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Evaluation of the Nutritional, Physical and Sensory Properties of Bread Made From Wheat-Maize-Acha Composite Flours Enriched With Cocoa (Theobroma cacao) Powder

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Abstract
The research was designed to ascertain the potential of cocoa flour inclusion in bread made from wheat-maize-acha composite flours. The cocoa flour was incorporated into the composite flour at 10, 15 and 20 % level and its proximate, physical and sensory properties were determined using standard methods. Fat and protein contents of the flour ranged from 7.89 to 10.57 % and 10.01 to 12.73 % while the fiber and ash contents were 2.01 to 2.75 % and 1.25 to 1.69 %. The bread has the fat and protein contents of 7.50 to 9.89 % and 9.45 to 10.83 %. The fiber content of the bread ranged from 2.90 to 3.86 %. The bulk density and foaming capacity of the flour ranged from 0.56 to 0.88 g/ml and 3.55 to 6.85 % while the water and oil absorption capacity were 2.15 to 2.75 g/ml and 2.18 to 3.10 g/ml. The loaf weight and loaf volume ranged from 112.98 to 312.55 g and 400.00 to 470.00 cm³. The specific volume of the bread was 1.28 to 3.79 cm³/g. $W_{60}M_{20}C_{20}$ showed the highest organoleptic scores among the bread samples. Conclusively, the samples may be used in formulating functional bread with high nutrient content for human consumption.

Keywords : Cocoa, bread, proximate, sensory properties, functional

Introduction

Bread consumption has increased continuously in many developing countries due to changing eating habits and steadily growing population (Zafar *et al*., 2015). Bread plays an important role in the human diet and relatively large amounts are consumed worldwide (Henchion *et al*., 2017). Bread is a dietary staple in human nutrition (Dewettinck *et al.*, 2008). Research on bread is globally conducted to improve its nutritional value (such as carbohydrates, proteins, fat and dietary fibers, minerals and vitamins), health supporting bioactive compounds, sensory acceptability, and shelf life and to match with the affordability. In many countries, particularly in sub- Saharan Africa, bread wheat production and supply are inadequate to meet the bread eating habit of consumers, which is increasing with an increase in urbanization. One method to alleviate the shortage of wheat flour, increase the nutritional quality and bioactive contents of the bread is to use composite flours prepared from different crops like protein rich legumes, tubers rich in starches and/or other cereal grain flours (Nwanekezi, 2013)

The awareness of the consumers on the importance of eating healthy and functional foods is increasing universally and health conscious consumers prefers food that provides extra or additional health benefits beyond the basic nutritional requirement (Ndife & Abbo, 2009); (Baba *et al*., 2015). Therefore, there is a trend to producing functional confectionary products made from composite flour and health promoting compounds from non-wheat flour known as functional ingredients (Dewettinck *et al*., 2008). The utilization of refined wheat flour alone and other ingredients result in confectionaries lacking those essential components of grains like dietary fibre and phytochemical that have some health benefits (Fardet, 2010); (Sozer *et al*., 2014). Wheat and other cereal flours on their own are good source of calorie and other nutrients but their antioxidant capacity is low probably due to refining processing, hence the need to composite it with cocoa powder in other to improve its nutritive values.

Acha (*Digitaria exilis*) is an underutilized crop recently gaining popularity. Like other grains, acha is widely reported to be rich in amino acids but particularly in methionine and cystine (Belton & Nuttall, 2002). Studies have shown that the methionine level in acha is twice that found in egg protein leading to suggestions that acha could be used to complement many diets that are low in the essential amino acids. Okeme *et al.* (2017) have reported acha as an excellent nutritional complement to legumes as most legumes are deficient in methionine and cystine. It is also a good source of vitamins, minerals, fibre, carbohydrate, lipids, proteins and ash (Barber *et al.*, 2010). Maize (*Zea mays L.*) is one of the most extensively cultivated cereal grain in the world and represents a crucial source of human food, livestock feed, fuel and fibre (Tenaillon & Charcosset, 2011). It is the third most important cereal grain worldwide after wheat and rice (Gwirt & Garcia-Casal, 2014). Maize is a basic staple food grain for large parts of the world including Africa, America and Asia and is consumed in many forms such as infant foods, snacks and main dishes (Ekpa *et al*., 2018). Maize grain contains 65-84 % starch, 9-10 % protein, 3-5 % fat, 3 % ash and 2-3 % fibre (Ranum *et al*., 2014). Maize provides many of the B vitamins and essential minerals but lacks some other nutrients such as vitamin B12 and vitamin C but poor source of calcium, folate and iron (Goya *et al*., 2012).

