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EFFECT OF AFRICAN BREADFRUIT (*Treculia africana*) SEED SUPPLEMENTATION ON SOME CHEMICAL AND SENSORY ATTRIBUTES OF FRIED WATER YAM (*Dioscorea alata*) BALL

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Fried water yam ball, traditionally known as Ojojo in western Nigeria, is a low protein snack, usually prepared as value added product from grated water yam paste. The influence of African breadfruit seed, a lesser known protein source on quality attributes of water yam ball (Ojojo) was evaluated. Wet-milled water yam (WY) was produced and supplemented with African breadfruit seed (AB) at 10-50%. A control sample was prepared from 100% WY. The blend was mixed with ingredients (salt, powder pepper, okra and onion) and the mixed dough was subsequently used for the production of Ojojo, through deep fat frying. Using standard methods, snack was evaluated for proximate composition, metabolisable energy and anti-nutrient contents (total phenolic, flavonoids, tannin, phytate, oxalate and alkaloids). Hedonic test was used to evaluate the sensory properties. Data were analysed using ANOVA (analysis of variance) at $\alpha_{0.05.}$ WY supplementation with AB significantly decreased moisture content (9.50-9.28%), fibre (2.20-1.80%) ash (5.50-4.00%) and carbohydrate (74.83-65.34%), but increased protein (7.02-13.50%), fat (0.95-6.00%) and metabolisable energy contents (340.97-373.39 kcal). There was significant increase in anti-nutrients (mg/100g), except total phenol (3.79-1.83), but they all fell within tolerable limits. Sample with 60% WY and 40% AB was the most acceptable by the panellists (7.02±0.38).

KEY WORDS: water yam, food supplementation, *Ojojo*, snack foods, deep frying.

INTRODUCTION

Globally, among most popular yam species, water yam (*Dioscorea alata)* is the most widely distributed after the *Dioscorea rotundata* and *Dioscorea cayenensis* (1). However, the utilization of this species of yam is limited in West Africa as it is unsuitable for pounded yam preparation, which is a highly valued article of diet in yam belt (2). Water yam is also well known for its high moisture content (65-76%) and consequently can deteriorate rapidly (3). Therefore, its preservation can be achieved by transforming its

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tubers into edible products, apart from flour. This will also promote its utilization. Fried water yam ball (*Ojojo*), a Nigerian traditional snack, is one of such value added products, which has been made from grated water yam, from time immemorial. The paste was mixed with seasonings into a batter and deep fried, similar to '*Akara* ball' (cowpea cake) (4). As in the case of *Akara,* it is mostly eaten with *pap*, *eko*, *gari* or *agidi*. It can also be eaten as a snack, but it is mainly carbohydrates as water yam itself was reported by Osagie (5) as high energy food with only 1.1-2.0% of protein. Snacks are identified as foods eaten at times other than meals but now expected to be balanced nutritionally, healthy, easy to eat, provide quick energy, safe, contribute variety to diet and possess great taste (6, 7; 8). Consequently, for water yam ball to be balanced nutritionally, its supplementation with more protein rich foods becomes imperative, so as to prevent protein-energy malnutrition (9; 10; 11). In Nigeria, commonly used legume for food fortification is soybean with resultant increased in its price due to high demand. Presence of beany flavour in such food product is another usual shortcoming. For these reasons, there is need to investigate other food crops that present relatively cheap, nutritive and underutilized source of protein. African breadfruit (*Treculia africana*) seed, is one of such underutilized plant sources of protein (18-23%) (12; 13). Nutritionally, it compares favourably with legumes such as cowpea and locust bean in the production of condiments and complementary foods (13; 14). Its tree grows wildly in many localities including south-east and western Nigeria, with enormous seed production (15). Contents of its essential amino acids; lysine, leucine, threonine and valine are comparable to those of cowpea, thus making it suitable for supplementing yam-based diet (12; 13; 16; 17).

