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QUALITY ASSESSMENT OFBREAKFAST GRUEL PRODUCED FROM SWEET POTATOES (*Ipomoea batatas*), SOYBEAN (*Glycine max)* AND CARROT (*Daucus carota)*

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ABSTRACT

This study aimed to evaluate the quality characteristics of a novel and quick breakfast gruel formulated from Sweet Potatoes, soybeans and Carrots, for children between 6 to 23 months contributing to developing nutritious and sustainable food products from locally sourced food materials. The breakfast gruels were formulated by mixing Sweet Potatoes, Soybean and Carrot flours in the ratio of 80:15:5, 70:20:10; 60:25:15 and 50:30:20 to obtain four composite blends designated as S1- S4. Functional analysis was performed on the flour samples before production while Chemical and sensory analysis were conducted on the breakfast gruels using standard methods, and the data obtained were subjected for statistical analysis. The flour blends showed: Bulk Density: 0.526% - 0.64%; Swelling capacity: 2.387 - 1.632; Water absorption capacity: 4.79 g/g - 1.47 g/g; Oil absorption capacity: 1.47 - 1.1 g/g; Foam capacity: 10 - 4.00cm3; and Gelation Temperature: 76 - 48^{o}C. The proximate composition of the breakfast gruel samples showed 10.65%–11.78% moisture, 1.90%–2.59% ash, 1.09–2.96% crude fibre, 14.45–18.25% protein, 3.65–4.68% crude fat, and 61.22-25.42% carbohydrate contents. The ranges for vitamins A, B6, and C were 0.59–1.38, 11.88–54.86%, and 8.84–13.02%, respectively. With an overall rating of 6.73, the blend with 50% sweet potato flour, 30% soybean flour, and 20% carrot flour (S4) was the most preferred. This research showed that novel and nutritious breakfast gruels can be processed from mixes of sweet potatoes, soybeans, and carrot flours, which are readily available and accessible.

Keywords: *Breakfast gruel, food insecurity, diversification, potatoes*

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1. INTRODUCTION

Breakfast is said to be the most significant meal of the day and provides a child with the greatest nourishment (Charles S, 2013). Research has shown that skipping breakfast increases the risk of weight problems, metabolic disorders, and focus problems (Cahill et al. 2013). The main ingredients of breakfast gruels are cereals like wheat and rice that have been cooked or boiled with milk or water. Nigeria is one of the African nations that is known for eating breakfast, and common cereal goods there include NASCO cornflakes, Good morning cornflakes NABISCO flakes, Weetabix Quaker Oats etc.

Soybean is a rich source of protein (35-40%) and a staple meal in the majority of Asian and African nations. Hence, soybeans are among the most valuablelegumes in the world (Liu and Li, 2017). It also contains vitamin A, B, C and D and very rich in unsaturated, cholesterol free fatty acids, minerals and antioxidants.

Another food that has an average number of calories is sweet potatoes. Nonetheless, it has low cholesterol and saturated fat and rich in dietary fiber, antioxidant, vitamin and minerals. Its major source of energy is starch, a complex carbohydrate. The global consumption of carrots has been continuously rising in recent years because of their benefits to health (Fiedor et al., 2014; Tanaka et al., 2012). Carrots are valued because they are high in antioxidant especially β-carotene. Carrot are sometimes dried and used in read to eat meals like powdered soup, snacks, seasonings and sauces (Ranum, et al, 2014)

Nigeria still battles macro and micro nutrient deficiency especially as rice and cassava consumption remains major staple foods. Hence, it is imperative to explore other sources of nutrient which are thought to be unappealing to combat macro and micro nutrient deficiency especially in little children (Santhi,2016). Potatoes are poor sources of protein but are cherished by little children, the supplementation of potatoes meal with soybeans and carrot rich in vitamin will create a meal well balanced food and combat manultrion posed by the continued growing population and economic inflation

Blends from the food crops listed in this study could diversify how people employ native, underutilized food crops for national nourishment and, most importantly, raise the standard of the food that is produced. This study aims to create a suitable process for producing flour for breakfast gruel using food crops like sweet potatoes, soybeans, and carrots; assess the nutritional value and content of gruels made with these ingredients; and analyze the sensory and quality characteristics of the breakfast gruel.

