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Proximate, micronutrients and sensory properties of instant breakfast flakes from orange fleshed sweet potato-cocoyam composite flour sweetened with date palms

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Abstract

The proximate, micronutrient, and sensory properties of flakes produced from orange-fleshed sweet potato (OFSP)-cocoyam composite flour sweetened with date palm were analyzed. Six sample ratios (50:50, 60:40, 70:30, 80:20, 90:10, and 100:0 for OFSP:cocoyam) were prepared and examined using standard methods. The proximate, vitamin, and mineral contents showed notable levels, with minimal heavy metals. Cocoyam flour had the highest protein (6.7%) and fiber (3.2%) content, while OFSP had the highest carbohydrate value (83.42%). Date flour exhibited superior vitamin A (7.5 mg/g) and vitamin D (2.15 mg/g) levels, followed by OFSP for vitamin A (2.01 mg/g), vitamin D (2.08 mg/g), vitamin E (2.10 mg/g), vitamin C (2.10 mg/g), and vitamin K (2.15 mg/g). Date flour also had the highest potassium, calcium, magnesium, and phosphorus values of 64.5, 39.9, 43, and 62 mg/g, respectively. OFSP was richer in iron (1.1 mg/g) and zinc (3.5 mg/g), with no detectable chromium or cadmium. Nutrient analysis of the instant breakfast flakes revealed protein (2.52-7.18%), ash (1.74-2.61%), fat (3.1-6.28%), moisture (7.01-9.36%), fiber (1.79-2.76%), and carbohydrate (78.14-80.93%). Vitamin contents included vitamin A (2.03-3.09 mg/g), D (1-5.5 mg/g), E (4.5-7.8 mg/g), C (2.9-7.5 mg/g), and K (1.8-3.7 mg/g). Mineral analysis indicated calcium (1.8-4.5 mg/g), magnesium (2.9-4.3 mg/g), sodium (5.56-10.65 mg/g), phosphorus (0.04-0.98 mg/g), iron (2.99-7.12 mg/g), zinc (0.09-1.05 mg/g), copper (0.45-0.78 mg/g), manganese (0.02-0.31 mg/g), chromium (0.03-0.4 mg/g), and cadmium (0.03-0.16 mg/g). Sensory evaluation using a 9-point Hedonic scale yielded high scores for color (7.1), taste (7.0), crunchiness (7.0), and overall acceptability (7.1), indicating a slightly liked product with potential for enhancement. This study establishes the feasibility of producing acceptable and nutritious instant breakfast flakes from OFSP-cocoyam composite flour sweetened with date palm, providing an affordable and accessible alternative to current breakfast options.

Keywords: Instant breakfast flakes, date palm, ofsp-cocoyam composite flour, proximate, micronutrients, sensory properties

1. Introduction

Breakfast is essential for physical and mental well-being, offering benefits like improved cognitive function, better weight management, increased energy, and reduced chronic disease risks^[56]. It replenishes glucose stores after fasting, supporting daily energy needs and dietary quality by providing nutrients such as fiber, vitamins, and minerals. Skipping breakfast is linked to poor academic and occupational performance, weight gain, insulin resistance, and metabolic syndrome^[30]. Regular breakfast consumption aids in appetite regulation and heart health by improving lipid profiles and lowering blood pressure^[60]. Additionally, it enhances emotional well-being, reducing irritability and fatigue while boosting mood and productivity^[49]. However, malnutrition and nutrient deficiencies remain significant global challenges, particularly in developing countries like Nigeria, where staple diets often fail to meet nutritional requirements^[63].

Developing a nutrient-enriched, accessible, and culturally accepted food product would be critical to mitigate these challenges. Composite flours—blends from different crops are

increasingly being utilized to develop functional foods. Among such innovations, composite flours from Orange-Fleshed Sweet Potato (OFSP) and cocoyam have garnered attention for their complementary nutrient profiles.

OFSP is some root crop rich in beta-carotene (a precursor to vitamin A), which is essential for vision and immunity, carbohydrates, fiber, and antioxidants. It addresses malnutrition and food security challenges [37]. OFSP supports sustainable diets, especially in resource-limited settings.

Cocoyam (*Colocasia esculenta*) is an underutilized tuber crop valued for its digestible starch, dietary fiber, and essential minerals like potassium and calcium [62]. It serves as an energy-rich staple in many tropical regions, offering benefits for gut health and managing chronic diseases. Its gluten-free nature and versatility make it suitable for various food applications, particularly for populations with dietary restrictions [5]. Cocoyam contributes to food security and supports sustainable agricultural practices.

Sweetening food products with natural sweeteners like date palms offer dual benefits of improved sensory appeal and enhanced nutritional value. Dates are rich in natural sugars, dietary fiber, and essential micronutrients such as potassium and magnesium, making them an ideal alternative to refined sugars [9].

Combining these ingredients offers the potential for developing nutrient-dense flakes, particularly targeting vulnerable populations such as children and the elderly, who require nutrient-rich diets.

The significance of this research lies in its potential to provide a healthier breakfast option while promoting the use of underutilized indigenous crops like cocoyam and addressing the excessive consumption of refined sugars to combat hidden hunger and enhance dietary quality, aligning with the Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger) and SDG 3 (Good Health and Well-being) [24]. Furthermore, it supports sustainable food systems by utilizing natural and locally available ingredients; which could be pivotal for policymakers and food manufacturers seeking to innovate nutrient-rich food products that promote health and reduce malnutrition.

Thus, the study aimed to evaluate the proximate composition, micronutrient content, and sensory properties of flakes developed from OFSP-cocoyam composite flour sweetened with dates to establish their suitability as nutrient-dense and palatable foods.

2. Materials and Methods

2.1 Raw materials source and research design

The UMUSP03 variety of orange-fleshed sweet potato (OFSP) was sourced from the National Root Crops Research Institute, Umudike, Abia state while Cocoyam (*Colocasia esculenta* variety) and date were sourced from Eke Awka market, Awka, Anambra state.

A completely randomized design was used and a total number of 8 samples were generated in the following ratio of 50:50, 60:40, 70:30, 80:20, 90:10, and 100:0 for OFSP: Cocoyam flour blends with 30g date (constant in all samples).

2.2 OFSP flour processing

The OFSP flour was produced according to the method as described by [54]. The OFSP root/tuber was washed with portable water, manually peeled with kitchen knife, sliced to

1.5mm thickness, dried at 75 °C for 15 hours using cabinet dryer and cooled. It was then milled using hammer mill (condition diesel brand), sieved with 125micron sieve mesh, packaged with air-tight container and stored at room temperature for further processing.

2.3 Cocoyam flour processing

The cocoyam flour was produced according the method as described by [51]. The cocoyam was washed using portable water, peeled manually using kitchen knife, sliced to 1.5 mm thickness, dried at 65 °C for 24 hours, cooled, milled (condition diesel brand hammer mill), sieved with 125-micron sieve mesh, packaged in air-tight container and stored at room temperature for further use.

