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The Physical and Chemical Properties of Sorghum Malt, Maize and Soya Beans Composite Flours

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ABSTRACT

Malnutrition is still endemic in many parts of Africa, with contribution factors including underutilization of locally available crops and Porridge, which is a staple food in sub-Saharan Africa, but due to its bulk nature, infants are frequently fed on watery gruels with low nutrient density for easy palatability. Therefore, there is need to reduce food bulk for infants and combine locally available crops to enhance the nutritional intake. In this study, Sorghum malt commonly used in formulation of weaning foods, were combined with maize and soya beans, to make composite flours at ratios of 55:30:15 for composite flour A (CFA), 50:30:20 for composite flour B (CFB), 45:30:25 for composite flour C (CFC) and 40:30:30 for composite flour D (CFD) respectively. The sorghum used was malted for nine days and soya beans were roasted for 20 minutes at 100 0C. Physical and Chemical properties of composite flours CFA, CFB, CFC and CFD were analysed for proximate content, phytate, condensed tannins, total phenolics, density, viscosity and pH. The General Linear Model (GLM) of statistical Analysis System has been used to analyse the data and means separated using Tukey's honest significance at p≤ 0.05. For proximate, CFD had the highest ash 2.59%, Fat 9.96%, protein 20.17% and crude fibre 4.8%. However, for carbohydrate, CFA had the highest at 72.02% while CFD was 62.74%. Phytate content of the composite flours ranged CFA, CFB, CFC and CFD was 7.883mg/g, 8.5mg/g, 8.833mg/g and 9.5mg/g respectively. Condensed tannins were 3.283-2.499 mgCE /g decreasing from CFA to CFD. Total phenolics ranged from 1.898-2.778mg TAE/g in the composite flours. The density ranged in 0.805-0.859, viscosity increased from CFA to CFD and the pH ranged from 6.08-6.23. Malting sorghum for nine days showed a significant decrease in phytate and total phenolics, fat, ash and density, and an increase in protein and crude fibre. This showed that using sorghum malt, maize and soya beans can provide composite porridge flour with high nutritional values.

Keywords
Sorghum malt, Composite flour, Malnutrion.

Introduction
Flour is obtained by grinding dried cereal grains and roots such as wheat, barley, sorghum and cassava roots into a fine powder. Many food products are made from flours. One food product made from cereal flour, particularly wheat flour, is bread, which is a staple food in various nations [1]. Since ancient times, corn flour has been significant in Mesoamerican cuisine, and it is now a common ingredient in American food. In northern and central Europe, bread often contains rye flour. The endosperm alone, also known as refined flour, or the endosperm, germ, and bran combined, collectively known as whole-grain flour, make up cereal flour. Meal can either be distinguished from flour by having somewhat larger particle size, or it can be used interchangeably with flour. Although there is no official distinction between cornmeal and corn flour, the former frequently refers to a grittier texture. Evidence of the creation of flour using primitive millstones to crush wheat seeds dates back to 6000 BC [2].

Composite flour is considered as a mixture of varying proportion of more than one non-wheat flour with or without wheat flour and used for production of leavened breads, unleavened baked products, pastas, porridges, snack food and meals which were traditionally made from wheat and increase the essential nutrients in human diet [3]. The idea of composite technology has been initiated by the Food and Agriculture Organization (FAO) of the united nation in 1964 which was targeting a reduction in developing nation dependency on food imports by encouraging the use of indigenous crops such as cassava, yam, maize and others in partial substitution of wheat flour [4]. According to the FAO, the use of composite flour in a variety of food products would be financially advantageous if wheat imports could be decreased or even completely eliminated, and the demand for bread and pastry products could be satisfied by using domestically produced products rather than wheat [5]. The bakery products produced using composite flour were of good quality, with some characteristics similar to wheat-flour bread, though the texture and the properties of the composite flour bakery products were different from those made from wheat flour, with an increased nutritional value and the appearance. Apart from being a good source of calories and other nutrients, wheat is considered nutritionally poor, as cereal proteins are deficient in essential amino acids such as lysine and threonine [6]. Therefore, integrating affordable staples products such as cereals and tubers to wheat products helps to increase the nutritional quality of products where Examples of typical findings include the fact that the protein quality of breads made from cassava-soya and cassava-groundnut is higher than that of bread made from common wheat [7].

