Websites:
http://www.sciencepub.net/nature
http://www.sciencepub.net

Emails:
naturesciencej@gmail.com
editor@sciencepub.net

Nature and Science

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

Production And Quality Evaluation Of "Tuwo" (A Cooked Paste Of Non Fermented Whole Maize Flour) Made From Maize And Different Cassava Adjuncts

Sunmonu Basirat A. O[1]., Akinsola Akinjide O*[2]., Ayanlola Bashirat T[1]., Obisesan Dorcas O[2]. And Taiwo-Oshin Mojisola A[2].
[1]Department of Food Technology, Federal Polytechnic, Offa, Kwara State.
[2]Department of Home Economics, Federal College of Education (Special), Oyo, Oyo State.
*Correspondence: akinsola4gold@gmail.com

Abstract: The production and quality evaluation of "tuwo" made from maize flour and different cassava adjuncts from cassava products of High Quality Cassava Flour, Cassava Starch and Lafun Flour. Maize flour was blended with different cassava adjunct flour at different ratios (100: 00, 90:10, 85:15) for each cassava adjunct flours and coded as sample MF, 10HQCF, 10CS, 10LF, 15HQCF, 15CS and 15LF. The blends were analyzed for functional properties, pasting properties, total starch, amylose, carbohydrate and colour intensity while tuwo-meals produced each blended flour were analyzed for sensory property. Data obtained were subjected to analysis of variance while significant mean were separated using Duncan multiple range test. Results for pH, bulk density, water holding capacity, swelling capacity, solubility index and wettability of the composite flour samples ranged from 5.8-5.9, 0.7-0.8g/g, 111.4-123.0g/ml, 0.0-17.2g/ml, 5.5-8.5g/ml, respectively at $p<0.05$. Pasting properties of the samples ranged from 1092.3-1763.5RVU, 115.5-1158.5RVU, 253.5-779.5RVU, 189.5-1811.5, 345.0-987.5RVU, 4.1-5.1mins and 50.1-85.7^{o}C for peak, trough, breakdown, final viscosity, setback, pasting time and pasting temperature, respectively. Result for total starch, amylose and carbohydrate content of the samples ranged from 82.9-87.0, 17.3-22.7 and 84.0-90.0%, respectively. The yellow colour of maize and cassava tuwo obtained showed that there was no significant difference ($p<0.05$) among the samples in term of colour. Sensory attributes for the tuwo-meal showed that sample 10CS was rated high in terms of colour, texture, flavour, taste and overall acceptability while sample 10HQCF was rated highest for appearance. The result obtained in this study showed that tuwo-meal produced from maize and cassava adjunct had significant advantage over 100 % maize tuwo in term of functional and sensory properties and can be used for both industrial and domestic purpose.
[Sunmonu Basirat A. O, Akinsola Akinjide O, Ayanlola Bashirat T, Obisesan Dorcas O. And Taiwo-Oshin Mojisola A. **PRODUCTION AND QUALITY EVALUATION OF "TUWO" (A Cooked Paste Of Non Fermented Whole Maize Flour) MADE FROM MAIZE AND DIFFERENT CASSAVA ADJUNCTS**. *Nat Sci* 2021;19(11):21-29]. ISSN 1545-0740 (print); ISSN 2375-7167 (online). http://www.sciencepub.net/nature. 3.doi:10.7537/marsnsj191121.03.

Keywords: Cassava adjunct, maize flour, high quality cassava flour, cassava starch, lafun flour.

1. Introduction

Maize tuwo (tyuu-woh) is one of the numerous traditional food products obtainable from maize; it is popular among the Hausa-speaking communities of West Africa in general and Nigeria in particular. The preparation and consumption of maize tuwo however, has spread to other non-Hausa-speaking communities as a result of inter-ethno tribal movement of people in the sub region (Bolade *et al.,* 2002). Maize (*Zea mays*) is a popular crop worldwide due to its functionality as a food source for both human and animals (Nuss *et al.*, 2010). It is a dietary staple food in many parts of the world, with the total production of maize surpassing that of wheat or rice for a teeming, world population of 400 million who are majorly Africa and Central America (Shindano, 2007). Generally, the processing of cereals (e.g., maize grains) into traditional food products particularly in Nigeria, has not progressed much beyond traditional techniques most probably due to misplaced government policy initiatives with respect to the importance of technology in industrialization coupled with the existence of a very few technological innovations (Bolade & Adeyemi, 2012).

One fundamental problem associated with maize "tuwo" has been observed to be that of textural and sensory quality inadequacies which are reflected in the product's inability to form highly elastic, long bodied gel, its retrograde easily when cooked and its ability to be easily brittle when moulded with the hand on consuming, particularly after cooking and over-night storage (Bolade *et al.*, 2002). Therefore, in order to establish a basis for technological improvement effort on the textural and sensory quality inadequacies of maize tuwo, composite flour involvement in maize-tuwo production is capable of enhancing both textural and sensory quality attribute of the food products (Bolade *et al*., 2002). Hence the use of cassava adjuncts will be examine in this research work in order to discern the quality attributes of "tuwo" meal.

2. Materials and methods

2.1 Materials

The maize used for this project was purchased from Owode Market in Offa while the fresh and mature cassava tubers was sourced from local farmer in Offa local government, Kwara State.

