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Utilization of sweet potato starches and flours as composites with wheat flours in the preparation of confectioneries

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Freshly harvested roots of sweet potato variety TIS 87/0087 were processed into flour and starch using standard methods. Blends of Wheat and sweet potato composite flour was developed in the ratios 80:20, 70:30, 60:40 and 50:50. Also, blends of wheat and sweet potato starch were developed in the ratios 80:20, 70:30, 60:40 and 50:50. Whole sweet potato flour and starch were also included where 100% wheat flour was used as control or standard. Functional properties of wheat: sweet potato composite flour showed that water absorption capacity ranged from 2.0-2.5 g/ml, oil absorption capacity: 1.5-2.5 g/ml and bulk density: 0.68-0.82 g/ml. Gelatinization temperature ranged from 49.00-70.25°C. Wheat: sweet potato composite starch showed that water absorption capacity ranged from 1.5-2.0 g/ml, oil absorption capacity: 1.0-2.0 g/ml and bulk density: 0.74-0.78 g/ml. Gelatinization temperature ranged from 48.0-65.5°C. Sensory evaluation scores showed that up to 40% inclusion of sweet potato starch gave acceptable bread. Up to 40 and 50% inclusion of starch or flour to wheat gave acceptable cakes with desired colours. Also, 50% inclusion of starch or flour to wheat gave acceptable chinchin for colour and general acceptability.

Key words: Sweet potato, flour, starch, confectionery, functional properties, sensory evaluation.

INTRODUCTION

Sweet potato is an important food security crop that feeds millions of people in the developing world. The crop is popular among farmers with limited resources and produces more biomass and nutrient per hectar than any other food crop in the world (Parkash, 1994). Sweet potato as food product is a source of energy, proteins, pro-vitamin A (β-carotene), vitamin C and iron (Dufour et al., 1996). In Nigeria, the roots are cooked and prepared in limited number of ways; most commonly boiled. They are also cooked with beans and other foods, and sometimes fried as chips (Woolfe, 1992). Sweet potato roots possess a variety of chemical compound relevant to human health. About 80-90% of sweet potato dry matter is made up of carbohydrate consisting mainly of starch and sugar with

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lesser amount of pectin and hemi-cellulose and cellulose. Sweet potato also contains protein (0.46-2.93%), dietary fiber (0.49-471%), lipids (0.06-0.48%) and ash (0.31-1.06%). It also contains essential minerals such as zinc, phosphorus, magnesium, potassium and iron. Sweet potato is also an important source of pro-vitamin A, thiamine, riboflavin, niacin, ascorbic acid and many other functional compounds (Woolfe, 1992). Sweet potato tuber and leaves also contain anti-nutrients such as phytate, oxalate and tanins (Fleming, 1981; Udoessien and Ifon, 1990; Osagie, 1990). Sweeetpotato is now consumed mainly for its nutrients rather than for its energy (Jack et al., 1992). The crop has high Beta-carotene than any other root and tuber crops (Suda et al., 1999). Orange fleshed sweet potato is very rich in pro-vitamin A (Jack et al., 1992).

Sweet potato starch is isolated same way like other starchy roots except that the solution is kept alkaline (pH 8) using lime which help to dissolve the pigment (Akoroda and Egeonu, 2009). Unlike cassava and maize starches, sweet potato starch does not have high viscosity values on pasting and gelatinization temperature (Garcia, 1993). Sweet potato flour can serve as a source of energy and nutrients: carbohydrate, beta-carotene (pro-vitamin A), minerals and can add natural sweetness, colour flavour and dietary fiber to processed food products (Woolfe, 1992; Ulm, 1988).

Bread may be described as a fermented confectionary product produced mainly from wheat flour, water, yeast and salt by a series of process involving mixing, kneading, proofing, shaping and baking (Dewettinck et al., 2008). Bread has been a major component of human diet dating back to pre-historic man. This has made the baking of yeast leavened and sour dough bread one of the oldest biotechnological process (Christine et al., 2012). Bread is an important staple food, the consumption of which is steady and increasing in Nigeria. It is however relatively expensive, being made from imported wheat that is not cultivated in the tropics for climate reasons (Edema et al., 2005).

Cake is a baked batter made from sugar, egg, shortenings, milk and leavening mixed together in such a way as to produce a fluffy fined grained baked product (Victor et al., 1995). It is described as a desirable delicate tender, highly sweetened, non-yeast baked product (Okaka, 2005). Cake has become a constant food in our diet for a long time and their continual popularity has encouraged the development of newer and more attractive product that is available in the market today (Eke et al., 2009). They can be served alone, packed with lunch, taken on a picnic or traditional favourite as refreshment for guests (Signori, 2004).

