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Optimizing the Bread Formulation of Sudanese Wheat Cultivars

Abu baker B. Makawi[1], Hayat A. Hassan[1], Mohammed I. Mahmood[1], Mohamed M. Eltayeb[2-3], and Isam A. Mohamed Ahmed[2-3-4]

[1]Department of Grain Technology, Food Research Center, Ministry of Science and Technology, Khartoum North, P.O. Box 213, Shambat, Sudan

[2]Department of Food Science and Technology, Faculty of Agriculture, University of Khartoum, Khartoum North, Shambat, Sudan

[3]Department of Agricultural, Biological and Environmental Sciences, Faculty of Agriculture, Tottori University, Koyama, Tottori 680-8553, Japan

[4]Arid Land Research Center, Tottori University, Tottori 680-0001, Japan

ABSTRACT: The objective of this study was to develop an effective bread formulation to achieve high loaf volume with good quality breads for Sudanese wheat cultivars. The response of Sudanese commercial wheat flour to different additives was studied. Alpha amylase, ascorbic acid (AA) and diacetyl tartaric esters of monoglyceride (DATEM) were tested in combination to produce bread with high loaf volume and good quality. Combination of AA (50 ppm) and DATEM (0.25%) with alpha amylase (0.05%) had a marked effect on the dough rheology. Dough development time, water absorption, and stability were reduced considerably. However the degree of softening, resistance to extension and energy were significantly increased. Incorporation of the combined improvers significantly increase the bread specific volume from 2.95 to 3.92 cm^3/g for Argeen, 2.85 to 4.28 cm^3/g for WadiElneel, 2.60 to 4.51 cm^3/g for Nepta, and 3.40 to 5.07 cm^3/g for Australian wheat (control). The high response of the Sudanese wheat flours to the improvers investigated indicated the possibility of producing high loaf volume with good quality breads from Sudanese wheat. However, the overall quality scores showed considerable improvement when these improvers were used in the formula in combination. Further research should be done to encourage using locally available ingredients as bread improvers.

KEYWORDS: Argeen, Dough rheology, Nepta, Sudanese wheat, Wadi Elneel.

1 INTRODUCTION

Wheat cultivars 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 [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 [2]. 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 a visco-elastic dough, which is fermented and baked [3]. 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 [3]. The optional ingredients such as acids, enzymes, surfactants, sugar, milk or milk solids and improvers are included in bread formulation to improve nutritional, sensory and keeping quality of bread [4]. These ingredients also have a significant effect on rheological and bread making properties. The salt imparts flavor, taste and strength to the dough [4]. Fat is used for providing softness to the bread. It acts as a plasticizer, improves volume and imparts antistaling properties to bread. Dairy ingredients are included in bread formulation for nutritional benefits through increasing calcium content and improving protein efficiency ratio. Ascorbic acid is an acceptable oxidizing agent to replace potassium bromate in natural, organic and health breads. Addition of ascorbic acid increased dough strength, reduced dough stickiness [5], improves crust characteristics, and crumb structure and colour [6]. Bread volume is associated with the use of alpha amylase in bread making. Alpha amylase also associated with an improvement of crumb grain, and antistaling effect [7], [8]. Diacetyl tartaric esters of monoglycerides (DATEM) are added to the dough to improve the mechanability of the dough and the quality of the baked product by increasing bread volume [5], [9] and produce finer crumb structure [10]. 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 [11]. 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 [12]. Generally Sudanese wheat cultivars gave dough with relatively low elasticity and low alpha – amylase activity, which results in a low bread volume. Since 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. Thus improvement of flour quality is very essential for production of good quality bread. Therefore, the aim of the present study was to investigate the effect of different improvers on the rheological and bread making properties of three local Sudanese wheat cultivars.

