Effects of Steeping Time on the Physicochemical, Functional and Sensory Properties of Custard Produced from Maize (*Zea Mays*) and Sorghum (*Sorghum Bicolor* L) Starch Blends

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Abstract

The aim of this study was to evaluate the physicochemical, functional and sensory characteristics of starch blends from steeped maize and sorghum. Starch were extracted from maize and sorghum after steeping for 6 and 12h. It was blended in the ratio; 100: 0, 90: 10, 80: 20, 70: 30, 60: 40, 50: 50, 0: 100 and labelled A1, A2, A3, A4, A5, A6, A7, respectively for samples soaked for 6h. While same maize-sorghum blend ratios from 12h soaking were labelled B1, B2, B3, B4, B5, B6 and B7, respectively. Percentage moisture, protein and fat content ranged from 9.60 to 13.04 %, 7.16 to 10.13 % and 3.49 to 4.96 %, respectively, while Percentage Ash, Crude fiber and total carbohydrate ranged from 0.97 to 1.46 %, 0.59 to 2.90 % and 71.46 to 74.84 %, respectively. Energy value of sample A1 was significantly higher (379.36 kcal/100g), followed by samples A2 and A3 with values of 375.05 and 373.10 kcal/100g, respectively. Bulk density, water absorption capacity and swelling index ranged from 1.02 to 1.85 g/ml, 1.70 to 2.70 g/g and 1.10 to 1.30, respectively. Water absorption capacity of samples A1, B1 and B2 were significantly higher, with value of 2.70g/g. Swelling index increase with less soaking time (6h). Calcium (Ca), Potassium (K) and Magnesium (Mg) content of the starch blends ranged from 15.08 to 52.48, 108 72 to 269.30 and 11.68 to 99.00 mg/kg, respectively. Calcium, Magnesium and Iron content increased with increased substitution of sorghum starch. pH and viscosity ranged from 3.41 to 3.77 and 1.390 to 1.514 pas, respectively. pH was relatively higher as soaking time increased. While viscosity of the custard was higher at 6h soaking time. Teaxture, Aroma and Taste score ranged from 5.50 to 6.60, 4.25 to 6.40 and 4.10 to 6.16, respectively. All the samples received equal acceptability, except sample sample B1 which was significantly lower.

Keywords: *Custard, Maize, Sorghum, Starch, Steeping, Physicochemical, Sensory*

1. Introduction

Custard powder is a fine textured dry food product made from corn starch (Okoye et al., 2008), commonly used as a breakfast cereal or used as weaning food in most developing nations of the world including the tropics (Tárrega and Costell, 2006). Custard pastes or gruel is made by dissolving custard starch in water, followed by the addition of calculated amount of boiling water (Alimi *et al.*, 2017). Custard emerged as a convenient food product to mimic the traditional fermented cereal gruel called Ogi,(Salami *et al*., 2018). Custard is widely consumed in many parts of Africa including Nigeria. According to Salami et al. (2018), the time required to ferment, mill and prepare custard prompted the development of products such as custard. However, the sour taste, typical of the fermented gruel is lacking in custard (Salami *et al*., 2018). Thus, the addition of souring agents such as tamarind (Tamarindicus indica), lime (*Citrus aurantifolia*) and soursop (*Annona muricata*) may be required to impact the desired sourness in custard powder. Extracts from these fruits are known for their tart and tangy flavor due to the presence of tartaric acid (Akubor and Egbekun, 2007). These fruits are generally rich in organic acid which contributes to their acidity and sourness. The sourness of lime has been associated with the presence of high amounts of citric acid, while the presence of malic and tartaric acid confers sourness to soursop (Shankaracharya, 1998) and tamarind respectively (Obulesu and Bhattacharya, 2011). Previous studies on custard focused on enriching the powder with protein sources such as soybean (Alake *et al*., 2016; Okoye *et al*., 2008) or the use of other starch sources such as cassava for the preparation of custard (Alake et al., 2016; Awoyale *et al*., 2016). Addition of defatted soybean flour up to 10 or 20% levels to cassava starch custard was reported to be acceptable by taste panel members (Alake *et al*., 2016). Furthermore, the addition of defatted soybean flour resulted in high water binding capacity which was associated with increase in protein content (Alake *et al*., 2016). Other studies on custard paste reported the use of composite starch from corn and banana starches for improved functionality and reduced digestibility (Alimi *et al*., 2017b). Recently, some authors reported the use of fruit extract to enhance the sourness of flour from germinated cereal grains (Salami *et al*., 2018). The authors reported that the addition of souring fruit extracts to germinated cereal grains significantly improved nutritional and decreased the anti-nutritional properties of the samples. As previously stated, custard powder represents a suitable alternative to Custard for convenience. However, previous studies reported that the taste in terms of sourness of the custard paste needs to be improved (Salami *et al*., 2018). Therefore, in this study, the effect of souring agent on the functional, pasting and sensory properties of corn starch custard were investigated. Custard prepared by fermentation was included as a reference sample.

In the sub-Saharan Africa, most of the breakfast meals for both adults and young kids are prepared using cereals, legume roots, cassava and potatoes. Custard is one of the popular porridges that are widely used in the West Africa nations. It is one of the cheap and popular weaning foods in most of the countries in West Africa. There are a variety of methods that is used to prepare Custard. Custard is primarily prepared from maize, sorghum or millet. Cereals form a big proportion of the food taken. Cereals have approximately 12-14% water, 65-75% carbohydrates, 2% lipids and a protein content of about 7-12%. Their constant use may cause anemia, malnutrition and other dietary diseases. Gelatinized Custard is commonly referred to as pap and is mostly used as the weaning food for infants and also as adult breakfast meal. There are different traditional names given to these semi solid foods such as Eko, Agidi, Akamu among others. Semi solid food made from sorghum is usually referred to as Custard-baba. The viscosity of the final semi solid food produced depends upon the water that was used during the preparations process. Custard is one of the staple foods for infants in African countries such as Nigeria (Nago *et al*.,1998). In Nigeria and other parts of Africa 90% of the infants are introduced to complementary foods to supplement the mother milk after the age of 6 months (Faber, 2001). In addition to infant weaning, Custard is also consumed by adults and used by an infant mother to stimulate the production of milk. The use of semi solid food such as Custard for nursing the sick has been encouraged by the doctors as it is light in the stomach and easily digested. The aim of this study was to evaluate the physicochemical, functional and sensory characteristics of starch blends from steeped maize and sorghum for enriched custard production.