Composite flours have some advantages for developing countries such as reduces the importation of wheat flour and encourages the use of domestic agricultural products as flour which will save the hard currency; seen that the demand of locally available crops will increase in making composite flour, resulting in promotion of high yielding and native plant species; for better supply of protein for human nutrition and better overall use of domestic agriculture production [8]. Different researchers including Noor Aziah and Komathi [9] in their research on acceptability attributes of crackers made from different types of composite flour, confirm that local raw materials substitution for wheat flour is increasing due to the growing market for confectioneries. The reason why several developing countries have encouraged the initiation of programs to evaluate the feasibility of alternative locally available flours as a substitute for wheat flour [10].

Sorghum is a staple food in many African countries and contains a reasonable amount of protein, ash, oil and fibre, however, it is deficient in essential amino acid content, particularly lysine [11]. According to Taylor and Dewar [12], throughout sub-Saharan Africa, by far the highest usage of the cereal sorghum is that of malting for its use in the brewing of traditional fermented beverages, it is estimated that in Southern Africa alone, approximately 200,000 metric tonnes of sorghum are malted annually and around 3000 million litres of sorghum beer are brewed each year. Attention has also been drawn to the possibility of substituting barley malt, traditionally the material of choice for breweries, with malted sorghum for the production of European clear lager type beers [13]. The reason for this is that barley does not grow well in the semi-arid areas of Africa and many cases has to be imported. In some cases, there was emergency of finding alternative to barley instead of spending on its importation like in 1988, when the government of Nigeria placed a total ban on the importation of cereals, in that time the clear lager beer brewing industry in that country was forced to utilize locally available sorghum and maize grains plus industrial enzymes, as a replacement for the previously imported barley malt [14].

Although sorghum malt is most commonly used for brewing, another application of this material is in the formulation of weaning foods. Taylor and Dewar [12] reported that inadequate energy intake during a child's growth period is a major cause of malnutrition among children in the developing countries of the world; The most problematic age of child weaning is about 9-12 months, when an already considerable nutritional demand, about 40 g/kg body weight, coincides with a still limited stomach capacity. In rural communities, the first weaning foods are generally gruels made from cereals which are staple foods with low energy and nutritional density. Conventional starchy weaning foods absorb large quantities of water, become bulky when prepared and the child generally cannot consume sufficient quantities to meet their calorific requirements. Simple means are available to enhance the energy and nutritional density of weaning foods by adding a certain amount of malted sorghum flour also known as power flour to thick porridge and it is thinned fairly quickly. The amylase enzymes in the malt break down the complex carbohydrates and liquefy the starch in the porridge. This reduces the viscosity of the porridge whilst maintaining the energy density. In addition, the porridge is also, to some extent, pre-digested and the malt enzymes somewhat reduce the anti-nutritional and flatus factors which enhance the vitamin content and improve the mineral availability. The malt also bestows flavour and sweetness to the porridge. The technology of malting has been shown to improve the nutritional value of sorghum by improving the in vitro digestibility of the sorghum protein [15].

Maize is the third most important crop after wheat and rice and is grown in more countries than any other crop in the world. Maize is also used as food, raw material for industrial use and also used as livestock feed. Maize flour can be used exactly like wheat flour in making bread, breakfast meals and other food products. Maize flour, also called corn flour is highly rich in protein, dietary fibre and very low in fat. Maize flour is by far the most widely eaten flour after wheat and rice flour [16]. It is uniquely rich in dietary fibre, protein, vitamin B6, magnesium and omega 6 acids, vital for a good heart and fight against infections. Fortified maize flour has been used in the eradication of malnutrition in some parts of the world [16].

