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EFFECTS OF DRYING TEMPERATURE ON PROXIMATE COMPOSITION AND FUNCTIONAL PROPERTIES OF (*Colocasiaesculenta*) COCOYAM FLOUR

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ABSTRACT

This research evaluated the effects of drying temperature on the proximate composition and functional properties of *(Colocasiaesculenta)* cocoyam flour. Flour was obtained from *Colocasiaesculenta* by peeling, slicing, washing, drying at different temperature (50 °C, 60 °C, 70 °C, 80 °C, and 90 °C), milling and sieving. The flours obtained were evaluated for proximate composition and functional properties. The flour samples had proximate composition ranging from 5.98 % to 11.28 % moisture content, 0.75 % to 3.22 % ash content, 4.93 % to 7.26 % crude protein, 0.41 % to 0.93 % fat content, 2.75 % to 3.19 % crude fiber and 72.69 % to 81.23 % carbohydrate. The flour samples have functional properties ranging from 1.32 mL/g to 2.90 mL/g water absorption capacity, 0.63 mL/g to 1.43 mL/g oil absorption capacity, 0.59 g/mL to 0.95 g/mL bulk density, 81 °C to 90°C gelatinization point, 14.30 to 18.60swelling capacity, 12 secs to 23 secs wett ability and 21 cp to 35cp viscosity measurement. The result of this study showed that the drying temperature have effect on both the proximate composition and functional properties of *(Colocasiaesculenta)* cocoyam flour.

KEYWORDS: *Colocasiaesculenta*, Proximate Composition, Functional Properties, Temperature, Drying.

INTRODUCTION

Food nutrients majorly include carbohydrate, lipids, proteins, minerals, vitamins and water which can be derived from plant and animals. Animals flesh are consumed as food while plant is the only living organism that is capable of carrying out photosynthesis which makes them grow and plants are the major source of food in nature's chain [1]. Food originated from plant may be classified into cereals, roots and tubers, sugars and syrups, legumes, pulses, nuts and oil seeds, vegetables and fruits [2].

Roots and tubers used as food include yams, cassava, potatoes, sweet potatoes and cocoyam. Cocoyams are monocotyledonous herbs that belong to the family Araceae and are grown primarily for their roots which are edible.

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The name cocoyam is generally applied to a variety of useful and edible species belonging to different genera including Colocasia, Xanthosoma, Alocasia, Crytospema and Amorphophallus [3]. They are the third most important root crop (after yam and cassava), one of the most valuable root crops cultivated in Nigeria, and the second most valuable in West Africa. By far, more important and more extensive cultivation in Nigeria are *Colocasia*and *Xanthosoma*. Nigeria has the largest population of cocoyam consumers, followed by Ghana. The Southern part of Nigeria is known for bulk production of cocoyam [4].

Roots and tubers contribute about 20-48% of the total calories and about 7.1% protein to the diets of the people of sub-Saharan Africa. In Nigeria, they are the main sources of calories accounting for over 50% of the caloric intake of the people of the south. Yam has less than 6% protein while cassava is a poor source of protein, less than 3%. Cocoyam is fair in protein, 7-9% and calcium while sweet potatoes are poor in protein [5].

However, considering the nutritional quality of cocoyam, the high starch content and it quality (*i.e*. fine starch grains), the level of utilization of cocoyam and its products both domestically and industrially is quite low. Cocoyam has high moisture content resulting in short storage life under ambient conditions and because of these, they are highly perishable and huge losses can occur after harvest [6]. There is a need to investigate the effect of temperature on the properties of cocoyam in order not to denature and devalue the nutrient in cocoyam while processing for storage.

MATERIALS AND METHODS

Fresh corm of cocoyam (*Colocasiaesculenta)* was purchased from a local market in Ondo State. All reagent and solvent that were used are of analytical grade.

SAMPLE PREPARATION

The fresh corms of cocoyam (*Colocasiaesculenta)* was washed, peeled, and then rinsed under running water. It was then sliced into 5mm thickness and the pieces were dried in the oven at 50^{o}C, 60^{o}C, 70^{o}C, 80^{o}C, and 90^{o}C for 3 hours. The samples were sieved and packaged in air tight properly labeled polythene sachets for further analysis.

Figure 2.1.*Colocasiaesculenta*leaves

Figure 2.2.*Colocasiaesculenta*tubers

PROXIMATE ANALYSIS

The proximate analysis was determined using themethod described by [8]

DETERMINATION OF MOISTURE CONTENT

Exactly 2 g each of the samples were weighed and dried at about 105 ^{o}C in theoven for four hours to constant weight. The moisture content was reported as percentage loss in weight [8].

