Journal of Advances in Microbiology

20(2): 61-69, 2020; Article no.JAMB.55074
ISSN: 2456-7116

Estimation of Phytochemical in Yam Flours and Sensory Attribute of Poundo Yam Produced from Yam and *Moringa oleifera* Seed Meal Blends

N. A. Kanu[1*] and T. L. Kingsley[1]

[1]*National Root Crops Research Institute, Umudike Abia State, P.M.B. 7006, Nigeria.*

Authors' contributions

This work was carried out in collaboration between both authors. Author NAK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author NAK managed the analyses of the study. Author NAK managed the literature searches. Author TLK read and edited the manuscript. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAMB/2020/v20i230220
Editor(s):
(1) Foluso O. Osunsanmi, University of Zululand, South Africa.
Reviewers:
(1) Schirley Costalonga, Universidade Federal do Espírito Santo, Brazil.
(2) Romer C. Castillo, Batangas State University, Philippines.
Complete Peer review History: http://www.sdiarticle4.com/review-history/55074

Original Research Article

Received 27 December 2019
Accepted 01 March 2020
Published 12 March 2020

ABSTRACT

The sensory characteristic can be quantified and defined by the use of the descriptive profile. A different cultivar of yam can be used for the production of poundo yam. The standard of a product is determined by the evaluation and its acceptability by a taste panelist. Four cultivars of yam; *Dioscorea alata*, *Dioscorea cayenensis*, *Dioscorea rotundata* and *Dioscorea bulbifera* were sourced and processed into flour. Moringa seed oleifera was defatted and the cake was blended at a different concentration of 5% and 10% with the yam flour. The qualitative phytochemical investigation of the yam flour and *Moringa oleifera* seed revealed the presence of, alkaloids, steroids, terpenoid oxalate, anthraquinone, phenol, saponins, tannins and flavonoids. Quantitative analysis showed that among the control samples *Dioscorea alata* (DAC), *Dioscorea Dioscorea bulbifera* (DBC), *cayenensis* (DCC) and *Dioscorea rotundata* (DRC). DRC and DAC have the highest values in the total phenol and total flavonoids. *Dioscorea cayenensis* recorded the highest value in steroid and saponin content. The flavonoids, steroid and terpenoid were improved by the inclusion of moringa seed meal at 5% and 10%. The result of the sensory analysis revealed that panellist preferred DRC in term of moldability, texture, taste and general acceptability. However, the

**Corresponding author: E-mail: chisoanns@yahoo.com;*

samples with moringa seed meal at 5% and 10% inclusion compete favourably with the control samples. The inclusion of *Moringa oleifera* seed meal at 10% improved the pounded yam and was more accepted than the 5% in term of general acceptability.

Keywords: Yam varieties; pytochemicals screening; sensory attributes; poundo yam; moringa seed meal.

1. INTRODUCTION

Yam is one of the earliest angiosperms which belong to the family *Dioscoreaceae*. The most cultivated and economically important species are the *D. alata, D. rotundata* and *D. cayenensis* [1]. The main nutrient in yam is carbohydrate with some proteins, lipids, vitamins and minerals [2]. Yam as a herbal plant possesses other non-nutrient components with some health benefits attached to it [3]. Medicinal plant constitutes some chemical component that confers physiological action to the human body. Among the chemical constituents in a medicinal plant with health potential are the alkaloids, tannins, flavonoids, and phenolic compounds which are the most predominant [4]. Yam contributes extensively to food security as seen in the diversification of its uses in food formulation. It diversification starts from the farm through the cultivation of different varieties which gives rise to different uses and extending the availability of food [5]. Yam can be utilized industrially or domestically, the domestic uses are namely; fufu, flour, fried yam, cooked, amala, pounded yam etc. poundo yam is produced by processing yam into flour and reconstitution of the flour by stirring into a boiling water. Combination of the different plant with a great number of phytochemicals gives a stronger and better effect than using the phytochemical singly [6]. The incorporation of *Moringa oleifera* seed meal to yam flour will improve the nutritional and the phytochemical composition of the blend. Whichever method or plants are incorporated, quality of the end product is always considered to be an important factor, which the consumers look out for.