According to Liu [17], there is some historical and geographical evidence that the soybean (Glycine max) first emerged as a domesticated crop in China thousands of years ago and was considered one of the five sacred grains together with rice, wheat, barley, and millet. During soybean domestication, the Chinese gradually transformed soybeans into various forms of soy foods. It is a remarkable source of protein for both animals and human consumption and is also a leading source of edible oils and fats [18]. Soybean the legume richest in nutrients and the one from which the most dietary products are made is used in various traditional farming systems of various countries. It contains valuable phytochemicals and has extraordinary capacity to nourish and prevent diseases. Soya has the advantage of containing virtually no sodium, a mineral that causes fluid retention in the tissues; this makes it very suitable in cases of cardiovascular disease. Soya is also known to be a good source of the trace elements copper, zinc and manganese and can be said to contain all the nutrients needed in food [19].

In general, foods which are traditionally prepared from soya beans, also known as Oriental soy foods, are classified as either non-fermented or fermented. Non-fermented soy foods include soymilk, tofu, soy sprouts, yuba (soymilk film), okara (soy pulp), vegetable soybeans, soynuts and toasted soy flour, whereas fermented soy foods include soy sauce, miso (fermented soy paste), natto, tempeh, soy yogurt (fermented soymilk), sufu (fermented tofu), and soy nuggets (fermented whole soya beans) [17]. Historically, all traditional soy foods were made from whole soybeans. However, with the use of modern processing technologies, some traditional foods, such as soy sauce, soymilk, and tofu, can now be made from defatted soy meal or its derivative products, such as soy protein isolate [20]. This study aims to evaluate the physical and chemical properties of porridge composite flours made from malted sorghum, maize and soya beans.

Materials and Methods

Sampling

Samples of 10kgs maize and 10kgs soya beans were collected from the local market in Nakuru County, Kenya. A sample of malted sorghum for nine days was also used. The three samples in sacks were kept in a dry and clean place at the Food Chemistry Lab, in the Department of Dairy and Food Science and Technology, Egerton University where the analysis was carried out.

Analysis of Flour Physical and Chemical Properties

A sample of red sorghum malted for nine days with high sugar content was used in the formulation of the composite flour; soya beans was prepared by roasting at 100 ^{0}C for 20 minutes [21]. Different flour ratios of the nine days malted sorghum: maize: soya of 55: 30: 15 for composite flour A (CFA), 50: 30: 20 for composite flour B (CFB), 45: 30: 25 for composite flour C (CFC) and 40: 30: 30 for composite flour D (CFD) respectively. According to Murekatete et al. [22] using soya beans at 25% in a composite flour could meet the recommended protein content of supplementary foods for older infants and young children which is 15g per 100g of food on dry matter basis. However according to Bolarinwa et al. [23] 10% soy flour substitution is most acceptable in terms of the sensory properties, using malted sorghum in porridge composite flour, causes the concentration of the porridge could achieve more than 20% solid therefore, more than 60% of daily energy requirements for children can be achieved with only two or three meals a day of average intake of 277ml per meal [24].

Chemical analysis of CFA, CFB, CFC and CFD

The chemical composition of CFA, CFB, CFC and CFD was obtained according to AOAC (2005) methods.

For moisture (method 967.19) using aluminium dish, a 2 g sample well mixed was added to a dish previously dried at 105°C, cooled in a desiccator, and accurately weighed soon after reaching room temperature. Heated at 105°C the dish containing the sample up to constant weight for 5 h in partial vacuum. Admit dry air into oven to bring it to atmospheric pressure. Transferred to desiccators, Air-tight desiccators, Reignited CaO was satisfactory drying agent, and weighed soon after reaching room temperature. The flour residue was reported as total solids and loss in weight as moisture content.

Total ash (method 930.05) weighed 2g well mixed test portion into shallow, relatively broad ashing dish that has been ignited, cooled in desiccator, and weighed soon after reaching room temperature. Heated the container in furnace at 550°C until light gray ash results. Cooled in a desiccator and weighed soon after reaching room temperature. Reignited CaO was drying agent used for desiccator. The weight of the residue was reported as total ash.