Cocoa powder is a plant product that has not enjoyed wide consumer acceptance in Nigeria as a result of its bitter aftertaste and astringency. It has however, recently received global attention as a functional food product/ingredient in the food and confection industry for numerous applications (Borchers *et al.*, 2000). Cocoa powder has been reported to confer health-promoting benefits including promotion of cardiovascular health, reduction of low-density lipoprotein (LDL) cholesterol and oxidation of LDL to prevent atherosclerosis or plaque formation. It also elevates high density lipoprotein (HDL) cholesterol (Taubert *et al.*, 2007); (Corti *et al*., 2009). This is owing to its rich content of natural antioxidants and it have been reported to exhibit greater antioxidant capacity than many other flavanol-rich foods and food extracts including red wine, blueberry, garlic, strawberry and green and black tea (Lee *et al.*, 2003). Nutritionally, cocoa powder is a rich source of protein, vitamin A, riboflavin and nicotinic acid, minerals including iron, calcium, copper, magnesium, phosphorus, potassium, sodium and zinc (Steinberg *et al.*, 2003). Thus, it may serve the dual purpose of enriching food with vital nutrients and health-promoting bioactive compounds. This study, hence, evaluated the potentials of the blends of these flours (wheat, maize acha, and cocoa flour) as composite flour in bread production to improve its nutritional and functional values.

Materials and Methods

Sourcing of raw materials

Maize and acha grains were obtained from a local market in Saki, Nigeria while other bakery ingredients were obtained from a supermarket also in Saki. The cocoa powder was obtained from COOP Cocoa Limited, Akure-Owo Expressway Akure, and Nigeria. All chemical (analytical grade) and reagents were purchased from Sigma (Sigma Chemicals, St. Louis, MO).

Methods

Processing of maize and acha flours

Cleaning and sorting of the grains was done so as to remove any unwanted particles. Winnowing was done by removing the chaff from the grains. The grains were washed with clean water for about four times. The grains were dried in a cabinet dryer (Sunshine scientific equipment, 07AFHPN3371D1ZL, New Delhi, India) at 50°C for 6 h. It was then allowed to cool and milled with hammer mill (I.G. Jurgens, Bremmer, Germany) and packaged in air-tight containers at room temperature until further use.

Bread dough formation

The bread dough was produced based on the Straight dough method. This method involves the addition of all ingredients; Wheat/Composite flour (100 g), sugar (12.5 g), salt (2.5 g), milk (12.5 g), yeast (0.5 Mc Farland standard), fat (20 g) and water (50 ml) at the mixing stage, then kneading to form the dough as described by (Cauvain, 2012).

Production of Bread Using wheat Composite Flour Blends

The bread samples were produced in batches by mixing and kneading manually each of the flour blends with other bread ingredients in a stainless-steel bowl. After thorough kneading in each case, the dough was allowed to ferment and develop for 1 h at 35^{o} C before being knocked back and then molded into cylindrical shape. After molding in each case, the dough was placed in a well-oiled baking pan where it was proofed for 30 min at room temperature before it was baked in an oven pre-heated and set at 210^{o}C. After baking, the dough was brought out in each case from the oven and immediately de-panned by knocking out. The knocked-out bread was allowed to cool, weighed and measured before being packed in polyethylene bag and stored at room temperature (Ayo *et al*., 2014)

Composite flours formulation with cocoa enrichment for bread production

Wheat and composite flour preparation were blended in different proportion where wheat flour was used as control sample as shown in Table 1

Table 1: Composite flours formulation

Samples code	Wheat	Maize	Acha	Cocoa
$W_{80}M_{10}C_{10}$	80	10	-	10
$W_{70}M_{15}C_{15}$	70	15	-	15
$W_{60}M_{20}C_{20}$	60	20	-	20
$W_{80}A_{10}C_{10}$	80	10	-	10
$W_{70}A_{15}C_{15}$	70	15	-	15
$W_{60}A_{20}C_{20}$	60	20	-	20
WHT	100	-	-	-

WMC: Wheat-maize-cocoa composite flour
WAC: Wheat-acha-cocoa composite flour
WHT: Wheat flour
Chemical analysis

Determination of the Proximate Composition of composite flour and bread

Proximate compositions (moisture content, ash, crude fiber, crude fat and crude protein content) of the bread samples were determined using the standard methods (AOAC, 2012). Carbohydrate content was determined by difference as thus:

