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Physiochemical and Sensory Characteristics of Wheat Flour Bread Blends with Sorghum Flour

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Abstract – **Many attempts have been made to increase sorghum substitution in composite sorghum-wheat bread for economic reasons. However, the amount can be substituted up to certain level of sorghum flour. This study aimed to investigate the rheological and chemical properties of Hageen and Tabat sorghum-wheat composite flours as well as the sensory valuation of the breads. The Hageen and Tabat sorghum flours were used to replace 5, 20, 35, and 50%, respectively of wheat flour to use in bread processing. Standard methods were used in this research to determine the rheological and chemical properties. Rheological properties of the dough of both types of bread (Hageen and Tabat) and the control (wheat) were determined. The results indicated that; with sorghum flours increased, wet gluten, dry gluten and gluten index decreased, wet gluten percentage for Tabat blends bread at addition 5, 20, 35 and 50% was 2.5, 2, 2 and 1%, dry gluten was 2, 1.5, 1 and 0.5%, and gluten index was 62, 61, 59 and 55, respectively, while for Hageen blends bread with the same additions were 2.5, 2, 2and 1% for wet gluten and 3, 1.5, 1 and 0.5% for dry gluten, while was 62, 61, 60 and 59 for gluten index, respectively. Also the falling number of Hageen, Tabat sorghum and wheat composite flours were determined. The falling number of Tabat and Hageen at 50% substitution was 509 and 551, respectively, while control (wheat) was 441. The results of this study indicated that Hageen and Tabat sorghum flours bread higher in protein, fat, fiber and ash content, while lower in carbohydrates content compared to the wheat flour bread. Study also was included determination of minerals contents in the processed bread. The results illustrated that the potassium values was higher in wheat flour bread (246 ml/g). Sodium content of Hageen blends was 583.4, 650, 583, and 616.7 mg/100g, while for Tabat blends was 666.7, 600, 616.7 and 600 mg/100g, at blends 5, 20, 35 and 50%, respectively, calcium content of Hageen bread was40, 53.4,53.4and 46.7 mg/100g and Tabat bread was 53.4,50,46.7 and 50 mg/100g, respectively as well as potassium content (166.7, 193.4, 226 and 186 mg/100g) for Tabat bread and(180, 186.7, 166 and 193.4 mg/100g) for Hageen bread, respectively. Sensory evaluation results revealed great acceptance for bread made from flour blends Tabat and Hageen cultivars and replaced up to 20%, while increasing the level of substitution decrease in all sensory properties. Based on the results, it is recommend using an improvers such as guar gum or some protein concentrates, which can increase the proportion of sorghum combination higher than 20% sorghum flour.**

Keywords – **Physiochemical, Sensory characteristics, Wheat flour, Bread, Sorghum flour.**

I. Introduction

Bread is a baked product made from wheat or rye. Bread is an important staple food in both developed and developing countries. Wheat flour of both hard and soft wheat classes has been the major ingredient of leavened bread for many years because of its functional proteins (Freund, 2013). In the Sudan, the consumption of wheat bread is increasing in both rural and urban areas as a consequence of changing taste, convenience and consumer subsidies. However, bread is being made from imported wheat which is not suitable for cultivation in the tropical area for climatic reasons. The local production of wheat, in the Sudan, is insufficient for local consumption, and the Sudanese mills spend much money to import wheat flour for bread and other baked products. This situation necessitated the need to find a replacement for wheat in bread making using a local cereal, legumes and root crops. (FAO/GIEWS, 2005). Several developing countries have encouraged the setting up initiation of programs to evaluate the feasibility of alternative locally available flours as a substitute for wheat flour. Many efforts have been carried out to promote the use of composite flours in which flour from locally grown crops replace a portion of wheat flour for use in bread, thereby decreasing the demand for imported wheat. The United Nations Food and Agriculture Organization (FAO) launched a program known as “Composite Flour Project” (1964). This program was intended to introduce non wheat cereals, root crops and tubers into bread baking (Abedelghafour, 2007) .The output of the program was encouraging when wheat was partially substituted with low quantities of non-wheat flours or starches. However, the bread produced from non-wheat flours was acceptable compared to that made of wheat. Moreover, many international institutions were invited by FAO to carry out research studies in order to develop composite bread that will include other cereals, roots and tubers. The findings of these researches were encouraging at the level of laboratories, with less acceptable results at the commercial level (Abedelghafour, 2007). In Africa, the Sudan, Nigeria, Ghana, Sierra Leone and Senegal successfully many composite bread programs were developed using both sorghum and millet flours. Sorghum is the staple food crop in the Sudan where it is consumed in fermented forms, mainly as Kisra (local thin bread), Aceda (thick porridge) and Nasha (thin porridge). Several studies have indicated the possibility of incorporating sorghum both as Hageen and Tabat grain in wheat flour at various levels to produce bread when wheat is in short supply (www. fews.net).

