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Characterization and improvement of flours of Sudanese wheat cultivars for flat bread making

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ABSTRACT: The aim of this study was to characterize and improve the flour of three Sudanese wheat cultivars for bread making. Three local wheat cultivars; Debaira, Wadi Elneel, and Elneelain, and Canadian wheat (as control) were treated with three improvers: Alpgida (A), Samabeel (S), and Zena (Z). The results showed significant ($P \leq 0.05$) difference in the quality tests among the flours and breads made from the three local cultivars and Canadian wheat flours. The local cultivars found to contain low alpha-amylase activity (676 to 486sec), sedimentation value(19.6 to32.3cm^3), Pelshenke test value (28.8 to 49.2min), water absorption(63.9 to 66.0%), resistance (140 to 208cm), extensibility(120 to 183mm), and high degree of softening(85 to 106FU). However the Canadian wheat cultivar was found to contain low alpha-amylase activity (603sec),water absorption (61.3%), degree of softening (38FU), relatively high sedimentation value (37.4cm^3), resistance (252cm), extensibility (235mm), and high Pelshenke test value(92.1 min). Addition of improvers to the three local cultivars and Canadian wheat flours significantly ($P \leq 0.05$) affected the quality tests with the exception of sedimentation value. Sensory evaluation of flat bread showed thatflat bread made from Debaira cultivar with S improver gained the highest score of general acceptability (8.0). Generally, Debaira cultivar showed better bread making quality as compared with the other two local cultivars.
Keywords: Bread-making, Debaira, Elneelain, Sudanese wheat, Wadi Elneel.

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 (Triticum aestivum) is the most important crop for making bread, due to its absolute baking performance in comparison to all other cereals (Dewettinck et al., 2008). 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 micro-organisms are mixed into visco-elastic dough, which is fermented and baked (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 optimize their functionality in bread making (Goesaert et al., 2005).Flat breads are oldest, most diverse, and most popular product in the world. It is estimated that over 1.8 billion people consume various kinds of flat breads all over the world. The popularity of these traditional breads is growing due to ethnic population, higher demand for exotic, healthy and natural breads (Qarooni, 1996).Qarooni (1996) defined flat breads in two groups as one (single) layered or two (double) layered and he made another two sub-groups for one (single) layered flat bread as leavened and unleavened (risen by a process of yeast fermentation).Two-layer flat bread is widespread in Middle Eastern and North African countries (Paulley et al. 1998), and is becoming increasingly popular in western countries.Two-layer flat bread is commonly produced from high extraction flour, making it likely to find widespread acceptance as a high dietary fibre food (Izydorczyk et al., 2008). 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 (Ishag, 1994). The consumption of wheat flat 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 (Edema et al., 2005). 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. Hence 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 compared with Canadian wheat.

Materials and methods

Materials

Three Sudanese wheat cultivars (Elneelian, Debaira, and Wadi Elneel) and one Canadian wheat cultivar were obtained from Hudieba Research Station and Wheata flour mill (Khartoum, Sudan), respectively. The samples were cleaned and the physical characters such as, 1000 kernel weight, hectoliter weight was determined. Then wheat grains were 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.

Three types of bread improvers: Z Zena (Zena, Khartoum North), A Alpgida (Healthcare) and S Samabeel (Samabeel Int. Ltd. Co., Khartoum, Sudan) were obtained from the local market (Khartoum, Sudan) and used according to the manufactures recommendation.All chemicals and reagents were of analytical grade.

Proximate composition analysis

The determination of moisture, fiber, fat, protein and ash were carried out according to AOAC (1990) methods.

Determination of 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 (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 with and without improvers 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 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 (Perten, 1996), corresponding to 7g at 14% moisture, no change is made in the quantity of the water used (25 ml).
Calculations:

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

Sedimentation value

Sedimentation value of wheat flours with and without improvers 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 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).