2 MATERIALS AND METHODS

2.1 Materials Procurement

Soybean, sweet potatoes and carrot were purchased from Douglas market, Owerri west, Imo State and blended in the pilot plant of the Department of food Sciences and Technology, FUTO, while other chemicals were acquired from Chemistry laboratory of the department of food science and technology, FUTO.

2.2 Method

2.2.1 Production process of Soybeans

The collected soybeans were washed to remove any impurities, including stones, fragments of pods, and immature beans. They were steeped in room temperature water for 8 hours, and the water was then allowed to boil for 20 minutes to eliminate any beany flavor and anti-nutritional compounds. The beans were boiled, then drained and baked for seven hours at 60 -70^{0}C, the dry beans were roasted in an aluminum pan at low heat using an electric plate for 50^{0}C. After toasting, the beans were ground into fine flour with a blender (model HL 3294/C Phillips) and stored (Adegunwaet al. 2015).

2.2.2 Production process of Sweet potatoes flour

The method used for sweet potato flour was extracted from Onabanjo *et al.,* (2014). The sweet potatoes were selected, washed with water to remove soils, peeled, and washed again. The peeled potatoes were chopped into smaller chips with a knife and pre-cooked for 10 minutes to preventdiscolouration due to browning. The chips were dried with an oven (model NX-7500S 6+0/ Assudamal& Sons Limited, China) at 60 degrees Celsius, milled with an electric blender (model HL 3294/C Phillips), and packed in a plastic container as shown in figure 1.

2.2.3 Production process of Carrot flour

Carrot flour was processed according to the method described by Marvin (2009). The carrots were washed with portable water, peeled, and sliced into 56mm thick pieces with a knife. The slices were blanched in water 60^{0}C hot, containing sodium metabisulphite for 3mins to avoid discolouration due to browning. After cooling, the sulphited carrots were dried for 12 hours at 50°C in an oven (model NX-7500S 6+0/ Assudamal& Sons Limited, China). The dried carrots were ground to fine powder (model HL 3294/C Phillips) and sieved with a sieve size of 0.150 µ, then stored in black polythene bag for furtheruses as shown in figure 1

2.2.4 Formulation of the Breakfast Gruel

The breakfast gruel was formulated by mixing sweet potato flour (SPF), soybeans flour (SF) and Carrot flour (CF). Four samples of the Breakfast gruel were produced by mixing the processed flour in different ratios (SPF: SF:CF). The formulated products were as follows: S1 (80:15:5), S2 (70:20:10) (70:20:10), S3 (60:25:15) and S4 (50:30:20). Sugar and salt were added and roasted at 280°C with continuous stirring till dried product was obtained. Clean water (100ml) was used to reconstitute 100g of the breakfast gruel. The formula was added into a pot containing 200ml of boiling water and stirred for 7 minutes to obtain a smooth texture. The ingredient combination of the breakfast cereals and the flowchart depicting the preparation of the breakfast gruel is presented in Table 1 and figure 4 accordingly.

2.3 Chemical Analysis

The AOAC (2010) standard was followed in the proximate analysis of the samples, and the difference technique was used to obtain the carbohydrate content. Using a pH meter (Clidal instrument; PHS-25 precision pH/ Mv meter), the food samples pH was determined. The procedure outlined by Onwuka (2005) was used to calculate the bulk density, gelation temperature, foam capacity, and absorption capabilities of water and oil. The swelling capacity (SC) was measured using the procedure outlined by Adeoti et al. (2017). The technique proposed by Kirk and Sawyer (1998) was applied to analyze the vitamin A content. The vitamin B content was assessed using the AOAC (2006) technique, and ascorbic acid was measured using the 2, 6-dichlorophenol titration method as outlined in the AOAC (2006).