2.4 Date flours processing

The date flour was produced using the method of [12]. The date palm was sorted to remove bad ones, washed with portable water, de-seeded manually with kitchen knife, sorted the second time to remove any insect feasted ones, oven dried at 75 °C for 5 hours, milled (condition diesel brand hammer mill), sieved using 0.35-micron mesh sieve, packaged in air-tight container for further use.

2.5 Instant breakfast flakes production

The OFSP-Cocoyam date-sweetened instant breakfast flakes was produced according the method described by [15]. This was achieved by blending of OFSP and cocoyam flour at different ratio as generated by the experimental design while keeping the amount of date used constant (30g). the blended flours were added 650ml of portable water with a pinch of salt and homogeneously mixed and spread on tray pans for oven baking at 100 °C for 1 hour 30 minutes. It was then cooled, manually flaked using kitchen knife, packaged with air-tight nylon pouches for sensory evaluation and further analysis.

2.6 Sensory Evaluation

According to the description of [32], a semi-trained panelist of 20 judges comprising of 10 male and 10 females (staff and students) of the Department of Food Science and Technology, Nnamdi Azikiwe University, Awka was used. The appearance, colour, taste, crunchiness, aftertaste and overall acceptability of the samples were using 9-point Hedonic scale, where 9 was equivalent to like extremely, and 1 meant dislike extremely. Presentation of coded samples was done randomly and potable water was provided for rinsing of mouth in between the respective evaluations.

2.7 Proximate composition

2.7.1 Moisture content determination

The moisture content of the fresh OFSP, tigernut, date, and snack was determined using the standard method of [3]. Five (5) g of the sample was weighed into a cleaned moisture dish. The sample in the dish was dried in the oven at 105 °C for 3 hours, it was cooled in a desiccator and weighed. It was returned to the oven for further drying, cooling, and weighing were done repeatedly at hourly intervals until there was no further diminution in the weight (that is a constant weight was obtained). The weight of moisture lost was calculated and expressed as a percentage of the weight of the sample analyzed. It was given by the expression below;

$$\text{Moisture content (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where: W_1 = Weight of empty can

W_3 = Weight of can + sample after drying

W_2 = Weight of empty can + sample before drying.

2.7.2 Ash content determination

Ash content was determined according to the method described by [3]. Two grams of sample were placed in a porcelain crucible. The dish and the sample were then gently ignited at 550 °C in a muffle furnace for 5 hours to become completely ashed, then it was cooled in a desiccator and weighed.

$$\% \text{ Ash content} = \frac{(W_3 - W_1)}{(W_2 - W_1)} \times 100$$

Where; W_1 = Weight of dish, W_2 = Weight of dish + sample before ashing, W_3 = Weight of dish + sample after ashing

2.7.3 Crude fiber content determination

Crude fiber was determined according to the method described by [3]. Five (5.0) g of the sample was boiled in 150 ml of 1.25% H_2SO_4 solution for 30 minutes under reflux. The boiled sample was washed in several portions of hot water using a two-fold cloth to trap the particles. It was returned to the flask and boiled again in 150 ml of 1.25% NaOH for another 30 minutes under the same condition, after washing in several portions of hot water the sample was allowed to drain dry before being transferred quantitatively to a weighed crucible where it was dried in the oven at 105 °C to a constant weight. It was therefore taken to a muffle furnace where it was burnt, only the ash was remaining. The weight of the fiber was determined by difference and calculated as a percentage of the weight of the sample analyzed. Thus;

$$\text{Crude Fiber (\%)} = \frac{W_2 - W_3}{\text{Weight of sample}} \times 100$$

Where; W_2 = Weight of crucible + after washing, boiling, and drying

W_3 = Weight of crucible + sample ash

2.7.4 Fat content determination

The Soxhlet extraction method as described by [3] was used. Five (5.0) g of sample was wrapped in a porous paper (Whatman filter paper) and put in a thimble. The thimble was put in a Soxhlet reflux flask and mounted into a weighed extraction flask containing 200 ml of petroleum ether. The upper of the reflux flask was connected to a water condenser. The solvent (petroleum ether) was heated, boiled, vaporized, and condensed into a reflux flask. Soon the sample in the thimble was covered with the solvent until the reflux flask filled up and siphoned over, carrying its oil extract down to the boiling flask. This process was allowed to go on repeatedly for 4 hours before the defatted sample was removed, the solvent recovered and the oil extract was left in the flask. The flask (containing) the oil extract was dried in the oven at 60 °C for 30 minutes to remove any residual solvent. It was cooled in a desiccator and weighed. The weight of oil (fat) extract was determined by difference and calculated as a percentage of the weight of the sample

analyzed thus;

$$\% \text{ Fat} = \frac{W_2 - W_1}{\text{Weight of sample 1}} \times 100$$

W_1 = Weight of empty extraction flask, W_2 = Weight of flask + oil extract

2.7.5 Crude protein content determination

The Kjeldahl method as described by [3] was used. The total nitrogen was determined and multiplied with a factor of 6.25 to obtain protein content. A 0.5 g sample was mixed with 10 ml of concentrated H_2SO_4 in a digestion flask. A tablet of selenium catalyst was added to it before it was heated under a fume cupboard until a clear solution was obtained (the digest). The digest was diluted to 100 ml in a volumetric flask and used for the analysis. The 100 ml of the digest was mixed with a volume of 45% Boric acid containing 3 drops of mixed indicator (bromo cresol, green/methyl red). A total of 50 ml of distillate was collected and titrated against 0.02 N EDTA from a green to a deep red point. A reagent blank was also digested, distilled, and titrated. The nitrogen content and hence the protein content was calculated using the formula below.

1ml of NH_2SO_4 = 14 mg, Protein (%) N_2 (%) $\times 6.25$

$$\% \text{ Total Nitrogen} = \frac{(\text{titre-blank}) \times \text{normality of acid} \times N_2}{\text{Weight of sample}}$$

W = Weight of sample (0.5) g, N = Normality of titrant (0.02 N H_2SO_4)

V_t = total digest volume (100 ml), T = Sample titre value, B = Blank titre value

2.7.6 Carbohydrate estimation

The carbohydrate was estimated by difference according to [55] as follows:

$$\% \text{ Carbohydrates} = 100 - (\% \text{ moisture} + \% \text{ fat} + \% \text{ ash} + \% \text{ protein} + \% \text{ crude fiber})$$

2.8 Vitamin determination

2.8.1 Vitamin A determination

Vitamin A was determined using the calorimetric method of [35]. One (1) g of the sample and standard was mixed with 30 ml of absolute b alcohol. Three (3) ml of 50% KOH solutions was added to it and boiled gently for 30 minutes under reflux. After washing with distilled water, the vitamin A was extracted with 3×50 ml of diethyl ether. The extract was evaporated to dryness at low temperature and then dissolved in 10 ml of isopropyl alcohol. One (1) ml of standard vitamin A solution prepared and that of the dissolved extract were transferred to separate cuvetts and their respective absorbance were read in a spectrophotometer meter at 325 nm with a reagent blank at zero. It was then calculated thus:

$$\text{Conc. Of Vit. A in sample (mg/g)} = \frac{AS}{ASt} \times CS$$

Where AS = Absorbance of sample, CS = Concentration of standard and ASt = Absorbance of standard.

