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Modification and Quality Characteristics of Cocoyam Starch and its Potential for Chin-Chin Production

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Abstract: Effect of modification and quality characteristics of cocoyam starch for the production of chin-chin was investigated. Cocoyam (*Xanthosoma sagittifollium*) starch was subjected to acid modification, blended with wheat flour in the ratios 90:10, 80:20, 70:30 and 60:40, the 100% and used to prepare chin-chin samples, 100% wheat flour was used as the control sample. Functional and pasting properties of the modified cocoyam starch, wheat flour and the blends were assessed; proximate composition and sensory properties of the chin-chin produced from the blends were investigated. Bulk density of the 100% modified cocoyam starch, 100% wheat flour, 80:50, 70:30 and 50:20 blends were 0.51, 0.66, 0.56, 0.62 and 0.68 g/mL, respectively. Oil absorption capacity, water absorption capacity and pasting temperature ranged between, 2.07-2.24 g/g, 1.42-1.78 g/g and 90.90-94.33°C, respectively. Proximate analysis revealed that the chin-chin sample from 100% modified cocoyam starch had the highest carbohydrate, ash and crude fibre (73.43±0.07, 1.625±0.0, 1.965±0.0, respectively), closely followed by 70:30 blend whereas sample from 100% wheat had the lowest. Sensory evaluation on the chin-chin samples revealed that the 70:30 blends was the most acceptable sample. Modified cocoyam starch blended with wheat flour gave good functional properties and the chin-chin samples produced from them have good sensory qualities which showed an enhancement in its utilization.

Key words: Modification, cocoyam starch, chin-chin, proximate and sensory qualities

INTRODUCTION

Cocoyam (*Xanthosoma sagittifolium*) is an herbaceous, monocotyledonous crop that belongs to the *Aracae* family (Purseglove, 2005). Cocoyam has nutritional advantages over other root and tuber crops. It has more crude protein than root and other tubers and its starch is highly digestible because of the size of the starch granules (Lyonga and Nzietchueng, 2008). Native starches have limited usefulness in food processing as they are sensitive to heat, pH, shear and concentration, production of shelf stable refrigerated, frozen, hot filled, retorted or aseptically processed foods require the use of modified starches (Abu, 2002). Despite the economic importance of cocoyam as a food material in some parts of the tropics, there is limited information on their post-harvest characteristics, which perhaps contributes to the very limited application of improved post-harvest technologies to maintain quality and improve marketing potential. The starches most commonly modified for commercial use are those from normal maize, tapioca, potato and waxy maize. Modified starches are used to improve viscosity, shelf stability and particulate integrity, processing parameters, textures, appearance and emulsification. Different starches have different properties and are used in the food industry for nutritional, sensory and even aesthetic purposes. Chemically modified starch for use in food stuffs is restricted in range and level of modification (European Union International Starch institute, 2001). Chin-chin is a fried snack popular in West Africa. It is a sweet, hard, donut- like baked or fried dough of wheat flour, eggs and other customary baking items (Akubor, 2004). Many people also bake it with ground nutmeg for flavor. It is usually kneaded and cut into small squares of one square inch or so, about a quarter of an inch thick before frying (Mepba *et al*., 2007). In Nigeria, the demand for baked foods has been growing continually and there has been an increase in the reliance on imported wheat. Nigeria's climate and weather condition does not support the cultivation of wheat but still produces staple crops like cocoyam which presently has limited application in the food industry; it would therefore be beneficial to integrate the utilization of cocoyam on an industrial scale and also create varieties especially in the production of pastries and confectioneries. The chin-chin is one food item, that invites a great deal of flexibility in terms of the ingredient used and method of preparation involved, while some like to eat it hard and crunchy, other prefer a softer easier to chew version. The purpose of this research is to evaluate the quality of chin-chin produced from composite wheat-modified cocoyam starch flour.

MATERIALS AND METHODS

Materials: The materials used were purchased from a local market in Abeokuta, Ogun state, Nigeria and they

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includes cassava tuber, Wheat flour, Sugar, Margarine, Baking powder, Eggs, Milk and Vegetable oil. All chemicals used were of analytical grade.

