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Evaluation of Starch Fractions, Color, Functional And Pasting Properties Of Composite Flours And Sensory Attributes Of Biscuits Containing Moringa Oleifera Seeds

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Abstract:
Composite flours were produced from blends of cassava, maize and wheat flours in varied proportions to which 3,5,10 and 20% Moringa oleifera seed flour was added respectively. Starch fractions, pasting properties, functional properties and color of the resultant composite flour samples were analyzed. Generally, the combination of the different flours in addition to the varied concentration of Moringa oleifera seed affected the various parameters analyzed. Results indicated that a concentration of more than 5% Moringa oleifera seed affected starch fractions such as resistant and digestible starch. Color analysis indicated lightness and negative a values showing the presence of greenish tinge. Sensory evaluation of biscuits from the composite flours and compared with biscuits from single flours of 100%wheat, cassava and maize showed that B_3 (85g Cassava:12g Maize:3g Moringa oleifera seed) and C_5 (90g Cassava:5g Maize:5g Moringa oleifera seed) compared well for the sensory parameters and overall acceptability with biscuits made from 100% wheat flour. A concentration of more than 5% inclusion of Moringa oleifera seed flour generally resulted to a decrease in the overall acceptability of biscuits from the composite flour blends. The order of acceptability of the composite flour blends was in this order: cassava/maize combination > wheat/cassava combination > wheat/maize and with not more than 5g Moringa oleifera seed flour /100g flour.*

Keywords: *Composite flour, cassava, maize, wheat, Moringa oleifera seed, color, functional properties, pasting properties, sensory evaluation, biscuits*

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I. Introduction

Wheat is one major cereal crop that is used in the manufacture of baked products. It is rich in carbohydrates, protein and minerals and is unique among the cereal grains flours in that when dispersed in water, its protein component forms an elastic network capable of holding gas and developing a firm spongy structure during baking (Hazelton *et al.,* 2003). The consumption of wheat flour in various food formulations have their profound good health benefits especially whole wheat flour. Refining has varied effects on wheat; hence the flour and some human populations react to wheat proteins i.e gluten such as in celiac disease. As such there is need to find alternative flour from other food raw materials and this have resulted to the advent of a technological term “Composite flour”. Composite flours can be considered as either a combination of wheat or other flour or entirely non- wheat blends of flours for the production of various baked goods which may be leavened or unleavened (Alim *et al.,* 2024). Blending of various types of flours from grains, tubers and legumes represent a promising alternative to traditional wheat flour in that these blends have enhanced nutritional profile by increased protein, dietary fiber, vitamins and antioxidants (Akinwotu *et al.*, 2025). Composite flours offer a viable strategy for enhancing the nutritional quality of pastry foods due to the fact that pastries from composite flours exhibit higher antioxidant activity, suggesting potential benefits of combating oxidative stress (Olamiti and Ramashia, 2024). The formulation of composite flours not only improves the nutritional quality of pastries, but also exploits under-utilized crops, contributing to food security and encouraging agricultural biodiversity (Olaoye and Ade-Omowaye, 2011).

The major carbohydrate polymer present in composite flours from various food sources is starch. Protein food ingredients are added to composite flours to enhance both nutritional and functional characteristics of such flours. The nature of starch in composite flours have both nutritional impacts, affects functional and rheological properties, hence the end use of the flour. Protein contents in flour is highly considered by bakers and millers as it affects functional performance of the flour and dough/batter such as water absorption, cohesiveness, viscoelasticity, dough strength, texture, loaf volume and crumb grain (Carson and Edwards, 2009; Finnie and Atwell, 2016). An important factor that determines the functional and physicochemical characteristics of starch is the ratio of amylose and amylopectin (Ritika *et al.,* 2010). Color is an important factor in flour quality and depends on both human vision studies and instrumental assessment (Philips, 2015).

Functional properties are fundamental physicochemical properties which shows how food ingredients behave during preparation and cooking (Orisa and Udofia,2020). The assessment of the functionality of composite flour in test baking is crucial to ensure and increase the use of such composite flours made from various raw materials (Noorfarahzilah *et al.,* 2014). Pasting property is an important starch physicochemical property and is influenced by many factors (Bemiller, 2011). These factors include amylose content, thermal properties, amylose-lipid complex formation of the starches which greatly influence pasting and gelling behaviors at different cooking temperatures (Liu *et al.,* 2019). Pasting properties of food can be linked to the cooking quality and texture of the food, hence a good index of the texture quality in most starch foods (Egwujeh *et al.,* 2016).

Cassava is a staple food crop grown and consumed by numerous populations of people in various parts of Africa, Asia, and Latin America and it is the fourth large source of calories in the world (Chavarriaga-Aguirre *et al.,* 2016). Cassava has been genetically modified to have various qualities such as resistance to cassava pest and diseases as well as improved nutritional qualities such as low cyanide, high carotenoid and in some varieties, appreciable mineral contents. This gives rise to phenomenon known as "sweet cassava varieties". These genetically modified cassava roots are processed into various products, one of such is the high-quality cassava flour (HQCF). HQCF is an unfermented cassava flour that can be used as partial replacement for wheat for many bakery and pasta products.

Maize is an important cereal crop with diverse uses as food, feed, fodder and industrial applications and is regarded as an 'nutri-cereal' because many tribal populations depend on maize as their essential diet ingredient (Joyti *et al.,* 2019). *Moringa oleifera* is cultivated across the world and has high nutritive values and every plant part is suitable for either nutrition or commercial purposes (Gopalakrishan *et al.,* 2016). *Moringa oleifera* seeds are good sources of protein and it can be combined with cereals such as rice, corn, sorghum, millet to produce complementary foods with balanced protein (Saa *et al.,* 2009).

This research work aimed at producing composite flour blends of cassava, maize and wheat to which varied concentrations of *Moringa oleifera* seed flours were added as the protein source. Color, pasting and functional properties as well as starch fractions of the composite flour blends were evaluated. Theses flours were used to produce biscuits and the sensory properties of the biscuit samples were evaluated.

II. Materials And Methods

Sourcing of Raw Materials

High quality cassava flour was produced using genetically modified cassava TMS419 variety. Yellow maize was used to produce maize flour. *Moringa oleifera* seeds were de-husked and milled to obtain flour (it was not defatted). TMS419 cassava roots where obtained from the National Root Crops Research Institute, Umudike, Abia State, Nigeria. Yellow maize, wheat flour and *Moringa oleifera* seeds were purchased from local markets namely Ubani Market and Orie Ugba market all in Umuahia, Abia State, Nigeria.

Figure 1 shows the flow chart of steps adopted in the production of high-quality cassava flour (HQCF), production of maize flour and steps adopted in the production of *Moringa oleifera* seed flour:

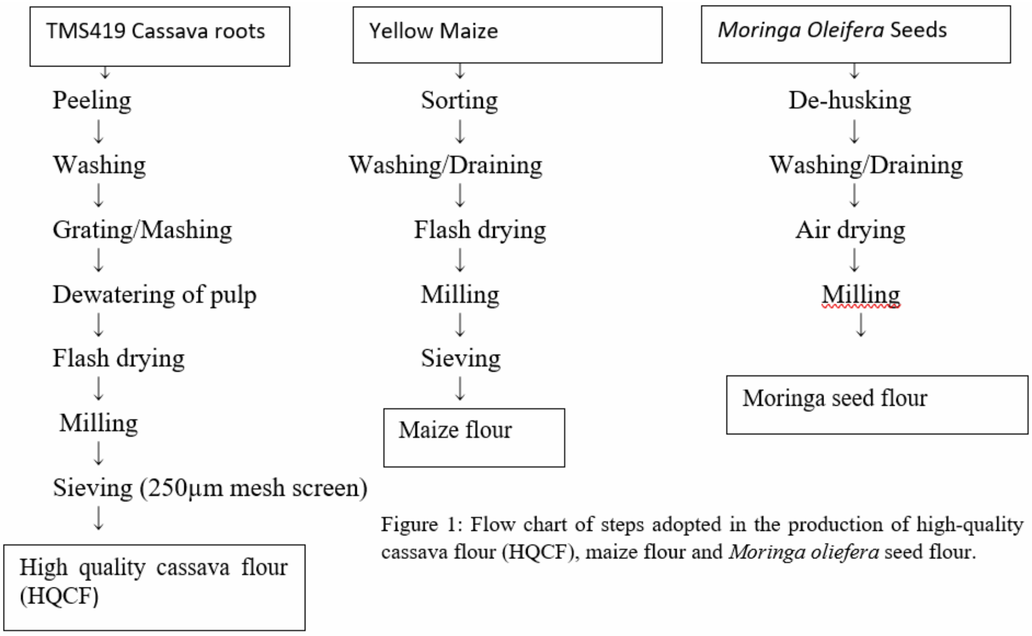

Figure 1: Flow chart of steps adopted in the production of high-quality cassava flour (HQCF), maize flour and *Moringa oliefera* seed flour.

Formulation of Composite Flour Blends: Composite flour lends were formulated using mixes of cassava flour, maize flour, wheat flour to which varied concentrations of *Moringa oleifera* seed flour of 3%, 5%, 10% and 20% were added. Table 1 shows the ratio of the flour samples and how they were combined to generate various composite flour blends.

Table 1: Formulation of Composite Flour Blends

Sample	Wheat flour(g/100g)	Cassava flour (g/100g)	Maize flour (g/100g)	*Moringa oleifera* seed flour(g/100g)
A_3	-	80	17	3
B_3	-	85	12	3
C_3	-	90	7	3
D_3	85	-	12	3
E_3	85	12	-	3
F_3	97	-	-	3
A_5	-	80	15	5
B_5	-	85	10	5
C_5	-	90	5	5
D_5	80	-	10	5
E_5	85	10	-	5
F_5	95	-	-	5
A_{10}	-	75	15	10
B_{10}	-	80	10	10
C_{10}	-	85	5	10
D_{10}	80	-	10	10
E_{10}	80	10	-	10
F_{10}	90	-	-	10
A_{20}	-	65	15	20
B_{20}	-	70	10	20
C_{20}	-	75	5	20
D_{20}	70	-	10	20
E_{20}	70	10	-	20
F_{20}	80	-	-	20

Color measurement: Color of the various flour samples was determined using a Chroma meter (CR 310, Konica Minolta, Japan). It was calibrated using a standard white tile. The respective flour samples were uniformly packed in clean petri plates with lid. The instrument head was placed on the plate and exposures were conducted using CIE L*a*b* system of color measurement where by L^*ranged from 0 (black) to 100

(Lightness/white), a^* values ranged from -80 (green) to +100 (red) and b^* values ranged from -80 (blue) to +70 (yellow). L^*a^* b^* values of the flour samples were recorded respectively. The indices Chroma (C^*) and hue angle (α) values which pertains to color perception of consumers (McGuire, 1992) were calculated from the a* and b* values stated by Karaaslan and Tunçer (2008) as:

.....………………(1)

h^o = Arc tan …………………..(2)

Whiteness and yellowness index were calculated by equations stated by Lin *et al*. (2009) and Saberi *et al*. (2016) respectively as:

Whiteness index (WI): 100- …………………………….(3)

Yellowness index (YI) : ………………………………………………………(4)

Analysis of starch components:

Determination of total starch: Total starch was determined by the AOAC method 996.11 described by McCleary *et al*. (1997). 50g of each flour sample was passed through a 0.5mm screen and 100mg of the sieved flour was weighed into a glass centrifuge. The tube was tapped to ensure all the samples falls to the bottom of the tube before 0.2mi ethanol (80% v/v) was added and the contents were stirred on a vortex mixer before 2ml dimethylsulphoxide was added and stirred continuously on the vortex mixer for 3min. Subsequently the tube with its contents were placed in a vigorously boiling water bath for 5min. Immediately3ml of thermostable α-amylase was added and the tube was incubated in a boiling water bath for 6min with intermediate vigorous stirring after 2,4, and 6min to ensure homogeneity. After which, the tubes were placed in a water bath at 50ºC and 0.1ml amyloglucosidase suspension was added to the mixture and the contents were stirred on a vortex mixer and incubated at 50ºC for 30min. After this step, the contents were transferred to a 100ml volumetric flask and distilled water was used to rinse tube contents thoroughly and the volume was adjusted to 10ml and mixed thoroughly before centrifuging at 3000rpm for 10min. 1ml of the supernatant was diluted to 10ml with distilled water. A reagent blank, glucose standard and test sample were subjected to endpoint analysis using GOD-PAP reagent. For the test sample, 0.1ml of diluted supernatant was dispensed into a test tube and 3ml GOD-PAP reagent was added, the blank contained 3ml GOD-PAP reagent and 0.1,m water while the standard contained 3ml GOD-PAP reagent plus 0.1ml glucose standard. All these were incubated at 50ºC for 20min and absorbance were read at 510nm against the reagent blank. Total starch was calculated as:

Starch (%) = ΔA X X FV X 0.9..(5)

ΔA is sample GOD-PAP absorbance read against reagent blank

F is the factor used to convert from absorbance to µg of glucose

W is weight of sample analysed in mg

FV is final volume of solution used.

Determination of amylose and amylopectin: Amylose was determined by the iodine colorimetric method described by Mohana *et al*. (2007). Each flour sample was defatted prior to analysis.100mg of the defatted flour was weighed into 100ml volumetric flask to which 1ml 95% ethanol and 9ml 1N NaOH were added and mixed thoroughly respectively. After which they were heated on boiling water bath to gelatinize the starch and later on cooled to room temperature. 5ml of the gelatinized starch solutions were dispensed into a 100ml volumetric flask to which 1ml of 1N acetic acid and 2ml of iodine solution were added and the volume made up to 100ml with distilled water respectively. All the contents were thoroughly vortexed mixed and allowed to stand for 20mins. Absorbance was measured at 620nm in a spectrophotometer using a blank containing 5ml 0.09N NaOH, 1ml acetic acid and 2ml iodine solution and made up to 100ml volume using distilled water. The amylose content was determined based on the standard curve prepared using potato amylose. Amylopectin was calculated by difference stated by Juan et al. (2006) as:

Amylopectin (%) = 100 - Amylose (%) ....**.......... (6)**

Evaluation of resistant starch: Resistant starch was evaluated by the method described by Goñi *et al*. (1996). 100mg of each flour sample was dispensed into centrifuge tube and 10ml KCl-HCl buffer (pH1.5) was added and the respective mixtures and homogenized. 0.2ml pepsin was added to the homogenized sample mixture and incubated at 40ºC for 60min with constant shaking in a water bath. After which the sample was cooled to room temperature, 9ml Tris -maleate buffer (pH 6.9) was added alongside 1ml α-amylase was added to the mixture, shaken well and incubated for 16h at 37ºC in a water bath with constant shaking. Subsequently the sample was centrifuged for 15min at 3000rpm and the supernatant was discarded leaving the sediment. The sediment was washed once with 10ml distilled water, centrifuged and the supernatant discarded before adding 3ml distilled water and 3ml 4M KOH. The contents were mixed thoroughly and left to stand at room temperature for 30min with constant shaking before 5ml buffer (pH 4.75) and 0.08ml amyloglucosidase were added and mixed. The respective sample mixtures were incubated for 45min at 60ºC in a water bath with constant shaking. The

mixtures were clarified by centrifuging at 3000rpm for 15min and the supernatant siphoned into volumetric flasks respectively. Each sample residue was washed twice with 10ml distilled water and clarified by centrifuging each time and the supernatant recovered and combined with was put into the volumetric flask. Each recovered sample supernatant solution was made up to 100ml using distilled water. A standard curve containing 10-60ppm glucose was generated. 0.5ml water, sample and standard glucose solution was dispensed into test tubes. 1ml GOD-PAP was added to each to each test tube and incubation was done for 30min at 37ºC in a water bath. Absorbance of test and standards were read at 500nm against reagent blank. The standard curve was used to calculated glucose concentration of the sample. Resistant starch was calculated as:
Resistant starch (%) = mg of glucose X 0.9...(7)
Digestible starch was calculated as: Total starch -Resistant starch……………………… (8)

Evaluation of pasting properties: Pasting properties of each flour sample was evaluated using Rapid Visco Analyser (Dingling RVU 232015, USA) by methods described by AACC (2000). A 3g flour sample was dispersed in an aluminium canister containing 25ml of distilled water. Each sample mixture underwent a controlled heating and cooling cycle under constant shear where it was held at 50ºC for 1min, heated from 50 to 95ºC at 6 ºC/min and held at 95ºC for 5min. Finally, each sample was cooled to 50ºC and held for another 2min. The starch viscosity parameters measured were peak viscosity(PV), hot paste viscosity (HPV; ie trough) is viscosity at the end of hold time at 95ºC, breakdown viscosity (BDV; PV- HPV), cool paste viscosity (CPU) ~ final viscosity-viscosity at the end of the hold time at 50ºC; setback viscosity (SBV) ~ (CPU-HPV), pasting time= time from onset of pasting to peak viscosity, pasting temperature= temperature from onset of pasting to peak viscosity. Stability ratio (SR) = and setback ratio (SBR) = were calculated prescribed by Julianti *et al*. (2017).

