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Quality Assessment of "Tuwo" (Maize Dumpling) Made From Maize Flour Modified With Maize and Cassava Starch

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Abstract: *This study investigated the production and quality evaluation of maize tuwo modified with maize and cassava starch adjuncts. Samples were prepared from 100% maize flour, 90% maize flour + 10% maize starch, 90% maize flour + 10% cassava starch, 80% maize flour + 20% maize starch and 80% maize flour + 20% cassava starch and were coded sample MF,10 MS,10CS, 20MS, and 20CS respectively. The samples were analyzed for pH, functional properties, total carbohydrate, colour intensity and chemical properties while" tuwo" meal produced from the tuwo flour samples were analyzed for sensory evaluation. pH result ranged from 6.07-6.38, functional properties showed loose bulk density result ranged from 0.44-0.49g/100g, packed bulk density result ranged from 0.71-0.74g/100g, water holding capacity result ranged from 121.31-245.76%, swelling capacity result ranged from 594.21-888.78%, solubility index result ranged from 9.69-13.97%, wettability result ranged from 2.00-5.00 min. total carbohydrate increased as the substitution of MF with cassava and maize starch increased.. Samples substituted with maize starch had higher amylose content than other samples,. Colour intensity showed that lightness result ranged from 70.09-88.69, yellowness result ranged from 1.97-2.70, and redness 0.39-0.68. Sensory evaluation showed that Substitution of MF with cassava starch up to 20% resulted in the improvement on texture and overall acceptability of maize-tuwo.*

Keywords: **Tuwo, Quality, Proximate, Mineral analysis, corn starch.**

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I. Introduction

Maize *tuwo*, one of the numerous traditional food products obtainable from maize, is popular among the Hausa-speaking communities of West Africa in general and of 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[1]. Maize *tuwo* is normally prepared from unfermented maize flour to form a gel-like food product. The general preparation procedure for the traditional food product involves initial slurry preparation by mixing maize flour with cold water in an appropriate proportion. Some quantity of water is brought to boiling after which the initially prepared maize slurry is added into it followed by a rigorous stirring to form a pap-like consistency.Flour is then gradually added to this pap-like consistency accompanied by rigorous stirring to form a gel-like product. Small quantity of water is finally added to this gel, left on the fire to cook for about 5–7 min after which the cooking gel is properly stirred in order to obtain a homogenous product called maize *tuwo*. The quality attributes normally used by the consumers for assessing maize *tuwo* are colour (white to creamy), texture (ease of mouldability and swallowability) and pleasant taste[2].

Corn starch is a valuable ingredient to the food industry, being widely used as thickener, gelling agent, bulking agent and water retention agent[3]. Normally starches are added for enhancing quality of products in food industries.

Cassava starch is a highly suitable material for food and industrial use. It is edible, non-toxic, and functionally important in the food and non-food sectors of industry. The advantages of cassava for starch production over other grains or root crop includes: high purity level, excellent thickening characteristics, a neutral (bland) taste, desirable textural characteristics, is relatively cheap and it contains a high concentration of starch (dry-matter basis)[4].

Cassava has a high proportion (65–80%) of starch which is low in contaminants compared to other botanical starches[5]. Cassava starch has many remarkable characteristics, including high paste viscosity, high paste clarity and high freeze-thaw stability which are advantageous to many industries. Cassava is a renewable, an almost unlimited resource and one of the most abundant substances in nature which makes it suitable for use in many foods.

The cassava project of the Nigerian government aimed at increasing the utilization of cassava for industrial purposes and as a foreign exchange earner has stimulated research into the processing and conversion of cassava and its products into industrial products and as raw materials. Therefore, it is highly desirable to select certain variants of cassava as industrial starch source, depending on their inherent characteristics[6].

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 ability to retrograde easily when cooled and its ability to be easily brittle when moulded with the hand on consuming, particularly after cooling and overnight storage[1]. It has, however, been observed that the quality and general acceptability of a cereal product is usually influenced by the physical and chemical properties of the cereal from which it is produced and these properties may be modified through chemical, physical and enzymic processes so as to obtain desired functional characteristics [7].One of the efforts being made to ameliorate the textural and sensory quality inadequacies associated with maize tuwo, particularly at household levels, is the use of composite flour (e.g. cassava or yam flour) in its production[2] . It is generally believed that the composite flour involvement in maize *tuwo* production is capable of enhancing both textural and sensory quality attributes of the food product. However, it is in line with this initiative that this study seeks the utilization of cassava starch and maize starch adjunct for the modification of maize flour for the production of maize tuwo.

There is therefore, a need to solve the identified quality problems with maize *tuwo* using available technological approach. It has been suggested, however, that any quality improvement effort made to a traditional food product should be carried out in such a way that the upgraded technologies could easily be integrated into the food processing system and should result in improved product quality and reduced drudgery without upsetting the social structure [8].

II. Material And Methods

Source of Raw Materials

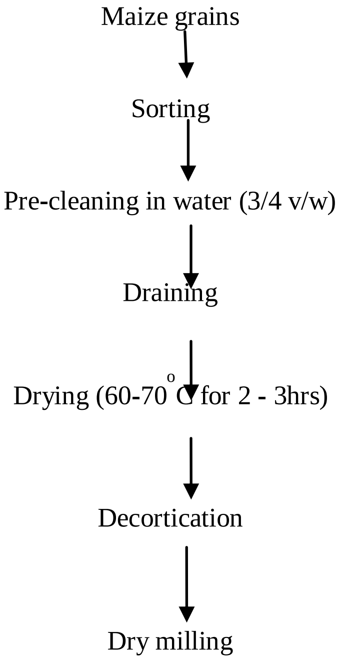
White maize variety and cassava tubers were procured from Owode market in Offa, Kwara State, Nigeria.

Equipment

The equipment used such as, heating element, bowl, measuring cylinder, weigh balance, knife etc., were obtained from the Food Processing Laboratory of the Department of Food Technology, Federal Polytechnic Offa, Kwara State, Nigeria.

Production of Maize Flour

Maize flour was prepared using the method described by[9]. The maize grains were sorted and initially cleaned manually by removing the stones, damaged kernels and other extraneous materials. The sorted maize grains were then washed in clean water and the water was drained off and the grains were dried immediately using Excalibur Food Dehydrator (Excalibur Parallex, USA). The dried grains were decorticated on a Grantex decorticating machine to aid the removal of the maize bran and the germ to obtain the grits. Thereafter, the decorticated maize grit was milled using a disc attrition mill (PUC, Germany) to obtain the flour followed by sieving using a sieve with 300-μm aperture and then kept in airtight polythene bags until needed.



