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Impact of *Monechma Ciliatum* Seeds Flour as Food Supplement on The Chemical Composition, Nutritional Value and Sensory Evaluation of Sorghum Kisra

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Monechma ciliatum (MC) seeds are a rich plant source of protein, fat, minerals, and other essential nutrients. The current study aims to investigate the impact of using MC seeds as a plant-based food supplement on kisra (Sudanese bread made of sorghum flour). To obtain the most benefits from the MC, seeds were subjected to three treatments, boiling, roasting, and germination. The raw and treated MC seeds were separately ground and added to sorghum flour with ratio of 1:10 each. The common kisra made of pure sorghum flour (K) flour as control and four samples of supplemented kisra were prepared as raw or untreated (UMK), boiled (BMK), roasted (RMK), and germinated (GMK). Chemical composition, mineral, amino acids, fatty acids, tocopherols, and amino acids content were determined and also sensory evaluation. Results showed that using *Monechma ciliatum* seeds flour as a supplement of sorghum's kisra significantly improved its nutritional value. Protein, Fat, fiber, mineral, unsaturated fatty acids, and amino acids significantly increased while tocopherol content wasn't affected by supplementation. The sorghum's kisra, supplemented with 10% roasted (RMK) *Monechma ciliatum* seed flour was found to be acceptable between the supplemented samples concerning all sensory attributes.

Keywords: *Monechma ciliatum,* Supplementation, Kisra, Boiling, Roasting, Germination.

Introduction

Monechma ciliatum MC is a species of Monchema genus plant that belongs to Acanthaceae family mainly grows in tropical and sub-tropical regions. *Monchema ciliatum* seeds are widely used in African traditional treatments as they contain a good amount of essential nutrient and medicinal components (Oshi et al., 2013). In sudan the plant is found in western and south-western of Sudan where it is well known and traditionally used, it has small brownish black seeds, this why the Sudanese people called it the black mahlab or El-Mahlab El-Aswad. Mariod et al. (2010) found that protein content of the *M. ciliatum* seed was 21% with 783.3 mg/g N, as an essential amino acids, fat content was 13% with main fatty acids were oleic 47.3%, linoleic 31.4%, stearic 16.0% and palmitic 4.5%. The tocopherols content was 45.2 mg/100g.

Sorghum (*Bicolor L. Monech*) is the most important cereal in Africa and parts of India, it is cooked in different ways according to preference and customs of specific region and population. Sudan according to FAO production of sorghum is about 3.86 million tons in 2017 and the annual consumption is about 1.5 to 2 million tons. Although sorghum is poor fat and other essential nutrients also its protein nutritional value is lower

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due to its content of polyphenols and tannins which make the protein unavailable for intestinal absorption (Duodu et al., 2002), but its cost is suitable for low-income people. The majority of Sudanese people especially in rural arias and poor communities depend on it as the main component of their daily meals due to its reasonable cost, (Abdelrahman et al., 2016), It is reflected in many dishes such as Asida, porridge or flatbread. Kisra (Osman, 2011).

Kisra is traditional Sudanese bread made of naturally fermented sorghum flour dough and baked in thin flakes in different sizes and colour depending on the baking plate and the experience of producer preference and also the sorghum type. It is a staple diet for most of the Sudanese population, (Farag & Matthaus, 2016). During Kisra preparation, a well-seen decline in fibre, oil and carbohydrate contents was reported (Hamad et al., 2019). Due to the high cost of animal protein supplementation, fortification or enrichment of cereals with rich protein seeds has been considered a practical and sustainable approach of combating protein-energy malnutrition in developing countries (Shewry, 2007).

This study aims to study the possibility of increasing the nutritional value of Kisra (Sudanese traditional sorghum bread) using advantage of the high percentage of protein, fatty acids, minerals and other valuable components in the *M. ciliatum* (black mahlab seeds) and to study the sensory properties of the new developed Kisra product and determine the efficient process to produce acceptable supplemented kisra in terms of taste, texture and appearance, then it can be beneficial in avoiding protein deficiency malnutrition especially for low-income communities in Sudan and Africa as well.

Materials and Methods

Materials

Sorghum grain 10 kg of sorghum seeds were purchased from Jeddah, kingdom of Saudi Arabia. *Monechma ciliatum* seeds (7 kg) were purchased from Sennar local market, Sennar state, Sudan. Both sample seeds were hand-sorted to remove stones, broken seeds and foreign materials. Then carefully cleaned under tap water and stored in polyethene bags at room temperature.

Methods

Boiling of M. ciliatum seeds

M. ciliatum seeds (600 g) were put in three 1.0 L beaker 200 g seeds in each beaker. Then water was added as 1:4 seed: water, then on the magnetic stirrer hot plate was boiled to 100˚C for 40 min until the seeds were cooked. The cooked seeds were grained then dried and ground in a grinder (Moulinex, Japan), and they were put in a plastic container and stored in a deep freezer for analysis Mariod et al. (2012a).