2. Materials and Methods

Maize (*Zea mays*), and sorghum (*Sorghum bicolor*) were purchased from mile 3 market in Port Harcourt, Rivers State, Nigeria

2.1 Production of Maize Starch

The method described by Ogiehor *et al.*, (2005) was used, as shown in Figure 1. Maize grains were sorted and cleaned; one kg of the maize grain was steeped in potable water (4L) for 72h at room temperature (29 ± 2°C). The steeped water was decanted and the grains washed thoroughly with potable water. The grain was wet milled using attrition mill. The slurry was sieved with excess potable water using a muslin cloth. The filtrate was allowed to settle for 12h and the supernatant decanted. The sediment was place in a cheese cloth and squeezed to remove excess water, dried at 65°C for 12h.

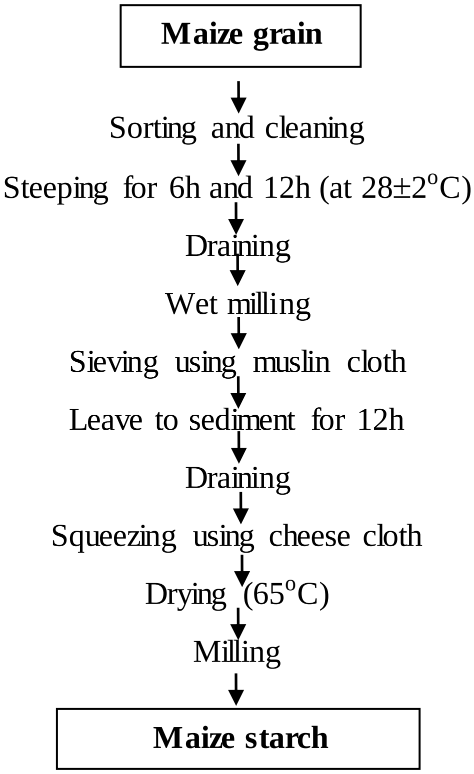

Fig 1: Flow diagram for the production of maize starch (Source: Ogiehor *et al.*, 2005)

2.2 Production of Sorghum Starch Flour

The method described by Akingbala *et al* (1981) was used. The starch was prepared by steeping sorted and clean sorghum grains of 1kg in four (4) litres of portable water for six (6) and twelve (12) hours respectively. Banigo and Muller, (1972). The steep water was decanted, and the grain washed with clean water and wet milled. The bran was removed by wet sieving and the sieved/filtrate allowed to settle for 3-4 hours a process referred to as souring which precipitates the solid starchy matter as shown in figure 2.

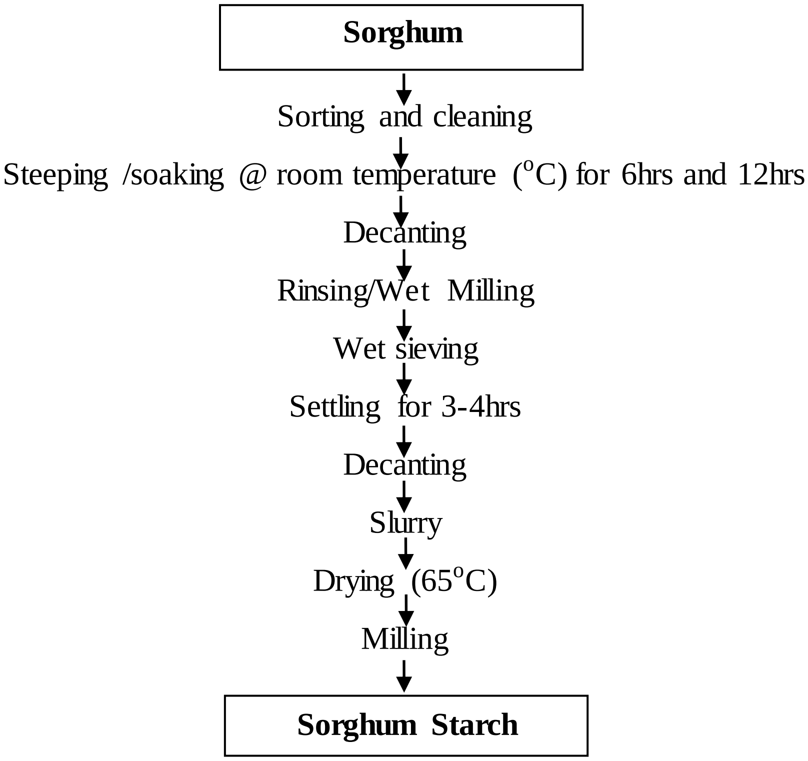

Figure 2: **Flow diagram for production of Sorghum Starch (**Akingbala *et al.*,1981) modified

2.3 Preparation of Custard from Blends of Maize and Sorghum Starch

Fourteen formulations designated composites; A, B, C, D, E, F, G, H, I, J, K, L, M and N were prepared by mixing various proportions of starch and flour recipes. The reconstituted blends were prepared and packaged separately in heat sealed HDPE packages and kept for further use.

Table 1: Formulation Table for Steeped Maize and Sorghum Starch Blends

Samples	Maize (%)	Sorghum flour (%)	Flavour (g) (vanilla)	Colorant (g) (sunset yellow)
A1	100	-	0.5	0.5
A2	90	10	0.5	0.5
A3	80	20	0.5	0.5
A4	70	30	0.5	0.5
A5	60	40	0.5	0.5
A6	50	50	0.5	0.5
A7		100	0.5	0.5
B1	100	-	0.5	0.5
B2	90	10	0.5	0.5
B3	80	20	0.5	0.5
B4	70	30	0.5	0.5
B5	60	40	0.5	0.5
B6	50	50	0.5	0.5
B7		100	0.5	0.5

Sample A1 to A7 (Steeped for 6h)
Sample B1 to B7 (Steeped for 12h)

2.4 Functional Properties of The Starch Blends

2.4.1 Water Absorption Capacity

The method described by Elkhalifa *et al*, (2005) was used. 5ml of water was added to 1.0g of the sample in a centrifuge tube. The mixture was sonicated for 1 minute to disperse the sample and the suspension allowed to stand for 30 minutes. The suspension was then centrifuged after standing at 3500rpm for 30minutes and the water absorbed is calculated using the following formula

$$\text{Water absorbed (ml/g)} = \frac{Volume\ of\ water\ before\ centrifuge - vol\ of\ water\ after\ centrifige}{Sample\ weight}$$

$$\text{Water absorbed (g/g)} = \frac{Weight\ of\ Cent.tube + Sediment) - Weight\ of\ Cent.\ tube + Sample}{Sample\ weight}$$

2.4.2 Least Gelation Concentration Capacity, Time and Temperature.

The methods of Sathe and Salunkhe, (1981) was used. Sample was prepared at 2-20% (W/V) in 5ml distilled water in test tubes. The test tubes were heated in a water bath for 1hr at temperature above 65°C. The tubes were cooled for 2hrs in a refrigerator (4°C) and inverted. Least gelation concentration was determined at that concentration when the sampled from the inverted test tube do not slip. Temperature and time of gelation was determined by heating a prepared slurry of a known mass with thermometer immersed in the beaker, gel formation was carefully observed to determine the temperature and time.