2.2 Sample preparation

2.2.1 Preparation of maize flour

This was achieved according to the method of Bolade and Adeyemi (2012). This was done by initially cleaning the maize grains manually by the removal of stones, damaged kernels and other extraneous materials. The cleaned grains were then tempered by sprinkling 5% water (v/w) on the grains coupled with thorough mixing. This was followed by decortications of the grains on a locally made decorticating machine which removed the brans and the germ to obtain the grits. The grits were dried in an air oven (Model: DC 500; Serial number 12B154) at 55±5^{o}C for 48 hours, milled using a disc attrition mill (model: Fritsch, D-55743, Idar-oberstein-Germany), sieved using 250 µm screen, packed in a low density polyethene bag, and store at room temperature (28±2^{o}C).

2.2.2 Preparation of high quality cassava flour

The tubers were processed into high quality cassava flour using the method described by IITA (2006). The fresh cassava tuber was weighed with weighing balance and peeled manually using stainless knife. The peeled cassava samples were washed with portable water and weighed to determine percentage yield after peeling. The cleaned tubers were later transferred to a grating machine which grated the cassava tubers to mash. The mash was dewatered using a hydraulic press to about 40% moisture. The cake was pulverized and subjected to drying in an air oven (Model: DC 500; Serial number 12B154) at 55±5^{o}C for 48 hours, milled using a disc attrition mill (model: Fritsch, D-55743, Idar-oberstein-Germany), sieved using 250 µm screen, packed in a low density polyethene bag. The fine HQCF obtained was store at room temperature (28±2^{o}C).

2.2.3 Preparation of cassava starch

This was prepared according to the modified method of Shittu *et al.* (2016). The cassava tubers were washed and peeled after which they were cut and rasp. Additional water was added in order to extract the starch and sifting was done. Sedimentation occurred and decanting of water was done to achieve cassava starch. Drying, milling and storing of the cassava starch were done according to the procedure used in obtaining maize flour.

2.2.4 Preparation of *lafun*

The method of Padonou *et al.,* (2009) was utilized in the preparation of lafun. Briefly, the cassava tubers were peeled and cut after which they were submerged in water and allowed to undergo fermentation. Dewatering was done afterwards followed by sun dried. Milling and storing of the "*Lafun*" flour obtained was done according to the procedure used for maize flour.

2.3 Formulation of maize-cassava adjunct composite flours

The formulation of composite flour of maize-cassava adjunct flours were mixed in proportion of 100 %; 90:10 %; 85:15 % for each cassava adjunct flourand coded as sample MF, 10HQCF, 10CS, 10LF, 15HQCF, 15CS and 15LF. Each sample was blended using a Kenwood mixer (Model: HC 750D, Kenwood, UK) to produce six composite flour and maize flour, MF. Sample MF served as control while sample 10HQCF, 10CS, 10LF, 15HQCF, 15CS and 15LF consist of maize and cassava adjunct flour.

2.4 Production of *Tuwo*

Tuwo was prepared from each blend flour sample using a method as described by Bolade *et al*., (2002) with slight modification. The overall ratio of flour to water was 1:3 (w/v). Cold slurry of the flour was first prepared by mixing 40 % of the desired quantity of flour (500 g) with 60 % of the desired quantity of water (3L). This was followed by bringing it into boiling and the cold slurry initially prepared was added to this boiling water coupled with vigorous stirring, using a wooden flat spoon to form a pap-like consistency. The remaining quantity of the flour (60 % of the desired total) was then added gradually to the boiling pap-like paste with continuous stirring so as to facilitate non-formation of lumps and to ensure a homogenous gel formation. The remaining quantity of water (40 % of the desired total) was finally added to the formed gel and stirred vigorously to ensure smoothness of the gel desired. The final product so obtained is called "tuwo"

2.5 Determination of Functional Properties of flour Samples

The functional properties of the maize composite sample flours determined included pH, loose and packed bulk density, water holding capacity, swelling capacity and solubility index by Sefa-dedeh *et al*. (2004) while wettability index of the composite flours were determined following the methods described by Bolade and Adeyemi (2012).

2.5.1 Determination of pasting properties of the flour samples

A Rapid Visco Analyser, RVA (Model RVA-SUPER3, USA) was used to determine the viscosity of the composite flours according to Bolade *et al.,* (2009) method. About 3 g of sample were weighed into a dried empty canister, and then 25 mL of distilled water was dispensed into the canister containing the sample. The suspension was thoroughly mixed so that no lumps were obtained and the canister was fitted into the rapid visco-analyzer. A paddle was then placed into the canister. The measurement cycle was initiated by depressing the motor tower of the instrument. Samples were pasted according to a programmed heating and cooling cycle. The dispersions were heated from 50 to 95^{o}C with constant stirring at 2.67 Hz, and were held at 95^{o}C for 2.5 min (breakdown). Then, the block temperature was cooled to 50^{o}C and held for 2 min. The total cycle was 13 min. Parameters estimated were peak viscosity, setback viscosity, final viscosity, trough, breakdown viscosity, pasting temperature and time to reach peak viscosity.

2.6 Methods of analysis

Determination of total starch and total carbohydrate was determined according to the method of Adriana *et al*., (2016) while amylose content of the flour samples were determined according to the method of McCready *et al.* (1950).

2.7 Determination of color characteristics of samples

The colour of tuwo from each samples were measured using a colour measuring instrument (ColorTecPCM, model SN 3000421, USA) and the values expressed on the L*, a*, b* tristimulus scale. A colour determination procedure as described by Bolade *et al*. (2009) was used for each sample. The value was reported as the mean of triplicate determinations.