Roasting of M. ciliatum seeds

According to Mariod et al. (2012a) 500 g of washed and dried *M. ciliatum* seeds were arranged in 3 aluminium foil dishes and then were put in an electric air oven. The seeds were roasted at 180 ˚C for 20 min. The roasted seeds were allowed to cool to room temperature, then were ground in an electric grinder (Moulinex, Japan) and were stored in a deep freezer for further uses and analysis.

Germination of M. ciliatum seeds

The germination process was carried out following Handa et al. (2017) method, where 500 g *M. ciliatum* seeds were soaked in 2500 mL of 0.7g/L sodium hypo-chlorite solution for half an hour at 25 ºC. Then seeds were well washed with tap water then drained, and then were soaked in deionized water for 5 h, after that they were kept between two layers of cotton cloth for 72 h in room temperature. Germinated seeds were dried in an air oven at 60 ˚C till constant weight, then were ground and stored for further use.

Preparation of composite flour and fermented dough

Three forms of composite flour were prepared from sorghum flour mixed with untreated *M. ciliatum* and the treated *M. ciliatum* seeds each (K, UMK, BMK, RMK and GMK). The ratios of *M. cilliatum* flour to sorghum flour were 1:10 for each sample. The fermented dough, known as (Ajin), was prepared in Sudanese traditional way, where each sample (500 g) was mixed with 700 mL of water and previously fermented dough (50 g) in a plastic ware container. Fermentation was carried out for 24 h (Handa et al., 2017).

Preparation of kisra

The process of baking the fermented dough is known as Aowasa, where a small amount of the fermented dough was baked on a hot iron square plate forming a very thin flake that baked for 1-2 seconds and then taken out and considered cooked ready for consumption. Fermented baked samples were dried in the shade, then ground to pass 0.5 mm and stored at 4 °C in polyethylene bags. All results were expressed on a dry weight basis (Ibnouf, 2012).

Proximate chemical analysis

The AOAC (2005) methods were used to analyze the moisture, crude fat, crude fibre and ash of all samples. Total nitrogen was analyzed by the micro-Kjeldahl method then nitrogen was converted to protein using the factor of 6.25. The carbohydrates content was calculated by subtracting the sum of fat, protein moisture, fibre and ash from 100.

Minerals determination

Ground sample (0.03g) was put in microwave vessel containing 5.0 mL of HNO_3 and 2 mL of H_2O_2 (Suprapur, Merck), then it was heated to 205 ˚C for 15 min, to obtain fine digested mixture after that the mixture was left to cool to 25 ºC and the colourless solution was obtained. The solution was analyzed by inductively coupled plasma-mass spectrometry (ICP-MS). Bartzatt & Martinez (2015) method with some modifications was followed for minerals analysis.

Fatty acids composition

Tested samples (15.0g each) were ground and their oil was separated utilizing Soxhlet contraption (Gerhardt) as indicated by AOCS Official strategies Am 2-93 (Bartzatt, & Martinez, 2015). The removed oil was methylated and changed over to methyl esters of the fatty acids as per the past technique, and afterwards was investigated utilizing a Shi-madzu GC-2010 gas chromatograph with a DB-23 column (60m x 0.25mm i.d. also, 0.25 µm film thickness). Injector, column and indicator temperatures were 230, 190 and 240 °C, individually. The split proportion was 80:1. Transporter gas was helium at 1.0 ml/min proportion.

Determination of tocopherols

For tocopherols determination, a solution of 250 mg oil of all studied samples in 25 mL *n*-heptane was directly used for the HPLC. The HPLC analysis was conducted using a Merck-Hitachi low-pressure gradient system, fitted with an L-6000 pump, a Merck-Hitachi F-1000 Fluorescence Spectrophotometer (detector wavelengths for excitation 295 nm, for emission 330 nm) and a D-2500 integration system; 20 µL of the samples were injected by a Merck 655-A40 autosampler onto a Diol phase HPLC column 25 cm x 4.6 mm ID (Merck, Darmstadt, Germany) using a flow rate of 1.3 mL/min. The mobile phase used was n-heptane/tert, butyl methyl ether (99+1, v/v), Balz (1992).

Amino acid composition

The content of amino acids was analyzed utilizing Amino Acid Analyzer where 200 mg sample was digested with 5.0 ml 6 N HCL in hydrolysis tube, then the solution incubated at 11 ˚C for 24 hr, then it was filtered through filter paper, then 200 mL of the filtered solution was evaporated at 140 °C for about an hour, then 1.0 ml of diluted buffer was added to the dried sample, the amino acids composition of the hydrolyzed sample was determined with automatic amino acid analyzer (SYKAM Amino Acid Analyzer S 4330), Mariod et al. (2012b).

Statistical analysis

The examinations were performed with triplicate. The mean qualities and standard deviation (mean ± SD) was determined and tested utilizing Duncan's test ($P < 0.05$). Measurable analysis of variance (ANOVA) was applied on all qualities utilizing Statgrafics® Statistical Graphics System version 18.1.12 (1985-1989).