Materials and Methods

Materials

Wheat (*Triticumaestivum* L.) flour (Sayga, Alawwal flour) and Sorghum [*Sorghum bicolor* (L).Moench] of the local cultivars Tabat and Hageen sorghum grains were purchased from the local market in Wad Medani city, Gezira State, Sudan. Yeast; Instant dry yeast was obtained from local market, Water; tap water was used, Sugar; Sucrose. Finely granulated, white, commercial grade was used, Salt; NaCl finely granulated, obtained from the local market was used, Shortening; partially hydrogenated vegetable oil was purchased from the local market.

Methods

Preparation of Sorghum and Wheat Grains for Analysis

Wheat flour from purchased from local market, Sayga (Alawwal flour). Sorghum grains were cleaned and freed from foreign materials. Grains were decorticated in an experimental mill in Wad Medani, Gezira state, Sudan. All of the grains were milled sorghum flour. Hageen sorghum flour, Tabat sorghum flour and (HWWW) wheat flour were kept in the freezer for subsequent chemical analysis, physicochemical characteristics.

Chemical Analyses

Moisture Content Determination

Moisture determination was conducted using the AOAC method, (2000). Disposable aluminum weighing dishes, (<50 mm diameter and <40 mm deep) which had been numbered, dried in the oven for 30 minutes, cooled in a desiccators and weighed again were used. A two g samples were weighed out and repeated in triplicate. Using tongs, aluminum weighing dishes containing the samples were placed in an air drying oven at 130° C for about one hour. The samples were removed and placed in a desiccators to cool for 30 minutes and reweighed.

Protein Content Determination

Digestion one gm of each sample wheat flour and sorghum flour was transferred to kjeldal flask (500 ml) with 20 ml concentrated sulphuric acid, 25 ml H2SO4 and one gm. Copper sulphate. The mixture was heated gently, so the initial has ceased to a loose pear shaped stopper in the top of the flask and then heated more strongly, so that the liquid boil at moderate, the flask were shaked from time to time and the heating was continued for 3hr . In 350^0 c until the liquid had become clear. Distillation twenty ml of the digest were transferred to the distillation flask, followed by 50ml of 40% sodium hydroxide. Therefore, the dilute digest was mixed up. The distillation apparatus was connected with the delivery tube dipping in 25 ml of 2% boric acids placed into the receiving flask. Ammonia liberated was distilled into the boric acid solution, after reaching 75ml, it was opened and the condenser washed down into delivery tube and into the received. Titration the distillate was titrated with 0.02 N hydrochloric acid. The blank should not exceed 0.5 ml. The nitrogen in the sample was calculated.

Ash Content Determination

The ash content was determined according to the AOAC method, (2000) using muffle furnace. Four grams of the sample were weighed and repeated in triplicate into porcelain crucibles, which have been ignited, cooled in desiccators and weighed and placed in a cool electric muffle furnace. The temperature was 540°C overnight for complete ashing. The ash crucibles were transferred directly into a desiccators, then cooled for 30 minutes and weighed immediately.

Fat Content Determination

The fat content was determined according to the AOAC method, (2000) with some modification. It was extracted by petroleum ether on a Goldfish extractor. Gold fish beakers were washed, dried and labeled by placing in an air oven at 130°C for one hour; then cooled in a desiccators for 30 minutes and weighed; repeated to constant weigh. Samples of 2g in triplicate were wrapped in filter paper and placed in a cellulose thimble condenser. 40ml of the solvent petroleum ether were added to the weighed Gold fish beakers. The extraction was carried out for 4 hours until all the soluble components of the sample were removed. Burners were allowed to cool for 30 minutes then the beakers were moved to a tray, covered with evaporation-type watch glass, and set in a hood to allow all ether to evaporate overnight. The air oven removed the traces of solvent at 130°C for 15 minutes; cooled in a desiccators for 30minutes and re-weight.

Total Carbohydrates Determination

The amount of carbohydrates was calculated by difference. The values refer to "total carbohydrate by difference" that is, the sum of the figures for moisture (MC %), protein (PC %), fat (FC %), and ash (Ash %) are subtracted from 100.

Total Carbohydrate % = 100 – [MC% + PC% + FC% + Ash C%].

Minerals Content Determination

According to AOAC Official Method, (2000), samples were dried and ashed at 525°C for 4 hours. The ash was dissolved in (1 ml hydrochloric acid +3 ml distilled water) and a few drops of nitric acid, brought to a final volume of 250 ml with distilled water and filtered. Sodium, calcium and potassium were determined by flame atomic absorption spectroscopy according to AOAC Official Method (2000).

Falling Number Determination

Falling number method determines alpha – amylase activity using the starch in the sample as substrate. The method is based upon other rapid gelatinization of a suspension of boiling water both and the subsequent

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measurement of the liquefaction by alpha – amylase of the starch contained in the sample. The aim of falling number to determine the alpha –amylase activity in the sample provided and determine its suitability for bread making .The method of falling number weight 7.00gof the flour and added 25 ml distilled water and fit a rubber stopper onto the tube and mix to obtain a homogenous suspension. Remove the stopper and place the viscometer stirrer. Scarping into the suspension any flour adhering to the walls of the tube. The tube with stirrer into the boiling water bath within 20 seconds after mixing, swing the motor unit immediately into its working position above the viscometer tube and viscometer. The apparatus has built in functions to carry out the test automatically from now on. The red light and bumper indicates the completion of the test. Swing back the motor unit by releasing the lever at back. The beeper stops and the cuter show the falling number value remote the viscometer tube wash the tube and stirrer. Read the falling number from the cuter display.