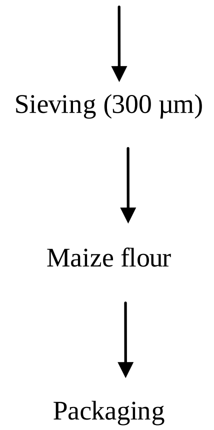
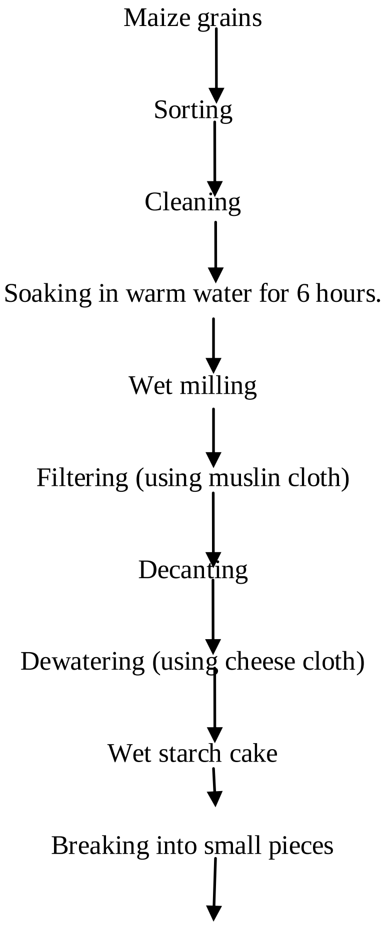


Fig. 1: Flow chart for the production of maize flour
Source: (Ayo *et al.,* 2008).

Production of Maize Starch Flour

Maize starch was prepared from corn grain according to the procedure of [10]with little modification. The grain was soaked in warm water (25 °C) for 6 hours for the softening of the seed coats, endosperm and germ. The maize grain was thereafter wet milled using attrition mill into smooth paste and mixed with water (at a ratio of 1:5). Filtration of the milled grains will be effected through the use of clean muslin cloth after which was allowed to settle. The supernatant was decanted and the sediment was dewatered with cheese cloth and the starch residue was washed three times with clean water. The starch cake obtained after dewatering process was broken, spread thinly on trays and dry in a cabinet dryer at 60°C for 8 hours. The dried starch samples was milled using milling machine and then sieved through a mesh sieve (British Standard Screens) with 0.33nm diameter to obtainsmooth maize starch flour. The maize starch flour was finally packaged in high density polyethylene bags prior to further uses.



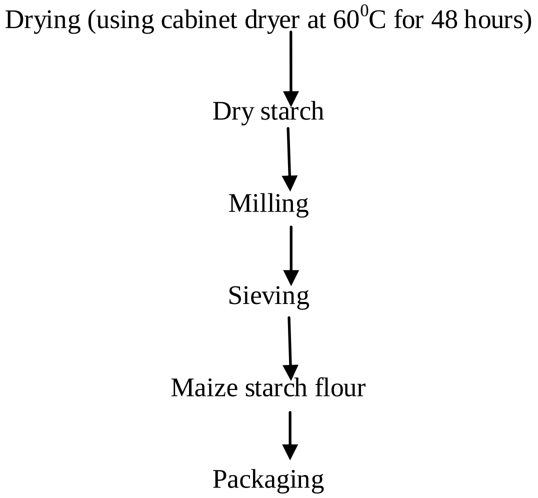
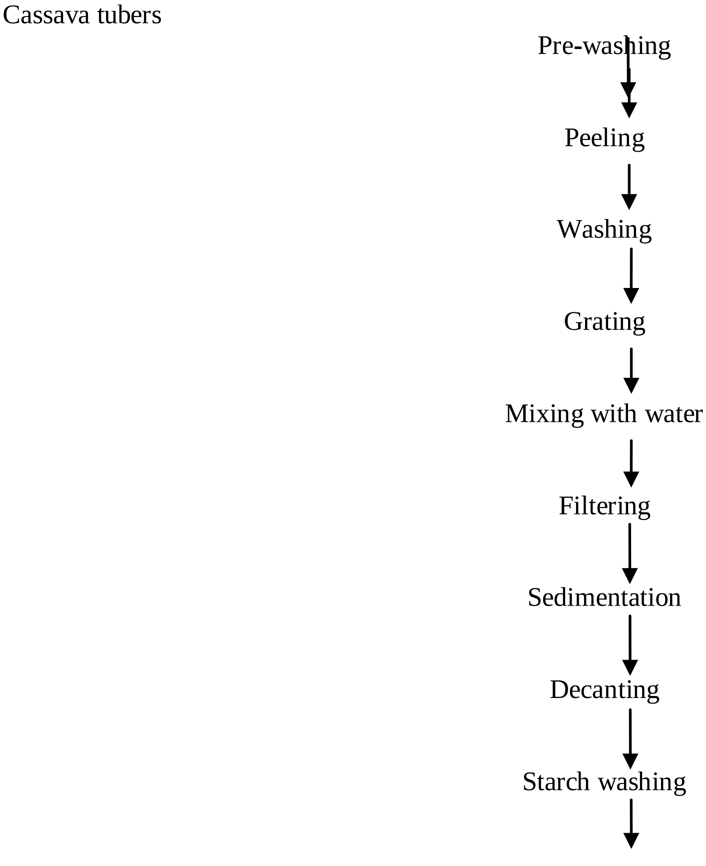


Fig. 2: Flow chart for the production of maize starch flour
Source: (Singh *et al.*, 2009)

Production of Cassava Starch

Cassava starch flour was produced using the method described by[11]. Fresh cassava tubers that are free from microbial, insect damage and bruises were selected. The cassava roots were thoroughly washed to remove sand and dirt and the cassava was peeled by hand using sharp knife and woody pieces were removed. After peeling, the cassava tubers were washed in clean water to remove any pieces of peel and dirt. Washed cassava tubers were grated into coarse form using a motorized cassava grater. Grated cassava was washed with clean water and strained through a cloth bag. The bag was squeezed to extract the starch milk which was collected into a clean bowl; this was done repeatedly until the squeezed liquid was no longer white. The squeezed liquid was left for 8 hours to allow the starch to settle to the bottom. The liquid was decanted off and the starch was washed repeatedly until the liquid decanted off was clear. The white starch remaining at the bottom of the basin was removed, sun died and milled into powder.