Carbohydrate (%) = 100 - (Moisture +Fat + Ash + Crude fibre + Crude protein) (1)

Determination of functional properties of composite flours

Determination of Bulk density

Bulk density

The bulk density (BD) of the flours was measured using modified method of (Amandikwa *et al*., (2015). Briefly, about 10 g of flours were weighed and put into 25 ml measuring cylinder and the volume was recorded as a loose volume. The bottom was tapped on a bench until a constant volume was observed. The bulk density was calculated as the ratio of the flour weight to the volume occupied by the flour before and after tapping using Equation 2 below

$$Bulk\ density = \frac{weight\ of\ flour}{volume\ of\ flour}\ g/ml \quad (2)$$

Determination of water absorption capacity

The method described by Chandra *et al.* (2015) was used to determine the water/oil absorption capacity and emulsion stability of the different flours. Briefly, about 0.5 g of the flour was dissolved in 10 mL of distilled water in centrifuge tubes and vortexed for 30 s. The dispersions stayed at room temperature for 30 min, centrifuged at 2000 x g for 25 min using a Model T-8BL LabyTM centrifuge (Laboratory Instruments, Ambala Cantt, India). The supernatant was filtered with Whatman No 1 filter paper and volume was accurately measured. The difference between initial volumes of distilled water added to the flour and the volume obtained after filtration was determined. The result was reported as g/g of water absorbed per gram of flour Equation 3 below.

$$\text{Water absorption capacity} = \frac{amount\ of\ water\ absorbed}{weight\ of\ sample}\ g/ml \quad (3)$$

Determination of oil absorption capacity

About 1 g of the flour (W0) was weighed into pre-weighed 50 ml centrifuge tubes and thoroughly mixed with 10 ml (V1) of refined pure sunflower oil using a vortex mixer (Heidolph Reax top, Germany). Flours stood for 30 min. The flour-oil mixture was centrifuged at 2000 x g for 20 min using a centrifuge (Universal 320 E Hettich, Germany). Immediately after centrifugation, the supernatant was carefully poured into a 10 ml graduated cylinder, and the volume was recorded (V2). Oil absorption capacity (OAC) was calculated using the following Equation 4 below

$$\text{Oil absorption capacity} = \frac{V1-V2}{WO} \quad (4)$$

Determination of solubility and swelling capacity

The solubility and swelling capacity (SC) of flour samples were determined using the method described by (Chatakonda *et al*., 2011) with some modifications. Approximately 1 gramme of flour sample was weighed into a 50 ml centrifuge tube containing 40 ml deionized water and vortexed for 30 min. The tubes were then heated in a thermostatically regulated water bath at 85 °C for 20 min and cooled to room temperature. The tube and its contents were centrifuged at 2200 rpm for 15 min and the clear supernatant carefully decanted into a reweighed petri dish. The weight of the residue/sediment was then noted. The water in the supernatant was evaporated and the difference in weight of petri dish was recorded as the weight of soluble fraction. Solubility and swelling power (SP) were calculated using the following equations:

Solubility (%) = (weight of soluble fraction)/ (weight of sample) × 100 (5)

Swelling Capacity (%) = (wt of sediment)/ (wt of sample × (100-solubility) ×100 (6)

Determination of foaming capacity

The method of Jitngarmkusol *et al.* (2008) was used for the determination of the foaming capacity of the samples with some slight modifications. About two gramme of each flour sample was mixed with 100 ml of distilled water and the suspension was whipped with a kitchen blender. The whipped suspension was transferred into a 250 ml graduated cylinder. Volumes of the whole mixture were recorded before and after whipping and the experiment was done in triplicate. The foaming capacity was calculated using the equation:

Foaming capacity (%) = $(V_1-V_2)/V_3) \times 100$ (7)

Where: V_1 is the volume of initial mixture and V_2 is the volume of the mixture after whipping and V3 is the volume of the foam after 5 h.

Determination of the physical properties of the bread

The loaf volume was measured by rapeseed displacement immediately after baking, loaf weight was determined by simple weighing using an electronic balance. Specific volume was measured by dividing the volume by the weight as described by (Maneju *et al*., 2011)

Specific volume = Volume/weight (cm^3/g) (8)

Sensory evaluation

The bread samples were subjected to organoleptic analysis within 24 hours of baking. The samples were evaluated by using a 60 untrained panelist on a 9-point hedonic scale of 9 (like extremely) to 1 (dislike extremely) for appearance, texture, taste, flavor and overall acceptability (Iwe *et al*., 2014).