2.4.3 Bulk Density

The method of Akpapunam and Markaku (1981), was used. A 10ml graduated cylinder was gently filled to mark with the sample. The filled cylinder was gently tapped on a laboratory bench about 10 times until there was no further diminution of the sample level after filling to the 10ml mark this procedure was adopted for each of the sample and the bulk density was calculated using the formula

$$\text{Bulk Density(g/ml} = \frac{Weight\ of\ sample}{Volume\ of\ Material\ after\ tapping}$$

2.4.4 Swelling Index

Method described by Kusumayanti (2015) was used. 3g (dry basis) of each flour were transferred into clean, dry graduated (50ml) cylinders. Flour samples were gently levelled into it and the volumes noted. Distilled water (30ml) was added to each sample; the cylinder was swirled and allowed to stand for 60 minutes while the change in volume (swelling) was recorded every 15 minutes. The samples were centrifuged at 1600 rpm for 15 minutes. The precipitated part was weighed. The swelling power of each flour sample was calculated as

$$\text{Solubility (\%)} = \frac{\text{Weight of soluble matter x 100}}{\text{Sample weight}}$$

$$\text{Swelling power (\%)} = \frac{\text{Weight of swelling sediment x 100}}{\text{Sample weight}}$$

2.5 Proximate Composition, pH and Viscosity

Proximate composition, pH and viscosity of the formulated custard blends were determined using AOAC (2012) standard methods.

2.6 Energy Value Energy value (kcal per 100 g) was estimated using the Atwater conversion factor (Kiin-Kabari *et al.*, 2020). Energy (kcal per 100 g) = [9 × Lipids% + 4 × Proteins% + 4 × Carbohydrates%]

2.7 Mineral Content

Mineral analysis was done by dry ashing according to procedure 14.013 of AOAC (2012). Muffle furnace (Model SKL, China) at temperature of 550 °C was used for ashing. After sample preparation, total mineral determination was done using Atomic Absorption spectrophotometer (AAS) (Hitachi Z-5300, polarized Zeaman, Hitachi Ltd; Japan). The light source was Hollow cathode lamp of each element, using acetylene and air combinations, with air pressure of 0.3 Mpa, and air flow rate of 6.5 L/min, acetylene pressure of 0.09 Mpa and a flow rate of 1.7 L/min was used. Other operating conditions such as wavelength and lamp current are given for each element as follows: Ca = 422.7 nm and 2 mA, Fe = 248.3 nm and 2 mA, K = 766.5 nm and 1 mA, mg = 285.2 nm and 1mA, Mg= 202.6nm and Na = 589.0 nm and 1mA.

2.7 Sensory Evaluation

Sensory evaluation was performed on the custard samples using the method of Iwe (2007). The samples were evaluated by selected semi-trained panelist on the 9-point Hedonic scale. The team consisted of 20 randomly selected tasters from the Department of Food Science and Technology, Rivers State University, Port Harcourt. Evaluation was on how they liked or disliked each custard blend with respect to color, appearance, flavor, aroma, texture, taste, and overall acceptability. The evaluation was conducted at room temperature on the same day.

2.8 Statistical Analysis

All the analyses were carried out in triplicate. Data obtained were subjected to Analysis of Variance (ANOVA); differences between means were evaluated using Turkey’s multiple comparison tests and significance accepted at $p \leq 0.05$ level. The statistical package in Minitab 20 computer program was used

3 Results and Discussion

3.1 Functional Properties of Maize and Sorghum Starch Blends

Functional properties evaluate the roles and functions of specific component in foods and how ingredients behave during preparation and cooking (Wijaya and Mehta, 2015). The nature and composition of macronutrients such as protein, fat and carbohydrates in the food greatly influences its functional characteristics (Prinyawiwatkul *et al.*,1997). Steeping conditions do not only affect starch recoveries but also induce physical and chemical changes in the granules, which affects its functional properties (Haros *et al.*, 2006). Bulk density, water absorption capacity and swelling index ranged from 1.02 to 1.85 g/ml, 1.70 to 2.70 g/g and 1.10 to 1.30, respectively (Table 2). Bulk density and water absorption capacity were higher than earlier reported values of 0.55 – 0.58 g/g and 1.09 – 1.36 g/ml, respectively for maize/millet/sorghum starch blends (Akusu *et al*., 2019). Significantly ($p<0.05$) higher bulk density of 1.85 g/ml was seen in sample A2 followed by sample A1, with value of 1.44 g/ml. Water absorption capacity of samples A1, B1 and B2 were significantly higher, with value of 2.70g/g.

Niba *et al*. (2001) described water absorption capacity as an important processing parameter that has an implication for viscosity. Furthermore, water absorption capacity is important in bulking and consistency of products. It is the ability of flour/starch to absorb water and swell for improved consistency in food (Akusu *et al*., 2019). Water absorption capacity is desirable in food systems to improve yield and stability and give body to food (Offia-Olua, 2014). The increased capacity of flour/starch to absorb and retain water may help to improve binding capacity of the structures, enhance flavour and reduce moisture loss and improve mouth feel (Loius *et al* 2000). High water absorption capacity is attributed to lose structure of starch polymers while low values indicate the compactment of the structure (Iombor *et al* 2014). Water absorption capacity is associated with swelling capacity since they are functions of protein and carbohydrates.

Swelling index of starch reflects the ability of starch to interact with water molecules (Tester and Morrison, 1990). Swelling index of samples A2, A7 and A6 were significantly ($p<0.05$) higher. Swelling index was shown to decrease with increase soaking time. Swelling capacity assists in faster digestibility with higher water absorption capacity (Adebayo-Oyetoro *et al*., 2012). The variation in the swelling index indicates the degree of exposure of the internal structure of the starch present, to the action of water (Adebayo-Oyetoro *et al*., 2012). Swelling index of starch granules according to is a function of starch's capacity to swell and imbibe water (Ojo *et al*., 2017). As the starch granules are heated above the initial gelatinization temperature, they swell as the hydrogen bonds are weakened, leading to drastic changes in the amorphous regions (Soison *et al*., 2015). It also indicated a water holding capacity of starch granules (Bello *et al*., 2014). Gelation time and gelation temperature ranged from 2.0 to 4.0 min and 60 to 63 ^{o}C, respectively. Gelation time was also seen to decrease with increase soaking time and the least gelation time was seen in sample B7.

