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Proximate, Mineral and Functional Properties of Maize Starch Complemented with Defatted Sesame Seed Flour

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ABSTRACT

Background: Maize is known to be one of the major cereals used as indigenous breakfast meal and for infant weaning. It is high in carbohydrate with limited protein content and deficient in lysine. There is a need to complement its nutritional attributes with the inclusion of sesame seed flour known to be rich source of protein, fat and some essential minerals to maximize adequate nutrition and minimize mal nutrition that could result from the deficiency of these essential nutrients.
Objectives: The physicochemical properties of maize starch complemented with defatted sesame seed flour were investigated.
Methods: Maize grains and sesame seed were processed into starch and flour respectively. The ratio of maize starch to sesame seed flour was 90:10, 85:15, with 100% maize starch as control and 100% maize flour as control. The samples were evaluated for proximate, mineral and functional properties using standard analytical procedure.
Results: The proximate composition varies significantly ($P \leq 0.05$).The moisture content was in the range of (9.25 to 12.0%), protein (10.58 to 21.70%), crude fiber (0.50 to 3.0%), fat content(1.75 to 10.0%), ash content (1.35 to 3.45%) and carbohydrate (50.55 to 72.67%).The mineral composition shows no significant difference ($P \leq 0.05$). Copper was in the range of (0.29 to 0.33 mg/100g), potassium (2.08 to 2.13 mg/100g), sodium (3.67 to 3.72 mg/100g), magnesium (0.77 to 0.84 mg/100g) and manganese (1.47 to 1.54 mg/100g). Most of functional properties investigated show no significant difference ($P \leq 0.05$). Bulk density was in the range of (0.62 to 0.64g/ml), swelling power (4.75 to 8.56 g/ml), water absorption capacity (1.8 to 3.0 g/g), oil absorption capacity (1.35 to 1.70 g/g) and gelation capacity (8.20 to 11.90%).
Conclusion: The inclusion of defatted sesame seed flour to maize starch during processing can significantly improve proximate, mineral and the functionality of the blends.

Keywords: Maize starch, physicochemical properties, sesame seed flour

INTRODUCTION

Maize is one of the most popular cereals in the world providing nutrients for humans and animals (FAO, 1992). African continent produces about 65% of maize in the world with Nigeria being the largest producer in Africa followed by South Africa. Nigeria produces about 8 million tons of maize annually with states like Niger, Taraba, Kaduna and Adamawa and Plateau State leading in the production (FAO, 1992). Maize is high in carbohydrate, limited in both quality and quantity of protein; it contains vitamin B, vitamin C and some other minerals as well as a good source of dietary fiber (Pandaya and Srivivasan, 2012). They are used in the formulation of animal feed and industrial raw material such as starches, acids and alcohols (Zhang *et al*., 2012). It is widely used for the preparation of corn starch, corn syrup, corn oil dextrose, corn flakes, gluten, grain cake, lactic acid and acetone used by various industries such as textile, foundry, fermentation and food industries (Zhang *et al*., 2012). Common foods prepared from maize include akamu, agidi, kokoro, abari, tuwo, kunu, masa (Okoruwa, 1997).

Maize has various health benefits such as improvement of joint motility, it contain B-complex which are good for proper digestion (Sen *et al*., 2006). The presence of vitamin A, C, and K as well as beta-carotene and selenium in maize help to improve the functioning of the thyroid gland and boost the immune system (Sen *et al*., 2006). Maize contain some essential fatty acid, especially linoleic acid in maize oil that plays an important role in diet by maintaining blood pressure, regulating blood cholesterol level and preventing cardiovascular maladies (Sen *et al*., 2006). Maize is an important source of various phytochemicals that plays a significant role in our health (Kopsell *et al*., 2009).

Sesame seed (*Sesamum indicum*) is known to be one of the most ancient oilseeds crop known to mankind, it is a cash crop produced in Nigeria in four leading states of Taraba, Jigawa, Nasarawa, and Benue (Naturland, 2002). Its color varies from cream-white to charcoal-black with others like yellow, red or brown (Naturland, 2002). Sesame seed plays an important role in human nutrition as they are rich source of protein, high in tryptophan and methionine, low in carbohydrate, cholesterol free, its oil are good sources of omega-6 fatty acids, flavonoid, phenolic anti-oxidant, vitamins and dietary fiber with potent anti-cancer and other health promoting properties (El Khier *et al*., 2008).