Evaluation of functional properties:
Bulk density: Bulk density of the flour samples was determined by the method described by Onabanjo and Ighere (2014). A 50g weight of each flour sample was put into 100ml measuring cylinder. The cylinder was tapped several times on a laboratory bench to a constant volume. The volume of sample was calculated as:
Bulk density (g/cm³)= ……………………………………….(9)

Water absorption capacity (WAC) and oil absorption capacity (OAC): These were determined by the methods described by Onabanjo and Ighere (2014). For WAC, 1g of each flour sample was dispensed into 25ml centrifuge tube and 15ml distilled water was added respectively. The tubes were agitated on a vortex mixer for 2min. Each sample suspension was centrifuged at 1000rpm for 20min and after which, the clear supernatant was decanted and discarded. The wet flour residues were reweighed and water absorption was expressed as weight of water bound by 100g dried flour respectively. The same procedure was used for oil absorption capacity except that water was replaced with vegetable oil of specific gravity of 0.98g/ml. Water absorption capacity and oil absorption capacity were expressed as:
WAC/OAC (g/g) = ………………………………………………………(10)

Emulsion Capacity: This was determined by the method described by Klompong*et al*. (2007). A mixture of 2g of the respective flour samples was blended with25ml distilled water at room temperature for 30seconds in a blender respectively. After complete dispersion, 25ml vegetable oil was added gradually and blending continued for another 30 seconds. The respective sample emulsions were transferred to calibrated centrifuge tubes and centrifuged at 1600rpm for 5min. The volume of oil separated from the sample centrifuging was read directly from the tube. Emulsion capacity was expressed as the amount of oil and held per gram of sample and expressed in percentage.

Emulsion stability: This was determined by the method of Yasumatsu *et al*. (1972). Emulsion stability was estimated after heating the emulsion in the calibrated centrifuge tube which was obtained from the determination of emulsion activity at 80ºC for 30min in a water bath. This was followed up by cooling for 15mins under running tap water and centrifuged at 2000rpm for 15min. Emulsion stability was expressed as:
Emulsion stability (%)= X …………………………… (11)

Foam capacity and Foam stability: Foam capacity and foam stability were determined by the methods described by Narayana and Narasinga Rao (1982) respectively. Foam capacity was evaluated by dispensing 1g flour sample into a blender and 10ml deionized water (pH adjusted to 7.4 using 1N NaOH and 1N HCl) was added. The mixture was blended for 5min before turning into a 250ml graduated cylinder and the foam volume was recorded immediately. Foam capacity was calculated as:
Foam capacity (%) = X ……………………….(12)

Foam stability: Foam stability was evaluated by recording foam volume in the cylinder 1h after whipping as percent of initial foam volume.
Foam stability (%)= X ……………..(13)

Swelling index and swelling capacity: These were analysed by the methods described by Ukpabi and Ndimele (1990). Swelling index was determined by dispensing 25g of each flour sample into 250ml measuring cylinder. 150ml deionized water was added and the mixture was shaken and allowed to stand for 4h before observing the extent of swelling. Swelling index was calculated as:
Swelling index (g/g)= ………………….(14)
Swelling capacity: The gel obtained after determining swelling index was used in calculating swelling capacity as:
Swelling capacity (g/g) = …………………………...(15)

Dispersibility index: This was determined by the methods described by Kulkarni *et al*. (1991). 10g of flour sample was weighed into a graduated cylinder and 100ml distilled water was added respectively. Each sample mixture was shaken vigorously and allowed to stand for 3h before the volume of settled particles was recorded and subtracted from 100.The difference was reported as percentage dispersion.

Gelatinization temperature: Gelatinization temperature was determined by Chandra *et al*. (2015). One gram of the respective flour samples was weighed and dispensed into 20ml screw capped tubes. Ten ml of water was added to each sample. The samples were heated slowly in a water bath until they formed a solid gel. When gels were formed completely, the respective temperatures were measured and taken as gelatinization temperature.

Production of biscuit samples:

Biscuits were produced using the various composite flour using the modified recipe of Onabanjo and Ighere (2014). Biscuit was also produced using single flours (ie 100%) of wheat, cassava and maize respectively. Each dough mixture was made of 250g flour, 63g fat, 63g sugar, 1g salt, 20ml whole egg, 5g powdered milk, 1.5nutmeg, 1g baking powder and 50 to 60ml water. These were mixed using the traditional creaming method described by Chinma *et al*. (2011). Fat and sugar were mixed in a Kenwood mixer to get a fluffy texture. Eggs and milk were added while mixing continued. Baking powder, salt, nutmeg (ground), flour was introduced into the mixture to form a soft dough respectively. After proper mixing in the mixer, each dough sample was removed from the bowl of the mixer onto a chopping board and kneaded. Each kneaded dough sample was rolled into sheets using a rolling pin and cut into desired shape using a stainless-steel cutter. Baking trays were labeled, lined with aluminum foil, greased with vegetable oil before the cut samples were placed on them. Baking was done at 170°C for 15min.

Sensory evaluation of biscuit samples

Sensory characteristics of the coded biscuit samples from the composite flours were evaluated for different sensory attributes by fifteen (15) semi-trained panelists of young adults drawn from the Faculty of agriculture, Abia State University, Umuahia Location. All the panelists were briefed before the commencement of the evaluation process. Water was provided to rinse the mouth between evaluations. Control biscuits made from single flours (i.e. 100%) wheat, cassava and maize were presented to the panelists. Sensory attributes namely aroma, color, texture, crispiness, taste and overall acceptability were evaluated. The rating was on a nine-point hedonic scale ranging from 9(like extremely) to 1(dislike extremely) (Ihekoronye and Ngoddy, 1985).

Statistical analysis

All the data were subjected to statistical analysis using one-way analysis of variance (ANOVA) using Statistical Package for the Social Sciences (SPSS) 20.0 version. Values were expressed as mean ± standard deviation. Means were separated using Duncan New Multiple Range Test (DNMRT)

III. Results And Discussion

Starch components of composite flour: Table 1 shows starch components of the composite flour blends. There was significant differences ($p<0.05$) in starch components of some of the composite flour blends. Total starch content ranged between 63.13% (A_3:80g cassava:17g maize:3g *Moringa oleifera* seed flour {MOSF}) and 71.15% (D_3:85g wheat:12g maize:3g MOSF). It was observed that samples without wheat flour but had varied concentrations of cassava and maize flour to which 3, 5 or 10g MOSF was added (i.e samples A_3 to C_3, A_5 to C_5 and A_{10} to C_{10}) had lower total starch content than in samples with blends of wheat and maize or wheat and cassava and had 3, 5,10g MOSF (i.e samples D_3, E_3, D_5, E_5 D_{10}, E_{10}, D_{20} and E_{20}). Cassava/maize flour combinations containing 20g MOSF namely A_{20} (65g cassava:15g maize:20g MOSF) and B_{20} (70g cassava:10g maize:20g MOSF) had higher starch concentrations than wheat/cassava (E_{20}: 70g wheat:10g cassava:20g MOSF) and wheat/maize (D_{20}:70g wheat:10g maize:20g MOSF) to which 20%MOSF was added.

Digestible starch (DS) content ranged between 54.62% (D_{20}:70g wheat:10g maize:20g MOSF) and 69.14% (D_3:85g wheat:12g maize:3gMOSF). Wheat/maize combinations containing 3 and 5g MOSF had the highest digestible starch content of 69.14% (D3) and 68.19% (D5). It was observed that blends of wheat/maize containing 3 and 5g MOSF had higher digestible starch than wheat/cassava blends containing same amount of MOSF while cassava/maize combinations containing 3g or 5g MOSF had lower DS. Generally, digestible starch of composite flour blends to which either 10 or 20% MOSF was added had lower values than composite flour blends which had 3 or 5g MOSF. This could be attributed to compounds present in *Moringa oleifera* seed notably saponins and tannins which at high levels inhibit the activity of enzymes. Leon-Lopez *et al.* (*2020*) reported moringa seed kernel to be a promising source of phenolics and protein, but it has high concentration of phytic acid, saponin and tannins. It was also reported that *Moringa oleifera* seeds is capable of inhibiting α-amylase hence inhibiting absorption of glucose resulting to its antihyperglycemic action (Azad *et al.,* 2020). This explains why a higher concentration of either 10 and 20g in the composite flour blends resulted to lower digestible starch than flour blends which had 3 to 5g MOSF.

Resistant starch of the composite flour samples ranged between 1.82% (D_5:85g wheat:10g Maize: 5g MOSF) and 14.70% (E_{20}:70g wheat:10g cassava:20gMOSF). There was no significance difference (p>0.05) in the resistant starch of D_{20} (70g wheat:10g maize:20gMOSF) and E_{20} (70g wheat:10g cassava:20gMOSF) which had values of 14. 64% and 14.70% respectively. It was observed that composite flour blends which had 10 and 20g MOSF had higher resistant starch content than those which had 3 and 5g MOSF. Resistant starch is considered a type of fiber which is resistant to the action of digestive enzymes and is thought to play crucial role in the body's glucose and insulin responses to food (Min *et al.,* 2024). The resistance of starch digestion is influenced by the ratio of amylose to amylopectin with amylose being more slowly digested while amylopectin is rapidly digested especially after retrogradation (Min *et al.,* 2024). Goñi *et al.,* (1996) classified resistant starch into negligible (≤1%), low (1 to 25%), intermediate (2.5 -5.0%), high (5-15%) and >15% as very high resistant starches. The results from our study showed that the composite flour blends which had 3 to 5g MOSF can be categorized into normal resistant starch groups while composite flour blends which had 10 to 20% MOSF can be classified as high resistant starch groups.

Amylose content of the flour samples ranged between 17.65% (C_3:90g cassava:7g maize:3g MOSF) and 47.88% (D5:85g wheat:10g maize:5g MOSF). Most of the flour samples which had MOSF at a concentration of 10 or 20g had lower amylose content than those which had 3 or 5g MOSF except cassava/maize combinations which had 3g MOSF ie A_3 to C_3. Amylose content of the composite flour blends obtained in our research work was comparable to those reported by Pakkawat *et al.* (2021) for rice and unripe banana composite flour with values which ranged between 15.91% to 42.64%. The lower amylose content obtained with the inclusion of a higher concentration of MOSF could be attributed to the high concentration of proteins and lipids from MOSF which got bound to amylose complexes making them unavailable. Yun *et al.,* (2020) reported the formation of amylose –lipid complexes which have characteristics such as lower bulk densities, poor digestion rates and high resistant starch. Amylose content is the underlying factor for categorizing starches into waxy, semi wax, normal and high amylose types when amylose content is 0-2%, 3-15% and > 40% of the total starch respectively (Morante *et al*., 2015) By this classification, the composite flour blends can be classified as normal/regular amylose types except D_3, D_5 and F_5 which are high amylose type starches.

Amylopectin of the composite flour blends ranged between 22.12% (D_5) and 49.38% (C_3). It was observed that composite flour blends which contained 10 or 20% MOSF had higher amylopectin content than combinations which had 3 or 5g MOSF except C_3. Yani *et al.,* (2014) reported values between 36.68 and 43.98% for composite blends of cassava, sweet potato, corn and rice bran. The lower values of amylopectin in composite flour blends which had 3 and 5g MOSF is beneficial in reducing postprandial blood glucose. It has been reported that digestive enzymes digest amylose slowly than amylopectin which has a branched structure (Guiberti *et al.,* 2015).

