flour has approved its effectiveness as improver for bread making from even low quality wheat, and this is due to its remarkable effect in strengthening the gluten network. The mixing ratio or 0.5% is the appropriate for good bread making for Debera variety cultivated in North Sudan, whereas 1% is the appropriate ratio of bread making from Debera variety cultivated in Central Sudan.

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