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Effect of Deep-Fat Frying on the Vitamins, Proximate and Mineral Contents of *Colocasia esculenta* Using Various Oils

[1]O.E. Omotosho, [1]O.C. Laditan, [3]O.E. Adedipe and [2]J.A.O. Olugbuyiro
[1]Department of Biological Sciences, Covenant University, Ota, Nigeria
[2]Department of Chemistry, Covenant University, Ota, Nigeria
[3]North Carolina University, United States of America

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Corresponding Author:
O.E. Omotosho
Department of Biological Sciences,
Covenant University, Ota, Nigeria

ABSTRACT

Colocasia esculenta (Cocoyam) is cultivated primarily for its edible tubers. The objective of this work was to study the effects of frying on the vitamins, proximate and mineral contents of cocoyam by using three different oils (canola oil, soya oil and vegetable oil). It was also oven-dried which served as the control sample. The HPLC method was used for the vitamin analysis. The vitamin A content of dried cocoyam was the highest (0.275±0.007 mg g^{-1}) but it was greatly reduced in cocoyam fried with canola oil (0.034±0.048 mg g^{-1}) and totally lost in cocoyam fried with soya oil and vegetable oil. Vitamins D, E and K were totally lost in cocoyam fried with canola oil. The results of the mineral analysis revealed that the dried cocoyam sample contained high amounts of sodium (257.500±2.121 mg g^{-1}), potassium (128.350±0.354 mg g^{-1}) and calcium (320.050±0.000 mg g^{-1}) and there was a general decrease in the values of most minerals especially sodium, magnesium and iron. The dried cocoyam samples had high levels of protein (26.64%), carbohydrate (44.91%), moisture content (13.2%), ash content (2.14%), crude fibre (11.27%) but low level of lipid in comparison with the fried samples. Cocoyam fried with vegetable oil had the lowest level of protein (22.41%) and carbohydrate (16.8%) but the highest level of lipid (23.03%) and moisture content (27%). The results show that oven-drying retains most of the nutrients of cocoyam compared to deep-fat frying and that each oil sample has its own disadvantage.

Key words: Cocoyam, deep-fat frying, minerals, vitamins, proximate analysis, canola oil, soya oil, vegetable oil

INTRODUCTION

Cocoyam is an herbaceous perennial plant which belongs to the family Araceae. The genus *Colocasia esculenta* and the genus *Xanthosoma sagittifolium* are the most consumed and cultivated species all over the world. Although, all parts of the cocoyam plant can be eaten, they are grown mainly for their edible roots also called corms. Cocoyam is one of the most important root and tuber crops worldwide (Ejoh *et al.,* 2013). Nigeria produces the largest amount of cocoyam in the world with an average figure of 5,068,000 Mt and accounts for about 37% of the world's total output (Okoye *et al*., 2009). The corm, cormel and leaves of the cocoyam plant are an important source of carbohydrates for human nutrition and animal feed (Ejoh *et al.*, 2013). Cocoyam can be processed in many different ways; it can either be boiled, fried, roasted, baked or steamed for consumption. Its leaves can also be eaten and are used as vegetable in soups. It contains digestible starch, protein and other valuable nutrients. The consumption of cocoyam is very high all over Nigeria (Alegbejo *et al*., 2009). Some parts of the cocoyam plant can also be used as traditional medicine. Deep-fat frying is defined as the process of cooking foods by soaking them in edible fat or oil at a temperature above the boiling point of water, usually 120-180ºC. Frying is often chosen because of its ability to create new and special flavours and textures in processed foods (Bassama *et al*., 2012). Frying is one of the oldest and most popular cooking methods in existence and its high heat transfer rates are largely responsible for the developed sensorial properties in fried foods (Pedreschi *et al*., 2005). The quality of the products from deep-fat frying also depends on the type of oils used during the process and not only on the frying conditions, the quality of the oil used for frying affects the nutritional quality and shelf life of the fried products (Debnath *et al*., 2012). The main structural changes produced during frying are starch gelatinization and protein denaturation. This research was aimed at determining the effect of frying using different oil samples (canola, vegetable and soya oils) on the vitamins, proximate and mineral contents of *Colocasia esculenta*.

MATERIALS AND METHODS

Plant material: Cocoyam corms were purchased from a local market in Ikorodu area of Lagos State, Nigeria.