Chinchin is a fried snack popular in West Africa. It is a sweet, hard, donut-like baked or fried dough of wheat flour, and other customary baking items. *Chinchin* may also contain cowpeas (Akubor, 2004). Many people also bake it with ground nutmeg for flavor. It is usually kneaded and cut into small squares of 1 square inch or so, about a quarter of an inch thick, before frying (Mepha, 2007).

Wheat as the chief raw material in the production of wheat flour cannot thrive well in Nigerian soils; therefore wheat flour has to be imported. This leads to relatively high price of bakery goods. The availability of adequate supply of flour has been a major economic and political issue in Nigeria.

The objective of this work is to utilize sweet potato flour and starch as substitutes to wheat in bread making and confectionery as this may help to improve nutrition of consumers of root crops in Nigeria and also ensure national food security.

MATERIALS AND METHODS

Source of materials

Fresh roots of sweet potato variety TIS 87/0087 were harvested at about 8 weeks old after planting from the experimental trial of sweet potato Programme, National Root Crops Research Institute (NRCRI), Umudike, Nigeria.

Processing of sweet potato roots to flour

The method described by Etudaiye et al. (2008) with some modifycations was employed. This involved washing of fresh roots, peeling, soaking (24 h to leach out sugars), decanting of water, sun-drying of chips, milling, sieving (with muslin cloth) to obtain fine flour and packaging.

Starch isolation from sweet potato roots

The method of Sanchez et al. *(*2005) with some modifications was used. This involved washing of fresh roots, peeling, grating, continuous washing with water (about 6 times),sedimentation of starch (6 h), decanting, sun-drying, milling and sieving (with muslin cloth) to obtained fine starch flour and packaging.

Development of wheat: sweet potato composites

The method of Etudaiye et al. *(*2008) was employed. Wheat flour was blended with sweet potato flour/starch as composites in the ratios: 80:20, 70:30, 60:40 and 50:50. Whole wheat flour, whole sweet potato flour and whole sweet potato starch were used as controls.

Preparation of recipes

The method of Aniedu and Oti (2008) was employed (Table 1).

Production of bread

The method recommended by Edema et al. (2005) with some modification was used. Whole wheat, sweet potato flour/ starch, and 80:20, 70:30, 60:40 and 50:50 blends of wheat: sweet potato flour/ starch were used. Samples were weighed based on 100 g standard. All ingredients as written in Table 1 were taken in a bowl and mixed at high speed with the aid of Philips hand mixer Type HR1453 for 10 min. The mixture was allowed to stand for 1 to 4 h at

Table 1. Preparation of recipes based on 100% wheat: sweet potato composite flours.

Ingredient	Bread	Cake	Chinchin
Sugar	1 table spoon	2 table spoon	1 table spoon
Margarine	1 table spoon	3 table spoon	½ table spoon
Yeast	½ table spoon	-	-
Salt	A pinch	-	-
Water	As required	-	-
Egg slurry	-	4 table spoon	2 table spoon
Baking powder	-	½ table spoon	1 table spoon
Grated nut meg	-	½ table spoon	½ table spoon
Vanilla essence	-	1 ml	-

Aniedu and Oti (2008).

room temperature for batter development. This was followed by gentle mixing for 5 min after which the batter was scaled into greased baking pans. Loaves were baked at 160 to 180°C for 35 min in an LG Gas cooker OMEGA 4B oven. After baking, the loaves were left for about 10 min in the oven. They were then quickly removed from the pans, arranged in trays and returned to the oven for 1 to 2 h or until required for analysis. Analyses were carried out after the baked loaves had attained room temperature or internal crumb temperature of about 35±2°C.

Production of cake

The method recommended by Okorie and Oyeneke (2012) with some modifications was used. Whole wheat, sweet potato flour/ starch, and 80:20, 70:30, 60:40 and 50:50 blends of wheat: sweet potato flour/ starch were used. The baking fat and granulated sugar were creamed together with the Kenwood mixer for 20 min until light. The eggs were beaten for 5 min with the homogenizer. This was done to prevent the curdling of batter. After batter development of a soft velvety feel, the vanilla essence (flavoring) was added. The mixed batter, each was mixed with milk and water to proportion and poured into greased cake pans. These were put in the oven and baked at temperature of 190°C for 15 min. The cakes were cooled and removed from the pan after 1 h. The cooled cake were packaged in aluminum foils and kept in shelf until required for sensory evaluation.