Pelshenke test

Pelshenke test was carried on wheat flours with and without improvers according to AACC method (2000). Approximately 4g of each sample were blended and weighed using quadruplicate one pair on each of two different days, the sample of two different days were put into 150 ml low form beaker. Then, 2.25 ml of yeast suspension were mixed with meal via stirring rod. The resulting mass was then transferred to palm of hand, kneaded, round meal ball, replaced in a beaker and covered with 80 ml water (30 °C). The time of immersion was noticed and the beaker was transferred to a constant temperature cabinet, the time was noted when ball started to disintegrate as time in min. The yeast suspension was made up daily (in the two days) by suspending 10 g fresh compressed yeast in 100 ml water.

Farinograph

Brabender farinograph method was carried on wheat flours with and without improvers according to AACC method (2000). 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 cleaned mixer. The farinogragh was switched on 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 farinogragh 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

Extensograph method was used according to ICC method (2001). 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.

Preparation of flat bread

The procedure described by Qarooni et al (1993) was modified for this type of bread. Bread improvers A, S, and Z were added at 0.025, 0.05, 0.06 g respectively. Dry ingredients (flour 250 g, sugar 2.5 g, salt 2.5 g and dry yeast 5 g), were mixed for 1 min. using Mono – Universal laboratory dough mixer. Water was added and mixed for 6 min at medium speed. The optimum amount of water was determined using the formula of Quarooni (1989) and Qarooni et al., (1993), with some modifications (baking absorption % = 20 + 0.596 × optimum water absorption from the farinograph). After 1 h of bulk fermentation at 30°C and 85% relative humidity the dough was divided into pieces of 60 g, rounded by hand, covered and allowed to relax for 15 min in the fermentation cabinet. Dough pieces were flattened by hand and cross sheeted (0.8 mm thickness). All sheeted doughs were put on a wooden board and transferred into the proofing cabinet for 30 min at 30°C and 85% relative humidity. The proofed pieces were put on a preheated solid aluminum tray and baked at 400°C for 2 min, instead of 425°C for 100 seconds.

Physical characteristics of flat bread

Flat bread was evaluated for thickness (cm). Diameter (cm).Three breads were used for the evaluation, the average was noted.

Sensory evaluation of flat bread

The bread pieces were prepared for sensory evaluation same day. The sensory evaluation of bread samples (aroma, taste, crust color and general acceptability) was carried out by 10 panelists semi trained. The surrounding conditions were kept the same all through the panel test.

Statistical analysis

The analysis of variance (ANOVA) was performed to examine the significant effect in all parameters measured (Gomez and Gomez, 1984). Duncan Multiple Range Test was used to separate the means (Duncan, 1955).

Results And Discussion

Chemical composition

The results on the chemical composition of the three local commercial wheat cultivars (season 2003/2004) and Canadian wheat is shown in Table 1. The moisture content of the wheat flour (72% extraction rate) of the three local wheat cultivars ranged from 11.50 to 12.07% compared to 10.4% of Canadian wheat. Analysis of variance showed significant differences ($P \leq 0.05$) among the three Sudanese cultivars in their moisture content. Debaira showed the highest value, while Elneelain gained the lowest value. The results obtained here were higher than values obtained by Ahmed (1995) who reported that, the moisture content of Sudanese wheat cultivars ranged from 6.33 to 8.6%. The lower moisture content values may be due to the dry season in which wheat cultivars were grown.Ash content of whole and white flours of the local wheat cultivars ranged from 1.63 to 1.51% and 0.55 to 0.41% respectively. These results were in agreement with the data reported by Zeleny (1971) who found that the ash content of the whole wheat flour was in the range of 1.4 to 2.0%.The ash content of Debaira, Wadi Elneel and Elneelain was higher than those reported by Elagib (2002) who found that, ash content for the same cultivars as 1.45, 1.40 and 1.0, respectively. This difference could be due to seasonal variation. Statistical analysis of the results showed significant difference ($P \leq 0.05$) among flours (100% extraction rate) and wheat flours (72% extraction rate) in their ash content of the three local cultivars. Protein contents of the whole flours and white flours of three local wheats ranged from 12.6 to 16.1% and 10.77 to 13.57%, respectively. 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. The results also are comparable with the data reported by Mohamed (2000) who reported, that protein content of white flour of different Sudanese cultivars ranged between 11.79 and 13.85, but, it showed high variation from that reported by Elagib (2002) who found that the protein content of whole flour of different Sudanese cultivars ranged between 9.37 and 11.17%. This may be due to variations in the growing conditions. Analysis of variance showed significant differences ($P \leq 0.05$) among the whole and white flours of the three local cultivars in their protein content. Fat contents of the whole and white flours of the local cultivars ranged from 1.55 to 1.78% and 1.04 to 1.22%, respectively. These values agreed with the results reported by Ahmed (1995) who found that fat content of white flour of the Sudanese wheat cultivars ranges between 0.85 and 1.73%. But, it showed some variation from that reported by Elagib (2002) who stated that, fat content of Debaira and