Table 2 Functional Properties of Maize and Sorghum Starch Blends

Sample	Bulk Density (g/ml)	Water Abs. Capacity (g/g)	Swelling Index	Gelation Time (min)	Gelation Temp. (^{0}C)
A1	$1.44^{b}\pm0.000$	$2.50^{abc}\pm0.141$	$1.25^{abc}\pm0.028$	$4.00^{a}\pm0.000$	$63.00^{a}\pm0.00$
A2	$1.85^{a}\pm0.000$	$2.70^{a}\pm0.141$	$1.30^{a}\pm0.000$	$3.00^{b}\pm0.000$	$61.00^{ab}\pm0.00$
A3	$1.06^{hi}\pm0.056$	$2.50^{abc}\pm0.000$	$1.20^{cde}\pm0.000$	$3.00^{b}\pm0.000$	$62.00^{ab}\pm0.00$
A4	$1.12^{fg}\pm0.021$	$2.60^{ab}\pm0.000$	$1.15^{def}\pm0.014$	$3.00^{b}\pm0.000$	$63.00^{a}\pm0.00$
A5	$1.26^{d}\pm0.001$	$2.50^{abc}\pm0.283$	$1.16^{def}\pm0.028$	$3.00^{b}\pm0.000$	$62.00^{ab}\pm0.00$
A6	$1.27^{d}\pm0.004$	$1.90^{cd}\pm0.000$	$1.27^{ab}\pm0.000$	$3.00^{b}\pm0.000$	$61.00^{ab}\pm1.41$
A7	$1.11^{gh}\pm0.003$	$2.00^{bcd}\pm0.000$	$1.30^{a}\pm0.000$	$3.00^{b}\pm0.000$	$60.00^{b}\pm0.00$
B1	$1.34^{c}\pm0.000$	$2.70^{a}\pm0.283$	$1.10^{f}\pm0.000$	$3.00^{b}\pm0.000$	$62.00^{ab}\pm0.00$
B2	$1.23^{de}\pm0.000$	$2.70^{a}\pm0.000$	$1.16^{def}\pm0.042$	$3.00^{b}\pm0.000$	$61.00^{ab}\pm1.41$
B3	$1.27^{d}\pm0.003$	$2.50^{abc}\pm0.141$	$1.21^{bcd}\pm0.000$	$3.00^{b}\pm0.000$	$61.00^{ab}\pm0.00$
B4	$1.03^{i}\pm0.000$	$2.60^{ab}\pm0.000$	$1.14^{ef}\pm0.000$	$2.50^{c}\pm0.141$	$62.00^{ab}\pm0.00$
B5	$1.18^{ef}\pm0.000$	$2.65^{a}\pm0.354$	$1.12^{f}\pm0.000$	$3.00^{b}\pm0.000$	$62.00^{ab}\pm0.00$
B6	$1.12^{gh}\pm0.000$	$1.80^{d}\pm0.141$	$1.20^{cde}\pm0.000$	$3.00^{b}\pm0.000$	$60.00^{b}\pm0.00$
B7	$1.02^{i}\pm0.001$	$1.70^{d}\pm0.000$	$1.20^{cde}\pm0.000$	$2.00^{d}\pm0.000$	$60.00^{b}\pm0.00$

Values are means ± standard deviation of triplicate samples.
Mean values bearing different superscripts in the same column differ significantly ($p<0.05$).

Key: A1=100% maize+0 % sorghum soaked 6h., A2= 90% maize+10 % sorghum soaked 6h, A3=80% maize+20 % sorghum soaked 6h, A4= 70% maize+30 % sorghum soaked 6h, A5= 60% maize+40 % sorghum soaked 6h, A6=50% maize+50 % sorghum soaked 6h, A7=0 % maize+100 % sorghum soaked 6h.
B1=100% maize+0 % sorghum soaked 12h, B2=90% maize+10 % sorghum soaked 12h, B3=80% maize+20 % sorghum soaked 12h, B4=70% maize+30 % sorghum soaked 12h, B5=60% maize+40 % sorghum soaked 12h, B6=50% maize+50 % sorghum soaked 12h, B7=0 % maize+100 % sorghum soaked 12h

3.2 Proximate Composition of Maize and Sorghum Starch Blends

Result for the proximate composition of maize and sorghum starch blends, processed by steeping for 6 and 12 hr showed percentage moisture ranging from 8.98 to 13.04 % (Table 3). This moisture range corroborated with 8.13 to 9.42 % moisture reported by Salami *et al.* (2019) for corn starch custard and 10.03 to 10.11 % moisture reported for sorghum/wheat starch (Chanapamokkhot and Thongngam, 2007). The moisture content of samples A1, A2 and A7 complied with the regulations of the National Agency for Food and Drug Administration and Control (NAFDAC) of ≤ 10 % for moisture content of cereal flours (Okoronkwo *et al.*, 2020). Moisture content of starch blends from 6h of steeping all fell within the recommended CODEX standard of <12 % (CODEX, 2009). Moisture contents of maize/sorghum starch from 12h steeping was higher than those from 6h steeping. Higher moisture was seen in sample B7, followed by sample B6 with values of 13.04 and 12,87 %, respectively. Lower moisture of 7.51 and 8.24 % had been reported earlier for high quality yellow cassava starch custard and maize/sorghum flour, respectively (Alake *et al.*, 2016; Sharma *et al.*, 2015). High moisture in a starch powder sample is an index of spoilage due to high water activity (Sandulachi, 2012; Ajatta *et al* 2016). High water activity of food enhances chemical and biochemical reactions that could lead to spoilage. Low moisture indicates good shelf life when properly packed and stored (Etudaiye *et al.*, 2000).

Protein content ranged from 7.16 to 10.13 %. These values corroborated with 8.62 % protein reported by Salami *et al.* (2019) for corn starch custard and 8.36 – 9.23 % protein reported by Sharma *et al.* (2015) for maize/sorghum flour blend. The protein content of sample A1 was higher (10.13 %), but not significantly different ($p>0.05$) from 10.00 % shown in sample A6. Antarlina *et al.* (2021) reported 9.18 % and 9.62 % protein for sorghum soaked for 12h and 24h, respectively.

Fat content ranged from 3.49 to 4.96 %. Percentage fat content was seen to reduce as steeping time increased. A reduction in fat content during soaking was probably due to breakdown of complex compounds into simpler ones and the disruption of the cell structure during processing (Kajihausa *et al.*, 2014). Adegunwa, *et al.* (2014) reported that low fat content in a dry product will help in increasing the shelf life of the sample by decreasing the chances of rancidity and also contribute to low energy value of the food product while high fat product will have high energy value. Lower fat of 2.01 % was earlier reported in flour from sorghum steeped for 12h (Antarlina *et al.*, 2021).