2.8.2 Vitamin C determination

Vitamin C was determined using the titrimetric method reported by [35]. One (1) g of the sample was homogenized in 6% EDTA/TCA solution. The homogenate was filtered and used for analysis. Twenty (20) ml of 30% KI solution was added to the homogenate followed by 100 ml of distilled water. One (1) ml of 1% starch solution was added to it and was titrated against 0.1M CUSO₄ solution. The end point was marked by a black coloration. A reagent blank was also titrated. Vitamin content was calculated based on the relationship below:

1ml of 0.1 mole CUSO₄=0.88mg vitamin C.

$$\text{Vitamin C (mg/100 g)} = \frac{0.88 \times \text{titre-blank}}{W} \times 100$$

2.8.3 Vitamin E determination

One (1) g of the sample was mixed with 10 ml of ethanoic sulphuric acid and boiled gently under reflux for 30 minutes. It was transferred to a separating funnel and treated with 3×30 ml diethyl ether and recovering ether layer each time, the ether extract was transferred to a dessicator and dried for 30 minutes and later evaporated to dryness at room temperature. The dried extract was dissolved in 10 ml of pure ethanol. One (1) ml of the dissolved extract and equal volume of standard vitamin E were transferred to separate tubes. After continuous addition of 5 ml of absolute alcohol and 1 ml of concentrated nitric acid solution, the mixtures were allowed to stand for 5 minutes and the respective absorbance measured in a spectrophotometer meter at 410 nm with blank reagent at zero [35].

$$\text{Conc. of vit. E in sample (mg/100 g)} = \frac{AS}{AS_t} \times CS$$

Where AS = Absorbance of sample, CS = Concentration of standard and AS_t = Absorbance of standard.

2.8.4 Vitamin D and K determination

Total Vitamin D and K was determined by the method described by [68]. The experiment was carried out in the dark to avoid photolysis of vitamin D once saponification was completed. The measured sample (0.5 g) was homogenized and saponified with 2.5 ml of alcoholic potassium hydroxide in a water bath at 60 °C for 30 minutes. The saponified extract was transferred to a separating funnel containing 15 ml of petroleum ether and mixed well. The lower aqueous layer was then transferred to another separating funnel and the upper petroleum ether layer containing the carotenoids was collected. The extract was repeated until the aqueous layer become colorless. A small amount of anhydrous sodium sulphate was added to the petroleum ether extract to remove excess moisture. The final volume of the petroleum ether extracted was noted. The absorbance of the yellow color was read in a spectrophotometer at 450 nm and 503 nm for vitamin D and K, respectively using petroleum ether as blank. The amount of total Vitamin D and K was calculated thus:

$$\text{Amount of total vitamin D} = \frac{A_{450} \times \text{Vol. of sample} \times 100 \times 4}{\text{Weight of the sample}}$$

$$\text{Amount of vitamin K} = 3.12 \times \frac{A_{503} \times \text{Vol. of sample} \times 100}{\text{Weight of the sample}}$$

2.9 Mineral determination

2.9.1 Determination of copper, zinc, magnesium, calcium, potassium, iron, sodium, phosphorous, cadmium, chromium and manganese

A wet digestion method described by [4] was adopted. Exactly one gram of the retained portion was digested with 15ml of 2:1 mixture of concentrated nitric and perchloric acid in a 100ml beaker and placed in a waterbath at 65 °C for 1hour. The clear digest obtained after the stipulated time was cooled at room temperature and filtered with whatman No 42. Filter paper. The mixture was made up to mark with deionized water in 100ml standard flask. It was then transferred into sterile sample bottle for elemental analysis using a BUCK 210 VGP Flame Atomic Absorption Spectrophotometer (FAAS) (BUCK 210 VGP). Analytical grade reagents and deionized water were used in preparing all solutions. Stock solutions containing 1000mg/kg of each element were prepared from salts of Cu, Zn, Mg, Cd, Ca, K, Mn, Fe, Na, P and Cr, working standard solutions were prepared by appropriate dilution of the stock solutions. Blank determination were carried out as described in the instrument manual. The concentrations of the metals in each digested samples were determined with an air acetylene flame. Metal contents were calculated by comparison with standard curves of the respective metals. Hollow cathode lamps having resonance lines at 228.9, 327.4, 279.5 and 372 nanometers were used as radiation sources for the determination of Cd, Cu, Mn and Fe respectively. Others are 422.7, 202.6 203.0, 589.0, 307.6, 214.9 and 359.3 nanometers for Ca, Mg, k, Na, Zn, P and Cr, respectively. Lamp intensity and band pass were used according to the manufacturer's recommendation. Acetylene and air flow rates were 5 and 20 l min⁻¹, respectively, for all elements.

3. Results and Discussion

3.1 Proximate composition of raw and processed (flour) OFSP, cocoyam and date (%)

The Proximate composition of raw and processed (flour) OFSP, Cocoyam and date is shown in Table 1. The protein content of raw OFSP (0.67%) significantly increased ($p < 0.05$) during processing to flour (1.81%), while cocoyam showed an increase from 2.57% to 6.5%. However, the protein content of dates decreased during processing, from 1.7% to 1.33%. The observed protein content of raw OFSP was lower than the 1.91% reported by [42] for raw OFSP. Similarly, the protein content of raw cocoyam was below the 7.79% and 8.61% values reported for raw taro by [6] and [13], respectively. The protein content of raw dates (1.71%) fell within the 1.5% to 3.0% range reported by [7] for raw dried dates. However, the protein content of cocoyam flour was lower than the 8.07% value reported for taro flour by [6]. Similarly, the protein content of date flour (1.33%) was below the 1.88% to 2.73% range reported by [66]. Other studies, including those by [31] and [19], have reported protein content values of 2.3% to 2.7% and 2.1% to 3%, respectively, for various date flour varieties. Notably, dates are generally not considered a good source of protein [8]. The protein content of the flour samples was lower than the reported values of 12.5% and 8.12% for guinea corn and unripe plantain flours, respectively, as noted by [48]. The reduction in protein content during tuber development may be influenced by the increase in average mass and starch accumulation. [16] observed that potatoes are not a significant source of protein but contain a type of

protein with high nutritional and biological value. The observed increase in protein content during processing may be attributed to the concentration effect of heat, which reduces moisture content and results in a higher protein concentration. Conversely, a decrease in protein content could be due to the destructive effects of heat on protein structure.