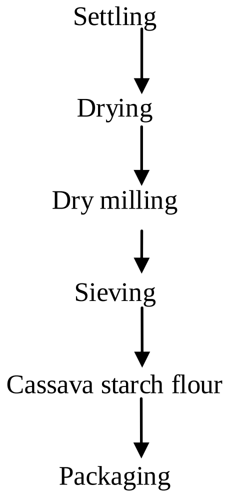


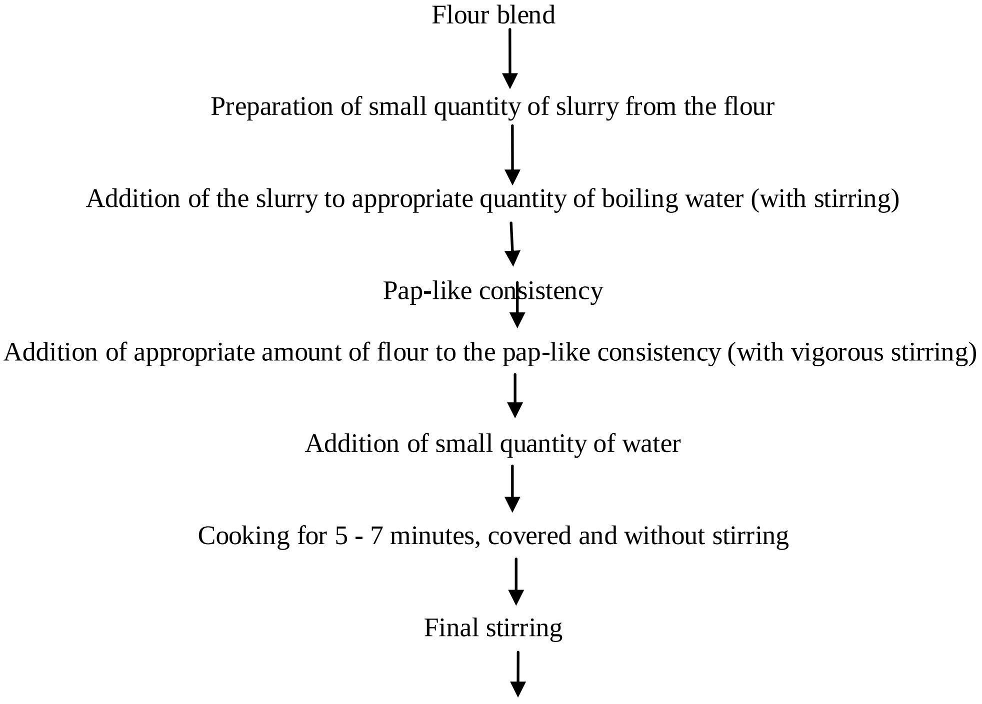
Fig. 3: Flow chart for the production of cassava starch flour
Source: Eke *et al. (*2007)

Samples Formulation

MF	100% Maize Flour
10MS	90% Maize Flour + 10% Maize Starch
10CS	90% Maize Flour + 10% Cassava Starch
20MS	80% Maize Flour + 20% Maize Starch
20CS	80% Maize Flour + 20% Cassava Starch

Preparation of Maize Tuwo

Maize *tuwo* was prepared from each flour sample using a method described by[1]. Cold slurry of the flour was firstly prepared by mixing 20% of the desired quantity of flour (1.0 Kg) with 25% of the desired quantity of water. This was followed by bringing 60% of the water into boiling and the cold slurry initially prepared was added to the boiling water coupled with vigorous stirring, using a wooden flat spoon, to form a pap-like consistency. The remaining quantity of the flour (80% of the desired total) was added gradually to the boiling pap-like paste with continuous stirring so as to facilitate non-formation of lumps and to ensure a homogenous smooth gel formation. The remaining quantity of water (15 % of the desired total) was finally added to the already formed gel, covered properly without stirring, and allowed to cook for about 7 min after which it was stirred vigorously to ensure smoothness of the gel which is known as maize *tuwo*.



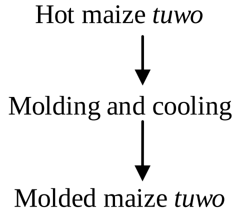


Fig. 4: Flow chart for the production of maize-tuwo
Source: Bolade *et al.* (2009)

Procedure methodology – Methods of Analysis

Determination of proximate composition

Moisture, crude protein, fat, fibre, ash and carbohydrate were determined according to the Association of Official Analytical Chemists [12](AOAC, 2006) methods in triplicate samples of the composite flour. The crude protein N×6.25 was determined by the Kjeldahl method, total lipids was analysed by the Soxhlet method, ash was determined by burning the samples at 550 degree Celsius, total dietary fibre was determined by Gerhardt method, air–oven method was used to determine the moisture content of the maize *tuwo*[12]. Carbohydrate was calculated by the difference method[12, 13]. % carbohydrate = 100% - (sum of the % of moisture, ash, fat, crude fiber and crude protein).

Determination of functional properties of samples

i)Bulk density

The method reported by[14]was used. An empty 10 ml capacity graduated measuring cylinder was weighed. The cylinder was gently filled with the sample, and then the bottom of the cylinder was gently tapped on the laboratory bench several times until there is no further diminution of the sample level after filling to the 10ml mark. The bulk density was calculated as weight of sample (g) per volume of the sample (ml).

$$\text{Bulk density (g/ml)} = \frac{\mathrm{W2-W1}}{\text{Volume of sample}}$$

W_1 = the already weighed measuring cylinder
W_2 = the weight of the sample and weight of the cylinder

ii) Water absorption capacity

Water absorption capacity was determined by using the method described by[15]. (2011). Ten milliliters of distilled water was mixed with 1g of flour each and blended for 30 seconds. The samples were allowed to stand for 30 minutes and centrifuged at 1300 rpm for another 30 min at room temperature (27 ± 2°C). The supernatant was decanted. The weight of water absorbed by the flour was calculated and expressed as percentage water absorption capacity.

iii) Wettability Index

Wettability index was determined using the method reported by[15]but with slight modification. 10ml of distilled water at 25 °C was poured into 400ml beaker (70mm diameter). A glass funnel (height 100mm, lower diameter 40mm, upper diameter 90mm) was placed and maintained on the upper edge of the beaker. A test tube was placed within the funnel to block the lower opening of the funnels. Three grams flour was placed around the test tube, while the time was started, the tube was simultaneously elevated. Finally the time was recorded when the flour was completely wet (visually assessed that all powder particles have diffused into the water). The measurement was performed at least twice for each flour sample until the relative difference between two results did not exceed 70%[16].

iv) pH

Ten grams of the flour samples was weighed and dissolved in a beaker containing 25ml distilled water to form slurry. It was allowed to stand for 10 minutes with constant stirring. The pH was then directly determined with the aid of pH meter (Model PHS-25CW Microprocessor pH/mv meter)[16].

v) Solubility and Swelling Index Power

1g of sample was weighed into a previously weighed empty centrifuge tube. 10ml of distilled water was added and mixed severally. The tube was placed in a boiling water bath for 30minutes. After 30minutes, the tube was allowed to cool and then centrifuged at 2200ppm for 15mins.The supernatant was decanted into a previously weighed petri dish and the five petri-dishes was dried in the oven. The tube and its content (gel) were also weighed. The swelling power was calculated by subtracting the weight of the tube from the weight of the tube and gel while the solubility index was calculated by subtracting the weight of empty crucible from the weight of dried crucible and content (residue), [17].

