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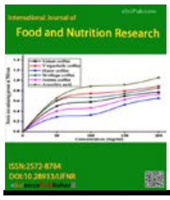

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Evaluation of the Physico-chemical, Functional and sensory attributes of instant fufu developed from bitter yam (*Dioscorea dumetorum*)

Felix Narku Engmann[1*] and Rita Elsie Sanful[2]

[1]Faculty of Applied Sciences and Technology, Kumasi Technical University, Kumasi, Ghana; [2]Department of Hotel, Catering and Institutional Management, Cape Coast Technical University, Cape Coast, Ghana

ABSTRACT

In this study, the eating qualities and physicochemical properties of three fufu samples were produced and evaluated, while the functional properties of the fufu flours were also determined. The results obtained for the functional properties of swelling power were 12.26, 12.13, and 12.35; solubility 8.73, 6.79 and 5.27; water binding capacity 276.15, 261.02 and 280.05; bulk density 0.53, 0.56 and 0.76; pH 6.4, 6.3 and 6.8; and dispersibility 59.2, 59.8 and 8.68 for samples A, B and R, respectively. Sample R (control) had the highest mean values for water binding capacity, pH, swelling power and bulk density while sample A had the highest mean value for solubility. Sample B had the lowest mean values for all the functional properties measured while Sample R (commercial yam fufu) was liked most in terms of aroma, taste, colour, mouldability and texture. From the results, sample A (80% bitter yam flour and 20% cassava starch) had relatively better sensory attributes than sample B (70% bitter yam flour and 30% cassava starch), as well as better functional properties.

Keywords: bitter yam, cassava starch, bulk density, dispersibility, swelling power, Water Binding Capacity

***Correspondence to Author:**
Felix Narku Engmann
Faculty of Applied Sciences and Technology, Kumasi Technical University, Kumasi, Ghana

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Introduction

Yam is known to be an economically useful plant which belongs to the genus *Dioscorea* (family: *dioscoreacea*). Different species of yam are widely grown in three parts of the world; West Africa, the Caribbean Islands and Southeast Asia. The largest acreage and greatest amount of yam is produced in West Africa, where over 95 per cent of the total world production takes place. In West Africa, production of yam is limited to the region stretching from the Ivory Coast to Cameroun.

There are over 600 species of yam and ten of these species are commonly cultivated for food while a number of them are harvested from the wild in times of famine [1,2]. Six are widely cultivated in West Africa and Central Africa and these *are D. alata, D. bulbifera, D. dumetorum* (pax), *D. esculenta* (*lour), D. cayenensis Lamk* and *D. rotundata* (Poir) [3]. The tuber of yam is believed to be the most economically important part of the plant [4] and can be processed for consumption by boiling and pounding with palm oil into a mealy mass, drying and converting into flour, fried into crispy chips or pounded into a local delicacy known as fufu in Ghana.

Fufu, a staple food well known in Ghana and other parts of West Africa, is normally prepared from boiled and pounded cassava and plantain. The preparation of fufu demands a lot of energy making its preparation tedious, most especially when it is prepared on a large scale. The drudgery of pounding various root and tuber crops into fufu has resulted in Food Scientists developing the instant fufu powders [5]. Due to the preference for *D. rotundata* and other yam varieties, bitter yam (*Dioscorea dumetorum*) is gradually losing its economic importance and may become extinct. In order to avert the looming loss of a potentially viable crop like the bitter yam and reduce its post-harvest losses, this study was carried out to explore the potential use of bitter yam in the production of instant fufu powder. Again, works done in producing instant fufu from yam focussed on well-known varieties other than *D. dumetorum* [6]. It is therefore important to explore the use of *D. dumetorum* in producing instant fufu to diversify its usage and to help prevent its extinction. This work has a great potential to transform bitter yam, an under-utilised yam variety, into an industrial raw material for fufu production. In this work, the physico-chemical and functional properties as well as the sensory attributes of instant fufu samples made from different proportions of *D. dumetorum* and cassava starch-substituted flours were analysed.

2. Materials and methods

2.1 Source of raw Materials

The bitter yam was purchased from Obuasi Market in the Ashanti Region of Ghana and other ingredients including commercial fufu powder (Instant yam powder) and cassava starch were also purchased from Abura market, Cape Coast, in the Central Region of Ghana.