Results and Discussion

Proximate chemical composition of sorghum kisra and kisra supplemented with 10% of raw, boiled, roasted and germinated M. ciliatum seeds flour

The proximate composition of kisra made of pure sorghum flour (K) and kisra supplemented with untreated raw or *M. ciliatum* (UMK) and kisra supplemented with boiled *M. ciliatum* (BMK), roasted *M. ciliatum* (RMK) and germinated *M. ciliatum* kisra (GMK) are presented in Table 1. The moisture content of K was found to be 9.81, after supplementation it was 7.14, 8.10, 9.44 and 9.42%, in UMK, BMK, RMK and GMK respectively. Supplementation with raw and boiled *M. ciliatum* seeds significantly decreased Kisra moisture content while it was insignificantly decreased with supplementation with roasted and germinated.

The fat content of sorghum kisra was 1.57% and it was significantly increased to be 2.59, 2.57, 2.96 and 2.41% in UMK, BMK, RMK, and GMK, respectively. The result agreed with that reported by Serrem et al. (2011) who found supplementation of sorghum flour with defatted soy flour increased oil content. Kisra supplemented with roasted *M. ciliatum* contained the highest fat content, which is referred to the initial fat content of *M. ciliatum* seeds.

The protein content of sorghum kisra was found to be 11.58% and after supplementation, it was significantly increased to be 13.58, 13.51, 13.31

and 12.95%, in UMK, BMK, RMK, and GMK respectively. This finding was agreed with Nour et al. (2016) who reported that, protein content of raw sorghum flour was found to be 10.31% and after supplementation, with 10 % Moringa leaves powder it was significantly increased to 12.89% additionally Kayitesi et al. (2010) showed that protein content of sorghum flour increase after supplementation with Marmara bean flour.

Fiber content of kisra was found to be 1.68%. After supplementation, it was significantly increased to be 2.21, 2.64, 2.20 and 2.41%, in UMK, BMK, RMK, and GMK respectively. The increase in fibre content of supplemented kisra may be due to the high content of fiber in *M. ciliatum* seeds. This study is in agreement with that reported by Serrem et al. (2011) who reported that supplementation of sorghum flours with defatted soy flour increased its fibre content.

The carbohydrate content of kisra K was found to be 73.79% and kisra supplemented with UM, BM, RM and GM was decreased to be 72.58, 71.18, 70.32, and 71.11%, respectively. Supplementation of kisra with untreated and treated *M. ciliatum* seeds flour decreased the carbohydrate content, and the UMK was the highest in carbohydrate.

The ash content kisra was found to be 1.57%. Supplementation was insignificantly increased the ash content to 1.70%, 1.67, 1.77, 1.70 %, in UMK, BMK, RMK, and GMK respectively. This finding was agreed with that reported by Mustafa (2006) who reported that supplemented sorghum flour with pumpkins seeds flour increased the ash content. Supplementation of sorghum kisra with *M. ciliatum* seeds flour increased its biological compounds and hence improved its nutritional composition.

TABLE 1. Proximate analysis of kisra made of sorghum K and kisra supplemented with 10% raw UMK, boiled BMK, roasted RMK and germinated GMK *Monechma ciliatum* seeds flour.

Sample	Moisture	Fat	Carbohydrate	Protein	Fibre	Ash
K	9.81±0.02[a]	1.57±0.23[a]	73.79±0.51[b]	11.58±0.12[a]	1.68±0.42[a]	1.57± 0.07[a]
UMK	7.14±0.15[b]	2.59±0.37[b]	72.58±0.63[c]	13.51±0.34[b]	2.21±0.39[b]	1.70±0. 12[b]
BMK	8.10±0.15[c]	2.57±0.33[b]	71.18±0.77[d]	13.84±0.30[b]	2.64±0.33[d]	1.67±0.12[cb]
RMK	9.44±0.01[d]	2.96±0.23[c]	70.32±0.86[a]	13.31±0.29[b]	2.20±0.31[b]	1.77±0.03[b]
GMK	9.42±0.03[d]	2.41±0.16[b]	71.11±0.27[d]	12.95±0.21[c]	2.41±0.41[c]	1.70±0.02[b]

Means in the same row followed by the same superscript are not significantly different at p<0.05. K (Kisra control); UMK: Untreated *Monechma ciliatum* kisra; GMK: Germinated *Monechma ciliatum* kisra; RMK: Roasted *Monechma ciliatum* kisra; BMK: Boiled *Monechma ciliatum* kisra. Values are means ± SD.