Chemical Analysis

i) Determination of amylose

Amylose contents of the samples were determined by the method of [18]. Iodine reagent was prepared by dissolving 1g and 10g potassium iodide in water and making it up to 500ml mark. 0.1g of sample was weighed into a flask and 1ml of distilled ethanol was added followed by addition of 10 ml 1N NaOH. This was heated for 10 min or left over night before continuation. The content was made up to 100 ml using distilled water. 2.5 ml was taken into a 10ml volumetric flask and 20 ml distill water added followed by addition of 3 drops of phenolphthalein indicator. Few drops of 0.1N HCl was introduced until the pink colour just disappears. 1 ml of iodine reagent was added and made up to 50 ml with distilled water. The absorbance was read at 590 nm using a spectrum lab23A UV visible spectrophotometer. The concentration was obtained from a standard amylase graph.

ii) Determination of total carbohydrate by anthrone method

Anthrone reagent was prepared by dissolving 0.2g of anthrone powder in 100 ml of 95 % sulphuric acid. 0.1g of sample was weighed into a centrifuge tube. This was hydrolysed by adding 5 ml of 2.5N HCl and placing it in a boiling water bath for 3hours. After 3hrs, it was neutralized by adding solid sodium carbonate until effervescence ceases. The content was transferred into 100 ml standard flask and made up to mark using distilled water. The content was centrifuged and 0.5ml aliquot was taken for total carbohydrate determination. 4ml of the prepared anthrone was added and heated in a boiling water bath for 8 min. This was cooled and absorbance read at 630nm using spectrum23A UV visible spectrophotometer. The total carbohydrate content was gotten by extrapolating the absorbances from a glucose standard graph[19].

iii) Colour Determination (Lightness (l), Redness (a), Yellowness (b)

This was determined according to[20]methods. 1.00 g of sample was weighed into a beaker and 25ml ethanol was added. It was stirred for 30min and allowed to stand for 10 minutes. The supernatant was filtered using filter paper into clean tubes and labeled accordingly. The absorbances of the supernatant were determined using UV visible spectrophotometer at the wavelengths of 615 nm, 650 nm and 585 nm for lightness (l), Redness (a) and Yellowness (b) respectively. The equivalent values for each colour is obtained.

iv) Mineral Analysis of selected mineral composition of samples

Total mineral determination was done using the Atomic Absorption Spectrophotometer (AAS), for the determination of micro and macro elements in the samples. The dry ashing method was used. About 1 g of a well-blended sample was pre ashed at 300 °C and further ashed at 600 °C for 2 hours in a muffle furnace and allowed to cool. 25ml of 3M HCl was added and filtered into a 100 ml volumetric flask and diluted to volume with deionized water. Sample was vortexed and centrifuged at 3000 rpm for 10 min. Supernatant was decanted into clean vials for micro and macro element determination using AAS at each elements set wavelength for detection[21].

Sensory evaluation of tuwo samples

Tuwo samples obtained from various flour samples were subjected to sensory evaluation using a scoring test. 10 pre-trained panelists were requested to carry out the rating of the tuwo samples. Each of the panelists was asked to rate the samples on the basis of colour, taste, aroma, texture (mouldability) and overall acceptability using a 9 -point hedonic scale , with 1 representing the least score and 9 the highest score. The scores from the rating were subsequently subjected to analysis of variance (ANOVA) and the means separated using Duncan Multiple Range test[2].

Statistical analysis

Data obtained were analysed by subjecting them to independent sample T-test using IBM SPSS (version 20)(SPSS Inc., Chicago, IL). Significant l differences were tested for at $p \leq 0.05$. Tukey's test was used to differentiate between the mean values.

III. Result

Table 1: Results for proximate composition of Tuwo flour samples

Parameters (%)	MF	10CS	20CS	10MS	20MS
Moisture	10.41 ± 0.02^{d}	10.00 ± 0.06^{b}	10.18 ± 0.09^{c}	9.83 ± 0.05^{a}	10.10 ± 0.03^{bc}
Crude protein	10.68 ± 0.06^{e}	9.87 ± 0.02^{d}	7.56 ± 0.15^{a}	9.08 ± 0.01^{c}	7.91 ± 0.04^{b}

Crude Fat	6.88 ± 0.05^{e}	6.16 ± 0.04^{d}	5.30 ± 0.04^{a}	5.94 ± 0.02^{c}	5.41 ± 0.03^{b}
Crude fibre	0.81 ± 0.01^{c}	0.70 ± 0.03^{b}	0.56 ± 0.01^{a}	0.61 ± 0.02^{a}	0.57 ± 0.01^{a}
Total Ash	1.70 ± 0.03^{b}	1.71 ± 0.01^{b}	1.52 ± 0.01^{a}	1.68 ± 0.02^{b}	1.56 ± 0.02^{a}
CHO	69.53 ± 0.06^{a}	71.57 ± 0.16^{b}	74.89 ± 0.17^{e}	72.88 ± 0.06^{c}	74.46 ± 0.01^{d}

Table no 1 Shows the proximate composition parameter of the tuwo flour samples.
Results are mean values of duplicate determination ± standard deviation. Mean value within the same row having the same superscript letters are not significantly different at $p \leq 0.05$. CHO= Carbohydrate

Key:
MF = 100% Maize Flour
10MS = 90% Maize Flour + 10% Maize Starch
10CS = 90% Maize Flour + 10% Cassava Starch
20MS = 80% Maize Flour + 20% Maize Starch
20CS = 80% Maize Flour + 20% Cassava Starch