The quality attributes in products are their color, texture, and taste which differs from one processor/location to another [7]. The texture is a quality indicator which must be accessed first before all other sensory criteria like taste and colour are considered for 1consumer acceptability of the food products [8]. Hence the aim of this research is to evaluate the physiochemical flour of four yam varieties and the quality attribute of poundo yam enriched with moringa seed meal.

2. MATERIALS AND METHODS

Four yam varieties *(Dioscorea alata, Dioscorea bulbifera, Dioscorea cayenensis* and *Dioscorea rotundata*) were sourced from Wuruku Market while *Moringa oleifera* seeds were collected from a local settlement in Umudike, Ikwuano Local Government Area of Abia State. The yam samples were processed into flour and the *Moringa* seeds were defatted to get *moringa* seed meal. *Moringa* seed meal at 5 and 10% were included into the different yam flour to form yam/*Moringa* seed meal. The blends were used to produce poundo yam. Standard method were adopted for quantitative, qualitative phytochemical and sensory attributes as described by Santhi and Sengottuvel [9], Gracelin et al. [10] and Iwe [11] respectively.

2.1 Statistical Analysis

Post Hoc analyses were carried out using the least significance difference (LSD) multiple range tests to test for significant difference among the means (P<.05). All statistical analyses were done using the IBM SPSS statistical Programme version 20.

3. RESULTS

3.1 Phytochemical Screening of Yam and *Moringa* Seed Meal

The results of the phytochemical screening of yam and *Moringa* seed meal are presented in Table 1. The screening of the yam flour and the *moringa* seed meal revealed the presence of some phytochemicals namely: steroid, terpenoid, oxalate, anthroquinine, phenol, saponins, tannins and flavonoid. The Table illustrated that the extract of the samples did not reveal the presence of steroid in *Dioscorea alata, Dioscorea bulbifera* and *Dioscorea rotundata.* Also D*ioscorea cayenensis* and *Dioscorea rotundata* did not show the presence of flavonoid and phenol.

3.2 Phtyochemical Composition of Yam Flour, *Moringa* Seed Meal and the Blends

The results of the phytochemical composition of yam flour *Moringa* seed meal and the blend is presented in Table 2. Evaluation of the phytochemical contents of the various species of yam and *Moringa* seed meal used for treatment in this study showed the presence of phenolic compounds, flavonoids, steroids, saponins and terpenoids in significant amounts, The result indicated that the 5% and 10% inclusion of *Moringa* seed meal was able to cause a significant (P<.05) increase in the total phenol,(for all tested samples), However, a significant decrease was also observed for some samples substituted with *Moringa* seed meal. There was a significant increase for steroid (DC95M5, DA95M5, DA90M10 and DC90M10), saponin (DA95M5, DA90M10) and terpenoid (DB95M5 and DB90M10).

3.3 Sensory Attributes of Poundo Yam Produced from Yam and *Moringa* Seed Meal Blend

The results of the sensory attribute of poundo yam produced from yam and *Moringa* seed meal blend are presented in Table 3. The result of the sensory evaluation as evaluated on 7-point hedonic scale is shown on the Table 3. There were significant differences (P>0.05) in all the sensory parameters. The panelists rated DRC, DAC and DCC and those of *Moringa* seed meal inclusion (DA90M10, DR90M10 and DC90M10) high in the scoring for mouldability, appearance and texture. However, the moudability of *Dioscorea bulbifera* at control, 5% and 10% *moringa* seed meal inclusion level had the least.