Crude fat (method 930.09) 2g test samples were extracted with anhydrous ether. Thimble with porosity permitting rapid passage of ether was used. Extraction period was 4 h at a condensation rate of 5–6 drops. The extract was dried for 30 min at 100°C, cooled and then weighed. The weight of the extract after drying was reported as crude fat of the flour.

Crude Fibre (method 987.10) 2 g ground test portion extracted with ether or petroleum ether. Transferred to 600 ml beaker, fibre contamination from paper and brush were avoided. Add 2.0 g dry weight of prepared ceramic fibre, 200 ml boiling 1.25% H_2SO_4 and one drop diluted antifoam. The blank was determined by treating 2 g dry weight of prepared ceramic fibre with acid and alkali as in determination. The beaker was placed on digestion apparatus with pre-adjusted hot plate and boiled exactly 30 min, rotating the beaker periodically to keep solids from adhering to sides. Removed the beaker and filter. The mat and residue were returned to the beaker by breaking suction and blowing back. Add 200 ml boiling 1.25% NaOH, and boil exactly 30 min. Removed the beaker and filter again. Mat and residue were dried for 2 h at 130°C. Cooled in desiccator and weighed. The dry matter was ashed for 30 min at 600 ± 15°C, Cooled in a desiccator and reweighed.

$$\text{Crude fiber \%} = \frac{(W2 - W3) + (B2 - B3)}{W1} \times 100$$

Where, B_2 and B_3 are average weights of all blanks after oven drying and ashing, respectively.
W1: weight of the sample

W2: weight after drying
W3: weight after ashing

Crude protein (method 978.04) weighed test portion 2 g, placed the portion in digestion flask. Added 40 ml H_2SO_4 containing 2 g salicylic acid. Shaked until thoroughly mixed and let stand, with occasional shaking for 30 min; then added 5 g $Na_2S_2O_3 \cdot 5H_2O$. Shaked and let stand 5 min; then heated over low flame until frothing ceases. Turned off heat, add 0.7 g selenium and 15 g powdered K_2SO_4 and boiled briskly until solution cleared, then cooled for 30 min, added 200 ml H_2O, cooled <25°C, added 25 ml of the sulphide solution and mixed to precipitate. Added layer of NaOH without agitation. Immediately connected flask to distilling bulb on condenser and with tip of condenser immersed in standard acid and 5–7 drops indicator in receiver, rotated flask to mix contents thoroughly; then heated until all NH_3 distilled. Removed receiver, washed tip of condenser and titrated excess standard acid in distillate with standard NaOH solution. Nitrogen % has been calculated using the following equation:

$$\%\mathrm{N} = N\,HCl \times \frac{corrected\ acid\ volume}{weight\ of\ sample(g)} \times \frac{14g}{mol} \times 100$$

N HCl: normality of HCl in mol per 1000ml
Corrected acid: ml standard acid for sample- ml standard acid for blank
14: atomic weight of nitrogen

To obtain the amount of protein, a conversion factor of 6.25 has been used.

Phytate was determined according to Sureshkumari et al. [25] method. 0.1g of composite flour was weighed and transferred into falcon tubes to which 1 ml of 0.4 M HCl was added and incubated for 12h at 4°c to extract the phytic acid present in sample. The samples were then vortexed briefly and 20µl aliquot transferred into microtiter plates and supplemented with 180 µl of Chen's reagent (1 volume 6N H_2S0_4, 1 volume 2.5% ammonium molybdate, 1 volume 10% ascorbic acid, 2 Volume H_20). After mixing the sample containing phytic acid with Chen's reagents, the reaction results in the formation of phosphor-molybdate compound which have a blue coloration and the colour intensifies depending on phytic concentration, i.e., cassava leaves and other root tubers have low concentration of phytic acid compared to legumes and cereals which concentration of phytic acid is high (deep blue). The assay was then allowed to develop for 2h at ambient room temperature. A picture is taken after 1h and 2 h, and a comparison is made between colour intensity of samples and control samples. The absorbance was measured at 500 nm in a double beam UV-Vis spectrophotometer. The standards were prepared by dissolving 0.174 g of di-potassium hydrogen phosphate (K_2HPO_4) in 1l distilled water to give a concentration of 1Mm K_2HPO_4. Standards are prepared in order of increasing concentration by pipetting 0,5,15,30,45 and supplementing it with 100µl of Chen's reagent,10µl 0.4 M HCl and distilled water in order of reducing volume. A 1 Mm dipotassium hydrogen phosphate solution has 155 ng of free phosphorus by fraction. The amount of phytic acid was calculated using phytic acid standard curve, and results were expressed as phytic acid in mg/g.