Table 2: Results for functional properties of Tuwo flour samples

Parameters	MF	10CS	20CS	10MS	20MS
Ph	6.38 ± 0.04^{c}	6.29 ± 0.06^{bc}	6.30 ± 0.03^{bc}	6.07 ± 0.03^{a}	6.23 ± 0.01^{b}
LBD (g/ml)	0.48 ± 0.07^{d}	0.43 ± 0.00^{a}	0.47 ± 0.01^{c}	0.44 ± 0.00^{ab}	0.45 ± 0.00^{bc}
PBD (g/ml)	0.72 ± 0.00^{b}	0.74 ± 0.00^{c}	0.73 ± 0.00^{b}	0.70 ± 0.01^{a}	0.73 ± 0.00^{bc}
WHC (%)	245.76 ± 1.42^{e}	143.39 ± 0.63^{d}	135.84 ± 0.39^{b}	139.90 ± 0.19^{c}	121.31 ± 0.60^{a}
SC (%)	765.63 ± 1.38^{d}	760.45 ± 0.27^{c}	594.21 ± 0.32^{a}	888.78 ± 1.17^{e}	615.52 ± 0.33^{b}
Solubility (%)	12.61 ± 0.13^{c}	9.69 ± 0.21^{a}	10.30 ± 0.08^{b}	10.43 ± 0.08^{b}	13.97 ± 1.18^{d}
Wettability(s)	2.00 ± 0.00^{a}	3.00 ± 0.00^{b}	4.50 ± 0.71^{c}	5.00 ± 0.00^{c}	3.00 ± 0.00^{b}

Results are mean values of duplicate determination ± standard deviation. Mean value within the same row having the same superscript letters are not significantly different at $p \leq 0.05$.
LBD = Loose bulk density, PBD = Packed bulk density, WHC = Water holding capacity, SC = Swelling capacity

Key:
MF = 100% Maize Flour
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10CS = 90% Maize Flour + 10% Cassava Starch
20MS = 80% Maize Flour + 20% Maize Starch
20CS = 80% Maize Flour + 20% Cassava Starch

Table 3: Total carbohydrate and Amylose content of tuwo flour samples produced

Sample	MF	10CS	20CS	10MS	20MS
TCHO (%)	68.71 ± 0.23^{a}	75.32 ± 0.31^{b}	77.32 ± 0.08^{c}	83.69 ± 0.06^{d}	86.87 ± 0.13^{e}
Amylose (%)	18.30 ± 0.04^{a}	19.00 ± 0.06^{b}	19.69 ± 0.09^{c}	20.04 ± 0.09^{c}	21.63 ± 0.34^{d}

Results are mean values of duplicate determination ± standard deviation. Mean value within the same row having the same superscript letters are not significantly different at $p \leq 0.05$
TCHO- Total carbohydrate

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20CS = 80% Maize Flour + 20% Cassava Starch

Table 4: Results for color characteristics of Tuwo flour samples

Samples	Lightness (l)	Yellowness (a)	Redness (b)
MF	70.06 ± 0.05^{a}	2.70 ± 0.07^{d}	0.68 ± 0.04^{c}
10MS	74.43 ± 0.18^{b}	2.49 ± 0.02^{c}	0.64 ± 0.01^{c}
10CS	79.53 ± 0.74^{c}	2.34 ± 0.01^{b}	0.60 ± 0.03^{c}
20MS	85.18 ± 0.11^{d}	2.28 ± 0.04^{b}	0.47 ± 0.03^{b}
20CS	88.69 ± 0.26^{e}	1.97 ± 0.02^{a}	0.39 ± 004^{a}

Results are mean values of duplicate determination ± standard deviation. Mean value within the same column having the same superscript letter are not significantly different at $p \leq 0.05$

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Table 5: Mineral composition of tuwo flour samples

Parameters (mg/100g)	MF	10CS	20CS	10MS	20MS
Calcium	15.32 ± 0.47^{d}	13.43 ± 0.13^{c}	10.05 ± 0.99^{b}	13.03 ± 0.11^{c}	8.06 ± 0.04^{a}
Sodium	14.33 ± 0.06^{e}	10.87 ± 0.29^{d}	9.05 ± 0.02^{b}	10.07 ± 0.03^{c}	7.79 ± 0.05^{a}
Magnesium	137.47 ± 0.83^{e}	127.93 ± 0.29^{d}	109.10 ± 0.24^{b}	118.41 ± 0.33^{c}	97.06 ± 0.13^{a}
Iron	32.60 ± 0.11^{e}	26.35 ± 0.24^{d}	20.64 ± 0.62^{b}	22.31 ± 0.04^{c}	15.59 ± 0.16^{a}
Zinc	1.79 ± 0.05^{d}	1.52 ± 0.06^{c}	1.29 ± 0.04^{b}	1.48 ± 0.03^{c}	1.09 ± 0.02^{a}

Results are mean values of duplicate determination ± standard deviation. Mean value within the same row having the same superscript letters are not significantly different at $p\leq 0.05$

Key:
MF = 100% Maize Flour
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20CS = 80% Maize Flour + 20% Cassava Starch

Table 6: Sensory evaluation of tuwo meal samples produced

Sample	MF	10CS	20CS	10MS	20MS
Taste	7.7	8.8	8.2	8.5	8.2
Texture	7.6	7.7	8.6	8.3	7.6
Colour	8.6	8.4	7.8	8.3	7.9
Appearance	8.7	8.4	7.8	8.1	8.1
Aroma	8.5	8.5	7.7	8.7	7.9
Overall acceptability	7.8	8.1	8.8	8.4	8.1

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IV. Discussion

The proximate compositions of the respective tuwo samples are given in Table 1. The moisture contents of the tuwo samples differed significantly ($p \leq 0.05$). The moisture content varied between (9.83 – 10.41%) with 100% maize flour (sample MF) having the best score (10.41%) while the least value (9.83%) was registered by sample 10MS. The higher moisture content recorded by 100% maize flour sample could be attributed to the processing condition which results in higher gelatinization-index and higher water holding capacity [22]. The values reported for tuwo samples in this current study are in consonance with (6.21 – 11.2%) quoted for moisture content of okara fortified plantain-sorghum Amala by[23] as well as (6.54 – 11.20%) for maize/spices ogi in the study of [24]. However, lower values (6.50 – 9.40%) were reported for moisture content of cocoyam flour in the previous work of [25]. The percentage moisture of all composite flours reported in this study is below 15% which is there commended maximum limit for Flours. This shows that the composite flours will have longer shelf-life [23]. Akoja and Coker, (2018) also quoted that Food and Agricultural Organization (FAO) recommended 12 to 14% for moisture content of flour based product, hence, the tuwo samples in this study have reduced possibility of microbial attack thus increasing its shelf stability.