2 Materials And Methods

2.1 Materials

Three commercial Sudanese wheat cultivars namely Nepta, Wadi Elneel, and Argeen (season 2008/2009) were obtained from Dongla Research Station, Elmultaga Research Station, and Khartoum (Sondos Scheme), respectively. Imported Australian wheat was used as control. The wheat grains were milled in Quadrumat junior mill. The patent flour was adjusted to extraction rate of (72%). The produced flour was used for chemical analysis and bread making. Ascorbic acid (AA), diacetyl tartaric esters of monoglycerides (DATEM) and alpha –amylase were obtained from local companies, Khartoum, Sudan.

2.2 Chemical Composition

The determination of moisture, protein and ash were carried out on the samples according to AOAC standard methods [13].

2.3 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 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.

2.4 Falling Number

Alpha – amylase activity of wheat flours with and without improvers was determined according to Perten [15]. 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 shaked 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 sinked 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 [15], corresponding to 7 g at 14% moisture, no change is made in the quantity of the water used (25 ml).
Calculations:

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

2.5 SEDIMENTATION VALUE

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

2.6 FARINOGRAPH AND EXTENSOGRAPH

Brabender farinograph method was carried on wheat flours with and without improvers according to AACC method [16]. Extensograph method was carried out according to the standard method [17].

2.7 BAKING QUALITY TESTS

The dough formulation used in this study were comprised of; flour 250 g, dry yeast 2.5 g, salt 1.5 g, sugar 3 g, oil 1% and water based on farinograph optimum absorption according to Badi *et al*. [18]. 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 ºC) and then scaled to three portions (120 g 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 ºC .Baking time was 13 minutes. After one hour, the loaves were weighed in grams and the volumes were measured in ml using the millet seed displacement method (Volumeter).

2.8 SENSORY EVALUATION

The loaves were sliced with an electric knife and prepared for sensory evaluation at the same day. The sensory evaluation of bread samples (aroma, taste, crumb texture, crumb color, crumb cell uniformity, general acceptability) was carried out by 10 semi trained panelists according to the method of Lwe [19]. The surrounding conditions were kept the same all through the panel test.

2.9 STATISTICAL ANALYSIS

The analysis of variance (ANOVA) was performed to examine the significant effect in all parameters measured [20]. Duncan Multiple Range Test was used to separate the means.

3 RESULTS AND DISCUSSION

3.1 FLOUR CHARACTERISTICS

The chemical characteristics of Sudanese and Australian wheats are presented in Table 1. With exception to Wadi Elneel cultivar, moisture content of Sudanese wheat cultivars (Nepta and Argeen) and Australian wheat cultivars showed insignificant differences. Argeen showed higher (13.66%) moisture content compared to other wheat cultivars including the Australian one. These results are similar to those of Mutwali [21] who reported a range of 10.21 to 13.13 for several Sudanese wheat cultivars grown in three different locations. Whereas, Ahmed [22] reported that the moisture content of

Sudanese wheat cultivars ranged from 6.33 to 8.6%. However, Mohamed [23] found that moisture content of four Sudanese wheat cultivars Debaira, Elneelain, Condor and Sasaraib range between 7.5 and 7.95%. The slight variation of the moisture content between these cultivars could be attributed to the differences in the environmental and soil conditions in wheat production sites as well as variation in genotypes. 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. Since it has direct economic impact, higher moisture content of Sudanese wheat cultivars (Nepta and Argeen) compared to that of Australian wheat might be preferable in milling industry as well as bread making. The ash content of the flour of Australian and Sudanese wheats is shown in Table 1. Analysis of variance indicated that there are insignificant differences between all flours of the cultivars under the study. Ash content of Sudanese wheat flours and Australian wheat is ranged between 0.60% and 0.67%. These results were well agreed with the data reported by Mutwali [21] 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% [24].The variation of these results 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 [25].

Table 1. Chemical characteristics of the Sudanese and Australian wheat flours.