Preparation of sample: The corms were peeled and washed in distilled water. After which they were cut into thin circular slices just like the locally sold "coco" chips. Three different oils: canola oil, soya oil and vegetable oil, were used in the frying of the cocoyam chips. A deep fryer was used for this and the cocoyam was fried at a temperature of 190°C for 10 min. After cooling, the samples were grinded into powder form using mortar and pestle. After grinding the different cocoyam powder samples that were fried with the different oils were kept in Ziploc bags and labeled accordingly.

Mineral analysis: The dried powdered samples were first digested with nitric acid and perchloric acid and then the aliquots were used for the determination of sodium, potassium, calcium, magnesium, phosphorus, iron, copper, zinc, lead and manganese content. Phosphorous was determined by spectrophotometer while sodium and potassium were determined by flame photometer (Khalil and Mannan, 1990). Iron, copper, zinc, manganese, calcium, lead and magnesium by atomic absorption spectrophotometer (AOAC., 1990).

Analysis of fat soluble vitamins: This was done using the HPLC method. The mobile phase was used for the analysis that contained methanol and water mixed in the ratio (95:5). The standard for vitamin A, D3, E, K3 were weighed ranging from ≥ 3 ≥ 5 and then dissolved in solvent methanol of appropriate and equal volume to get a concentration of 1000 µg mL^{-1}. Concentration of 5, 10, 25, 50, 75 and 100 were then prepared. Calibration curve was made by using mix standard in mobile phase with five point calibration, analyzed independently by HPLC and a standard curve was plotted between concentration and peak area. The injected quantities showed good linearity. The data of peak area vs. used standard vitamin concentration were treated by linear least square regression from the regression equation. Standard curve from different vitamins standard concentrations was used to estimate fat soluble vitamins in different samples. One gram of the already grinded sample was weighed using weighing balance into the sample bottles. Ten milliliter of n-hexane was added to the samples and then shaken at 9000 rpm using a vortex mixer for 5 min. It was left for 24 h and the resulting solution was poured into a 5 mL sample bottle. For the HPLC analysis, a waters symmetry C18 column (150×4.6 mm 5 µm) was used with a linear gradient methanol and water mixed in the ratio (95:5) at a constant flow rate of 1 mL min^{-1} with a wavelength of 280 nm. All the analyses were performed with 2 replicates.

Proximate analysis: The nutrients in the food were evaluated under 6 parameters: moisture content, ash content, crude protein, lipid or fat content, crude fiber and carbohydrate content.

Moisture determination: The moisture contents of the cocoyam powders were determined by the oven drying method at 105°C (AOAC., 1990). The reading was taken at a constant weight. The moisture content was then expressed as the percentage (%) of the dry weight of sample.

Lipid content: The lipid content was extracted using a Soxhlet apparatus. Petroleum ether was used to extract the fat from the sample. The extraction continued for about 4 h then the extracted fat is dried to a constant weight and expressed as percent fat per weight.

Crude fibre: The fat-free material was transferred into a flask and 200 mL of pre-heated 1.25% H_2SO_4 was added then the solution was gently boiled for about 30 min, maintaining constant volume of acid by the addition of hot water. The boiled acid sample mixture was filtered hot under sufficient suction and washed thoroughly with hot water and twice with ethanol. The residue was dried at 65°C for about 24 h and weighed. The residue was transferred into a crucible and placed in muffle furnace (400-600°C) and ashed for 4 h, then cooled in desiccator and weighed.

Crude protein: About 2 g of the sample was weighed and the crude protein was determined by Kjeldahl method. The method involved digestion, distillation and titration.

Ash content: The ash content of each sample was determined at 550°C. The ash content is expressed as the inorganic residue left as a percentage of the total weight of sample incinerated.

Carbohydrate content: The carbohydrate content was obtained by subtracting the sum of percentages of all the nutrients already determined from 100. It was determined by mathematical calculation using the formula:

$$\text{Carbohydrate (\%)} = 100\text{-(moisture (\%)+crude fibre (\%)+ crude protein (\%)+lipid (\%)+ash (\%))}$$

It represents soluble carbohydrates and other digestible and easily utilizable non-nitrogenous substances in the food sample.

Statistical analysis: All the experimental results were the Mean±S.D of three parallel measurements. Data was evaluated by using Excel 97 as a tool for the analysis.

