

## Research Article

## Grains Quality Characteristics of Local Wheat (*Triticum aestivum*) Cultivars Grown at Khartoum State, Sudan

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### ABSTRACT

*Three wheat cultivars, Elnelain, Nepta and Argeen were studied for their various quality and rheological characteristics compared with the Australian wheat flour (control). Physicochemical characteristics as well as farinograph, extensograph, gluten content, sedimentation value and bread quality were assessed. Significant differences ( $P \leq 0.05$ ) were found for hectoliter weight and 1000 kernel weight between the Australian and Sudanese wheat cultivars. However, Sudanese wheat flours had a lower wet gluten (22.7-28.9 g), sedimentation values (15-20 ml), water absorption (57.9-66.4%), dough development time (2.5-6.8 min), stability (1.5-7.9 min), resistance to extension (160-304 Bu), energy (62-80 cm<sup>2</sup>) and bread specific volume (3.06-3.40 cm<sup>3</sup>) compared to the Australian one. Nepta cultivars gave the best characteristics of farinograph, extensograph and the highest bread specific volume among Sudanese wheat investigated.*

## INTRODUCTION

With an annual production of about 620 million tonnes, bread wheat (*Triticum aestivum* L.) is one of the world's most important crops (Bordes et al. 2008). 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 (Khatkar et al. 1995). 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 (Caballero et al. 2007). Wheats produced in different parts of the world differ 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 (Bordes et al. 2008). 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 (Menkovska et al. 2002). 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 one of the oldest biotechnological processes. In wheat bread making, flour, water, salt, yeast and/or other microorganisms are mixed into visco-elastic dough, which is fermented and baked (Goesaert et al. 2005). 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 (Goesaert et al. 2005). 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

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optimize their functionality in bread making (Goesaert et al. 2005). Wheat is getting more important as one of the main cereal foods in the Sudan. Wheat production was confined to the Northern Sudan, along the Nile banks (17- 22°N). 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 (13- 15°N) (Ishag, 1994). The short growing season of wheats in the Sudan and excessively high temperature during early and late crop growth stages contribute greatly to low wheat productivity and quality (Ishag and Ageeb, 1991). In arid and semi-arid areas of Sudan, temperatures as high as 38°C are very common during the grain filling period (Tahir et al. 2005). A number of studies were carried out to study the effects of such environmental conditions on growth and grain yield of local wheat (Tahir et al. 2005) cultivars. However, studies on high temperature effects on grain end-use quality of Sudanese wheat under such environments are very scarce. Such information is of paramount importance for non-traditional as well as traditional wheat areas in the light of global warming and ensuing climate changes. 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. The low quality of Sudanese wheat is also attributed to the high temperature effects during the grain filling period (Tahir et al. 2006). Recently, one of the main goals of Agricultural Revival programme is to achieve self-sufficient in wheat production. Therefore, the wheat growing areas in Sudan have been expanded gradually in recent years and consequently Khartoum state became an important wheat growing area. However, lack of adequate data on the functional quality characteristics of local wheat cultivars grown at Khartoum State in recent years calls for a systematic study on the suitability of such wheat for specific end-uses. Thus, the main objectives of the present study were to evaluate the grain quality characteristics of three Sudanese wheat cultivars grown at Khartoum State regarding to their bread making performance.

## MATERIALS AND METHODS

### Materials

Three Sudanese wheat cultivars grown at Khartoum State namely; Elnelain and Nepta obtained from Elsururab (North Omdurman) Agricultural Scheme; Argeen obtained from Sondos Agricultural Project (South Khartoum) for season 2008/2009. Imported Australian wheat was used as control for comparison in this study. The samples were cleaned and the physical characters such as, 1000 kernel weight, hectoliter weight was determined (AACC 2000). The cleaned samples were conditioned (tempered) overnight to a moisture level of 13.5% and milled in Quadrumat Junior Mill (Brabender, GmbH & Co. KG, Duisburg, Germany) to white flour (72% extraction rate), and prepared for chemical analysis and bread making.

### Chemical composition

The determination of moisture, protein and ash were carried out on the samples according to AOAC (1995) standard methods.

### Gluten quantity and quality

Gluten quantity and quality of wheat flours were carried out according to the revised standard ICC method No. 155 and 158 (1995) by using Glutomatic 2200 system (Perten Instruments

AB, Huddinge, Sweden). Ten grams of the sample was 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.