Parameter	Australian	Nepta	Wadi Elneel	Argeen
Moisture (%)	13.30 ^{a}	13.49 ^{a}	12.96 ^{b}	13.66 ^{a}
Ash (%)	0.66 ^{a}	0.67 ^{a}	0.60 ^{a}	0.67 ^{a}
Protein (%)	13.70 ^{a}	13.29 ^{a}	11.610 ^{c}	12.81 ^{b}
Wet gluten (%)	36.00 ^{a}	32.40 ^{b}	30.70 ^{b}	34.80 ^{b}
Dry gluten (%)	12.21 ^{b}	10.80 ^{b}	10.30 ^{b}	11.60 ^{b}
Falling No (sec)	868.00 ^{a}	597.00 ^{b}	471.00 ^{c}	833.00 ^{a}
Sedimentation values (ml)	32.00 ^{a}	21.00 ^{b}	22.00 ^{b}	20.00 ^{b}

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

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 Sudanese wheat flour is ranged between 11.61% and 13.29% (Table 1). Among Sudanese wheat cultivars, Nepta showed the highest protein content (13.29%) whereas Wadi Elneel showed the lowest value (11.61%). The protein content of Nepta cultivar is comparable to that of Australian wheat cultivar (13.70%). The results of the present study lies within the range obtained by Mutwali [21] 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%. Moreover, the current results are in consistent with the results reported by Anjum *et al*. [26] and Khan *et al*. [24] who reported variation in protein content among Pakistani wheat varieties from 9.68 to 13.45 % and from 10.23 to 11.60 %, respectively. The results were also within the optimum range reported by Mailhot and Patton [27] 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 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 30.7and 34.8% (Table 1). The minimum value (30.7%) was found for Wadi Elneel whereas the maximum value (34.8%) was observed for Argeen wheat flour. Australian wheat flour on the other hand showed the maximum (36%) wet gluten compared to Sudanese wheat cultivars. It has recently been reported that the wet gluten content of Pakistani spring wheat cultivars are ranged between 28.47 and 38.83% [24]. Moreover, Mutwali [21] 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 [28]. These results demonstrated that the local cultivars could efficiently be used for bread making as Australian wheat is the major wheat flour used in baking industry in Sudan. Dry gluten values of wheat flours are ranged between 10.30% and 12.21% (Table 1). These results are in a good agreement with range 10.49 to 13.60% of Pakistani spring wheat [24]. Similar results were also obtained by Mutwali [21] who reported that the dry gluten content of Sudanese wheat cultivars grown in three different regions are ranged between 8.96 and 16.76 %. The sedimentation values of local Sudanese and Australian wheat flours ranged from 20 to 32 ml (Table 1). Australian flour had significantly higher sedimentation values (32 ml) fallowed by Wadi Elneel (22 ml), Nepta (21 ml) and lower value by Argeen (20 ml). Recently, Mutwali [21] 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 [23] showed that, the sedimentation value of Sudanese wheat cultivars Debaira, Elneelian, 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 [28]. 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 [29]. The falling number of the three Sudanese cultivars and Australian wheat flours was shown in Table 1. Alpha – amylase activity of the cultivars is found to be in the range of 868 to 471 seconds. Similarly, higher falling numbers in the range of 508.0 to 974.7 sec were reported by Mutwali [21] 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 [22] showed that the falling number values of some Sudanese wheat cultivars ranged between 396 and 486 seconds. However, Mohamed [23] found that the falling number values of four Sudanese wheat cultivars Debaira, Elneelain, 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 [30]. High values of falling number for all cultivars indicated their very low alpha amylase activity. These results bring out the necessity for the use of alpha amylase as one of additives in bread recipe to improve the bread making quality of Sudanese wheat flours.

3.2 Optimizing Bread Improver Recipe

Our preliminary experiments to optimize the bread formulation for Debaira cultivar flour season 2006-2007 (protein 11.2% , falling number 529 sec, sedimentation value 22 ml, and loaf specific volume 3.33 cm^3/g), had shown that the combination of AA(50ppm) and DATEM (0.25%) with alpha- amylase (0.05%) produced bread with significantly higher specific volume of 4.12 cm^3/g (Table 2), hence this form of combination had been used as the optimum improver level in Sudanese wheat cultivars (Nepta, Wadi Elneel, and Argeen) in addition to Australian wheat (control) to evaluate their responses to these improvers.