Extraction and modification of cocoyam starch: The starch was extracted using the method described by Ihekoronye (2005). The cocoyam was washed and peeled and then wet milled using double disc attrition milling machine. The slurry was then sieved. The cocoyam starch was allowed to settle at the bottom of the container before decanting the water. The extracted starch slurry was transferred into a clean dry tray and dried in a cabinet dryer at a temperature of 60°C, the dried starch was milled and acid modification was done using the method described by Varavinit *et al.* (2002). The acid-modified starch was dried in an air convention oven at 30°C for 48 h and then milled and stored in an air tight container for analysis.

Preparation of chin-chin: The composite flour, sugar, butter, egg, baking powder, water and milk were mixed together at appropriate rate in a large bowl. The dough was placed on a floured surface and kneaded until smooth and elastic. The kneaded dough was rolled out to approximately 2 cm thickness and then cut into small squares 2 cm by 2 cm in size. The oil was put inside a deep fryer MC 1800 model and allowed to be hot enough until the temperature of fryer reached 180°C, the dough cubes were placed in the hot oil and the chin-chin was deep fried for 8 min until golden brown. The fried chin-chin was removed and drained off excess oil before serving (Akubor, 2004).

Analytical determination

Proximate composition: protein, fat, minerals, crude fibre, moisture and carbohydrates contents were determined using (AOAC, 2004) method.

Functional properties: Water Absorption Capacity and Water Absorption Index were determined using the method of Wang and Kinsella (1976). Bulk density was determined using the method of Wang and Kinsella (1976). Swelling capacity was determined using the method of Ukpabi and Ndimele (1990). Pasting property was determined by using rapid visco-analyzer (IITA, 2001).

Sensory evaluation: The sensory attributes of the chin-chin was obtained by using simple hedonic tests as described by Larmond (1991). This was done using a 20 member panel comprising of students of the department, who were familiar with the sensory attributes of chin-chin. Each panelist was asked to score each attribute on a 9 point hedonic scale where 1 and 9 represent dislike extremely and like extremely, respectively. The attributes that were evaluated includes colour, taste, flavour, texture, appearance, crispness and overall acceptability.

Statistical analysis: All data collected were subjected to analysis of Variance (ANOVA) using SPSS (version 15, 2007). Duncan multiple range test was used to separate the differences in the mean scores.

RESULTS AND DISCUSSION

Proximate composition of chin-chin produced from modified cocoyam-wheat flour: Table 1 shows the proximate composition of modified cocoyam-wheat composite chin-chin. All the chin-chin samples were high in carbohydrate. Chin-chin produced from 100% wheat flour (100% WF) has the lowest carbohydrate content of 69.16%. Substituting wheat flour with modified cocoyam starch at 40, 30, 20 and 10% increased the carbohydrate content of the chin-chin to 73.43, 71.16 and 70.15%, respectively, as the substitution level increased, the carbohydrate content increased, this may be attributed to the higher carbohydrate content of the modified cocoyam starch. The high value of crude fibre and carbohydrate observed in chin-chin of sample (100% MCF and 60:40) may be as a result of the sample having the largest cocoyam starch substitution in wheat flour at 100 and 40% substitution. There were significant differences ($p<0.05$) in protein content of composite chin-chin, The protein content of the blends ranged from 7.10-9.11 and 100% wheat flour chin-chin has the highest protein content while 100% modified cocoyam starch chin-chin has the lowest protein content. It was observed that there was decrease in protein content as level of modified starch substitution was increase. This may due to the gluten content of the wheat flour which is an indication of protein content, this result is in agreement with the report of Asumugha and Uwalaka (2000) who said that the protein content of cookies produced from cocoyam-wheat flour ranged from 5.95-12.25%. The fat content ranged from 7.81-8.27%, sample (90:10) recorded the lowest fat content of 7.81% while sample (80:20) had the highest fat content. Fasasi (2009) 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 content product will have high energy value and promotes lipid oxidation. The ash content ranged from 1.16-1.74%, increase in ash content was observed as the proportion of modified starch substitution was increase except for sample 60:40 which had overall least value. The ash content indicate a rough estimation of the mineral content of product, sample (100% MCF) had the largest ash content of 1.74% while sample (100% WF) had the lowest ash content. There were significant differences ($p<0.05$) in crude fibre and carbohydrate content of chin-chin samples of composite flour. Moisture content of the chin-chin ranged from 3.98 to 5.05%. Sample (70:30) had the highest moisture content (5.05%) while sample (80:20) had the lowest moisture content of 3.98%.