Percentage Ash and Crude fiber were seen ranging from 0.97 to 1.46 % and 0.59 to 2.90 %, respectively. Ash content of sample B7 was higher and significantly different ($p<0.05$) from samples A1, A2, A3 and A5. Increased percentage ash was noticed with increased steeping time, probably due to leaching of soluble minerals from the cereal bran. Similar increase in ash content of sorghum starch was reported after soaking for 12 and 24h, with values of 1.01 and 1.05 %, respectively (Antarlina *et al.*, 2021). Percentage ash in this work fell within the range of 0.09 –

2.15 % reported by Alake *et al.* (2016) for high quality yellow cassava starch custard. Crude fiber content of sample A7 was significantly higher ($p<0.05$), followed by sample A6 (2.79 %), these values were however, not significantly difference ($p>0.05$) from those of samples B5 and B6. The higher fiber value obtained for samples with more sorghum starch could imply better bowel movement (Achimugu *et al.*, 2021). Crude fiber ranges in this experiment was similar to 1.10 – 1.55 % reported by Achimugu *et al.* (2021) for maize, Guinea corn and millet starch custard.

Percentage crude fiber of 0.59 to 2.90 % in this work was lower than 5.46 % reported by Salami *et al.* (2019) for corn starch powder. Crude fiber was seen to increase with increase substitution of sorghum starch. The crude fiber content in this study was higher than 0.14 – 0.24 % and 1.70 % reported for sorghum/wheat starch blend (Chanapamokkhot and Thongngam, 2007) and sorghum starch (Tobias *et al.*, 2018). Crude fiber is one of the nondigestible carbohydrates, which provides the fecal bulkiness, less intestinal transit, role in cholesterol level reduction, and trapping dangerous substance like cancer-causing agents, and also encourages the growth of natural microbial flora in gut (Dhingra *et al.*, 2012; Sánchez-Zapata *et al.*, 2015; Slavin, 2013). Total carbohydrate ranged from 71.46 to 74.84 %.

Table 3 Proximate Composition Maize and Sorghum Starch Blends

Sample	Moisture	Protein	Fat	Ash	C. Fiber	Carbohydrate
A1	$9.60^{ef}\pm0.643$	$10.13^{a}\pm0.410$	$4.96^{a}\pm0.134$	$0.97^{c}\pm0.113$	$0.79^{fg}\pm0.057$	$73.56^{abcd}\pm1.131$
A2	$9.82^{def}\pm0.863$	$9.19^{bc}\pm0.106$	$4.37^{abc}\pm0.219$	$0.98^{bc}\pm0.184$	$0.90^{ef}\pm0.064$	$74.76^{a}\pm0.940$
A3	$10.81^{cde}\pm0.643$	$9.12^{c}\pm0.120$	$4.15^{bcde}\pm0.064$	$0.95^{c}\pm0.021$	$0.16^{h}\pm0.092$	$74.84^{a}\pm0.813$
A4	$10.74^{cdef}\pm0.304$	$9.19^{bc}\pm0.382$	$4.01^{bcde}\pm0.057$	$1.06^{abc}\pm0.057$	$1.41^{c}\pm0.078$	$73.60^{abcd}\pm0.764$
A5	$11.08^{cde}\pm0.099$	$9.23^{bc}\pm0.375$	$4.02^{bcde}\pm0.283$	$1.03^{bc}\pm0.134$	$2.77^{a}\pm0.064$	$71.89^{bcde}\pm0.827$
A6	$11.48^{abcd}\pm0.177$	$10.00^{ab}\pm0.071$	$3.77^{cde}\pm0.495$	$1.15^{abc}\pm0.106$	$2.79^{a}\pm0.050$	$70.83^{e}\pm0.445$
A7	$8.98^{f}\pm0.325$	$9.28^{bc}\pm0.099$	$3.64^{cde}\pm0.120$	$1.41^{ab}\pm0.148$	$2.90^{a}\pm0.085$	$73.80^{abcd}\pm0.537$
B1	$11.19^{bcde}\pm0.325$	$8.13^{de}\pm0.127$	$4.62^{ab}\pm0.134$	$1.32^{abc}\pm0.127$	$0.59^{g}\pm0.057$	$74.16^{abc}\pm0.262$
B2	$11.58^{abcd}\pm0.629$	$8.26^{d}\pm0.205$	$4.27^{abcd}\pm0.078$	$1.30^{abc}\pm0.021$	$0.78^{fg}\pm0.014$	$73.83^{abcd}\pm0.750$
B3	$11.50^{abcd}\pm0.207$	$7.32^{ef}\pm0.156$	$3.99^{bcde}\pm0.042$	$1.33^{abc}\pm0.106$	$1.06^{de}\pm0.057$	$74.81^{a}\pm0.144$
B4	$12.28^{abc}\pm0.247$	$7.16^{f}\pm0.064$	$3.78^{cde}\pm0.042$	$1.18^{abc}\pm0.113$	$1.21^{cd}\pm0.035$	$74.41^{ab}\pm0.290$
B5	$12.28^{abc}\pm0.198$	$7.09^{f}\pm0.078$	$3.67^{cde}\pm0.148$	$1.28^{abc}\pm0.042$	$2.71^{a}\pm0.028$	$72.98^{abcde}\pm0.198$
B6	$12.87^{ab}\pm0.339$	$8.15^{de}\pm0.191$	$3.58^{de}\pm0.042$	$1.29^{abc}\pm0.106$	$2.67^{a}\pm0.050$	$71.46^{de}\pm0.728$
B7	$13.04^{a}\pm0.410$	$8.06^{de}\pm0.078$	$3.49^{e}\pm0.092$	$1.46^{a}\pm0.078$	$2.37^{b}\pm0.064$	$71.60^{cde}\pm0.566$

Values are means ± standard deviation of triplicate samples.

Mean values bearing different superscripts in the same column differ significantly ($p<0.05$).

Key: A1=100% maize+0 % sorghum soaked 6h., A2= 90% maize+10 % sorghum soaked 6h, A3=80% maize+20 % sorghum soaked 6h, A4= 70% maize+30 % sorghum soaked 6h, A5= 60% maize+40 % sorghum soaked 6h, A6=50% maize+50 % sorghum soaked 6h, A7=0 % maize+100 % sorghum soaked 6h.

B1=100% maize+0 % sorghum soaked 12h, B2=90% maize+10 % sorghum soaked 12h, B3=80% maize+20 % sorghum soaked 12h, B4=70% maize+30 % sorghum soaked 12h, B5=60% maize+40 % sorghum soaked 12h, B6=50% maize+50 % sorghum soaked 12h, B7=0 % maize+100 % sorghum soaked 12h

3.3 Energy Value (kcal/100g) of Maize/Sorghum Flour Blends

Energy value ranged from 349.985 to 379.300 kcal/100g (figure 3). Energy value of 100 % maize starch (from 6h soaking, sample A1) gave significantly higher value of 379.36 kcal/100g, followed by samples A2 and A3 with values of 375.05 and 373.10 kcal/100g, respectively. This indicated that custard produced from steeped maize/sorghum blends would be a good source of energy. Energy needs is expressed as the number of kilocalories needed per unit of a person's body weight (Lawrence *et al.*, 2005). Energy values was seen to decrease with increase substitution of maize starch with sorghum starch. This was probably due to higher carbohydrate and fat content of custard blends containing more maize powder. Higher energy value of 416.60 – 423.40 kcal/100g was reported earlier by Ikya *et al.* (2013) for Agidi prepared from maize starch and soybean flour blends. Energy value of samples soaked for 12h were respectively lower, probably due to seen reduction in carbohydrate and fat content. Macro nutrients such as carbohydrate, protein and fats are major sources of energy in foods.