Minerals content sorghum kisra and kisra supplemented with 10% raw boiled, roasted and germinated Monechma ciliatum seeds flour

The minerals content of pure sorghum kisra and kisra supplemented with *Monechma ciliatum* seeds flour is shown in Table 2. Although supplementation of Kisra with 10% of untreated and boiled, roasted and germinated *Monechma ciliatum* seeds was slightly varied in their effect on kisra mineral content, in general, kisra content of minerals was increased, this result was in agreement with Mustafa (2009) who reported that addition of both wheat and pumpkin flour increased the mineral content of sorghum flour. Table 2 shows the effect of supplementation Kisra with 10% of untreated and boiled, roasted and germinated *Monechma ciliatum* seeds flour.

Sodium (Na) content of sorghum kisra K was found to be 362.6, mg/kg after supplementation this value was significantly increased in UMK and BMK to 413.7 and 420.0 mg/kg, respectively, and was significantly decreased to 307.8, and 296.2 mg/kg, in RMK and GMK, respectively.

Calcium (Ca) content was found to be 174.4 mg/kg in K after supplementation it was significantly increased to be 554.8, 527.2, 565.0 and 459.5 mg/kg in UMK, BMK, RMK and GMK, respectively.

Potassium (K) content was found to be 4358.3 mg/kg in K after supplementation it was significantly increased to be 4806.5, 4930.9 and 4706.3 mg/kg in UMK, RMK and GMK, respectively and insignificantly increased to 4406.5 mg /kg in BMK.

Copper (Cu) content was found to be 3.31 mg/kg in K, after supplementation it was significantly increased to be 4.90, 4.19, 4.32 and 4.26 mg/kg, in UMK, BMK, RMK and GMK respectively. Kisra supplemented with untreated *Monechma ciliatum* seeds flour was the highest of copper.

Iron (Fe) content was found to be 67.61 mg/kg in K, after supplementation it was insignificantly decreased to be 62.24, 60.46, and 61.40 mg/kg in UMK, RMK and GMK respectively and significantly decreased to 41.17 in BMK. Supplementation with untreated and treated *Monechma ciliatum* decreased the iron content. Kisra supplemented with boiled *Monechma ciliatum* seeds flour was the lowest iron content.

Zinc content was found to be 15.94 in K, after supplementation it was 15.74 and 16.03 mg/kg in UMK and BMK closely with kisra and significantly increased to be 16.91 and 17.21 mg/kg in RMK and GMK respectively.

Magnesium (Mg) content was found to be 1592.0 mg/kg in K after supplementation with *Monechma ciliatum* seed flour it was significantly increased to be 1874.6, 1822.6, 1999.4 and 1868.1 mg/kg, in UMK, BMK, RMK and GMK respectively. Kisra supplemented with roasted *Monechma ciliatum* seeds flour was the highest in Mg content.

Manganese (Mn) content was found to be 14.55 mg/kg in K after supplementation with *Monechma ciliatum* seed flour it was significantly increased to 41.44, 20.84, 22.06 and 19.29 mg/kg in UMK, BMK, RMK and GMK, respectively. Kisra supplemented with untreated *Monechma ciliatum* was the highest in manganese content.

Phosphorus (P) content was 2221.2 mg/kg in control sample K, after supplementation with *Monechma ciliatum* seeds flour it was significantly increased to be 2673.3, 2491.6, 2480.0 mg/ kg in UMK, BMK, RMK and was decreased to 2140.5 mg/kg, in and GMK respectively. Supplementation with untreated, boiled and roasted *Monechma ciliatum* seeds flour significantly increased the phosphorus content, while supplementation with germinated seeds flour decreased it. Kisra supplemented with untreated *Monechma ciliatum* seed flour was the highest in phosphorus content.

TABLE 2. Mineral content (mg/kg) of Kisra made of sorghum K and kisra supplemented with 10% raw UMK, boiled BMK, roasted RMK and germinated GMK *Monechma ciliatum* seeds flour.

Sample	K	UMK	BMK	RMD	GMK
N	362.6 ±0.12[a]	413.7±0.27[b]	420.0±0.55[b]	307.8±32[c]	296.2±0.33[d]
Ca	174.7 ±1.01[a]	554.8±0.31[b]	527.2±0.43[c]	565.0±2.11[b]	495.5±0.74[c]
K	4359.6±1.21[a]	4806.3±0.27[b]	4406.5±0.32[a]	4930.9±0.17[c]	48706.3±1.07[b]
Cu	3.31 ±0.32[a]	4.90±0.09[b]	4.19±0.17[c]	4.32±0.30[c]	4.26 ±0.23[c]
Fe	67.61 ±0.21[a]	62.24±0.34[b]	49.17±0.33[d]	60.46±0.10[c]	61.49±0.77[b]
Zn	15.94±0.43[a]	15.74±0.41[a]	16.03±0.41[a]	16.91±0.34[b]	17.21±0.53[b]
Mg	1592.0±0.23[a]	1874.6±0.22[b]	1822.6±0.45[c]	1999.4±0.37[d]	1868.1±1.04[b]
Mn	14.55 ±1.21[a]	41.44±0.21[b]	20.84±2.12[c]	22.06±0.10[c]	19.22±1.03[d]
Se	ND	0.06±0.02	0.03±0.01	ND	0.04±0.04
P	2221.7±0.32[a]	2673.3±0.24[b]	2491.6±1.90[c]	2480.0±2.03[c]	2140.5±1.87[d]

Means in the same row followed by the same superscript are not significantly different at $p<0.05$K (Kisra control); UMK: Untreated *Monechma ciliatum* kisra; GMK: Germinated *Monechma ciliatum kisra*; RMK: Roasted *Monechma ciliatum* kisra; BMK: Boiled *Monechma ciliatum* kisra, ND: not detected. Values are means ± SD.