Elneelain cultivars was 2.0 and 1.8% respectively. Analysis of variance showed significant differences ($P \leq 0.05$) among the whole and white flours of the local cultivars in their fat content. Fibre contents of the whole and white flours of the local cultivars ranged from 1.74 to 1.86% and 1.06 to 1.15, respectively. These results are comparable with those reported by Ahmed (1995) and Mohamed (2000) who found that the fiber contents for whole wheat flours were in the range of 1.75 to 2.34% and 1.85 and 2.25%, respectively. Statistical analysis of results showed insignificant differences ($P \geq 0.05$) among the whole and white flours of the local cultivars in their fiber content. Generally, local wheat cultivars showed superior results of moisture, ash and fat compared to that of Canadian wheat. Among the Sudanese local varieties, Debaira cultivars is superior to others varieties because it showed the highest values of moisture, protein, ash and fat contents.

Gluten quantity and quality

Gluten values (wet, dry and gluten index) of the three Sudanese cultivars and Canadian wheat flours with and without improvers were shown in Table 2. Wet gluten contents ranged from 40.0 to 24.6%. Similarly, it has recently been reported that the wet gluten content of Pakistani spring wheat cultivars are ranged between 38.83 and 28.47% (Khan et al. 2009). Moreover, Mutwali (2011) reported that the wet gluten value of 20 Sudanese cultivars is ranged between 46.94% and 28.63%.The Canadian wheat flour with A improver gave the highest value, whereas the lowest value was observed in Elneelain with A improver. The wet gluten of Debaira cultivar (37.60%) without improver is higher ($P \leq 0.05$) than those of other local cultivars, Elneelain (31.05%) and Wadi Elneel (28.05%), and was close to that of Canadian wheat flour (39.10%) without improver. Furthermore, addition of improvers showed similar enhancement of the wet gluten content of Debaira and Canadian wheat flours. This result demonstrated that the local cultivar Debaira could efficiently be used for bread making as Canadian wheat is the major wheat flour used in baking industry in Sudan. Dry gluten values of wheat flours with and without improvers were ranged from 14.0 to 7.97%. These results are in a good agreement with range 10.49 to 13.60% of Pakistani spring wheat (Khan et al. 2009). Similar results were also obtained by Mutwali (2011) 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 Canadian wheat without improvers gained the highest values, while Elneelain with A improver gained the lowest value. Within the local varieties the highest dry gluten content was observed in Debaira wheat flour, whereas, the lowest dry gluten content was recorded for Elneelain cultivar. It is worth to note that, addition of improvers has insignificant effect of the dry gluten values of all wheat cultivars. The Gluten Index (GI) is a method of analyzing wheat protein that provides simultaneous determination of gluten quality and quantity (AACC 2000). Gluten index values of Sudanese and Canadian wheat cultivars and were found to be in the range of 93.34 to 64.53%. These results agreed with those of Mutwali (2011) who reported a range of 36.4 to 92.8% for gluten index of 20 Sudanese wheat cultivars from three different locations. Canadian wheat flour without improvers gained the highest value, whereas the lowest value was gained by Elneelain without improvers. Among the Sudanese wheat cultivars, Debaira cultivar without improver showed highest gluten index (86.71%) followed by Wadi Elneel (81.80%) and then Elneelain (64.53%). Although, addition of improvers reduced the gluten index of Canadian and Debaira wheat flours, it is however on the other hand, increased the gluten index of Wadi Elneel and Elneelain cultivars. Throughout all improvers, the improver S gave the best results of gluten index all cultivars compared to other improvers. It is worth to note that the gluten index of Sudanese local varieties is within the optimal range (55-100) for bread making. According to Curic et al. (2001) gluten index in the range of 75-90% provides the optimal bread making quality for Central European cultivars. Whereas, in Israel, grains with gluten index lower than 40 are restricted to animal feed, hence their price is lower than for bread making grains. In addition, there are penalties for the 40–55 gluten index class, while the 55–100 gluten idex class is considered suitable for bread making (Har Gil et al. 2011) Generally, analysis of variance showed significant differences ($P \leq 0.05$) among the four cultivars with and without improvers in their wet, dry and gluten index values. Debaira gained the higher values of Sudanese cultivars followed by Wadi Elneel and then Elneelain; this is due to the difference in their protein content and quality. From the gluten quality results, it could be assumed that the wheat variety Debaira possessing higher wet and dry gluten content may have better potential for bread making and should be used to explicit its potential in the development of new varieties by the wheat scientists.