Table 2. Effects of combinations of dough improvers on average loaf volume (cm^3/g) of Debaira bread

Alpha-amylase (%)	DATEM (%)	AA(ppm)	
		50	100
0.025	0.25	3.89 ^{b}	3.94 ^{ab}
0.050	0.25	4.12 ^{a}	3.87 ^{bc}
0.025	0.50	3.84 ^{c}	3.59 ^{e}
0.050	0.50	3.68 ^{d}	3.92 ^{ab}

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

3.3 Farinogram Characteristics

The farinogram characteristics of the flours tested with and without improvers are presented in Table 3. Water absorption values of the cultivars with and without improvers ranged from 68.4 to 55.9%. The highest value (68.4%) was observed in Nepta without improvers, while the lowest value (55.9%) was found in Wadi Elneel wheat flour with improver. These results were within the range 57 to 62% obtained by Mutwali [21] 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].

Table 3. Farinogram characteristics of the flours of the three local wheat cultivars and Australian wheat flour with and without improvers

Samples	Water absorption (%)	Development time(min)	Stability(min)	Degree of softening(fu)
Australian without improver	67.4	7.3	13.3	36
Australian with improver	61.9	2.2	9.5	56
Nepta without improver	68.4	5.2	6.1	84
Nepta with improver	59.2	1.5	3.2	126
WadiElneel without improver	60.5	5.5	8.5	48
WadiElneel with improver	55.9	1.2	1.6	110
Argeen without improver	63.3	2.5	1.6	99
Argeen with improver	59.3	2.0	1.4	162

Furthermore, these findings were in agreement with that reported by Kaur and Bains [32], and Ravi *et al*. [9]. From the results it is clear that addition of improver to the cultivars exhibited decrease in water absorption compared with the same cultivars without improvers. 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 [33]. The development time of all flour with and without improver were ranged from 7.3 min to 1.2 min (Table 3). These results agreed with the findings of Mutwali [21] who reported that dough development time of Sudanese wheat cultivar in the range of 1.68 – 5.16 min. The Australian wheat without improvers gave the highest value, while Wadi Elneel with improver gained the lowest value. From the present results it is clear that the dough development time was decreased in the flour with improvers. Faubion and Hoseney [34] reported that, the full bread making potential of the dough is attained only at the optimum point of dough development. The dough stability values of all cultivars are ranged from 13.3 to 1.4 min (Table 3). In Sudanese cultivars with and without improver the dough stability was ranged between 9.5 and 1.4 min, whereas that of Australian wheat flour was 13.3 min. Recently, it is reported that the dough stability of Sudanese wheat cultivars are ranged between 6.2 and 2.0 minutes [21]. Compared to Australian wheat the Sudanese wheats showed considerably lower dough stability. It is well known that weak flour gives dough of low elasticity and stability, while the strong flour gives elastic dough with high stability. Mailhot and Patton [27] recommended a minimum dough stability of 7.5 min for bread making. Thus, the Sudanese cultivar such as Wadi Elneel (8.5 min) might efficiently be used for bread making. The degree of softening of all cultivars was ranged from 36 FU to 162 FU (Table 3). Consistent with these results, the degree of softening of Sudanese wheat cultivars is recently reported to be in the range of 301 FU to 62.5 FU [21]. The highest degree of softening was observed for Argeen with improvers, whereas the lowest value was obtained for Australian wheat without improver. Sudanese wheat flours showed significantly higher degree of softening compared to that of Australian wheat flour. This indicated that the Sudanese wheat cultivars are of hard type wheat. Obviously, addition of improvers increased the degree of softening and reduced water absorption, dough development time and stability. This may be due to the incorporation of alpha –amylase in the formula.