Fatty acid and tocopherol composition of sorghum kisra and kisra supplemented with raw, boiled, roasted and germinated Monechma ciliatum seeds flour.

Fatty acids composition of sorghum Kisra K (unsupplemented) and Kisra supplemented with untreated *M. ciliatum* (UMK), boiled *M.ciliatum* (BMK), roasted *M.ciliatum* (RMK) and germinated *M. ciliatum* (GMK) are presented in Table 3. The results showed that the major fatty acids in both supplemented and unsupplemented Kisra were oleic, linoleic and palmetic. Supplementation with untreated *M.ciliatum* and treated *M.ciliatum* were varied in their effect on fatty acids content.

Supplementation with untreated and boiled *M.ciliatum* had a similar effect on Kisra fatty acids content, they significantly increased Kisra saturated fatty acids from 26.236% to 28.309% and 29.237%, respectively, and at the same time, these two processing methods increased Kisra unsaturated fatty acids increased from 67.016 to 68.058% and 67.347%, respectively. This increasing is a result of increasing in C: 23 from 0.122 in K to 4.101% and 4.153% in UMK and BMK, and the increasing in C18:2 from 19.501% to 20.423% and 20.939% in UMK and BMK, respectively.

In contrast, Kisra supplemented with roasted and germinated *M.ciliatum* seeds flour was the lowest in the saturated fatty acids content and the highest in unsaturated fatty acids. Saturated fatty acids were found to be 23.619% and 24.695 % in RMK and GMK, respectively, while unsaturated fatty acids were found to be 74.936 and 73.273. This increasing in unsaturated fatty acids is a result of the increase in C18:3 from 19.501% to 31.666 and 30.468% in RMK and GMK, respectively. Generally, supplementation of sorghum kisra with roasted and germinated *M.ciliatum* seed flour can significantly increase its unsaturated fatty acids content. Sorghum Kisra tocopherols content was not affected by supplementation with untreated and treated *M.ciliatum,* seeds flour and it was found to be 0.8 mg/100 g in all samples.

TABLE 3. Fatty acids and tocopherols content mg/100g of kisra made of sorghum K and kisra supplemented with 10% raw UMK boiled BMK, roasted RMK and germinated GMK *Monechma ciliatum* seeds flour.

Fatty acids	K	UMK	BMK	RMK	GMK
Lauric	0.107±0.00[a]	0.207±0.14[a]	1.285±0.21[b]	0.795±0.07[c]	1.362±0.17[b]
Myristic	0.208±0.33[a]	0.375±0.07[a]	0.144±0.11[b]	0.175±0.11[b]	0.587±0.00c
Palmitic	13.662±0.23[a]	13.903±0.21[a]	12.890±0.21[a]	10.702±0.11[b]	10.820±0.37[b]
Stearic	3.152±0.11[a]	2.239±0.06[b]	3.177±0.10[a]	2.737±0.54[c]	2.771±0.13[c]
Archidic	4.933±0.83[a]	4.825±0.11[a]	5.025±0.25[a]	4.115±0.23[b]	4.194±0.21[b]
Behenic	4.052±0.03[a]	0.565±0.00[b]	0.489±0.15[b]	0.413±0.23[c]	0.437±0.09[c]
Tricosanoic	0.122±0.43[a]	4.101±0.22[b]	4.153±0.17[b]	3.078±0.43[c]	3.083±0.07[c]
Lignoceric	1.923±0.09[a]	2.095±0.19[a]	2.075±0.22[a]	1.0664±0.81[b]	1.711±0.27[a]
Pamitdeic	0.380±0.53[a]	0.528±0.22[b]	0.353±0.22[a]	0.326±0.02[a]	0.387±0.05[a]
Oleic	43.920±0.17[a]	43.896±0.08[a]	43.360±0.17[a]	39.972±0.05[b]	39.391±0.02[b]
Linoleic	19.501±0.31[a]	20.423±0.11[b]	20.939±0.06[b]	31.666±0.33[c]	30.468±0.33[c]
Eicosenoic	3.215±0.77[a]	3.211±0.12[a]	3.317±0.15[a]	2.972±0.31[a]	3.027±0.51[a]
α-tocopherol	0.8±0.00[a]	0.8±0.02[a]	0.8±0.02[a]	0.8±0.04[a]	0.8±0.00[a]
Saturated	**26.236[a]**	**28.309[b]**	**29.237[b]**	**23.619[c]**	**24.965[c]**
Unsaturated	**68.016[a]**	**68.058[b]**	**67.347[b]**	**74.936[c]**	**73.273[c]**

Means in the same row followed by the same superscript are not significantly different at $p<0.05$. K (Kisra control); UMK: Untreated *Monechma ciliatum* kisra; GMK: Germinated *Monechma ciliatum* kisra; RMK: Roasted *Monechma ciliatum* kisra; BMK: Boiled *Monechma ciliatum* kisra. Values are means ± SD.