2.8 Sensory evaluation of samples

Tuwo samples obtained from various flour sample blends were subjected to sensory evaluation using a preference test as described by Akinsola *et al.* (2018). A 15-member, semi-trained taste panel consisting of students of Food Technology Department of Federal Polytechnic Offa Kwara State were requested to carry out the rating of tuwo samples. The panelists were all familiar with the food product while they were also instructed on the use of sensory evaluation procedures. Each of the panelists was asked to rate the samples on the basis of colour, taste, aroma, texture (mould-ability) and overall acceptability using a nine-point hedonic scale (i.e. 9=like extremely; 5=neither like nor dislike; 1=dislike extremely). Each panelist sat in an enclosed cubicle designed for sensory evaluation and water was provided to rinse mouths before and after tasting each of the samples.

2.9 Statistical analysis

Data were statistically analyzed using SPSS version 17.0 while mean and standard error of means (SEM) of the duplicate analyses were calculated. The significant differences between the mean were determined with Duncan's multiple range tests at 95% confidence interval. All results obtained were expressed as mean of triplicate values ± standard deviations.

3.0 Results and Discussion

3.1 Functional property of the *tuwo* composite flour samples

The functional property of the *tuwo* composite flour samples was as shown in table 1. pH result showed that sample MF had (5.89%) , sample had 10HQCF had (5.91%), sample 10CF had (5.88%), sample 10LF had (5.80%), sample 15HQCF had (5.94%), sample 15CS had (5.91%) and sample 15LF had (5.91%). The result showed that there was no significant difference between the samples. The result in this research work was in agreement with the result obtained by Aryee *et al*. (2006) of pH (5.3 to 6.5) reported for cassava flour, and for other flour products from other root crops (Falade & Okafor, 2013). According to Njintang & Mbofung (2003), acidic products are more shelf stables that non acidic counterpart. Therefore, based on the results obtained from pH analyses, it can be concluded that all the samples will be more shelf stable. Knowledge of the pH value of flour is essential, as it provides a guide in determining the ratio of cassava flour that could be substituted when mixing composite flour for baking (Aryee *et al*., 2006).

Loose bulk density result showed that sample MF had (0.51%), sample had 10HQCF had (0.45%), sample 10CF had (0.44%), sample 10LF had (0.45%), sample 15HQCF had (0.46%), sample 15CS had (0.44%) and sample 15LF had (0.46%). The result showed that sample MF (100% Maize flour) had the highest value (0.51%) while sample 10CS and 15CS having the same value both had the least value (0.44%). The result showed that sample 10CS and sample 15CS were significantly the same ($p<0.05$). The reason could be as a result of producing both flour from the same flour (cassava starch). Loose bulk density promotes easy digestibility of food products. The small amount of loose bulk density of food samples would be advantage in the preparation of "Tuwo". Therefore, sample 10CS (0.44%) would be advantage in the preparation of "tuwo". Packed bulk density result showed that sample 10LF had the highest score (0.76%), while sample 15CS had the least value (0.71%). The result showed significant different among the samples. The variation in their subscript could be as a result of different processing method. Packed bulk density could aid easy packing and transportation of food products. The bulk density is influenced by particle size and density of the flour. It is an important requirement for determining the packaging and material handling and low bulk density is influenced by the loose structure of the starch polymer (Malomo *et al.,* 2012).

The water holding capacity of the flour samples ranged from (111-123%) with significant differences at ($p < 0.05$). The result obtained in this research work is higher than the result obtained (1.87%) by Bolade and Adeyemi (2012) as early reported/shown. The water holding capacities of 90% + 10% maize/cassava flour mixes was observed to be low in water holding capacity. This observation implies that the incorporation of 10% cassava flour into maize flour has a tendency to lowering the overall water holding capacity. Water holding capacity is essentially a measure of the ability of the flour to associate with water, particularly in a food product where hydration is required in its preparation, so as to enhance its handling characteristics such as in dough and pastes. It has however been observed that the water holding capacity of flour can be influenced by certain factors such as the particle size of the flour (Kerr et al., 2000), temperature of water and the quantity of hydrophilic constituents in the flour such as starch, protein and fibre (Sefa-Dedeh et al., 2004). Water holding behaviour may be a function of several parameters including size, shapes, conformational characteristics, hydrophilic-hydrophobic balance in the starch molecule, lipids and carbohydrates associated with the proteins thermodynamic properties of the system physicochemical environment, solubility of starch molecules and others (Falade & Okafor, 2013).

Swelling properties of this study showed that sample MF had 810.92%, sample 10HQCF (399.93%), sample 10CS (551.85%), sample 10LF (539.40%), sample 15HQCF (719.95%) and sample 15CS (668.37%) and 15LF (730.38%). The result showed that there was significant difference between the samples ($p<0.05$). The result may be due to the variety of the samples and processing method adopted. Swelling capacity is regarded as a quality criterion in some food formulations. It is an evidence of non-covalent bonding between molecules within starch granules and also a factor of the ratio of α-amylose and amylopectin ratios. Swelling power is a measure of hydration capacity because the determination is a weight measure of swollen starch granules and their included water (Yellavila *et al*., 2015). It is an indication of the extent of associative forces within the granule and it is also related to the water absorption index of starch-based flour during heating. The result showed that sample MF (100% maize flour) suitable in composite flour in baking industries than other flour produced from composite flour of the cassava.