Gluten Content Determination

Wet gluten content was determined by washing the flour sample by a salt solution to remove the starch and other soluble from the sample. The residue remaining after washing was the wet gluten. This determination was adapted according to the AACC method, (2000). A 10g sample was weighed and placed into the glutamic washing chamber on top of the polyester screen. The sample was mixed and washed with 2% salt solution (NaCl) for 5 minutes. At the end of the wash cycle, the wet gluten was removed from the washing chamber, placed in the centrifuge holder, and centrifuged. The residue retained on top of the screen and through the screen was weighed to get total gluten. Wet gluten content results were expressed as a percentage on 14% moisture basis. It was then dried in a heater to give the dry gluten.

Bread Making

Preparation of Composite Flour Blends

Wheat flour which was used for bread making was mixed with 5, 20, 35, and 50 % Hageen sorghum flour its common name is (Dura 1),the same was repeated with Tabat sorghum flour common name is (Tabat). Blender was used to mix the blends well with an amount of 500 g flour for about one hour per cycle. The composite flours were stored in an air tight container and kept until required.

Preparation of Bread Samples

The various sorghum blends and the control (wheat flour) were used to make the samples of Hageen and Tabat bread. Standard formula: Flour 500g (wheat 475 gm, Tabat 25 gm) (wheat 400gm, Tabat 100 gm), (wheat 325, Tabat 175 gm) (wheat 250gm,Tabat 250 gm), yeast 5.5 g, salt 7.5 g, sugar 3.5 gm, oil 20ml, water 350 ml.All ingredients mentioned above were weighed and made into dough in cereal technology laboratory in Gezira University in Gezira state (Sudan) dough mixer for 5 minutes at medium speed. The dough was placed in a fermentation cabinet at 28°C and 85% relative humidity for 1 hour. After removal from the fermentation cabinet, the dough was divided into three pieces of 140- 148g each and formed into balls by hand, then, rested for 30 minutes at the same conditions, then dusted with flour and shaped into a round flat form by hand. The flattened dough pieces were returned to the fermentation cabinet and proofed for45 minutes, and then baked in a commercial oven (cereal laboratory in Gezira University) at 250°C for 8-10 minutes. The bread was left to cool for 7 minutes, then kept closed in polyethylene bags at room temperature 25°C for sensory evaluation and physical characteristics.

Sensory Evaluation

Semi trained panelists were given a hedonic scale questionnaire to evaluate the bread. Hageen and Tabat bread were evaluated through crust color, crumb color, texture, flavor and overall acceptability. They were scored on a scale of 9 points, in which (1: extremely bad, 2: very bad, 3: bad, 4: fairly bad, 5: satisfactory, 6: fairly good, 7: good, 8: very good, 9: excellent). During sensory evaluation, panelists were instructed to drink water or wash mouth after each evaluation. Sensory evaluation was done on the day in which breads were prepared.

Statistical Analysis

The analysis of variance (ANOVA) was performed to examine the significant level in all parameters measured. Duncan's test was used to separate between the means. All analyses were performed in triplicate (n = 3). The level of significance was 0.005 (Gomez and Gomez, 1984).

Results and Discussion

Chemical Composition of Wheat and Sorghum Bread

The results of moisture, ash, crude protein, fat, carbohydrates, and some minerals contents of wheat and sorghum bread are illustrated in Table 1.

Moisture Content

As shown in Table 1, the moisture content of wheat bread was 5.90%. This result was lower than that reported by Carson and Sun, (2000), who found that the moisture content of wheat bread was 9.9%. Moreover, Mariam *et al.,* (2009), reported the moisture content of wheat flour was 11 – 10%.

Protein Content

Results in Table 1, illustrated the protein content of wheat bread was 13.10%. This result is higher than result obtained by Abed-Elmonem, (1994) who found 11.5% and higher than 12.68 which reported by Eladawy, (1995). It is lower than that obtained by Olaoye *et al.,* (2006) who stated that the protein content of wheat bread was 7.01 % and higher than result to obtained by Abdalla, (2003) who reported that the protein content of wheat bread, and reported that the protein content was 10.3%.

Ash Content

Data in Table 1, showed that the ash content of wheat bread was 1.76%. This result was lower than (1.90%) which reported by AbouAzm, (1982). However was higher than result of Mohsen *et al*., (1997) (1.2 %) and also higher than that result 1.18% which reported by Eladawy, (1995). On the other hand, Ammar *et al*., (2009) reported that the ash content of wheat bread was 0.5%.

Fat Content

The results showed that the fat content of wheat bread was 5.9 % (Table 1).This value was higher than that obtained by Malmomo *et al*., (2011), who found fat content of 2.60%.