The crude protein contents of the tuwo samples ranged between (7.56 – 10.68%). 100% maize flour (sample MF) had the best crude protein content (10.68%) while the least value (7.56%) was recorded by sample 20CS. All the samples exhibited statistical variation at ($p \leq 0.05$). Akoja and Coker, (2018) revealed (10.56 – 21.93%) for protein content of wheat-okra flour which are not in agreement with the values reported for protein content of tuwo samples in this current study. High protein content of samples quoted by [26] could be attributed to the okra substitution which justifies increase in protein content of weaning food to 211 gkg^{-1}.On the flip side, lower values were reported for protein content of okara fortified plantain-sorghum flours (2.09 – 5.30%) by [23] and (1.31 - 5.7%) for protein content of sweet potato in the previous work of [27]. To improve the protein content of tuwo samples in current study, there is need for combination of legume such as soybean or velvet bean flour to provide better overall essential amino acid balance, helping to overcome the world protein malnutrition problems. This could help to ameliorate protein-energy malnutrition (PEM) especially where many people can hardly afford high protein foods because of their high cost[28].

The mean results for the crude fat content of tuwo samples indicated a range between (5.30 – 6.88%) with 100% maize flour (sample MF) sample ranking the highest (6.88%) while the least score was registered by sample 20CS. The low fat content observed in sample 20CS could be attributed to cassava's low fat content which justifies (0.60 – 3.13%) reported for garri by [29]. All samples in this current study exhibited statistical variation ($p \leq 0.05$). These values are incredibly higher than (1.77 – 3.56%) quoted for okra fortified plantain-sorghum flour by[23], (0.45 – 1.40%) for cocoyam flour in the previous work of [25] as well as (3.13 –4.48%) for maize/selected spices ogi by [24]. However, Rendón-Villalobos *et al.*, (2012)[30] reported (4.08 – 10.95%) for fat content of maize-chia seed tortilla which is evidently higher than the fat content of tuwo samples in this present study. Chia seed used in their study could have contributed to the increase in the fat content due to its high oil concentration[31, 32]. Fat contributes greatly to the energy value of foods, slow down the rate of utilization of carbohydrate[23].

The fibre contents of the tuwo samples varied between (0.56 – 0.81%). 100% maize flour (sample MF) had the best fibre content (0.81%) while sample 20 CS recorded the least value (0.56%). With the exception of sample MF and 10 CS, other samples had no significant difference ($p \leq 0.05$). These values are slightly synonymous to (0.19 - 0.59%) for maize/selected spices ogiby[24]. Ikujenlola and Olubukola (2018)[33] quoted (3.55 – 5.79%) for fat content of maize supplemented with sesame and mushroom complementary food which is evidently higher than the fibre content of tuwo samples in this current study. The sesame and mushroom used in their study undoubtedly increased the fibre content of complementary food samples. Fibers contain food components such as cellulose, hemicellulose, pectin, gum which remain undigested on entering the human large intestine. These food components are useful in the management of diseases such as obesity, diabetes, cancer and gastrointestinal disorders [34].

The mean results for total ash content of tuwo samples ranged between (1.52 – 1.71%) with sample 10 CS ranking the highest (1.71%) while the least score was accorded to sample 20 MS. Sample MF, 10 CS and 10 MS had statistical variation ($p \leq 0.05$) while equal phenomenon was evident between sample 20CS and 20MS. These are in consonance with (0.66 – 1.72%) registered for potato flour varieties in the previous work of [27]. Ukom*et al*., (2018) quoted (1.50 – 2.40%) for ash content of cocoyam flour which is higher than the values reported in this current study. The ash content is a measure of the total amount of minerals present within a food, whereas the mineral content is a measure of the amount of specific inorganic components present within a food, such as Fe, Cu, Zn, Ca, Na and K. The determination of these parameters in food is important for nutritional labeling, quality, microbiological stability, nutrition and processing among others [35].

The carbohydrate contents ranged (69.53 – 74.89%). Sample 20CS had the highest CHO (74.89%) while 100% maize flour had the least score (69.53%). All the samples had statistical variation ($p \leq 0.05$). The highest CHO content registered by sample 20CS could be attributed to the high percentage of cassava (20%) present in the sample. Cassava has been known to be rich source of carbohydrate[36]. This affirms the carbohydrate content of garri (30.08 – 91.80%) quoted in the study of [29]. However, Akoja and Coker, (2018)[26] reported (42.56 – 56.45%) for carbohydrate content of wheat-okra flour which is lower than the carbohydrate content of tuwo samples in this current study.

The results for the functional properties of tuwo samples from different maize/cassava starch are represented in Table 2. The pH of samples ranged between (6.07 – 6.38) with sample MF having the best score (6.38) while the least value (6.07) was registered by sample 20MS. No statistical variation ($p \leq 0.05$) was observed between samples 10CS and 20CS while samples MF, 10MS and 20MS differed significantly ($p \leq 0.05$). Proximity of the pH values registered for the samples weere close to pH 7 (Neutral pH), hence, suggesting that the samples are not acidic. Odunola and Adekunle, (2017)[37]reportedted (5.72 – 6.01) for pH of cassava flours in their study. The previous work of [38] revealed (3.55 – 4.35) for pH of yam flour suggesting slight acidity in their samples. The pH is an indication of the acid content of food. The lower the pH value of food, the more acidic is the food[29].

The loose bulk density (LBD) of the samples ranged between (0.44 – 0.48g/ml). Sample MF had the highest LBD (0.48g/ml) while sample 10CS maintained the least value of (0.44g/ml). All samples had statistical variation ($p \leq 0.05$) except for sample 10MS and 20MS with close proximity of statistical variation. These results suggest that incorporation of cassava flour into maize flour has a tendency of lowering the overall bulk density. These values are in conformity with (0.45 – 0.53g/ml) for loose bulk density of maize and baobab pulp flour blends in the previous work of [39]. Variation in values could be attributed to the processing methods and concentration of baobab pulp flour used in their study. Flours with lower bulk density have been observed to be of an advantage in the area of infant food preparation [40]. Bolade and Bello, (2006)[41] revealed that bulk density also plays a role in flour packaging as less weight would be packaged in a specific volume of container with flour of lower bulk density.

The mean results for the packed bulk density (PBD) of tuwo samples ranged between (0.70 – 0.74g/ml) with sample 10CS having the highest PBD (0.74g/ml) while sample 10MS registered the least score (0.70g/ml). No significant difference ($p>0.05$) existed between sample MF and 20CS while other samples exhibited statistical variation ($p \leq 0.05$). According to [42], bulk density is an indication of the relative volume of packaging material required. Higher bulk density is desirable for greater ease of dispersibility and reduction of paste thickness. Bolarin*et al.*, (2018)[43] quoted (0.67 – 0.72g/ml) for bulk density of cocoyam flour while similar range of values (0.59 – 0.77g/ml) were obtained by[44] for wheat, sweet potato and hamburger bean flour blends. Conversely, low bulk density of flours are good physical attributes when determining transportation and storability since the products could be easily transported and distributed to required location [45].