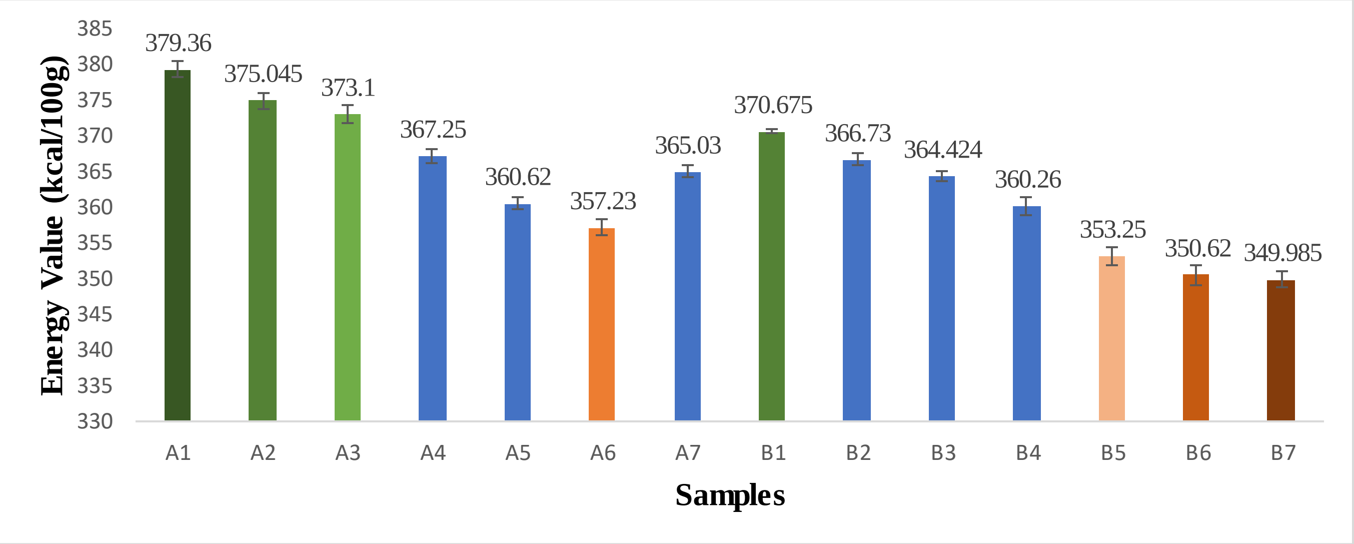

Figure 3 **Energy Value (kcal/100g) of Maize/Sorghum Starch Blends**

3.4 Mineral Content of Maize/Sorghum Flour Blends

From the result in Table 4, Calcium (Ca) and Potassium (K) content ranged from 15.08 to 52.48 and 108.72 to 269.30 mg/kg, respectively while Magnesium (Mg) content of the starch blends ranged from 11.68 to 99.00 mg/kg. Ca content of sample A7 was significantly ($p<0.05$) higher. Calcium content was seen to increase as the percentage substitution of sorghum starch increased. Calcium is an essential mineral used by the body for bone health, blood pressure regulation and other vital functions (WHO, 2004; Ross *et al.*, 2011). Adequate intake of calcium protects against bile-induced mucosal damage and experimental bowel carcinogenesis (Pence, 1993). Calcium plays an important role in blood clotting and maintenance of normal heartbeat (Zemel, 2009). It has been reported to prevent blood pressure reduction and hypertensive disorders of pregnancy and also prevent osteoporosis and colorectal adenomas (Heaney, 2006; Omotayo *et al.*, 2018; Onakpoye *et al.*, 2011).

Significantly ($p<0.05$) higher Potassium and Magnesium content were also seen in sample A7. Magnesium is associated with strong bones, optimal blood pressure and appropriate cardiac tempo (Saris *et al*., 2000). The recommended daily allowance (RDA) of mg to men and women is 420 and 320 mg, respectively (FDA, 2020). This implied that sample A7 starch blend could provide 30.94 % 0f the RDA of Mg, while sample B7 (steeped for 12h) will provide 21.7 % of the RDA of Mg per 100g portion. Iron (Fe) and Sodium (Na) content ranged from 2.28 to 7.49 and 31.02 to 59.58 mg/kg, respectively. Iron content was seen to increase as sorghum content and soaking time increased. This was probably due to high Fe content of sorghum, as reported earlier by Patekar *et al*. (2017). The Reference-Daily-Intake of iron for children 4 years old and adults of both sexes is 18 mg/kg (FDA, 2020). Which implied that starch blends from samples A1 – A7 (6h steeping) will provide 18 to 20 % of RDI of Fe, while starch blends from samples B1 -B7 (12h steeping) will provide 25 to 41 % of RDI of Fe. Sodium is a vital mineral that regulates fluid balance in the body and also in the proper functioning of muscles and nerves (Payne, 1990). High sodium content in the body has been associated with high blood pressure in the body (Olusanya, 2008). However, sodium content from this study is low and may not cause adverse health problems