In addition, fatty acid composition of African breadfruit seed was reported to be mainly unsaturated, which is good for health promotion and compare very well with fatty acid composition of melon seed, soybean and groundnut oil. Its efficacy in nutritional rehabilitation of malnourished children was documented (15). Combination of this important but neglected food material with water yam in *Ojojo* production may serve as vehicle of nutrient conveyor. There is little or no information on the supplementation of water yam or its products with African breadfruit seed or its products. The objective of this work was to determine the chemical and sensory qualities of '*Ojojo'* (a popular African water yam based snack) supplemented with African breadfruit seed.

EXPERIMENTAL

Clean and bruises-free water yam tubers were purchased from Malate Market, Kwara State, Nigeria. Modified method of Olapade and Akinyanju (4) was used to process water yam tubers into wet-milled paste. The water yam tubers were washed to remove physical dirt and other contaminants. The water yam was then peeled using knife and washed, diced into small pieces before wet milling using a hammer mill to obtain a paste (WY). African breadfruit seed was purchased from a local supplier at Ojo-Alaba market, Lagos State, Nigeria. The method of Onweluzo and Odume (18) was used for the production of African breadfruit seed (AB) paste, with slight modification. The seed was rinsed with water in stainless bowl and wet milled, using hammer mill. The two resultant pastes (WY

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and AB) were weighed using a digital balance (JT302N, England) and blend together in the ratio 100:00, 90:10, 80:20, 70:30, 60:40, and 50:50 respectively. Blends were thoroughly stirred in cleaned stainless bowl together with seasonings using wooden pestle. This was continued until formation of well mixed viscous dough which was fried into golden brown balls. The fried balls were allowed to cool and wrapped with aluminium foils pending the analysis. Proximate composition, namely crude protein, fat, moisture content, crude fibre, ash and carbohydrate of the balls were carried out using standard methods described by AOAC (19). The energy value of the water yam ball was calculated from percentages of major nutrients in kilojoules per 100 g from equation 1 and the values were converted to kcal by dividing them by the conversion factor (4.184).

$$Energy\ value\,(kcal) = \frac{(\%\ carbohydrate \times 17 + \%\ protein \times 17 + \%\ fat\ x\ 37)}{4.184} \qquad [1]$$

Total phenolic content was determined by the Folin–Ciocalteu spectrophotometric method, AOAC (20), while tannin content was determined by Folin Denis colorimetric method (21). Method described by Koleva *et al.* (22) was used to determine the flavonoid contents. Measured weight of flour sample (5 g) was refluxed for 40 min and was allowed to cool, before being filtered. The filtrate was treated with equal volume of ethyl acetate while the liquid was transferred to a separation funnel. The flavonoid extract contained in the ethyl acetate portion was received by filtration with the aid of weighed fitter paper. The weight was obtained after drying in the oven and cooling in a desiccator. The weight was expressed as percentage of weight analysed and was thereby calculated using the equation 2 below and the value was converted to mg/100 g.

$$\%\ Flavonoid = \frac{W_2 - W_1}{W_t\ of\ sample} \times 100 \qquad [2]$$

For alkaloid, the alkaline precipitation gravimetric method (23) was used. A measured weight of the flour sample (5 g) was dispersed in 100 ml of 10% acetic in ethanol solution. The mixture was properly shaken (every 30 min) and allowed to stand for 4 h at room temperature. Whatman No 42 fitter paper was used to filter the mixture. The filtrate (extract) was concentrated by evaporation to a quarter of its original volume. The extract was treated with drop wise addition of concentrated NH_3 solution to precipitate the alkaloid. The dilution was done until the NH_3 was in excess. The alkaloid precipitate was removed by filtration using weighed Whatman No 42 filter paper. After washing with 1% NH_4OH solution, the precipitate in the filter paper was dried at 600^0C and weighed after cooling in a desiccator. The calculation of alkaloid content was as shown in equation 3, and was converted to (mg/100 g).

$$\%\ Alkaloid = \frac{W_2 - W_1}{W_t\ of\ sample} \times 100 \qquad [3]$$

where W_1 = Weight of empty filter paper; W_2 = weight of filter paper + alkaloid precipitate.