Sesame seed contains health benefiting components like minerals, antioxidants and vitamins that are essential for wellness and with positive effects on human health (Brochani *et al*., 2010). They are abundant in B-complex vitamins such as niacin, folic acid, thiamin, pyridoxine and riboflavin. The seeds are also good source of many essential minerals such as calcium, iron, manganese, zinc, magnesium, selenium and copper in sufficient quantities. In Nigeria, the seeds are consumed fresh, dried, fried or when blended with sugar (Fariku *et al.,* 2007). In Nigeria, industrial processing and utilization of sesame have not been fully developed (Fariku *et al.,* 2007). However, the product is locally processed and utilized in various forms in the states where the crop is cultivated. Principal among the products are: "*Kantun Ridi*" and "*Kunun Ridi*" (Fariku *et al.,* 2007). At the local level, oil is also extracted from the seed and the cake is made into "*Kulikuli*" which together with the leaves are used to prepare local soup known as "*MiyarTaushe*". The oil can be used locally for cooking as well as for medicinal purposes (Fariku *et al.,* 2007). The objective of this study is to determine the proximate, mineral and functional properties of blends of maize starch and sesame seed flour.

MATERIALS AND METHODS

Sources of material

Maize and sesame seed (*Sesamum indicum*) were purchased from Kure Market Minna, Niger State, Nigeria.

Sample preparation

Preparation of maize starch

Maize was processed according to the method described by Akingbala *et al.,* (1981).The maize grains were cleaned manually and sorted to remove husks, stems, damaged as well as discolored grains achieved through winnowing, hand picking and washing with clean water. The sorted grains were thereafter steeped in water at room temperature for 48 h and wet milled. The slurry was filtered through 80mm mesh screen and the filtrate allowed to sediment for 12 h, reslurried twice, and decanted. The starch cake was oven dried at 55°C for 8 h, milled after drying and sieved through 0.35mm mesh screen to get fine starch powder fig 1.

Preparation of sesame seed flour

The sesame seed flour was processed according to the procedure outlined by (Giami and Isichei, 1999). Sesame seeds were cleaned, sorted, washed, and dried. Drying was done at 45ºC for 30 min and allowed to cool after which the seed was milled to get sesame seed flour. The milled sesame seed flour was defatted using N-hexane in a soxhlet extractor. Five (5g) of the sesame seed flour was weighed into a filter paper and the filter paper containing the weighed flour was placed into the Soxhlet extractor. The N-hexane was filled into a fat free round bottom flask up to $^{2}/_{3}$of the volume of the flask; the soxhlet apparatus was assembled and allowed to reflux for 6h with heating mantle (KDM 1000) adjusted to 60 -70ºC. The filter paper was removed from solvent extractor and the defatted flour was collected. The deffated sesame seed flour was air dried at room temperature, and milled to get finer particle size. The milled sesame flour was sieved to removed lumps and make the particle sizes uniform Fig 2.

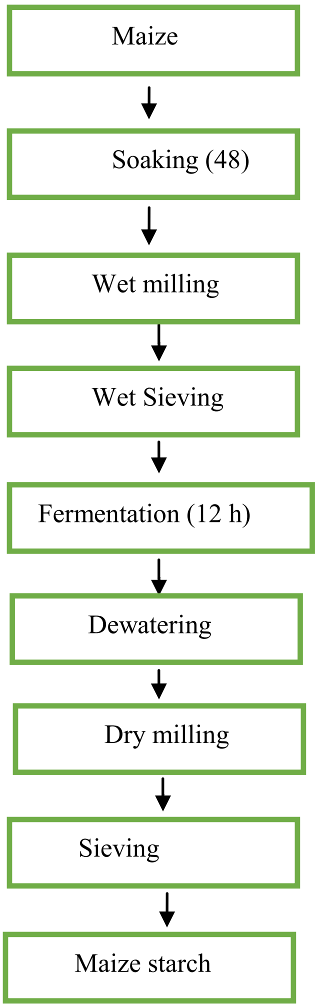

Fig 1: Flow chart for the production of maize starch (Akingbala *et al.,* 1981) (Modified).

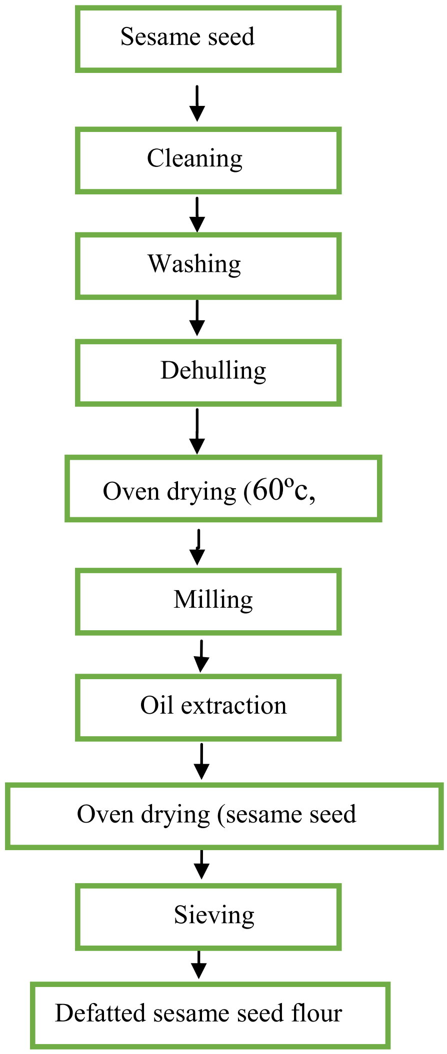

Fig 2: Flowchart for the production of Sesame seed flour (Apolo, 2001) (Modified)