Table 1: Proximate composition of formulated chin-chin samples from flour blend

Samples WF:MCS	Carbohydrate (%)	Protein (%)	Fat (%)	Moisture (%)	Ash (%)	Crude fibre (%)
60:40	73.43 ± 0.07^{b}	7.10 ± 0.03^{e}	7.85 ± 0.03^{c}	4.55 ± 0.01^{d}	1.63 ± 0.0^{b}	1.97 ± 0.0^{b}
70:30	71.16 ± 0.16^{c}	8.14 ± 0.04^{d}	7.81 ± 0.07^{c}	5.05 ± 0.02^{a}	1.47 ± 0.01^{c}	1.74 ± 0.23^{c}
80:20	70.59 ± 0.06^{d}	9.05 ± 0.02^{c}	8.27 ± 0.0^{a}	3.98 ± 0.01^{f}	4.00 ± 0.24^{e}	1.25 ± 0.0^{d}
90: 10	70.15 ± 0.05^{e}	9.11 ± 0.05^{b}	8.10 ± 0.15^{b}	1.41 ± 0.0^{bc}	1.66 ± 0.18^{d}	1.45 ± 0.11^{e}
100% WF	69.16 ± 0.11^{f}	9.25 ± 0.07^{a}	8.04 ± 0.03^{ab}	4.91 ± 0.04^{b}	1.16 ± 0.0^{e}	0.77 ± 0.1^{f}
100% MCS	75.28 ± 0.06^{a}	6.80 ± 0.02^{f}	8.01 ± 0.08^{ab}	4.82 ± 0.03^{c}	1.74 ± 0.01^{a}	2.15 ± 0.11^{a}

Mean values with different superscript in the same column are significantly different ($p>0.05$)

MCS: 100% modified cocoyam starch

Table 2: Functional and physicochemical properties of the composite flour blends of modified cocoyam and wheat

Samples WF: MCF	Bulk density (g/mL)	Oil absorption capacity (g/g)	Water absorption capacity (g/g)	Swelling capacity (g/g)	pH	Titratable acidity
60:40	0.56 ± 0.01^{e}	2.07 ± 0.05^{d}	1.79 ± 0.01^{a}	1.14 ± 0.01^{c}	6.95 ± 0.07^{c}	1.28 ± 0.18^{e}
70:30	0.62 ± 0.03^{d}	2.10 ± 0.01^{c}	1.75 ± 0.05^{ab}	1.12 ± 0.01^{bc}	7.05 ± 0.07^{ab}	1.50 ± 0.00^{c}
80:20	0.68 ± 0.02^{b}	2.09 ± 0.01^{bc}	1.70 ± 0.07^{c}	1.11 ± 0.01^{ab0}	7.45 ± 0.07^{b}	2.20 ± 0.14^{ab}
90:10	0.70 ± 0.01^{a}	2.12 ± 0.02^{b}	1.69 ± 0.01^{c}	1.07 ± 0.05^{d}	7.50 ± 0.12^{a}	2.28 ± 0.12^{a}
100% WF	0.66 ± 0.01^{c}	2.24 ± 0.01^{a}	1.79 ± 0.01^{a}	1.09 ± 0.01^{a}	7.45 ± 0.07^{b}	2.05 ± 0.07^{b}
100% MCS	0.51 ± 0.01^{f}	2.13 ± 0.01^{b}	1.79 ± 0.01^{a}	1.17 ± 0.02^{b}	6.85 ± 0.07^{c}	1.45 ± 0.07^{d}

Mean values with the different superscript in the same column are significantly different ($p>0.05$)

MCS: 100% modified cocoyam starch

Generally there was reduction in moisture contents as the rate of millet substitution is increase. The values were within the range reported to have no adverse effect on quality attribute of the product (Mepba *et al.*, 2007). Sanni *et al.* (2006) reported that the lower the moisture content of a product to be stored the better the shelf stability of such products. Hence, low moisture ensures higher shelf stability of dried product. The moisture content of a food is indicative of the dry matter in that food however, low residual moisture content in confectionaries is advantageous in that microbial proliferation is reduced and storage life may be prolonged if stored inside appropriate packaging materials under good environment condition.