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Phytate content was determined according to the method of Young and Greaves (24). About 4 g of the sample were soaked in 100 ml of 2% HCl for 3 hours and then filtered. Then, 25 ml of the filtrate was placed in the conical flask. A 5 ml of 0.3 % ammonium thiocyanate solution was added as an indicator and 53.3 ml of distilled water was also to give it proper acidity. This was titrated with standard $FeCl_3$ solution until a brownish yellow colour persists for 5 min.

$$\textit{Phytate in mg/100g} = \textit{titre value} \times 564.11 \qquad [4]$$

The Oxalate content determination was done according to (25). One gram of sample was weighted into separate plastic bottles followed by the addition of 75 ml of 0.1 N H_2SO_4. The content was thoroughly mixed and allowed for 1h for extraction, with constant agitation using a mechanical shaker. This was then filtered and 25 ml of the filtrate was titrated with 0.1 ml $KMnO_4$ while hot (80-90 °C) until a purple colour was observed at the end point. The titre value was then multiplied by 0.9004 to give the result expressed as mg/g. Calculation of oxalate content was as shown in equation 5:

$$\textit{Oxalate in mg/100g} = \textit{titre value} \times 0.9004 \qquad [5]$$

Sensory evaluation was conducted at sensory evaluation laboratory of the Department of Food Science and Technology, Kwara State University, Malete. Sensory evaluation was carried out on *Ojojo* for colour, taste, flavour, crispness, hardness and overall acceptability using multiple comparison analysis. The samples were presented to fifty man panellists comprising of undergraduate students and non-academic staff of the department who evaluated and scored them on a 9-point hedonic scale, where 9 represented = like extremely and 1 = dislike extremely (26). All tests were replicated in triplicates and data were statistically analysed using a one-way analysis of variance (ANOVA) and means were separated by Duncan's Multiple Range Test (DMRT) using the Statistical package for social science (SPSS) IBM VERSION 21.0 package. Significance was accepted at 0.05 probability level.

RESULTS AND DISCUSSION

Proximate composition and energy value of *Ojojo*

The moisture content decreases with increased addition of African breadfruit seed (Table 1) and ranged between 9.50 and 9.28%. The decrease in moisture content of snack will discourage the growth of spoilage microorganisms and promote the shelf stability of the food (27). Protein content of water yam balls ranged between 7.02 and 13.50% and increased with increase in African breadfruit seed. This increase in the protein of blends was the basis for the enrichment, such that the final products will have higher protein content and quality. This is because tubers, including yam, are low in sulphur amino acid and the protein in African breadfruit seed flour complement those of water yam, thus improving the nutritional quality of traditional recipes (28).

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Table 1. Proximate composition of *ojojo* from blends of water yam and African breadfruit seeds pastes.

Samples (%) WY: AB	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fibre (%)	Carbohydrate (%)
100:00	9.50±0.00[a]	7.02±0.03[g]	0.95±0.01[g]	5.50±0.04[a]	2.20±0.02[a]	74.83±0.09[a]
90:10	9.45±0.40[b]	9.10±1.00[f]	2.00±0.30[f]	4.00±0.00[e]	1.80±0.10[d]	72.00±0.02[b]
80:20	9.44±0.00[b]	10.24±0.14[e]	3.00±0.01[e]	4.90±0.01[b]	2.09±0.01[b]	70.33±0.01[c]
70:30	9.37±0.00[c]	11.38±0.03[d]	3.69±0.40[d]	4.63±0.02[c]	2.02±0.01[b]	68.92±0.29[d]
60:40	9.31±0.01[d]	12.45±0.01[c]	5.00±0.02[c]	4.33±0.01[d]	1.94±0.01[c]	67.00±0.01[e]
50:50	9.28±0.00[d]	13.50±0.01[b]	6.00±0.02[b]	4.05±0.01[e]	1.85±0.03[d]	65.34±0.02[f]
00:100	9.00±0.00[e]	18.05±0.07[a]	11.0±0.12[a]	2.45±0.01[g]	1.56±0.08[e]	57.96±0.10[g]