RESULTS AND DISCUSSION

The results of the mineral compositions of the samples are represented in Table 1. The results demonstrated that frying at a temperature of 190°C for 10 min generally led to a significant reduction of the minerals especially sodium and magnesium. There was really no significant difference in the amount of zinc after frying. Sodium, potassium and calcium were present in very high quantities; magnesium, zinc and iron were present in significant amounts. Nitrogen was present in small amounts while copper, manganese occurred in smaller amounts. However, lead was present in trace amounts in dry cocoyam and cocoyam fried with canola oil but it was not detected in cocoyam fried with soya and vegetable oils. The sodium, calcium, magnesium and zinc levels of the cocoyam fried with canola oil and soya oil were significantly reduced; cocoyam fried with vegetable oil reduced the sodium, potassium, magnesium and zinc levels significantly. There was no significant change in the nitrogen, lead, copper and manganese contents of the cocoyam fried with canola, vegetable and soya oils. The iron, potassium and calcium levels of the cocoyam seemed to increase in canola, soya and vegetable oils respectively compared to dry cocoyam. There was slight increase in the levels of manganese in soya oil and nitrogen in vegetable oil. The results reveal that calcium is the most abundant element in the cocoyam sample and also portrays it as a good source of sodium, potassium, magnesium, zinc and iron and this agrees with the findings of Lewu *et al.* (2010). It was also observed that the *C. esculenta* tuber studied is a poor source of nitrogen and manganese.

The analysis of the vitamin contents of the processed cocoyam samples are displayed in Fig. 1. The vitamin value of the dry cocoyam sample was very low: vitamin A (0.28 IU), vitamin D (0.027), vitamin E (0.006) and vitamin K (0.024) which shows that cocoyam is not a rich source of fat soluble vitamins. Vitamins D, E and K were not detected in cocoyam fried with canola oil but were detected in cocoyam fried with soya oil. Vitamin A was detected in cocoyam fried with canola oil but was not found in cocoyam fried with soya oil. In cocoyam fried with vegetable oil, vitamin A was not detected but vitamins D, E and K were found present. It appeared most of the vitamins were lost in cocoyam with canola oil. The analysis suggests that frying of the cocoyam greatly reduce the vitamin contents and may cause the total loss of some vitamins.

The proximate composition of the cocoyam samples is presented in Table 2. The moisture contents of the cocoyam samples were moderate: dry cocoyam sample (13.2%), cocoyam fried with canola oil (24.7%), cocoyam fried with soya oil (18.6%), cocoyam fried with vegetable oil (27%). Cocoyam with vegetable oil had the highest moisture content. Moisture content is more reduced in drying cocoyam compared to frying with the different oil samples. The loss in the moisture content of foods is due to evaporation and the content of water in samples cooked by different methods could be attributed to the extent of moisture loss in each cooking method through drippings and evaporation. According to the work of Kumar and Aalbersberg (2006), the moisture contents of earth-oven-cooked cassava and taro were lower than the moisture contents of boiled cassava and taro. The gain of about 30-40% moisture in the boiled tubers was obviously because

Table 1: Mineral composition of cocoyam samples (X±S.D)

Minerals	Dry cocoyam	Cocoyam with canola oil	Cocoyam with soya oil	Cocoyam with vegetable oil
Na	257.500±2.121	118.200±0.212	105.750±0.071	96.480±0.354
K	128.350±0.354	94.440±0.0424	150.400±0.283	121.715±0.262
Ca	320.050±0.000	211.000±0.000	273.500±0.000	328.500±0.000
Mg	63.350±0.354	41.700±0.070	24.500±0.212	26.300±0.212
Zn	33.120±0.141	27.200±0.071	24.650±0.141	24.680±0.212
Fe	78.450±0.071	91.210±0.141	51.580±0.283	49.080±0.071
Cu	1.730±0.028	1.350±0.212	0.800±0.141	1.380±0.212
Pb	0.055±0.021	0.045±0.035	Not detected	Not detected
N	4.245±0.021	3.915±0.007	3.780±0.014	4.395±0.007
Mn	1.360±0.014	1.160±0.028	1.550±0.028	0.700±0.141

Table 2: Proximate composition of cocoyam sample

Samples	CHO (%)	Crude protein (%)	Lipid (%)	Moisture (%)	Ash (%)	Crude fibre (%)
Dry cocoyam sample	44.91	26.64	01.84	13.2	2.14	11.27
Cocoyam with canola oil	35.12	24.35	07.26	24.7	0.39	8.18
Cocoyam with soya oil	32.35	23.69	13.74	18.6	1.91	9.71
Cocoyam with vegetable oil	16.08	22.41	23.03	27.0	1.07	9.06