### Falling number

Alpha - amylase activity of wheat flours was determined according to Perten (1996). Appropriate flour sample weight, was weighed and transferred into falling number tube and 25 ml distilled water was added, the stopper was fitted into the top of the viscometer, and shaken well until a homogenous suspension was formed. The viscometer tube was placed in the boiling water bath, and locked into position. The test automatically starts. The sample was stirred for 60 seconds, and then the viscometer stirrer was stopped in up position, released and sunk under its own weight through the uniform gelatinized suspension. The time in seconds for the stirrer to fall through the suspension was recorded as the falling number (seconds), the required flour sample weight (RFW) was obtained from the correction tables of sample weight to 14% moisture basis (Perten, 1996), corresponding to 7g at 14% moisture, no change is made in the quantity of the water used (25 ml).

Calculation --

$$\text{Required Flour Weight (g)} = 7 \times \frac{100 - 14}{100 - \text{Actual moisture content}}$$

### Sedimentation value

Sedimentation value of wheat flours was carried out according to the official standard methods (AACC, 2000). About 3.2 g of fine flour samples were placed in 100 ml glass stoppered graduated cylinder, simultaneously timing started when 50 ml distilled water containing bromophenol blue was added.

Then the flour and water were thoroughly mixed by moving stoppered cylinder horizontally length wise, alternately right and left, through space of 7 In 12 times in each direction in 5 seconds, then flour was completely swept into suspension during mixing. At the end of first 2 min period, the contents were mixed for 30 seconds, in this manner the cylinder was completely inverted then righted up, as if it were pivoted at center, this action was performed smoothly 18 times in the 30 seconds then was let to stand 1.5 min. After that 25 ml of isopropyl alcohol and lactic acid were added, mixed immediately by inverting cylinder four times as the latest step then was let to stand 1.75 min., mixed again for 15 sec, then the cylinder was immediately placed in upright position and let to stand for 5min. The factor to obtain sedimentation value was brought from table on 14% moisture basis, (AACC, 2000).

### Rheological characteristics

Bread dough characteristics of different cultivars were determined according to the method of the ICC (2006) using Barabender Farinograph and Extensograph.

### Baking quality tests

Bread samples were prepared according to the procedure described by Badi et al. (1978). Briefly, the bread making recipe that contained;

flour 250g, salt 2.5g, sugar 2.5g, yeast 2.5g and water based on Farinograph result. The ingredients were mixed in mono-universal laboratory dough mixer at medium speed. The dough was allowed to rest for 5 minutes at room temperature (25°C) and then scaled to three portions (120g each). The three portions were made into round balls and allowed to rest for another 5 minutes and then molded, put into pan and placed in the fermentation cabinet for final proof which varies according to the fermentation power of the different dough's. Baking was done in Simon Rotary Test Oven at 250°C for 13 minutes. After one hour, the loaves were weighed in grams and the volumes were measured in ml using the millet seed displacement method (AACC, 2000).

### Statistical analysis

The analysis of variance (ANOVA) was performed to examine the significant effect in all parameters measured (Mead and Gurnow, 1990). Duncan Multiple Range Test was used to separate the means (Duncan, 1955).

## RESULTS AND DISCUSSION

### Physical characteristics of Sudanese wheat grains

The physical characteristics of the wheat grain cultivars are shown in Table 1. Thousand kernel weights of local wheat cultivar grown at Khartoum state were found to be in the range of 31.7 to 32.9 g. Australian wheat grain had the highest hectoliter weight as well as 1000 kernel weight compared with the local wheat grains investigated. Nepta and Argeen obtained similar values of test weight 81.5 g. Normally higher test weight indicates sound grains. Similarly, Ahmed (1995) and Mutwali (2011) stated that the thousand kernels weight of Sudanese cultivars ranged between 28.0 - 44.0 and 28.7 - 48.5g, respectively. Moreover, Zeleny (1971) found that the thousand kernels weight for hard red spring and hard red winter wheats ranged from 20 to 32g, whereas soft white and durum wheats ranged from 30 to 40g. However, Mohamed (2000) reported that the thousand kernels weight of four Sudanese wheat cultivars Debaira, Elnelain, Condor and Sasaraib ranged between 32 and 38g. On the other hand, hectoliter weight (i.e. test weight) of local wheat grains grown in Khartoum State is ranged from 80.6 to 81.5 kg/hl, whereas hectoliter weight of Australian wheat cultivar was 83.6 kg/hl. This result agreed with those of Mutwali (2011) who stated that the hectoliter weight of 20 Sudanese wheat cultivars grown in north and central Sudan ranged between 76.6 and 85.25 kg/hectoliter. Flour yields of the Australian and Sudanese wheat ranged from 66 to 70%. Elnelain was found to be the highest flour yield (70%). Whereas Nepta resulted in the lowest flour yield (66%) among the wheat grains tested and no significant difference ( $P > 0.05$ ) were found between Elnelain, Argeen and Australian wheat in flour yield. Williams, et al. (1986) 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). Generally immature wheat or wheat affected by drought or diseases is of low density and invariably gives low yields of flour. However, the rounder the kernels, and the smaller the crease, the higher the test weight and flour yield.