2.2 Preparation of Bitter Yam Flour

Washed *D. dumetorum* tubers were peeled, cut into 2 cm strips and immersed in sodium metabisulphate solution (800 ppm for 20 min) to delay enzymatic browning. The treated diced yams were blanched at 70 ºC for 10 min and dried in a cabinet dryer at 60 ºC for 72 h. The dried yam samples were milled into powder using a locally manufactured disc attrition mill and sifted through a 600 µm sieve.

2.3 Formulation of instant fufu samples

Table 1 shows the various formulations of instant fufu samples produced in this work. The cassava starch was used as a binder in samples A and B. A commercial instant yam fufu served as the control (R) in this work.

2.4 Determination of Physico-chemical and Functional Properties of Fufu Flour Samples

2.4.1 Determination of pH

The pH of the samples was determined according to the method of [7]. Ten (10) grams of fufu flour sample was weighed and mixed in a beaker containing 50 ml of distilled water to form a slurry. The slurry was stirred constantly for 10 min and allowed to stand. The pH was then determined by dipping the electrode of the pH meter (Hanna Instruments, model HI 9017) into the slurry. The pH meter was calibrated using buffers of pH 4.0 and 7.0. Duplicate determinations were done for each fufu flour sample.

Table 1: Instant fufu flour formulation

Sample	Yam flour (%)	Bitter yam flour (%)	Cassava starch (%)
A	0	80	20
B	0	70	30
R	100	0	0

2.4.2 Determination of swelling power and solubility index

Solubility and Swelling power determinations were carried out based on a modification of the method of [8]. One gram of fufu flour was mixed with distilled water to a total volume of 40 ml in a weighed 50 ml graduated centrifuge tube. The suspension was stirred just sufficiently and uniformly, avoiding excessive speed since it might cause fragmentation of the starch granules. The slurry in the tube was heated at 85 °C in a thermostatically regulated temperature water bath for 30 min with constant gentle stirring. The tube was then removed, wiped dry on the outside and cooled to room temperature. It was then centrifuged at 2200 rpm for 15 min. The supernatant was decanted into a pre-weighed moisture can and evaporated to dryness and the residue weighed to determine the solubility. The swollen sediment obtained after decanting the supernatant was weighed and the swelling power calculated as the weight of sedimented paste per weight of sample used (Equation 1). The percent solubility was computed using equation 2.

$$Swelling\ power(g/g) = \frac{Weight\ of\ sediment(g)}{Sample\ weight(g)}$$ Equation 1

$$\%Solubility = \frac{Weight\ of\ \mathrm{soluble}}{Weight\ of\ sample} x100\%$$ Equation 2

2.4.3 Determination of water binding capacity

Water binding capacity of yam flour/starch was determined according to the method of [9] as modified by [10]. An aqueous suspension of fufu flour was made by mixing 2.0 grams of flour in 40 ml of distilled water. The suspension was agitated for 1 hour on a Griffin flask shake and centrifuged at 2200 rpm for 10 min. The free water (supernatant) was decanted from the wet flour for 10 minutes and the wet flour/starch was then weighed. The weight of bound water was calculated by difference, and the percent water binding capacity calculated using equation 3.

$$\%Water\ binding\ capacity = \frac{Weight\ of\ bound\ water}{Weight\ of\ sample} x100\%$$ Equation 3

2.4.4 Determination of Bulk density

The bulk density was determined by the method of [11]. Ten grams of the sample was weighed into 25 ml graduated measuring cylinder. The samples were packed by gently tapping the cylinder on the bench top ten times from a height of 5 cm. The volume of the sample was recorded and the bulk density calculated using Equation 4.

$$Bulk\ density\ (g/ml) = \frac{Weight\ of\ the\ sample}{Volume\ of\ the\ sample\ after\ tapping} \quad \text{Equation 4}$$

2.4.5 Determination of Dispersibility

Dispersibility was determined using the method described by [12]. Ten grams (10 g) of the flour sample was weighed into a 100 ml measuring cylinder, and water was added to reach the 100 ml mark. The set up was stirred vigorously and allowed to stand for three hours. The volume of settled particles was recorded and subtracted from 100. The difference was reported as percentage dispersibility (Equation 5).

$$\%\ dispersibility = 100\ ?\ volume\ of\ settled\ particles \quad \text{Equation 5}$$

2.5 Preparation of Fufu

The fufu was prepared by stirring 1000 g of fufu flour sample in 2000 ml water. The slurry was put on fire and stirred continuously until it became a thick gelatinized mass. It was then removed from fire, moulded into desirable shapes then served for sensory evaluation. This procedure was followed for all samples including the control.