Production of *chinchin*

The method of Aniedu and Omodamiro (2012) with some modifications was used. Whole wheat, sweet potato flour/ starch, and 80:20, 70:30, 60:40 and 50:50 blends of wheat: sweet potato flour/ starch were used for the preparation of *chinchin*. Samples were weighed based on 100 g standard. Ingredients with the right measurements as reported on Table 1 were added with required water to form pastry samples. The pastry samples were spread on a board and cut into bits and the bits were cooked in deep hot oil until attractively brown in colour.

Functional properties and gelatinization temperature

Functional properties (water absorption capacity, oil absorption capacity, bulk density) and gelatinization temperature were determined by the methods of Etudaiye et al. (2008).

Determination of oil absorption (OAC) and water absorption capacities (WAC)

About 1 g of dry starch sample was weighed into 15 ml centrifuge tube and 10 ml of distilled water or oil was added. The sample was mixed thoroughly and allowed to stand for 30 min at room temperature and centrifuged at 2000-5000 rpm for 30 min. The volume of free water or oil (the supernatant) was read directly from the calibrated centrifuge tube. The amount of water or oil retained by the starch sample was from the difference in volume of the initial amount of water or oil added to that decanted after centrifugation.

Determination packed bulk density (BD)

About 50 g of dry starch sample was weighed into a granulated measuring cylinder and its volume was recorded. Next, the measuring cylinder was tapped constantly on the Table (10-15 times) until there was no further change in volume. Bulk density was calculated as the weight of the flour sample in grams per volume (g/ml).

Determination of gelatinization Temperature

About 10% of the starch sample was prepared in a test tube and the mixture was boiled with continuous stirring. The temperature was recorded 30 s after gelatinization was visually observed. Gelatinization temperature was taken with a thermometer and recorded in degree centigrade.

Sensory evaluation

Sensory evaluation was carried out with the method of Iwe (2002). Seven (7) points Hedonic scale was used where 7 = like extremely, 4 = neither like nor dislike and 1 = dislike extremely. Fourty (40) panelists comprising males and females who are regular consumers of confectioneries participated in the experiment. Bread, cakes and *chinchin* produced from 100% wheat flour were used as control.

Statistical analysis

Statistical analytical system (SAS) software, version 8, (2009) was used for data analysis. Analysis of variances was carried out and means separation was done using Fischer LSD to determine significant differences (P at 0.05%).

Tables 2. Functional properties of wheat : sweet potato and wheat: starch composite flour.

Sample	Wheat : sweet potato				Wheat : starch			
	Water absorption capacity (g/ml)	Oil absorption capacity(g/ml)	Gelatinization temperature (ºC)	Bulk density(g/ml)	Water absorption capacity (g/ml)	Oil absorption capacity(g/ml)	Gelatinization temperature (ºC)	Bulk Density (g/ml)
100% wheat	2.0^{b}	2.0^{a}	58.00^{d}	0.78^{b}	2.0^{a}	2.0^{a}	58.0^{b}	0.78^{a}
80:20	2.0^{b}	2.0^{a}	60.25^{d}	0.82^{a}	2.0^{a}	1.5^{b}	54.3^{c}	0.78^{a}
70:30	2.0^{b}	2.0^{a}	70.25^{a}	0.73^{c}	1.5^{b}	2.0^{a}	58.0^{b}	0.74^{b}
60:40	2.0^{b}	1.5^{b}	60.25^{c}	0.68^{d}	1.5^{b}	1.5^{b}	65.3^{a}	0.74^{b}
50:50	2.5^{a}	2.0^{a}	60.45^{c}	0.68^{d}	1.5^{b}	1.5^{b}	65.5^{a}	0.77^{a}
100% Sweet potato	2.5^{a}	2.0^{a}	49.00^{e}	0.69^{d}	1.5^{b}	1.0^{c}	48.0^{d}	0.77^{a}
LSD (0.5%)	0.02	0.03	1.54	0.01	0.02	0.02	0.87	0.01

Mean values down the columns with the same alphabet are not significantly different (P>0.05). 80:20, 70:30, 60:40 and 50:50= wheat: sweet potato blends.