### Chemical composition

The data of the chemical characteristics are presented in Table 2. Moisture content of wheat flours was ranged from 13.40 to 13.80%. The moisture content for the wheat was found significantly lower in Nepta (13.40%) and Argeen (13.46%)

Table 1. Physical characteristics and flours yield of the Sudanese and Australian wheat

Cultivars	Test weight (kg/hl)	1000 kernel weight (g)	Patent flour yield (%)
Australian (control)	83.6 <sup>a</sup>	34.8 <sup>a</sup>	67.0 <sup>ab</sup>
Elnelain	80.6 <sup>c</sup>	31.7 <sup>c</sup>	70.0 <sup>a</sup>
Nepta	81.5 <sup>b</sup>	32.9 <sup>b</sup>	66.0 <sup>b</sup>
Argeen	81.5 <sup>b</sup>	32.8 <sup>b</sup>	69.0 <sup>a</sup>

Means values within the column having different superscripts letters are significantly different ( $P < 0.05$ )

Table 2. Chemical characteristics of the Sudanese and Australian wheat flours

Characteristics	Cultivars			
	Elnelain	Nepta	Argeen	Australian
Moisture (%)	13.80 <sup>a</sup>	13.40 <sup>b</sup>	13.46 <sup>b</sup>	13.70 <sup>a</sup>
Ash (%)	0.31 <sup>b</sup>	0.39 <sup>a</sup>	0.32 <sup>b</sup>	0.35 <sup>a</sup>
Protein (%)	9.5 <sup>c</sup>	12.9 <sup>a</sup>	11.3 <sup>b</sup>	12.6 <sup>a</sup>
Wet gluten (g)	22.7 <sup>c</sup>	28.9 <sup>a</sup>	24.2 <sup>c</sup>	33.5 <sup>a</sup>
Falling No. (s)	883 <sup>b</sup>	1032 <sup>a</sup>	955 <sup>b</sup>	1029 <sup>a</sup>
Sedimentation value (ml)	20.0 <sup>b</sup>	20.0 <sup>b</sup>	15.0 <sup>c</sup>	30.0 <sup>a</sup>

Means values within the row having different superscripts letters are significantly different ( $P < 0.05$ )

compared with Elnelain (13.80%) and Australian (13.70%) wheat flours. These results are similar to those of Mutwali (2011) who reported a range of 10.21 to 13.13 for several Sudanese wheat cultivars grown in three different locations. The moisture content of wheat is important for both farmer and miller. Moisture content is greatly affected by relative humidity at harvest and during storage. It is well known that moisture content is one of the most important factors affecting the quality of wheat (Anon 1987). The ash content was found to be ranged from 0.31% for Elnelain to 0.39% for Nepta and no significant difference ( $P > 0.05$ ) were found between Nepta and the Australian; and between Elnelain and Argeen. These results were lower than those reported by Mutwali (2011) who found that the ash content of 20 Sudanese wheat cultivars was ranged between 0.47 to 0.85%. Furthermore, the ash contents in white flour of Pakistani spring wheats cultivars were ranged from 0.41 to 0.55% (Khan et al. 2009). The variation of 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. Ash content has been considered an important indicator of flour quality. It gives some indication of the miller's skill and the degree of refinement in processing and it is directly related to the amount of bran in the wheat, and hence has a rough inverse relationship to flour yield (Zeleny 1971). 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 contents of the wheat flour were ranged from 9.5 to 12.9%. Lowest value (9.5%) of protein was observed in Elnelain cultivar and the highest value (12.9%) in Nepta, while Argeen obtained value of 11.3% of protein showing significant difference ( $P \leq 0.05$ ) compared with the protein content of the Australian wheat flour (12.6%). No significant difference was found between Nepta and the control in protein content. The results of the present study are in consistent with the results reported by Anjum et al. (2005) and Khan et al. (2009) who reported variation in protein content among Pakistani wheat varieties from 9.68 to 13.45 % and from 10.23 to 11.60 %, respectively. Moreover, Mutwali (2011) reported protein content of white flours of 20 different Sudanese cultivars grown in three different locations ranged between 9.59% and 14.06%. The results were also within the optimum range reported by Mailhot and Patton (1988) who stated that flours with protein content between 11- 14% were considered acceptable for bread making. Thus, with regards to protein content Sudanese