Amino acids composition of sorghum kisra and kisra supplemented with 10% raw, boiled, roasted and germinated Monechma ciliatum seeds flour.

Data presented in Table 4 shows the amino acid composition of kisra K and kisra supplemented with 10% of untreated UMK, boiled BMK, roasted RMK, and germinated *Monechma ciliatum* GMK. Most of the amino acids were significantly increased in supplemented samples. In all supplemented samples. This result agreed with Awad alkareem et al. (2008) who reported supplementation of sorghum flour with soybean protein showed a significant increase in lysine and threonine contents, with a slight increase in methionine. Total amino acids was found to be 11.584 g/100g in pure sorghum flour kisra K after supplementation they were significantly increased to 13.508, 13.840, 13.310 and 12.945 g/100g in UMK, BMK, RMK and GMK, respectively.

Sensory evaluation of kisra and kisra supplemented with 10% raw, boiled, roasted and germinated Monechma ciliatum seeds flour.

The sensory evaluation of Kisra made of sorghum flour (K) and sorghum flour supplemented with 10% of utreated, boiled, roasted and geminated *Monechma ciliatum* seed flour was carried out and data was presented in Table 5. Analysis of variance showed a significant difference between Kisra made of sorghum flour (control) and Kisra made of sorghum flour supplemented with untreated, boiled, roasted and germinated *Monechma ciliatum* seeds flour in terms of colour, smell, taste, texture and general acceptability, but insignificant variation was observed in terms of colour, between kisra of sorghum flour (control) and flour supplemented with Monechma ciliatum seeds flour, this may be due to the effect of roasting on *Monechma ciliatum* seeds colour and flavour.

TABLE 4. Amino acid composition g/100g of sorghum kisra made of sorghum K and kisra supplemented with 10% raw UMK, boiled BMK, roasted RMK and germinated GMK *Monechma ciliatum* seeds flour.

Amino acid	K	UMK	BMK	RMK	GMK
Hydroxyproline	ND	ND	ND	ND	ND
Aspartic acid	0.717±0.01	0.931±0.03	0.995±0.02	1.026±0.13	1.009±0.01
Serine	1.018±0.03	0.860±0.03	0.854±0.02	0.799±0.07	0.783±0.03
Glutamic acid	2.308±0.10	2.737±0.11	3.028±0.01	2.881±0.23	2.698±0.00
Glycine	0.399±0.03	0.547±0.04	0.473±0.03	0.487±0.06	0.502±0.00
Histidine	0.112±0.02	0.303±0.01	0.309±0.01	0.245±0.00	0.233±0.01
Arginine	0.782±0.02	0.940±0.02	0.975±0.03	0.936±0,07	0.893±0.02
Threonine	0.444±0.03	0.561±0.02	0.575±0.06	0.514±0.04	0.514±0.01
Alanine	1.155±0.01	1.085±0.03	1.074±0.03	1.130±0.05	1.106±0.03
Proline	1.116±0.03	1.069±0.06	1.045±0.06	1.040±0.05	1.038±0.03
Thyrosine	0.208±0.02	0.288±0.01	0.487±0.05	0.325±0.00	0.320±0.02
Valine	0.656±0.06	0.732±0.03	0.714±0.05	0.699±0.00	0.691±0.01
Methionine	0.105±0.04	-	0.107±0.01	-	-
Lysine	0.142±0.01	0.492±0.04	0.144±0.00	0.364±0.03	0.342±0.00
Isoleusine	0.436±0.01	0.626±0.04	1.611±0.12	0.590±0.03	0.582±0.02
Leusine	1.392±0.21	1.720±0.02	1.658±0.14	1.696±0.02	1.670±0.04
Phenylalanine	0.594±0.11	0.618±0.02	0.788±0.07	0.5800.05	0.563±0.03
Total	**11.584[a]**	**13.508[b]**	**13.840[b]**	**13.310[c]**	**12.945[d]**

Means in the same row followed by the same superscript are not significantly different at p<0.05. K (Kisra control); UMK: Untreated *Monechma ciliatum kisra*; GMK: Germinated *Monechma ciliatum* kisra; RMK: Roasted *Monechma ciliatum* kisra; BMK: Boiled *Monechma ciliatum* kisra. Values are means ± SD.

TABLE 5. Sensory evaluation of kisra made of sorghum K and kisra supplemented with 10% raw UMK, boiled BMK, roasted RMK and germinated GMK *Monechma ciliatum* seeds flour.