Table 1: Results on Starch component of composite flour blends of cassava, maize and wheat containing varied concentrations of *Moringa oleifera* seed flour

Sample	Total Starch (%)	Digestible Starch (%)	Resistant Starch (%)	Amylose (%)	Amylopectin (%)
A_3	$63.13^{l} \pm 0.01$	$59.62^{j} \pm 0.01$	$3.51^{m} \pm 0.00$	$28.52^{j} \pm 0.02$	$39.62^{g} \pm 0.01$
B_3	$67.61^{h} \pm 0.43$	$63.58^{g} \pm 0.47$	$4.03^{k} \pm 0.04$	$24.20^{l} \pm 0.01$	$43.43^{f} \pm 0.44$
C_3	$67.03^{i} \pm 0.00$	$62.78^{h} \pm 0.01$	$4.25^{j} \pm 0.00$	$17.65^{n} \pm 0.03$	$49.38^{a} \pm 0.01$
D_3	$71.15^{a} \pm 0.00$	$69.14^{a} \pm 0.00$	$2.01^{a} \pm 0.00$	$46.81^{b} \pm 0.00$	$24.34^{n} \pm 0.00$
E_3	$69.34^{c} \pm 0.01$	$65.91^{d} \pm 0.01$	$2.45^{m} \pm 0.03$	$35.11^{g} \pm 0.01$	$34.24^{i} \pm 0.01$

F_3	$70.02^{b} \pm 0.00$	$66.99^{c} \pm 0.00$	$3.23^{o} \pm 0.02$	$39.91^{e} \pm 0.03$	$30.11^{k} \pm 0.04$
A_5	$67.10^{i} \pm 0.00$	$63.88^{g} \pm 0.00$	$3.22^{n} \pm 0.00$	$37.21^{f} \pm 0.02$	$29.90^{k} \pm 0.01$
B_5	$66.22^{j} \pm 0.01$	$62.42^{h} \pm 0.01$	$3.81^{l} \pm 0.02$	$34.03^{h} \pm 0.01$	$32.20^{j} \pm 0.03$
C_5	$65.84^{k} \pm 0.01$	$61.84^{ij} \pm 0.01$	$4.01^{k} \pm 0.01$	$29.72^{i} \pm 0.01$	$36.13^{h} \pm 0.01$
D_5	$70.00^{b} \pm 0.01$	$68.19^{b} \pm 0.01$	$1.83^{f} \pm 0.02$	$47.88^{a} \pm 0.00$	$22.12^{o} \pm 0.01$
E_5	$68.20^{a} \pm 0.00$	$65.00^{e} \pm 0.00$	$3.20^{n} \pm 0.00$	$41.10^{d} \pm 0.02$	$27.12^{l} \pm 0.02$
F_5	$69.02^{od} \pm 0.01$	$66.20^{d} \pm 0.03$	$2.82^{p} \pm 0.02$	$43.92^{c} \pm 0.01$	$25.11^{m} \pm 0.01$
A_{10}	$68.37^{fg} \pm 0.06$	$51.43^{mn} \pm 0.13$	$13.94^{e} \pm 0.06$	$23.30^{m} \pm 0.00$	$45.07^{bc} \pm 0.05$
B_{10}	$68.20^{g} \pm 0.01$	$54.38^{mn} \pm 0.02$	$13.83^{f} \pm 0.01$	$23.36^{m} \pm 0.04$	$44.84^{cd} \pm 0.06$
C_{10}	$68.33^{fg} \pm 0.01$	$55.37^{k} \pm 0.04$	$12.96^{c} \pm 0.04$	$23.36^{m} \pm 0.04$	$44.97^{bcd} \pm 0.05$
D_{10}	$67.97^{g} \pm 0.05$	$54.62^{lmn} \pm 0.03$	$13.35^{g} \pm 0.02$	$24.71^{k} \pm 0.45$	$43.26^{f} \pm 0.05$
E_{10}	$68.01^{g} \pm 0.03$	$54.77^{klm} \pm 0.00$	$13.24^{h} \pm 0.03$	$23.92^{l} \pm 0.06$	$44.09^{e} \pm 0.09$
F_{10}	$68.05^{g} \pm 0.06$	$55.07^{kl} \pm 0.04$	$12.98^{c} \pm 0.02$	$23.99^{l} \pm 0.00$	$44.06^{e} \pm 0.06$
A_{20}	$69.18^{cd} \pm 0.22$	$55.02^{kl} \pm 0.12$	$14.16^{c} \pm 0.10$	$24.01^{l} \pm 0.01$	$45.17^{bc} \pm 0.21$
B_{20}	$69.27^{cd} \pm 0.07$	$54.87^{klm} \pm 0.05$	$14.41^{b} \pm 0.02$	$23.91^{l} \pm 0.04$	$45.37^{b} \pm 0.11$
C_{20}	$68.17^{g} \pm 0.33$	$54.34^{n} \pm 0.41$	$13.84^{f} \pm 0.08$	$24.16^{l} \pm 0.10$	$44.01^{e} \pm 0.42$
D_{20}	$68.15^{a} \pm 0.06$	$53.49^{p} \pm 0.01$	$14.66^{a} \pm 0.04$	$24.22^{l} \pm 0.02$	$43.94^{e} \pm 0.04$
E_{20}	$68.61^{ef} \pm 0.56$	$53.91^{o} \pm 0.59$	$14.70^{a} \pm 0.03$	$23.99^{l} \pm 0.01$	$44.62^{d} \pm 0.57$
F_{20}	$68.95^{de} \pm 0.08$	$54.91^{klm} \pm 0.18$	$14.04^{d} \pm 0.10$	$24.16^{l} \pm 0.10$	$44.79^{cd} \pm 0.02$

Values are Means ± standard deviation. Values with different superscripts in the same column are significantly different ($p<0.05$). A_3:80g Cassava:17g Maize:3g *Moringa oleifera* seed flour; B_3:85gCassava:12g Maize:3g *Moringa oleifera* seed flour; C_3: 90gCassava:7gMaize:3g*Moringa oleifera* seed flour; D_3:85gWheat:12gMaize:3g *Moringa oleifera* seed flour; E_3: 85gWheat:12gCassava:3g *Moringa oleifera* seed flour; F_3:97gWheat: 3g*Moringa oleifera* seed flour; A_5: 80gCassava:15gMaize:5g*Moringa oleifera* seed flour; B_5: 85gCassava:10gMaize:5g*Moringa oleifera* seed flour; C_5: 90gCassava: 5gMaize:5g*Moringa oleifera* seed flour; D_5:85gWheat:10gMaize:5g *Moringa oleifera* seed flour; E_5: 85gWheat:10gCassava:5g *Moringa oleifera* seed flour; F_3:95gWheat: 5g*Moringa oleifera* seed flour; A_{10}:75g Cassava:15g Maize:10g*Moringa oleifera* seed flour; B_{10}:80g Cassava: 10gMaize:10g *Moringa oleifera* seed flour; C_{10}: 85gCassava:5gMaize:10g*Moringa oleifera* seed flour; D_{10}:80gWheat:10gMaize:10g *Moringa oleifera* seed flour; E_{10}: 80gWheat:10gCassava:10g *Moringa oleifera* seed flour; F_{10}:90gWheat: 10g*Moringa oleifera* seed flour; A_{20}:65gCassava:15g Maize:20g *Moringa oleifera* seed flour; B_{20}:70gCassava:10gMaize:20g*Moringaoleifera*seed flour; C_{20}: 75gCassava:5gMaize:20g*Moringa oleifera* seed flour; D_{20}:70gWheat:10gMaize:20g *Moringa oleifera* seed flour; E_{20}: 70gWheat:10gCassava:20g *Moringa oleifera* seed flour; F_3:80gWheat: 20g*Moringa oleifera* seed flour;

Color attributes of Composite flour: Table 2 shows results on the color parameters of the composite flour samples and compared with 100% wheat. Color is the most significant distinctive characteristics in the view of consumers which may reflect the final quality of the product (Salamon *et al.*, 2024). L^* values measures lightness (100) and darkness (0), a^* value measures greenness (negative values) and redness (positive while b^* value measures blueness (negative) and yellowness (positive). There were significant differences ($p<0.05$) in these color parameters of the composite flours. L^* values ranged between 66.48 (D_3) and 74.27 (F_3) for the composite flour blends while 100% wheat had a value of 69.33. This indicated that blending the various ingredients in the composite flours resulted to light colored flours.

a* values ranged between -1.49 (D_3) and -0.39 (F_3). This indicated there was a greenish color at varied concentrations in the flour samples. It was observed that as the concentration of maize decreased in cassava/maize blends, the greenish color increased with the addition of varied concentrations of MOSF. b* values ranged between 8.57 (C_3) and 15.57 (D_{20}). The addition of yellow maize and MOSF affected yellowness of the composite flours. Yellowness decreased gradually as the concentration of maize decreased in the cassava maize blends. For wheat composite blends, it was observed that the wheat/maize blends with varied concentration of MOSF had more intense yellow color than wheat/cassava blends having same concentration of maize with varied MOSF. Yellowness is often associated with carotenoid content in foods. This is evident based on the values obtained for whitening index (WI) and yellowness index (YI). Results indicated that as the concentration of maize decreased in the cassava/maize blends, whiteness index increased while yellowness index decreased. Whiteness index was higher in the wheat/cassava composite blends (ie Samples $E_{3,5,10,20}$) than in the wheat/maize blends (ie samples $D_{3,5,10,20)}$. Maize and MOSF contributed to the yellowness index of the composite flour blends.

Hue angle (h°) describe the relative amount of redness and yellowness where 0°/360° is defined for red/magenta, 90° for yellow, 180° for green and 270° for blue or purple or intermediate colors between adjacent pairs of these basic colors (McGuire, 1992; Kortei and Akonor, 2015) which represents first, second, third and fourth quadrant respectively. Our results showed that both wheat flour and composite flour blends were located in the second quadrant (90° to 180°) that corresponds to color varying from yellow to green. Singh *et al*. (2023) reported h° which ranged between 94.29 and 110.68 for sugar cane juice heated at varied time and temperatures and classified them to have hue of yellow to green.

Chroma represents color saturation. It was observed that a higher concentration of maize alongside a gradual increase in MOSF resulted to more saturated colors in cassava/maize blends as well as wheat/maize blends with varied MOSF than in wheat/cassava blends with same varied concentration of MOSF. The higher the chroma values, the higher the color intensity of samples perceived by humans (Pathare *et al*., 2013). It can be deduced that maize in the blends had a good effect in producing more saturated color in the composite flours in combination with color from *Moringa oleifera* seed flour.

Table 2: Results on Color attributes of composite flour blends of composite flour blends of cassava, maize and wheat containing varied concentrations of *Moringa oleifera* seed flour and compared with 100% wheat flour

Sample	L*	a*	b*	Hue (h°)	Chroma	WI	YI
A_3	$71.03^{bcd} \pm 0.62$	$-1.38^{lm} \pm 0.03$	$11.22^{h} \pm 0.11$	$97.02^{a} \pm 0.21$	$11.13^{g} \pm 0.11$	$69.01^{cde} \pm 0.84$	$22.54^{g} \pm 2.22$
B_3	$71.86^{b} \pm 0.17$	$-1.08^{j} \pm 0.00$	$9.32^{lm} \pm 0.06$	$96.61^{ab} \pm 0.05$	$9.25^{m} \pm 0.06$	$70.40^{b} \pm 0.12$	$18.55^{m} \pm 0.13$
C_3	$73.75^{a} \pm 0.09$	$-0.90^{fgh} \pm 0.10$	$8.57^{a} \pm 0.13$	$95.99^{abcd} \pm 0.57$	$8.52^{o} \pm 0.12$	$72.40^{a} \pm 0.57$	$16.60^{o} \pm 0.23$
D_3	$68.88^{f} \pm 0.33$	$-1.49^{m} \pm 0.04$	$12.59^{e} \pm 0.06$	$96.95^{a} \pm 0.22$	$12.50^{d} \pm 0.06$	$66.46^{hj} \pm 0.29$	$26.11^{d} \pm 0.01$
E_3	$71.53^{bc} \pm 0.24$	$-0.68^{cde} \pm 0.09$	$9.74^{k} \pm 0.04$	$94.02^{fgh} \pm 0.52$	$9.71^{k} \pm 0.03$	$69.92^{bc} \pm 0.29$	$19.44^{k} \pm 0.14$
F_3	$71.08^{bcd} \pm 0.38$	$-0.39^{a} \pm 0.06$	$10.67^{i} \pm 0.11$	$92.09^{ij} \pm 0.28$	$10.69^{h} \pm 0.15$	$69.18^{cd} \pm 0.32$	$21.45^{h} \pm 0.11$
A_5	$70.80^{bcd} \pm 0.18$	$-1.31^{l} \pm 0.04$	$10.25^{i} \pm 0.09$	$97.29^{a} \pm 0.17$	$10.16^{j} \pm 0.09$	$69.08^{cd} \pm 0.14$	$20.67^{i} \pm 0.13$
B_5	$71.01^{bcd} \pm 0.04$	$-1.02^{hij} \pm 0.09$	$9.28^{lmn} \pm 0.09$	$96.24^{abc} \pm 0.50$	$9.22^{mn} \pm 0.08$	$69.58^{bc} \pm 0.02$	$18.67^{lm} \pm 0.16$
C_5	$70.91^{bcd} \pm 0.72$	$-0.73^{de} \pm 0.09$	$7.76^{p} \pm 0.07$	$95.38^{bcde} \pm 0.67$	$7.73^{p} \pm 0.08$	$69.90^{bc} \pm 0.71$	$15.64^{p} \pm 0.20$
D_5	$71.37^{bc} \pm 0.13$	$-1.24^{kl} \pm 0.04$	$13.08^{c} \pm 0.00$	$95.42^{bcde} \pm 0.18$	$13.02^{c} \pm 0.04$	$68.54^{def} \pm 0.12$	$26.18^{d} \pm 0.05$
E_5	$71.71^{b} \pm 0.05$	$-0.80^{efg} \pm 0.04$	$9.41^{l} \pm 0.01$	$94.83^{def} \pm 0.21$	$9.38^{lm} \pm 0.01$	$70.22^{b} \pm 0.08$	$18.75^{lm} \pm 0.02$
F_5	$74.27^{a} \pm 0.17$	$-0.77^{ef} \pm 0.09$	$10.44^{ij} \pm 0.14$	$94.22^{efg} \pm 0.41$	$10.41^{l} \pm 0.14$	$72.24^{a} \pm 0.11$	$20.08^{j} \pm 0.23$
A_{10}	$70.08^{de} \pm 0.57$	$-1.07^{ij} \pm 0.00$	$11.69^{g} \pm 0.09$	$95.22^{cdef} \pm 0.03$	$11.62^{f} \pm 0.12$	$67.89^{fg} \pm 0.50$	$23.83^{f} \pm 0.02$
B_{10}	$71.90^{b} \pm 0.98$	$-1.15^{jk} \pm 0.04$	$9.66^{k} \pm 0.19$	$96.79^{a} \pm 0.12$	$9.59^{n} \pm 0.19$	$70.30^{b} \pm 0.87$	$19.18^{k} \pm 0.12$
C_{10}	$71.21^{bcd} \pm 0.21$	$-1.11^{jk} \pm 0.09$	$9.06^{n} \pm 0.13$	$96.95^{a} \pm 0.48$	$8.99^{n} \pm 0.12$	$69.84^{bc} \pm 0.17$	$18.18^{n} \pm 0.20$
D_{10}	$66.48^{h} \pm 0.12$	$-0.78^{efg} \pm 0.10$	$12.83^{d} \pm 0.16$	$91.60^{j} \pm 0.25$	$12.81^{c} \pm 0.15$	$6411^{j} \pm 0.17$	$27.57^{b} \pm 0.38$
E_{10}	$67.62^{g} \pm 0.48$	$-0.39^{a} \pm 0.09$	$10.59^{l} \pm 0.05$	$92.09^{ij} \pm 0.21$	$10.57^{hi} \pm 0.09$	$65.94^{i} \pm 0.44$	$22.34^{g} \pm 0.02$
F_{10}	$69.60^{ef} \pm 0.22$	$-0.61^{cd} \pm 0.08$	$11.63^{g} \pm 0.01$	$92.72^{ij} \pm 0.20$	$11.99^{e} \pm 0.01$	$67.45^{gh} \pm 0.20$	$23.87^{f} \pm 0.05$
A_{20}	$69.39^{ef} \pm 0.15$	$-1.02^{hi} \pm 0.02$	$13.52^{b} \pm 0.07$	$94.29^{efg} \pm 0.07$	$13.48^{b} \pm 0.07$	$66.55^{hi} \pm 0.11$	$27.84^{b} \pm 0.09$
B_{20}	$65.40^{i} \pm 0.89$	$-0.93^{ghi} \pm 0.01$	$12.61^{f} \pm 0.21$	$94.35^{efg} \pm 0.04$	$12.13^{e} \pm 0.21$	$63.34^{j} \pm 0.77$	$26.56^{c} \pm 0.10$
C_{20}	$67.71^{g} \pm 0.77$	$-0.73^{de} \pm 0.02$	$9.67^{k} \pm 0.12$	$94.29^{efg} \pm 0.18$	$9.64^{k} \pm 0.12$	$66.30^{i} \pm 0.70$	$20.39^{j} \pm 0.02$
D_{20}	$70.11^{de} \pm 1.16$	$-0.84^{efg} \pm 0.14$	$15.57^{a} \pm 0.21$	$93.09^{ghi} \pm 0.56$	$15.55^{a} \pm 0.22$	$66.31^{i} \pm 0.93$	$31.73^{a} \pm 0.09$
E_{20}	$69.60^{ef} \pm 0.22$	$-0.58^{bc} \pm 0.04$	$11.63^{g} \pm 0.01$	$92.88^{hij} \pm 0.24$	$11.59^{f} \pm 0.02$	$67.45^{gh} \pm 0.20$	$23.87^{f} \pm 0.05$
F_{20}	$70.41^{cde} \pm 0.10$	$-0.57^{bc} \pm 0.04$	$12.01^{f} \pm 0.01$	$92.72^{ij} \pm 0.20$	$11.99^{e} \pm 0.01$	$68.07^{efg} \pm 0.09$	$24.36^{e} \pm 0.02$
Wheat	$69.33^{ef} \pm 0.84$	$-0.45^{ab} \pm 0.03$	$9.17^{mn} \pm 0.11$	$92.81^{hij} \pm 0.21$	$9.16^{mn} \pm 0.11$	$67.99^{fg} \pm 0.77$	$18.87^{j} \pm 0.01$