The result showed that the samples were significantly difference ($p<0.05$) in term of solubility index. Solubility index is a measure of the ease with which the flour particles are able to dissolve in cooking water. It permits rapid and extensive dispersion of flour particles in solution. However, solubility is influenced by the starch granular size and gelatinization, which is a reflection of the breaking phase of the intermolecular hydrogen bond (Shimelis et al., 2006). The samples recorded wettability range of (5.0-9.5 %), with flour from 100 % High quality cassava flour recording the highest wettability value, while flour from 10% HQCF had the least wettability values. However, the value recorded for 100% maize flour was higher than the value obtained (1.87%) by Bolade and Adeyemi (2012) in their study. Wettability is a function of ease of dispersing flour samples in water and the sample with the lowest wettability dissolves fastest in water. This result reveals that 10 HQCF and 10LF wets faster compared to flours.

Table 1: Functional properties of the "Tuwo" blend flour samples

Sample (g/ml)	MF	10HQCF	10CS	10LF	15HQCF	15CS	15LF
Ph	$5.89{\pm}0.0^{b}$	$5.91{\pm}0.0^{ab}$	$5.88{\pm}0.0^{b}$	$5.80{\pm}0.0^{b}$	$5.94{\pm}0.0^{a}$	$5.91{\pm}0.0^{ab}$	$5.91{\pm}0.0^{ab}$
LBD	$0.51{\pm}0.0^{a}$	$0.45{\pm}0.0^{bc}$	$0.44{\pm}0.0^{c}$	$0.45{\pm}0.0^{bc}$	$0.46{\pm}0.0^{b}$	$0.44{\pm}0.0^{c}$	$0.46{\pm}0.0^{b}$
PBD	$0.73{\pm}0.0^{b}$	$0.74{\pm}0.0^{ab}$	$0.73{\pm}0.0^{b}$	$0.76{\pm}0.0^{a}$	$0.75{\pm}0.0^{a}$	$0.71{\pm}0.0^{c}$	$0.74{\pm}0.0^{ab}$
WHC	$122.03{\pm}0.4^{a}$	$119.26{\pm}0.2^{b}$	$115.31{\pm}0.0^{c}$	$111.38{\pm}0.1^{d}$	$123.63{\pm}0.3^{a}$	$123.02{\pm}0.2^{a}$	$121.00{\pm}0.4^{a}$
S.C	$810.92{\pm}0.2^{a}$	$399.93{\pm}1.0^{f}$	$551.85{\pm}1.6^{e}$	$539.40{\pm}0.3^{e}$	$719.95{\pm}0.2^{c}$	$668.38{\pm}0.2^{d}$	$730.38{\pm}211.5^{b}$
S	$3.93{\pm}0.1^{d}$	$0.00{\pm}0.0^{e}$	$16.50{\pm}0.4^{b}$	$6.04{\pm}0.1^{c}$	$25.38{\pm}0.1^{a}$	$5.54{\pm}0.1^{cd}$	$17.23{\pm}0.1^{b}$
W	$8.50{\pm}2.1^{a}$	$5.50{\pm}0.0^{e}$	$8.00{\pm}2.8^{b}$	$6.00{\pm}1.4^{de}$	$7.00{\pm}1.4^{c}$	$8.50{\pm}2.1^{a}$	$6.50{\pm}2.1^{d}$

Results are mean values of duplicate determination ± standard deviation. Mean value within the same row having the same letter are not significantly different at p<0.05. LBD = Loose bulk density, PBD = Pack bulk density, WH = Water holding capacity, SC = Swelling capacity, S – Solubility index. W = Wettability, TS = Total starch, A = Amylose, T.CHO = Total carbohydrate.

3.2 Pasting property of the *tuwo* composite flour samples

The pasting properties of the blend flour samples are as shown in Table 2. When heat is applied to starch-based foods in the presence of water, a series of changes occur known as gelatinization and pasting. 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 (Ajanaku *et al.,* 2012; Onweluzo and Nnamuchi, 2009). It is an index for predicting the ability of a food to form a paste when subjected to heat applications.

Peak viscosity is the maximum viscosity developed during or soon after the heating portion. It is an index of the ability of starch-based foods to swell freely before their physical breakdown (Adebowale *et al.,* 2008; Sanni, *et al.,* 2006). The peak viscosity ranged from 1092.30 – 2582.51 RVU. The values obtained were very high than the value (112.4-260.0 RVU) obtained by Bolade and Adeyemi, (2012). High peak viscosity is an index of high starch content and reflects fragility of the swollen granules which first swell, then breaks down under the continuous mixing of the rapid visco analyzer. The high peak viscosity values noted in this study is of processing advantage and has been reported to be significant in the preparation of stiff dough products like tuwo, a stiff dough product made from cereal flour and eaten with stew and vegetable (Danbaba *et al.,* 2012).