2.4 Sensory Evaluation

The formulated breakfast gruels were analyzed by 30 untrained panelistswhich consisted of students and staffs of the Federal University of Technology, Owerri. the procedure was carried out at about 10.00 am using a 9-point Hedonic scale (1=dislike extremely, 9=like extremely). The panelistsjudged the product based on their appearance, flavor, aftertaste, consistency, mouth feel, taste and overall acceptability. The breakfast gruels were presented with warm water and milk

2.5 Statistical Analysis

The study's data were examined by ANOVA using SPSS version 17 at 5% level of significance. Duncan Multiple Range Tests was utilized to differentiate the means. Results were done in triplicates.

3.0 RESULTS AND DISCUSSION

3.1 Functional Properties of the Flour Samples

The results of the functional determination of the Sweet potatoes, soybeans and carrot flour are shown in table 2. From the result, the bulkdensity of the samples ranges from 0.526-0.645g/g while carrot flour had the highest bulk density. Statistically, the bulk densities of the formulations do not differ significantly ($p<0.05$) among each other. Bulk density (BD) is used to define the flour's weightiness, handling requirement and appropriate storage materials for packing and moving of food materials (Ukeyima et al., 2019). The lowbulkdensityobtainedisofadvantagebecausethegruelmadefromtheformulationswillhaveadietary bulk suitable for children. The result for swellingcapacity does not significantly differ($p<0.05$) among the flour samples and it ranged from 1.63-2.387g/g (table 2). Carrot flour with a meanscore of 2. 387g/g was higher than other samples. Swellingcauseschangestothehydrodynamicpropertiesoffoodanddetermines the type of gruel to be produced in this case. The swelling capacity (SC) of flours is determined by the particles size, variety and processing methods (Chandra, 2013).

The Water absorption capacity went from 1.47-4.79g/ml and was significantly different ($P<0.05$) among the sample. Carrot flour hasthe highest water absorption capacity with a value of 4.79g/ml. The lowerwater absorption capacity obtained is desirable as the formulations will have lower binding capacity for making thinner gruels with high calorie and nutrient density per unit volume. Similar observations were made byIjarotimiandOluwalana (2013). However, this contrast with report from Chandra, (2013) where the highest WAC was observed in potato flour. This was ascribed to higher amount of carbohydrates (starch) and fibre present in potatoes. The oil absorption capacity results are presented in Table 2. The results were significantlydifferent ($p<0.05$) and the values ranged from 1.1ml/g to 1.47g/ml, Sweet potatoes has the highest oil absorptioncapacity with a mean value of 1.47g/ml while carrot flour has the lowest` value of1.1g/ml. High oil absorption can contribute to the enhancement in flavor and mouthfeel offlours when used in foodpreparations (AyoandGidado,2017). Foaming Capacity (FC) is used to assess the flour's capacity to form foam, which relies on the flexible protein molecules presentto reduce the surface tension of water (Ohizua, et al., 2017). From the result, FC varied between 4% and 10%. Soybean flour exhibited the highest foaming capacity at 57 (10%), while sweet potato flour showed the lowest at 4%. Soybeans flour obtained the highest foam capacity which may be due to its higher protein content (Chandra, 2013). The flour's gelation temperature ranged from 48 to 76%, with soybean flour having the highest value among the raw materials. A gel can signify a state between liquid and solid material. In a food system, molecular structure comprises proteins, polysaccharides, or a combination of both, with water as the usual liquid. The gelation properties are determined by the affected by ionic strength, pH, and non-protein components present (Sridaran et al., 2012).

3.1 Proximate Composition

The proximate composition of the formulated breakfast gruel from sweet potatoes, soybeans and carrot flour blend (g/100 g dry weight) is summarized in Table 3. The moisture content of the breakfast gruel ranged from 10.65-11.78%. Sample S1 (80:15:5) had the highest moisture content of 11.78% while sampleS3(60:25:15) had the least moisture content. There was no significant difference($P<0.05$) between Sample S3 (60:25:15) and S4 (50:30:20). The values from this study were lesser than themaximum 12.5% water content for shelf stable storage viability of food grains (Bolarinwa et al., 2015). This implies that theproductswould have a longer keeping quality.