Moisture content= $\frac{W2-W3}{W2-W1}$x 100.....**Equation1**

Where: W_1 = Weight of empty dish.

W_2 = Weight of dish and sample before drying

W_3 = Weight of dish and sample after drying

DETERMINATION OF ASH CONTENT

The ash content was determined by igniting 5 g of dry sample in a muffle furnace at about550 ^{o}C to constant weight. It was cooled in a desiccator and weighed. The ash content was reported as a percentage dry mass [9].

Percentage Ash = $\frac{\text{Weight loss } (W_2-W_3)}{\text{Weight of sample } (W_1)}$ x 100 **Equation 2**

Where: W_1 = weight of sample

W_2 = weight of sample + crucible

W_3 = weight of sample + crucible (constant weight after drying)

DETERMINATION OF CRUDE PROTEIN

Exactly 5 g of the samples were weighed and digested in macro-Kjeldahl apparatus with concentrated sulphuric acid. The ammonia liberated from the resulting ammonium sulphate after adding sodium hydroxide was distilled into 1 M boric acid and then titrated with 0.1 M HCl. The nitrogen value estimated was multiplied by 6.25 (protein factor) to obtain the value of the crude protein, expressed as the percentage of sample mass [9].

$$\% \text{ Nitrogen} = \frac{\text{Vol.of acid used} \times \text{Molarity} \times 0.014 \times \text{Dilution factor}}{\text{Weight of sample}} \text{ x } 100 \quad \textbf{Equation3}$$

$$\% \text{ Protein} = \% \text{ N} \times 6.25 \quad \textbf{Equation4}$$

DETERMINATION OF FAT

The crude fat was extracted from 5 g of each sample using a solvent extraction apparatus (Soxhlet apparatus) with low boiling point petroleum ether as solvent. The weight of the lipid obtained after evaporating off the solvent

from the extract gave the weight of the lipid present in the sample [9].

$$\text{Percentage of Crude fat} = \frac{\text{Weight loss } (W_2 - W_3)}{\text{Weight of sample } (W_1)} \times 100 \quad \textbf{Equation 5}$$

Where:W_1 = weight of sample

W_2 = weight of sample + filter paper
W_3 = weight of sample + filter paper (constant weight after drying)

DETERMINATION OF CRUDE FIBRE

Exactly 5 g of sample were weighed and exhaustive extraction of substances soluble in 1.25% boiling sulphuric acid and 1.25% boiling sodium hydroxide was employed. The residual matter of crude fibre and inorganic material recovered and ash yielded the crude fibreexpressed as percentage loss in weight of ashed residue [9].

$$\text{Percentage of Crude fibre} = \frac{\text{Weight loss } (W_2 - W_3)}{\text{Weight of sample } (W_1)} \times 100 \quad \textbf{Equation 6}$$

Where:W_1 = Initial weight of sample
W_2 = weight of sample + crucible before ashing
W_3 = weight of sample + crucible after ashing (constant weight after drying).

CARBOHYDRATE CONTENT DETERMINATION

Carbohydrate content was determined by difference. The percentage total carbohydrate is estimated to be equal to the sum of percentage moisture, protein, ash and fibre subtracted from 100.

$$\%\,\text{Carbohydrate} = 100 - (\%\,\text{protein} + \%\text{fat} + \%\text{fibre} + \%\text{ash} + \%\,\text{moisture}) \quad \textbf{Equation 7}$$

DETERMINATION OF FUNCTIONAL PROPERTIES

The method of [10] was used for thedetermination of functional properties. The functionalproperties determined include water and oil absorption capacities (1g sample); bulk density (5g sample); swelling index (3g sample) and wett ability capacity (1g sample). Gelatinization temperature was determined using the method described by [10].