Falling number (seconds)

The falling number of the three Sudanese cultivars and Canadian wheat flours with and without improvers was shown in Table 2. Alpha – amylase activity of the cultivars with and without improvers is found to be in the range of 676 to 396 seconds. Extremely 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. Debaira without improvers gained the highest value (low alpha-amylase activity), whereas Elneelain with S improver gained the lowest value (high alpha – amylase activity). Statistical analysis revealed highly significant differences ($P \leq 0.05$) among the four cultivars with and without improvers, in their falling number values. From these results it could be observed that the values of falling number of the four cultivars without improvers, were relatively high (low alpha – amylase activity), and this may be attributed to dry harvest time. It was also observed that the addition of improvers increase the alpha-amylase activity, perhaps these improvers contain alpha – amylase enzyme. Generally, Debaira cultivar showed the highest values of falling number (low alpha – amylase activity) among the four cultivars. S improver gave the best result (high alpha – amylase activity) compared with the other two improvers.

Sedimentation value (cm^3)

Sedimentation values of the three Sudanese cultivars and Canadian wheat flour with and without improvers were shown in Table 2. Sedimentation values of the four cultivars with and without improvers ranged from 37.4 to 19.6 (cm^3). Similarly, 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, Elneelian, Sasaraib, and Condor ranged between 21 and 24 cm^3. These results showed variation from those reported by Elagib (2002) who found that sedimentation values for the same local cultivars ranged from 13.67 to 19.07 cm^3, this may be due to the variation in the growing seasons and/or conditions. Canadian wheat without improvers gave the highest value, while Elneelain without improvers gave the lowest value. The present result indicated that the sedimentation values among the four cultivars were not affected by the addition of improvers. Generally, Debaira revealed the highest values of sedimentation compared with Wadi Elneel and Elneelain cultivars. These results showed variation from those reported by Elagib (2002) who found that sedimentation values for the same local cultivars ranged from 13.67 to 19.07 cm^3, this may be due to the variation in the seasons.

Pelshenke test

The Pelshenke test of the three Sudanese cultivars and Canadian wheat flours with and without improvers was shown in Table 2. The values of Pelshenke test of the four cultivars with and without improvers ranged from 103.4 to 28.8 min. Slightly similar observation was reported by Khan et al. (2009) who found the Pelshenke value of Pakistani spring wheat ranged from 51.04 to 150.12 minutes. The Canadian wheat with S improver gained the highest value, whereas, Elneelain without improvers gained the lowest value. Analysis of variance showed significant difference ($P \leq 0.05$) among the four cultivars with and without improvers in their pelshenke test values. From these results it could be observed that the values of pelshenke test of the four cultivars indicated the positive effect of adding improvers. S improver gave the best result compared with the other two improvers. Debaira gained the highest value among the Sudanese cultivars studied.