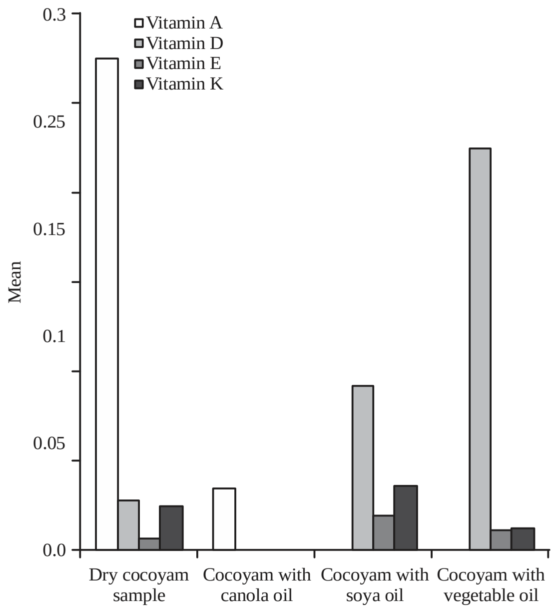

Fig. 1: Graphical representation of the vitamin contents of cocoyam sample

of the water that undoubtedly got absorbed by tubers during boiling. This justifies the increase in the moisture contents of the cocoyam samples which simply shows that the samples absorbed the oil from the oil samples thereby increasing their moisture content.

The ash content measures the amount of the nutritionally important minerals present in a food material (Lewu *et al.*, 2009). The ash contents of all the cocoyam samples were low: dry cocoyam sample (2.14%), cocoyam with canola oil (0.39%), cocoyam with soya oil (1.91%) and cocoyam with vegetable oil (1.7%). Frying in the different oil samples reduced the ash content of the cocoyam sample but not significantly. Cocoyam with canola oil had the lowest ash content (0.39%) and cocoyam with soya oil had the highest (1.91%). The decrease in the ash content after frying implies that the potential ability of the cocoyam to supply essential nutrients has been reduced.

There was a significant increase in the lipid contents of the cocoyam samples: dry cocoyam sample (1.84%), cocoyam with canola oil (7.26%), cocoyam with soya oil (13.74%), cocoyam with vegetable oil (23.03%) with cocoyam in vegetable oil being the highest value and cocoyam with canola oil being the lowest and this shows that canola oil contains low fat and is good for cooking. This result also shows that frying can greatly increase the level of lipids in foods. The results are higher than the values reported for coagulated soy milk (Oboh and Omotosho, 2005).

The crude protein contents of the cocoyam samples were moderate. Frying decreased the protein contents of the cocoyam samples insignificantly: dry cocoyam sample (26.64%), cocoyam with canola oil (24.35%), cocoyam with soya oil (23.69%) and cocoyam with vegetable oil (22.41%). The value of the protein after drying cocoyam is high compared to the value reported in cheese coagulated with *Calotropis procera* (Omotosho *et al*., 2011). This result shows that cocoyam contains small amounts of protein which are degraded after frying with the different oil samples.

High levels of fibre in foods help in digestion and prevention of colon cancer. The crude fibre content of the dry cocoyam sample (11.27%) was decreased after frying in each oil sample: cocoyam with canola oil (8.18%), cocoyam with soya oil (9.71%) and cocoyam with vegetable oil (9.06%).

Hosseini *et al*. (2014) reported that in all the treated samples there was an increase in protein, ash and lipid contents and decrease in the content of total omega-3 fatty acids (n-3) in comparison with raw samples.

The composition analysis shows that the dry cocoyam sample (44.91%) was very rich in carbohydrate but this was reduced after frying in with oil samples: cocoyam with canola oil (35.12%), cocoyam with soya oil (32.35%) and cocoyam with vegetable oil (16.8%). The average composition shows that cocoyam tuber is a very good source of carbohydrate.