Total Carbohydrates

Chemical composition of wheat bread and Hageen bread in Table 1, and Appendices 7, showed total carbohydrates content of wheat bread was 76.38%. This result was higher than that reported by Abdalla, (2003) who studied the total carbohydrate content of Indian wheat flour (75.39%), and lower than that obtained by Abed-Elmonem, (1994) who found to be was 75%. However, it is lower than that obtained by Eladawy *et al.,* (1995), who reported total carbohydrates content of wheat bread was 83.8%.

Table 1. Chemical composition (%) of wheat (control) and Hageen blends bread.

Type of flour	Moisture	Ash	Crude fat	Crude protein	Carbohydrate
Control wheat	5.90±0.1	1.760±0.15	5.90±0.11	13.10±0.15	76.380±0.9
Hageen 5%	7.490±0.9	1.870±0.6	7.90±0.5	12.250±0.19	72.420±0.8
Hageen 20 %	6.490±0.11	2.40±0.32	7.330±0.1	12.25±0.19	70.860±0.12
Hageen 35%	6 .880±0.7	2.130±0.22	8.30±0.33	10.060±0.9	70.080±0.14
Hageen%50	6.490±0.12	2.490±0.19	12.600±12	10.060±0.6	66.790±0.6

MINERALS

The minerals content of wheat bread are shown in Figure 1, among major minerals sodium, calcium and potassium content in wheat bread had were 0.616.7ml/g, 0.53.4ml/g, and 0.24ml/g, respectively. Micheal, (2013) studied the minerals content; sodium, calcium and potassium of wheat flour (305.25%, 81.315%, 80.74%), respectively, while Taha (2000) studied the minerals content of two Sudanese wheat cultivars (Condor 72%, Debeira 72%), and found that the amount of calcium, content were 0.51%.

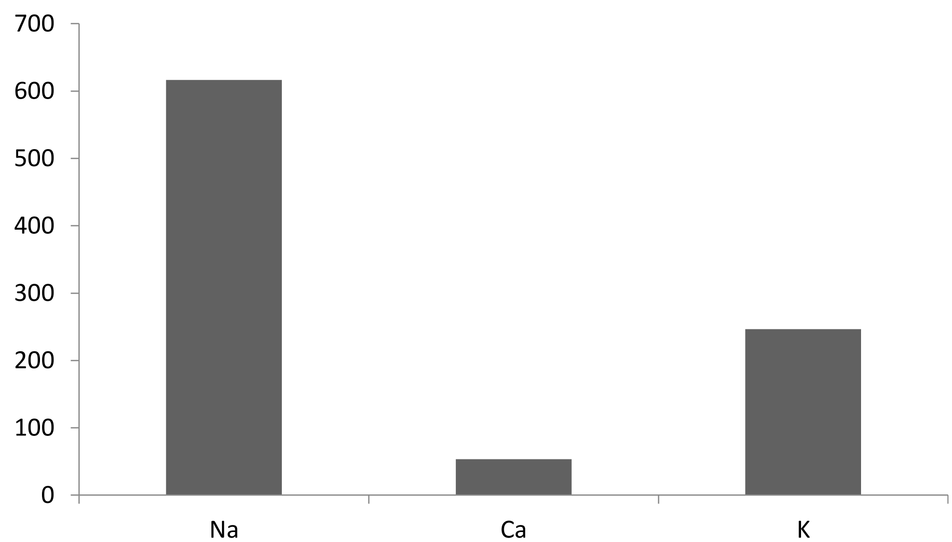

Fig. 1. Minerals content (mg/100g) of wheat bread (control)

PROXIMATE COMPOSITION OF HAGEEN AND TABAT BREAD

Moisture Content

The moisture content of the Hageen bread and Tabat bread to which have been added as 5%, 20 %, 35 %and 50%sorghum flour are shown in Tables 2, for Hageen bread were 7.49 %, 6.49%,6.88%and 6.49%, respectively, while the same percentages from Tabat bread were found 5.76%, 6.57 %, 4.88 % and 5.96%, respectively. The results of moisture content of Hageen bread were within the range of 6.49 to 7.49 and the results of moisture content of Tabat bread were within the range of4.88 to 6.57%, this indicate the moisture content of Hageen bread higher than the moisture content of Tabat bread. These findings are agreement with those reported by Yousif and Magboul, (1972) for Sudanese sorghum cultivars, However, these values were lower than those reported by Arbab, (1995) and Elsayed,(1999) for Sudanese cultivars (Tabat and Feterita), who reported as values of 8.89% to 9.88% and(7.37 % and 8.00%),respectively .

Protein Content

As shown in Table 2, the protein content of Hageen bread blends (5%, 20% 35% and 50%) were 12.250%, 12.250%, 10.060 % and 10.060%, respectively. The results of protein content of Tabat bread shown in Tables 2 were 10.94%, 13.12%, 12.25% and 10.50%, respectively. The results are the same in protein content for two cultivars (Hgeen, Tabat bread) But when added 50% the protein content of the Hageen bread was higher than that protein content of Tabat bread. The findings are in agreement with to those obtained by Abedelghafour, (2007) and Eltainay *et al*.,(1979), who found average protein contents of 10.85 % and (8.8 – 11.0) for Tabat cultivars, respectively. whereas the results were not far from that reported by Elshewaya (2003), who reported protein contents of 6.64,and 12.71 % for Sudanese cultivars (Tabat, Feterita), on the other hand the results were lower than that reported by Abdalla (2003) who found protein content 15.47 % for Sudanese sorghum variety (Fakimustahi) flour bread .