Farinogram Results

The farinogram results of the flours of the three Sudanese cultivars and Canadian wheat with and without improvers are shown in Table 3. Water absorption values of the cultivars with and without improvers ranged from 66.0to59.7%.The highest value was observed in Debaira without improvers, while the Canadian wheat with S improver gained the lowest value. 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, comparing the Canadian to Sudanese wheat flours (control) the water absorption for Canadian wheat flour is lower than Sudanese wheat flours, this may be due to the difference in milling system between Sudanese and Canadian wheat flours. Dough development time was found to be in the range of 7.8 to 1.5 min. The Canadian wheat without improvers gave the highest value, while Elneelain with A improver gained the lowest value. From the present results it is clear that the dough development time was decreased in the flour without improvers with low protein content, these results were in general agreement with the findings of Anaka and Tipples (1979) who reported that, dough development time decreases in the flour with low protein content. The dough stability values ranged from 17.8 to 1.1 min. The highest value was observed in the Canadian wheat with Z improver, whereas the lowest value was observed in Elneelain with A improver. The degree of softening values was found to be in the range of 205 to 23 F.U. Elneelain with A improver gave the highest degree, whereas the Canadian wheat with Z improver gave the lowest degree.

Extensogram Results

The extensogram results of the flours of the three Sudanese cultivars and Canadian wheat with and without improvers are showed in Table 4. Flour cultivars with improvers exhibited an increase in the energy and resistance at 45 min, 90 min, 135 min, compared to the cultivars without improvers. The energy of the Canadian wheat flour is quite higher than that of Sudanese wheat. However, among the Sudanese wheat flours the Debaira cultivar showed the highest energy compared to the other cultivars. From the present results, using S improver with the four cultivars flours showed higher values of energy at 45 min, 90min, 135 min compared with cultivars without improvers and with the other two improvers. The results also showed that as the fermentation time increased the resistance values of the four cultivars with and without improvers increased. Generally, the addition of improvers to the four cultivars flours showed decrease in extensibility at 45 min, 90min, 135 min compared with cultivars without improvers. 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 (2003) has published results from comparative investigations of dough rheology and dough yield and he concluded that only resistance is positively related to baked volume.

Physical characteristics of flat bread

Characteristic of flat bread of the three Sudanese cultivars and Canadian wheat flour with and without improvers is shown in Table 5 and Figure 1. Diameter (cm) values of the four flours bread with and without improvers ranged from 14.80 to 12.77 cm. The Canadian wheat with A improvers gave a higher value, with no significant difference ($P \geq 0.05$) compared with Elneelain with A improver. While Debaira with S improver gave a lower value, with no significant difference compared with Wadi Elneel with S improver. Generally, Elneelain gained the higher values of diameter compared with the other two Sudanese cultivars. Treatment with A improver gave the best results compared with the other two improvers. Thickness (cm) values of the four flours bread with and without improvers ranged from 1.613 to 0.4233 cm. Debaira with S improver gave the highest value. Whereas Elneelain without improvers gave the lowest value. Generally, Debaira gained the higher values of thickness compared with the other two Sudanese cultivars. Treatment with S improver gave the highest value compared with the other two improvers.

Sensory evaluation of flat bread

The aroma scores of flat bread made from three Sudanese cultivars and Canadian wheat flours with and without improvers are shown in Table 6. The scores of bread aroma are found to be in the range of 8.3 to 4.9. The aroma score of bread made from Debaira with Z improver gained a higher value but with no significant difference ($P \geq 0.05$) compared with bread made from the same cultivar with S improver, and with bread made from Canadian wheat with A improver. While the aroma score of bread made from Debaira with A improver gained the lowest value.The scores of bread taste ranged from 8.2 to 4.9. The taste score of bread made from Debaira with S improver gained a higher value, showing insignificant difference ($P \geq 0.05$) compared with bread made from the same cultivar with Z improver, and with bread made from Canadian wheat with A improver. Whereas, taste of bread made from Elneelain without improvers gained the lowest value. The scores of bread crust color are found to be in the range of 8.0 to 3.8. A higher crust color was gained by bread made from Debaira with Z improver, forming insignificant difference ($P \geq 0.05$) with bread made from the same cultivar with S improver, breads made from the Canadian wheat flour with A and S improvers and breads made from Wadi Elneel with A and without improvers. While crust color of bread made from Debaira with A improver gained the lowest value. The scores of general acceptability for breads ranged from 8.1 to 4.3. The highest score of general acceptability was gained by bread made from the Canadian wheat with A improver, with no significant difference ($P \geq 0.05$) compared with breads made from Debaira with S and Z improver and bread made from Wadi Elneel without improver. Whereas the lowest score of general acceptability was gained by bread made from Debaira with A improver. Generally, the results showed the ability of Sudanese cultivars in making flat bread. Debaira gave higher values of general acceptability among local cultivars when treated with Z and S improvers.