The ash content differs significantly ($P<0.05$) among all the samples. Table 3 demonstrates an increase (1.90% - 2.59%) in the ash content as the amount of soybeans and carrot increased. This corresponds with report from Joshua et al., (2021) who recorded that ash content of maize flour increased when it was fortified with carrot and contrary to study by Xu et al. (2020) which support that potatoes has high ash and rich in minerals. The higher ash content of sample S4 (50:30:20) can be due to the increasein carrot flour supplementation at a level of 20%. Carrots are rich inminerals, like calcium and phosphorouswhich are needed in higher amount for little children and the elderly for bone formation and maintenance (Augspoleet al.,2014).

The crude fibre contents of samples ranged from 2.88-2.55% from sample S1 (80:15:5) to S4 (50:30:20). These result showed a reduction in the fiber content when the quantity of potato flour reduced. This trend is in contrast with findings from Vito and Wordu, (2021) who recorded highest fiber content for lowest substitution of Orange-Flesh Sweet Potato Starch in complementary food produced with Orange-Flesh Sweet Potato Starch, Soybean and Groundnut Flour. These results were similar to 1.8- 3.2% reported for Ogi made from Acha (*Digitariaexilis*), Soybean (*Glycine max*) and Carrot (*Daucus carota L.*) Composite flour by Ukeyima et al., (2019), but lesser than

1.1-1.7% crude fiber of complementary food produced from blends of Orange-Flesh Sweet Potato Starch based Complementary Food reported by Vito & Wordu, (2021). Thevariation may be due to impact fromexperimental variables. However, the fiber content was below 5% as recommended by the joint FAO/WHO 2004 vitamin and mineral requirements in human nutrition. Fiber is useful in providing roughage that supports food digestion, eases stooling and reduces cholesterol level in the body. High fiber content could result to high water absorption and dislodgment of nutrient and energy required for the growth of children below 24months (Vito & Wordu, (2021). Therefore, in this case, low fiber is desirable.

The result for Protein of the breakfast gruel samples varied significantly (p<0.05) from 14.45-18.25%. This result demonstrated protein content improved as the quantity of soybeans increased in the sample. S4(50:30:20) with highest amount of soybean (30%) had the highest protein while S1(80:15:5) had the least. From previous studies, soybean protein is reported to range from 20-23% (Obatolu et al., 2001). Similarly, Vito & Wordu (2021) observed that in their complementary food blend, the sample with the highest amount of soybeans flour (50%) had highest protein value of 21.91%. Similar range of protein (16.00 – 19.82%) was presented by Oguizu et al., (2019) for infant food processed from blend of orange fleshed sweet potatoes and soybean flour. The protein content is above the acceptable limit from the USDA Food Patterns at Various Calorie Levels, (2015) for 1-3 years. The high amount of protein demonstrated in this work, showed the effect of legumes in breakfast gruel.

The fat results of the formulated breakfast cereal were low, the value ranged from 3.65% to 4.68%. There was a significant increase in fat content with the addition of soybeans. However, no significant different exist (P>0.05) for sample S2(70:20:10) and S3(60:25:15). This was attributed to the high level of fat present in soybean. The fat content recorded in this work is more than 1.09 – 1.99% reported by Amagloh and Coad (2014) for Orange-fleshed sweet potato-based infant food but lower than 6.31-17.22% reported by Vito & Wordu (2021) forComplementary Food produced from Orange-fleshed sweet potato Starch, Soybean and Groundnut Flour. This may be attributed to difference in the raw material used as the inclusion of groundnut which is another oilseed is able to cause a rise in the fat content. The moderately low fat of the blends makes is advantageous in increasing the keeping quality of the dry food product by decreasing the chances of rancidity (Adegunwa et al., 2014). However, the produce will be of low energy value. The carbohydrate result of the gruels was significantly different (P<0.05).Sample S1 had highest value of carbohydrate of 65.42% which is likely as cerealsstore starch as means of energy and are low in protein, fat and ash. Similar report was made by Ugwuona et al.(2012)in cake formulated with soyabeans and cassava flour.SampleS4 (50:30:20) hasthelowestcarbohydratecontent with a mean value of 61.22±0.62. The carbohydrate value reduced as thepercentages of soybean flour increased. This is attributed to the highprotein contained in soybeanflours.