The result obtained for trough ranged from 821.56 – 1158.5.00. Sample 10LF and 15CS had the highest and least value of 1767.00 and 821.56 respectively. There was a significant difference ($p < 0.05$) in the trough viscosity of the flour varieties. Trough viscosity is the minimum viscosity value in the constant temperature phase of the rapid visco analyzer pasting profile. In simple terms, trough viscosity is the point at which the viscosity reaches its minimum during either heating or cooling processes. It measures the ability of the paste to withstand breakdown during cooling. The significantly high trough viscosity observed in this study indicates the tendency of the maize flour to breakdown during cooking in have been proved by many field workers. The breakdown viscosity of maize and cassava flour ranged from (253.56 – 779.50 RVU). Sample 15LF and sample 10CS had the highest and least value of 813.50 and 253.56 RVU, respectively. The values obtained in this study were very high to the range score (71.4-134.8 RVU) of maize and cassava tuwo flour reported by Bolade and Adeyemi (2012). The breakdown viscosity is an index of the stability of the starch and a measure of ease with which the swollen granules can be disintegrated (Kaur *et al.*, 2007).

The breakdown viscosity values of the flour samples were significantly different ($p < 0.05$). Adebowale *et al.* (2005) reported that the higher the breakdown viscosity, the lower the ability of the flour to withstand heating and shear stress during cooking. For cassava, a higher breakdown viscosity is considered to be an indicator of better palatability. Final viscosity ranged from 1189.50 – 1811.50 RVU. The result showed that sample 10LF had the highest value while sample 10CS had the lowest value. The value obtained in this research work was higher than the result obtained (132.7-176.8 RVU) by Bolade and Adeyemi (2012) who early worked on cassava composite flour with maize for the production of tuwo flour. Final viscosity is commonly used to define the quality of particular starch-based flour since it indicates the ability of the flour form a viscous paste after cooking and cooling. It also gives a measure of the resistance of the paste to shear force during stirring. The variations in the final viscosity might be due to the simple kinetic effect of cooling on viscosity and the re-association of starch molecules in the flour samples during cooling. The high score obtained in 10% LF may be attributed to the hydrogen bonding during cooling and the high amylose content of the cassava starch flour.

There was no significant different in the setback viscosity of samples with the same superscript (sample MF and sample 10CS). The higher the setback viscosity, the lower the retrogradation of the flour paste during cooling and the lower the staling rate of the products made from the flour. Setback viscosity has been correlated with the texture of various end products. High setback viscosity is also an indication of the amount of swelling power of the maize and cassava samples and usually related to the amylose content of the sample (Jennifer & Les, 2004). Setback viscosity indicates the tendency of starch granules to retrograde on cooling. Peak time is the time at which the peak viscosity occurs in minutes and a measure of the cooking time of the flour (Adebowale *et al.*, 2008). Peak time for this research work ranged between 4.10-5.10 min. Peak time values reported in this work are within the range of peak time values of 5.13-5.80 min and 5.01-6.30 min reported for instant yam- breadfruit composite flour and germinated tigernut flour, respectively (Adebowale *et al.,* 2008; Chinma *et al.,* 2007).

The pasting temperature value of the maize and cassava was ranged between 50.13-87.29 °C. The high pasting temperature score was observed in sample 10LF which could be attributed to the buffering effect of fat on starch which interferes with the gelatinization process. A higher pasting temperature indicates high water-binding capacity, higher gelatinization tendency and lower swelling property of starch-based flour due to high degree of associative forces between starch granules (Adebowale *et al*., 2008). Pasting temperature is one of the properties which provide an indication of the minimum temperature required for sample cooking, energy costs involved and other components stability. It is therefore clear from Table 2 that sample 15LF (85% of maize flour and 15% lafun flour) will cook faster and less energy will be consumed, thus saving time and cost when compared to other flour blends because of its lower pasting temperature.

Table 2: Pasting properties of the "tuwo" flour samples

Parameter (RVU)	MF	10HQCF	10CS	10LF	15HQCF	15CS	15LF
Peak	1096.0±3.6[e]	1685.7±6.1[a]	1092.3±9.8[e]	1478.6±3.4[c]	1360.7±10.5[d]	167.56±2.2[d]	1763.5±71.3[b]
Trough	841.5±6.3[d]	1158.5±3.5[a]	843.5±3.5[d]	821.5±3.5[e]	1090.5±6.3[b]	115.50±3.5[f]	1034.5±3.6[c]
BK	255.5±3.5[e]	522.5±3.5[a]	253.5±0.6[e]	654.5±3.5[b]	370.5±7.8[d]	517.5±3.5[c]	779.5±3.5[a]
FV	1189.5±3.5f	1686.5±3.3[a]	189.5±3.5[g]	1811.5±3.5[b]	1431.5±3.5[e]	1687.0±2.8[c]	1766.5±5.5[d]
SB	345.0±1.4[e]	528.0±0.0[c]	345.0±1.4[e]	987.5±3.6[a]	439.5±3.5[d]	528.0±0.0[c]	735.6±2.0[b]
PT, min	4.1±0.2[bc]	4.2±0.0[b]	4.5±0.3[b]	5.0±1.0[a]	5.1±1.0[a]	4.1±0.2[a]	5.1±0.1[a]
P.Temp,°C	80.7±0.0[b]	80.2±0.0[b]	80.7±0.0[b]	85.7±2.2[a]	80.7±0.0[b]	80.1±0.2[b]	50.1±0.2[c]

Results are mean values of duplicate determination ± standard deviation. Mean value within the same column having the same letter are not significantly different at p<0.05. BK = Breakdown, FV = Final viscosity, SB = Setback, PT = Peak time, P.Temp = Peak temperature

3.3 Total starch, amylose and carbohydrate content of the *tuwo* flour samples

The total starch contents of the flours as shown in table 3 ranged between 82.56%-88.62%. 10HQCF and 10CS had the highest and least starch content, respectively. The result showed significantly different between the samples (p<0.05). This may be due to difference in unit operations adopted in production of the adjuncts. The low starch content in 10HQCF products could be attributed to the breed of the cassava tubers used which contributed to its low starch. This observation agrees with that of Abass *et al*. (2018) who obtained in their research work for lafun, starch and HQCF in assessment of the chemical and trace metal composition of dried cassava products from Nigeria.