Table 1: Blends formulation of maize starch and sesame seed flour

	100.0% (A)	90:10% (B)	85:15% (C)
Maize starch (g)	100	90	85
Sesame seed flour (g)	0	10	15

*100% maize starch as control sample

Formulation of blends

Three different samples of maize and sesame seed flour were formulated as follows 90:10, 85:15 and 100% maize as control sample (Table 1).

Sample analyses

Moisture content, ash content, protein content, fibre content and content were determined using the method described AOAC (2005). The mineral composition was determined using the method described by Onwuka (2005). The bulk density of the sample were determined by the method described by Okaka and Porter (1999), The water and oil absorption capacities was determined by the method of Okezie and Bello (1988), gelation capacity and swelling power were determined by the method described by Onwuka, (2005).

Statistical analysis

All experiments were carried out in triplicate. Data obtained were subjected to one-way analysis of variance (ANOVA) while Duncan's multiple range tests were conducted to separate the means. These were done using the Statistical Package for the Social Scientists (SPSS version 16.0). Significance level was accepted at 5%.

RESULTS AND DISCUSSION

Proximate composition of maize starch and defatted sesame seed flour is presented in Table 2. Moisture content of the samples shows a significant difference (P≤0.05) with samples with sesame seed flour having the least values. This could be attributed to the fact that addition of sesame seed flour increases the fat content of the samples thereby reducing the moisture content (Malomo, 2012). The protein content of the samples was found to have increased significantly (P≤0.05) with an increase in addition of sesame seed flour. This is probably due to the fact that sesame seed is a good source of protein (Alobo, 2001). Sesame seed protein is known to have a good balance of amino acid with a chemical score of 62% and a net protein utilization of 54% (Alobo, 2001). There was a significant increase (P≤0.05) in the fibre content with an increasing addition of sesame seed flour. This could be because sesame is a rich source of fibre (Lasekan, 1996).

The significant increase (P≤0.05) observed in the fat content of the samples containing sesame seed flour might be due to the fact that sesame seed is an oil seed despite the fact that it has been defatted (Olayanju *et al.,* 2006). The ash content increased significantly (P≤0.05) with an increase in the inclusion of sesame seed flour (Sanni *et al.,* 2008). Ash is important in determining the total mineral composition in foods since it is an organic residue remaining after the water and organic matter are removed by application of heat (Sanni *et al.,* 2008). The carbohydrate content was found to have decreased significantly (P≤0.05) in the samples with sesame seed flour. This is due to the fact that sesame seed is a rich source of protein (Lasekan, 1996).

There was significant increase (P≤0.05) in the mineral content of the samples with an increase in the inclusion of sesame seed flour as shown in Table 3. This is probably due to the fact that sesame seed is a good source of mineral (Obiajunwe *et al*., 2005). The seeds are incredibly rich sources of many essential minerals which include phosphorus, sodium, and magnesium in concentrated amounts.

Most of these minerals have vital role in bone mineralization, red blood cell production, enzyme synthesis, hormone production as well as regulation of cardiac and skeletal muscle activities (Tunde *et al*., 2012). Mineral elements play vital role in metabolic processes; this includes regulation of muscle contractions, transmitting of impulses, bone formation, maintenance of osmotic pressure, acid-base balance, absorption of glucose e.t.c (Peters *et al.,* 2016). Potassium is essential and it has an important role in synthesizing amino acid and protein (Oshodi *et al*., 1999).

The result of the functional properties of maize starch and sesame seed flour is presented in Table 4. There was no significant difference (P≤0.05) in the bulk density of the samples. However, the sample with the highest percentage of sesame seed flour was found to have the least value for bulk density. Low bulk density is an advantage in complementary food formulation (Akpata and Akubor, 1999). Infant diet ought to be low in dietary bulk because of the capacity of their gastric system which may not be able to handle bulkier foods. Bulk density promotes easy digestibility of food particularly for children with immature digestive system (Gopaldas *et al*., 1992). There was significant difference (P≤0.05) in the water absorption capacity of the samples with the sample containing sesame seed flour recording higher value. This could be as a result of high presence of more hydrophilic carbohydrate with good water retention capacity (Ocheme and Chinma, 2008). Water absorption capacity is an index of the maximum amount of water it can absorb and retain as well as increases digestibility of food (Ijarotimi and Keshinor, 2012). Excessive water absorption capacity has tendency to make food deteriorate and eventual spoilage (Ocheme *et al*., 2010).