wheat cultivars grown at Khartoum state could possibly be used for bread making. 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. Regarding the quality of the protein of local wheat cultivar, the wet gluten values were found to be ranged between 22.7 and 33.5%. The minimum value (22.7%) was found for Elnelain whereas the maximum value (33.5%) was observed for Australian wheat flour. It has recently been reported that the wet gluten content of Pakistani spring wheat cultivars are ranged between 28.47 and 38.83% (Khan et al. 2009). Moreover, Mutwali (2011) reported that the wet gluten value of 20 Sudanese cultivars is ranged between 28.63% and 46.94%. However, Sudanese Standard Specifications (SDS) recommended minimum wet gluten value of 27% for bread making (SDS 036/2007). Only Nepta had wet gluten in the desirable value (28.9%) among Sudanese wheat flour investigated and no significant difference ( $P > 0.05$ ) were found between Nepta and Australian wheat flour in wet gluten content. The high values of falling number for the Sudanese and Australian wheat flours ranged between 883 and 1029 second. Similarly, higher falling numbers in the range of 508.0 to 974.7 sec were reported by Mutwali (2011) for 20 Sudanese wheat cultivars. This higher falling number may be attributed to dry harvest season which consequently affect the activity of alpha-amylase. By contrast Ahmed (1995) showed that the falling number values of some Sudanese wheat cultivars ranged between 396 and 486 seconds. However, Mohamed, (2000) found that the falling number values of four Sudanese wheat cultivars Debaira, Elnelain, Condor and Sasaraib ranged between 425 and 675 seconds. The difference in the falling number of Sudanese wheat in these studies could be attributed to the variation in the genotypes and environmental conditions. The falling numbers above 400 second indicated that the flour is deficient in alpha- amylase and that the flour should be supplemented with a form of amylase to achieve the desirable level of enzyme activity (Cauvain and Young, 2001). The sedimentation values of local Sudanese and Australian wheat flours ranged from 15 to 30 ml. Australian wheat flour had the highest value (30 ml) whereas, Argeen gained the lowest value (15 ml). Recently, Mutwali (2011) reported a range of 19.0 to 40.3 ml for the sedimentation value of 20 Sudanese wheat cultivars grown at three different locations. While, Mohamed (2000) showed that, the sedimentation value of Sudanese wheat cultivars Debaira, Elnelain, Sasaraib, and Condor ranged between 21 and 24 ml. The variation in these results might be due to the variation in the growing seasons and/or conditions. Sedimentation value, however, should be more than 20% for optimum bread making quality (SDS 036/2007). Elnelain and Nepta gave similar values of sedimentation (20 ml) and significant difference ( $P \leq 0.05$ ) was found between them and the Australian wheat flour.

### Rheological and baking characteristics

Rheological and baking characteristics are presented in Table 3. Water absorption values varied between 57.9 and 66.5%. Lower value of water absorption was obtained by Elnelain 57.9% followed by Argeen 62.0% and Nepta 66.4% whereas Australian wheat flour gained the higher value 66.5%. These results were similar to the range 57 to 62% obtained by Mutwali (2011) for Sudanese wheat cultivars grown in three different locations. Optimum water absorption for bread making ranged between 60- 64% (Mailhot and Patton, 1988). Generally high 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. Thus Sudanese wheat cultivars especially Nepta and Argeen could possibly be used for bread making because they showed high water absorption compared to Australian wheat cultivar. Dough development time (DDT) varied between 2.5 and 10.0 min. Australian flour had the highest DDT (10min) while the lowest value (2.5 min) of DDT was obtained by Argeen. However, Nepta and Elnelain obtained DDT values of 6.8 and 3.7 min, respectively. Similarly, Mutwali (2011) reported that the dough development time for Sudanese wheat cultivar is found in