The amylose content of the flour ranged between 17.34% - 22.65%. The result obtained in this research work showed that sample 10CS and 10% HQCF had the highest and least value of 22.65% and 17.34, respectively. The result obtained in this research work was higher than the result obtained (17.3%) by Bolade and Adeyemi (2012) in functionality enhancement of composite flour in the production of maize-tuwo (a non-fermented maize-based food dumpling). Amylose content is simply the linear molecular structure of starch. It is an important factor with regard to the end use properties of various products such as noodles and dough. It has a strong bond and therefore takes a lot of energy to breakdown during digestion due to its tightly packed structure. It is reputed to be an effective pre-biotic. Amylose positively influences the functioning of the digestive tract microbial flora, the blood cholesterol level and the glycemic index, and assists in the control of diabetes (Hu *et al*., 2012).

The total carbohydrate of the flour ranged between 84.01 and 90.95. The result showed that there was no significant difference between the samples (p<0.05). It is well known that cassava flour is normally rich in carbohydrate with starch as main constituent Koko *et al*. (2010). Oyewole and Afolami (2001) determined the starch content of cassava flour to be 77-78.7%. Therefore the result obtained in this research work is higher than the report of Oyewole and Afolami (2001). This may be due to varietal difference in the cassava tubers used.

Table 3: Total starch, total carbohydrate and amylose content of the "tuwo" flour blend samples

Sample (%)	MF	10HQCF	10CS	10LF	15HQCF	15CS	15LF
TS	85.41±0.04[bc]	82.86±0.57[d]	88.62±0.18[a]	88.30±0.05[a]	87.04±0.16[a]	86.62±0.06[b]	85.90±0.28[c]
A	20.77±0.08[bc]	17.34±0.54[d]	22.65±0.21[a]	22.05±0.13[a]	20.93±0.10[bc]	21.47±0.08[b]	20.31±0.76[c]
T.CHO	86.92±0.04[c]	84.01±0.01[d]	90.95±0.18[a]	90.67±0.11[a]	89.68±0.98[ab]	88.70±0.09[b]	86.92±0.04[c]

Results are mean values of duplicate determination ± standard deviation. Mean value within the same column having the same letter are not significantly different at $p<0.05$. TS = Total Starch, A = Amylose, T.CHO = Total Carbohydrate

3.4 Colour analysis of the *tuwo* flour samples

The colour characteristics of tuwo prepared from different maize/cassava flour mixes are presented in Table 4. The result for lightness (L) of the tuwo flour obtained from maize/cassava flour mixes ratio ranged from 70.26-74.78%. The high score for the lightness index of tuwo obtained from 90%maize +10% lafun flour mixes was most probably due to the processing method adopted. The increase in the values also implies that the lightness index of the tuwo could be enhanced by incorporating graded levels of cassava flour. Therefore, the use of composite flour in maize tuwo preparation has revealed that colour lightness of the food product could be positively affected.

The yellow (Y) colour of maize/cassava tuwo showed sample values ranged from 2.51 in 15CS to 2.77 in 100% MF. The result obtained showed that there was no significant difference between samples 10HQCF, 10CS, 10LF, 15HQCF and 15LF ($p<0.05$) while other samples were significantly difference ($p<0.05$). Therefore, the use of composite flour in maize tuwo preparation has revealed that both red and yellow colour of the food product could be positively affected. Since it has been stated that the colour of maize and cassava flour is one of the factors being used for the product acceptability assessment, it implies that the variation in the colour indices of maize flour and tuwo samples is another critical area that needs to be attended to when embarking on a technological improvement effort for tuwo quality.

Redness (R) colour showed that there was significant difference between the samples ($p<0.05$). Sample MF having the highest score (0.75%) while sample 10LF (0.46%) had the lowest score. The highest score obtained in sample MF could be as a result of producing it from 100% of maize flour.

TABLE 4: Colour analysis of the "Tuwo" blend flour samples

Sample (%)	MF	10HQCF	10CS	10LF	15HQCF	15CS	15LF
L	74.19±0.0[a]	73.54±0.0[b]	74.58±0.7[a]	74.78±0.1[a]	71.14±0.3[cd]	70.26±0.1[d]	71.68±0.7[c]
Y	2.77±0.1[a]	2.60±0.0[a]	2.55±0.1[a]	2.57±0.1[a]	2.55±0.0[a]	2.51±0.0[a]	2.67±0.0[a]
R	0.75±0.0[a]	0.52±0.0[b]	0.51±0.0[c]	0.46±0.1[d]	0.54±0.0[bc]	0.50±0.0[cd]	0.65±0.0[a]

Results are mean values of duplicate determination ± standard deviation. Mean value within the same row having the same letter are not significantly different at $p<0.05$. L = Lightness, Y = Yellow, R = Redness

3.5 Sensory attributes of the *tuwo-meal* produced samples

The sensory quality rating of tuwo prepared from maize and cassava flour mixes is presented in Table 5. Tuwo prepared from M10CS was rated highest in terms of colour while tuwo prepared from 100% maize was rated lowest. In terms of appearance tuwo prepared from M10LFwas rated highest while tuwo prepared from M15LF was scored low. Also, tuwo prepared from M10CS and M15LF had the highest and least score respectively in term of texture while sample M10H and MF was rated the highest and the least score, respectively in term of flavour. Tuwo prepared from M10CS was rated highest in term of colour, texture, taste and overall acceptability. The overall acceptability of tuwo from M10CS could be as a result of increase in softness index due to the structural modification in the food product caused by dilution of starch granules.