The water holding capacity (WHC) of the samples as shown in table 4.1 indicated a range between (121.31 – 245.76%) with sample MF recording the best WHC (245.76%) while the least score of (121.31%) was registered by sample 20CS. There existed significant different ($p \leq 0.05$) between all samples. This clearly suggests that incorporation of cassava flour into maize flour has a tendency of lowering the overall WHC. As reported by[46], high WHC causes high retention of water without dissolution of protein, thus increasing the body and viscosity of gel. Note worthily, all tuwo samples in this study could fulfill the performance quoted in the cited literature of [46]. Adedeji and Tadawus (2019)[39] revealed (2.19 – 2.49%) for WHC of maize-baobab pulp flour blends which are lower than the WHC of samples in this current study.

Particle sizes and starch components of the different blends are contributing reasons for variation in values of the different cited literatures and this current study. This supports the claim of [47] that WHC is dependent on factors such as particle size, amylose/amylopectin ratio and molecular structures of component flours. WHC is a essentially a measure of 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 doughs 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 [48], temperature of water and the quantity of hydrophilic constituents in the flour such as starch, protein and fibre, degree of damaged starch in the flour, among others[49].

The mean results for swelling capacity (SC) of tuwo samples had a range of (594.21 – 888.78%). Sample 20MS had the highest score (888.78%) while the least value (594.21%) was registered by sample 10CS. The best SC obtained by sample 20MS could be attributed to the blend formulation (80% maize flour and 20% maize starch) and increased hydration of starch [50]. All the samples were significantly different ($p \leq 0.05$). Adedeji and Tadawus (2019)[39] revealed (5.44 – 5.95%) for SC of maize-baobab pulp flour which is evidently lower than the SC of samples in this present study. Ukom*et al.*(2018)[25] reported (1.26 – 2.00%) for SC of cocoyam flour; Moses and Jeremiah (2019)[38] also reported (11.50 – 14.50%) for SC of yam flours which does not conform with SC of tuwo samples in this present study. Swelling capacity is the volume of expansion of molecules in response to water uptake, which it possess until a colloidal suspension is achieved or until further expansion and uptake is prevented by intermolecular forces in the swollen particles[51].

The results for the solubility index (S.I) of samples ranged between (9.69 – 13.97%) with sample 20CS registering the highest value (13.97%) while the least score (9.69%) was maintained by sample 10MS. There was no significant difference ($p \leq 0.05$) between sample 10CS and 20MS while statistical variation ($p \leq 0.05$) was observed between MF, 10MS and 20CS. These are not in consonance with (36.60 – 50.53%) for S.I of sorghum-okara flour by[23]. The S.I is commonly used to measure the amount of starch. Leashing of amylose is said to be responsible for solubility of starch in most starch-based products. As reported by[23], leaching is enhanced by hydrolysis to amylose during soaking; hence, the higher the solubility index, the better the reconstitution of the flour.

Wettability is the time taken for samples to absorb water[23]. The results ranged between (2.00 – 5.00 sec) with sample 20MS having the highest score (5.00 sec) while sample MF had the least value (2.00 sec). This implies that the more the level of cassava starch substitution, the more the period taken for samples to absorb water. No significant difference ($p \leq 0.05$) was registered between sample 10CS and 20MS while equal phenomenon was observed between 10MS and 20CS. Contrarily, MF differed from the other samples significantly ($p \leq 0.05$). Ilelaboye and Ogunsina (2018)[23] recorded (27.33 – 122.00 sec) for wettability of plantain-sorghum-okara flour blends which are evidently higher than the scores registered for samples in this current study. Glaring variation in the values could be attributed to the okara used in their study which must have changed the physical and chemical compositions of the plantain-sorghum flour thus making it less susceptible to imbibe water[52]. Dhingra and Jood (2004)[53] contributed that wettability is a function of ease of dispersing flour samples in water and the sample with the lowest wettability dissolves faster in water, hence, an indication that sample MF will dissolve faster in water that other samples.

The total carbohydrate contents of the tuwo samples varied between (68.71–86.87%). The result showed that the result showed that sample 20CS had the highest value (86.87%) while sample MF had the least value (68.71%). All samples had statistical variation ($p \leq 0.05$) while sample MF and 20CS differed significantly ($p \leq 0.05$).The carbohydrate contents obtained in this report was higher than (88.95 – 85.44%) reported by [54] for soy-cassava flour. Variation in the values of this current study and the cited literature could be due to difference in unit operations adopted in production of the flours. The low starch content in MF (100% maize flour) products could be attributed to the activities of microorganisms, which might have converted the starch into organic acids during processing[55] thus resulting in the low starch content.. The result obtained in this research work was higher than the result reported by[56] for lafun, starch and HQCF (55.60%, 63.75% and 65.17%) respectively in Assessment of the chemical and trace metal composition of dried cassava products from Nigeria.

The mean results ranged between (18.30 – 21.63 %) with sample 20CS having the highest amylose content (21.63%) while the least score (18.30%) was recorded by sample MF. All samples varied significantly ($p \leq 0.05$). This is slightly in consonance with (21.81 – 26.41%) reported for amylose content of Amala from different varieties of sweet potato in the previous work of[27]. On the other hand, the amylose content (17.3 – 20.1%) of maize/cassava flour in the study of [57] is in agreement with the values obtained for amylose content of tuwo samples in this current study. Amylose content represents the soluble content of starch in flour samples[58]. Idowu *et al.* (2013)[27] further added that the influence of amylose on the pasting properties of flour depends on its leaching out of the amylopectin network into the solution during heating which affects the starch present in the flour. As quoted by [57], the amylose/amylopectin ration in a food has been implicated to influence such properties as gelatinization, viscosity and retrogradation as well as textural quality of food. They further added that higher amylose content could contribute to more hardness of food gels obtained from starchy materials.

The color characteristics of tuwo samples prepared from different maize/cassava starch mixes are presented in Table 4. There was an increase in the lightness, L*-value of tuwo obtained from maize/cassava starch mixes ranging between (70.06 and 88.69). Sample 20CS recorded the highest score (88.69) while the least value (70.06 was observed by sample MF. Statistical variation ($p \leq 0.05$) existed between all samples. Bolade and Adeyemi, (2012)[57] registered (67.7 – 71.8) for color lightness of maize-cassava tuwo. Conversely, the increase in the values implies that lightness color intensity of tuwo could be enhanced by incorporating graded levels of cassava starch.