A method by Mezgebo et al. [26] was used for tannin determination. A 0.2 g of sample was added into 100ml conical flask, and then 10 ml of 4% HCl in methanol (v/v) were added and the content was incubated at 30^{o}C for 20 min. The mixture was then centrifuged at 2000×g for 20min at room temperature. Sample extracts (1ml) were mixed with 5ml of the vanillin-HCl reagent in a clean test tube. The specific reagent vanillin-HCl for the determination was prepared just before use by mixing equal volume of 1% vanillin in methanol (w/v) and 8% concentration HCl in methanol(v/v). Absorbance read at 500nm using UV/VIS Spectrophotometer after exactly 20min. Sample blanks in which 4% HCl in methanol replaced vanillin reagent were included. For setting the calorimeter to zero, 1ml blank which was 1%HCl in methanol was used. Catechin was used as standard and condensed tannin was expressed as mg catechin equivalent per 100mg sample.

Total phenolics were analysed according to Tian et al. [27] method with some modifications. A 70% ethanol was added to 0.2g sample, vortex for 90min at 1500×g and centrifuge for 15min at 3000×g. One ml of extract was pipette into 100ml volumetric flask containing 75ml of distilled water, mix with 5 ml Folin Denis reagent and then after 5 min, 10 ml sodium bicarbonate solution was added. The final mixture was allowed to stand for 2 h for colour development, and the absorbance at 760 nm was recorded using UV/VIS spectrophotometer. Tannic acid was used as a standard to establish the calibration curve for the quantification.

Physical properties analysis of composite flours

The water absorption capacity was determined according to the method described by Akubor [28]. A 1g sample was mixed with 10ml distilled water and allowed to stand at ambient temperature for 30 min, and then centrifuged at 3,000×g for 30 min. Supernatant water was decanted. The samples were allowed to drain for about 35 min and the weight of bound water was determined by the difference between the initial and final weights of the sample.

The bulk density was determined according to the method described by Oladunmoye et al. [29]. A dish of known volume was well washed, dried and weighed with its lid. Each flour sample was filled into the dish, tapped thrice and then weighed. And then bulk density was calculated from the volume and weight of the flour sample.

$$\text{Bulk density} = \frac{\text{mass of dish with flour} - \text{mass of the empty dish}}{\text{volume of the dish}}$$

Viscosity measurement was carried out by mixing 100g flour with 300ml of water. The mixture was heated to 70°C with continuous stirring until the starch is gelatinized, then it was cooled up to 40°C. The viscosity was determined using a rotary DV-E Brookfield viscometer, a method by Mtebe et al. [30].

Measurement of pH was determined according to the method described by Supriya and Rajinder [31]. The glass electrode pH meter was used. Ten grams of the sample were weighed and then transfer to 100 ml volumetric flask and make up to 100 ml with distilled water. The pH was obtained by dipping the electrode into the solution and allowing stabilizing, and then results were recorded for every sample.

Statistical analysis

The analysis of variance was done through an ANOVA table to identify if there is a significant difference in physical and chemical properties of the different composite flours CFA, CFB, CFC and CFD, considering also the raw materials used which are the malted sorghum, maize and soya beans using SAS software, General Linear Model (GLM) of Statistical Analysis Systems computer package. Means were separated using Tukey's honest significance test at $p \leq 0.05$.