2.6 Sensory Evaluation

Thirty (30) panellists who eat fufu regularly were selected and trained to conduct the sensory evaluation. Coded samples were evaluated for the sensory attributes of colour, taste, flavour, textural quality (smoothness) and overall acceptability, using a 9-point hedonic scale (where 1 = dislike extremely, 5 = neither like nor dislike and 9 = like extremely). Water and tissue paper were provided to aid the evaluation process. The panellists were required to wash their hands before the start of the sensory evaluation exercise and rinse their mouths using a slice of cucumber and water before and after evaluating the taste and overall acceptance of each sample.

2.7 Statistical Analysis

The data obtained were statistically analysed using a one-way analysis of variance (ANOVA) to determine whether significant differences existed among the samples for the hedonic rating test. Where significant differences existed, Duncan's least significance difference (LSD) test was applied to specify where the differences occurred. All the analyses were done using the Statistical Product and Service Solutions (IBM SPSS version 20.0) software.

3.0 Results and discussion

3.1 Physico-chemical and Functional Properties of composite fufu flours

The physico-chemical and functional properties of a food product define its quality characteristics, consumer acceptability and determines the suitability of the foodstuff for a given purpose. In this work, the functional properties determined for the fufu samples included pH, loose and packed bulk densities, dispersibility, swelling power, solubility and water binding capacity. The results from these determinations are presented in Table 2.

In terms of swelling power, there were significant differences among the samples. All the samples exhibited high swelling power with the highest being the control (R) and lowest being sample B. There was an inverse correlation between the amount of cassava flour in a sample as against the swelling power, because increase in the percentage of cassava starch in a sample led to a decrease in the swelling power of the fufu flour. [13] reported similar outcomes in their work, where increase in the percent of cassava flour and a reduction in that of potato flour resulted in a lower swelling power of samples. [14] also reported similar values for cassava, but lower swelling power values for different varieties of sweet potatoes.

The swelling power gives an indication of varied degrees to which starch granules in a sample absorb water [15].

In terms of solubility, there were significant differences ($p<0.05$) among the three samples, with samples A and B being high in solubility relative to the control. It was also observed that, the solubility of the composite flours decreased as the proportion of cassava starch was increased. The results obtained is corroborated by [6] who reported that the addition of cassava flour to plantain results in a decreased solubility of the composite flour. Interestingly, the control (100% yam) had the least solubility in this work. Factors such as source, swelling power, inter-associative forces within the amorphous and crystalline domains, as well as presence of phosphorous and other compounds may influence the solubility of starches [16,17].

All the composite flour samples exhibited high water binding capacities (WBC) with significant differences ($p<0.05$) existing between samples A and B, as well as samples B and R. Even though the control (sample R) had the highest value of 280.05% it was not significantly different ($p<0.05$) from sample A (276.15%) statistically. The water binding capacity of cassava starch is relatively low among root, tuber and cereal crops [6] and this may account for the observation made. Sample B had the highest percentage of cassava flour followed by sample A, with the control having none. According to [18] water binding capacity (WBC) is very essential in the development of ready to eat foods and so foods with high WBC will ensure product cohesiveness. Water binding capacity is reported to be an essential processing parameter and has implications for viscosity. It is also essential in bulking and consistency of products, as well as in baking application [19]. Increase in cassava starch content of the composite fufu flour samples resulted in decrease in their water binding capacity. High water binding capacities observed for the composite fufu flours assure their potential usage in the bakery industry, due to the fact that higher water binding capacities increase the yield of the end product. [20] noted that the higher the WBC, the greater the amount of water needed to make dough of desired quality.

The bulk density values obtained for fufu flour samples A and B were not statistically different ($p>0.05$), but lower than that obtained for the control sample. Values obtained in this work were similar to those obtained by [21] for fufu samples produced from cassava.

Concerning pH, differences were observed between the control sample and samples A and B. However, there were no significant difference between samples A and B. The pH levels recorded for all three samples were within pH ranges of many fufu flour samples reported by other authors [21,22].