Sample	Colour	Smell	Taste	Texture	General acceptability
K	7.95±0.49^{a}	7.75±0.58^{a}	7.60±0.43^{a}	7.75±0.36^{a}	7.60±0.14^{a}
UMK	6.15±0.37^{b}	5.60±0.2^{b}	5.25±0.28^{b}	5.85±0.24^{b}	5.10±0.13^{b}
BMK	5.30±0.27^{c}	4.95±0.15^{c}	4.60±0.22^{c}	4.80±0.23^{c}	4.75±0.11^{c}
RMK	7.30±0.24^{a}	6.10±0.18^{d}	5.45±0.2^{d}	6.70±0.22^{d}	5.70±0.23^{b}
GMK	6.15±0.32^{b}	6.00±0.26^{d}	5.55±0.27^{d}	6.55±0.34^{d}	5.85±0.23^{b}

K (Kisra control); UMK: Untreated*Monechma ciliatum kisra*; GMK: Germinated *Monechma ciliatum kisra*; RMK: Roasted *Monechma ciliatum kisra*; BMK: Boiled *Monechma ciliatum kisra*. Values are means ± SD. Means in the same row followed by the same superscript are not significantly different at P<0.05.

To the performance of panellists, the majority gave the sensory performance for the colour of kisra made of raw sorghum flour followed by that supplemented with roasted *Monechma ciliatum* seeds flour, while kisra supplemented with raw or untreated and germinated *Monechma ciliatum* seeds flour had the same performance and boiled, had the lowest performance. Moreover high sensory performance for smell, taste, texture and overall acceptability were also recorded for kisra made of sorghum flour K (control). No significance differences was observed in smell, taste, texture and general acceptability values of kisra made from sorghum flour supplemented with roasted and germinated *Monechma ciliatum* seeds flour. Kisra supplemented with boiled *Monechma ciliatum* seeds flour has the lowest score in all values; this result is in an agreement with Serrem et al. (2011) who reported sensory evaluation by school children showed that the composite biscuits were rated as acceptable as the cereal only biscuits.

Conclusion

Using the untreated and treated *Monechma ciliatum* as a food supplement with the sorghum flour in the ratio of 1:10 in kisra products showed a significant increase in its nutritional value. Fat, fibre, protein, most of minerals, also saturated fatty acid and amino acids were significantly increased. Sensory evaluation showed that kisra made of sorghum supplemented with roasted *Monechma ciliatum* seed flour was the most acceptable and preferred product between supplemented samples by the panellists. *M. ciliatum* seeds could be an effective plant-based supplement to improve nutritional value of sorghum flour meals and considered as good and cheap source of human nutrients.

References

Abdelrahim, S.M.K., Mudawi, H.A. and Ahmed, O.B. (2016) Quality Evaluation of Three Sudanese Sorghum Cultivars for (Asida) Porridge Making. *International Journal of Life Sciences Research,* **4**, 133-137.

AOAC (2005) Association of Official Analytical Chemists. Official Methods of Analysis. Washington, DC, USA.

AOCS (2003) American oil chemist's society. Official Methods of fat Analysis and recommended practices of the American Oil Chemists› Society, Method Am 2-93, AOCS Press, Champaign, IL (USA).

Awadalkareem, A.M., Mustafa, A.I. and El Tinay, A.H. (2008) Protein, Mineral Content and Amino Acid Profile of Sorghum Flour as Influenced by Soybean Protein Concentrate Supplementation. *Pakistan Journal of Nutrition,* **7**, (3), 475-479. DOI: 10.3923/pjn.2008.475.479.

Balz, M., Schulte, E., and Thier, H.P. (1992) Trennung von Tocopherolen und Tocotrienolen durch HPLC. *European Journal of Lipid Science and Technology,* 94, 209–213. DOI.org/10.1002/lipi.19920940604.

Bartzatt, R., and Martinez, C. (2015) Instrumental Analysis of Foods: Inductively Coupled Plasma Mass Spectrometry for Determination of Metals in Cereals and Fast Ion Chromatography Analysis for Minerals in Sports Drinks. Advances in Research, 3(4), 357-365. DOI: 10.9734/AIR/2015/13579.

Duodu, K.G., Nnes, A., Delgadillo, I., Parker, M.L., Mills, E.N.C., Belton, P.S. and Taylor, J.R.N. (2002) Effect of grain organizational structure and cooking on sorghum and maize in-vitro protein digestibility. *Journal of Cereal Science,* **35**, 161-174. DOI: 10.1006/jcrs.2001.0411.

Elkhalifa, A.O., Ali, A. M., El Tinay, A. H. (2007). Fermented sorghum foods of Sudan A review. *Journal of Food Science and Technology,* **44** (4), 343-349.