3.2 Vitamins Content of the Breakfast Gruel

The vitamin contents of the breakfast gruel samples (in mg/100g) is summarized in Figure 2. Vitamin A contents ranged from 0.59 to 1.38mg/100g, which falls below the U.S Recommended Dietary Allowance (RDA) of 3mg/100g for children aged 1-3 years (US Department of Health and Human Services, 2021). This means the formulated samples could meet about 20-46% of the daily vitamin A requirement. Sample S1 (80% Sweet Potatoes, 15% Soybeans and 5% Carrot flour) recorded the lowest vitamin A content likely due to its lower carrot composition. Carrots are a primary source of beta-carotene and incorporating high levels of beta-carotene-rich ingredients can significantly boost vitamin A contents in composite foods (leka, 2012; Joshua et al., 2021). Vitamin A is crucial for vision, immune function, cellular health, and deficiency, particularly in children, is associated with morbidity during infections (Liomba *et al*., 2018).

The result for vitamin C contents showed lowest value (8.84mg/100g) in S4 (60% Sweet Potatoes, 30% Soybeans and 20% Carrot flour) and highest value (13.02mg/100g) in S2 (70% Sweet Potatoes, 20% Soybeans and 10% Carrot flour). These values are below the recommended 15mg/100g for children (US Department of Health and Human Services, 2021). However, the samples could provide about 58-86% of the recommended value. As an antioxidant, Vitamin C plays a crucial role in protein metabolism, boosts immune health and aids in iron absorption (Usman, 2012).

3.3 **Sensory Evaluation**

Table 5 shows the result of the sensory properties of the breakfast gruels. All the samples were accepted with no significant difference ($p<0.05$) in appearance, consistency, flavour, taste, after-taste and mouth-fell. Sample S4 (50:30:20 ratio) received the highest value for consistency (6.53), after-taste (6.70), mouth-feel (6.80), and overall acceptability (6.73). This preference for sample S4 may be attributed to the higher soybean and carrot composition, aligning to the report of Ukeyima et al. (2019). In terms of flavour and taste, S2 (70% Sweet potato flour, 20% Soybean flour, 10% Carrot flour) received the highest acceptance score of 6.83 and 6.7 respectively. This implies that the breakfast gruel samples with moderate blends of sweet potatoes, soybean and carrot may have a more appealing taste and flavour.

4.0 Conclusion

This work was aimed to explore the potential of producing a breakfast gruel from the blends of sweet potatoes, soybean and carrot flours. Proximateanalysis and functional properties was done todetermine thattheformulatedmixisrich in protein, fatand carbohydrate and rich in essential nutrient. Sample S4 (50%Sweet potatoesflour,30%Soybeanflour,20%Carrotflour) was chosen as the best sensory attribute of all the formulations. The results of the analysis clearly showthat the production of a nutritious meal from local staples using a simple yetadequatemethodcanbe adoptedby manyhouseholds and the diversification of these staples will be highly efficient in providing food security on the basis of availability and accessibility.

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Table 1: Ingredient Formulation of the Breakfast cereals

Ingredient	S1	S2	S3	S4
Sweet Potato Flour	80	70	60	50
Soyabean Flour	15	20	25	30
Carrot Flour	5	10	15	20
Sugar	10	10	10	10
Salt	4	4	4	4

.**Table 2: Result of Functional Properties**

Samples	BD	SC.	WAC g/g	OAC g/g	FC (cm3)	GT(ºC)
Sweet potatoes flour	$0.556^{a}\pm0.21$	$1.632^{b}\pm0.1$	$1.47^{c}\pm0.18$	$1.47^{a}\pm0.21$	$4.0^{c}\pm0.1$	$65.0^{b}\pm0.21$
Soybean flour	$0.526^{a}\pm0.21$	$1.79^{b}\pm0.1$	$2.15^{b}\pm0.18$	$1.26^{a}\pm0.21$	$10.0^{a}\pm0.1$	$76.0^{a}\pm0.21$
Carrot flour	$0.645^{a}\pm0.21$	$2.387^{a}\pm0.1$	$4.79^{a}\pm0.18$	$1.1^{a}\pm0.21$	$8.0^{b}\pm0.1$	$48.0^{c}\pm0.21$

Valuesaremeans±SDofTriplicatedeterminations.Meanswiththesamesuperscripts along acolumn arenot significantly (P≤0.05) different.