Values are Means ± standard deviation. Values with different superscripts in the same column are significantly different ($p<0.05$). A_3:80gCassava:17gMaize:3g*Moringa oleifera* seed flour; B_3:85gCassava:12gMaize:3g*Moringa oleifera* seed flour; C_3: 90gCassava:7gMaize:3g*Moringa oleifera* seed flour; D_3:85gWheat:12gMaize:3g *Moringa oleifera* seed flour; E_3: 85gWheat:12gCassava:3g *Moringa oleifera* seed flour; F_3:97gWheat: 3g*Moringa oleifera* seed flour; A_5: 80gCassava:15gMaize:5g*Moringa oleifera* seed flour; B_5: 85gCassava:10gMaize:5g*Moringa oleifera* seed flour; C_5: 90gCassava:

5gMaize:5g*Moringa oleifera* seed flour; D_5:85gWheat:10gMaize:5g *Moringa oleifera* seed flour; E_5: 85gWheat:10gCassava:5g *Moringa oleifera* seed flour; F_3:95gWheat: 5g*Moringa oleifera* seed flour; A_{10}:75gCassava:15gMaize:10g*Moringa oleifera* seed flour; B_{10}:80gCassava:10gMaize:10g*Moringa oleifera* seed flour; C_{10}: 85gCassava:5gMaize:10g*Moringa oleifera* seed flour; D_{10}:80gWheat:10gMaize:10g *Moringa oleifera* seed flour; E_{10}: 80gWheat:10gCassava:10g *Moringa oleifera* seed flour; F_{10}:90gWheat: 10g*Moringa oleifera* seed flour; A_{20}:65gCassava:15gMaize:20g*Moringa oleifera* seed flour; B_{20}:70gCassava:10gMaize:20g*Moringa oleifera* seed flour; C_{20}: 75gCassava:5gMaize:20g*Moringa oleifera* seed flour; D_{20}:70gWheat:10gMaize:20g *Moringa oleifera* seed flour; E_{20}: 70gWheat:10gCassava:20g *Moringa oleifera* seed flour; F_3:80gWheat: 20g*Moringa oleifera* seed flour;

Functional properties of composite flour: Various functional properties of the composite flour blends were analyzed. The addition of varied concentrations and combinations of wheat, cassava, and maize in varied proportions caused significant differences ($p<0.05$) in the parameters analyzed. Most of the composite flour blends of cassava/maize mixture containing varied concentrations of MOSF had higher water absorption capacity (WAC) than blends containing wheat flour. Composite flour with the highest WAC was A_{10} 1.77g/g while F_5 had the least value of 0.83g/g. High WAC of cassava/maize blends signifies the presence of more hydrophilic constituents than either wheat/cassava or wheat/maize flour blends. This correlates with its appreciable amylopectin content 45.07%. Wheat/cassava, wheat/maize composite flour samples showed a constant decrease in their WAC with increased concentrations of MOSF. This could be due to dilution of wheat's gluten following the addition of maize as well as varied concentrations of MOSF. Chandra *et al.* (2015) reported that a good WAC of composite flour may prove useful in products where good viscosity is required.

Oil absorption capacity (OAC) is an indication of the rates at which proteins bind to fat in food formulations (Oppong *et al.,* 2015). It was observed that composites of cassava/maize combinations had higher OAC than wheat/maize or wheat/cassava or even wheat to which MOSF was added irrespective of concentrations. OAC of cassava/maize composite flour increased with the inclusion of MOSF in this order: 20% > 10% > 5%>3%. This entails that there was synergistic interaction of fats and proteins from MOSF alongside those of maize flour which caused an increase in OAC as the concentrations of MOSF in the blends gradually increased. Chandra *et al.* (2015) reported that the major component affecting OAC is protein which has both hydrophilic and hydrophobic constituents. Composites with high MOSF contributed more non-polar side chains of proteins which bound the hydrocarbon side chains of oil, hence resulting to a high OAC.

Emulsion capacity (EC) and emulsion stability (ES) of the flour samples ranged between 27.58% (F_{10}) and 40.77% (C_{10}); and 22,03% (E_{10}) and 45.38% (A_{10}) respectively. It was observed that cassava/maize combinations had higher emulsion capacities especially blends B_3, C_3, B_5, C_5, B_{10}, C_{10}, B_{20} and C_{20} with the highest being C_{10} (85g cassava:5g maize:10gMOSF) with EC of 40.77% and B_{10} (80g cassava:10g maize:10gMOSF) with EC of 39.46% than wheat/cassava or wheat/maize containing varied concentrations of MOSF. Chandra *et al.,* (2015) reported a value of 38.38% ES and 43.88% for EC for 100% wheat flour. Our results indicated that EC of wheat substituted with 3 to 20% MOSF resulted to lower EC and ES. Emulsion capacity of foods is associated with the amount of oil, non-polar amino acid residues on the surface of the protein, water and other components of the food (Awuchi *et al.,* 2019). An increased number of non-polar amino acids residues on the surface of protein will reduce the energy barrier to adsorptions which depends on the protein structure (Awuchi *et al.,* 2019). Emulsion stability is the ability of emulsion system of foods to resist the changes and alterations in its physicochemical properties over time (Awuchi *et al.,* 2019). It was also observed that the emulsion stability of the flour blends was also higher in cassava/maize blends than in wheat/cassava or wheat/maize blends having varying concentrations of MOSF. This implies that cassava/maize combination with associated varied concentrations of MOSF could have resisted changes and alterations in their physicochemical properties than in wheat/cassava or wheat/maize combinations which could be due to the nature of the non-polar amino acids on the surface of the protein, and amount of oil entrapped within the molecules. Chandra *et al.* (2015) reported 41.49 and 44.69% for composite flour blends of rice, green gram and potato flour while Twinomunwezi *et al.* (2020) reported values between 50 and 53.69% for composite flour blends, rice, amaranth and soybean mixed in varied concentrations.

Bulk density (BD) of the composite flour blends ranged between 0.60 (C_{20}) and 0.79g/g (F_3). Chandra *et al.* (2015) reported values of 0.774 and 0.820g/cc for composite flour blends of wheat, rice, green gram and 0.762 for 100% wheat flour. It was observed that wheat flour substituted with 3, 5, 10 and 20g MOSF had relatively higher BD than other composite flour blends. Also, the BDs of wheat/cassava combinations ($E_{3,5,10,20}$) had higher BDs than wheat/maize combinations ($D_{3,5,10,20}$). Generally, composite flour blends of cassava/maize had lower BDs especially with higher concentrations of MOSF (>10g) than wheat/cassava or wheat/maize combinations with the varied concentrations of MOSF. A low bulk density will be advantageous in compounding complementing foods (Chandra *et al*., 2015) and also reflects the relative volume or capacity of the required packaging material (Chandra *et al*., 2015) such that the higher the bulk density of a flour, the denser the packaging material needed for packaging (Awuchi *et al*., 2019).

Foam capacity (FC) of the flours blends ranged between 9.45 (D_3) and 26.57% (C_{20}) while foam stability (FS) ranged between 18.60 (E_3) and 36.97% (A_{20}). There was no significant difference ($p>0.05$) in FS of A_{20} (36.97) and B_{20} (36.52). It was observed that cassava/maize blends containing varied concentrations of MOSF had higher FC and FS than wheat/cassava and wheat/maize blends. Also, substitution of MOSF resulted of a gradual increase in FC of the flour blends in this order: 20g>10g>5g>3g. Foam capacity depends on the surface tension at the water/air interface while foam stability depends on the relative electrostatic attractive and repulsive forces of the polypeptides and protein molecules (Nawaz *et al.,* 2015). FC and FS increased with a higher concentration of MOSF. This indicated that MOSF contributed majorly in addition to the cereal proteins in the dispersion to form a continuous cohesive film around the air bubbles in the foam. Foaming properties are desirable in food products such as cakes, bread, meninge, crackers, ice cream and several bakery items to maintain their texture and structure throughout processing and storage (Nawaz *et al.,* 2015).

Gelation temperature (GT) of the flour samples ranged between 65°C (E_{10}) and 75.33°C (C_5). These values were higher than 56.22 to 60.56°C reported by Chandra *et al.* (2015) for composite flour blends of wheat, green gram and potato. Gelation temperature was higher in cassava/maize blends than in blends containing wheat. The incorporation of a concentration of 10 and 20g MOSF to the flour blends resulted to a gradual decrease in the gelation temperature. The addition of a higher concentration of MOSF to wheat composite flours resulted to a decrease in GT with the lowest observed in F_{10} (90g wheat:10g MOSF). Lower values for GT observed in composite flours containing wheat than in cassava/maize blends could be attributed to the nature of starch granules of the flours as well as components from the MOSF.

Swelling capacity (SC) of the composite flour blends ranged between 2.14 (F_5) and 3.87 (E_{10}) g/g . It was observed that at a concentration of 3 and 5g MOSF, cassava/maize blends had higher SC than blends containing wheat flour. At a higher concentration of 10 and 20g MOSF, cassava/maize blends having either both concentrations of MOSF had lower SC than flour blends containing wheat flour with the highest values observed for wheat/cassava blends namely E_{10} (3.87g/g) and E_{20} (3.64g/g). Generally, blends containing wheat in addition to 10g or 20g MOSF had significantly higher SC than blends of cassava and maize having same concentrations of MOSF. Swelling index (SI) of the composite flour blends ranged between 0.95 (A_5) and 1.35 (D_{20}). It was also observed that blends which had a concentration of 10 and 20g MOSF had higher swelling index than blends with a lower concentration of MOSF. Also, blends of either wheat/maize or wheat/cassava had higher values for SI than cassava maize blends irrespective of the concentration of MOSF.

Dispersibility index (DI) is influenced by chemical composition and particle size profile of the compounds in the composite flours. The dispersibility of flour corresponds to its ability to reconstitute in water (Anon *et al.,* 2021). The differences in dispersibilities of composite flours is influenced by the presence of hydrophilic molecules such as polysaccharides and proteins (Aguemon *et al*., 2019). It was observed that DI of the composite flour blends was higher in flours with 10 and 20g MOSF. DI of cassava/maize blends with varied concentrations of MOSF increased gradually as maize concentration in each blend decreased. DI was also higher in wheat/cassava blends than in wheat/maize blends with varied concentration of MOSF. The higher the percentage of dispersibility, the greater the ability of the flour to reconstitute in water to give a fine and coherent paste (Oulai *et al.,* 2014). A high percentage dispersibility is an indicator of good water absorption capacity (Kulkarni *et al.,* 1991).

Table 3A: Results on functional Properties of composite flour blends of cassava, maize and wheat containing varied concentrations of *Moringa oleifera* seed flour

Sample	WAC (g/g)	OAC (g/g)	EC (%)	FC (%)	BD (g/g)	GT (°C)
A_3	$1.27^{efg}\pm0.23$	$1.00^{ghi}\pm0.10$	$31.70^{kl}\pm0.30$	$10.00^{r}\pm0.20$	$0.67^{f}\pm0.002$	$70.00^{efg}\pm1.00$
B_3	$1.50^{bcd}\pm0.10$	$1.20^{ef}\pm0.00$	$33.75^{gh}\pm0.00$	$12.50^{h}\pm0.00$	$0.71^{h}\pm0.000$	$72.00^{cd}\pm1.00$
C_3	$1.60^{ab}\pm0.00$	$1.30^{de}\pm0.00$	$34.92^{e}\pm0.02$	$15.20^{b}\pm0.30$	$0.73^{g}\pm0.002$	$74.00^{ab}\pm 0.00$
D_3	$1.07^{hij}\pm0.15$	$0.90^{hi}\pm0.10$	$32.59^{ij}\pm0.00$	$9.45^{s}\pm0.00$	$0.74^{def}\pm0.002$	$69.00^{gh}\pm1.00$
E_3	$1.20^{fgh}\pm 0.10$	$1.20^{ef}\pm 0.10$	$33.90^{gh}\pm 0.17$	$11.30^{p}\pm 0.20$	$0.75^{d}\pm 0.002$	$71.00^{de}\pm 1.00$
F_3	$0.90^{jk}\pm 0.00$	$1.00^{ghi}\pm 0.10$	$33.15^{hij}\pm 0.10$	$10.80^{q}\pm 0.10$	$0.79^{a}\pm 0.005$	$68.00^{hij}\pm 0.00$
A_5	$1.33^{def}\pm 0.06$	$0.93^{hij}\pm 0.06$	$31.80^{kl}\pm 0.20$	$11.05^{pq}\pm 0.15$	$0.66^{l}\pm 0.00$	$70.67^{def}\pm 0.58$
B_5	$1.43^{bcde}\pm 0.06$	$1.13^{fg}\pm 0.06$	$33.75^{gh}\pm 0.09$	$13.17^{m}\pm 0.21$	$0.71^{h}\pm 0.002$	$72.67^{bc}\pm 0.58$
C_5	$1.53^{bc}\pm0.06$	$1.23^{ef}\pm0.12$	$34.65^{ef}\pm0.35$	$15.47^{l}\pm0.49$	$0.72^{g}\pm0.002$	$75.33^{a}\pm 0.58$
D_5	$0.97^{ijk}\pm0.12$	$0.87^{ij}\pm0.06$	$32.45^{jk}\pm0.55$	$9.87^{rs}\pm0.12$	$0.74^{f}\pm 0.000$	$70.00^{efg}\pm1.00$
E_5	$1.07^{hij}\pm 0.15$	$1.00^{ghi}\pm 0.10$	$33.53^{ab}\pm 0.23$	$11.53^{op}\pm 0.14$	$0.74^{def}\pm 0.005$	$71.67^{cd}\pm 0.58$