4. DISCUSSION

4.1 Phytochemical Screening of Yam and *Moringa* Seed Meal

The presence of phenolic compounds such as phenol, flavonoids and tannins in plant show the potential antioxidant and free radical scavenging properties. Flavonoids are known to check lipid peroxidation and there is a correlation between flavonoid and antioxidant activity [12], alkaloids contain large group of nitrogenous compounds which are widely used as cancer chemotherapeutic agents [13]. Tannins possess anti carcinogenic potential and also reduce mutagenic activity of a number of mutagens due to their antioxidant property which prevents cellular oxidative damage and lipid peroxidation. Tannin also inhibits the generation of superoxide radicals thereby relieving oxidative damage to body cells [14,15]. The ability of tannins in the treatment of inflammations and ulcers has also been reported [16]. Most plants that contain tannins as their main component have been used for treating intestinal disorders such as diarrhea and dysentery [17].

Steroids and terpenoids increase protein synthesis, promote growth of muscles and bones and show some level of antiviral activities [14], Saponins and glycosides are reportedly used to alleviate cardiac problems associated with hypertension. Saponins have been used to treat hypercholesterolaemia in humans, to bind to cholesterol in the body to inhibit the re absorption of the later thereby facilitating its excretion from the body [18].

4.2 Phytochemical Composition of Yam Flour, *Moringa* Seed Meal and the Blend

Plant materials are endowed with bioactive compounds which may be of benefit in the management of diseases. The presence of phytochemical may be responsible for the liver function modulatory effects of the yam species and *Moringa* seed meal observed in diabetic treated rats reported by previous worker [19].

Phytochemicals are plant secondary metabolite used as a defense mechanism to fight against predator. However, they have health benefiting potentials. They are known to confer important biological and pharmacological activities, such as anti-oxidative, anti-allergic, antibiotic, hypoglycemic and anti-carcinogenic [20]. Total Phenolic compound are known as antioxidant by reacting with free radical and possesses free radical scavenging property [12], metal chelating activity, and singlet oxygen quenching ability hence protecting the cell against damage [21]. Total phenols represent a wider range of other plant secondary metabolite.

The decreased of total phenol as was observed at 5% M*oringa* seed meal inclusion could be attributed to the low total phenol content of *Moringa* seed meal. Thus, the low concentration caused a reduction in the initial higher value of the control sample and as the substitution increases then the value increases.

Table 1. Phytochemical screening of yam flour and *Moringa* seed meal

Sample	Alkaloids	Steroids	Terperoid	Oxacate	Anthroquinous	Phenol	Saponins	Tannins	Flavonoids
Dioscorea alata	+	−	+ + +	+	+	+	+ + +	+	+ +
Dioscorea bulbifera	+	−	+	+	+	+ + +	+	+	+
Dioscorea Cayenensis	+	+	+ + +	+ +	+	+ + +	+ +	+	+ + +
Dioscorea rotundata	+	−	+ + +	+ +	+	−	+ + +	+	−
MSM	+	+ + +	+ + +	+ +	−	+ +	+ +	+ +	+ + +

Key: + (Presence of the phytochemicals), ++ (Highly present) and (Absence of the phytochemical)