Key: BD: Bulk Density; WAC: WaterAbsorptionCapacity; SC: Swelling Capacity; OAC: Oil Absorption Capacity; FC: Forming Capacity; GT: Gelation time

Table 3: Proximate composition of the breakfast gruel from blends of sweet potatoes, soybeans and carrot flour

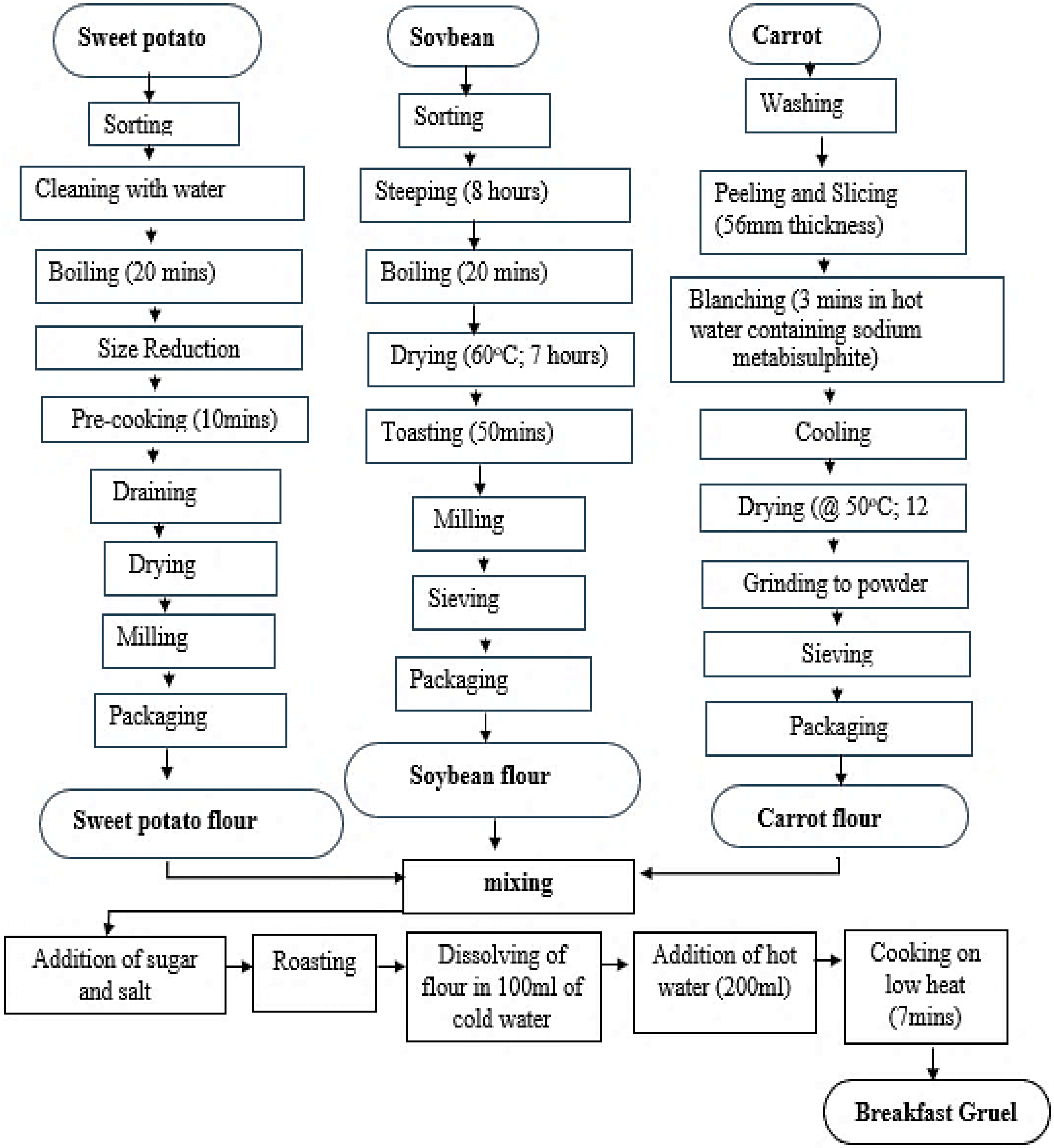
Samples	%MC	%Ash	%Fiber	%Crude Protein	%Fat	%CHO
S1	$11.78^{a}\pm0.31$	$1.90^{c}\pm0.13$	$2.80^{a}\pm0.13$	$14.45^{d}\pm0.21$	$3.65^{c}\pm0.17$	$65.42^{c}\pm0.13$
S2	$11.14^{b}\pm0.18$	$2.16^{bc}\pm0.21$	$2.70^{b}\pm0.12$	$15.06^{c}\pm0.16$	$4.40^{b}\pm0.1$	$64.54^{bc}\pm0.57$
S3	$10.65^{c}\pm0.18$	$2.23^{b}\pm0.21$	$2.65^{ab}\pm0.12$	$16.35^{b}\pm0.16$	$4.50^{ab}\pm0.1$	$63.62^{b}\pm0.57$
S4	$10.71^{c}\pm0.14$	$2.59^{a}\pm0.11$	$2.55^{b}\pm0.1$	$18.25^{a}\pm0.15$	$4.68^{a}\pm0.12$	$61.22^{a}\pm0.62$