Also, the dispersibility values recorded for the three samples were significantly different ($p<0.05$) from each other, with the control having the highest value followed by samples B and C in that order. There was an inverse relationship between the percentage of cassava in samples and percentage dispersibility, as dispersibility increased with decrease in the percentage of cassava in the samples. Apart from the control, the other two samples had dispersibility values lower than that earlier reported [23]. Again, the authors [23] included glycerol monostearate and monoglyceride phosphate to the fufu flour samples, and these had significant effect on their physico-chemical properties, including dispersibility.

Table 2: Physico-chemical and Functional Properties of Fufu Flour Samples

Sample	Swelling Power (g/g)	Solubility (%)	Water Binding Capacity (%)	Bulk Density (g/ml)	pH	Dispersibility (%)
A	12.26±0.27^{b}	8.73±0.14^{a}	276.15±5.13^{a,b}	0.53±0.13^{b}	6.4^{b}	59.20^{c}
B	12.13±0.27^{c}	6.79±0.16^{b}	261.02±4.98^{c}	0.56±0.15^{b}	6.3^{b}	59.80^{b}
R	12.35±0.42^{a}	5.27±0.20^{c}	280.05±4.19 ^{a}	0.76±0.14^{a}	6.8^{a}	68.00^{a}

Values are means ± standard deviation triplicate determinations. Means with the same superscript within the same column are significantly different at $p < 0.05$. R = commercial yam flour; A = 80% bitter yam flour and 20% starch; B = 70% bitter yam flour and 30% starch.

3.2. Sensory Analysis of fufu samples

The results of the preference test of the fufu samples are presented in Table 3. The results of the preference test of the cooked fufu samples show significant differences ($p<0.05$) among the three samples for all the sensory attributes evaluated. Sample A (20% starch and 80 yam flour) was most preferred in terms of aroma, colour and mouldability relative to sample B (30% starch and 70% yam flour) while it was rated statistically the same with the control sample R in terms of colour. Sample B was rated the same relative to sample A in terms of taste and texture. The control sample (R) was rated higher than sample B in all the sensory attributes evaluated, except for acceptability. Surprisingly, the level of acceptance for the two study samples (samples A and B) were above that of the control. The relatively high rating of sample R in all the attributes measured except for acceptance could be attributed to panellists' familiarity with the control product and may want to try a different variety of fufu.

Table 3: Effect of percentage composition on the sensory attributes of cooked fufu samples

Variables	Samples		
	R	**A**	**B**
Aroma	6.05±2.74^{a}	4.95±2.80^{b}	4.10±2.79^{c}
Colour	4.85±2.49^{a}	4.85±2.23^{a}	4.50±2.42^{b}
Taste	5.15±2.72^{a}	4.55±2.33^{b}	5.00±1.72^{b}
Mouldability	5.40±2.76^{a}	4.85±2.39^{b}	4.65±1.98^{c}
Texture	5.55±2.65^{a}	5.05±2.59^{b}	5.10±2.05^{b}
Acceptability	1.35±.49^{c}	1.60±.50^{b}	1.75±44^{a}

Values are means ± standard deviations of triplicate determinations. Means with the same superscript within the same column are significantly different at $p < 0.05$. R = commercial yam flour; A = 80% bitter yam flour and 20% starch; B = 70% bitter yam flour and 30% starch.

4. Conclusion

In general, the study samples were acceptable to the panellists, even though there were differences in some of the sensory attributes evaluated. However, the values obtained for the test samples did not deviate far from the control sample. Again, the physico-chemical and functional properties of the test samples, especially sample B, did not deviate much from the control. From the sensory evaluation test, physico-chemical and the functional properties determined for all the samples, it can be concluded that bitter yam and cassava starch composite fufu flour will be acceptable by consumers, especially sample A, and therefore could be introduced to the market as another variety of fufu flour.

Again, this work has demonstrated another way that bitter yam can be used, therefore diversifying its usage as it is an under-utilized yam variety.

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Disclosure statement

All authors have no conflicts of interest.

References

1. Coursey DG. Yams. In: Handbook of Tropical Foods. Chan HT (ed.). New York, NY. Marcel Dekker, 1983.

2. Bhandari MR, Kasai T, Kawabata J. Nutritional evaluation of wild yam (*Dioscorea* spp.) Tubers of Nepal. *Food Chem*. 2003; 82(4):619–623.

3. Tetteh JP, Saakwa C. “Prospects and constraints to yam production in Ghana”, In Ofori, F., and Hahn, S. (Eds) Proceedings of Ninth Symposium of the International Society for Tropical Root Crops. Accra: ISTRC, 1991.