F_5	$0.83^{k}\pm 0.06$	$0.93^{hij}\pm 0.06$	$33.44^{gh}\pm 0.56$	$11.90^{o}\pm 0.00$	$0.78^{b}\pm 0.005$	$69.33^{fgh}\pm 0.58$
A_{10}	$1.77^{a}\pm 0.15$	$1.60^{b}\pm 0.10$	$32.42^{jk}\pm 0.86$	$22.50^{g}\pm 0.35$	$0.67^{i}\pm 0.002$	$70.00^{efg}\pm 1.02$
B_{10}	$1.60^{ab}\pm 0.10$	$1.43^{c}\pm 0.06$	$39.46^{b}\pm 0.64$	$23.02^{ef}\pm 0.16$	$0.63^{k}\pm 0.005$	$68.00^{hij}\pm 1.00$
C_{10}	$1.40^{cde}\pm 0.00$	$1.37^{cd}\pm 0.06$	$40.77^{a}\pm 0.26$	$23.67^{d}\pm 0.15$	$0.61^{m}\pm 0.005$	$66.00^{kl}\pm 0.00$
D_{10}	$1.20^{fgh}\pm 0.10$	$0.90^{hig}\pm 0.00$	$28.57^{n}\pm 0.58$	$18.88^{j}\pm 0.32$	$0.71^{h}\pm 0.005$	$67.00^{jk}\pm 1.00$
E_{10}	$1.00^{ijk}\pm 0.06$	$0.67^{k}\pm 0.06$	$29.78^{m}\pm 0.24$	$19.67^{i}\pm 0.06$	$0.74^{ef}\pm 0.000$	$65.00^{l}\pm 0.00$
F_{10}	$1.13^{ghi}\pm 0.06$	$0.83^{j}\pm 0.08$	$27.58^{o}\pm 0.58$	$17.37^{k}\pm 0.30$	$0.77^{c}\pm 0.004$	$66.33^{kl}\pm 0.58$
A_{20}	$1.60^{ab}\pm 0.10$	$1.90^{a}\pm 0.10$	$37.23^{d}\pm 0.20$	$24.42^{c}\pm 0.20$	$0.64^{j}\pm 0.000$	$72.00^{cd}\pm 2.00$
B_{20}	$1.50^{bcd}\pm 0.00$	$1.70^{b}\pm 0.10$	$38.62^{c}\pm 0.09$	$25.80^{b}\pm 0.00$	$0.61^{c}\pm 0.000$	$70.00^{efg}\pm 1.00$
C_{20}	$1.40^{cde}\pm 0.10$	$1.63^{b}\pm 0.06$	$39.22^{bc}\pm 0.08$	$26.57^{a}\pm 0.17$	$0.60^{m}\pm 0.003$	$69.00^{gh}\pm 1.00$
D_{20}	$1.10^{ghi}\pm 0.10$	$1.20^{ef}\pm 0.00$	$33.25^{hi}\pm 0.45$	$22.46^{de}\pm 0.99$	$0.71^{h}\pm 0.004$	$68.67^{ghi}\pm 0.58$
E_{20}	$0.90^{jk}\pm 0.00$	$0.97^{hig}\pm 0.06$	$39.10^{fg}\pm 0.20$	$22.90^{fg}\pm 0.10$	$0.73^{g}\pm 0.011$	$66.33^{kl}\pm 0.58$
F_{20}	$1.03^{hij}\pm 0.06$	$1.03^{gh}\pm 0.06$	$31.15^{l}\pm 0.25$	$21.68^{h}\pm 0.24$	$0.75^{de}\pm 0.007$	$67.33^{ijk}\pm 0.58$

Values are Means ± standard deviation. Values with different superscripts in the same column are significantly different ($p<0.05$). A_3:80gCassava:17gMaize:3g*Moringa oleifera* seed flour; B_3:85gCassava:12gMaize:3g*Moringa oleifera* seed flour; C_3: 90gCassava:7gMaize:3g*Moringa oleifera* seed flour; D_3:85gWheat:12gMaize:3g *Moringa oleifera* seed flour; E_3: 85gWheat:12gCassava:3g *Moringa oleifera* seed flour; F_3:97gWheat: 3g*Moringa oleifera* seed flour; A_5: 80gCassava:15gMaize:5g*Moringa oleifera* seed flour; B_5: 85gCassava:10gMaize:5g*Moringa oleifera* seed flour; C_5: 90gCassava: 5gMaize:5g*Moringa oleifera* seed flour; D_5:85gWheat:10gMaize:5g *Moringa oleifera* seed flour; E_5: 85gWheat:10gCassava:5g *Moringa oleifera* seed flour; F_3:95gWheat: 5g*Moringa oleifera* seed flour; A_{10}:75gCassava:15gMaize:10g*Moringa oleifera* seed flour; B_{10}:80gCassava:10gMaize:10g*Moringa oleifera* seed flour; C_{10}: 85gCassava:5gMaize:10g*Moringa oleifera* seed flour; D_{10}:80gWheat:10gMaize:10g *Moringa oleifera* seed flour; E_{10}: 80gWheat:10gCassava:10g *Moringa oleifera* seed flour; F_{10}:90gWheat: 10g*Moringa oleifera* seed flour; A_{20}:65gCassava:15gMaize:20g*Moringa oleifera* seed flour; B_{20}:70gCassava:10gMaize:20g*Moringa oleifera* seed flour; C_{20}: 75gCassava:5gMaize:20g*Moringa oleifera* seed flour; D_{20}:70gWheat:10gMaize:20g *Moringa oleifera* seed flour; E_{20}: 70gWheat:10gCassava:20g *Moringa oleifera* seed flour; F_3:80gWheat: 20g*Moringa oleifera* seed flour; WAC: Water absorption capacity; OAC: Oil absorption capacity; EC: Emulsion capacity: FC: Foam capacity; BD: Bulk density: GT: Gelatinization temperature

Table 3B: Functional Properties of composite flour blends of cassava, maize and wheat containing varied concentrations of *Moringa oleifera* seed flour

Sample	SC (g/g)	DI (%)	SI (g/g)	FS (%)	ES(%)
A_3	$2.85^{h}\pm 0.10$	$25.20^{jk}\pm 0.20$	$0.96^{m}\pm 0.02$	$28.65^{ef}\pm 0.50$	$42.45^{de}\pm 0.25$
B_3	$2.94^{gh}\pm 0.04$	$26.40^{gh}\pm 0.00$	$1.05^{kl}\pm 0.02$	$24.07^{l}\pm 0.25$	$39.67^{f}\pm 0.33$
C_3	$2.97^{g}\pm 0.00$	$28.00^{e}\pm 0.20$	$1.10^{ij}\pm 0.00$	$21.70^{jk}\pm 0.10$	$37.00^{g}\pm 0.40$
D_3	$2.39^{jk}\pm 0.02$	$22.60^{m}\pm 0.15$	$1.00^{mn}\pm 0.10$	$21.45^{k}\pm 0.00$	$27.50^{h}\pm 0.30$
E_3	$2.45^{j}\pm 0.07$	$26.60^{fjh}\pm 0.20$	$1.11^{hij}\pm 0.02$	$18.60^{n}\pm 0.40$	$24.65^{j}\pm 0.00$
F_3	$2.25^{l}\pm 0.00$	$24.00^{l}\pm 0.10$	$1.17^{efg}\pm 0.02$	$19.40^{m}\pm 0.20$	$22.07^{l}\pm 0.25$
A_5	$2.77^{i}\pm 0.03$	$24.93^{k}\pm 0.15$	$0.95^{m}\pm 0.01$	$29.07^{e}\pm 0.25$	$42.85^{d}\pm 0.09$
B_5	$2.90^{gh}\pm 0.00$	$26.23^{hi}\pm 0.15$	$1.03^{lm}\pm 0.02$	$24.30^{i}\pm 0.26$	$39.88^{f}\pm 0.10$
C_5	$2.94^{gh}\pm 0.02$	$27.77^{e}\pm 0.22$	$1.08^{jk}\pm 0.00$	$22.17^{j}\pm 0.25$	$37.15^{g}\pm 0.10$
D_5	$2.34^{k}\pm 0.06$	$22.55^{m}\pm 0.09$	$0.97^{m}\pm 0.00$	$21.58^{k}\pm 0.18$	$27.75^{h}\pm 0.00$
E_5	$2.40^{jk}\pm 0.00$	$26.33^{gh}\pm 0.15$	$1.10^{ijk}\pm 0.01$	$19.27^{m}\pm 0.12$	$24.77^{j}\pm 0.25$
F_5	$2.14^{m}\pm 0.06$	$23.85^{l}\pm 0.13$	$1.16^{fgh}\pm 0.01$	$20.08^{l}\pm 0.12$	$22.23^{l}\pm 0.21$
A_{10}	$3.32^{e}\pm 0.04$	$32.00^{b}\pm 0.10$	$1.11^{hij}\pm 0.01$	$35.53^{b}\pm 0.48$	$43.85^{c}\pm 0.18$
B_{10}	$3.43^{d}\pm 0.02$	$33.00^{a}\pm 0.20$	$1.14^{ghi}\pm 0.00$	$31.87^{d}\pm 0.48$	$42.95^{d}\pm 0.78$
C_{10}	$3.53^{c}\pm 0.03$	$33.50^{a}\pm 0.30$	$1.18^{efg}\pm 0.01$	$28.32^{f}\pm 0.55$	$42.00^{e}\pm 0.89$
D_{10}	$3.65^{b}\pm 0.03$	$26.82^{fg}\pm 0.23$	$1.20^{ef}\pm 0.00$	$26.50^{g}\pm 0.46$	$24.40^{j}\pm 0.28$

E_{10}	$3.87^{a} \pm 0.04$	$28.88^{d} \pm 0.28$	$1.25^{cd} \pm 0.02$	$25.51^{h} \pm 0.25$	$22.03^{i} \pm 0.88$
F_{10}	$3.72^{b} \pm 0.10$	$25.68^{ij} \pm 0.45$	$1.29^{bc} \pm 0.03$	$24.15^{i} \pm 0.33$	$19.87^{m} \pm 0.20$
A_{20}	$2.91^{gh} \pm 0.10$	$30.28^{c} \pm 0.63$	$1.21^{de} \pm 0.02$	$36.97^{a} \pm 0.21$	$45.33^{a} \pm 0.60$
B_{20}	$3.08^{f} \pm 0.04$	$31.82^{b} \pm 0.90$	$1.18^{efg} \pm 0.01$	$36.52^{a} \pm 0.26$	$44.60^{b} \pm 0.10$
C_{20}	$3.28^{e} \pm 0.00$	$32.35^{b} \pm 0.43$	$1.16^{fgh} \pm 0.02$	$34.30^{c} \pm 0.43$	$44.08^{bc} \pm 0.16$
D_{20}	$3.37^{de} \pm 0.03$	$26.12^{hi} \pm 0.25$	$1.35^{a} \pm 0.03$	$31.48^{d} \pm 0.39$	$27.72^{h} \pm 0.36$
E_{20}	$3.64^{b} \pm 0.04$	$27.03^{f} \pm 0.35$	$1.29^{bc} \pm 0.01$	$28.47^{f} \pm 0.13$	$26.02^{h} \pm 0.27$
F_{20}	$3.45^{cd} \pm 0.04$	$25.10^{k} \pm 0.18$	$1.32^{ab} \pm 0.01$	$26.43^{g} \pm 0.34$	$23.48^{k} \pm 0.53$

Values are Means ± standard deviation. Values with different superscripts in the same column are significantly different ($p<0.05$). A_3:80gCassava:17gMaize:3g*Moringa oleifera* seed flour; B_3:85gCassava:12gMaize:3g*Moringa oleifera* seed flour; C_3: 90gCassava:7gMaize:3g*Moringa oleifera* seed flour; D_3:85gWheat:12gMaize:3g *Moringa oleifera* seed flour; E_3: 85gWheat:12gCassava:3g *Moringa oleifera* seed flour; F_3:97gWheat: 3g*Moringa oleifera* seed flour; A_5: 80gCassava:15gMaize:5g*Moringa oleifera* seed flour; B_5: 85gCassava:10gMaize:5g*Moringa oleifera* seed flour; C_5: 90gCassava: 5gMaize:5g*Moringa oleifera* seed flour; D_5:85gWheat:10gMaize:5g *Moringa oleifera* seed flour; E_5: 85gWheat:10gCassava:5g *Moringa oleifera* seed flour; F_3:95gWheat: 5g*Moringa oleifera* seed flour; A_{10}:75gCassava:15gMaize:10g*Moringa oleifera* seed flour; B_{10}:80gCassava:10gMaize:10g*Moringa oleifera* seed flour; C_{10}: 85gCassava:5gMaize:10g*Moringa oleifera* seed flour; D_{10}:80gWheat:10gMaize:10g *Moringa oleifera* seed flour; E_{10}: 80gWheat:10gCassava:10g *Moringa oleifera* seed flour; F_{10}:90gWheat: 10g*Moringa oleifera*seed flour; A_{20}:65gCassava:15gMaize:20g*Moringa oleifera* seed flour; B_{20}:70gCassava:10gMaize:20g*Moringa oleifera* seed flour; C_{20}: 75gCassava:5gMaize:20g*Moringa oleifera* seed flour; D_{20}:70gWheat:10gMaize:20g *Moringa oleifera* seed flour; E_{20}: 70gWheat:10gCassava:20g *Moringa oleifera* seed flour; F_3:80gWheat: 20g*Moringa oleifera* seed flour; SC: Swelling capacity; DI: Dispersibility index; SI: Swelling index; FS: Foam stability; ES: Emulsion stability.

Pasting properties of composite flour blends:

Table 4 shows results on pasting properties of the composite flours blends. Results indicated significant differences ($p<0.05$) in the various parameters evaluated. Peak viscosity (PV) ranged between 272.18RVU (B_5:85g cassava:10g maize:5gMOSF) and 366.27RVU (D_3:85 wheat:10g maize:5gMOSF). It was observed that cassava/maize composite flour blends to which varied concentrations of MOSF was added had lower peak viscosities than blends of wheat/maize or wheat/cassava blends with varied concentrations of MOSF. Wheat/maize flour blends which had varied concentrations of MOSF had higher PV than wheat/cassava flour blends with the same varied concentrations of MOSF. Low peak viscosities observed in cassava/maize composites (ie A to C) than composites containing wheat (ie D, E, F) is indicative of higher damaged starch content (Devi *et al.,* 2020). The higher the peak viscosity, the higher the swelling index while low peak viscosity shows higher solubility due to starch degradation or dextrinization (Shittu *et al.,* 2001). The reduction in peak viscosity as observed in the cassava/maize and wheat/cassava containing varied concentrations of MOSF could be as a result of decreased interaction between starch, fat and protein contents of the blends (Ocheme *et al.,* 2018).

Hot paste viscosity (HPV) also known as trough indicates the disruption of granules resulting to a decrease in paste viscosity (Kumar and Khatkar, 2017). It is the minimum viscosity value measuring the ability of paste to withstand breakdown during cooling (Kaur and Singh, 2005). HPV values obtained in our research for these composite flours ranged between 90.21RVU (C5:90g cassava:5g maize:5gMOSF) and 190.57RVU (A3:80g cassava:17g maize:3gMOSF). Imoisi *et al.,* (2020) reported HPV of 247.3 -260.8 RVU for cassava-citrus flour while 100% cassava flour had 158.5 RVU. It can be deduced that the inclusion of higher concentrations of maize flour with 3 and 5% MOSF for the cassava /maize composite flour blends resulted to higher HPV but when MOSF increased to 10 and 20% HPV decreased. A similar observation was also made for wheat/maize composite which had either higher HPV than wheat/cassava composites which had either 3 or 5% MOSF. Devi *et al.,* (2020) reported a decrease in trough viscosity of wheat flour following the addition of fats and oil.