Statistical Analysis

The data were analyzed using SPSS version 23.00. The analysis of variance (ANOVA) was used to determine significant differences between the means (P<005) while the means was separated using the Duncan multiple range test (DMRT).

Results and discussion

Proximate composition of the composite flour

The proximate composition of the composite flours is presented in Table 2. The moisture content of the composite flours ranged from 3.10 to 4.31 % for (WHT) and ($W_{60}M_{20}C_{20}$). The results showed a significant (p< 0.05) difference in the moisture content of the samples. The values obtained in this study was lower than the moisture content of wheat-yellow maize composite flour enriched with African walnut protein isolate which ranged from 8.33 to 9.17 % (Olapade & Awofadeju, 2021) and composite flour from cooking banana and yellow maize which ranged from 8.33 to 9.17 % (Asonzu *et al*., 2020). Moisture is an important factor in flour products which consequently changes the life span of foods. The percentage of moisture in this study was lower than the minimum limit value (10 %) (Shahzadi *et al*., 2006). Hence, this is an indicator that the composite flours will produce a shelf stable food product. The lower moisture in the composite flour also attest to that fact that there is no moisture retention and this will subsequently prolong the shelf life of any food product made from the composite flours.

The fat content of the composite flours ranged from 7.89 to 10.57 % for (WHT) and ($W_{60}M_{20}C_{20}$). The values of the fat content in this study were higher than the fat content of unripe cooking banana-pigeon bean-sweet potato flour blends which ranged from 0.51 to 2.34 % (Ohizua *et al*., 2017) and composite flour made from cooking banana and yellow maize which ranged from 2.10 to 6.20 % (Asouzu *et al*., 2020). The relative high fat content makes the composite flours suitable in the development of confectionary products for growing children. The protein content ranged from 10.01 to 12.73 % for (WHT) and ($W_{60}M_{20}C_{20}$). It could be observed that as the level of cocoa powder increases, the protein content equally increases in all the flour samples. This increase in protein content is expected as it has been long established that bread making performance of flours does not only depends on the quantity of protein alone but also the quality of the protein. The fibre and ash contents of the composite flours ranged from 2.01 to 2.75 % and 1.25 to 1.69 % for (WHT) and ($W_{60}M_{20}C_{20}$) respectively. The concomitant increase observed in the fibre content as the cocoa flour increased showed that the composite flours are rich in fibre which could be used in processing of functional foods which can help in ameliorating the incidence of some metabolic disorder such as diabetes and hypercholesteromia (Chukwu *et al*., 2013); (Jaja & Yahere, 2015). Though, the value obtained for fibre in this study are low for rich-fibre food when compared with suggested range of 20-35 g/day for adults and 5 g/dy for chidren (Dhingra *et al*., 2012); (Neha & Chandra, 2012). Nevertheless, the amount of fibre reported is non negligible content which is possibly able to contribute to fibre recommended daily allowance. The ash content recorded are in agreement values of 1.60 to 2.63 % for wheat-yellow maize-African walnut protein isolate composite flours (Olapade & Awofadeju, 2021). Ash content is a reflection of the mineral matters in food samples, hence, the composite flours, more importantly ($W_{60}M_{20}C_{20}$) contain high mineral content. The carbohydrate content of the composite flours ranged from 67.95 to 75.74 % for ($W_{60}M_{20}C_{20}$) and (WHT), This study recorded high carbohydrate with the exception of the ($W_{70}M_{15}C_{15}$) and ($W_{60}M_{20}C_{20}$) composite flours and this is an indication that all other flour samples are good source of carbohydrate.