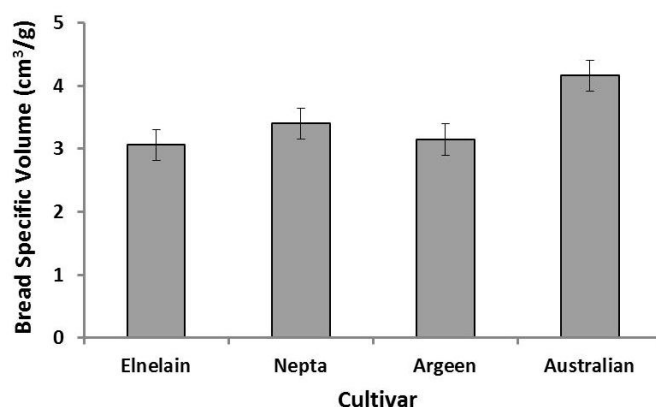
the range of 1.68 to 5.16 min. Dough stability times varied between 1.5 min which was obtained by Argeen and 18 min obtained by Australian while Nepta obtained value of 7.9 min and Elnelain 5.3 min. Recently, it is reported that the dough stability of Sudanese wheat cultivars are ranged between 2.0 and 6.2 minutes (Mutwali 2011). Mailhot and Patton (1988) recommended a minimum dough stability of 7.5min for bread making. Thus, the Sudanese cultivars such as Argeen and Nepta might efficiently be used for bread making. Extensibility and resistance to extension ranged between (142- 202mm) and (160- 346Bu), respectively. William (1970) mentioned that strong wheat has a higher water absorption resistance to extension coupled with good extensibility and a longer dough development time and stability when compared with the weak one.

**Table 3. Rheological characteristics of the flours of Sudanese and Australian wheats**

Characteristics	Cultivars			
	Elnelain	Nepta	Argeen	Australian
Water absorption (%)	57.9 <sup>c</sup>	66.4 <sup>a</sup>	62.0 <sup>b</sup>	66.5 <sup>a</sup>
Dough development time (min)	3.7 <sup>c</sup>	6.8 <sup>b</sup>	2.5 <sup>d</sup>	10.0 <sup>a</sup>
Stability (min)	5.3 <sup>c</sup>	7.9 <sup>b</sup>	1.5 <sup>d</sup>	18.0 <sup>a</sup>
Extensibility (mm)	169 <sup>c</sup>	142 <sup>d</sup>	202 <sup>a</sup>	181 <sup>b</sup>
Resistance to extension (Bu)	246 <sup>c</sup>	304 <sup>b</sup>	160 <sup>d</sup>	346 <sup>a</sup>
Energy (cm <sup>2</sup> )	80 <sup>b</sup>	78 <sup>b</sup>	62 <sup>c</sup>	137 <sup>a</sup>

Means values within the row having different superscripts letters are significantly different ( $P < 0.05$ )

The results of bread specific volume of Sudanese and Australian wheat flours are presented in figure 1. Bread specific volume for Sudanese wheat flour was found to be ranged between 3.06 cm<sup>3</sup>/g for Elnelain cultivar to 3.40cm<sup>3</sup>/g for Nepta compared with the Australian wheat flour which produced the highest bread specific volume (4.16 cm<sup>3</sup>/g). This results are well agreed with those of Mutwali (2011) who reported a range of 2.4 to 3.54 cm<sup>3</sup>/g that the bread specific volume of eight Sudanese wheat cultivars grown at three different location. It is clear that bread of Australian wheat flour has significantly higher specific volume compared to that made from Sudanese wheat cultivars that grown in Khartoum state. Among the Sudanese wheat flour Nepta cultivar has good characteristics that close to Australian wheat cultivar and thus this local cultivar could potentially be used for bread making.



**Figure 1: Bread specific volume of Sudanese and Australian wheat cultivars.**

## CONCLUSION

Generally, the above results clearly indicate that the investigated Sudanese wheat cultivars that grown in Khartoum state are of semi hard to soft types. Of them, Nepta cultivars gave the best characteristics of farinograph,

extensograph and the highest bread specific volume, and thus could efficiently be used for bread making. The other cultivars showed low bread making quality and should be used for making other bakery products. The low bread making quality of these local cultivars shade the light on the need to bread high yielding with high quality and disease resistant cultivars of local wheat.

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