Valuesaremeans±SDofTriplicatedeterminations.Meanswiththesamesuperscripts along acolumn arenot significantly (P≤0.05) different

Table 5: Sensory evaluation of gruel produced from the composite flours

Samples	Appearance	Consistency	Flavour	Taste	Aftertaste	Mouth Feel	Overall Acceptabilit y
S1	$6.97^{a}\pm1.03$	$6.40^{a}\pm1.33$	$6.57^{a}\pm1.55$	$6.40^{a}\pm1.28$	$6.37^{a}\pm1.30$	$6.37^{a}\pm1.35$	$5.97^{b}\pm1.38$
S2	$6.57^{a}\pm1.22$	$6.43^{a}\pm1.25$	$6.70^{a}\pm1.21$	$6.83^{a}\pm1.18$	$6.57^{a}\pm1.38$	$6.63^{a}\pm1.47$	$6.00^{b}\pm1.36$
S3	$6.87^{a}\pm1.11$	$6.20^{a}\pm1.13$	$6.47^{a}\pm1.28$	$6.57^{a}\pm1.36$	$6.47^{a}\pm1.48$	$6.57^{a}\pm1.36$	$6.03^{b}\pm1.56$
S4	$6.73^{a}\pm1.05$	$6.53^{a}\pm1.50$	$6.67^{a}\pm1.45$	$6.70^{a}\pm1.47$	$6.70^{a}\pm1.74$	$6.80^{a}\pm1.69$	$6.73^{a}\pm0.87$

Valuesaremeans±SDofTriplicatedeterminations.Meanswiththesamesuperscripts along acolumn arenot significantly (P≤0.05)different



Key: S1:80%Sweet potatoflour,15%Soybeanflour,5%Carrotflour; S2:70%Sweet potatoflour,20%Soybeanflour, 10%Carrotflour; S3:60%Sweet potatoflour,25%Soybeanflour, 15%Carrotflour; S4: 50%Sweet potatoflour,30%Soybeanflour,20%Carrotflour