Table 2. Phytochemical compositions of yam flour, *Moringa s*eed meal and blends

Samples	T. PHEL (mgGAE/100 g)	T. FLAVD (mg/Re/g)	STERD (mg/100 g)	SAP (mg/100 g)	TERPD (mg/100 g)
DRC	$1.78^{a}\pm0.01$	$0.50^{c}\pm0.00$	$30.24^{a}\pm0.002$	$0.27^{a}\pm0.01$	$1.18^{m}\pm-.02$
DAC	$1.32^{l}\pm0.02$	$0.70^{b}\pm0.00$	$17.55^{i}\pm0.00$	0.06i±0.00	$1.25^{e}\pm0.00$
DCC	$1.61^{d}\pm0.01$	$0.60^{c}\pm0.00$	$23.76^{d}\pm0.01$	0.19d±0.00	$0.39^{j}\pm0.00$
DBC	$1.27^{j}\pm0.12$	$0.80^{a}\pm0.00$	$15.53^{j}\pm0.02$	$0.05^{j}\pm0.00$	$1.56^{d}\pm0.00$
MGRA	$1.10^{m}\pm0.00$	$0.80^{a}\pm0.00$	$12.54^{m}\pm0.00$	$0.02^{m}\pm0.00$	$2.09^{a}\pm0.00$
DR95M5	$1.67^{c}\pm0.02$	$0.50^{c}\pm0.00$	$26^{f}.32\pm0.10$	$0.23^{C}\pm0.00$	$0.29^{k}\pm0.00$
DR90M10	$1.73^{b}\pm0.00$	$0.50^{c}\pm0.00$	$27.74^{b}\pm0.02$	$0.25^{b}\pm0.00$	$0.24^{l}\pm0.01$
DA95M5	$1.44^{h}\pm0.00$	$0.70^{b}\pm0.00$	$18.89^{h}\pm0.02$	$0.08^{h}\pm0.00$	$1.00^{f}\pm0.00$
DA90M10	$1.45^{g}\pm0.00$	$0.70^{b}\pm0.00$	$19.67^{g}\pm0.10$	$0.11^{g}\pm0.00$	$0.83^{g}\pm0.00$
DC95M5	$1.57^{e}\pm0.00$	$0.60^{c}\pm0.00$	$21.44^{f}\pm0.10$	$0.15^{f}\pm0.00$	$0.51^{i}\pm0.00$
DC90M10	$1.51^{f}\pm0.01$	$0.60^{c}\pm0.00$	$22.02^{e}\pm0.01$	$0.17^{e}\pm0.00$	$0.69^{h}\pm0.10$
DB95M5	$1.16^{L}\pm0.02$	$0.80^{a}\pm0.00$	$13.00^{l}\pm0.00$	$0.03^{L}\pm0.00$	$1.87^{c}\pm0.17$
DB90M10	$1.22^{k}\pm0.00$	$0.80^{a}\pm0.00$	$14.77^{k}\pm0.00$	$0.04^{K}\pm0.00$	2.00b±0.00

Values are mean± SD of 3 replications .Means within a column with the same superscripts were not significant difference (P>0.05)
Key: DRC (D. rotundata control), DAC (D. alata control), DCC (D. cayenensis control) and DBC (D. bulbifera control), MRGA(Moringa seed meal), DR95M5 (95% D. rotundata & 5% moringa seed meal), DR90M10 (90% D. rotundata & 10% moringaseedmeal), A95M5 (95% D. alata & 5% moringa seed), DA90M10 (90% D. alata & 10% moringa seed meal), DC95M5 (95% D. cayenensis & 5% moringa seed meal), DC90M10 (90% D. cayenensis &10% moringa seed meal), DB95M5 (95% D. bulbifera & 5% moringa seed meal), DB90M10 (90% D. bulbifera & 10% moringa seed meal

Table 3. Sensory attributes of poundo yam produced from yam flour and *Moringa* seed meal blends

Samples	Moudability	Appearance	Texture	Taste	G/A
DRC	5.25a±1.41	5.39ab±1.33	5.43a±1.71	4.58a±1.52	5.61a±1.08
DAC	4.80bc±1.61	5.93a±1.11	4.71ab±1.37	4.43a±1.73	4.97bc±1.33
DCC	4.60bc±1.74	4.60bc±1.32	5.16a±1.32	4.63a±1.27	4.43d±1.72
DBC	4.82bc±1.51	4.27d±1.87	3.92c±1.37	3.80a±1.71	5.10ab±1.52
DR95M5	3.93c±1.64	4.17d±1.53	4.73ab±1.62	4.53a±1.55	4.33d±1.75
DR90M10	4.93ab±1.68	4.60bc±1.56	4.53cd±1.50	4.56a±1.43	4.93bc±1.39
DA95M5	4.27bc±1.48	5.00ab±1.55	3.76cd±1.72	4.56a±1.41	4.67cd±1.32
DA90M10	5.43a±1.49	5.23ab±1.61	4.70ab±1.49	4.66a±1.52	5.17ab±1.53
DC95M5	4.30bc±1.67	5.10ab±1.32	3.47cd±1.17	4.30a±1.84	4.17d±1.66
DC90M10	4.87ab±1.54	4.90bc±1.39	4.57ab±1.85	4.70a±1.34	5.06ab±1.31
DB95M5	4.21bc±1.61	4.69bc±1.60	4.14c±1.43	4.24a14±1.57	3.72e±2.10
DB90M10	3.10d±1.83	3.67c±1.88	3.13d±1.33	3.16b±1.57	3.17e±1.70