Proximate composition of the bread made from the composite flour

The proximate composition of bread made from wheat-maize and wheat-acha composite flour enriched with cocoa powder in Table 2 shows that the moisture value of the bread samples ranged from 7.50 to 9.89 % for wheat (WHT) and wheat-maize composite bread ($W_{80}M_{10}C_{10}$). The moisture value of the wheat-acha composite bread were found to be significantly (p> 0.05) higher that the control sample (WHT) with (W80A10C10), ($W_{70}A_{15}C_{15}$) and ($W_{60}A_{20}C_{20}$) has the values of 8.90 %, 8.67 % and 8.45 % respectively. The values reported in this study was significantly (p< 0.05) lower than 20.61-33.22 % reported by Oguntuase *et al*. (2022) for bread samples made from wheat-bambara groundnut composite flour. The values were found to be also significantly (p> 0.05) lower than values of 13.40-14.15 % for bread made from wheat-Rosehip composite flour (Nicoleta & Maria, 2021). However, the moisture values of bread in the present study was similar to values of 7.80 to 9.01 % for wheat-leafy vegetable-based bread reported by Okoye and Ezeugwu (2019). Food products with high moisture concentration tends to have the ability to rapidly reproduced high rate of microorganism, therefore reduced the storage life of the products. The experimental bread samples moisture values in this study showed that it can be stored for a longer time due to its relatively low moisture. The fat and protein content of the bread ranged from 9.45 to 10.83 % for (WHT) and ($W_{60}M_{20}C_{20}$) and 11.25 to 13 87 % for (WHT) and ($W_{60}M_{20}C_{20}$) respectively. The result showed increase in the fat and protein values with increase in cocoa powder. The values obtained for fat content of the bread was significantly (p< 0.05) lower than the values of 1.78-2.38 % obtained for whole wheat-bambara groundnut bread while the protein content was found was found to be within the range of 8.65-18.41 % reported by Yusufu and Ejeh (2018). The protein value was also similar to the value of 8.00-15.57 % for wheat-leafy vegetable-based bread (Odunlade *et al*., 2017). The increase in protein value of the bread samples could be as a result of inclusion effect of the protein found in wheat and cocoa. Study have shown that cocoa contain between 11-15 % protein (Bertazzo *et al*., 2011) while wheat contain 11-13 % protein (Stahl *et al*., 2009). The increased protein in the bread sample made from the composite flour could improve the nutrient intake of the consumers particularly, the amino acid concentration. The fiber content of the bread ranged from 2.66 to 3.86 % ($W_{80}A_{10}C_{10}$) and ($W_{60}M_{20}C_{20}$) while the ash value ranged from 1.13 to 2.89 % (WHT) and ($W_{60}M_{20}C_{20}$) respectively. The values of fiber and ash obtained in this study is found to be significantly (p> 0.05) higher than the values of 1.52 and 1.91 % for wheat bread enriched with hazelnuts and walnuts (Karolina & Eva, 2020). The values were however similar to 2.77 and 2.44 % for whole wheat-bambara groundnut bread (Yusufu & Ejeh, 2018). Enrichment of the cocoa powder with the composite flour significantly improved the fiber and ash content of the bread. Inclusion of flours obtained from by-products rich in phenolic compounds such as cocoa powder has been found to increase ash and fiber content of bread as reported by Pop *et al*. (2016) and Subiría-Cueto *et al*. (2021). The carbohydrate values of the bread samples ranged from 59.40 to 67.77 % for (WHT) and ($W_{60}M_{20}C_{20}$). This value was similar to 53.05 to 69.85 % for whole wheat-bambara groundnut bread (Yusufu and Ejeh, 2018). However, the values were significantly ($p< 0.05$) lower to 71.04-73.66 % for wheat-Rosehip bread reported by (Nicoleta and Maria, 2021). The observed decrease in carbohydrate of the bread made from the composite flour enriched with cocoa powder compared to the wheat bread was also reported for bread enriched with moringa seed flour and soy-enriched bread reported by Bolarinwa *et al*. (2017); Sanful and Darko (2010).