Breakdown viscosity ranged between 165.61RVU (A_5:80g cassava:15g maize:5g MOSF) and 241.71RVU (D_3:85g wheat:12g maize:3gMOSF). Breakdown viscosity (BDV) of cassava/maize composite flours containing varied concentrations of MOSF were lower than those wheat composite flour blends containing same concentration MOSF. Wheat/Maize composite flour blends had higher BDV but decreased with increase in MOSF while wheat/cassava composite flour blends had lower BDV which increased slightly with a higher concentration of MOSF. Breakdown viscosity is the difference between peak viscosity and hot pasted viscosity (trough viscosity) (Anberbir *et al.,* 2024). Decreased BDV in the cassava/maize composite flour blends than in the wheat/maize or wheat/cassava blends with increase in MOSF could be due to restricted swelling of starch granules resulting to a decrease in available water for starch granules and high resistance to shear when held at high temperatures (Julianti *et al.,* 2017). Therefore, it implies that the cassava: maize composite flour blends with varied concentrations of MOSF have a greater tendency to resist heat and shear than wheat base composite flour blends.

Final viscosity (FV) of the flour blends ranged between 346.06RVU (A_5) and 430.66 RVU (D_3). Wheat/maize, wheat/cassava with varied concentrations of MOSF had higher FV than cassava/maize composite flour blends with the same varied concentrations of MOSF. Also, a reduction in the concentration of maize with a gradual increase in cassava concentrations for the cassava/maize composite flour blends resulted to a gradual decrease in FV. There was a gradual decrease in FV with a higher concentration of MOSF in the different flour blends with significant differences ($p<0.05$). Low final viscosity indicates decreased ability to form a viscous paste (Awolu, 2017). This implies that a decreased concentration of maize flour and a concentration of 3 to 5% MOSF in the cassava/maize or wheat/maize and wheat/cassava composite flour blends will be suitable in flours that will be utilized for different purposes.

Setback viscosity (SBV) reflects the retrogradation tendency of starch (Devi *et al*., 2020), SBV of the composite flour blends ranged between 164.26 RVU (A_3:87g cassava:17g maize:3g MOSF) and 306.622 RVU (D_3:85g wheat:12g maize:3g MOSF). SBV of cassava/maize composite flour blends increased gradually with a decrease in maize concentration while the wheat composite showed that SBV was significantly higher ($p<0.05$) in the wheat/maize blends than in the wheat/cassava blends. A higher inclusion of MOSF >5g caused a gradual decrease in SBV. High setback viscosity indicates a lower tendency to retrograde during cooling (Aidoo *et al.,* 2022) while flour blends with comparatively lower setback values could be utilized in making low viscous foods like complementary baby foods (Aidoo *et al*., 2022).

Pasting temperature (PTem) is defined as the temperature at which viscosity of starch begins to rise during heating (Kumar and Khatkar, 2017). Cassava/maize blends had higher PTem than wheat/maize and wheat/cassava blends. It was observed that for the cassava/maize blends and irrespective of the MOSF concentration, PTem decreased gradually as maize concentration decreased in the blends. PTem ranged between 53.94^{0}C (D_5:85g wheat:10g maize:5gMOSF) and 69.98^{0}C (A_3). A high pasting temperature indicates the resistance potential against swelling in the ingredients which could be correlated for the quantity of amylose and amylopectin in the flour (Anberbir et al., 2024).

Pasting Time (PT) gives an indication of the least time required to cook the flour (Anberbir *et al*., 2024). Results indicated that pasting time ranged between 4.40min (D_3) and 6.86min (A_5). Cassava/maize composite flour blends had higher pasting time than wheat composite flour blends. It was observed that PT of the cassava/maize blends decreased with a gradual reduction in maize concentration. Conversely, wheat/maize composite flours had lower PT than wheat/cassava composite flour blends irrespective of the concentration of MOSF.

Stability and setback ratio varied significantly ($p<0.05$) for the various flour blends. Stability ratio elaborates on the resistance of a starch paste to viscosity breakdown as shear is applied while setback ratio gives an indication of starch retrogradation propensity after gelatinization (Julianti *et al*., 2017). Results indicated that cassava/maize composite flour blends containing 3 and 5% MOSF has a lower tendency to breakdown when shear is applied than in flour blends which had 10 or 20g MOSF. Similarly, results indicated that with 3 or 5g inclusion of MOSF, wheat/cassava blends were more stable to shear stress than wheat/maize composite blends which had same concentration of MOSF.

Table 4A: Pasting Properties of composite flour b of composite flour blends of cassava, maize and wheat containing varied concentrations of *Moringa oleifera* seed flour

Sample	PV (RVU)	HPV (RVU)	BDV (RVU)	FV (RVU)	SBV (RVU)
A_3	$273.53^{i} \pm 0.76$	$190.57^{a} \pm 0.44$	$183.67^{j} \pm 1.56$	$354.83^{kl} \pm 1.81$	$164.26^{n} \pm 1.19$
B_3	$287.03^{q} \pm 0.13$	$95.53^{j} \pm 0.01$	$192.50^{h} \pm 0.91$	$391.69^{e} \pm 3.44$	$296.56^{c} \pm 3.42$
C_3	$298.65^{op} \pm 0.83$	$102.76^{ef} \pm 0.61$	$196.33^{g} \pm 0.87$	$398.68^{d} \pm 0.47$	$295.92^{c} \pm 0.13$
D_3	$366.27^{a} \pm 0.06$	$124.04^{b} \pm 1.29$	$241.71^{a} \pm 0.62$	$430.66^{a} \pm 1.87$	$306.62^{a} \pm 3.15$
E_3	$300.23^{no} \pm 0.15$	$111.50^{d} \pm 2.12$	$191.26^{h} \pm 1.31$	$401.40^{cd} \pm 1.27$	$289.52^{d} \pm 0.86$
F_3	$321.39^{c} \pm 0.08$	$120.69^{c} \pm 0.57$	$202.07^{ef} \pm 1.45$	$403.78^{c} \pm 1.55$	$283.09^{e} \pm 0.98$
A_5	$266.59^{c} \pm 0.67$	$100.56^{hi} \pm 0.63$	$165.61^{l} \pm 0.55$	$346.06^{o} \pm 0.71$	$245.50^{m} \pm 0.04$
B_5					

	272.18^{r} ± 1.46	93.59^{j} ± 0.36	177.02^{k} ± 1.12	358.24^{ij} ± 1.44	264.66^{f} ± 1.80
C_5	287.78^{q} ± 0.77	90.21^{k} ± 1.25	188.41^{i} ± 2.24	380.93^{f} ± 2.25	289.72^{d} ± 0.41
D_5	344.77^{b} ± 2.19	111.19^{d} ± 0.06	232.08^{b} ± 0.01	413.66^{b} ± 3.28	302.47^{b} ± 3.22
E_5	296.89^{p} ± 2.21	93.58^{j} ± 0.60	203.31^{e} ± 2.81	392.62^{e} ± 0.71	299.04^{bc} ± 1.32
F_5	309.67^{efg} ± 0.77	102.22^{fgh} ± 1.66	207.63^{d} ± 0.64	400.81^{cd} ± 0.89	298.60^{c} ± 2.55
A_{10}	301.99^{mn} ± 1.25	99.87^{i} ± 0.01	202.13^{ef} ± 1.27	355.72^{jkl} ± 0.69	255.85^{ij} ± 0.68
B_{10}	304.43^{kl} ± 1.27	101.07^{fghi} ± 0.01	203.36^{e} ± 1.26	357.16^{jk} ± 1.46	256.09^{ij} ± 1.44
C_{10}	307.18^{ij} ± 0.06	104.23^{e} ± 1.58	202.96^{e} ± 1.52	367.29^{g} ± 1.49	263.05^{fgh} ± 3.09
D_{10}	312.52^{d} ± 0.68	99.94^{i} ± 0.00	212.61^{e} ± 0.64	362.10^{h} ± 1.54	262.16^{fgh} ± 1.54
E_{10}	311.49^{de} ± 0.38	101.44^{fghi} ± 0.77	210.05^{d} ± 1.15	352.72^{lmn} ± 0.62	251.29^{k} ± 0.15
F_{10}	309.00^{fgh} ± 0.33	104.22^{e} ± 0.00	204.78^{e} ± 0.33	363.28^{h} ± 1.34	259.06^{hi} ± 2.91
A_{20}	300.28^{no} ± 0.07	100.38^{hi} ± 0.24	199.90^{f} ± 0.17	353.80^{klm} ± 2.24	253.12^{jk} ± 2.91
B_{20}	303.13^{lm} ± 0.03	100.68^{ghi} ± 0.27	202.47^{ef}±0.27	356.11^{jk} ± 0.60	255.42^{ij} ± 0.35
C_{20}	305.83^{jk} ± 0.08	102.64^{efg} ± 0.71	203.14^{e}±0.57	349.86^{n} ± 0.01	247.23^{lm} ± 0.69
D_{20}	310.56^{ef} ± 0.65	100.67^{ghi} ± 0.95	209.89^{d}±1.60	361.67^{hi} ± 0.07	260.41^{gh} ± 0.84
E_{20}	308.39^{ghi} ± 0.52	97.84^{i} ± 0.07	208.55^{d}±0.45	350.65^{mn}±0.28	250.81^{kj} ± 0.21
F_{20}	306.65^{ij} ± 0.12	102.18^{fgh}±0.09	204.47^{e} ± 0.03	358.33^{ij}±0.14	256.16^{ij} ± 0.23

Values are Means ± standard deviation. Values with different superscripts in the same column are significantly different ($p<0.05$). A_3:80gCassava:17gMaize:3g*Moringa oleifera* seed flour; B_3:85gCassava:12gMaize:3g*Moringa oleifera* seed flour; C_3: 90gCassava:7gMaize:3g*Moringa oleifera* seed flour; D_3:85gWheat:12gMaize:3g *Moringa oleifera* seed flour; E_3: 85gWheat:12gCassava:3g *Moringa oleifera* seed flour; F_3:97gWheat: 3g*Moringa oleifera* seed flour; A_5: 80gCassava:15gMaize:5g*Moringa oleifera* seed flour; B_5: 85gCassava:10gMaize:5g*Moringa oleifera* seed flour; C_5: 90gCassava: 5gMaize:5g*Moringa oleifera* seed flour; D_5:85gWheat:10gMaize:5g *Moringa oleifera* seed flour; E_5: 85gWheat:10gCassava:5g *Moringa oleifera* seed flour; F_3:95gWheat: 5g*Moringa oleifera* seed flour; A_{10}:75gCassava:15gMaize:10g*Moringa oleifera* seed flour; B_{10}:80gCassava:10gMaize:10g*Moringa oleifera* seed flour; C_{10}: 85gCassava:5gMaize:10g*Moringa oleifera* seed flour; D_{10}:80gWheat:10gMaize:10g *Moringa oleifera* seed flour; E_{10}: 80gWheat:10gCassava:10g *Moringa oleifera* seed flour; F_{10}:90gWheat: 10g*Moringa oleifera*seed flour; A_{20}:65gCassava:15gMaize:20g*Moringa oleifera* seed flour; B_{20}:70gCassava:10gMaize:20g*Moringa oleifera* seed flour; C_{20}: 75gCassava:5gMaize:20g*Moringa oleifera* seed flour; D_{20}:70gWheat:10gMaize:20g *Moringa oleifera* seed flour; E_{20}: 70gWheat:10gCassava:20g *Moringa oleifera* seed flour; F_3:80gWheat: 20g*Moringa oleifera* seed flour; PV: Peak viscosity; HPV: Hot paste viscosity; BDV: Breakdown viscosity; FV: Final viscosity; SBV: setback viscosity.

Table 4B: Pasting Properties Pasting Properties of composite flour b of composite flour blends of cassava, maize and wheat containing varied concentrations of *Moringa oleifera* seed flour

Sample	Pasting Temperature (°C)	Pasting Time (min)	SBR	STR
A_3	69.98^{a} ± 0.02	6.77^{b} ± 0.06	1.86^{n} ± 0.03	0.730 ± 0.00
B_3	68.95^{bc} ± 0.87	6.55^{a} ± 0.02	4.12^{b} ± 0.04	0.33^{efgh} ± 0.001
C_3	67.61^{ef} ± 0.55	6.31^{fg} ± 0.55	3.88^{cd} ± 0.02	0.34^{c} ± 0.001
D_3	53.04^{k} ± 0.83	4.40^{o} ± 0.00	3.47^{jkl} ± 0.05	0.34^{cde} ± 0.004
E_3	67.91^{def} ±1.35	6.05^{j} ± 0.06	3.60^{fg} ± 0.06	0.37^{b} ± 0.008
F_3	62.79^{j} ± 0.54	5.38^{l} ± 0.01	3.35^{m} ± 0.03	0.38^{b} ± 0.002
A_5	69.45^{ab} ± 0.15	6.86^{a} ± 0.04	3.44^{kl} ± 0.02	0.38^{b} ± 0.001
B_5	68.32^{cde} ± 0.18	6.67^{c} ± 0.01	3.83^{d} ± 0.03	0.34^{c} ± 0.000
C_5	67.02^{fg} ± 0.04	6.37^{ef} ± 0.06	4.22^{a} ± 0.03	0.31^{l} ± 0.005
D_5	53.94^{j} ± 0.08	4.61^{n} ± 0.01	3.72^{e} ± 0.03	0.32^{k} ± 0.002
E_5	66.49^{g} ± 0.40	5.83^{k} ± 0.01	4.20^{a} ± 0.04	0.32^{l} ± 0.004
F_5	69.94^{h} ± 0.08	5.17^{m} ± 0.04	3.92^{c} ± 0.07	0.33^{ghij} ± 0.005

A_{10}	$69.03^{abc} \pm 0.04$	$6.10^{ij} \pm 0.01$	$3.57^{fghi} \pm 0.01$	$0.33^{fghi} \pm 0.001$
B_{10}	$68.73^{bcd} \pm 0.06$	$6.15^{i} \pm 0.02$	$3.53^{ghij} \pm 0.01$	$0.33^{efgh} \pm 0.001$
C_{10}	$68.83^{bcd} \pm 0.07$	$6.12^{ij} \pm 0.04$	$3.53^{ghij} \pm 0.07$	$0.34^{cd} \pm 0.005$
D_{10}	$68.66^{bcd} \pm 0.17$	$6.05^{j} \pm 0.04$	$3.62^{f} \pm 0.02$	$0.32^{kl} \pm 0.001$
E_{10}	$68.10^{cde} \pm 0.17$	$6.16^{hi} \pm 0.02$	$3.48^{jkl} \pm 0.02$	$0.33^{hijk} \pm 0.003$
F_{10}	$69.03^{abc} \pm 0.04$	$6.12^{ij} \pm 0.04$	$3.49^{ijk} \pm 0.04$	$0.34^{cdef} \pm 0.003$
A_{20}	$69.40^{ab} \pm 0.19$	$6.13^{ij} \pm 0.01$	$3.53^{ghij} \pm 0.03$	$0.33^{defg} \pm 0.001$
B_{20}	$68.98^{bc} \pm 0.01$	$6.25^{gh} \pm 0.02$	$3.54^{ghij} \pm 0.04$	$0.33^{efgh} \pm 0.001$
C_{20}	$68.98^{bc} \pm 0.01$	$6.44^{e} \pm 0.13$	$3.41^{lm} \pm 0.02$	$0.34^{defg} \pm 0.002$
D_{20}	$68.86^{bcd} \pm 0.07$	$6.10^{ij} \pm 0.01$	$3.59^{fgh} \pm 0.03$	$0.32^{ijk} \pm 0.004$
E_{20}	$68.77^{bcd} \pm 0.06$	$6.74^{bc} \pm 0.04$	$3.51^{hijk} \pm 0.00$	$0.32^{jk} \pm 0.004$
F_{20}	$69.11^{abc} \pm 0.04$	$6.19^{hi} \pm 0.01$	$3.51^{ijk} \pm 0.01$	$0.33^{defg} \pm 0.001$