Table 1. Chemical composition of the flours of the three local wheat cultivars (harvested season 2003/2004) and Canadian wheat flour (72% extraction rate).

Cultivar	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	Fibre (%)
Canadian	10.40^{c}	14.36^{a}	0.35^{c}	1.01^{c}	1.12^{a}
Debaira	12.07^{a}	13.57^{b}	0.55^{a}	1.22^{a}	1.08^{a}
Wadi Elneel	11.50^{b}	11.97^{c}	0.41^{b}	1.13^{b}	1.15^{a}
Elneelain	12.00^{a}	10.77^{d}	0.50^{a}	1.04^{c}	1.06^{a}

Mean values having different superscript letter in each column differ significantly at ($P \leq 0.05$) using Duncan's Multiple Range Test (DMRT).

Conclusions

From this work it could be concluded that, the addition of improvers showed positive effect on rheological properties of the cultivars investigated. Cultivar Debaira gave the best flour quality for flat bread-making compared with the other local cultivars investigated. This study revealed the ability of producing good flat bread from Sudanese cultivars. The most convenient improver for flat bread is improver S. Further studies shall specifically focus on the production of suitable improvers to increase the bread making quality for the local wheat cultivars.

Table 2. Gluten quantity and quality, falling number, pelshenke test and sedimentation value of the three Sudanese wheat cultivars and Canadian wheat flours with and without improvers

Cultivar	Improver	Gluten quantity and quality			Falling No. (sec.)	Pelshenke test (min.)	Sedimentation value (cm^{3})
		wet gluten %	Dry gluten %	Gluten index %			
Canadian	Control	39.10^{ab}	14.00^{a}	93.34^{a}	602.7^{c}	92.10^{c}	37.40^{a}
	Z	39.75^{ab}	13.65^{b}	87.93^{bc}	546.7^{e}	97.00^{b}	37.40^{a}
	A	40.00^{a}	13.90^{ab}	84.13^{cdef}	525.0^{f}	98.17^{b}	37.40^{a}
	S	39.60^{ab}	13.70^{b}	91.17^{ab}	467.3^{i}	103.4^{a}	37.40^{a}
Debaira	Control	37.60^{c}	12.75^{c}	86.71^{cd}	676.0^{a}	49.23^{h}	32.30^{b}
	Z	39.10^{ab}	12.80^{c}	82.65^{ef}	647.3^{b}	57.13^{f}	32.30^{b}
	A	38.85^{b}	12.65^{c}	83.14^{def}	517.0^{fg}	65.33^{e}	32.30^{b}
	S	39.05^{ab}	12.75^{c}	86.42^{cde}	466.7^{i}	69.23^{d}	32.30^{b}
Wadi Elneel	Control	31.05^{d}	10.20^{e}	81.80^{f}	595.0^{c}	40.63^{i}	27.90^{c}
	Z	31.00^{d}	10.30^{e}	82.27^{f}	583.0^{d}	49.93^{h}	27.90^{c}
	A	30.80^{d}	10.35^{e}	81.99^{f}	513.7^{g}	52.97^{g}	27.90^{c}
	S	31.35^{d}	11.35^{d}	83.26^{def}	412.0^{j}	56.23^{f}	27.90^{c}
Elneelain	Control	28.05^{e}	8.90^{f}	64.53^{i}	486.3^{h}	28.83^{l}	19.60^{d}
	Z	26.70^{f}	8.60^{g}	71.51^{h}	485.3^{h}	29.50^{l}	19.60^{d}
	A	24.60^{g}	7.97^{h}	70.95^{h}	405.3^{j}	31.50^{k}	19.60^{d}
	S	28.50^{e}	8.39^{g}	78.05^{g}	396.3^{k}	34.57^{j}	19.60^{d}

Mean values having different superscript letter in each column differ significantly at ($P \leq 0.05$) using Duncan's Multiple Range Test (DMRT).