Table 2: Proximate composition (%) of the composite flour and bread

Samples	Moisture	Fat	Protein	Fibre	Ash	Carbohydrate
Flour						
$W_{80}M_{10}C_{10}$	4.02^{c}±0.01	10.18^{c}±0.12	11.39^{c}±0.11	2.35^{c}±0.02	1.45^{c}±0.01	70.61^{e}±0.02
$W_{70}M_{15}C_{15}$	4.12^{b}±0.03	10.33^{b}±0.13	12.66^{b}±0.12	2.55^{b}±0.01	1.54^{b}±0.02	68.80^{f}±0.03
$W_{60}M_{20}C_{20}$	4.31^{a}±0.02	10.57^{a}±0.14	12.73^{a}±0.11	2.75^{a}±0.03	1.69^{a}±0.03	67.95^{g}±0.03
$W_{80}A_{10}C_{10}$	3.62^{f}±0.01	8.15^{f}±0.12	10.11^{f}±0.12	2.07^{f}±0.01	1.35^{f}±0.02	74.70^{b}±0.02
$W_{70}A_{15}C_{15}$	3.67^{e}±0.01	8.55^{e}±0.01	10.19^{e}±0.01	2.67^{d}±0.03	1.45^{e}±0.03	73.47^{c}±0.03
$W_{60}A_{20}C_{20}$	3.87^{d}±0.01	8.85^{d}±0.01	10.34^{d}±0.03	2.61^{e}±0.01	1.53^{d}±0.03	72.80^{d}±0.02
WHT	3.10^{g}±0.03	7.89^{g}±0.01	10.01^{g}±0.03	2.01^{g}±0.03	1.25^{g}±0.01	75.74^{a}±0.02
BREAD						
$W_{80}M_{10}C_{10}$	9.89^{a}±0.03	10.45^{c}±0.13	13.45^{c}±0.13	3.35^{c}±0.03	2.69^{c}±0.01	60.17^{d}±0.03
$W_{70}M_{15}C_{15}$	9.25^{b}±0.03	10.71^{b}±0.13	13.65^{b}±0.13	3.47^{b}±0.03	2.78^{b}±0.01	60.14^{d}±0.02
$W_{60}M_{20}C_{20}$	9.15^{c}±0.03	10.83^{a}±0.13	13.87^{a}±0.12	3.86^{a}±0.03	2.89^{a}±0.01	59.40^{e}±0.02
$W_{80}A_{10}C_{10}$	8.90^{d}±0.01	10.25^{f}±0.12	12.55^{f}±0.12	2.66^{f}±0.03	1.64^{f}±0.01	64.00^{b}±0.03
$W_{70}A_{15}C_{15}$	8.67^{e}±0.01	10.33^{e}±0.13	12.65^{e}±0.12	2.78^{e}±0.03	1.69^{e}±0.01	63.88^{c}±0.02
$W_{60}A_{20}C_{20}$	8.45^{f}±0.01	10.45^{d}±0.13	12.78^{d}±0.12	2.99^{d}±0.03	1.77^{d}±0.01	63.56^{c}±0.03
WHT	7.50^{g}±0.01	9.45^{g}±0.13	11.25^{g}±0.12	2.90^{g}±0.03	1.13^{g}±0.01	67.77^{a}±0.03

Mean (±)Values with different alphabetical superscripts in a column differ ($P > 0.05$) significantly
WMC: Wheat-maize-cocoa composite flour
WAC: Wheat-acha-cocoa composite flour
WHT: Wheat flour

Functional properties of the composite flours

Table 3 shows the result of the functional properties of the composite flours. The bulk density values ranged from 0.56 to 0.88 g/ml for (WHT) and ($W_{60}M_{20}C_{20}$). The results obtained from this present study was similar to value of 0.45 to 0.0.86 g/ml for wheat-finger millet composite flour as reported by Mudau *et al*. (2021). Omah and Okafor (2015) reported similar results of bulk density for wheat-millet-pigeon pea flour which varied from 0.64 to 0.84 g/ml. Flour with bulk density lower than 1 g/ml can be used in manufacturing low bulk weaning foods and high-energy foods and it also facilitate easy storage, transport and marketing due to low volume of packaging materials requirement for any flour products (Klang *et al*., 2020); (Dereje *et al*., 2022); (Anosike *et al*., 2020). Water absorption capacity of the composite flour ranged from 2.15 to 2.75 g/ml for (WHT) and ($W_{60}M_{20}C_{20}$).Water absorption capacity values were significant ($p< 0.05$) differed between ($W_{80}M_{10}C_{10}$) and ($W_{80}A_{10}C_{10}$), however, there were no significant different between ($W_{70}M_{15}C_{15}$) and ($W_{60}M_{20}C_{20}$). It is worth noting that as the cocoa flour increases, the water absorption capacity of the composite flours increases. Similar results were observed by Chandra *et al*. (2015) and Menou *et al*. (2015) for cereal-pulse-fruit seeds composite where an increased in water absorption capacity was recorded. Increased in water absorption capacity has been associated with increase in amylose leaching and solubility and loss of starch crystalline structure (Dasa & Binh, 2019). Mbofung *et al*. (2006) reported that dough from composite flours absorbs more water than the one from wheat flour and hence may be used in the formulation of different food products such as sausages, dough and other bakery products.

The oil absorption capacity of the composite flours increased with increasing level of cocoa flour and the value ranged from 2.18 to 2.76 g/ml. The wheat flour recorded the lowest oil absorption capacity while ($W_{60}M_{20}C_{20}$) have the highest value. The values observed in this study is significantly higher than 0.69-0.92 g/ml for whole wheat-bambara groundnut composite flour reported by Yusufu and Ejei (2018). It is however lower than the values of 120.55 g/ml for wheat-finger millet composite flour reported by (Mudau *et al*. 2021). The increase in oil absorption capacity may be caused by the presence of more hydrophobic proteins which shows dominance in binding lipids. The oil absorption capacity depends on some intrinsic factors such as protein conformation, amino acid and surface polarity or hydrophobicity. The non-polar amino acids chains of protein can form hydrophobic interactions with hydrocarbon chains of lipids (Shrestha & Srivastava, 2017); (Tharise *et al*., 2014). The composite flours in this study hence, has the potentials of being utilized in food structural interactions like retention of flavors, improved palatability and shelf-life extension in bakery products where the absorption of fat is desirable.