Results are presented as mean values ± standard deviation from triplicates. Value with difference equal to or greater than corresponding LSD in the same column is significantly different at $p \leq 0.05$

Protein is essential in the human diet for growth and repair of worn-out tissue (29). The result indicated that mixing AB with WY increases the protein content and was higher than the values (3.04 - 4.63%) reported by Olapade and Akinyanju (4) at 30% level of substitution. Fat content of the snacks ranged between 0.95 and 6.00% and increased as AB increases. These were higher than crude fat contents of 0.39-2.15% reported by Olapade and Akinyanju (4), but lower than 13.37 to 21.50%, reported by Gabriel and Faith (27) in similar studies. The lipid components will contribute to the texture, flavour and aroma of foods. Dietary fats that provide essential fatty acids (EFA) have been shown to enhance the taste and acceptability of foods, slow gastric emptying and intestinal motility, thereby prolonging satiety and facilitate the absorption of lipid-soluble vitamins. However, high fat content could be undesirable in snack as it could hamper the shelf life of the food products. This is because fat can promote rancidity in food leading to development of unpleasant and odorous compound (11). Increased fat content of this snack could be attributed to fat content of AB (9-12%), which was initially higher than that of WY (1-2%). Notwithstanding, the fatty acid composition of AB was said to be mainly unsaturated, which are good for health promotion as it compares very well with fatty acid composition of melon seed, soybean and groundnut oil (16; 17; 12; 13; 7). Ash content of the water yam balls decreases with addition AB and ranged between 4.00 and 5.50%, with 100% WY having the highest value. Ash is inorganic component reflecting the mineral content of food. It may also give an indication of contaminations. Nutritionally, ash aids the metabolism of other organic compounds such as carbohydrate and fats (32). The result indicated that mixing African breadfruit seed paste with that of water yam reduces its ash content. This might be attributed to low ash content of African breadfruit flour. Comparative ash content (3.00%) was reported for breadfruit flour (27). Fibre content of supplemented *ojojo* ranged from 1.80 to 2.20% and decreases with increased addition of AB. Fibre is important for the removal of waste from the body thereby preventing constipation and many health disorders. However, in diet with children as target, such as snacks, including the water ball, low fibre is desirable (30). It was observed that the crude fibre of the 100% WY was higher compared to their respective blends with AB. Yams have been reported to have high fibre. Mixing WY with AB decreased the carbohydrate content and ranged from 74.83 to 65.34%. This might be attributed to high carbohydrate content of water yam itself. However, the high percentage

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in the blends suggested that they are good sources of energy and this implies that snacks are good source of energy needed for various activities. The energy value (340.97-373.39kcal) (Table 2) is much due to carbohydrate content of water yam supplemented with African breadfruit seed.

Table 2. Metabolisable energy of *ojojo* from WY and AB

Sample (WY:AB)	Metabolisable energy(kcal)
100:00	340.97
90:10	347.20
80:20	354.94
70:30	358.90
60:40	367.03
50:50	373.39
00:100	406.11

Phytochemical composition of *ojojo* from blends of water yam and African breadfruit seeds pastes

There was significant increase in some phytochemical contents of *ojojo* samples, except total phenolics (3.79-1.83 mg/100 g) (Table 3) with substitution of water yam by African breadfruit seed.

Table 3. Antinutritional content of *ojojo* from water yam flour (WY) and African breadfruit seeds flour (AB) blends