Table 4. Extensogram characteristics of the flours of the three local wheat cultivars and Australian wheat flour with and without improvers

Sample	Extensibility (mm)	Resistance to extension	Ratio	Energy(cm2)
Australian without improvers	199	284	2.3	125
Australian with improvers	183	436	4.4	184
Nepta without improvers	141	270	2.4	67
Nepta with improvers	142	302	3.1	81
WadiElneel without improver	148	336	2.9	92
WadiElneel with improvers	158	348	3.7	118
Argeen without improvers	193	134	0.8	46
Argeen with improvers	233	133	0.8	64

3.4 EXTENSOGRAM 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. Table 4.shows the extensogram characteristics of the dough of wheat with and without improvers. With exception of Australian wheat, the extensibility of the dough of all Sudanese cultivars was significantly improved with the addition of the formulated improvers. These results disagree with those of Rao *et al*. [35] who reported a decrease in extensibility with addition of surfactant gels to wheat flour. The variation in these results could be attributed to the differences in genotypes and its nutritional constituents. Uthayakumaran *et al*. [36] reported 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.

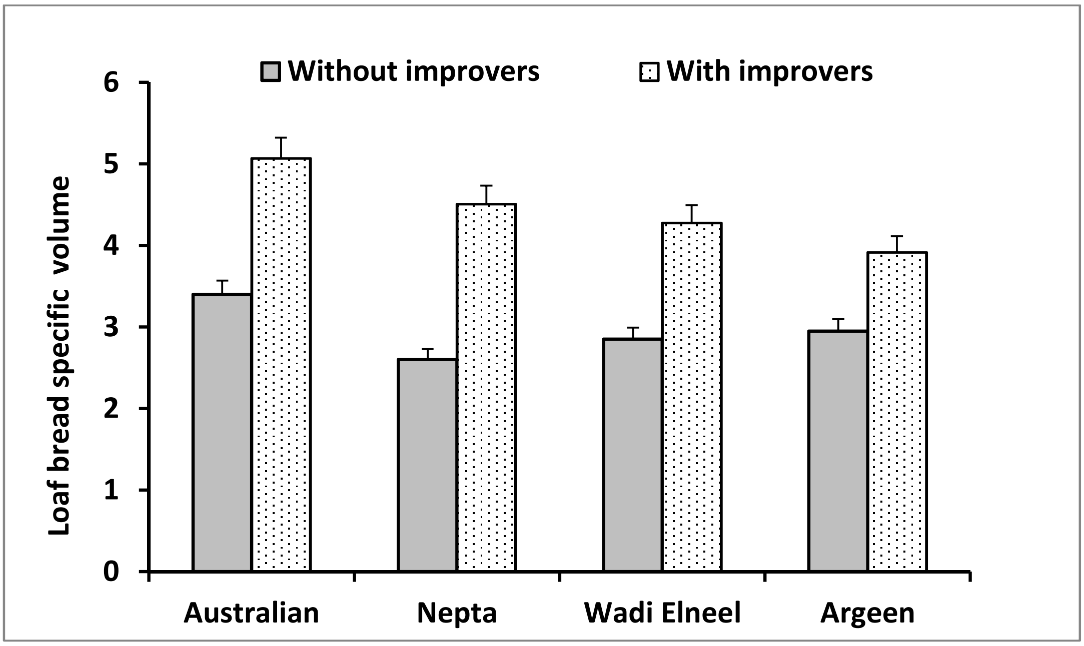

Fig. 1. Loaf bread specific volume (cm^3/g) of Sudanese wheat cultivars and Australian wheat flours with and without improvers

In the flours of all wheat cultivars the resistance to extension of the doughs significantly increased with the addition of bread improvers. This effect is in agreement with study of Rao *et al*. [35] who reported an increase in resistance to extension by addition of guar gum to wheat flour. While the addition of improvers to the same cultivars flours revealed an increase in resistance/ extensibility ratio compared to the cultivars without improvers. Perhaps these improvers contain oxidizing agents causing more s – s groups in the dough resulting in high resistance to extension. Kieffer [37] has published results from comparative investigations of dough rheology and dough yield and he concluded that only resistance is positively related to baked volume. However, the strengthen effect of the improvers indicated by increased energy in all the flours. This may be due to the incorporation of ascorbic acid and DATEM in the formula. The results were in close agreement with the previous findings of Ravi *et al*. [9] and Aamodt *et al*. [5].