Ash Content

The ash content of Hageen bread and Tabat bread when replace the wheat bread by 5%, 20%, 35% and 50% replacement for two sorghum flour (Hageen and Tabat) are shown in Tables 2, for Hageen bread were 1.870%, 2.40 %, 2.130 %and 2.490%, respectively. Tabat bread ash content were 1.4%, 1.19%, 1.62%, and 1.83%, respectively, ash content of Hageen bread was higher than the ash content of Tabat bread. The results were similar with results reported by Hussien *et al*., (1976) who found 1.34%, and 1.84%. In addition, these values are in agreement with previous study by Elsayed, (1999), who reported value ranged from 1.5 to 2.0 % and 1.5% to 1.8 %, respectively. But not far from that by shephered *et al*., (1970) and Yousif and Magboul (1972) who found that ash content value 1.1 to 1.9% and1.1%- 2.7 % respectively. However, the results are higher than that reported by Elshewaya (2003) who found ash content of the sorghum Sudanese cultivar (Tabat) 1.43%.

Fat Content

The fat content of Hageen and Tabat bread flour when blended as 5%, 20%, 35% and 50% were shown in Tables 2, for Hageen bread were 7.9%, 7.33%, 8.3%and 12.6%, respectively, while for Tabat bread (Tables 2) were 10%, 7.8%, 9% and 8.8% respectivly. These results at the same range for two cultivars with an average (7.9% – 12.6%). when we added 5% Tabat bread result of fat content was higher than the fat content of Hageen bread. Also when added 50% Hageen sorghum the result of fat content of Hageen was higher than fat content of Tabat bread. These results were higher than that results obtained by Hussein *etal*,(1976) who found fat content of sorghum bread when added as 5%,20%, 30% and 100 % sorghum of 1.25%, 1.70%, 2.17%,and 3.87 % respectively. Also the results were higher than those reported by Eltinay, (1979) and Elshewaya, (2003) and Elsayed, (1999) who found fat contents were 3.25%, 3.37 %, 4.68 % respectively, for two Sudanese sorghum cultivars (Tabat, Feterita).

Total Carbohydrates

Table 2, shows the total carbohydrates of Hageen bread and Tabat bread when blended as 5%, 20%, 35% and 50%, for Hageen bread were 72.42%, 70.68%, 70.08% and 66.79%, respectively. Table 4.4 also showed the carbohydrate content of Tabat bread were 71.94%, 71.32%, 72.25% and 72.91%, respectively. The results showed the carbohydrate content of Tabat bread were higher than the carbohydrate content of Hageen bread but when added 5 % Hageen bread the result was (72.42%). The results were similar of that result obtained by Abdalla, (2003) who reported that the total carbohydrates of Sudanese sorghum cultivar (Fakimustahi) flour was 72.68%, while these results were lower than that reported by Elsayed, (1999) who reported (78.967%) where as higher than that reported by Eggum *et al*., (1983) who stated that the carbohydrates range from 71.0 to 73.4%.

Table 2. Chemical composition (%) of Tabat sorghum blends bread.

(%)	Moisture	Ash	Crude fat	Crude protein	Carbohydrate
5%	5.76±0.12	1.4±0.15	10±0.15	10.94±0.12	71.94±0.17
20%	6.47±0.11	1.19±0.18	7.8±0.12	13.12±0.14	71.32±0.15
53%	4.88±0.15	1.62±0.19	9.0±0.16	12.25±0.18	72.25±0.18
50%	5.96±0.19	1.83±0.11	8.8±0.10	10.25±0.11	72.91±0.10

Mean values having different superscript letter(s) in each column differ significantly ($p<0.005$).

Minerals

As shown in Figures 2, sodium, calcium, and potassium content of Hageen bread and Tabat bread. For Hageen bread, sodium content was583.4 mg/100g, 650mg/100g, 583 mg/100g, and 616.7 mg/100g, respectively, while sodium content for the Tabat sorghum bread was 666.7 mg /100g, 600 mg /100g, 616.7 mg/100g and 600 mg/100g, respectively (Figure 3), and calcium content of Hageen sorghum bread was40 mg/100g, 53.4 mg/100g,53.4 mg/100g and 46.7 mg/100g, respectively, and calcium content of Tabat bread was 53.4 mg/100g,50mg/100g,46.7 mg/100g, 50

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mg/100g, respectively, and Potassium content of Tabat bread were 166.7 mg/100g, 193.4 mg/100g, 226 mg/100g and 186 mg/100g, respectively. Potassium content of Hageen bread was 180mg/100g, 186.7 mg/100g, 166 mg/100g and 193.4 mg/100g, respectively. Taha, (2000) reported the minerals content of three Sudanese sorghum cultivars, Dabar, Fakimustahi and Tetron, (100% extraction rate), found to be that the amount of calcium was 0.62%.