The foam capacity of the composite flours ranged from 3.55 to 6.85 % for (WHT) and ($W_{60}M_{20}C_{20}$). This value was lower than 19.89-26.60 % for whole wheat-bambara composite flour (Yusufu & Ejei, 2018). Foam capacity improves the textural consistency of food systems due to its high percentage of porosity intended for the production of variety of baked products such as ice cream, muffins and also acts functional agent in other food formulations (El-Aawy & Taha, 2001). The water solubility index and swelling power ranged from 60.00 to 88.00 % and 30.00 to 39.00 % for (WHT) and ($W_{60}M_{20}C_{20}$) respectively. The water solubility index and swelling power are indicators of starch hydration (Dereje *et al*., 2020). They demonstrate the degree of interaction between the starch chains within both the amorphous and crystalline areas (Otondi *et al*., 2020). Water solubility index and swelling power values determine the textural, pasting and thickening properties of starch-based food preparations, hence the composite flours in the study may be suitable to develop consistent dough which may help to produce foods with good eating quality.

Table 3: Functional properties of the composite flour

Samples	BD (g/ml)	FC (%)	WAC (g/ml)	OAC (g/ml)	SI (%)	SP (%)
$W_{80}M_{10}C_{10}$	0.63^f±0.01	6.77^b±0.02	2.50^b±0.11	2.35^e±0.11	65.00^f±0.12	33.00^d±0.14
$W_{70}M_{15}C_{15}$	0.79^b±0.01	6.43^c±0.03	2.75^a±0.12	2.65^c±0.12	70.00^e±0.13	35.00^c±0.15
$W_{60}M_{20}C_{20}$	0.88^a±0.03	6.85^a±0.02	2.75^a±0.11	3.10^a±0.12	75.00^d±0.14	35.00^c±0.13
$W_{80}A_{10}C_{10}$	0.67^e±0.01	5.84^e±0.01	2.20^e±0.13	2.55^d±0.12	81.00^c±0.13	37.00^b±0.14
$W_{70}A_{15}C_{15}$	0.70^d±0.01	5.95^d±0.03	2.35^d±0.13	2.66^c±0.13	84.00^b±0.13	37.00^b±0.13
$W_{60}A_{20}C_{20}$	0.77^c±0.01	5.95^d±0.03	2.55^c±0.13	2.76^b±0.13	88.00^a±0.13	39.00^a±0.13
WHT	0.56^g±0.01	3.55^f±0.03	2.15^f±0.13	2.18^f±0.13	60.00^g±0.13	30.00^d±0.13

Mean (±)Values with different alphabetical superscripts in a column differ (P > 0.05) significantly
WMC: Wheat-maize-cocoa composite flour
WAC: Wheat-acha-cocoa composite flour WHT: Wheat flour

Physical properties of the bread

The physical properties of the bread samples are presented in Table 4. The loaf weight of the bread samples ranged from 112.98 to 312.55 g for (W80M10C10) and (WHT). The present study showed a significant increase in weight in all bread samples than the control sample (WHT). The results obtained in the study was similar to 245.60 g for whole wheat-bambara groundnut bread (Yusufu & Ejie, 2018). The values however were significantly (p> 0.05) higher than 134.40 g for bread fortified with green leafy vegetables (Odunlade *et al*., 2017). The increase in loaf weight could be attributed to increase moisture absorption and less retention of carbon dioxide gas in the blended dough resulted in heavy dough and thus heavy loaves (Olaoye *et al*., 2006). The loaf volume and specific volume of the bread ranged from 400.00 to 470.00 cm^3 for (WHT) and ($W_{70}M_{15}C_{15}$) and 1.28 to 3.79 cm3/g for (WHT) and ($W_{80}M_{10}C_{10}$) respectively. The result showed that the higher the loaf volume and loaf weight, the lower the specific volume of the bread and this assertion was in accordance with the report of Abdelghafar *et al*. (2015) and Juliana *et al*. (2011) who observed higher loaf weight and volume of bread made from composite flour as a result of less carbon dioxide gas in the blended dough, thus producing dense bread texture. Loaf volume is considered as the most important bread characteristic since it provides a quantitative measurement of baking performance (Tronsmo *et al*., 2003). Loaf volume is said to have positive economic effect on bread and this is because consumers always attracted to the higher volume and weight of bread as they belief those bread is more attractive but at the same price with other bread. Lack of weight and volume in bread is an indicator of weak flour or flour low in enzyme activity (Nour *et al*., 2015).