Fig. 2. ***loaf bread of Sudanese wheat cultivars and Australian wheat flours with and without improvers***

3.5 Bread Making Quality

The main factor, which places wheat in the front position among the world crops, is its bread-making quality. Wheat is used for several purposes, but the traditional staple food is bread, which is produced in many forms by different processes. The results of loaf bread specific volume made from flours with and without improvers are presented in figure 1. Incorporation of the combined improvers significantly increased the bread specific volume from 2.95 to 3.92, 2.85 to 4.28, 2.60 to 4.51 and 3.40 to 5.07 for Argeen, Wadi Elneel, Nepta and Australian flours, respectively. This results are well agreed with those of Mutwali [21] who reported a range of 2.4 to 3.54 cm3/g that the bread specific volume of eight Sudanese wheat cultivars grown at three different location. These results are also supported by the photos in figure 2, in which it is clearly demonstrated that addition of the formulated improvers significantly enhanced the bread volume. Sudanese wheat cultivars flour produced bread with low specific volume, in spite of their high values of protein (ranged between 11.61 and 13.29%).This confirm the fact that the high protein quantity of Sudanese wheat does not compensate for the poor bread quality , and thus underlines the importance of gluten quality in baking. 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 [39] 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.

3.6 SENSORY EVALUATION

The data on sensory evaluation of the bread made from flours with and without improvers are presented in Table 5. Addition of improvers significantly enhanced the taste preference of all wheat cultivars with the highest being for Australian cultivars and the lowest for Argeen cultivar. In one hand, flavor, crumb texture, crust colour and general acceptability were also significantly improved by the incorporation of the formulated improvers in the bread making flours from all wheat cultivars. Interestingly, the addition of improvers to the flours enhanced all the sensory characteristics of the bread compared to the wheat flour without improvers. Similar findings have been reported by Junge *et al*. [10], Yamada and Preston [6], Ravi and Rao [40], and Ravi *et al*. [9] who observed that addition of improvers to various wheat flours significantly enhanced the sensory attributes of the bread.

Table 5. Sensory evaluation of the bread made from the three local wheat cultivars and Australian wheat flour with and without improvers

Sample	Taste	Flavour	Crumb texture	Crust colour	General acceptability
Australian without improvers	5.14^{d}	5.14^{d}	5.42^{d}	5.28^{d}	5.42^{d}
Australian with improvers	8.28^{a}	8.42^{a}	8.14^{a}	8.28^{a}	8.28^{a}
Nepta without improvers	4.42^{e}	4.14^{e}	3.71^{e}	4.28^{e}	4.28^{d}
Nepta with improvers	7.57^{ab}	6.71^{b}	7.14^{b}	7.00^{c}	6.85^{b}
WadiElneel without improver	4.42^{e}	4.28^{e}	3.71^{e}	3.85^{f}	4.00^{d}
WadiElneel with improvers	7.28^{b}	6.57^{bc}	6.71^{c}	5.28^{d}	6.14^{b}
Argeen without improvers	4.14^{e}	4.00^{e}	4.00^{de}	3.85^{f}	4.14^{d}
Argeen with improvers	6.42^{c}	6.00^{c}	5.71^{d}	7.14^{b}	5.91^{c}

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

4 CONCLUSIONS

The results clearly revealed that the Sudanese wheat cultivars investigated are of poor bread making quality in spite of their relatively high protein values due to their low gluten strength as indicated by their lower sedimentation values and loaf specific volume. The high response of the Sudanese wheat flours to the improvers investigated indicated the possibility of producing high loaf volume with good quality breads from Sudanese wheat. Further research should be done to encourage using locally available ingredients as bread improvers.

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