Results

The raw materials (sorghum, maize, and soya beans) and composite flours (CFA, CFB, CFC and CFD) were analysed for moisture content, ash, crude fat, crude protein, crude fibre and total carbohydrate. The obtained results are presented in Table 1. Malting sorghum for nine days had reduced the ash and fat content of the grains, from 1.85% to 1.41% (ash) and 6.54% to 4.71%(fat). However, protein and fibre had significantly increased after nine days malting, respectively from 10.46% to 11.8% and 3.78% to 4.67%. There is no significant difference in carbohydrate content of the unmalted and malted sorghum. Soya beans dominated with the highest level of ash, fat, fibre and protein, respectively 5.3%, 23.05%, 6.38% and 39.32% which made soya beans the major influencer of ash, fat, fibre and protein content of the composite flour CFA, CFB, CFC and CFD. As the ratio of the soya beans increase in composite flours, there were also increase of ash, fat, fibre and protein of composite flours. Maize was the highest in carbohydrate content with 83.59%, followed by malted sorghum with 77.39%. The ratio of maize was constant in all the composite flours; therefore, the carbohydrate content of the flours was affected by malted sorghum, the more malted sorghum the more carbohydrate in a composite flour. Composite flour D (40:30:30) dominated in ash, fat, protein and fibre content with 2.59%, 9.69%, 20.17% and 4.8% respectively, while composite flour A (55:30:15) was the highest in carbohydrate content with 72.02%.

The results for antinutritional content analysis for the raw materials and the composite flours are shown in Table 2. Malting sorghum for nine days had reduced Phytate content from 8.499mg/g to 5.166mg/g and total phenolics from 2.46 to 1.784 mg TAE/g. Soya beans had the highest level of phytate (17mg/g) and total phenolics (2.974mgTAE/g), and malted sorghum was the highest in condensed tannins with 4.383mgCE/g. Composite flour D(40:30:30) was the highest in phytate(9.5mg/g) and total phenolics(2.778mgTAE/g), while Composite flour A was the highest in condensed tannins(3.283mg CE/g).

Table 2: Antinutritional content of raw materials and composite flours.

Sample	Phytate (mg/g)	Condensed Tannins (mg CE/g)	Total Phenolics (mgTAE/g)
US	8.499±1.64^{bc}	3.983±0.49^{ab}	2.46±0.23^{abc}
MS	5.166±0.7^{c}	4.383±0.16^{a}	1.784±0.03^{c}
M	8.833±0.23^{b}	0.049±0.02^{d}	2.26±0.02^{abc}
SB	17±1.41^{a}	0.166±0.04^{d}	2.974±0.5^{a}
CFA	7.833±0.23^{bc}	3.283±0.07^{bc}	1.898±0.01^{bc}
CFB	8.5±0.7^{bc}	2.949±0.3^{c}	2.092±0.02^{abc}
CFC	8.833±0.23^{b}	2.616±0.02^{c}	2.472±0.27^{abc}
CFD	9.5±0.7^{b}	2.499±0.04^{c}	2.778±0.14^{ab}

Values are means ± standard deviation, n= 3. U.S: Unmalted Sorghum, M.S: Malted sorghum, M: Maize, S.B: Soya Beans, mg/g: milligram per gram, mgCE/g: milligram Catechin Equivalent per gram of sample, mgTAE/g: milligram Tannic Acid Equivalent per gram of sample, CFA: composite flour A, CFB: composite flour B, CFC: composite flour C, CFD: composite flour D., means in the same column with the same letter are not significantly different and these having different letters in the same column means that they are significantly different ($p \leq 0.05$).

The results of physical properties which were the water absorption capacity, density and viscosity, and pH are presented in Table 3. Malting sorghum for nine days had increased its water absorption capacity from 1.495 to 1.827 and decreased its density (from 0.867 to 0.71), its viscosity (from 1680 to 1234.5) and also the pH decreased from 6.22 to 5.78. Soya beans were the highest in water absorption capacity and pH with 1.873 and 6.59. Maize had the highest value in viscosity and density (3569mPa.s and 0.853). Composite flour D was the highest in water absorption capacity

Table 1: Proximate analysis of flours.