Table 4: Physical properties of bread made from the composite flour

Samples	Loaf weight(g)	Loaf volume (cm^3)	Specific volume (cm^3/g)	Loaf width (cm)
$W_{80}M_{10}C_{10}$	112.98^h±0.15	428.01^c±1.24	3.79^a±0.01	6.00^d±0.01
$W_{70}M_{15}C_{15}$	188.89^g±0.17	470.00^a±1.14	2.49^b±0.01	7.00^c±0.01
$W_{60}M_{20}C_{20}$	188.98^f±0.17	462.00^b±1.17	2.44^c±0.01	9.00^a±0.01
$W_{80}A_{10}C_{10}$	218.67^d±0.16	420.00^d±1.29	1.92^d±0.01	8.00^b±0.01
$W_{70}A_{15}C_{15}$	223.67^b±0.16	402.00^e±1.17	1.79^e±0.01	9.00^a±0.01
$W_{60}A_{20}C_{20}$	223.55^c±0.16	402.00^e±1.17	1.79^e±0.01	9.00^a±0.01
WHT	312.55^a±0.16	400.00^f±1.14	1.28^f±0.01	5.00^e±0.01

Mean (±)Values with different alphabetical superscripts in a column differ (P > 0.05) significantly

WMC: Wheat-maize-cocoa composite flour
WAC: Wheat-acha-cocoa composite flour
WHT: Wheat flour

Sensory characteristic of bread made from the composite flour

The sensory characteristic of bread made from the composite flour is shown in Table 5. The mean value for taste, flavor and appearance of the bread ranged from 4.78 to 6.89, 5.12 to 7.37 and 5.00 to 6.87 for (WHT) and ($W_{60}M_{20}C_{20}$) while the texture and overall acceptability were 5.00 to 7.00 and 5.02 to 6.65 for (WHT) and ($W_{60}M_{20}C_{20}$). It was noted that as the level of cocoa powder increased, the sensory properties of the bread increased. This result was in agreement with the result obtained by Bolarinwa *et al*. (2019) whereby fortification of moringa seeds powder in bread significantly improved the sensory characteristics of the bread. It can be concluded that the cocoa powder improved the formulated bread, more importantly, the ($W_{60}M_{20}C_{20}$) bread sample.

Table 5: Sensory characteristic of bread made from the composite flour

Samples	Taste	Flavor	Appearance	Texture	Overall acceptability
$W_{80}M_{10}C_{10}$	6.15[c]	7.11[c]	6.57[c]	6.59[c]	6.35[c]
$W_{70}M_{15}C_{15}$	6.67[b]	7.15[b]	6.77[b]	6.91[b]	6.55[b]
$W_{60}M_{20}C_{20}$	6.89[a]	7.37[a]	6.87[a]	7.00[a]	6.65[a]
$W_{80}A_{10}C_{10}$	5.00[f]	5.73[d]	5.91[e]	5.45[d]	5.64[f]
$W_{70}A_{15}C_{15}$	5.67[e]	5.73[d]	5.96[d]	5.12[f]	5.76[e]
$W_{60}A_{20}C_{20}$	5.98[d]	5.73[d]	5.11[f]	5.26[e]	5.89[d]
WHT	4.78[g]	5.12[e]	5.00[g]	5.00[g]	5.02[g]

Mean (±)Values with different alphabetical superscripts in a column differ ($P > 0.05$) significantly
WMC: Wheat-maize-cocoa composite flour
WAC: Wheat-acha-cocoa composite flour
WHT: Wheat flour

Conclusion

The addition of cocoa flour increased significantly the functional quality of the bread made from the composite flour by increasing the nutritional properties compared to the control sample. Increasing the amount of cocoa flour resulted in increased protein, fat and fiber contents of the bread. Also, the inclusion of cocoa flour into the composite flour resulted in increased organoleptic properties scores of overall acceptability. Conclusively, the samples may be used in formulating functional bread with pro-health values to the consumers.

Conflict of Interest

None was declared by the authors

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