In respect to yellowness of tuwo samples, the values had a range of (1.97 – 2.70) with sample MF maintaining the highest score (2.70) while sample 20CS had the least value (1.97). Except for sample 10CS and 20MS ($p>0.05$), sample MF, 10MS and 20CS differed significantly ($p \leq 0.05$). This indicated that the higher the level of cassava starch substitution, the lesser the yellowness-index of the tuwo samples which could mean that the beta-carotene that may be a contributing factor to the yellowness was gradually reduced by substitution with maize and cassava starch adjuncts. Low yellowness index (a*) ranging between (-0.10 – 1.26) for maize-baobab tuwo was reported by[39] and (-0.10 – 1.26) for pre-gelatinized maize flour in the previous work of[2].

Redness-index (b*) of samples ranged between (0.39 and 0.68) with sample MF having the best score (0.68) while the least score (0.39) was observed in sample 20CS. Sample MF, 10MS and 10CS had no significant variation ($p>0.05$) while sample 20MS and 20CS differed significantly ($p \leq 0.05$). b* decreased with increase in level of cassava starch. Higher b* (9.64 – 13.77) were recorded for maize-baobab tuwo in the previous work of [39]. Conversely, color intensity is an index for color purity [59]; therefore, inclusion of cassava starch improved maize flour in that regard.

Table 5 presents the results for the selected mineral composition of tuwo samples. Knowledge of the concentration and type of specific metals present in food products is often important in the food industry. Trace metals such as calcium, sodium, magnesium, Fe, Zn and Cu are involved in the function of several enzymes and are essential for maintaining health throughout life[60]. This is because these metals are naturally present in food stuffs and are nutritionally important to humans, but toxic when consumed in excess. The deficiencies of these metals constitute the largest nutrition and health problem to populations in developed and developing countries [61]. The calcium content of the tuwo samples ranged between (8.06 – 15.32 mg/100g) with sample 20MS having the highest score (15.32 mg/100g) while the least score (8.06 mg/100g) was recorded for sample 20MS. No significant variation ($p>0.05$) was observed between samples 10CS and 10MS while other samples varied significantly ($p \leq 0.05$). The highest calcium content observed in 100% maize flour tuwo could be attributed to the maize phenotype [62, 63]. Calcium is necessary for the formation of bone and teeth in growing children [34].

The mean result for sodium level of tuwo samples ranged between (7.79 – 14.33 mg/100g). 100% maize flour tuwo (sample MF) had the best sodium content (14.33 %) while the least score of (7.79 mg/100g) was recorded for sample 20MS. All samples had statistical variation ($p \leq 0.05$). This slightly conforms to (7.77 – 11.41 mg/100g) for maize/spices ogi gruel in the previous work of [24]. Contrarily, [33]recorded (42.50 – 268.20 mg/100) for sodium level of maize/mushroom complementary food thus being evidently higher than the sodium level of tuwo samples registered in this current study. Their study also revealed that sodium to potassium (Na/K) ratio in the body is of great concern for the prevention of high blood pressure[33].

The mean result for the magnesium level of tuwo samples indicated a range between (97.06 – 137.47 mg/100g). 100% maize flour tuwo sample had the best level of magnesium (137.47 g/100g) while the least score (97.06 mg/100g) was recorded for sample 20MS. Statistical variation existed between all samples at ($p \leq 0.05$). This is synonymous to (95.29 – 167.47 mg/100g) reported for maize/mushroom complementary food in the previous work of [33]. However, lower level of magnesium (0.14 – 0.25 mg/100g) was observed for soybean/groundnut/crayfish flour in the study of [64].

The iron content of tuwo samples ranged between (15.59 – 32.60 mg/100g) with 100% maize flour having the highest score of (32.60 mg/100g) while the least value (15.59 mg/100g) was registered by sample 20MS. All the samples exhibited significant difference ($p \leq 0.05$). These values are exceedingly higher than (1.25 – 2.54 mg/100g) registered for maize/sesame/mushroom flour in the previous work of[33]. Higher values of iron (54.20 – 74.30 mg//100g) were reported for maize/soybean/groundnut/crayfish flour by[64].

Zinc is required for the satisfactory growth and maintenance of the human body and magnesium is required for energy generation, oxidative phosphorylation and glycolysis [64]. Zinc content of the tuwo samples ranged between (1.09 – 1.79 mg/100g). No significant difference ($p > 0.05$) occurred between sample 10CS and 10MS while other samples had statistical variation ($p \leq 0.05$). Omueti*et al*. (2009)[64] recorded (14.20 – 64.65 mg/100g) for zinc content of maize/soybean/groundnut/crayfish flour. According to [65], zinc level of foods remains constant after two months.

The results for the sensory evaluation of the respective tuwo samples are presented in Table 6. Sensory evaluation depicts the human perception of tuwo samples. For colour, sample produced from 100% maize flour was most acceptable by the panelist (8.6) while sample produced from 20% maize starch was least preferred (7.9). For appearance, sample MF was most preferred (8.7) while sample 20CS was least preferred (7.8). For texture, sample produced from 100 % maize flour was the least preferred by the panelist (8.5) while sample produced from 20CS had the highest preference value (8.7). For taste analysis sample MF was rated low (7.7) while sample 20CS had the least value (8.2). In term of aroma, sample 10MS had the highest value (8.7) while sample 20CS had the least value (7.7). For overall acceptability sample produced from 80% maize flour and 20% cassava flour was rated highest (8.8) while sample produced from 100% maize flour was the least preferred (7.8). The sensory quality rating of tuwo from maize flour/cassava and maize starch blends showed that tuwo from 80% maize and 20 % cassava starch inclusion was preferred in terms of texture (hand-mouldability) and overall acceptability.

V. Conclusion

The study established the variation in the proximate, functional properties, total carbohydrate, amylose content and mineral compositions among samples of maize flour blended with adjuncts of cassava starch and maize starch for tuwo preparation. The study revealed that results of functional properties, total carbohydrate and amylose content of maize-cassava starch results had advantage over 100% maize flour sample. The substitution of cassava starch in the production of maize tuwo has resulted in the production of tuwo with an improved acceptability level and better texture (hand mouldability) of maize tuwo.

Utilization of maize and cassava starch for production of tuwo should be encouraged on a commercial scale for tuwo flour production in order to improve acceptability level, better hand-mouldability and easier swallowability. These findings from this research would also be of immense relevance to the food industry particularly in the areas of ingredient formulation and food product development for quality enhancement.

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