The ash content generally increased with processing, from 0.30% to 1.48% for OFSP, 1.46% to 2.41% for cocoyam, and 2.00% to 2.45% for date flour. There was no significant difference ($p>0.05$) between the ash values of cocoyam (2.41%) and date (2.45%) flours. The increase in ash content during processing can be attributed to the concentration effect caused by moisture loss due to heat. The ash content of raw OFSP (0.30%) was lower than the 2.04% reported for raw OFSP by [57]. Similarly, the ash content of raw cocoyam (1.46%) was below the 2.44% and 4.82% reported for raw taro grown in Ethiopia by [6] and [1], respectively. In contrast, the ash content of raw dates (2.00%) exceeded the range of 1.3% to 1.9% reported by [7]. For the flour samples, the ash content of OFSP flour (1.48%) was lower than the 2.11% reported by [57], while the ash content of cocoyam flour (2.41%) aligned with the 2.78% reported by [6]. The ash content of date flour (2.45%) fell within the range of 1.82% to 3.02% reported for various date flour varieties by [66] and was comparable to the 1.88% to 2.36% reported by [31]. Compared to other flours, the ash content of OFSP flour was above the 1.01% reported for cassava sievate flour, while cocoyam and date flours had ash contents below the 2.53% and 2.46% reported for guinea corn and unripe plantain flours, respectively, by [48]. The increase in ash content during processing is consistent with observations in taro flour, where moisture loss during drying led to ash concentration [6]. Variations in the ash content of date flour may also reflect the soil characteristics in which the date palms were cultivated [66].

The fat content showed no significant difference ($p>0.05$) between the raw and flour forms of OFSP (4.13% and 3.8%), cocoyam (1.75% and 1.6%), and date (8.55% and 9.38%), indicating minimal impact of processing, despite slight decreases. The fat content of raw OFSP (4.13%) was higher than the 0.42% reported by [57], and raw cocoyam (1.75%) exceeded the 0.65% reported for taro by [6]. Raw date (8.55%) also surpassed the 0.10%-0.50% range reported by [34]. In flour form, OFSP (3.8%) and cocoyam (1.6%) both showed higher fat content than the respective values reported by [57] and [6], while date flour (9.38%) was well above the 0.17%-0.50% range noted by [9]. Low fat content in taro flour, as suggested by [36], may result from precooking, which reduces fat by leaching it into boiling water. All flour samples had higher fat content compared to cassava sievate (3%), guinea corn (1%), and unripe plantain flours (1.5%) by [48].

The moisture content of the raw samples decreased significantly ($p<0.05$) during processing to flour, dropping from 79.08% to 7.75% for OFSP, 65.41% to 8.51% for cocoyam, and 12.53% to 6.81% for date. This reduction was attributed to heat-induced evaporation during processing. The raw OFSP moisture content (79.08%) exceeded the 72-75% range reported by [21], while raw cocoyam (65.41%)

was lower than the 70-77% reported by [45]. The moisture content of raw date (12.53%) fell within the 7.2-29.5% range reported by [7]. High moisture levels in raw OFSP and cocoyam are characteristic of water-rich root and tuber crops [13]. For the flours, OFSP moisture content (7.75%) matched the 6.9-10.97% range reported by [57], while cocoyam (8.51%) was below the 6.21% reported for taro flour by [6]. The moisture content of date flour (6.81%) was within the 5.24-11% range reported by [50] but below the values reported for other date varieties by [26]. Variations in moisture content between studies may reflect differences in location, climate, maturity, and agricultural practices [59]. The moisture contents of all flour samples were below the values reported for cassava sievate (10%), guinea corn (9.01%), and unripe plantain flours (8.52%) by [48]. The reduction in moisture content during drying is critical for inhibiting microbial growth, enhancing shelf life, and improving flour quality [11]; [17].

The fiber content increased significantly ($p<0.05$) with processing, rising from 0.3% to 1.74% for OFSP, 1.54% to 3.2% for cocoyam, and 2.19% to 2.44% for date. Cocoyam flour had the highest fiber content (3.2%), followed by date flour (2.44%). This increase is attributed to moisture loss during drying, which concentrated the fiber content. The crude fiber content of raw OFSP (0.3%) was close to the 0.35% reported by [21] but below the 3.6% reported by [59]. Raw cocoyam (1.54%) was similar to the 1.71% reported for taro by [13], while raw date (2.19%) was below the 3.6% reported by [20] and within the broader 4-8% range for dried dates noted in earlier studies [61]; [10]. Variations in fiber content for OFSP across studies may result from differences in variety and agroclimatic conditions [59]. For the flour samples, OFSP fiber (1.74%) was lower than the 2.57% reported by Rodrigues *et al.* (2016). Cocoyam fiber (3.2%) matched the 3.1% reported by [6], while date flour fiber (2.44%) fell within the 1.71%-2.77% range reported by [66]. The fiber content of dates is influenced by cultivar and ripening stage [28]. The observed increases in fiber content across all flour types are consistent with the concentration effect caused by moisture reduction during drying.

As expected, carbohydrate content increased significantly with processing, rising from 15.52% to 83.42% for OFSP, 27.27% to 77.78% for cocoyam, and 73.02% to 77.59% for date. This increase is attributed to moisture loss during processing, which concentrated the carbohydrates in the samples. The carbohydrate content of raw OFSP (15.58%) aligns with the 14.46%-22.86% range reported in previous studies [58]; [52]; [44]. However, it is lower than other studies, likely due to differences in cultivar, climate, and soil type [47]. Raw cocoyam (27.27%) was below the 86.11% reported for taro by [6], while raw date (73.02%) matched the 66.1%-88.6% range reported by [7]. For the flour samples, OFSP (83.42%) and cocoyam (77.78%) had lower carbohydrate content compared to 90.13% and 85.6% reported for OFSP and taro flour by [57] and [6], respectively. Date flour (77.59%) fell within the ranges for total, reducing, and non-reducing sugars reported by [66]. High carbohydrate levels in cocoyam and its flour align with findings by the [25], indicating roots and tubers are primary sources of dietary energy from carbohydrates [46].

Table 1: Proximate composition of raw and processed (flour) OFSP, Cocoyam and date (%)

Parameters Samples	Protein	Ash	Fat	Moisture	Fiber	Carbohydrate
OR	0.67 ^d ±0.02	0.30 ^c ±0.01	4.13 ^b ±0.1	79.08 ^a ±0.4	0.3 ^d ±0.0	15.52 ^e ±0.4
OF	1.81 ^c ±0.2	1.48 ^b ±0.0	3.8 ^b ±0.0	7.75 ^e ±0.4	1.74 ^c ±0.1	83.42 ^a ±0.1
CR	2.57 ^b ±0.2	1.46 ^b ±0.01	1.75 ^c ±0.0	65.41 ^b ±0.3	1.54 ^c ±0.1	27.27 ^d ±0.5
CF	6.5 ^a ±0.3	2.41 ^a ±0.1	1.6 ^c ±0.0	8.51 ^d ±0.2	3.2 ^a ±0.0	77.78 ^b ±0.1
DR	1.7 ^c ±0.3	2.0 ^a ±0.3	8.55 ^a ±0.1	12.53 ^c ±0.1	2.19 ^b ±0.1	73.02 ^c ±0.05
DF	1.33 ^d ±0.1	2.45 ^a ±0.0	9.38 ^a ±0.3	6.81 ^f ±0.0	2.44 ^b ±0.1	77.59 ^b ±0.0

Values are means ± SD of duplicate determination. The values with different superscript differ significantly at ($p < 0.05$)

OR = Orange fleshed sweet potato raw, OF= Orange fleshed sweet potato flour, CR= Cocoyam raw, CF= Cocoyam flour, DR= Date raw, DF= Date flour

3.2 Sensory evaluation of the date-sweetened OFSP-cocoyam instant breakfast flakes

The sensory evaluation of date-sweetened OFSP-cocoyam instant breakfast flakes is presented in Table 2. There was no significant difference ($p > 0.05$) in the appearance and aftertaste among all samples. However, significant differences ($p < 0.05$) were observed in color, taste,

crunchiness, and overall acceptability for most samples. The overall acceptability of the flakes with ratios 80:20 (7.1), 70:30 (7), and 60:40 (7) were not significantly different ($p > 0.05$) from each other, indicating they were slightly liked based on the 9-point Hedonic scale. This suggests that improvements may be needed to enhance the overall acceptability and achieve higher ratings.