Values are mean ±SD of 3 replications. Means within a column with the same superscripts were not significant difference (P>0.05)

Key: DRC (D. rotundata control), DAC (D. alata control), DCC (D. cayenensis control) and DBC (D. bulbifera control), MRGA (Moringa seed meal), DR95M5 (95% D. rotundata & 5% moringa seed meal), DR90M10 (90% D. rotundata & 10% moringa seed meal), DA95M5 (95% D. alata & 5% moringa seed meal),DA90M10 (90% D. alata & 10% moringa seed meal), DC95M5 (95% D. cayenensis & 5% moringa seed meal), DC90M10 (90% D. cayenensis & 10% moringa seed meal), DB95M5 (95% D. bulbifera & 5% moringa seed meal), DB90M10 (90% D. bulbifera & 10% moringa seed meal)

The variation of the total phenols as observed in this study may be attributed to the time of harvest and growing conditions [22].

Flavonoids and other phenolic compounds are common dietary components present in many beverages and foods; hence their presence in these yam species and *Moringa* seed is not surprising. Both flavonoids and phenolic compounds have demonstrated significant antioxidant activities and free radical scavenging effects. The ability of flavonoids to prevent coronary heart diseases and their usefulness in cancer management and prevention has also been reported by Lin et al., [23]. Flavonoids also have been implicated in wound healing, cellular regeneration and cytoprotection and as such may be of benefit in the treatment of ulcer [15, 24].

Dioscorea bulbifera has the highest total flavonoid when compared with the other control samples this is in line with the work of Ukom et al*.,* [21] who evaluated the flavonoid content of some yam samples (*Dioscorea bulbifera, Dioscorea cayenensis* and *D. dumenterum*) and observed that *Dioscorea bulbifera* had the highest value while, *D. cayenensis* had the least value. There is no significant difference in between a particular control samples and it associated blend both at 5% and 10% *Moringa* seed meal. The variation of the total flavonoid as observed in this study may be linked to varietal differences as shown in the makeup of their genotype [25]. Flavonoids display free radical scavenging activity; in that they prevent the decomposition of hydrogen peroxide into free radical [26].

Steroids and terpenoids increase protein synthesis, promote growth of muscles and bones and show some level of antiviral activities [27]. Saponins and glycosides are reportedly used to alleviate cardiac problems associated with hypertension. Saponin has been used to treat hypercholesterolemia in humans. This is because it is believed to bind to cholesterol in the body to inhibit the re absorption of the later thereby facilitating its excretion from the body [15].

4.3 Sensory Attributes of Poundo Yam Produced from Yam and *Moringa* Seed Meal Blend

The higher mouldability score for DR90M10, DA90M10 and DC90M10 as compared with other samples with the *Moringa* seed meal may be associated with the particle size of the *Moringa* seed meal which is known to influence the quality attribute as reported by Ayodele et al., [28] that particle size distribution of wheat flour was observed to influence quality attribute of masa and tortillas production as the incorporation of wheat flour increases. Also, *Moringa oleifera* flour is known to increase viscosity. The increase concentration of defatted *Moringa* seed flour caused an increase in the viscosity and thickness of soup as reported by Sahay et al. [29]. Texture is a quality indicator which must be accessed first before all other sensory attributes like taste and appearance are considered for consumer acceptability of the food products [30]. The DRC having the highest for moudability was an indication of its mealy nature. The mealy nature of *Dioscorea rotundata* was observed during the boiling where it demonstrated complete cell separation and rounding off, whereas *Dioscorea alata* is said to be waxy because it shows partial retention which is characterized by partial cell separation with no rounding off [31], These properties are also reflected even at 5 and 10% levels of *Moringa* seed meal inclusion for both yam samples (*Dioscorea rotundata* and *Dioscorea alata*). The high score of *Dioscorea rotundata* and *Dioscorea cayenensis* when compared to *Dioscora alata*, cannot be far from the starch content and the firmness of *Discorea alata* which has been reported to be low and thus responsible for it poor performance [32]. The easiness to mold, springiness, and less lumpy property found in *Dioscorea cayenensis* are the desires characteristic in pounded yam [33]. Furthermore, *Dioscorea alata* is more rigid in their cell disruption and also its high fiber content may contribute to the low score in the textural attributes [34].