Functional properties of modified cocoyam-wheat composite flour: Table 2 presents the functional properties of modified cocoyam-wheat composite flour. The functional properties are those parameters that determine the application and end use of food materials for various food products. The bulk density of the flour sample ranged between 0.51-0.70 g/mL. There were significant difference ($p<0.05$) in the bulk density. The bulk densities of the blends is lower compared to 100% wheat flour, the bulk density of the samples decreases with increase in modified cocoyam substitution, however this is a significant difference between the bulk density of 100% wheat flour sample and the 80:20 sample. Bulk density of foods is affected by the particle size and the starch content important in determining the packaging requirement and raw materials handling and application in wet processing in food industry (Adebowale *et al.*, 2008; 2012; Ajanaku *et al.*, 2012). This means that sample 80:20 will exhibit better packaging properties than the other samples. Result showed that significant differences ($p<0.05$) existed among the samples in terms of the water absorption capacity. Samples (60WF:40MCS), (100% WF) and (100% MCS) had the highest values, these values reduces gradually with decrease in substituting modified cocoyam flour. This could be indicative of the fact that addition of modified at higher rate confers high water binding capacity to wheat flour, which in turns improves the reconstitution ability (Ajanaku *et al.*, 2012; Adebowale *et al.*, 2012). High water absorption capacity is attributed to loose structure of starch polymers while low values indicate the compactness of the structure (Adebowale *et al.*, 2005, 2012). Better water absorption capacity and retention suggests better performance in texture of baked products (Okezie and Bello, 1988). Increase in water absorption capacity implies increase in the digestibility of the starch (Ayele and Nip, 1994). Swelling capacity recorded significant differences ($p<0.05$) among the samples, the same trend as water absorption capacity was observed for swelling capacity, the range is between 1.168 and 1.089 g/g with modified cocoyam starch and wheat flour having the highest and the lowest respectively, this is agreement with the findings of Bainbridge *et al.* (1996) who opined that good quality starch with a high starch content will have a low solubility and high swelling volume and swelling power. The higher the water absorption capacity, the higher the swelling capacity and the more readily digestible the product will be, indicating that the 70:30 blend would give a better digestible product when compared with the other blends. 100% wheat flour recorded higher oil absorption capacity, the result is in the order 100% wheat > modified cocoyam starch >70:30 >50:50 >80:20 samples, the 100% cocoyam starch and its blends were significantly different from 100% wheat flour sample.

Table 3: Pasting properties of the composite flour blends of modified cocoyam and wheat

Sample WF:MCS	Peak viscosity (RVU)	Trough (RVU)	Breakdown value (RVU)	Final viscosity (RVU)	Setback (RVU)	Peak time (min)	Pasting temperature (°C)
100% WF	195.01±0.0[a]	190.11±1.2[a]	55.12±0.2	30.55±0.55	22.53±2.4	6.20±0.4[a]	78.44±0.1[a]
100% MCS	66.00±4.4[f]	60.50±3.3[a]	6.50±0.7[a]	39.50±6.36[a]	25.00±2.83[a]	4.33±0.9[a]	79.22±0.2[a]
60:40	70.00±4.4[e]	64.50±3.3[b]	5.50±0.7[a]	199.00±9.90[b]	134.50±6.3[b]	4.96±0.0[b]	78.55±0.3[a]
70:30	88.50±6.3[d]	60.00±5.6[c]	42.50±0.7[b]	528.50±1.02[c]	338.50±6.3[c]	5.33±0.0[c]	94.33±0.5[a]
80:20	95.50±7.7[c]	55.00±5.6[d]	109.50±2.2[c]	901.50±1.61[d]	524.50±4.9[d]	5.53±0.0[d]	90.90±0.4[b]
90:10	108.12±1.2[b]	100.50±2.1[a]	55.66±2.5	201.44±1.42	120.22±2.2	6.00±0.5[a]	84.88±0.2[a]

Mean values with different superscript in the same column are significantly different (p>0.05)

Table 4: Mean scores of sensory evaluation of chin-chin from modified cocoyam-wheat flour