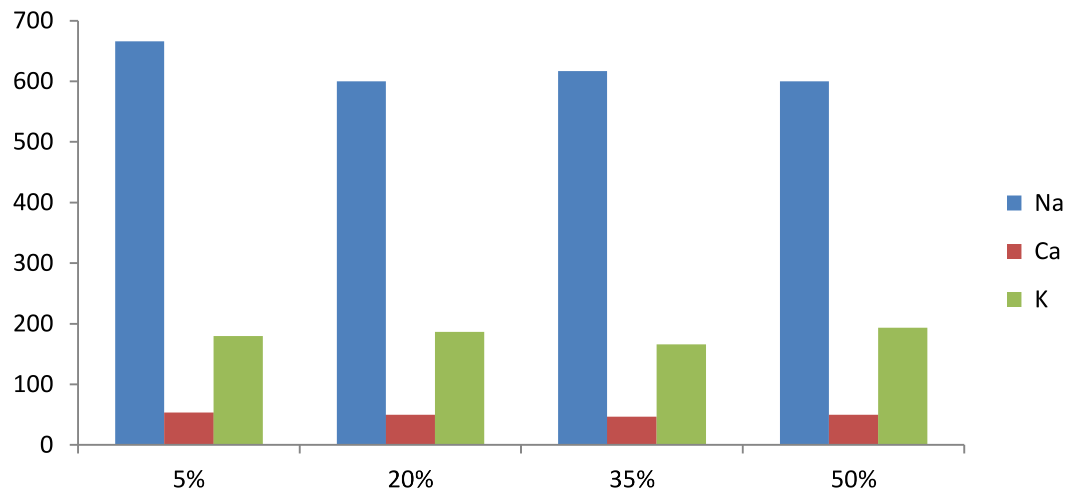

Fig. 2. Minerals content (mg/100g) of Hageen bread

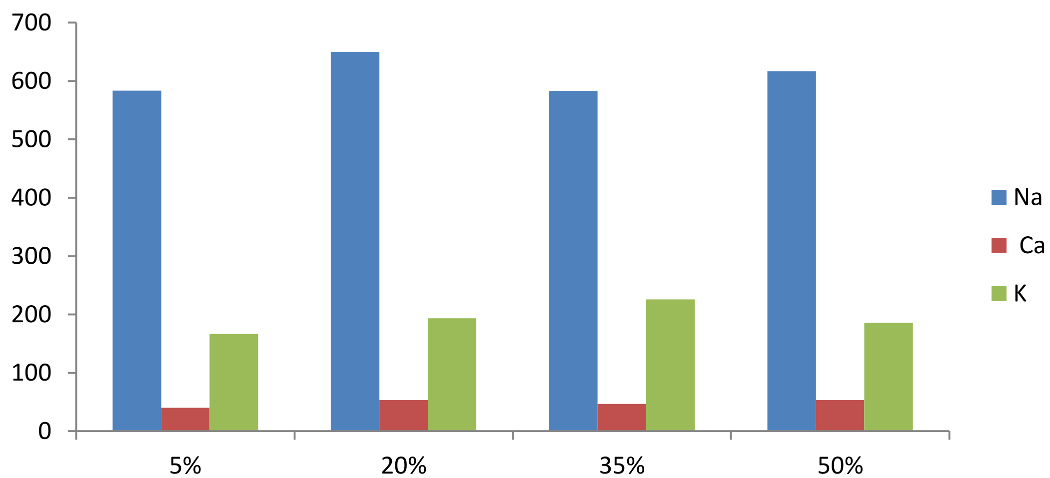

Fig. 3. Minerals content (mg/100g) of Tabat bread

FALLING NUMBER

The results of falling number of wheat (control), Hageen and Tabat flour are shown in Figure 4, for wheat flour was 441second When used different percentages for two cultivars (Hageen, Tabat) 5%, 20% 35%, and 50% the results of the falling number of Hageen flour were 502 second, 551second, 507 second and 686 second respectively, while the falling number of Tabat flour were513 second, 629 second, 641 second and 502 second, respectively. The results of falling number of Hageen flour were higher than that of falling number of Tabat flour but when added 50% the result was lower than that falling number of Hageen flour. The results of two cultivars (Hageen and Tabat) flour indicated that the falling number of Hageen and Tabat flour were higher than that falling number of wheat flour. The falling number of wheat flour was lower than the falling number of wheat flour obtained by Mariam *et al*., (2009) was 536.4 second. In addition, the falling number of wheat flour was lower than studies obtained by Salim *et al.,* (2005) was 521second (Figure 4).