Values are Means ± standard deviation. Values with different superscripts in the same column are significantly different ($p<0.05$). A_3:80gCassava:17gMaize:3g*Moringa oleifera* seed flour; B_3:85gCassava:12gMaize:3g*Moringa oleifera* seed flour; C_3: 90gCassava:7gMaize:3g*Moringa oleifera* seed flour; D_3:85gWheat:12gMaize:3g *Moringa oleifera* seed flour; E_3: 85gWheat:12gCassava:3g *Moringa oleifera* seed flour; F_3:97gWheat: 3g*Moringa oleifera* seed flour; A_5: 80gCassava:15gMaize:5g*Moringa oleifera* seed flour; B_5: 85gCassava:10gMaize:5g*Moringa oleifera* seed flour; C_5: 90gCassava: 5gMaize:5g*Moringa oleifera* seed flour; D_5:85gWheat:10gMaize:5g *Moringa oleifera* seed flour; E_5: 85gWheat:10gCassava:5g *Moringa oleifera* seed flour; F_3:95gWheat: 5g*Moringa oleifera* seed flour; A_{10}:75gCassava:15gMaize:10g*Moringa oleifera* seed flour; B_{10}:80gCassava:10gMaize:10g*Moringa oleifera* seed flour; C_{10}: 85gCassava:5gMaize:10g*Moringa oleifera* seed flour; D_{10}:80gWheat:10gMaize:10g *Moringa oleifera* seed flour; E_{10}: 80gWheat:10gCassava:10g *Moringa oleifera* seed flour; F_{10}:90gWheat: 10g*Moringa oleifera*seed flour; A_{20}:65gCassava:15gMaize:20g*Moringa oleifera* seed flour; B_{20}:70gCassava:10gMaize:20g*Moringa oleifera* seed flour; C_{20}: 75gCassava:5gMaize:20g*Moringa oleifera* seed flour; D_{20}:70gWheat:10gMaize:20g *Moringa oleifera* seed flour; E_{20}: 70gWheat:10gCassava:20g *Moringa oleifera* seed flour; F_3:80gWheat: 20g*Moringa oleifera* seed flour; SBR: Setback ratio; STR: Stability ratio.

Sensorial attributes of composite flour biscuits and compared with biscuits produced from single flours of wheat, cassava and maize:

Table 5 shows results on sensory scores of biscuits from the composite flour blends. Sensorial attributes namely aroma, color, texture, crispiness, taste and overall acceptability were evaluated. These were compared with biscuits made from single flours of wheat, cassava and maize. Results of the study showed that there were significant differences ($p<0.05$) for the parameters analyzed. Biscuits made from B_3 (85g Cassava:12g maize: 3gMOSF) had the highest scores for aroma, color, texture, taste and overall acceptability. This was followed by C_5 (90gCassava:5gmaize:5g MOSF). These compared well with biscuits made from 100% wheat flour. A high concentration of as much as 20g MOSF/100g flour affected the sensorial parameters of biscuits made from the composite flour blends. Biscuits made from flours with 3 to 5g *Moringa oleifera* seed flour had higher acceptability for the sensorial parameters analyze than biscuits containing 10g *Moringa oleifera* seed flour and decreased h the inclusion of 20g *Moringa oleifera* seed flour.

Table 5: Results on Sensorial scores of composite flour biscuits and compared with biscuits produced from single flours of wheat, cassava and maize:

Sample	Aroma	Colour	Texture	Crispness	Taste	Overall acceptability
A_3	$7.27^{abcde} \pm 1.22$	$7.33^{abc} \pm 1.50$	$7.07^{ab} \pm 1.33$	$7.20^{abcde} \pm 1.47$	$7.80^{abc} \pm 1.37$	$7.93^{abc} \pm 1.03$
B_3	$7.73^{a} \pm 1.49$	$7.80^{a} \pm 0.94$	$7.67^{a} \pm 0.98$	$7.67^{ab} \pm 1.11$	$8.13^{a} \pm 1.06$	$8.13^{a} \pm 0.92$
C_3	$7.13^{abcdef} \pm 1.06$	$6.87^{abc} \pm 1.25$	$6.60^{abc} \pm 1.18$	$6.07^{defg} \pm 1.24$	$7.33^{abcd} \pm 0.90$	$7.53^{abc} \pm 0.99$
D_3	$6.87^{abcdefg} \pm 1.41$	$6.80^{abc} \pm 1.74$	$7.00^{abc} \pm 1.25$	$6.60^{bcdef} \pm 1.12$	$7.60^{abcd} \pm 1.06$	$7.27^{abc} \pm 1.03$
E_3	$7.40^{abc} \pm 1.50$	$6.80^{abc} \pm 1.74$	$6.93^{abc} \pm 1.95$	$7.60^{abc} \pm 1.45$	$8.00^{ab} \pm 1.25$	$8.00^{ab} \pm 1.25$
F_3	$6.67^{abcdefg} \pm 1.57$	$6.93^{abc} \pm 1.16$	$6.93^{abc} \pm 1.67$	$6.67^{bcdef} \pm 1.84$	$7.00^{abcd} \pm 1.81$	$7.53^{abc} \pm 1.41$

A_5	$6.67^{abcdefg} \pm 1.54$	$6.60^{abcd} \pm 1.45$	$7.00^{abc} \pm 1.13$	$7.00^{abcde} \pm 1.20$	$7.73^{abcd} \pm 1.22$	$7.93^{abc} \pm 0.88$
B_5	$6.53^{abcdefg} \pm 1.13$	$6.20^{bcd} \pm 1.70$	$6.27^{abc} \pm 1.39$	$6.07^{defg} \pm 1.33$	$6.40^{cdef} \pm 1.64$	$6.73^{cd} \pm 1.16$
C_5	$7.07^{abcdef} \pm 1.22$	$7.53^{ab} \pm 0.92$	$7.67^{a} \pm 0.8$	$7.47^{abcd} \pm 1.25$	$7.33^{abcd} \pm 1.50$	$8.07^{a} \pm 0.88$
D_5	$6.13^{cdefg} \pm 1.06$	$6.53^{abcd} \pm 1.73$	$6.20^{bc} \pm 1.78$	$6.13^{cdefg} \pm 1.77$	$6.53^{bcde} \pm 1.25$	$6.73^{cd} \pm 1.58$
E_5	$6.73^{abcdefg} \pm 1.10$	$6.47^{abcd} \pm 1.39$	$5.93^{bc} \pm 1.95$	$6.53^{bcdef} \pm 1.85$	$6.93^{abcd} \pm 1.79$	$7.27^{abc} \pm 1.79$
F_5	$7.00^{abcdef} \pm 1.25$	$6.53^{abcd} \pm 1.41$	$6.47^{abc} \pm 1.92$	$6.80^{abcdef} \pm 1.92$	$7.20^{abcd} \pm 1.15$	$7.27^{abc} \pm 1.22$
A_{10}	$6.13^{cdef} \pm 2.33$	$7.80^{a} \pm 1.21$	$6.93^{abc} \pm 1.10$	$7.07^{abcde} \pm 1.75$	$3.73^{jk} \pm 1.98$	$5.67^{de} \pm 1.54$
B_{10}	$6.00^{cdefg} \pm 1.69$	$7.40^{abc} \pm 1.50$	$6.60^{abc} \pm 1.40$	$6.40^{bcdef} \pm 1.80$	$4.80^{ghijk} \pm 2.01$	$5.73^{de} \pm 1.22$
C_{10}	$6.53^{abcdefg} \pm 1.85$	$7.73^{a} \pm 1.22$	$6.87^{abc} \pm 1.60$	$6.40^{bcdef} \pm 1.88$	$5.27^{efghi} \pm 1.75$	$5.93^{de} \pm 1.03$
D_{10}	$6.67^{abcdefg} \pm 1.68$	$6.47^{abcd} \pm 1.64$	$6.27^{abc} \pm 1.53$	$6.40^{bcdef} \pm 1.60$	$4.93^{fghij} \pm 2.19$	$5.67^{de} \pm 1.05$
E_{10}	$6.27^{bcdefg} \pm 1.98$	$6.53^{abcd} \pm 1.85$	$6.33^{abc} \pm 1.18$	$5.93^{efg} \pm 2.02$	$4.67^{hijk} \pm 2.58$	$5.40^{e} \pm 1.55$
F_{10}	$7.67^{ab} \pm 1.45$	$7.13^{abcd} \pm 1.64$	$6.93^{abc} \pm 2.15$	$7.40^{abcde} \pm 2.26$	$6.20^{defg} \pm 2.37$	$6.80^{bcd} \pm 1.15$
A_{20}	$5.53^{g} \pm 2.36$	$7.40^{abc} \pm 1.50$	$6.67^{abc} \pm 1.99$	$5.40^{fg} \pm 2.06$	$4.00^{hijk} \pm 2.73$	$4.13^{f} \pm 2.17$
B_{20}	$5.93^{defg} \pm 2.19$	$6.33^{bcd} \pm 2.09$	$6.27^{abc} \pm 1.95$	$6.07^{defg} \pm 2.02$	$3.40^{k} \pm 2.26$	$3.87^{f} \pm 1.69$
C_{20}	$5.87^{efg} \pm 2.17$	$7.20^{abcd} \pm 1.70$	$6.67^{abc} \pm 2.06$	$6.60^{bcdef} \pm 1.92$	$3.60^{jk} \pm 1.96$	$4.07^{f} \pm 2.22$
D_{20}	$5.47^{g} \pm 2.36$	$6.53^{abcd} \pm 1.64$	$6.60^{abc} \pm 2.17$	$4.87^{g} \pm 1.89$	$3.80^{ijk} \pm 2.11$	$3.80^{f} \pm 1.86$
E_{20}	$5.73^{fg} \pm 1.71$	$6.07^{cd} \pm 1.87$	$5.60^{c} \pm 2.10$	$6.13^{cdefg} \pm 2.48$	$5.27^{efghi} \pm 2.25$	$4.87^{ef} \pm 1.55$
F_{20}	$5.80^{fg} \pm 2.08$	$6.53^{abcd} \pm 1.81$	$6.67^{abc} \pm 1.84$	$7.33^{abcde} \pm 1.84$	$5.40^{efgh} \pm 2.47$	$5.73^{de} \pm 2.25$
Wheat	$7.67^{ab} \pm 0.98$	$7.00^{abcd} \pm 1.36$	$7.20^{ab} \pm 1.15$	$8.13^{a} \pm 0.92$	$7.67^{abcd} \pm 0.90$	$8.07^{a} \pm 0.96$
Cassava	$6.53^{abcdefg} \pm 1.13$	$5.87^{d} \pm 1.25$	$5.80^{bc} \pm 1.32$	$6.20^{bcdefg} \pm 1.32$	$6.20^{defg} \pm 1.01$	$7.13^{abc} \pm 0.74$
Maize	$7.33^{abcd} \pm 0.82$	$7.27^{abc} \pm 0.80$	$7.07^{ab} \pm 0.88$	$7.33^{abcde} \pm 1.11$	$6.40^{cdef} \pm 1.35$	$7.60^{abc} \pm 1.06$

Values are Means ± standard deviation. Values with different superscripts in the same column are significantly different ($p<0.05$). A_3:80gCassava:17gMaize:3g*Moringa oleifera* seed flour; B_3:85gCassava:12gMaize:3g*Moringa oleifera* seed flour; C_3: 90gCassava:7gMaize:3g*Moringa oleifera* seed flour; D_3:85gWheat:12gMaize:3g *Moringa oleifera* seed flour; E_3: 85gWheat:12gCassava:3g *Moringa oleifera* seed flour; F_3:97gWheat: 3g*Moringa oleifera* seed flour; A_5: 80gCassava:15gMaize:5g*Moringa oleifera* seed flour; B_5: 85gCassava:10gMaize:5g*Moringa oleifera* seed flour; C_5: 90gCassava: 5gMaize:5g*Moringa oleifera* seed flour; D_5:85gWheat:10gMaize:5g *Moringa oleifera* seed flour; E_5: 85gWheat:10gCassava:5g *Moringa oleifera* seed flour; F_3:95gWheat: 5g*Moringa oleifera* seed flour; A_{10}:75gCassava:15gMaize:10g*Moringa oleifera* seed flour; B_{10}:80gCassava:10gMaize:10g*Moringa oleifera* seed flour; C_{10}: 85gCassava:5gMaize:10g*Moringa oleifera* seed flour; D_{10}:80gWheat:10gMaize:10g *Moringa oleifera* seed flour; E_{10}: 80gWheat:10gCassava:10g *Moringa oleifera* seed flour; F_{10}:90gWheat: 10g*Moringa oleifera*seed flour; A_{20}:65gCassava:15gMaize:20g*Moringa oleifera* seed flour; B_{20}:70gCassava:10gMaize:20g*Moringa oleifera* seed flour; C_{20}: 75gCassava:5gMaize:20g*Moringa oleifera* seed flour; D_{20}:70gWheat:10gMaize:20g *Moringa oleifera* seed flour; E_{20}: 70gWheat:10gCassava:20g *Moringa oleifera* seed flour; F_3:80gWheat: 20g*Moringa oleifera* seed flour;

IV. Conclusion

A variation in the concentration in the flour mix of the ingredients used in composite flour formulation influenced the various parameters analyzed. A higher concentration of more than 5g *Moringa oleifera* seed flour/100g flour was not generally accepted for the biscuit samples. The order of acceptability of the composite flour blends was in this order: cassava/maize combination > wheat/cassava combination > wheat/maize combination with not more than 5g *Moringa oleifera* seed flour /100g flour

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References

[1]. Aacc (2000). Approved Methods Of The American Association Of Cereal Chemists (10th Ed). Methods Of Analysis 54-21 And 10-10b. American Association Of Cereal Chemists, St. Paul Minn, Usa.

[2]. Aguemon, T. M., Mankambou, J.A., Tectchi, A. F., Due, E. A. And Kouame, L. P (2019). Evaluation Of Functional Properties Of Bligha Sapida Seeds Flour From Cote D'ivoire. European Journal Of Pharmaceutical And Medical Research 6(6):80-95

[3]. Aidoo, R., Oduro, I.N., Agbenorhevi, J.K., Ellis, W.O And Pepra-Ameyaw, N.B. (2022). Physicochemical And Pasting Properties Of Flour And Starch From Two New Cassava Ascensions. International Journal Of Food Properties, 25(1):561-569.

[4]. Akinwotu, K. O., Taiwo, K. A., And Ikujenlola, A. V. (2025). Advancements In Composite Flours: Applications, Nutritional Benefits And Processing Techniques. Asian Food Science Journal, 24(6) 24-36,

[5]. Alim, Md. A., Abedin, Md. Z., Al Reza, Md. S., Obidul Huq, A. K., Bari, L., Esarafil, Md. And Zubair, Md. A. (2024). Development And Characterization Of Composite Wheat Flour Incorporated With Psyllium Husk (Plantago Ovata) And Peanut (Arachis Hypogea) And Sensory Properties Of Composite Flour Noodles. Food And Humanity, 2, 100279. Doi/10/1016/J.Foodhum.2024.100279

[6]. Anberbir, S. M., Satheesh, N., Abera, A.A., Kassa, M. G., Tenagashaw, M.W., Asres, D.T., Tiruneh, A. T., Habtu, T. A., Sadik, J.A., Wudineh, T. A., And Yehuala, T.F.(2024). Evaluation Of Nutritional Composition, Functional And Pasting Properties Of Pearl Millet, Teff And Buckwheat Grain Composite Flour. Applied Food Research 4(1):100390.