Table 2: Sensory evaluation of the date-sweetened OFSP-Cocoyam instant breakfast flakes

Sample (OFSP:C)	Appearance	Colour	Taste	Crunchiness	Aftertaste	Overall acceptability
100:0	6.2 ^b ±1.6	5.9 ^c ±2.0	6.8 ^b ±1.6	6.8 ^b ±1.9	6.2 ^b ±2.2	6.6 ^b ±1.4
90:10	6.2 ^b ±1.3	6.1 ^c ±1.8	6.1 ^c ±1.9	5.8 ^c ±1.1	6.5 ^a ±1.1	6.5 ^b ±1.3
80:20	6.6 ^b ±1.5	7.1 ^a ±1.3	7.0 ^a ±1.4	7.0 ^a ±1.5	6.5 ^a ±1.5	7.1 ^a ±1.5
70:30	5.6 ^b ±1.7	5.9 ^c ±1.5	6.9 ^b ±1.3	7.6 ^a ±1.2	6.6 ^a ±1.1	7.0 ^b ±1.3
60:40	5.9 ^b ±1.8	6.4 ^b ±1.6	7.1 ^a ±1.2	7.3 ^a ±1.3	6.9 ^a ±1.0	7.0 ^a ±1.4
50:50	5.5 ^b ±1.8	5.6 ^c ±1.9	5.9 ^c ±1.5	5.4 ^d ±1.7	6.0 ^b ±1.4	6.1 ^c ±1.3

Values are means ± SD of duplicate determination. The values with different superscript differ significantly at ($p < 0.05$)

OFSP = Orange fleshed sweet potato, C= Cocoyam

3.3 Proximate composition of the date-sweetened OFSP-Cocoyam instant breakfast flakes

The Proximate composition of the date-sweetened OFSP-Cocoyam instant breakfast flakes is in Table 3. The protein content of the instant flakes increased with a higher blending ratio of cocoyam flour. The flakes made with a 50:50 OFSP-to-cocoyam ratio had the highest protein content (7.18%), while the 70:30 ratio had the lowest (2.91%). This trend reflects the higher protein content of cocoyam flour (6.5%) compared to OFSP (1.81%) and date (1.33%). The inclusion of cocoyam flour significantly enhanced the protein content of the flakes. While OFSP is primarily a high-energy, low-protein food, its combination with cocoyam flour makes the flakes a moderately better protein source.

The ash content of the flakes produced with the sample ratio 70:30, 60:40 and 50:50; and 80:20 and 100:0 had no significant ($p > 0.05$) difference among each other except that of 90:10 which differed significantly ($p < 0.05$) from all other samples. Sample ratio 60:40 had the highest ash value of 2.61% while ratio 100:0 had the least (1.74%). This could mean that combining the cocoyam flour with the OFSP flour improved the ash content of the instant flakes significantly ($p < 0.05$). The ash value of the instant flakes ranges is within these values of 1.36% and 1.50 to 2.50% for breakfast cereals by [2] and [40], respectively.

The fat content of the instant breakfast flakes made with blends of OFSP and cocoyam flour had significant ($p < 0.05$) difference and also decreased when compared with OFSP flour only. This could be attributed that the fat value of the cocoyam value was the least (1.6%) amongst OFSP (3.8%) and date (9.38%). This is under stable why the fat content of

the flakes produced with 100% OFSP flour and 30g date rose to 6.28% from 3.8% (OFSP flour). This showed that date addition did not only sweetened the flakes sample but increased the fat content positively. The instant flakes with the lowest fat content of 3.1% was produced with 50:50 ratio and it could be noted to be of better health value especially for adult with sedentary life style who could be concerned with their daily fat intake not exceeding expected intake. The decrease in the fat content of the blends might be attributed with the oxidation of fat during the period of drying of the samples [41].

The moisture content of the instant flakes sample ranged from 7.01 to 9.36%. flakes made from sample ratio 60:40 had the least moisture value of 7.01%. The moisture content of the flakes sample is higher than the range 3.38 to 4.2% reported by [64] for breakfast cereals produced from African yam bean, maize, and defatted coconut. Moisture content of a food affects its stability and overall quality [27]. The low moisture content generally observed in the samples may add the advantage of prolonging the shelf life of the products, if properly packaged [65].

The fiber content of the breakfast instant flakes ranged from 1.79 (80:20) to 2.76% (60:40). The fiber content obtained is of lower values compare to 1.54 to 4.0% [40] for other breakfast cereals formulation. The NASCO corn flakes however contained a fiber value of 3%.

The carbohydrate values ranged from 76.68 (50:50) to 80.93% (70:30). This simply shows that the instant flakes could be a good source of energy especially for physically active individuals such as children.

Table 3: Proximate composition of the date-sweetened OFSP-Cocoyam instant breakfast flakes (%)

Sample (OFSP: C)	Protein	Ash	Fat	Moisture	Fiber	Carbohydrate
100:0	2.52 ^e ±0.20	1.74 ^c ±0.03	6.28 ^a ±0.01	8.15 ^b ±0.08	1.85 ^c ±0.06	79.46 ^c ±0.30
90:10	3.83 ^c ±0.09	2.25 ^b ±0.19	5.64 ^e ±0.04	7.49 ^{cd} ±0.09	2.29 ^b ±0.07	78.50 ^d ±0.01
80:20	3.92 ^c ±0.18	1.75 ^c ±0.00	5.04 ^c ±0.01	9.36 ^a ±0.78	1.79 ^c ±0.01	78.14 ^d ±0.24
70:30	2.91 ^d ±0.08	2.54 ^a ±0.04	4.39 ^d ±0.01	6.58 ^e ±0.43	2.65 ^a ±0.06	80.93 ^b ±0.48
60:40	5.43 ^b ±0.09	2.61 ^a ±0.07	3.79 ^e ±0.01	7.01 ^{de} ±0.25	2.76 ^a ±0.06	78.40 ^d ±0.04
50:50	7.18 ^a ±0.03	2.47 ^a ±0.02	3.10 ^f ±0.01	7.94 ^{bc} ±0.20	2.63 ^a ±0.40	76.68 ^a ±0.19

Values are means± SD of duplicate determinations. The values with the different superscript differ significantly at (p<0.05)

OFSP = Orange fleshed sweet potato C = Cocoyam-taro

3.4 Vitamin composition of the raw and processed samples of OFSP, Cocoyam and date

Vitamin composition of the raw and processed samples of OFSP, Cocoyam and date is shown in Table 4. The vitamin A of OFSP (7.35mg/g) was not significantly (p>0.05) different from that of date flour (7.5mg/g). processing had no significant effect in the vitamin A of raw cocoyam (1.98mg/g) to the flour (1.74mg/g) even though it decreased slightly with processing. Vitamin A of raw OFSP (7.35mg/g) significantly decreased with processing into flour (2.01mg/g) while the decrease in raw cocoyam and its flour was not significant. this indicated that the processing caused severely loss of vitamin A and could probably be due to leaching during washing. These values were in agreement with that reported by [59] as 7.4 to 6.18 mg/g for vitamin A, for fresh OFSP. Even though, there was a decrease in vitamin A content, it was still slightly above the recommended daily value of 0.7 to 0.9 mg/g [67].