Sample (%) WF:AB	Total phenolic (mg/100g)	Flavonoid (mg/100g)	Tannin (mg/100g)	Phytate (mg/100g)	Oxalate (mg/100g)	Alkaloid (mg/100g)
100:00	3.79±0.37[a]	0.80±0.01[f]	0.28±0.10[b]	2.79±0.02[a]	0.45±0.01[f]	1.03±0.01[g]
90:10	3.00±0.15[b]	0.83±0.02[f]	0.18±0.32[e]	1.30±0.02[g]	0.41±0.01[g]	4.00±0.02[b]
80:20	2.90±0.15[b]	1.90±0.02[e]	0.30±0.10[a]	2.50±0.01[b]	1.08±0.01[e]	1.90±0.01[f]
70:30	2.79±0.21[b]	2.38±0.05[d]	0.25±0.10[b]	2.37±0.01[c]	1.41±0.02[c]	2.41±0.03[e]
60:40	2.22±0.15[c]	2.91±0.04[c]	0.23±0.15[c]	2.25±0.02[d]	1.70±0.01[c]	2.85±0.05[d]
50:50	1.83±0.15[d]	3.41±0.01[b]	0.22±0.10[d]	2.09±0.01[e]	2.00±0.01[b]	3.29±0.05[c]
00:100	0.11±0.15[e]	6.01±0.12[a]	0.16±0.11[f]	1.37±0.10[f]	3.55±0.10[a]	5.50±0.01[a]

Results are presented as mean values ± standard deviation from triplicates. Value with difference equal to or greater than corresponding LSD in the same column is significantly different at $p \leq 0.05$

Flavonoid content ranged between 0.80 and 3.42 mg/100 g, tannin between 0.16 and 0.30mg/100 g, phytate between 1.30 and 2.79 mg/100 g, oxalate between 0.41 and 2.00 mg/100 g and alkaloid between 1.03 and 3.29 mg/100 g. However, they all fell within tolerable limits and are not expected to pose any serious threat in this food (32; 33).

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Moreover, health benefits of these phytochemicals are well known (34). For example, it could reduce pathogenesis of cancer development and damage to intestinal tract. The low levels of tannin content in the samples correspond to the value reported by (35). Although, phenolic compounds were reported to inhibit the activities of digestive and hydrolytic enzymes (36), their anti-carcinogenic, anti-viral, anti-microbial, anti-inflammatory, hypotensive and antioxidant activities make them useful in diets (37). Similarly, flavonoids are potent water soluble antioxidants with free radical scavengers which prevent oxidative cell damage and have strong anticancer and anti-ulcer activity (38).

Sensory attributes of *ojojo* from blends of water yam and African breadfruit seeds pastes

Sensory attributes of water yam balls are presented in Table 4. The colour of the samples ranged from 5.00 to 6.36 and slightly became darker with addition of the AB. Sample containing 40% AB was adjudged the best (6.36) by the panellists in terms of colour. Colour is a very important parameter in judging properly snack's sensory attributes (39). It does not only reflect the suitability of raw material used for it preparation, but also provides information about the formulation and quality of the product (40; 41). The taste of *ojojo* ranged between 5.44 and 6.68, with 60%WY:40%AB blend having the highest mean value, while 50%WY:50%AB had the lowest mean value, which is not significantly different from control (100%WY). There was no significant difference between all samples in terms of texture (range 6.20-6.86). The crispness values ranged between 5.84 and 6.70, with 60%WY:40%AB blend having the highest mean value, while 70%WY:30%AB had the lowest value and which translate to neither like nor dislike and like slightly on the hedonic scale. Flavour is the main criteria that makes the product to be liked or disliked (41). The flavour of the water yam ball samples ranged from 5.70 to 6.70, with 60%WY:40%AB blend having the highest mean value, while 50%WY:50%AB had the lowest mean value. Sample containing 60%WY:40%AB also had overall acceptability of 7.02. This sample was found to be best in all aspects of sensory quality. It can be suggested that supplementation of water yam with African bread fruit seeds should not exceed 40% in production of fortified water yam ball.