[7]. Anon, A. H., Fagbohoun, J. B., Koffi, A.G., Anon, H.F.A And Kouame, P. (2021). Functional Properties Of Composite Flours Produced With Ivorian Taro (Colocosia Esculenta L. Cv Foué) Corms Flour And Wheat (Triticum Aestivum L.) Gsc, Biological And Pharmaceutical Science, Elssn: 2518-3250.

[8]. Awolu, O. O. (2017). Optimization Of The Functional Characteristics, Pasting And Rheological Properties Of Pearl Millet Based Composite Flour. Heliyon, 3(2):1002.40

[9]. Awuchi, C. G., Igwe, V. S., And Echeta, C. K. (2019). The Functional Properties Of Foods And Flours. International Journal Of Advanced Academic Research/Sciences, Technology And Engineering 5(11):139-160.

[10]. Azad, S. B., Ansari, P., Azam, S., Hossain, S. M., Shahid, M. I. B., Hasan, M And Hannan, J. M.A. (2017). Anti-Hyperglycaemic Activity Of Moringa Oleifera Is Partly Mediated By Carbohydrates Inhibition And Glucose-Fiber Binding. Bioscience Reports 37:1-11 Doi/10.1042/Bsr20170059.

[11]. Bemilles, J. N. (2011) Pasting, Paste Ad Gel Properties Of Starch-Hydrocolloid Combinations Of Starch-Hydrocolloid Combinations. Carbohydrate Polymer 86:386-423.

[12]. Carson, G. R. And Edwards, N. M. (2009). Criteria Of Wheat And Flour Quality. Wheat Chemistry And Technology, 4th Edition, Aacc International Inc, Pp 97-118.

[13]. Chandra, S., Singh, S And Umari, D. (2015). Evaluation Of Functional Properties Of Composite Flours And Sensorial Attributes Of Composite Flours For Biscuits. Journal Of Food Science And Technology, 52(6):3681-3688.

[14]. Chavarriaga-Aguirre, P., Brand, A., Medina, A., Prias, M., Escobar, R., Martinez, J., Diaz, P., López, C., Roca, W.M And Tohme, J. (2016). The Potential Of Using Biotechnology To Improve Cassava: A Review. In Vitro Cellular And Development Biology, 52(5): 461-478.

[15]. Chinma, C.E., James, S., Imam, H., Ocheme, O.B., Anuonye, J.C And Yakubu, C.M. 92011). Physicochemical And Sensory Properties And Invitro Digestbity Of Biscuits Made From Blends Of Tiger Nut (Cyperus Esculentus) And Pigeon Pea (Cajanus Cajan). Nigerian Journal Of Nutritional Sciences, 32:55-62.

[16]. Detchewa, P., Prasájak, P., Sriwichai , W And Moonanganm, A. (2021). The Effects Of Unripe Banana Flour On Resistant Starch Content And Quality Characteristics Of Gluten Free Rice Cookies. Journal Of Sustainability Science And Management, 16(2):67-78.

[17]. Devi, A., Sindhu, R., And Khatkar, B. S. (2020). Effect Of Fat And Oils On Pasting And Textural Properties Of Wheat Flour. Journal Of Food Science And Technology 57(10):3836-3842.

[18]. Egwujeh, S. I. D., Adeyemi, S. A And Egbunu, G. F. (2010). Evaluation Of Proximate, Pasting And Sensory Properties Of Complementary Food From Millet And From Ripe Pawpaw Flour Blends. Indian Journal Of Nutrition, 3(1):128

[19]. Finnie, S And Atwell, W. A. (2016). Composition Of Commercial Flour Wheat Flour, 2nd Edition Aacc International Inc. Pp. 31-48.

[20]. Goňi, I., Garćia-Diz, L., Mañas, E And Saura-Calixto, F. (1996). Analysis Of Resistant Starch: A Method For Food And Food Products. Food Chemistry, 56(4):445-449.

[21]. Gopalakrishnan, L., Doriya, K. And Kumar, D. S. (2016). Moringa Oleifera: A Review On Nutritive Importance And Its Medicinal Application. Food Science And Human Wellness 5(2):49-56.

[22]. Guiberti, G., Gallo, A., Cerioli, C., Fortunati, P., And Masoero, F. (2015). Cooking Quality And Starch Digestibility Of Gluten Free Pasta Using New Bean Flour. Food Chemistry 175:43-49.

[23]. Hazelton, J. L., Desrochers, J. L., And Walker, C. E. (2003). Biscuits, Cookies And Crackers : Chemistry Of Biscuit Making. Encyclopedia Of Food Sciences And Nutrition (2nd Ed.), 533-539.

[24]. Ihekoronye, A.I And Ngoddy, P.O. 9985). Intergrated Food Science And Technology, Macmilian Publishers, New York. Pg 296-301.

[25]. Imoisi, C., Iyasele, J.U., Imhntu, E. E., Ikpahwore, D. O And Okpebho, A. O. (2020). Pasting Properties Of Composite Cassava And Wheat Flours. Journal Of Chemical Society Of Nigeria, 45 (6):1157-1163.

[26]. Joyti, K., Jain, K And Olakih, D. (2019). An Overview Of Role Of Yellow Maize In Food, Feed And Nutrition Security. International Journal Of Current Microbiology And Applied Sciences, 8(2):3037-3048.

[27]. Juan, G., Luis, A And David, B. (2006). Isolation And Molecular Characterization Of Makal (Xanthosoma Yucatanensis) Starch. Starch, 58:300-307.

[28]. Julianti, E., Rusmarilin, H And Yusraini, R.E. (2017). Functional And Rheological Properties Of Composite Flour From Sweet Potato, Maize, Soybean And Xanthan Gum. Journal Of The Saudi Society Of Agricultural Sciences, 16(2):171-177.

[29]. Karaaslan, S.N., Tunçer, I.K., 2008. Development Of Drying Model For Combined Microwave-Fan-Assisted Convection Drying Of Spinach. Biosystems Engineering, 100:44-52.

[30]. Kaur, M And Singh, N. (2005). Studies On Functional, Thermal And Pasting Properties Of Flours From Different Chickpea (Cicer Arietinum L) Cultivars. Food Chemistry, 91:403-411.

[31]. Klompong, V., Benjakul, S., Kantachote, D And Shahidi, F. (2007). Antioxidative Activity And Functional Properties Of Protein Hydrolysate Of Yellow Stripe Trevally (Selaroides Leptolepis) As Influenced By The Degree Of Hydrolysis And Enzyme Type. Food Chemistry, 102:1317-1327.

[32]. Kortei, N.K And Akonor, N.L. (2015). Correlation Between Hue Angle And Color Lightness Of Gamma Irradiated Mushrooms. Annals. Food Science And Technology, 16(1): 98-103.

[33]. Kulkarni, K.D., Kulkarni, D.N And Ingle, U.M. (1991). Sorghum Malt Based Weaning Food Formulation Preparation, Functional Properties And Nutritive Values. Food Nutrition Bulletin, 13(14): 322-327.

[34]. Kumar, R. And Khatkar, B.S (2017). Thermal, Pasting And Morphological Properties Of Starch Granules Of Wheat (Triticum Aestivum L.) Varieties. Journal Of Food Science And Technology 54 (8):2403-2410.

[35]. León-López, L., Escoba-Zúñinga, Y., Milán-Carrillo, J., Dominguez-Arispuro, D. M., Gutiérrez-Dorado, R., And Cuevas-Rodriguez, E. O. (2020). Chemical Proximate Composition, Anti-Nutritional Factors Content And Anti-Oxidant Capacity Of Anatomical Seed Fractions Of Moringa Oleifera . Acta Universitaria Multidisciplinary Scientific Journal, 30:1-11.

[36]. Liu, S., Yuan , T. Z., Wang, X., Reimer, M., Isaak, C. And Ai, Y. (2019). Behaviors Of Starches Evaluated At High Heating Temperatures Using A New Model Of Rapid Visco Analyzer-Rva4800. Food Hydrocolloids, 94: 217-228

[37]. Mccleary, B.V., Gibson, T.S And Mugford, D.C. (1997). Measurement Of Total Starch In Cereal Products By Amyloglucosidase/A-Amylase Method: Collaborative Study. Journal Of The Association Of Analytical Chemists, 80:571-579.

[38]. Mcguire, R,C. (1992). Reporting Of Objective Color Measurements. Hort Science, 27:1254 -1255.

[39]. Min, K. K., Juri, P., And Doo-Man, K. (2024). Resistant Starch And Type 2 Diabetes Mellitus: Clinical Perspective. Journal Of Diabetes Investigation 15(4)395-401.

[40]. Mohana, K., Asna, U And Prasad, N.N. (2007). Effect Of Storage On Resistant Starch And Amylose Content Of Cereal Pulse Based Ready-To-Eat Commercial Products. Food Chemistry, 102:1425-1430.

[41]. Morante, N., Ceballos, H.,Sanchez, T., Rolland-Sabate, A And Salle, F. (2016). Discovery Of New Spontaneous Sources Of Amylose-Free Cassava Starch And Analysis Of Their Structure And Techno-Functional Properties. Food Hydrocolloids, 56:383-395.

[42]. Narayana K. And Narsinga Rao, M.S. (1982). Functional Properties Of Raw And Heat Processed Winged Bean (Psophocarpus Tetragonolobus) Flour. Journal Of Food Science, 42:534-538.

[43]. Nawaz, H., Shad, M. A., Mehmood, R., Rehman, T. And Munir, H. (2015). Comparative Evaluation Of Functional Properties Of Commonly Used Cereal And Legume Flours With Their Blends. International Journal Of Food And Allied Sciences, 1(2):67-73.

[44]. Noorfarazilah, M., Lee, J. S., Sharifudin, M.S. Mohd-Fadzelly, A. B And Hasmadi, M. (2014). Applications Of Composite Flour In Development Of Food Products. International Food Rseach Journal, 21(6):2061-2074

[45]. Ocheme, O. B., Adedeji, O.E., Chinma, C. E., Yakubu, C. M., And Ajibo, U. H. (2018). Proximate Composition, Functional And Pasting Properties Of Wheat And Groundnut Protein Concentrate Flour Blends. Food Science And Nutrition, 6(5):1173-1178.

[46]. Olamiti, G And Ramshia, S. E. (2024). Impact Of Composite Flour On Nutritional Bioactive And Sensory Characteristics Of Pastry Foods: A Review Current Research In Nutrition And Food Science Journal, 12(3): Doi/10.129441/Grnfsj:12:3.4

[47]. Olaoye, O. A. And Ade-Omowaye, B. I. (2011). Composite Flours And Breads:Potential Of Local Crops In Developing Countries In Preedy, V. T, Watson, R. R., Pate, Y. B., (Eds). Flour And Breads And Their Fortification In Health And Disease Prevention Chapter 17, Pgs 183-192.

[48]. Onabanjo, O.O And Ighere, D.A. (2014). Nutritional, Functional And Sensory Properties Of Biscuit Produced From Wheat-Sweet Potato Composite. Journal Of Food Technology Research, 1(2):111-121.

[49]. Onwuka, G.I. (2005). Food Analysis And Instrumentation: Theory And Practice. Naphtali Prints, Lagos.

[50]. Oppong, D., Arthur, E., Kwadwo, S. O., Badu, E., And Sakyi, P. (2015). Proximate Composition And Some Functional Properties Of Soft Wheat Flour . International Journal Of Innovative Research In Science Engineering And Technology, 4(2):753-758.

[51]. Orisa, C. A., And Udofia, S. U. (2020) Functional And Pasting Properties Of Composite Flours From Triticum Dumum , Digitaria Exilis, Vigna Uguiculata And Moringa Oleifera Powder. Asian Food Science Journal 19(2): 40-49

[52]. Pathare, P.B, Opara, U.L And Ai-Said, F.A.J. (2012). Colour Measurement And Analysis In Fresh And Processed Foods: A Review. Food And Bioprocess Technology, 6:36

[53]. Philips, K. (2015). The Color Of Flour. Evaluating Grain Products With Spectral Analysis. Hunterslab>703.471.6870 Cooperate Headquarters 11491, Sunset Hills Road, Reston, Virginia, 20190.

[54]. Ritika, B. Y., Khatkar, B. S. And Yadav, B. S. (2010) Physiochemical, Morphological, Thermal And Pasting Properties Of Starches Isolated From Rice Cultivars Grown In India. International Journal Of Food Properties, 13:1339-1354.

[55]. Saa, R. W., Fombang, E. N., Ndjantou, E. B. And Nijjintang, N.Y.C. (2019). Treatments And Uses Of Moringa Oleifera Seeds In Human Nutrition: A Review. Food Science And Nutrition, 7:1911-1919.

[56]. Saberi, B., Thakur, R., Voung, Q.V., Chockchaisawasdee, S., Golding, J.B., Scarlett, C.J And Stathopoulos, C.E. (2016). Optimization Of Physical And Optical Properties Of Biodegradable Edible Films Based On Pea Starch And Guar Gum. Industrial Crops And Products, 86:342-352.

[57]. Salamon, A., Kowalska, H., Stępniewska, S And Szafrańska, A. (2024). Evaluation Of The Possibilitis Of Using Oat Malt In Wheat Bread Making. Applied Sciences, 14:4101.Doi/10.33901/App14104101

[58]. Shittu, T. A., Lasekan, O.O., Sanni, L. O., And Oladosu, M. O. (2001). The Effect Of Drying Methods On The Functional And Sensory Characteristics Of Pupuru: A Fermented Cassava Product. Asset, 1(2):9-16

[59]. Singh, P., Anam, S.C., Kumar, D., Singh, A.K And Singh, P. (2023). Sugarcane Blanching At Specific Temperature And Time Combination Preserves Juice Physio-Biochemical, Microbial And Sensory Attributes. International Journal Of Food Science And Technology, 58:586-594.

[60]. Twinomuhwezi, H., Awuchi, C.G And Mihigo, R. (2020). Comparative Study Of The Proximate Composition And Functional Properties Of Composite Flours Of Amaranth, Rice, Millet And Soybean. American Journal Of Food Science And Nutrition, 6(1): 6-19.

[61]. Ukpabi, U.J And Ndimele, C. (1990). Evaluation Of The Quality Of Gari Produced In Imo State. Nigerian Food Journal, 8:105-109.

[62]. Yani, A., Asropi, A., And Utomo, J. S. (2014). Physiochemical Characteristics Of Composite Flour Made From Cassava, Sweet Potato, Corn And Rice Bran. International Journal On Advanced Science And Technology 494):11-15.

[63]. Yasumatsu, K., Sawada, K., Moritaka, S., Misaki, M.,Toda, J., Wada, T And Ishii, K. (1972). Whipping And Emulsifying Properties Of Soy Bean Products. Agricultural And Biological Chemistry, 36(5):719-727.

[64]. Yun, P., Devahastin, S., And Chiewchan, N. (2020). Physical Properties, Microstructure And Digestion Behavior Of Amylose-Lipid Powder Complexes Prepared Using Conventional And Spray Drying Based Methods. Food Bioscience Article, 100724.