Samples WF:MCF	Taste	Colour	Crispness	Overall acceptability
60:40	5.65±1.8[d]	5.20±2.2[c]	5.55±2.3[c]	5.70±2.3[c]
70:30	5.80±2.3[c]	6.90±2.5[b]	6.50±2.4[b]	7.30±2.5[b]
80:20	6.88±2.3[ab]	7.15±2.6[a]	6.55±2.2[b]	7.35±2.3[ab]
90: 10	6.95±1.2[ab]	7.15±2.1[a]	6.80±2.1[a]	7.35±2.0[ab]
100% WF	7.12±1.2[a]	7.40±1.2[a]	6.88±1.5[a]	7.88±2.1[a]
100% MCF	5.60±1.5[d]	5.21±2.1[c]	5.52±2.1[c]	5.75±1.5[c]

WF: wheat flour, MCF: Modified cocoyam flour. Mean values with different subscripts in the same column are significantly different (p>0.05)

The pH of the modified cocoyam starch is significantly lower than all other flour samples; with the value of 6.85 compared with 7.45 recorded for 100% wheat flour, this may be due the lactic acid component in the modified cocoyam starch, however the pH of 80:20 composite flour is not significantly different from 100% wheat flour. Decrease in pH in the order MCS<60:40<70:30<80:20 was accompanied with a corresponding slight increase in total titratable acidity.

Pasting properties of modified cocoyam-wheat composite flour: Table 3 shows the pasting properties of the different composite modified cocoyam starch-wheat flour. The pasting property is one of the most important properties that influence quality and aesthetic consideration in the food industry since they affect texture and digestibility as well as the end use of starch based food commodities (Onweluzo and Nnamuchi, 2009). The peak viscosity, which is the maximum viscosity developed during or soon after the heating portion. It is also an index of the ability of starch-based food to swell freely before their physical breakdown (Sanni *et al*., 2006; Adebowale *et al*., 2008). There was decrease in the values of this property as proportion of modified cocoyam starch increases property as proportion of modified cocoyam starch increases. There was significant differences ($p<0.05$) in peak viscosity of the composite flour.

High peak viscosity indicates high starch content and this could explain why 100% wheat flour sample had highest peak viscosity while 100% modified cocoyam starch had the lowest peak viscosity. High peak viscosity also reflects frangibility of the swollen granules, which first swell and then break down under the continuous mixing of the Rapid Visco Analyzer. Significant decrease was also observed in the final viscosity as the amount of millet substitution increases. The final viscosity is a measure of stability of the granules, the value ranged from 115-280RVU. 100% modified cocoyam starch flour had the least value while 100% wheat flour had the highest value; it was observed that the value of final viscosity decreases as the rate of substitution of modified cocoyam starch flour increases. 100% wheat flour with highest final viscosity value of 280 RVU will be more stable under certain conditions than other composite sample (Fasasi, 2009). Shimels *et al*. (2006) reported that final viscosity is used to indicate the ability of starch to form various paste or gel after cooling and that less stability of starch paste is commonly accompanied with high value of breakdown. Trough is the minimum viscosity value in the constant temperature phase of the RVA pasting profile and it measures the ability of the paste to withstand breakdown during cooling. This property also decreases with increase in millet substitution. The value ranged between 46-133RVU with sample (50W50M) composite flour having the lowest value and 100% wheat flour having the highest value. There was significant increase ($p<0.05$) in breakdown value as rate of substitution of wheat flour in modified cocoyam starch increases, Adebowale *et al*. (2005) reported that the higher the breakdown in viscosity, the lower the ability of the sample to withstand heating and shear stress during cooking. The pasting temperature which indicates the gelatinization temperature ranged between 90.90-94.33°C. This may be due to the buffering effect of fat (from pigeon pea) on starch which interferes with the gelatinization process (Egouletey and Aworh, 1991). The pasting temperature is one of the pasting properties which provide an indication of the minimum temperature required for sample cooking, energy cost involved and other components stability. The rate of starch breakdown depends on the nature of the material, temperature and degree of mixing and shear applied to the mixture. Peak viscosity is often correlated with the final product quality. It provides an indication of the viscous load likely to be encountered during mixing. The peak time of the fortified flour is lower which may be due to the fact that composite four is partially gelatinized. The peak time is a measure of the cooking time (Adebowale *et al*., 2005). Peak viscosity is often correlated with the final product quality. It also provides an indication of the viscous load likely to be encountered during mixing (Maziya-Dixon *et al.*, 2004). It is customary to measure the peak time that occurs with peak viscosity. The peak time is a measure of the cooking time. The rate of starch breakdown depends on the nature of the material, the temperature and the degree of mixing and shear applied to the mixture (Newport Scientific, 1998). The ability of a mixture to withstand heating and shear stress that is usually encountered during processing is an important factor for many processes especially those requiring stable paste and low retrogradation/syneresis.