Table 3. Effect of bread improvers on farinogram readings of the three Sudanese wheat cultivars and Canadian wheat flours.

Cultivar	Improver	Water absorption corrected to14%	Dough Stability (min)	Dough development time (min)	Degree of softening (ICC), FU
Canadian	Control	61.3	17.1	7.8	38
	Z	60.5	17.8	2.5	23
	A	60.0	14.4	3.7	35
	S	59.7	14.8	3.0	34
Debiara	Control	66.0	2.7	4.5	95
	Z	65.1	4.0	4.8	120
	A	63.5	4.1	3.8	128
	S	62.7	4.4	3.2	126
Wadi Elneel	Control	64.4	3.2	4.0	85
	Z	63.4	4.3	4.3	106
	A	62.5	3.6	2.0	147
	S	62.1	2.8	1.7	160
Elneelain	Control	63.9	2.6	3.0	106
	Z	63.3	2.2	1.7	155
	A	62.7	1.1	1.5	205
	S	61.6	1.2	1.7	192

Each value is the mean of triplicate samples.

Table 4. Effect of bread improvers on Extensogram readings of the three Sudanese wheat cultivars and Canadian wheat flours:

Cultivar	Improver	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
Canadian	Control	153	139	151	252	277	290	235	207	209	2.1	2.5	2.7
	Z	176	187	186	390	666	813	189	145	138	4.0	7.0	7.4
	A	181	181	165	366	547	594	199	164	146	3.6	5.3	6.4
	S	207	177	185	401	600	664	202	148	152	4.0	6.7	6.6
Debiara	Control	68	73	72	191	191	188	183	194	191	1.4	1.4	1.4
	Z	115	113	129	290	342	426	187	162	154	2.5	3.3	4.2
	A	103	107	122	257	294	314	183	170	180	2.3	2.9	3.0
	S	145	167	162	306	413	444	198	181	170	2.9	4.1	4.5
Wadi Elneel	Control	48	49	51	208	210	227	137	139	137	1.7	1.7	1.9
	Z	64	76	74	279	395	506	131	119	102	2.7	4.0	5.6
	A	66	72	74	258	308	350	140	132	124	2.4	3.2	3.8
	S	69	79	75	256	325	396	146	136	118	2.5	3.3	4.2
Elneelain	Control	27	31	32	140	152	162	120	129	126	1.2	1.2	1.4
	Z	43	39	36	246	363	410	110	81	71	2.5	4.6	5.8
	A	44	47	39	200	329	330	128	102	91	2.0	3.6	3.8
	S	47	41	42	230	326	378	123	93	88	2.3	3.8	4.5

Each value is the mean of triplicate samples.

Table 5. Physical characteristics of flat breads made from the three Sudanese wheat cultivars and Canadian wheat flours with and without improvers.

Cultivar	Improver	Diameter (cm)	Thickness (cm)
Canadian	Control	14.27^{b}	0.9400^{bc}
	Z	14.21^{bc}	1.017^{bc}
	A	14.80^{a}	0.6133^{fg}
	S	13.89^{de}	1.070^{b}
Debiara	Control	13.27^{f}	0.7800^{de}
	Z	13.68^{e}	1.067^{b}
	A	13.93^{d}	0.9333^{c}
	S	12.77^{g}	1.613^{a}
Wadi Elneel	Control	14.21^{bc}	0.6700^{ef}
	Z	13.78^{de}	0.6433^{f}
	A	13.86^{de}	0.7867^{de}
	S	12.83^{g}	0.9900^{bc}
Elneelain	Control	14.00^{cd}	0.4233^{h}
	Z	14.23^{b}	0.6733^{ef}
	A	14.67^{a}	0.5000^{gh}
	S	13.13^{f}	0.8900^{cd}

Mean values having different superscript letter in each column differ significantly at ($P \leq 0.05$) using Duncan's Multiple Range Test (DMRT).