RESULTS AND DISCUSSION

Table 2 shows the functional properties of sweet potato flour and starch and their composites with wheat flour. Values of water absorption capacity, oil absorption capacity, gelatinization temperature and bulk density were within the range of previous values reported by Etudaiye et al. (2008) in a work titled functional properties of wheat: sweet potato composite flour and sensory qualities of confectioneries produced from the composites. Also, values of water absorption capacity were in line with that of Ojinaka et al. (2009) in cocoyam starch modification effects on functional, sensory and cookies qualities which ranged from 0.83-1.67 g/ml. Gelatinization temperature (GT) of the flours and starches and their blends with wheat flour were within the ranges of values reported by Woolfe (1992) where GT ranged from 58-69°C, 58-75°C and 65-80°C. GT is a measure of consistency of a starch suspension when it is heated at a certain temperature for a given period of time. It enhances the body and texture of a product (Onimawo et al., 1998). High gelatinization gives a good and easier cooking quality than low gelatinization. However, high gelatinization temperature may require more heat energy and costs. This suggests that flours and starches of the sweet potato variety should not be added to a formula where gelling is required below 58ºC. Bulk density (BD) of wheat: sweet potato starch composites gave higher values than the previous report made by Etudaiye et al. (2008) but was within the range of values 0.62-0.75 g/ml of Ojinaka et al. (2009). BD is an indication of porosity of a product which influences package design. It is affected by moisture content and particle size distribution of the flour (Onimawo et al., 1998).

High bulk density of the of flours and starches indicate that they would serve as good thickeners in food products (Adebowale et al., 2005), while the low bulk density of flours and starch samples will be suitable for the formulation of high nutrient density weaning food (Mepba et al., 2007).

Tables 3 shows that up to 40% inclusion of sweet potato starch gave acceptable bread. This is an advantage over the recommended 10% inclusion of cassava flour with wheat in bread making in Nigeria. The process modification improved the colours of the cake sample (Though, not a primary focus in the study) (Table 4). Acceptable cakes up to 60:40 wheat:sweet potato starch composite and 50:50 wheat:sweet potato composites flour were achieved as compared with cakes prepared from 80:20 wheat:sweet potato composite flour in the work reported by Etudaiye et al. (2008).

Table 5 shows that general acceptability of *chinchin* prepared from 80:20 and 50:50 wheat: sweet potato starch composites were acceptable by the panelists. However, *chinchin* produced from wheat: sweet potato composite flour (Table 5) showed general acceptability up to 50:50 ratios. Colours of products from composites up to 50:50 ratios were also acceptable and showed no significant difference (P>0.05).

Conclusion

The study shows that sweet potato flour and starch gave acceptable products: cake, *chinchin* and bread. They also showed appealing, desirable

Tables 3. Sensory evaluation of Bread produced from wheat: sweet potato starch and flour composite.

Sample	Starch					Flour				
	Colour	Taste	Texture	Aroma	General acceptability	Colour	Taste	Texture	Aroma	General acceptability
100% Wheat	6.0^{a}	6.4^{a}	6.2^{a}	6.1^{a}	6.1^{a}	5.9^{a}	5.6^{a}	6.1^{a}	5.9^{a}	6.0^{a}
80:20	5.9^{a}	5.4a^{b}	5.6^{ab}	5.3^{ab}	5.3^{ab}	5.5^{a}	4.8^{ab}	5.4^{a}	5.1^{ab}	5.0^{ab}
70:30	5.4^{ab}	4.9^{bc}	5.4^{ab}	5.1^{ab}	5.1^{ab}	4.9^{ab}	4.0^{bc}	4.3^{b}	4.3^{bc}	4.0^{bc}
60:40	5.0^{b}	4.7^{bc}	5.6^{ab}	5.2^{ab}	5.0^{b}	4.1^{bc}	3.3^{cd}	3.8^{d}	3.6^{cd}	3.3^{cd}
50:50	4.0^{c}	4.0^{e}	4.6^{b}	4.4^{bc}	4.3^{b}	3.4^{cd}	2.5^{d}	3.4^{b}	2.9^{de}	3.1^{cd}
100% Sweet potato	2.8^{d}	2.4^{d}	2.9^{c}	3.3^{c}	2.9^{c}	2.6^{d}	2.4^{d}	2.1^{c}	2.3^{e}	2.3^{d}
LSD (0.5%)	0.99	1.1	1.2	1.1	1.1	1.2	1.0	1.1	1.1	1.0

Mean values down the columns with the same alphabet are not significantly different (P>0.05). 80:20, 70:30, 60:40 and 50:50= wheat: sweet potato blend.