Mariod, A. A., Idris, Y.M.A., Osman, N.M., Mohamed, M.A., Sukrab, A.M.A., Farag, M.Y. and Matthaus, B. (2016) Three Sudanese sorghum-based fermented foods (kisra, hulu-mur and abreh): Comparison of proximate, nutritional value, microbiological load and acrylamide content. *Ukrainian Journal of Food Science,* **4**, (2), 216-226. DOI: 10.24263/2310–1008-2016-4-2-4

Hamad, S.A.A., Mustafa, A.I., Magboul, B.I., Qasem, A.A.A. and Ahmed, I.A.M. (2019 Nutritional quality of raw and cooked flours of a high β-glucan sorghum in bird line. *Journal of Cereal Science,* **90**, 102857. DOI:10.1016/j.jcs.2019.102857.

Handa, V., Kumar, V., Panghal, A., Suri, S. and Kaur, J. ((2017 Effect of soaking and germination on physicochemical and functional attributes of horsegram flour. *Journal of Food Science and Technology,* **54** (13), 4229-4239. DOI:10.1007/s13197-017-2892-1.

Ibnouf, F.O. (2012) The Value of Women›s Indigenous Knowledge in Food Processing and Preservation for Achieving Household Food Security in Rural Sudan. *Journal of Food Research,* (1), 238-253 DOI: 10.5539/jfr.v1n1p238.

Kayitesi, E., de Kock, H.L., Minnaar, A. and Duodu, K. G. (2010) Nutritional quality and antioxidant activity of Marama–sorghum composite flours and porridges. *Food Chemistry,* **131**, 837–842. DOI.org/10.1016/j.foodchem.2011.09.055.

Mariod, A., Ibrahim, R.M., Ismail, M. and Ismail, N. (2010) Antioxidant activities of phenolic rich fractions (PRFs) obtained from black mahlab (*Monechma ciliatum*) and white mahlab (*Prunus mahaleb*) seed cakes. *Food Chemistry,* **118** (1), 120-127. DOI.org/10.1016/j.foodchem.2009.04.085

Mariod, A.A., Edris, Y.A., Cheng, S.F., and Abdelwahab, S.I. (2012b) Effect of germination periods and conditions on chemical composition of fatty acids and amino acids of two black cumin seeds. *Acta Scientiarum Polonorum, Technologia Alimentaria,* **11**(4), 401-410.

Mariod, A.A., Ahmed, S.Y., Abdelwahab , S.I., Cheng, S.F., Eltom, A.M., Yagoub, S.O. and Gouk, S.W. (2012a) Effects of roasting and boiling on the chemical composition, amino acids and oil stability of safflower seeds. *International Journal of Food Science & Technology,* **47**, 8, 1737-1743. DOI.org/10.1111/j.1365-2621.2012.03028.x

Mariod, A.A., Ahmed, Y.M., Matthaus, B., Khaleel, G., Siddig, A., Gabra, A.M. and Abdelwahab, S.I. (2009) A comparative study of the properties of six Sudanese cucurbit seeds and seed oils. *Journal of American Oil Chemist Society,* **86** (12), 1181-1188. DOI.org/10.1007/s11746-009-1459-3.

Mustafa, M.A. (2006) Evaluation of Nutrient Content of Sorghum Flour Supplemented with Wheat and Pumpkin Seed Flour. *M.Sc Thesis,* Faculty of Agriculture, Department of Food Science and Technology, University of Khartoum, Sudan..

Nour, A.A.M. and Ibrahim M.A.E.M. (2016) Effect of Supplementation with Moringa Leaves Powder (MLP) and Fermentation on Chemical Composition, Total Minerals Contents and Sensory Characteristics of Sorghum Flour. *International Journal of Science and Research,* **5**, (3), 672 - 677. DOI:10.21275/v5i3.nov161822

Oshi, M.A. and Abdelkarim, M.A. (2013) Phytochemical screening and evaluation of Monechma ciliatum (black mahlab) seed extracts as antimicrobial agents. *Avicenna Journal of Phytomedicine,* **3** (2), 126–134.

Osman, M.A. (2011) Effect of traditional fermentation process on the nutrient and anti-nutrient contents of pearl millet during preparation of Lohoh, *Journal of the Saudi Society of Agricultural Sciences,* **10**, (1), 1-6. DOI: 10.1016/j.jssas.2010.06.001

Serrem, C.A., de Kock, H. L. and Taylor, J.R.N. (2011) Nutritional quality, sensory quality and consumer acceptability of sorghum and bread wheat biscuits fortified with defatted soy flour. *International Journal of Food Science and Technology,* **46**, (1), 74 - 83. DOI.org/10.1111/j.1365-2621.2010.02451.x

Shewry, P.R. (2007) Improving the protein content and composition of cereal grain. *Journal of Cereal Science,* **46**, (3), 239-250. DOI.org/10.1016/j.jcs.2007.06.006

STATGRAPHICS®. 1985–1989. Statgraphics Statistical Graphics Systems, Version 4.0, STSC Inc. & Statistical Graphics Cooperation, Rockville, MD.