Table 6. Sensory evaluation of flat bread made from the three Sudanese wheat cultivars and Canadian wheat flours with and without improvers.

Cultivar	Improver	Aroma	Taste	Crust color	General acceptability
Canadian	Control	5.9^{defg}	5.9^{def}	5.3^{cd}	6.2^{def}
	Z	5.4^{fgh}	5.7^{efg}	5.2^{cd}	5.3^{fg}
	A	8.1^{a}	8.0^{a}	7.3^{ab}	8.1^{a}
	S	7.0^{bc}	6.8^{bcd}	7.3^{ab}	$7.^{1bc}$
Debaira	Control	5.9^{defg}	6.1^{cdef}	5.6^{cd}	6.2^{def}
	Z	8.3^{a}	7.5^{ab}	8.0^{a}	7.5^{ab}
	A	4.9^{h}	5.4^{efg}	3.8^{e}	4.3^{h}
	S	7.8^{ab}	8.2^{a}	7.7^{a}	8.0^{a}
Wadi Elneel	Control	6.3^{cdef}	7.0^{bc}	7.4^{ab}	7.5^{ab}
	Z	6.8^{ed}	6.2^{cdef}	6.8^{b}	6.6^{cde}
	A	6.6^{cd}	6.8^{bcd}	7.2^{ab}	6.9^{bcd}
	S	6.4^{cde}	6.0^{cdef}	5.6^{cd}	5.8^{efg}
Elneelain	Control	5.2^{gh}	4.9^{g}	4.8^{d}	6.2^{def}
	Z	5.5^{efgh}	5.2^{fg}	5.5^{cd}	5.1^{gh}
	A	5.5^{efgh}	6.0^{cdef}	5.8^{c}	6.1^{def}
	S	6.2^{cdef}	6.3^{cde}	5.8^{c}	5.9^{efg}

Mean values having different superscript letter in each column differ significantly at ($P \leq 0.05$) using Duncan's Multiple Range Test (DMRT).

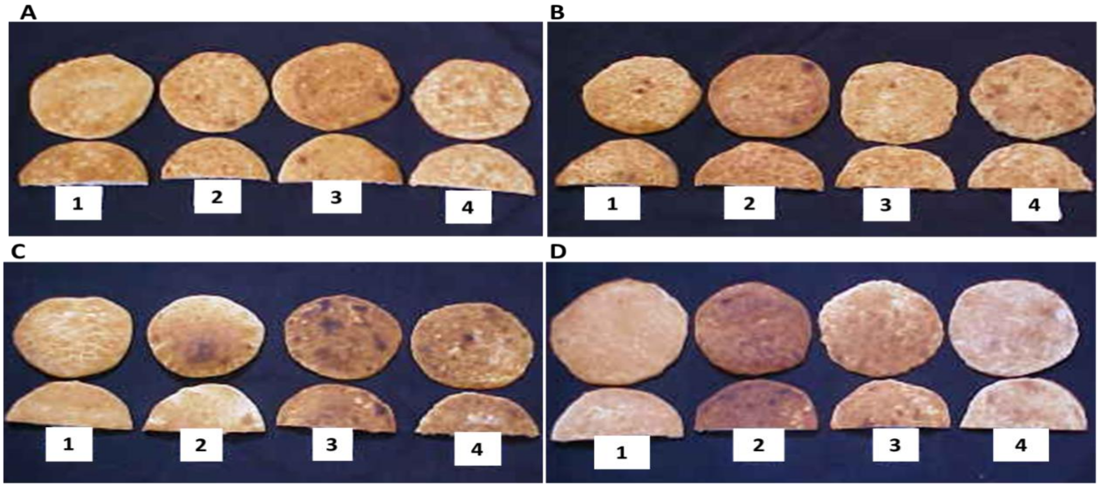

Figure1. Flat bread prepared from the flours of Canadian (1), Debaira (2), Wadi Elneel (3), and Elneelain (4) wheat cultivars. (A) Without improver, (B) with Z improver, (C) with S improver, and (D) with A improver.

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