Table 5: Sensory properties of the "Tuwo" blend flour samples

Attribute	MF	10HQCF	10CS	10LF	15HQCF	15CS	15LF
Colour	6.2±0.00[d]	6.3±0.01[d]	8.3±0.01[a]	7.5±0.00[b]	6.9±0.02[cd]	7.0±0.00[c]	6.7±0.01[cd]
Appearance	6.6±0.02[c]	7.2±0.00[a]	7.2±0.00[b]	7.5±0.02[b]	6.3±0.01[d]	6.4±0.01[cd]	6.1±0.00[d]
Texture	6.4±0.01[c]	7.4±0.01[a]	7.5±0.02[a]	6.8±0.01[b]	6.4±0.01[c]	6.8±0.00[b]	6.0±0.00[d]
Flavour	6.2±0.00[d]	7.6±0.00[a]	7.4±0.00[a]	6.3±0.00[d]	6.9±0.00[b]	6.6±0.00[c]	6.3±0.01[d]
Taste	6.0±0.01[d]	7.2±0.01[b]	8.1±0.01[a]	6.7±0.00[c]	6.1±0.00[d]	6.0±0.01[d]	6.2±0.00[d]
OA	6.3±0.00[b]	6.3±0.00[b]	7.2±0.01[a]	7.1±0.01[a]	6.1±0.00[bc]	6.0±0.00[c]	6.3±0.01[b]

Results are mean values of duplicate determination ± standard deviation. Mean value within the same column having the same letter are not significantly different at $p<0.05$. OA = Overall acceptability.

4. Conclusion

The findings from this study would be of immense relevance to the food industry particularly in the areas of ingredient formulation and food product development for quality enhancement. Result of total starch, total carbohydrate and amylose content showed that cassava adjunct samples had advantage over 100% maize flour sample. Moreover, the knowledge on pasting properties of cassava adjuncts with maize flour will assist consumers to determine the reconstitution property of tuwo prepared from maize and cassava composite flour. The results of the study indicated that samples with 10-15 % cassava adjunct with maize flour will be the best for the formulation of cassava-maize flour for tuwo preparation.

5. Correspondence:-

Dr Akinsola Akinjide Olubunmi
Department of Home Economics
Federal College of Education (Special) Oyo
Oyo State, Nigeria.
email: akinsola4gold@gmail.com

References

1. Abass, A.B., Awoyale, W. & Alamu, E.O. (2018) Assessment of the chemical and trace metal composition of dried cassava products from Nigeria. *Quality Assurance and Safety of Crops & Foods*, 1-10.
2. Adebowale, A.A., Sanni, L.O., & Awonarin, S.O. (2005). Effect of texture modifiers on the physicochemical and sensory properties of dried fufu. *Food Science and Technology International,11*, 373–382.
3. Adebowale, A.A., Sanni, L., Awonorin, S., Daniel, I. & Kuye, A. (2008). Effect of roasting cassava varieties on the sorption isotherm of tapioca grits. *Electronic Journal of Environmental Agriculture and Food Chemistry*. 5(6), 42, 448-452.
4. Adriana V., Juan P.A., Daira A., Silvia O. & Mario A. (2016). Structured model and parameter estimation in plant cell cultures of Thevetia peruviana, *Bioprocess and Biosystems Engineering*, 40(4), 573-587.
5. Ajanaku, K.O., Ajanaku, C.O., Edobor-Osoh, A. & Nwinyi, O.C. (2012).Nutritive value of sorghum ogi fortified with groundnut seed (*Arachis hypogaea* L.). *American Journal of Food Technology,7*, 82–88.
6. Akinsola, A., Segilola, V., Oloso, S., & Durojaiye, O. (2018). Quality evaluation of plantain-African yam bean flour blends and sensory properties of its cooked (amala) paste. *Research Journal Food Science and Nutrition*, 3, 31-40.
7. Aryee, F.N.A., Oduro, I., Ellis, W.O. & Afuakwa, J.J. (2006). The physicochemical properties of flour samples from the roots of 31 varieties of cassava. *Food Control*, 17, 916–922.
8. Bolade, M.K. & Adeyemi, I.A. (2012) Functionality enhancement of composite cassava flour in the production of maize tuwo (a non-fermented maize-based food dumpling). *Food Bioprocess Technol*, 5, 1340–1348.
9. Bolade, M.K., Adeyemi, I.A. & Ogunsua, A.O. (2009). Influence of particle size fractions on the physicochemical properties of maize flour and textural characteristics of a maize-based non-fermented food gel. *International Journal of Food Science and Technology*, 44, 646–655.
10. Bolade, M.K., Usman, M.A., Rasheed, A.A., Benson, E.L., & Salifou, I. (2002). Influence of hydrothermal treatment of maize grains on the quality and acceptability of tuwon marsara (traditional maize gel). *Food Chemistry*, 79, 479-483.
11. Chinma, C.E., Ingbian, E.K. & Akpapunam, M. (2007).Processing and acceptability of fried cassava balls (Akara-akpu) supplemented with melon and soybean flours. *Journal of Food Processing and Preservation,* 31(2), 143–156.
12. Danbaba, N., Anounye, J.C., Gana, A.S., Abo,M.E., Ukwungwu, M.N. & Maji, A.T. (2012). Physical and pasting properties of