WATER / OIL ABSORPTION CAPACITY

Exactly 1 g of sample was weighed into a clean conical graduated centrifuge tube and was mixed thoroughly with 10 mL distilled water/oil using a warring mixer for 30 secs. The sample was then allowed to stand for 30 mins at room temperature, after which it was centrifuged at 1000 rpm for 30 mins. After centrifugation, the volume of the free water (supernatant) or oil was read directly from the graduated centrifuge tube. The absorbed water was converted to weight (in grams) by multiplying by the density of oil (0.894 g/mL) and water (1 g/mL). The oil and water absorption capacities were express in grams of oil/water absorbed per gram of flour sample.

$$\text{Absorbed water} = \text{total water} - \text{free water} \quad \textbf{Equation8}$$

BULK DENSITY

The gravimetric method was used. A weighed sample (10 g) was put in a calibrated 10 mL measuring cylinder. Then the bottom of the cylinder was tapped repeatedly onto a firm pad on a laboratory bench until a constant volume was observed. The packed volume was recorded. The bulk density is calculated as the ratio of the sample weight to the volume occupied by the sample after tapping [11].

$$\text{Bulk density (g/mL)} = \frac{\text{Weight of Sample(g)}}{\text{Volume of sample (mL)}} \quad \textbf{.Equation 9}$$

GELATINIZATION POINT

Exactly 10 g of flour sample was suspended in distilled water in a 250 mL beaker and made up to 100 mL flour suspension. The aqueous suspension was heated in a boiling water bath,

with continuous stirring using a magnetic stirrer. A thermometer was then clamped on a retort stand with its bulb submerged in the suspension. The heating and stirring continued until the suspension began to gel and corresponding temperature was recorded 30 secs after gelatinization was visually noticed.

SWELLING CAPACITY

This was determined as the ratio of the swollen volume to the ordinary volume of a unit weight of the flour. The method of [11] was used. One gram (1 g) of the sample was weighed into a clean dry measuring cylinder. The volume occupied by the sample was recorded before 5 mL of distilled water was added to the sample. This was left to stand undisturbed for an hour, after which the volume was observed and recorded again. The capacity of swelling ability of the sample was given by the formula below:

$$\text{Swelling Capacity} = \frac{\text{Volume occupied by sample after swelling}}{\text{Volume occupied by sample before swelling}}$$

WETTABILITY

The method described by [12] was used. A graduated cylinder (25 mL) was washed and dried in the oven and one gram of sample was weighed out and filled into the cylinder. A 600 mL beaker was filled with distilled water up to the 500 mL mark. A finger was placed over the open end of the 25 mL cylinder containing the sample. The cylinder was inverted and clamped at a height of 10 cm from the surface of a 600 mL beaker containing distilled water. The finger was then removed to allow the test flour sample to be dumped into distilled water. The wettability was recorded as the time required for the sample to be completely wet.

VISCOSITY

The rotating spindle method described by [13] was employed in the viscosity determination. The viscosities of each of the sample were determined with a viscometer. 5 gof the sample was dissolved in 100 mL of water in a disposable plastic cup. The cup with its content was placed in a water bath and heated up to boiling. Each sample was in a separate cup. The cups were then removed and cooled to room temperature of about 25 °C. Each sample in the disposable cup was placed under the equipment at speed of 30 rpm. The viscosity was recorded in centipoises (cp).

STATISTICAL ANALYSIS

All analyses were done in triplicate to evaluate experimental reproducibility and reported as Mean ± Standard Deviation. The data obtained were subjected to one way analysis of variance (ANOVA) using SPSS version 21. Duncan's multiple range test (DMRT) was used to determine means that were significantly different at a level of significance (α) of 0.05.

RESULTS AND DISCUSSION

PROXIMATE ANALYSIS

The result of the proximate analysis is presented in table 3.1. The moisture content of *Colocasiaesculenta* flour ranges from 5.98% to 11.28% whileCE90 has the lowest value (5.98%) and CE50 having the highest value (11.28%). Significant differences were observed in the obtained result. It was also observed that moisture content reduces in the flour sample as the drying temperature increases and this was in agreement with the research earlier reported by [15]. The ash content of the samples ranges from 0.75% to 3.22%. The highest value (3.22%) was recorded in CE50 and the lowest value recorded in CE90 (0.75%). Earlier research by [16] and [17] reported ash content of *Colocasiaesculenta*ranges from 0.51% to 2.98% and 0.93% to 3.02% respectively, which is similar to that reported in this research. It was observed that the ash content decreases with increase in

temperature. The result indicates the presence of inorganic nutrients in the flour samples, therefore the samples could be a source of mineral elements having nutritional importance [18].

The fiber content ranges from 2.75 % to 3.19%. CE90 recorded the highest value (3.19%) while CE70 recorded the lowest value (2.75%) even though significant difference wasn't noticed in the five samples. The fat content of the cocoyam flour samples ranges from 0.93% to 0.41%. CE50 had the highest value (0.93%) while CE90 had the lowest value (0.41%). It was observed that the fat content reduces with increase in temperature as earlier reported by [19] and this may be attributed to the oxidation of fat as temperature increases [20].The low content of fat would enhance the shelf life of the flour due to the lowered chance of rancid flavor development [21]. Hence CE90 would tend to have longer shelf life than CE50.