Sensory evaluation of modified cocoyam-wheat composite chin-chin: Table 4 shows the result of the sensory evaluation of modified cocoyam-wheat chin-chin samples. There were significant differences ($p<0.05$) in all the attributes measured. The values of taste and colour attributes ranged from 5.60-7.12 and 5.20-7.40, respectively. Generally decreases in the values of these attributes were observed as modified cocoyam starch substitution increases, in both cases sample (100% WF) had the highest value of 7.12 and 7.40, respectively while sample (100% MCS) had the lowest values of 5.60 and 5.20, respectively. The high value observed from 100% wheat chin-chin may be as a result of changes in taste and colour of chin-chin as a result of addition of modified cocoyam starch which had impact on both taste and colour as a result of colour of cocoyam flour compared with whitish colour of all-purpose wheat flour. It was also observed that likeness in terms of colour and taste decreases as modified cocoyam substitution increases and thus accounted for low value of likeness obtained from 100% cocoyam starch chin-chin. There was significant differences ($p<0.05$) in crispness of chin-chin samples. 100% wheat chin-chin had the highest value of crispness of 6.88 while 100% modified cocoyam starch chin-chin had the lowest value of 5.52. Significant differences ($p<0.05$) were observed among samples of chin-chin in terms of overall acceptability. 100% wheat chin-chin had the highest value of likeness with 7.88; while 100% modified cocoyam starch had the lowest value of 5.70. It was observed that likeness of chin-chin sample decreases with increase in modified cocoyam starch substitution. Similarly, there were no significant difference in overall acceptability among samples (100% WF), (80WF:20MCS) and (70WF:30MCS). This shows that the panelist still preferred modified cocoyam substitution of up to 30% in term of overall acceptability.

Conclusion: From the result obtained, it was concluded that cocoyam modified flour substitution in wheat flour of up to 30% will still meet the quality requirement of 100% wheat flour in chin-chin production in terms of nutrient requirement, functionality and sensory attributes. The use of modified starch in chin-chin making would greatly enhance the utilization of this crop in many cocoyam tuber cultivating developing countries where the crops have not been optimally utilized. The use of modified cocoyam starch blended in the ratio up to 30% with wheat flour should be encouraged as its starch is highly digestible. It will be a good substitute for children, diabetics and also the aged. Furthermore substituting cocoyam modified starch in wheat flour will greatly reduce cost in terms of production by 30% as modified cocoyam starch is far cheaper and available than wheat.

REFERENCES

Abu, J.D., 2002. Influence of modification on the paste viscosity and sorption characteristics of starch from maize. Proceedings of 25th Annual NIFSTS Conference, pp: 179-180.

Adebowale, A.A., M.T. Adegoke, S.A. Sanni, M.O. Adegunwa and G.O. Fetuga, 2012. Functional properties and biscuit making potentials of sorghum-wheat flour composite. Am. J. Food Technol., 7: 372-379.

Adebowale, A.A., L.O. Sanni and M.O. Onitilo, 2008. Chemical composition and pasting properties of tapioca grit from different cassava varieties and roasting method. Afr. J. Food Sci., 2: 77-82.

Adebowale, A.A., L.O. Sanni and S.O. Awonorin, 2005. Effect of texture modifies on the physiochemical and sensory properties of dried fufu. J. Food Sci. and Technol. Int., 11: 373-385.

Ajanaku, K.O., C.O. Ajanaku, A. Edobor-osoh and O.C. Nwinyi, 2012. Nutritive value of sorghum Ogi fortified with groundnut journal seed (*Arachis hypogeal*). Am. J. Food Technol., 79: 82-88.

Akubor, P.I., 2004. Protein contents, physical and sensory properties of Nigerian snack foods (cake, chin-chin, puff-puff) prepared from cowpea-wheat flour blends. Int. J. Food Sci. and Technol., 39: 419-424.

AOAC, 2004. Official Methods of Analysis of the Association of Official Analytical Chemists International, Association of Official Analytical Chemists, Arlington, Va, USA, 17th edition.