The Tables showed that the sample DRC (*Dioscorea rotundata* control) was generally accepted by the panelists more than the other samples. This was so because it is the most preferred specie for the production of pounded yam [35]. The inclusion of *Moringa* seed meal improved the acceptability of some of the poundo yam. Sample DR90M10 (*Discorea rotundata*) DC90M10 (*Dioscorea cayenensis*), DA95M5, and DA90M10 (*Dioscorea alata*) at 5% and 10% *Moringa* seed were greatly improved in their level of acceptability by the test panelists. The acceptability of *Dioscorea alata* at 5% and 10% *Moringa* seed meal may be attributed to the white appearance of *Dioscorea alata* which seem to have a better appearance than all the samples. This finding in the appearance of *Dioscorea alata* strongly agreed with the work of other researchers who reported that *D. alata* varieties were better than or not significantly different from *D. rotundata* in terms of appearance [36]. The general acceptability of *Discorea bulbifera* decreased significantly from the control sample (DBC), 5% and 10% *moringa* seed meal inclusion and had the least score. It was rejected by the panelists. This may be attributed to the lack of appealing quality [37] as compared to *Dioscorea alata* and *Discorea rotundata*.

There was no significant (P>0.05) different in the taste of the entire sample. The inclusion of *moringa* seed meal at 5 and 10% level did not alter the taste of the poundo yam. They compared favorably with the control samples. However, the *Dioscorea bulbifera* control and the sample containing both at 5% and 10% *Moringa* seed meal had the least scores for all the sensory attributes. This may be due to inclusion scored the least. This may be due to the distinctive flavor, which is one of the characteristic features of *Dioscorea bulbifera* [37].

5. CONCLUSIONS

The result of the study revealed that the quantitative screening of yam showed the presence of the following phytochemicals tannin, alkaloid, steroid, saponin etc, however, the inclusion of the *Moringa oleifera* seed meal elevated the quantitative phytochemicals. The sensory attributes showed that *Dioscorea rotunda* was more accepted by the taste panelist in all the parameters tasted however, the inclusion of *Moringa oleifera* seed meal at both 5% and 10% inclusion improve the mouldability and the appearance for *Dioscorea cayenensis* and *Dioscorea bulbifera.*