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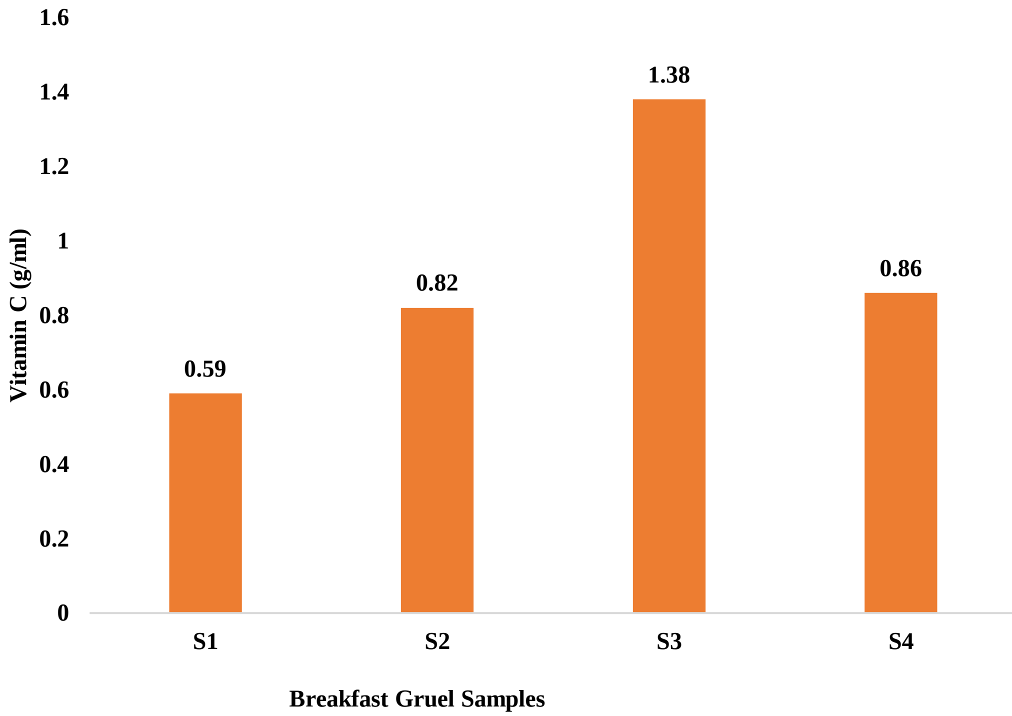

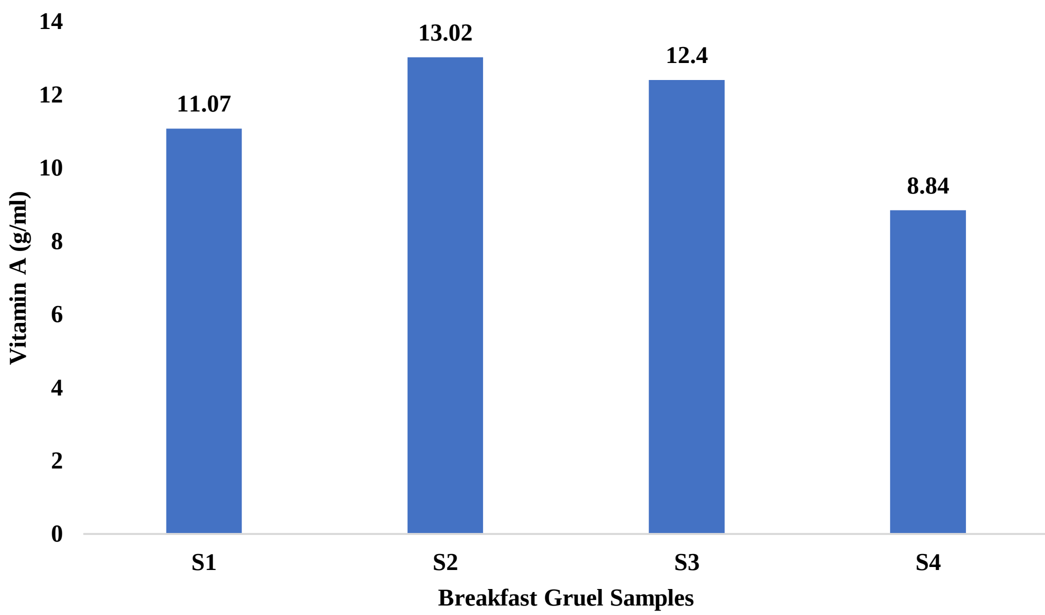

Figure 1: Flowchart for the preparation of Breakfast Gruel