Table 4 Mineral Content (mg/kg) of Maize/Sorghum Starch Blends

Sample	Ca	K	Mg	Fe	Na
A1	$19.26^{gh}\pm1.266$	$112.75^{e}\pm3.300$	$19.18^{i}\pm1.167$	$2.28^{i}\pm0.078$	$33.07^{e}\pm0.071$
A2	23.58efg±2.740	124.61e±0.785	$29.16^{g}\pm1.470$	$2.28^{i}\pm0.028$	$31.02^{e}\pm0.050$
A3	$26.06^{def}\pm0.106$	$126.31^{de}\pm1.146$	$29.00^{g}\pm1.410$	$2.41^{i}\pm0.021$	$43.59^{cd}\pm2.000$
A4	$32.15^{cd}\pm1.273$	$136.81^{de}\pm0.785$	$35.93^{ef}\pm0.099$	$2.60^{i}\pm0.050$	$46.51^{bc}\pm2.110$
A5	$35.18^{bc}\pm1.470$	$199.40^{c}\pm3.890$	$39.78^{e}\pm0.481$	$3.08^{h}\pm0.120$	$49.08^{b}\pm0.000$
A6	$39.63^{b}\pm0.735$	$220.02^{bc}\pm11.290$	$57.05^{c}\pm1.344$	$3.41^{h}\pm0.078$	$49.88^{bc}\pm0.177$
A7	$52.48^{a}\pm5.030$	$269.30^{a}\pm23.600$	$99.00^{a}\pm1.410$	$4.01^{g}\pm0.042$	$59.58^{a}\pm0.601$
B1	$15.08^{h}\pm0.085$	$129.94^{de}\pm1.750$	$11.08^{j}\pm0.064$	$4.58^{f}\pm0.078$	$31.04^{e}\pm1.110$
B2	$16.13^{h}\pm0.177$	$108.72^{e}\pm1.800$	$24.47^{h}\pm0.983$	$4.93^{ef}\pm0.050$	$30.63^{e}\pm0.530$
B3	$20.29^{fgh}\pm0.233$	$119.50^{e}\pm2.120$	$29.25^{g}\pm1.061$	$5.18^{de}\pm0.099$	$40.93^{d}\pm0.106$
B4	$23.31^{efg}\pm0.219$	$121.59^{e}\pm0.580$	$31.57^{fg}\pm2.020$	$5.56^{cd}\pm0.368$	$43.61^{cd}\pm0.559$
B5	$29.75^{cde}\pm0.707$	$156.55^{d}\pm4.880$	$29.66^{g}\pm0.481$	$6.00^{c}\pm0.007$	$41.15^{d}\pm1.209$
B6	$29.24^{cde}\pm1.075$	$215.00^{bc}\pm1.410$	$45.92^{d}\pm0.120$	$6.99^{b}\pm0.014$	$47.18^{bc}\pm1.167$
B7	$36.01^{bc}\pm0.014$	$246.64^{ab}\pm12.020$	$69.38^{b}\pm0.884$	$7.49^{a}\pm0.099$	$56.41^{a}\pm0.841$

Values are means ± standard deviation of triplicate samples.
Mean values bearing different superscripts in the same column differ significantly ($p<0.05$).
Key: A1=100% maize+0 % sorghum soaked 6h., A2= 90% maize+10 % sorghum soaked 6h, A3=80% maize+20 % sorghum soaked 6h, A4= 70% maize+30 % sorghum soaked 6h, A5= 60% maize+40 % sorghum soaked 6h, A6=50% maize+50 % sorghum soaked 6h, A7=0 % maize+100 % sorghum soaked 6h.
B1=100% maize+0 % sorghum soaked 12h, B2=90% maize+10 % sorghum soaked 12h, B3=80% maize+20 % sorghum soaked 12h, B4=70% maize+30 % sorghum soaked 12h, B5=60% maize+40 % sorghum soaked 12h, B6=50% maize+50 % sorghum soaked 12h, B7=0 % maize+100 % sorghum soaked 12h.

3.5 Physicochemical Properties of Maize/Sorghum Flour Blends

The pH value of the maize-sorghum starch blends ranged from 3.41 to 3.77, with sample B7 given significantly ($p<0.05$) higher value of 3.77, followed by sample B6, with pH of 3.68. These pH values corroborated with pH of 3.40 to 3.77 reported earlier by Akusu *et al*. (2019) for agidi' produced from maize, millet and sorghum starch blends. Low pH is necessary for good keeping quality of any food sample (Bankole *et al*., 2013). The pH values of samples A1, A2, A3 and A4 were not significantly different from those of samples B1, B2, B3 and B4. Starches make for a smoother texture and thicker mouth feel for custard, It is however, affected by the value of pH, if the mixture pH is 9 or higher, the gel becomes too hard; if it is below 5, the gel structure has difficulty forming because protonation prevents the formation of covalent bonds. So, the mean pH value must be moderate (Matringe *et al*., 1999).

Viscosity of the custard samples ranged from 1.390 to 1.514 pas (Table 5), with higher viscosity seen in sample A4 and this was significantly different ($p<0.05$) from that of sample B5. Higher viscosity of sample A4 was probably due to lower steeping time. Viscosity values in this work were similar to those reported earlier by Akusu *et al*. (2019) for maize, millet and sorghum starch blends. However, viscosity for 100 % maize starch was higher (1.95pas), this could probably be due to varietal difference and method of extraction. Esther *et al*. (2015) had also reported high viscosity in maize than in millet and sorghum ogi.

Table 5 Physicochemical Properties of Maize/Sorghum Starch Blends

Sample	pH	Viscosity (pas)
A1	$3.43^{ef}\pm0.000$	$1.457^{ab}\pm0.009$
A2	$3.43^{ef}\pm0.000$	$1.477^{ab}\pm0.037$
A3	$3.49^{def}\pm0.000$	$1.438^{ab}\pm0.009$
A4	$3.45^{ef}\pm0.071$	$1.514^{a}\pm0.024$
A5	$3.51^{de}\pm0.000$	$1.408^{ab}\pm0.029$
A6	$3.55^{cd}\pm0.021$	$1.467^{ab}\pm0.020$
A7	$3.61^{bc}\pm0.000$	$1.397^{ab}\pm0.013$
B1	$3.41^{f}\pm0.000$	$1.459^{ab}\pm0.002$
B2	$3.45^{ef}\pm0.000$	$1.448^{ab}\pm0.016$
B3	$3.47^{def}\pm0.000$	$1.438^{ab}\pm0.016$
B4	$3.47^{def}\pm0.028$	$1.486^{ab}\pm0.006$
B5	$3.51^{de}\pm0.000$	$1.390^{b}\pm0.055$
B6	$3.68^{b}\pm0.000$	$1.497^{ab}\pm0.055$
B7	$3.77^{a}\pm0.000$	$1.439^{ab}\pm0.023$

Values are means ± standard deviation of triplicate samples.
Mean values bearing different superscripts in the same column differ significantly ($p<0.05$).
Key: A1=100% maize+0 % sorghum soaked 6h., A2= 90% maize+10 % sorghum soaked 6h, A3=80% maize+20 % sorghum soaked 6h, A4= 70% maize+30 % sorghum soaked 6h, A5= 60% maize+40 % sorghum soaked 6h, A6=50% maize+50 % sorghum soaked 6h, A7=0 % maize+100 % sorghum soaked 6h.