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Shajeela PS, Mohan VR, Jesudas L, Tresina Soris P. Nutritional and antinutritional evaluation of wild yam *(Dioscorea* spp.), Tropical and Subtropical Agroecosystems. 2011;14:723-730.
2. Polycarp D, Afoakwa EO, Budu AS, Otoo. Characterization of chemical composition and anti-nutritional factors in seven specieswithin the Ghanaian yam (*Dioscorea*) germplasm. International nternational Food Research Journal. 2012; 19(3): 985-992.
3. Lee MH, Lin YS, Lin YH, Hsu FL, Hou WC. The mucilage of yam (Dioscorea batatas decne) tuber exhibited angiotensin converting enzyme inhibitory activities, Botanical Bulletin of Academia Sinica. 2003;44.
4. Mbaebie B, Edeoga H, Afolayan A. Phytochemical analysis and antioxidants activities of aqueous stem bark extract of Schotia latifolia jacq. Asian Pacific Journal of Tropical Biomedicine. 2012;2(2):118-124.
5. Zannou A. Economic assessment of seed-tuber practices of yam *Dioscorea cayenensis* and *Dioscorea rotundata* planting materials. African Journal of Agricultural Research. 2009;4(3):200-207.
6. Kapinova A, Stefanicka P, Kubatka P, Zubor P, Uramova S, Kello M, Mojzis J, Blahutova D, Qaradakhi T, Zulli A, Caprnda M. Are plant-based functional foods better choice against cancer than single phytochemicals? A critical review of current breast cancer research. Biomedicine & Pharma Cotherapy. 2017; 96:1465-1477.
7. Obadina AO, Babatunde BO, Olotu I. Changes in nutritional composition, functional and sensory properties of yam flour as a result of presoaking. Food Science & Nutrition. 2014;2(6):676-681.
8. Falade KO, Onyeoziri NF. Effects of cultivar and drying method on color, pasting and sensory attributes of instant yam (*Dioscorea rotundata*) flours, Food and Bioprocess Technology. 2012;5(3): 879-887.
9. Santhi K, Sengottuvel R. Qualitative and quantitative phytochemical analysis of *Moringa concanensis nimmo*, International Journal of Current Microbiology and Applied Sciences. 2016;5(1):633-640.
10. Gracelin DHS, Britto AJ, Kumar BJ. Qualitative and quantitative analysis of phytochemicals in five pteris specie. Int J Pharm Pharm Sci. 2013;5(1):105-107.
11. Iwe MO. Hand book of sensory methods and analysis. Re-joint Communication Services Limited Enugu; 2002.