CONCLUSION

The general results of this study show that although most of the nutrients and vitamins were lost during the frying process of cocoyam such as vitamin A which was totally lost in canola oil or reduced in other oils, some were increased such as vitamin D in soya oil and vegetable oil. The results also show that the different oil samples increased the overall lipid contents of all the fried cocoyam samples as compared with the dry cocoyam sample, with vegetable oil being the highest and canola oil being the lowest, which indicates that canola oil is low in fat and that fried foods are rich in fat. The mineral contents were greatly affected by the different oil samples but all the minerals were retained and none was lost but some of their values were lower than that of the dry sample. The ash content was reduced in all the fried samples as compared with the dry sample signifying that the potential ability of the cocoyam to supply essential nutrients has been reduced after frying. The cocoyam sample which was oven-dried retained most of its nutrients. In general, drying cocoyam tubers retains most of the nutrients and vitamins in the cocoyam and this stands to provide a better alternative to frying with oils as far as food processing is concerned.

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REFERENCES

AOAC., 1990. Official Methods of Analysis. 15th Edn., Association of Official Analytical Chemists, Washington, DC., USA., Pages: 684.

Alegbejo, J.O., D.A. Ameh, W.N. Ogala and S. Ibrahim, 2009. Glycaemic index of boiled cocoyam and stew. Sahel Med. J., 11: 80-83.

Bassama, J., P. Brat, R. Boulanger, Z. Gunata and P. Bohuon, 2012. Modeling deep-fat frying for control of acrylamide reaction in plantain. J. Food Eng., 113: 156-166.

Debnath, S., N.K. Rastogi, A.G.G. Krishna and B.R. Lokesh, 2012. Effect of frying cycles on physical, chemical and heat transfer quality of rice bran oil during deep-fat frying of poori: An Indian traditional fried food. Food Bioprod. Process., 90: 249-256.

Ejoh, S.I., V.A. Obatolu, O.T. Olanipekun and E.O. Farinde, 2013. Extending the use of an underutilised tuber I: Physicochemical and pasting properties of cocoyam (*Xanthosoma sagittifolium*) flour and its suitability for making biscuits. Afr. J. Food Sci., 7: 264-273.

Hosseini, H., M. Mahmoudzadeh, M. Rezaei, L. Mahmoudzadeh, R. Khaksar, N.K. Khosroshahi and A. Babakhani, 2014. Effect of different cooking methods on minerals, vitamins and nutritional quality indices of kutum roach (*Rutilus frisii kutum*). Food Chem., 148: 86-91.

Khalil, I.A. and F. Mannan, 1990. Colorimetry and Flame photometry. In: Chemistry One (Bio-analytical Chemistry), Khalil, I.A. and F. Mannan (Eds.). 2nd Edn., Taj Printing Press, Peshawar, Pakistan, pp: 131-157.

Kumar, S. and B. Aalbersberg, 2006. Nutrient retention in foods after earth-oven cooking compared to other forms of domestic cooking: 2. Vitamins. J. Food Comp. Anal., 19: 311-320.

Lewu, M.N., P.O. Adebola and A.J. Afolayan, 2009. Effect of cooking on the proximate composition of the leaves of some accessions of *Colocasia esculenta* (L.) Schott in KwaZulu-Natal province of South Africa. Afr. J. Biotechnol., 8: 1619-1622.

Lewu, M.N., P.O. Adebola and A.J. Afolayan, 2010. Effect of cooking on the mineral contents and anti-nutritional factors in seven accessions of *Colocasia esculenta* (L.) Schott growing in South Africa. J. Food Compos. Anal., 23: 389-393.

Oboh, G. and O.E. Omotosho, 2005. Effect of types of coagulant on the nutritive value and *in vitro* multienzyme protein digestibility of Tofu. J. Food Technol., 3: 182-187.

Okoye, B.C., A.C. Okoye, M.U. Dimelu, C.C. Agbaeze, O.N. Okoroafor and A.B. Amaefula, 2009. Adoption scale analysis of improved cocoyam production, production and storage technologies across gender in Enugu North agricultural zone of Enugu State Nigeria. MPRA Paper No. 17432. http://mpra.ub.uni-muenchen.de/17432/1/MPRA_paper_17432.pdf

Omotosho, O.E., G. Oboh and E.E.J. Iweala, 2011. Comparative effects of local coagulants on the nutritive value, *in vitro* multienzyme protein digestibility and sensory properties of *Wara* cheese. Int. J. Dairy Sci., 6: 58-65.

Pedreschi, F., P. Moyano, K. Kaack and K. Granby, 2005. Color changes and acrylamide formation in fried potato slices. Food Res. Int., 38: 1-9.