The crude protein content of the flour samples ranges from 7.26% to 4.93% with CE90 having the lowest (4.93%) and CE50 with the highest (7.26%). The protein content reported in this present research is slightly higher than 6.96 to 4.34% reported by [22].It was observed that as temperature increases, the protein content decreases and this variation could be attributed to the denaturing of protein as temperature increases. The carbohydrate content of the flour samples ranges from 81.23% to 72.69%. CE90 was observed to have the highest value while CE50 had the lowest value. CE90, CE80, CE70 showed no significant difference compared to CE60 and CE50. It was observed that temperature affect the composition of carbohydrate as it increases with increase in temperature. The result reported high carbohydrate content values in *Colocasiaesculenta* which is in line with the research done by [23]. Carbohydrate has been discovered to the predominant of all the nutrients in roots and tubers[24].

Table 3.1.Proximate Analysis of *Colocasiaesculenta*

PARAMETERS						
Sample	Moisture Content (%)	Ash Content (%)	Protein	Fat	Crude fiber	Carbohydrate
CE50	$11.28^{a}\pm1.86$	$3.22^{a}\pm0.91$	$7.26^{a}\pm1.11$	$0.93^{a}\pm0.07$	$2.82^{b}\pm0.43$	$72.69^{c}\pm1.71$
CE60	$9.82^{a}\pm1.13$	$1.81^{b}\pm0.47$	$6.74^{a}\pm0.83$	$0.81^{b}\pm0.04$	$3.08^{a}\pm0.80$	$75.74^{b}\pm1.67$
CE70	$8.73^{b}\pm1.04$	$1.39^{b}\pm0.55$	$5.51^{b}\pm0.46$	$0.67^{c}\pm0.06$	$2.75^{b}\pm0.61$	$77.51^{a}\pm1.95$
CE80	$6.51^{b}\pm1.19$	$1.08^{c}\pm0.63$	$5.12^{b}\pm0.58$	$0.55^{d}\pm0.02$	$3.13^{a}\pm0.88$	$80.59^{a}\pm2.54$
CE90	$5.98^{c}\pm0.85$	$0.75^{d}\pm0.27$	$4.93^{c}\pm0.21$	$0.41^{e}\pm0.05$	$3.19^{a}\pm0.74$	$81.23^{a}\pm2.31$

Number of replicates = 3; Mean ± Standard Deviation; Mean with different superscript across rows are significantly different at ($P<0.05$)

Sample codes: *Colocasiaesculenta*dried at 50 ^{o}C denoted as CE50

*Colocasiaesculenta*dried at 60 ^{o}C denoted as CE60

*Colocasiaesculenta*dried at 70 ^{o}C denoted as CE70

*Colocasiaesculenta*dried at 80 ^{o}C denoted as CE80

*Colocasiaesculenta*dried at 90 ^{o}C denoted as CE90

FUNCTIONAL PROPERTIES

WATER ABSORPTION CAPACITY (WAC)

The water absorption capacity (WAC) of the flour samples ranges from 1.32 mL/g to 2.9mL/g (Table 3.2) with CE90having the highest and CE50had the lowest. There was a significant difference in the water absorption capacity of the flour samples. CE90 showed higher absorption capacity than the other samples. [25] reported a slightly close WAC values with the obtained result in this research. However, [26] recorded a higher value compared to the values recorded in this research.

It was observed that WAC increased with increase in temperature. This same observation was reported by [27] and this can be attributed to the fact that the hydrophilic tendency of the starch increased with increase in its drying temperature. Also at higher temperature, starch expands rapidly especially in the amorphous region [28]. WAC is important in the development of ready to eat foods and a high absorption capacity may assure product cohesiveness [29].

OIL ABSORPTION CAPACITY (OAC)

The oil absorption capacity (OAC) of the floursamples ranges from 0.63 mL/g to 1.43 mL/g. CE90 had the highest oil absorption capacity value (1.43 mL/g) and CE50 had the lowest value (0.63 mL/g). It was observed that OAC increased with increase in temperature which couldbe attributed to the fact that higher temperature yieldedlow moisture content thereby allowing oil to be absorbed. The absorption of oil by food products improves flavour retention and mouth feel thereby giving soft texture and good flavour to food [30].