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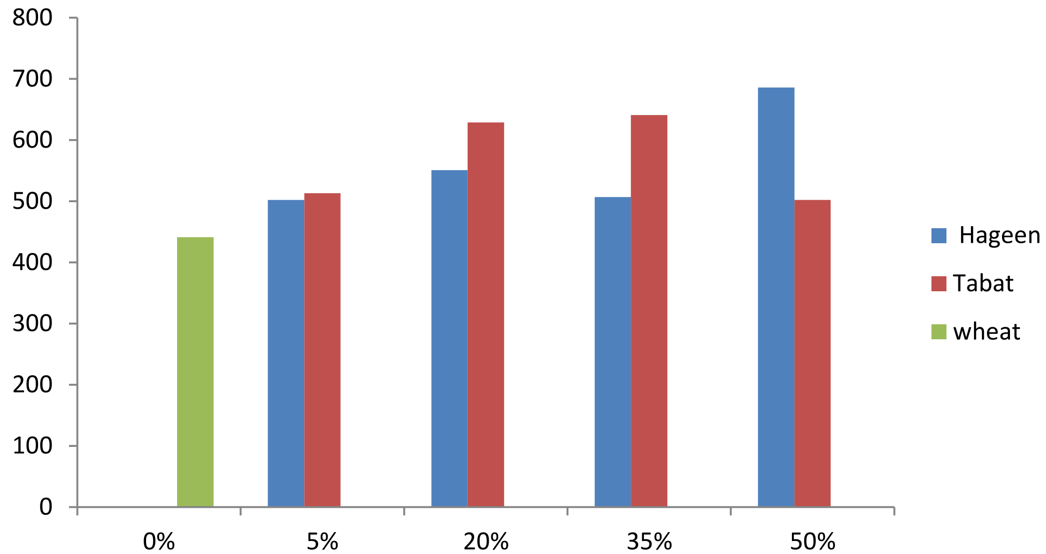

Fig. 4. Falling number of Hageen, Tabat and wheat (control) flour.

Gluten Content and Gluten Index

The results of gluten content of wheat flour and Hageen flour are shown in Table 3, for wet gluten, dry gluten and gluten index of wheat flour were 4%, 3% and 66 %, respectively. For Hageen flour; when added 5%the wet gluten, dry gluten and gluten index the results were 2.5%, 3.0 %and 62%, respectively, but when added 20% of Hageen flour of the wet gluten, dry gluten, and gluten indexwere2.0 %, 1.5%, and 61 %, respectively, while at 35% the results were 2%, 1%, 60%, respectively, and when added percentage 50% the result were 1.5%, 0.5%, 59.5%, respectively. Also for Tabat flour when added 5 %the wet gluten, dry gluten and gluten index were 2.5%, 2% and 62% (Table 4), respectively. but when added percentage 20% of Tabat flour of the wet gluten, dry gluten, and gluten index were 2 %,1.5%, and 61 %, respectively, and at35% the results were 2%, 1% and 59%, respectively, and when added percentage 50% the results were 1%, 0.5% and 55%, respectively. These results indicates to the wet gluten, dry gluten, index gluten of (control), wheat were higher than the two cultivars (Hageen and Tabat) flours, while in Hageen flour was higher than the Tabat flour. The values were lower than that reported by Huebner and Rothfus, (1968) who concluded that dry gluten from different cultivars of hard wheat ranged between 9 to11%, while Taha, (2000), who reported that the dry gluten content of wheat flour is higher than that in composite flour (wheat/ sorghum).

Table 3. Gluten quantity and quality (%) of composite flour of Hageen flour with wheat flour.

Quality Characteristics	Control (wheat)	Hageen flour blends			
		5%	20%	35%	50%
Wet gluten (%)	4.0±0.13	2.5±0.11	2.0±0.12	2.0±0.23	1.5±0.14
Dry gluten (%)	3.0±0.22	3.0±0.14	1.5±0.11	1.0±0.21	0.5±0.13
Gluten index (%)	66.0±0.14	62±0.09	61.±0.12	60.0±0.17	59.5±0.18

Table 4. Gluten quantity (%) and quality of Tabat flour.

Quality characteristics	Tabat flour blends			
	5%	20%	35%	50%
Wet gluten (%)	2.5±0.21	2±0.41		1±0.11
Dry gluten (%)	2±0.10	1.5±0.31	2±0.13	0.5±0.14
Gluten index (%)	62±0.22	61.5±0.19	59±0.14	55±0.09

Sensory Evaluation of Breads

Sensory scores of Hageen bread and Tabat bread samples made with substitution with sorghum flours are presented in Table 5 and 6. The analysis of variance (ANOVA) of the data showed that the effect of wheat and sorghum blends on sensory properties was statistically significant ($p<0.005$) for all types of breads evaluated in this study.