Sample	Moisture (%)	Ash (% dwb)	Fat (% dwb)	Protein (% dwb)	Fibre (% dwb)	Carbohydrate (% dwb)
U.S	10.13±0.45^{a}	1.85±0.02^{cd}	6.54±0.06^{d}	10.46±0.01^{f}	3.78±0.27^{cd}	77.36±0.44^{b}
M.S	10.17±0.24^{a}	1.41±0.25^{de}	4.71±0.1^{e}	11.8±0.05^{e}	4.67±0.4^{b}	77.39±0.4^{b}
M	10.29±0.34^{a}	1.21±0.005^{e}	2.98±0.5^{f}	9.54±0.1^{f}	2.67±0.11^{e}	83.59±0.57^{a}
S.B	7.55±0.27^{b}	5.3±0.1^{a}	23.05±0.16^{a}	39.32±0.17^{a}	6.38±0.3^{a}	25.94±0.38^{g}
CFA	9.61±0.44^{a}	1.92±0.1^{cd}	7.12±0.5^{cd}	15.63±0.33^{d}	3.3±0.33^{de}	72.02±1^{c}
CFB	9.95±0.18^{a}	2.06±0.16^{bc}	8.31±0.64^{bc}	16.96±0.43^{c}	4.11±0.15^{bc}	68.54±0.78^{d}
CFC	9.54±0.17^{a}	2.34±0.33^{bc}	9.21±1.03^{b}	19.15±0.19^{b}	4.53±0.05^{bc}	64.76±0.71^{e}
CFD	9.66±0.32^{a}	2.59±0.21^{b}	9.69±0.43^{b}	20.17±0.8^{b}	4.8±0.2^{b}	62.74±0.52^{f}

Values are means ± standard deviation, n= 3. %dwb: percentage dry weight basis, U.S: Unmalted Sorghum, M.S: Malted sorghum, M: Maize, S.B: Soya Beans, CFA: composite flour A, CFB: composite flour B, CFC: composite flour C, CFD: composite flour D. Means in the same column with the same letter are not significantly different and different letters in the same column means significantly different ($p \leq 0.05$).

1.577, composite flour A, the highest in density 0.859 and viscosity 1722. 5mPa.s, while composite flour B had the highest pH of 6.23.

Table 3: Physical properties and pH of raw materials and composite flours.

Sample	WAC	Density	Viscosity in mPa.s	pH
US	1.495 ± 0.08^{b}	0.867 ± 0.00^{a}	1680 ± 46.66^{b}	6.22 ± 0.02^{b}
MS	1.827 ± 0.00^{a}	0.71 ± 0.00^{e}	1234.5 ± 10.6^{bc}	5.78 ± 0.00^{e}
M	1.214 ± 0.02^{c}	0.853 ± 0.00^{ab}	3569 ± 230.5^{a}	6.23 ± 0.00^{b}
SB	1.873 ± 0.00^{a}	0.75 ± 0.00^{d}	739 ± 120.2^{c}	6.59 ± 0.02^{a}
CFA	1.45 ± 0.01^{b}	0.859 ± 0.00^{ab}	1722.5 ± 215.6^{b}	6.08 ± 0.00^{d}
CFB	1.485 ± 0.05^{b}	0.84 ± 0.00^{b}	1205 ± 63.6^{bc}	6.23 ± 0.00^{c}
CFC	1.527 ± 0.1^{b}	0.844 ± 0.01^{b}	1140 ± 127.2^{c}	6.18 ± 0.00^{bc}
CFD	1.577 ± 0.00^{b}	0.805 ± 0.00^{c}	1067 ± 66.4^{c}	6.22 ± 0.02^{b}

Values are means ± standard deviation, n= 3. U.S: Unmalted Sorghum, M.S: Malted sorghum, M: Maize, S.B: Soya Beans, WAC: Water Absorption capacity, CFA: composite flour A, CFB: composite flour B, CFC: composite flour C, CFD: composite flour D. Means in the same column with the same letter are not significantly different and these having different letters in the same column mean that they are significantly different ($p \leq 0.05$).