There was no detectable vitamin D in raw OFSP while its flour (2.08mg/g) had no significant (p>0.05) difference to that of date flour (2.15mg/g). there was no significant decrease in the raw cocoyam (1.98mg/g) and its flour (1.95mg/g). These values were in a close range with that reported by [59] as 2.83 to 2.17 mg/g for vitamin D.

Generally, vitamin E decrease with processing but there was no significant (p>0.05) difference between the vitamin E of

raw OFSP (2.5mg/g) and its flour (2.10mg/g); raw cocoyam (1.99mg/g) and its flour (1.50mg/g) while that of date flour was the lowest value of 0.03mg/g. The general decrease in the vitamin E during processing could be due to negative effective of heat.

Vitamin C decreased significantly (p<0.05) with processing from 4.5 to 2.1mg/g and 2 to 0.78mg/g for raw OFSP and its flour; and raw cocoyam and its flour, respectively while the date flour had the lowest value of 0.21mg/g. vitamin C is known to be heat sensitive and as such would have be destroyed during heating process involved in conversion of the raw samples to its flour product. The vitamin C of the raw cocoyam and its flour is below the value of 8mg/100g as reported by [33].

Vitamin K differed significantly (p>0.05) among all the samples with date having the highest value of 2.7mg/g followed by OFSP flour (2.15mg/g) and raw cocoyam (2.01mg/g).

Loss in the vitamins especially with A and C is in agreement with that reported by [14] that the nutrient loss for commercially dried foods varies between 30 to 80% for vitamin C and 10 to 50% for vitamin A. the amount of loss is dependent on many factors including storage time, drying temperature and drying time and that vitamin A and C diminishes when food is dried.

Table 4: Vitamin composition of the raw and processed samples of OFSP, Cocoyam and date (mg/g)

Sample	Vit. A	Vit. D	Vit. E	Vit. C	Vit. K
Raw OFSP	7.35 ^a ±0.4	0.00 ^c ±0.0	2.50 ^a ±0.5	4.50 ^a ±0.7	1.00 ^c ±0.0
OFSP flour	2.01 ^b ±0.9	2.08 ^a ±0.9	2.10 ^a ±0.9	2.10 ^b ±0.9	2.15 ^a ±1.0
Raw Cocoyam	1.98 ^b ±0.9	1.98 ^{ab} ±0.9	1.99 ^b ±0.9	2.00 ^b ±0.9	2.01 ^a ±0.9
Cocoyam flour	1.74 ^b ±0.8	1.95 ^{ab} ±0.9	1.50 ^b ±0.7	0.78 ^c ±0.4	1.53 ^b ±0.7
Date flour	7.50 ^a ±0.3	2.15 ^a ±0.4	0.03 ^c ±0.0	0.21 ^c ±0.3	2.70 ^a ±1.4

Means with the same letter along a column showed no significance difference at (p>0.05). Values are means ± standard deviation of two determinations.

OFSP = Orange fleshed sweet potato

3.5 Vitamin composition of the date-sweetened OFSP-Cocoyam instant breakfast flakes

Table 5 shows the vitamin composition of the date-sweetened OFSP-Cocoyam instant breakfast flakes. The vitamin A content of the instant flakes range from 2.03 to 3.09mg/g. the vitamin A content of the flakes made with 100% OFSP flour and 30g of date could reflect that processing of flakes drastically affected the vitamin content considering the value of the flour samples and may have also be affected by that of cocoyam flour vitamin A content (1.74mg/g). the vitamin content of the instant breakfast flakes range is slightly below the value of 3.76mg/g reported by [53] for potato flakes.

The instant flakes sample had vitamin content ranging from 1 (80:20) to 5.5mg/g (50:50). This could mean that the

instant flakes made with 50:50 flour ratio of OFSP and cocoyam with 30g date had a better appreciable level of vitamin D. the maximum value of vitamin D content in the produced instant breakfast flakes is above the value of 4.7mg/g as reported by [53] for potato flakes.

The vitamin E content of the instant flakes ranged from 4.5 (50:50) to 7.8mg/g (70:30). The instant breakfast flakes made with the flour blending ratio 70:30 had the highest value of vitamin E. considering the values of the flour samples, it could be said that the vitamin E of the instant flakes samples increased with the combination of OFSP, cocoyam and date flour and processing as shown in Table 3.4 and 3.5. this connotes positive interaction amongst the flour samples used for the instant flakes. The vitamin content of the flakes is below the value of 15mg/g reported

by ^[53] for potato flakes.

The vitamin C content of the instant flakes sample ranged from 2.9 (100:0) to 7.5mg/g (80:20). Relating the vitamin C value of the OFSP flour of 2.10mg/g it could be said that the addition of date flour (0.21mg/g) had a positive interaction that elevated the vitamin C of the 100:0:30 from 2.1 to 2.9mg/g despite the effect of processing that involved heat. The flakes sample made with 80:20 ratio had the highest value of vitamin C. the vitamin C content of the instant flakes could be said to be in appreciable level considering

the fact that vitamin C in heat sensitive. Despite the loss in vitamin C, it was still above the value of 2.45mg/g as reported by ^[53] for potato flakes.

The instant breakfast flakes vitamin K ranged from 1.8 (50:50) to 3.7mg/g (60:40). The vitamin K of the flour samples as seen in Table 6.4 shows a positive interaction of the composite flour in improving the vitamin content of the instant breakfast flakes. The values of flakes vitamin K is below the value of 8.8mg/g reported by ^[53] in potato flakes.

Table 5: Vitamin composition of the date-sweetened OFSP-Cocoyam instant breakfast flakes (mg/g)

Sample (OFSP:C)	Vit. A	Vit. D	Vit. E	Vit. C	Vit. K
100:0	3.06 ^a ±1.7	2.50 ^d ±1.2	5.00 ^c ±2.4	2.90 ^e ±1.4	2.90 ^b ±1.6
90:10	3.05 ^a ±1.4	4.50 ^{ab} ±2.1	5.50 ^c ±2.6	5.80 ^b ±2.7	2.90 ^b ±1.4
80:20	2.03 ^b ±0.9	1.00 ^e ±0.5	6.50 ^b ±3.1	7.50 ^a ±3.5	2.00 ^a ±0.9
70:30	3.09 ^a ±1.5	3.10 ^c ±1.5	7.80 ^a ±3.7	4.90 ^c ±2.3	2.10 ^a ±0.9
60:40	2.04 ^b ±1.4	1.50 ^e ±0.7	6.90 ^b ±3.3	4.75 ^c ±2.2	3.70 ^a ±1.7
50:50	2.05 ^b ±0.9	5.50 ^a ±2.6	4.50 ^d ±2.1	3.90 ^d ±1.8	1.80 ^c ±0.8

Means with the same letter along a column showed no significance difference at ($p>0.05$). Values are means $\pm$ standard deviation of two determinations.