The oil absorption capacity shows a significant decrease (P≤0.05) with addition of sesame seed flour. These findings were in contrast to the observation of Walde *et al,* (2005) which reported that lower protein content could lead to lower oil absorption capacity due to the lipophilic tendency. High oil absorption capacity enhances flavor and mouth feel of flour when used in food preparation (Balogun and Olatidoye, 2010). The swelling power shows a significant decrease (P≤0.05) with inclusion of sesame seed flour. This observation is in agreement with Zubair and Osundahunsi (2016) who reported that the higher the fat content of sample, the lower will be its ability to swell. Swelling power is the amount of water a food sample will absorb and swell within a given temperature and time (Zubair and Osundahunsi, 2016). The swelling power of flour granules is an indication of the extent of associative forces within the granules (Malomo, 2012). The higher the value of swelling power, the higher the associative force (Malomo, 2012). Fat may complex with starch and limit swelling (Zobel, 1984). There was a significant reduction (P≤0.05) in the gelation capacity of the sample with inclusion of sesame seed flour. This is probably due to the fact that sesame seed been high in oil reduce the ability of the flour to form gel (Zobel, 1984). Gelation is an important functional property of food sample as it affects the textural properties of food. Hence, it is required for food system use as a thickening and gelling agent (Zobel, 1984).

CONCLUSION

The study shows that complementing maize starch with sesame seed flour in infant food formulation significantly improves the nutritional composition as well as its functionality during processing. However, percentage inclusion of not more than 5 % in order to control the fat content level may be recommended.

Table 2: Proximate composition of maize starch and defatted sesame seed flour

	Samples		
Parameters (%)	A	B	C
Moisture content	$12.00^{a}\pm 1.13$	$10.10^{b}\pm0.14$	$11.00^{ab}\pm1.41$
Crude protein	$16.24^{b}\pm2.74$	$19.26^{ab}\pm1.78$	$21.70^{a}\pm0.99$
Crude fiber	$0.5^{b}\pm0.00$	$2.25^{a}\pm1.06$	$3.00^{a}\pm 0.57$
Fat content	$1.75^{c}\pm0.35$	$7.75^{b}\pm1.06$	$10.00^{a}\pm0.00$
Ash content	$1.35^{b}\pm0.49$	$2.00^{b}\pm0.00$	$3.45^{a}\pm0.57$
Carbohydrate	$68.11^{a}\pm2.39$	$56.94^{b}\pm0.76$	$50.55^{c}\pm0.92$

Values are mean ± standard deviation of duplicate determination. Mean in the same row followed by different superscript are significantly different (P≤0.05).

Table 3: Mineral composition of maize starch and defatted sesame seed flour

	Samples		
Parameters (mg/100g)	A	B	C
Copper	$0.29^{b}\pm0.01$	$0.32^{a}\pm0.03$	$0.33^{a}\pm0.04$
Potassium	$2.08^{a}\pm0.01$	$2.11^{a}\pm0.04$	$2.13^{a}\pm0.05$
Sodium	$3.67^{a}\pm0.02$	$3.70^{a}\pm0.03$	$3.72^{a}\pm0.06$
Magnesium	$0.79^{b}\pm0.01$	$0.80^{b}\pm0.02$	$0.84^{a}\pm0.04$
Manganese	$1.50^{b}\pm0.01$	$1.51^{b}\pm0.02$	$1.54^{a}\pm0.04$

Values are mean ± standard deviation of duplicate determination. Mean in the same row followed by different superscript are significantly different (P≤0.05)

Table 4: Functional composition of maize starch and defatted sesame flour

	Samples		
Parameters	A	B	C
BD (g/ml)	$0.63^{a}\pm0.04$	$0.64^{a}\pm0.03$	$0.62^{a}\pm0.06$
WAC (g/g)	$1.80^{b}\pm0.28$	$3.0^{a}\pm0.03$	$2.4^{a}\pm0.06$
OAC (g/g)	$1.48^{a}\pm01.00$	$1.40^{b}\pm0.21$	$1.35^{b}\pm0.20$
SP (g/ml)	$5.79^{a}\pm0.43$	$5.58^{a}\pm0.28$	$4.75^{b}\pm2.18$
GC (%)	$11.90^{b}\pm0.14$	$8.20^{b}\pm0.28$	$8.70^{a}\pm0.14$

Values are mean ± standard deviation of duplicate determination. Mean in the same row followed by different superscript are significantly different (P≤0.05); A = 100% maize starch, B =90% maizestarch and 10% Sesame seed flour, C =85% maize starch and 15% Sesame seed flour; BD = Bulk density, WAC = Water absorption capacity, OAC = Oil absorption capacity, SP = Swelling power, GC = Gelation capacity

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