Discussion

The proximate analysis results obtained as shown in Table 1 are in range with other researcher's results, including Abdulrahman and Omonyi [32], Jimoh and Abdullahi [33], Murekatete et al. [22] and Njuguna et al. [34]. It has been observed that malting sorghum for nine days had significantly increased the protein and fibre content of the grain and significantly decreases the fat content of the grain; this is due to the metabolic activities of the grain to synthesis new materials for the growth of the germ during the germination process.

In composite flours CFA, CFB, CFC and CFD, a significant difference in ash content between CFA and CFD has been observed, where CFD is the highest with 2.59% and this indicates that the increase in soya beans ratio is proportional to the increase in ash content of the composite flours. Fat content is also different in the analysed composite flours ranging from7.12-9.69%. CFC and CFD are not significantly different but a significant difference has been observed among others. The increase is related to the increase in content of the soya beans the grain with highest amount of fat. For the protein content of the flour, the obtained results showed an increase which is relatively related to the increase in soya beans flour in the mixture, the composite flours range from 15.63 to 20.17% respectively from CFA to CFD. There is a difference among the composite flours but the difference between CFC and CFD is not significant regarding their protein content. The fibre content of composite flour ranges from 3.3- 4.8%, only CFA with 3.3% is significantly different to CFB, CFC and CFD. The carbohydrate results obtained decrease from CFA to CFD, ranging from 72.02%- 62.74%, and they are significantly different in a decreasing order. The decreasing ingredient is malted sorghum showing that this one has a significant effect on carbohydrate content of the composite flours.

The obtained results on phytate, condensed tannins and total phenolics as shown in Table 2 are in range with results by other researchers such as Makokha et al. [35] and Hidvegi and RAdomir. The phytate content for all the flour was in the range of 5.166-17mg/g. Soya beans have the highest value compared to sorghum and maize and this explains the reason behind the increase in phytate content of the flour as the soya beans ratio increase from CFA to CFD. It has been observed that malting of sorghum decreased significantly the phytate level in the grain, the nine days of germination has reduced the phytate level from 8.499mg/g to 5.166mg/g. Condensed tannins levels were in range of 0.049 – 4.383mgCE/g. Sorghum has the highest level of condensed tannins, influencing the level of tannins in the composite flour, the more sorghum the higher is condensed tannins level. The nine days of germination had not decreased the level of condensed tannins, differently; it has slightly increased the level of condensed tannins. Results show that the total phenolics range from 1.784 to 2.778mgTAE/g and soya beans have the highest level of total phenolics. It has been also observed that nine days of germination of sorghum has a significant reduction in level of the total phenolics content of the grain. The total phenolics level in composite flours increases as the soya beans level increase too.

Results show a significant difference in physical properties and pH of analysed flours (Table 3). Germinating sorghum grains for nine days has reduced the density, viscosity and pH of the sorghum flour. An increase in water absorption has been observed in malted sorghum compared to the unmalted sorghum. There is no significant difference in the water absorption of the composite flours ranging from 1.45- 1.57. Density was decreasing from CFA to CFD with no significant difference between CFB and CFC. Viscosity was in range of 1067 to 3569 mPa.s in all the flour, with maize having the highest viscosity among the flour used. The viscosity was decreasing with the decrease in malted sorghum concentration from CFA to CFD with no significant difference between CFC and CFD. The pH was ranging from 5.78 to 6.59, with some significant differences among the flours of grains and composite flour.

Conclusion

It has been observed that the application of malted sorghum in composite flour has a significant effect on improving chemical and physical properties. The combination of malted sorghum, maize and soya beans can provide nutritious composite flours, because of increase in protein due to malting sorghum and the high protein content in soya beans. High energy content of sorghum malt and maize, and other nutrients in all the three grains. The low density of sorghum malt makes possible the production of porridge with high nutritional density.

The malting technology should be used in composite porridge flours formulation to improve the physical and chemical properties of the flour. Soya beans and maize should be considered while making composite flour due to improve the nutritional value of the final composite flour in protein and carbohydrate.

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