OFSP= Orange fleshed sweet potato, C= Cocoyam, Vit. = vitamin

3.6 Mineral composition of the raw and processed samples of OFSP, Cocoyam and date (mg/g)

The mineral composition of the raw and processed samples of OFSP, cocoyam and date is shown in Table 3.6. There was significant ($p<0.05$) difference in the potassium content of all the samples and increased significantly with processing from 5.9 to 6.7 mg/g and 6 to 8.9mg/g for raw and flour of OFSP and Cocoyam, respectively while date flour had the highest value of 64.5. the increased in the potassium content of the raw sample with processing to flour could be due to concentration effect of loss of moisture during heating. ^[21] reported the same trend of increase in potassium with processing (1.38 to 3.34mg/g) and the values obtained were higher than reported in OFSP samples but lower than the values of 1085.7 and 1223.30 for green and purple cocoyam ^[23].

Calcium content significantly increased with processing in OFSP but decreased in cocoyam from 10.8 to 12.9mg/g and 40.5 to 13.8mg/g, respectively while date flour had 39.9mg/g. the reduction in the calcium content of the cocoyam from 40.5 to 13.8mg/g could be as a result processing operation. The calcium value reported is higher than the value range of 2.44 to 4.55mg/g reported by ^[21] in OFSP samples but below the value of 51mg/g and 56.57mg/g reported by ^[33] and ^[23] for cocoyam samples.

The magnesium content decreased with processing from 14.6 to 13.8, 40.5 to 13.8mg/g for OFSP and cocoyam, respectively. The magnesium content of the instant flakes is above and within the value range of 0.03 to 0.37mg/g and 24 to 43mg/g, respectively for OFSP samples and cocoyam according to ^[21] and ^[39]. The decrease could be attributed to varietal and agro-climatic conditions ^[21].

There was no significant ($p>0.05$) difference observation in the value of the sodium of the raw and processed samples even though there was a partial decrease in cocoyam. The sodium content ranged from 1.1 to 2mg/g and above the

value of 0.23 to 0.59mg/g and 6mg/g reported by ^[21] for OFSP samples and cocoyam.

The phosphorous content of the raw OFSP increased from 12.1 to 14.9mg/g while that of raw cocoyam decreased from 85.1 to 13.9mg/g and date flour having the highest value of 62mg/g. the increase and reduction could be due to positive and negative effect of heating/leaching during processing. This value is higher than the value range of 0.15 to 0.51mg/g reported by ^[38].

There was reduction in the iron values from 1.5 to 1.1 and 7.5 to 1mg/g with processing while date flour had 0.5mg/g. these values are higher than the value range of 0.06 to 0.15mg/g reported by ^[21] for OFSP samples.

The zinc content of the raw OFSP increased from 2.5 to 3.5mg/g while that of cocoyam (0.1mg/g) had no effect with processing and date flour had 0.3mg/g. these values are higher than the value range of 0.24 to 0.93mg/g by ^[39] for raw cocoyam and its flour.

The processing had no effect on the OFSP copper value (0.01mg/g) but that of cocoyam reduced from 0.8 to 0.5mg/g while date flour was 0.01mg/g. the reduction is a positive desired effect due to heat processing as expected for heavy metal

The manganese, chromium and cadmium reduced from 0.2 to 0.03 and 3.7 to 0.06mg/g; 0.09 to 0.0 and 0.09 to 0.03mg/g; 0.09 to 0.0 and 1.2 to 0.06mg/g, OSFP and cocoyam, respectively with processing and date had 0.1mg/g (manganese); 0.2mg/g (chromium) and 0.3mg/g (cadmium) as expected. the reduction of these heavy metals showed a positive effect of heat treatment and other processing operations ^[29]. The cadmium, chromium and manganese is below the maximum limit of 0.1mg/kg, 1.0mg/kg and (0.1mg/l-water, 11mg/day- other foods) as stipulated by ^[18], ^[22], (China National food safety standard) and (World Health Organisation and European Food Safety Authority), respectively.

Table 6: Mineral composition of the raw and processed samples of OFSP, Cocoyam and date

S	K	Ca	Mg	Na	P	Fe	Zn	Cu	Mn	Cr	Cd
I	5.9 ^d ±2.7	10.8 ^d ±5.0	14.6 ^d ±6.8	1.9 ^b ±0.9	12.1 ^a ±5.7	1.5 ^b ±0.7	2.5 ^b ±1.1	0.01 ^c ±0.0	0.2 ^b ±0.0	0.09 ^b ±0.0	0.09 ^c ±0.0
J	6.7 ^c ±3.1	12.9 ^c ±6.1	13.8 ^c ±6.4	1.9 ^b ±0.9	14.9 ^c ±7.0	1.1 ^b ±0.5	3.5 ^a ±1.6	0.01 ^c ±0.0	0.03 ^c ±0.0	0.0 ^c ±0.0	0.0 ^d ±0.0
L	6.0 ^c ±3.1	40.5 ^a ±0.9	33.5 ^b ±3.1	1.2 ^c ±3.9	85.1 ^a ±3.3	7.5 ^a ±1.7	0.1 ^c ±1.1	0.8 ^a ±0.1	3.7 ^a ±0.6	0.09 ^b ±0.0	1.2 ^a ±0.0
M	8.9 ^b ±4.2	13.8 ^b ±6.4	17.9 ^c ±8.4	1.1 ^c ±0.5	13.9 ^d ±6.5	1.0 ^b ±0.4	0.1 ^c ±0.4	0.5 ^b ±0.2	0.06 ^b ±0.1	0.03 ^b ±0.0	0.06 ^c ±0.0
N	64.5 ^a ±1.5	39.9 ^a ±8.4	43.0 ^a ±4.2	2.0 ^a ±1.4	62.0 ^b ±4.2	0.5 ^c ±0.7	0.3 ^c ±0.1	0.01 ^c ±0.0	0.1 ^b ±0.0	0.2 ^a ±0.0	0.3 ^b ±0.1

Means values with the same letter in the same column showed no significance difference at ($p>0.05$). Values are means $\pm$ standard deviation of two determinations.

Where: S= Sample, I= OFSP (Orange fleshed sweet potato) raw, J= OFSP Flour, L= Cocoyam raw, M= Cocoyam flour, N= Date flour, K= Potassium, Ca= calcium, Mg= magnesium, Na= sodium, P= phosphorous, Fe= iron, Zn= zinc, Cu= copper, Mn= manganese, Cr= chromium, Cd= cadmium

3.7 Mineral composition of the date-sweetened OFSP-Cocoyam instant breakfast flakes

Table 7 shows the mineral composition of the date-sweetened OFSP-Cocoyam instant breakfast flakes. The potassium values of the instant breakfast flakes ranged from 1.8 (90:10) to 4.5mg/g (80:20). The value reported is below the value of 6.05mg/g for yam flakes by [53]. Drawing observation from Table 3.5 it could be said the processing of the instant flakes had negative effect on the content of the potassium and could be due to the negative interaction of the composite flour blends used under heat processing condition that would have initiated some other chemical reactions.