4. Asiedu JJ. Processing tropical crops; A Technological Approach. Mission Press. Ndola, Zambia, 2010.

5. Awuku L. Development of instant fufu from bitter yam (*Dioscorea dumentorum*)

A project submitted to the Department of Hotel, Catering and Institutional Management, Cape Coast Polytechnic. Thesis, 2016.

6. Oduro-Yeboah C, Arthur W, Amponsah SKK, Sampare SA, Yakubu M, Addo P, Dowona S, Mensah D, Delabor P. Physiochemical and Functional Properties of Plantain, Cocoyam Yam Fufu Flours and Maize Flour Production Using a Drum Dryer. Technical Report Submitted To CSIR-Food Research Institute. CSIR-FRI/RE/O-YC/2017/004, 2017.

7. AOAC. Official Methods of Analysis. Association of Official Analytical Chemists.

Ed. Sidney Williams. AOAC. Arlington USA, 1984.

8. Leach HW, McCoven LD, Scoch TJ. Structure of the starch granule, swelling and solubility patterns of various starches. *Cereal Chem*. 1959; 36:534–544.

9. Yamazaki WT. An alkaline water retention test for the evaluation of cookie baking potentialities of soft winter wheat flour. *Cereal Chem*. 1953; 30:242 –246.

10. Medcalf DG, Gilles, K. A. Wheat Starches 1. Comparison of Physico- chemical properties. *Cereal Chem*. 1965; 42:538–568.

11. Kinsella JE. Functional Properties of proteins in foods: A survey critical Review. *Food Sci Nutr*. 1976; 7:219–280.

12. Kulkarni KD, Ingle UM. Sorghum malt based weaning formulations preparation, functional properties and nutritive value. *Food Nutr. Bulletin*, 1996; 13(4):322–327.

13. Tharise N, Julianti E, Nurminah M. Evaluation of physico-chemical and functional properties of composite flour from cassava, rice, potato, soybean and xanthan gum as alternative of wheat flour. *Int. Food Res. J*. 2014; 21(4):1641–1649.

14. Kusumayanti H, Handayani NA, Santosa H. Swelling power and water solubility of cassava and sweet potatoes flour. *Procedia Environ Sci*. 2014; 23:164 – 167.

15. Carcéa M, Acquistucci R. 1997. Isolation and functional characterization of Fonio (*Digitaria*

exillis Stapf.) starch. *Starch/Stärke*. 49:131–135.

16. Zuluaga M, Baena Y, Mora C, Ponce D’León L. Physicochemical Characterization and Application of Yam (*Dioscorea cayenensis-rotundata*) Starch as a Pharmaceutical Excipient. *Starch/Stärke*. 2007; 59:307–317.

17. Kumoro AC, Retnowati DS, Budiyati CS, Manurung T, Siswanto. Water Solubility, Swelling and Gelatinization Properties of Raw and Ginger Oil Modified Gadung (*Dioscorea hispida* Dennst) Flour. *Res. J. Applied Sci*, Engineering and Technology, 2012; 4(17):2854–2860.

18. Housson P, Ayernor GS. Appropriate processing and food functional properties of

maize flour. *Afr. J. Sci. Technol*, Science and Engineering series, 2002; 3(1):126–131.

19. Niba LL, Bokonga MM, Jackson EL, Schlimme DS, Li BW. Physicochemical properties and starch granular characteristics of flour from various *Manihot*

esculenta (cassava) Genotypes. *J. Food Sci*. 2001; 67(5):1701–1705.

20. Rosell CM, Santos E, Collar C. Mixing properties of fibre-enriched wheat bread doughs: A response surface methodology study. *Eur Food Res Technol*. 2006; 223(3):333–340.

21. Chukwuemeka OC. Effect of process modification on the physio-chemical and sensory

quality of fufu-flour and dough. *Afr J. Biotechnol*. 2007; 6(16):1949–1953.

22. Sobowale AO, Olurin TO, Oyewole OB. Effect of lactic acid bacteria starter culture fermentation of cassava on chemical and sensory characteristics of fufu flour. *Afr. J. Biotechnol*. 2007; 6(16):1954–1958.

23. Adebowale AA, Sanni LO, Awonorin SO. Effect of Texture Modifiers on the Physicochemical and Sensory Properties of Dried Fufu. Food Sci. Tech. Int. 2005; 11(5):373–382.