'ofada' rice (*Oryza sativa* L.) varieties. *Nigerian Food Journal, 30*, 18–25.
13. Falade K.O. & Okafor C.A. (2013). Physicochemical properties of five Cocoyam (*Colocasia esculenta* and *Xanthosoma sagittifolium*) starch. *Food Hydrocolloids*, 30(1), 173–181
14. Hu, E.A., Pan, A., Malik, V. & Sun, Q. (2012). White rice consumption and risk of type 2 diabetes: Meta-analysis and systematic review. *British Medical Journal,* 344.
15. IITA (2006). Cassava Recipes for Household Food Security. Printed in Nigeria by International Institute of Tropical Agriculture (IITA). Pp:10-25.
16. Jennifer, M.D. & Les, C. (2004).Genotype and environmental influences on pasting properties of rice flour. *Journal of Cereal Chemistry,81*, 486–489.
17. Kaur, M., Shandu, K. S., & Singh, N. (2007).Comparative study of the functional, thermal and pasting properties of flour from different chickpea cultivars. *Journal of Food Chemistry,104*, 259–267.
18. Kerr, W.L., Ward, C.D.W., McWalters, K.H. & Resurrection, A.V. A. (2000). Effect of milling and particle size on functionality and physicochemical properties of cowpea flour. *Cereal Chemistry*; 77(2), 213 – 219.
19. Koko, A.C., Assidjo N.E., & Amani, G. (2010). Cultivars and sampling regions influence on cassava roots and their fermented flours characteristics. *J. Appl. Sci. Res*., 6(12), 2219-2229.
20. McCready, R.M.; Guggolz, J.; Siliviera, V. & Owens, H.S. (1950). *Anal. Chem.,* 22, 1156.
21. Njintang, Y.N. & Mbofung, C.M.F. (2003) Development of taro (*Colocasia esculenta*) as an ingredient for food processing: Effect of gelatinization and drying temperature on the dehydration kinetics and colour of flour. *Journal of Food Engineering*, 58, 259-265.
22. Nuss, E.T., Tanumihardjo, S.A. (2010), Maize: A paramount staple crop in the context of global nutrition. *Comprehensive Revision in Food Science and Safety*, 9(4), 417-436.
23. Malomo O., Ogunmoyela O.A.B., Adekoyeni O.O., Jimoh O., Oluwajoba S.O., & Sobanwa M.O. (2012) Rheological and Functional Properties of Soy-Poundo Yam Flour. *International Journal of Food Science and Nutrition Engineering*, 2(6), 101-107.
24. Oyewole O.B. & Afolami O.A. (2001). Quality and preference of different cassava varieties for "Lafun" production. *J. Food Tec. Afr*., 6, 27-29.
25. Padonou S.W., J. D. Hounhouigan, & M. C. Nago, (2009). "Physical, chemical and microbiological characteristics of lafun produced in Benin". *African Journal of Biotechnology*, 8(14), 3320–3325.
26. Sefa-Dedeh S., Cornelius B, Sakyi-Dawson E & Afoakwa E O (2004). Effect of nixtamalization on the chemical and functional properties of maize. *Food Chemistry,* 86(3), 317-324.
27. Sanni, L.O., Adebowale, T. A., Filani, T. A., Oyewole, O. B., & Westby, A. (2006).Quality of flash and rotary dryer dried fufu flour.*Journal of Food, Agriculture and Environment,4*, 74–78.
28. Shimelis, E. A., Meaza, M., & Rakshit, S. (2006). Physico-chemical properties, pasting behavior and functional characteristics of flours and starches from improved bean (*Phaseolus vulgaris L*) varieties grown in East Africa. Agricultural Engineering International: CIGR Ejournal, 8, 1–18.
29. Shindano, J. (2007). Functional properties of white maize meal stored under tropical conditions. Thesis submitted in fulfillment of the requirements for the degree of doctor (PhD) in Applied Biological Sciences:chemistry. Falculty of Bioscience Enguneering.Ghent University, Belgium, pp.23-25.
30. Shittu T.A., Alimi B.A., Wahab, B., Sanni, L.O. & Abass, A.B. (2016). Cassava Flour and Starch: Processing Technology and Utilization: Production, Processing and Technology. Edited by Harish K. Sharma, Nicolas Y. Njintang, Rekha S. Singhal and Pragati Kaushal. © 2016 John Wiley and Sons, Ltd. Published 2016 by John Wiley and Sons, Ltd.
31. Yellavila, S.B., Agbenorhevi, J.K., Asibuo, J.Y., & Sampson, G.O. (2015). Proximate compoxition, mineral content functional properties of five liman accessions. *J. of Food Security*, 3(3), 69-74.

11/2/2021