B1=100% maize+0 % sorghum soaked 12h, B2=90% maize+10 % sorghum soaked 12h, B3=80% maize+20 % sorghum soaked 12h, B4=70% maize+30 % sorghum soaked 12h, B5=60% maize+40 % sorghum soaked 12h, B6=50% maize+50 % sorghum soaked 12h, B7=0 % maize+100 % sorghum soaked 12h

3.6 Sensory Properties

Result for the sensory properties of custard showed colour scores ranging from 5.55 to 6.75, with sample B5 scored significantly higher (Table 6). Colour is an important sensory characteristic as it affects initial perception for flavor, aroma and taste (Hutching, 1999). Texture, Aroma and Taste score ranged from 5.50 to 6.60, 4.25 to 6.40 and 4.10 to 6.16, respectively. Consistency and overall acceptability scores ranged from 4.95 to 6.35 and 5.02 to 6.16, respectively. The high consistency obtained in samples A1, A3, A4 and A6, and those of Samples B4 and can be attributed to the long chain polysaccharide, as reported by Schober *et al.* (2005). There was no significant difference in texture scores for all the samples soaked for 6h. Overall acceptability scores for custard produced from maize/sorghum starch steeped for 6h were not significantly difference (p>0.05). The values were also higher, significantly than those of samples B1 and B2.

Table 6 Sensory Properties of Custard Produced from Maize/Sorghum Starch Blends

Samples	Colour	Texture	Aroma	Taste	Consistency.	Overall
A1	$6.25^{abcde}\pm0.639$	$6.05^{ab}\pm1.050$	$5.70^{a}\pm0.865$	$5.85^{a}\pm0.671$	$5.35^{cd}\pm0.813$	$5.84^{ab}\pm0.398$
A2	$6.35^{abc}\pm0.489$	$6.40^{ab}\pm0.754$	$5.40^{ab}\pm0.821$	$5.25^{a}\pm0.550$	$6.05^{abc}\pm0.686$	$5.89^{ab}\pm0.294$
A3	$5.60^{de}\pm0.754$	$6.25^{ab}\pm0.639$	$6.05^{a}\pm1.050$	$5.65^{a}\pm0.587$	$6.25^{ab}\pm0.639$	$5.96^{a}\pm0.479$
A4	$5.90^{bcde}\pm0.553$	$6.35^{ab}\pm0.489$	$6.40^{a}\pm0.754$	$5.80^{a}\pm0.696$	$6.35^{a}\pm0.489$	$6.16^{a}\pm0.341$
A5	$5.55^{e}\pm0.686$	$5.60^{ab}\pm0.754$	$6.40^{a}\pm0.821$	$5.50^{a}\pm0.688$	$5.5^{bcd}\pm0.688$	$5.71^{ab}\pm0.433$
A6	$6.30^{abcd}\pm0.801$	$5.90^{ab}\pm0.718$	6.15a±0.813	$5.55^{a}\pm0.686$	$5.65^{abcd}\pm0.671$	$5.91^{a}\pm0.452$
A7	$6.10^{abcde}\pm0.718$	$5.70^{ab}\pm0.733$	5.60ab±0.681	$6.15^{a}\pm0.745$	$5.95^{abc}\pm0.826$	$5.90^{ab}\pm0.308$
B1	$6.30^{abcd}\pm0.733$	$5.50^{b}\pm1.433$	4.25c±1.803	$4.10^{b}\pm1.683$	$4.95^{d}\pm1.146$	$5.02^{c}\pm0.931$
B2	$6.50^{ab}\pm0.513$	$6.20^{ab}\pm0.616$	$4.55^{bc}\pm2.038$	$4.30^{b}\pm1.302$	$5.3^{cd}\pm0.657$	$5.37^{bc}\pm0.816$
B3	$6.20^{abcde}\pm0.616$	$6.00^{ab}\pm1.076$	$5.75^{a}\pm0.967$	5.85a±0.671	$5.35^{cd}\pm0.875$	$5.83^{ab}\pm0.451$
B4	$6.20^{abcde}\pm0.616$	$6.10^{ab}\pm0.852$	$5.70^{a}\pm0.923$	$5.65^{a}\pm0.745$	$5.75^{abcd}\pm0.910$	$5.88^{ab}\pm0.386$
B5	$6.75^{a}\pm0.550$	$6.05^{ab}\pm0.999$	$6.00^{a}\pm0.795$	$5.35^{a}\pm0.875$	$5.40^{cd}\pm0.754$	$5.91^{a}\pm0.381$
B6	$6.05^{abcde}\pm0.826$	$6.30^{ab}\pm0.979$	$5.80^{a}\pm0.696$	$5.75^{a}\pm0.716$	$5.40^{cd}\pm0.821$	$5.86^{ab}\pm0.482$
B7	$5.65^{cde}\pm0.671$	$6.60^{a}\pm0.598$	$5.80^{a}\pm0.894$	$5.65^{a}\pm0.671$	$5.65^{abcd}\pm0.489$	$5.87^{ab}\pm0.465$

Values are means ± standard deviation of triplicate samples.
Mean values bearing different superscripts in the same column differ significantly (p<0.05).

Key: A1=100% maize+0 % sorghum soaked 6h., A2= 90% maize+10 % sorghum soaked 6h, A3=80% maize+20 % sorghum soaked 6h, A4= 70% maize+30 % sorghum soaked 6h, A5= 60% maize+40 % sorghum soaked 6h, A6=50% maize+50 % sorghum soaked 6h, A7=0 % maize+100 % sorghum soaked 6h.

B1=100% maize+0 % sorghum soaked 12h, B2=90% maize+10 % sorghum soaked 12h, B3=80% maize+20 % sorghum soaked 12h, B4=70% maize+30 % sorghum soaked 12h, B5=60% maize+40 % sorghum soaked 12h, B6=50% maize+50 % sorghum soaked 12h, B7=0 % maize+100 % sorghum soaked 12h.

4 Conclusion

The research was focused on evaluating the physicochemical, functional and sensory characteristics of custard produced with blends of maize and sorghum starch. The results showed higher percentage protein and fat in sample soaked at 6h. Percentage Ash and crude fiber content increased with increase substitution of maize with sorghum starch. Energy value of 100 % maize starch processed from 6h of soaking (sample A1) was higher (379.36 kcal/100g). Energy values was seen to decrease with increase substitution of maize starch with sorghum starch. Swelling index was higher at 6h soaking time. Gelation time was also seen to decrease with increase soaking time. Calcium, Potassium, Magnesium and Sodium content increased to 52.48, 269.30, 99.00 and 69.58 mg/kg at higher percentage of sorghum starch (sample A7) soaked for 6h. Relatively higher pH of 3.77 and 3.68 as soaking time increased (samples B7 and B6). Viscosity of the custard was higher at 6h soaking time. Consistency and overall acceptability scores ranged from 4.95 to 6.35 and 5.02 to 6.16, respectively. All the samples received equal acceptability, except sample sample B1 which was significantly lower. Blending of maize and sorghum starch for custard production is recommended, for enhanced functionality. Soaking of maize and sorghum at an average time of 6 hours, for higher mineral retention, increased swelling power and viscosity is recommended.

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