Tables 4. Sensory evaluation of Cakes produced from wheat: sweet potato starch and flour composite

Sample	Starch					Flour				
	Colour	Taste	Texture	Aroma	General acceptability	Colour	Taste	Texture	Aroma	General acceptability
100% wheat	6.0^{a}	5.9^{a}	5.5^{ab}	5.7^{a}	5.8^{a}	6.3^{a}	5.7^{a}	5.7^{a}	5.8^{a}	6.1^{a}
80:20	5.4^{a}	5.6^{ab}	5.6^{a}	5.4^{ab}	5.8^{a}	5.5^{b}	5.7^{a}	5.0^{b}	5.5^{ab}	5.4^{b}
70:30	5.3^{a}	5.6^{ab}	5.7^{a}	5.7^{a}	5.5^{ab}	5.8^{ab}	5.6^{ab}	5.2^{ab}	5.5^{ab}	5.8^{ab}
60:40	5.3^{a}	5.5^{ab}	5.7^{a}	5.3^{abc}	5.8^{a}	5.1^{bc}	5.2^{ab}	4.9^{bc}	5.1^{abc}	5.1^{bc}
50:50	4.3^{b}	5.1^{b}	5.0^{ab}	4.8^{c}	5.2^{ab}	5.6^{ab}	5.3^{ab}	4.9^{bc}	4.9^{bc}	5.4^{b}
100% Sweet potato	3.9^{b}	5.0^{b}	4.8^{b}	5.0^{bc}	4.9^{b}	4.4^{c}	4.9^{b}	4.2^{c}	4.7^{c}	4.7^{c}
LSD (0.5%)	0.8	0.7	0.7	0.6	0.6	0.8	0.7	0.7	0.7	0.7

Mean values down the columns with the same alphabet are not significantly different (P>0.05). 80:20, 70:30, 60:40 and 50:50= wheat: sweet potato blends.

Tables 5. Sensory evaluation of *Chin-Chin* produced from wheat: sweet potato starch and flour composite.

Sample	Starch					Flour					
	Colour	Taste	Texture	Aroma	General acceptability	Colour	Taste	Texture	Crispiness	Aroma	General acceptability
100% wheat	5.96^{a}	5.76^{a}	5.7^{a}	5.8^{a}	5.5^{a}	5.5^{a}	5.6^{a}	5.5^{a}	5.4^{a}	5.3^{a}	5.9^{a}
80:20	5.7^{a}	5.2^{ab}	5.2^{ab}	5.1^{ab}	5.1^{abc}	5.1^{a}	5.1^{a}	5.2^{a}	5.2^{a}	4.8^{ab}	4.9^{ab}
70:30	5.2^{ab}	4.4^{bc}	4.4^{bc}	5.2^{a}	4.4^{bcd}	5.2^{a}	4.9^{a}	5.1^{a}	4.9^{a}	4.7^{ab}	5.1^{a}

Table 5. Contd

60:40	4.3^{bc}	4.3^{bc}	4.2^{c}	4.2^{bc}	4.2^{cd}	5.6^{a}	5.6^{a}	5.2^{a}	5.2^{a}	5.3^{a}	5.3^{a}
50:50	5.5^{a}	5.2^{ab}	5.4^{a}	5.1^{ab}	5.2^{ab}	5.0^{a}	4.9^{ab}	4.9^{ab}	4.7^{ab}	4.9^{ab}	5.1^{a}
100% Sweet potato	3.7^{c}	3.8^{c}	3.6^{c}	4.0^{c}	3.5^{d}	3.6^{b}	4.0^{b}	4.0^{b}	3.7^{b}	4.0^{b}	4.0^{b}
LSD (0.5%)	1.0	0.92	0.9	1.98	1.0	1.0	0.9	1.0	1.0	1.0	1.0

Mean values down the columns with the same alphabet are not significantly different (P>0.05). 80:20, 70:30, 60:40 and 50:50= wheat: sweet potato blends.

and acceptable colours except in products from 100% sweet potato flour and starch. Flours and starches blended with wheat flour at different ratios gave good functional properties which enhanced their utilization potentials. This work recommends the promotion and utilization of sweet potato flour and starch in bread making, preparation of cake and *chinchin* in Nigeria, that is known to fully depend on imported wheat for bread and other confectionery production. Furthermore, the utilization of sweet potato will help to improve nutrition of consumers of root crops in Nigeria and also ensure national food security.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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