The calcium content of the instant breakfast flakes ranged from 2.9 (70:30) to 4.3mg/g (90:30). This value is below the reported value of 7.42mg/g by [53]. Considering the values of the calcium content of the flour samples blended from Table 3.6, it could be said that it reduced drastically with the processing of the instant flakes as seen in Table 3.7.

The magnesium content of the instant breakfast flakes ranged from 5.56 (80:20) to 10.65mg/g (90:10). This value higher than the value of 5.86mg/g of yam flake by [53].

The sodium values of the flakes samples ranged from 0.04 (100:0) to 0.9 8mg/g (90:10).

The phosphorus content of the instant breakfast flakes produced with 100% OFSP and 30g date flours had the highest value of 7.12 mg/g with 5070:30 ration having the lowest value of 2.99 mg/g.

The instant flakes had a maximum iron value of 1.05mg/g (50:50) and lowest value of 0.09mg/g (60:40). The highest value obtained is higher than the value of 0.58 mg/g

reported for yam flakes by [53].

The zinc content of the instant breakfast flakes ranged from 0.45mg/g (50:50) to 0.81mg/g (100:0). These values are within the range of 0.55mg/g for yam flakes reported by [53]. This could be said that the interaction of the date with OFSP flour had a positive effect that increased the zinc value higher than other samples.

The copper content of the instant breakfast flakes ranged from 0.02 to 0.31mg/g and this is within the value of 0.03 and 0.02 reported by [43] per safe daily consumption.

The chromium, manganese and cadmium values of the instant breakfast flake ranged from 0.03 (70:30) to 0.15 (50:50); 0.03 (60:40 and 50:50) to 0.4mg/g (70:30); and 0.04 (100:0) to 0.16mg/g (70:30), respectively. Considering the cadmium contents of the flour samples as shown in Table 6.6, it could be deduced that processing of the instant flakes further reduced value, same trend occurred for manganese and chromium except for sample 70:30 (0.4mg/g) and 90:10 (0.13mg/g) which increased slightly. This could be due to interactions effect under processing conditions. The further decreased in the amount of these heavy metals is positively desired for safety in the consumption of the instant breakfast flakes produced from OFSP-cocoyam flour sweetened with date. However, the cadmium, chromium and manganese is below the maximum limit of 0.1mg/kg, 1.0mg/kg and (0.1mg/l-water, 11mg/day-other foods) as stipulated by [18], [22] and Codex Alimentarius Commission), (China National food safety standard) and (World Health Organisation and European Food Safety Authority), respectively.

Table 7: Mineral composition of the date-sweetened OFSP-Cocoyam instant breakfast flakes (mg/g)

S	K	Ca	Mg	Na	P	Fe	Zn	Cu	Mn	Cr	Cd
A	3.81 ^b ±1.8	3.11 ^b ±1.4	8.98 ^b ±4.2	0.04 ^c ±0.0	7.12 ^a ±3.3	0.94 ^a ±0.4	0.81 ^a ±0.3	0.03 ^b ±0.0	0.05 ^a ±0.0	0.06 ^a ±0.0	0.04 ^a ±0.0
B	1.80 ^d ±0.8	4.30 ^a ±2.0	10.65 ^a ±5.0	0.98 ^a ±0.4	5.88 ^c ±2.7	1.02 ^a ±0.4	0.65 ^a ±0.3	0.30 ^a ±0.1	0.05 ^a ±0.2	0.13 ^a ±0.1	0.12 ^a ±0.1
C	4.50 ^a ±2.1	3.11 ^b ±1.4	5.56 ^c ±2.6	0.09 ^{bc} ±0.0	4.91 ^d ±2.2	1.00 ^a ±0.4	0.75 ^a ±0.3	0.05 ^b ±0.0	0.05 ^a ±0.0	0.04 ^a ±0.0	0.15 ^a ±0.0
D	3.70 ^b ±1.7	2.90 ^c ±1.3	7.89 ^c ±3.7	0.85 ^{ab} ±0.3	2.99 ^d ±1.4	0.90 ^a ±0.4	0.78 ^a ±0.3	0.03 ^b ±0.0	0.40 ^a ±0.0	0.03 ^a ±0.0	0.16 ^a ±0.7
E	2.75 ^c ±1.3	4.10 ^a ±1.9	6.89 ^d ±3.2	0.07 ^c ±0.0	3.90 ^e ±1.8	0.09 ^b ±0.0	0.63 ^a ±0.2	0.31 ^a ±0.1	0.03 ^a ±0.0	0.04 ^a ±0.0	0.14 ^a ±0.7
F	2.80 ^c ±1.3	3.20 ^b ±1.5	8.91 ^b ±4.2	0.94 ^a ±0.4	6.11 ^b ±2.8	1.05 ^a ±0.4	0.45 ^b ±0.5	0.02 ^b ±0.0	0.03 ^a ±0.0	0.15 ^a ±0.1	0.12 ^a ±0.1

Means values with the same letter in the same column showed no significance difference at ($p>0.05$). Values are means $\pm$ standard deviation of two determinations.

Where: A= 100:0, B= 90:10, C= 80:20, D= 70:30, E= 60:40, F= 50:50, S= Sample, K= Potassium, Ca= calcium, Mg= magnesium, Na= sodium, P= phosphorous, Fe= iron, Zn= zinc, Cu= copper, Mn= manganese, Cr= chromium, Cd= cadmium

4. Conclusion

The cocoyam flour was noted to have a good level of protein (6.5%) and ash (3.2%) while date had 9.38% fat. Instant breakfast flakes sample made from 70:30 formulation ratio of OFSP and cocoyam flour had the highest sensory score of 7.6, on approximation is 8 which means liked moderately and scored 7 (liked slightly) for

overall acceptability rating suggesting further improvement to enhance the overall acceptability and achieve higher rating. Flakes sample made with ratio 50:50 had the highest protein content of 7.18% followed by 60:40 with 5.43% which is an indication that protein levels increased with increase in cocoyam flour. Flakes sample made from ratio 60:40 had the highest fiber value of 2.76% and 70:30 with

80.93% carbohydrate. The processing had a negative effect on the vitamins (A, D, C and K) of the flour samples with the highest vitamin A in date flour (7.5mg/g). The flakes samples had an appreciable level of vitamins especially for vitamin E and C. The flour had an appreciable level of minerals of interest and very minute level (below maximum acceptable limits) of heavy metals analyzed. The flakes samples also had an appreciable level of all the minerals analyzed with very minute levels (below maximum acceptable limits) of heavy metals analyzed. The flakes sample with ratio 70:30 stood out in rating for crunchiness and overall acceptability, adding to the list of instant breakfast flakes. Thus, the possibility of use of composite flour of OFSP and cocoyam sweetened with date in instant breakfast flakes.

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6. Conflict of interest

The authors declare no conflict of interest.

7. References

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