Sensory Evaluation of Hageen Bread

The sensory properties of pan breads made from blends of wheat and Hageen sorghum flours as well as the control bread are presented in Table 5. All sensory scores crust color, crumb color, texture, flavor, and over all acceptability were significantly different among blend samples, except flavor. All breads were rated as acceptable by the panel except mouth feel attribute of the samples up to 20% Hageen and Tabat sorghum flour, but the preference was decreased as the substitution of sorghum level increased. According to the results in Table 5, bread made from 100% wheat flour (control) showed excellent attributes in comparison with other types of bread. Generally, individual sensory scores of Hageen bread made with sorghum flour were slightly lower than those of blends of Tabat sorghum flour. These results may be explained by the characteristics of the grain coat in the flour. The results showed that the level of preference declined with decreasing the level of wheat flour substitution in the bread. However, Anglani, (1998); Carson *et al*., (2000); Hugo *et al*., (2003), reported that addition of 20 to 50% sorghum flour to wheat flour produce excellent bread, while, Summer and Nielson, (1976) produced acceptable Nigerian bread using an 80/20 wheat/ sorghum composite flour blend. Moreover, Perten, (1977) reported that the satisfactory production of French- type bread from composites of 85% wheat and 15% sorghum flour. Composite bread produced from composite flours at the ratios 90/10, 80/20 and 70/30 wheat/sorghum were found to give acceptable bread quality (Taha, 2000).

Table 5. Sensory evaluation of (%) Hageen bread from wheat flour bread.

Sensory attributes	Control (Wheat)	Hageen bread blends			
		5%	20%	35%	50%
Crust color	9.40^{a}	8.30^{a}	7.40^{a}	7.90^{b}	6.90^{c}
Crumb color	9.60^{a}	8.50^{a}	7.40^{c}	7.90^{d}	5.40^{e}
Texture	9.30^{a}	8.90^{bc}	7.70^{cd}	5.20^{ef}	4.80^{f}
Flavor	9.30^{a}	8.70^{bc}	7.60^{d}	5.50^{e}	3.00^{f}
Over all acceptability	9.30^{a}	8.70^{b}	7.50^{bc}	5.00^{c}	4.10^{c}

Mean values having different superscript letter(s) in each row differ significantly ($p<0.05$).

TABAT BREAD SENSORY EVALUATION

With respect to the sensory evaluation of the bread produced, the overall quality correlates with the ratio of the sorghum flour are shown in Tables 6, The crust color bread was significantly ($p<0.005$) different with increasing levels of sorghum flours (Hageen/Tabat). The crumb color of the breads substituted with 5% and 20% sorghum flour was significantly comparable to the control; whereas at higher levels of substitution, samples were significantly darker ($p<0.005$). These results are in agreement with those reported by Sumner and Nielsen, (1976), who concluded that incorporation of 20% sorghum flour in bread formulation darkens the internal and external loaf color. Texture scores decreased significantly as the level of sorghum flour increased. As light bitter taste at a 50% or greater replacement level of whole sorghum, flour may be due to the phenolic compound and tannins found in the seed- coat. When the proportion of sorghum flours increased in breads, the crumb color and flavor of bread scores decreased significantly. These results were apparently found in the samples with whole sorghum flour levels rather than those with decorticated sorghum flour. Generally, it is observed that both the control bread and that bread made with up to 20% sorghum flours did not vary significantly ($p<0.005$) in flavor characteristic. However, there was a variation in general acceptability among sorghum flours substitution levels. The control had a higher acceptability score compared to all sorghum flours substitution. Generally, the bread was accepted with at its different levels of Hageen and Tabat sorghum flours substitution levels. However, the preference was reduced with increasing levels of substitution. These results are in agreement with those reported by Kyomugisha, (2002). On the other hand, there was a steady deterioration of bread quality as the percentage of non-wheat flour was increased, and the additions of sorghum flours to the wheat flour blend did not improve the sensory properties of the flat breads. It should be realized that the preference, according to taste, differs from one region in the Sudan to another. It is expected that composite flour bread assumes a higher degree of preference in rural areas where the people are more accustomed to the taste of products made from sorghum alone. Accordingly composite flour bread should be tested in rural areas first.

Table 6. Sensory evaluation of (%) Tabat bread from wheat flour.

Sensory attributes	Tabat bread blends			
	5%	20%	35%	50%
Crust color	9.60^{ab}	8.20^{a}	7.50^{b}	7.60^{b}
Crumb color	8.60^{bc}	7.60^{d}	6.20^{da}	8.0^{b}
Texture	8.20^{b}	8.70^{b}	5.20^{ef}	5.20^{ef}
Flavor	8.10^{ab}	7.00^{cd}	7.70^{d}	5.10^{e}
Overall acceptability	8.50^{b}	6.40^{cd}	6.90^{e}	7.20^{b}

Mean values having different superscript letter(s) in each row differ significantly ($p<0.05$).

Conclusion

The general conclusion which can be derived from this research work is that replacement of wheat flour by sorghum reduced the water particularly when the replacement rate increased, due to the lower levels of gluten. Even though, the only significant difference was observed with the maximum replacement of sorghum (50%). Breads crumb and crust color showed no significant difference between bread made of 5% sorghum substitution and the control. In terms of sensory evaluation, no significant differences were detected in any aspect in breads with sorghum flour substitutions of 5% and 20% compared to the control. The treatments significantly improved the quality of the bread and its acceptability. The study also established that up to 50% sorghum substitution was unacceptable and produced bad quality bread compared to the others. There was observation that the best effect of the additives achieved when the additives added at the lowest addition of sorghum flour and no further improvements were obtained by increasing the additives up to 50%. From the other side this result is good for economic reasons.

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