BULK DENSITY

The bulk density ranges from0.59 g/mL to 0.95 g/mL with CE50 having the highest value and CE90had the lowest value. There was no significant difference between CE60 and CE70. The bulk density reduces with increase in temperature and this is as a result of the sample dried at high temperature had lower moisture content thereby having less surface area compare to the samples with higher moisture content. High bulk density is desirable for greater ease of dispersibility and reduction of paste thickness as it gives an indication of the relative volume of packaging material required [31].

SWELLING CAPACITY

The swelling index of the flour samples varied from 14.30 to 18.60. Significant difference was observed among CE70, CE80, and CE90 while there was no significant difference between CE50 and CE60.The values obtained in this research were more than value of cocoyam reported by [32]. It was observed that swelling capacity increases with increase in temperature and as expected also varies directly as water absorption capacity. Swelling capacity indicate strength and character of the starch granules. Generally cocoyam samples show good swelling index when compared to other root crops like cassava. This is because cocoyam has starch granules with highly digestible nature. The starch grain of cocoyam is about one tenth of potato starch grain [33].

WETTABILITY CAPACITY

The flour samples have wettability capacity ranged from 12secs to 23secs with CE90 and CE80 having the lowest value (12 secs) while CE50 has the highest value (23 secs). There were significant differences in the wettability capacity of CE50, CE60, and CE70 while CE90 and CE80 did not differ significantly. It was observed that wettability reduces with increase in temperature and this could be attributed to the high temperature treatment which made them to absorb moisture faster thereby making them to have a low wetting time [34][35].

VISCOCITY

The viscosity of the flour samples varied from 21 cp to 35 cp. CE90 had the highest value while CE50 had the lowest value. The viscosity of CE90 (34 cp) differed significantly from CE80 (29 cp), CE60 (26 cp) and CE50 (21cp). It was observed that viscosity increases with increase in temperature. This result implies that more viscous cocoyam flour could be obtained with further raising of the drying temperature [36]

GELATINIZATION POINT

Gelatinization in food refers to the disruption of starch in which starch granules swell when heated in the presence of water [37].The

gelatinization point of the flour samples varied from 81 °C to 90 °C with CE50 having the lowest while CE90 had the highest value. There was no significant difference in the gelling point of CE90, CE80 and CE70 although CE50 differs significantly from CE60. The low gelatinization point of CE50 might be attributed to the low water absorption capacity of sample CE50 compared to CE90 which has a higher gelatinization point and water absorption capacity.

Table 3.2.Functional Properties of *Colocasiaesculenta*

PARAMETERS							
Sampe	**WAC(mL/g)**	**OAC(mL/g)**	**BD (g/mL)**	**GP (°C)**	**SC**	**WC(Secs)**	**VM (cp)**
CE50	1.32^{c}±0.17	0.63^{d}±0.09	0.95^{a}±0.12	81^{c}±2.70	14.30^{d}±0.96	23^{a}±3.00	21^{e}±1.50
CE60	1.69^{b}±0.11	0.91^{c}±0.18	0.91^{a}±0.09	82^{b}±2.40	14.80^{d}±1.11	18^{b}±1.50	26^{d}±1.50
CE70	1.93^{b}±0.28	1.08^{c}±0.05	0.87^{ab}±0.09	85^{ab}±1.75	15.90^{c}±1.06	15^{c}±2.00	32^{ab}±2.50
CE80	2.44^{a}±0.45	1.12^{b}±0.18	0.71^{b}±0.10	87^{a}±2.85	16.20^{b}±1.28	12^{d}±1.50	29^{c}±1.86
CE90	2.90^{a}±0.61	1.43^{a}±0.12	0.59^{c}±0.08	90^{a}±4.50	18.60^{a}±1.56	12^{d}±1.00	35^{a}±3.50

Number of replicates = 3; Mean ± Standard Deviation; Mean with different superscript across rows are significantly different at (P<0.05). WAC- water absorption capacity.OAC- oil absorption capacity.BD- bulk density.GP- gelatinization point. SC- swelling capacity. WC- wettability capacity. VM- viscosity measurement

CONCLUSION

The results of this research indicate that drying temperature have effect on the proximate and functional composition of (*Colocasiaesculenta)* cocoyam flour. Depending on the storage method and intended end use of the flour, different drying temperatures can be adopted. The use of high drying temperature can be a good advantage for sample's easy transportation and storability, since high drying temperature showed low bulk density.

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