12. Sakthidevi G, Mohan V. Total phenolic, flavonoid contents and *in vitro* antioxidant activity of *Dioscorea alata* I. Tuber, Journal Food Drug Anal. 2013;5:115-119.
13. Nnah IS. Blood coagulation tests and platelets counts in diabetic rats treated with ficussur, jatrophatanjorensis, mucunapruriens and chromolaenaodorata leaf extracts. International Blood Research and Reviews. 2015;3(1):47-53.
14. Chen X, Li X, Mao X, Huang H, Wang T, Qu Z, Gao W. Effects of drying processes on starch-related physico-chemical properties, bioactive components and antioxidant properties of yam flours. Food Chemistry. 2017;224(1):224-232.
15. Ijioma SN, Osim EE, Nwankwo AA, Nwosu CO, Nwankudu ON, Igwe KK, Nwawuba IN. Plants composition and identification of phytocomponents in a polyherbal formulation used in southeast Nigeria, International Blood Research and Review. 2017;1(3):84-98.
16. Prakash G, Hosetti B. Investigation of antimicrobial properties of *Dioscorea pentaphylla* from Mid Western Ghats, India. Scientific World. 2010;8(8):91-96.
17. Zhang Z, Gao W, Wang R, Huang L. Changes in main nutrients and medicinal composition of chinese yam (*Dioscorea opposita*) tubers during storage, Journal of Food Science and Technology. 2014;51 (10):2535-2543.
18. Tolulope M. Cytotoxicity and antibacterial activity of methanolic extract of Hibiscus sabdariffa. Journal of Medicinal Plants Research. 2007;1(1):009-013.
19. Kanu AN, Alakali JS, Eke MO, Girgih AT, Bosha JA, Ijioma SN. Yam and *Moringa oleifera* seed blend in lipid profile disorders, kidney and liver toxicities, in alloxan induced diabetic rats. Asian Food Science Journal. 2018;2(3):1-11.
20. Stankovic MS. Total phenolic content, flavonoid concentration and antioxidant activity of *Marrubium peregrinum* I. Extracts, Kragujevac Journal; 2011.
21. Ukom AN, Ojimelukwe PC, Ezeama CF, Ortiz DO, Aragon IJ. Phenolic content and antioxidant activity of some under-utilized Nigerian yam (*Dioscorea* spp.) and cocoyam (xanthosomamaffa (scoth)) tubers. Journal of Environmental Science, Toxicology and Food Technology. 2014;8 (7):104-111.
22. Koh E, Wimalasiri K, Chassy A, Mitchell A. Content of ascorbic acid, quercetin, kaempferol and total phenolics in commercial broccoli. Journal of Food Composition and Analysis. 2009;*22*(7-8): 637-643.
23. Tada Y, Kanda N, Haratake A, Tobiishi M, Uchiwa H, Watanabe S. Novel effects of diosgenin on skin aging, Steroids. 2009;74 (6):504-511.
24. Akomas SC, Ezeifeka GO, Ijioma SN Justification for the use of musa paradisiaca fruit extract for git mucosa protection and ulcer treatment Continental Journal Animal and Veterinary Research. 2014;6(1):29-35.
25. Huang YC, Hin CA, You SE. Effects of genotype and treatment on the antioxidant activity of sweet potato in Taiwan, Food Chemistry. 2005;98:529–538.
26. Fatemeh S, Saifullah R, Abbas F, Azhar M. Total phenolics, flavonoids and antioxidant activity of banana pulp and peel flours: Influence of variety and stage of ripeness, International Food Research Journal. 2012;19(3):1041.
27. Huang Q, Lu G, Shen HM, Chung M, Ong CN. Anti-cancer properties of anthraquinones from rhubarb, Medicinal Research Reviews. 2007;27(5):609-630.
28. Ayodele B, Bolade M, Usman M. Quality characteristics and acceptability of ‘amala’(yam-based thick paste) as influenced by particle size categorization of yam (*Dioscorea rotundata)* flour, Food Science and Technology International. 2013;19(1):35-43.
29. Sahay S, Yadav U, Srinivasamurthy S. Potential of *Moringa oleifera* as a functional food ingredient: A review. Magnesium. 2017;8(9):4-9.
30. Efiong E, Igile G, Mgbeje B, Otu E, Ebong P. Hepatoprotective and anti-diabetic effect of combined extracts of *Moringa oleifera* and Vernonia amygdalina in streptozotocin-induced diabetic albino wistar rats. Journal of Diabetes and Endocrinology. 2013;4(4):45-50.
31. Anderson L, Gugerty MK. Root, tuber and banana textural traits a review of the available food science and consumer preferences literature, Evan school of policy analysis and research Prepared for the Agricultural Policy Team of the Bill and Melinda Gates Foundation; 2015.
32. Baah FD. Characterization of water yam (*Dioscorea alata*) for existing and potential food products in Food Science and Technology, A Thesis submitted to the

department of Food Science and Technology, Kwame Nkrumah University of Science and Technology in partial fulfillment of the requirements for the degree of Doctor of Philosophy Faculty of Biosciences, College of Sciences. 2009;1-193.

33. Nindjin C, Otokoré D, Hauser S, Tschannen A, Farah Z, Girardin O. Determination of relevant sensory properties of pounded yams (*Dioscorea spp*.) using a locally based descriptive analysis methodology, Food Quality and Preference. 2007;18(2):450-459.
34. Brunnschweiler J, Mang D, Farah Z, Escher F, Conde-Petit B. Structure–texture relationships of fresh pastes prepared from different yam (*Dioscorea* spp.) varieties, LWT-Food Science and Technology. 2006;39(7):762-769.
35. Olaoye JO, Oyewole SN. Optimization of some "poundo" yam production parameters, Agricultural Engineering International Journal. 2012;14(2): 58-67.
36. Wireko-Manu F, Ellis W, Oduro I, Asiedu R, Maziya-Dixon B. Prediction of the suitability of water yam (*Dioscorea alata*) for amala product using pasting and sensory characteristics. Journal of Food Processing and Preservation. 2014;38(3): 1339-1345.
37. Aathira M, Siddhuraju P. Evaluation on suitability of differentially processed *Dioscorea bulbifera* tubers (aerial and underground) as alternative in composite flours for future food innovations. International Journal of Food Science and Nutrition. 2017;2(6):142 -148.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/55074