Asumugha, V.U. and B.C. Uwalaka, 2000. Chemical and organoleptic evaluation of snacks developed from cocoyam (*Colocasia esculenta*, *Xanthosoma mafafa*) and wheat (*Triticum* spp) composite flours. Nig. Agric. J., 31: 78-88.

Ayele, T. and W.K. Nip, 1994. Functional properties of raw and precooked taro (Colocasia esculenta) flours. Int. J. Food Sci. Techno., 29: 457-462.

Bainbridge, Z., K. Tomlins, K. Wellings and A. Wesby, 1996. Methods of Assessing Quality Characteristics of Non-Grain Starch Staples (Part 3-Laboratory Methods). 1st Edn., Natural Resources Institute, Chatham, UK., ISBN: 0-85954-400-1, pp: 1-70.

European Union International Starch Institute, 2001. Food additives (modified starches) in the European union, Science Park, Aarhus, Denmark.

Egouletey, M. and O.C. Aworh, 1991. Production and Physiocochemical properties of tempe-fortified maize based weaning food. In proceedings of seminar on Development of the protein energy foods from grain legumes (Sefe Dedeh S. Ed). University of Lagos, pp: 5-7.

Fasasi, O.S., 2009. Proximate, Anti nutritional factors and functional properties of processed pear millet. J. Food Tec., 7: 92-97.

Ihekoronye, A.I., 2005. Integrated Food Science And Technology. 5th edition. Macmillan publishers. pp: 108.

IITA, 2001. Operation manual for the series 3 Rapid Visco Analysis using thermocline for windows. Newport Scientific pty. Ltd. 1995.

Larmond, E., 1991. Laboratory Methods for Sensory Evaluation of Foods. Canadian Agricultural Publications. Series iv, Ottawa. Canada.

Lyonga, S.N. and S. Nzietchueng, 2008. Cocoyam and African food crisis. In Proc. of the 3rd Triennial Symposium, Int. Soc. Trop. Root Crops. African Branch, Owerri-Imo State, Nigeria.

Maziya-Dixon, B., A.G.O. Dixon and A.A. Adebowale, 2004. Targeting different end uses of cassava: genotypic variations for cyanogenic potentials and pasting properties. A paper presented at ISTRC-AB Symposium, 31 October-5 November 2004, Whitesands Hotel, Mombassa, Kenya.

Mepba, H.D., S.N. Achinewhu and C.K. Wachukwu, 2007. Microbiological quality of selected street foods in Port Harcourt, Nigeria. J. Food Safety, 27: 208.

Newport Scientific, 1998. Applications manual for the Rapid viscoTM analyzer using thermocline for windows. Newport Scientific Pty Ltd., 1/2 Apollo Street, Warriewood NSW 2102, Australia. pp: 2-26.

Okezie, B.O. and A.B. Bello, 1988. Physicochemical and functional properties of winged bean flour and isolate compared with soy isolate. J. Food Sci., 53: 450-454.

Onweluzo, J.C. and O.M. Nnamuchi, 2009. Production and evaluation of porridge-type breakfast product from Treculia africana and sorghum bicolor flours. Pak. J. Nutr., 8: 731-736.

Purseglove, J.W., 2005. Tropical crops: Monocotyledons. Longman, London, UK. pp: 61.

Sanni, L.O., A.A. Adebowale and S.O. Tafa, 2006. Proximate, Functional, Pasting and Sensory Qualities of Instant Yam Flour. A Paper Presented at the 14 ISTRC Symposium, Central Tuber Crops the Research Institute, Trivandrum, Kerala State, India.

Shimels, A.E., M. Meaza and S. Rakshit, 2006. Physicochemical properties, Pasting Behaviour and Functional characteristics of flour and starches from improved Bean (*Phaseoluus vulgaris* L.). Varieties Grown in East Africa, CIGRE J., 8: 1-18.

Ukpabi, U.J. and C. Ndimele, 1990. Evaluation of gari production in Imo State Nigeria. Nig. Food J., 8: 105-110.

Varavinit, S., N. Atichokudomchai and P. Chinachoti, 2002. A study of annealing and freeze-thaw stability of acid-modified tapioca starches by differential scanning calorimetry (DSC). Starch/Starke, 54: 343-349.

Wang, J.C. and J.E. Kinsella, 1976. Functional properties of novel proteins: alfalfa leaf protein. J. Food Sci., 41: 286-289.