Table 4. Sensory attributes of *Ojojo* prepared from WY/AB blends

Sample WF:AB (%)	Colour	Texture	Crispness	Taste	Flavour	Overall acceptability
100:00	5.00±0.82 ^{c}	6.20±0.02 ^{a}	5.96±0.05 ^{b}	5.60±0.08 ^{c}	5.80±0.02 ^{b}	5.96±0.34 ^{d}
90:10	6.02±0.82^{b}	6.50±0.12^{a}	6.43±0.32^{ab}	6.16±0.72^{ab}	5.94±0.24^{b}	6.64±0.70^{abc}
80:20	6.14±0.12^{ab}	6.22±0.28^{a}	5.98±0.27^{b}	6.08±0.10^{ab}	5.84±0.10^{b}	6.48±0.16^{a}
70:30	5.98±0.04^{b}	6.36±0.14^{a}	5.90±0.52^{b}	5.78±0.38^{c}	5.90±0.04^{b}	6.34±0.30^{bcd}
60:40	6.36±0.34^{a}	6.86±0.36^{a}	6.92±0.49^{a}	6.68±0.76^{a}	6.70±0.76^{a}	7.02±0.38^{a}
50:50	5.02±0.82^{c}	6.38±0.12^{a}	6.10±0.32^{b}	5.44±0.72^{c}	5.70±0.24^{b}	5.94±0.70^{d}
00:100	5.66±0.36^{bc}	6.36±0.14^{a}	6.16±0.12^{b}	6.26±0.04^{ab}	5.90±0.04^{b}	6.12±0.52^{cd}

Results are presented as mean values ± standard deviation from triplicates. Value with difference equal to or greater than corresponding LSD in the same column is significantly different at $p \leq 0.05$

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CONCLUSIONS

Fortified water yam balls with acceptable chemical composition and sensory qualities were produced from water yam paste supplemented with African breadfruit seed. The water yam balls compared favourably with control (100% water yam base) in proximate composition, metabolisable energy and phytochemical compositions. Sensory attributes were not significantly different among the samples and the control, with sample (60:40) of water yam and African bread fruit seed being the most acceptable in all sensory parameters. Production of fortified *ojojo* from WY-AB blends may be an answer to increase in consumption of this underutilized crop with the resultant effect of increase intake of quality protein. This study has shown that significant improvement in the chemical composition and sensory attributes are achievable through supplementation of water yam based recipe (*ojojo*) with African breadfruit seed. Future research should be directed towards the microbial and nutritional (using experimental animal) evaluations of this fortified snack.

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ЕФЕКАТ СУПЛЕМЕНТАЦИЈЕ СЕМЕНА АФРИЧКОГ ХЛЕБНОГ ДРВЕТА (*Treculia africana*) НА НЕКА ХЕМИЈСКА И СЕНЗОРНА СВОЈСТВА ПРЖЕНИХ УШТИПАКА ОД ВОДЕНОГ ЈАМА (*Dioscorea alata)*

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Пржени уштипци од воденог јама, традиционално познати у западној Нигерији као "оџоџо", представљају ниско-протеинску брзу храну, обично припремљену као производ повишене вредности од одговарајуће пасте. Испитиван је утицај додатка семена афричког воћног дрвета, мање познатог извора протеина, на карактеристике квалитета уштипака од оџоџоа. Мокро-млевеном воденом јаму (WY) је додавано семе афричког воћног дрвета (AB) у опсегу од 10-50%, док је контролни узорак био 100% (WY). Од овакве смеше, којој су додати потребни састојци (со, млевени бибер, окра и бели лук), умешено је тесто које је затим коришћено за припрему оџоџоа дубоким пржењем. Примењујући стандардне методе овако априпримљена брза храна је оцењивана у погледу приближног састава, метаболичке енергије и садржаја антинутријената (укупни феноли, флавоноиди, фитати, оксалати и алкалоиди). Сензорне карактеристике су оцењиване органолептичким тестом. Подаци су анализирани применом ANOVA теста при $\alpha_{0.05}$ WY са додатком AB имао је нижи садржај влаге (9,50-9,28%), влакана (2,20-1,80%), пепела (5,50-4,00%) и угљених хидрата (74,83-65,34%), а повећан садржај протеина (7,02-13,50%), масти (0,95-6,00%) и метаболичке енергије (340,97-373,39 kcal). Нађено је значајно повећање садржаја анти-нутријената (mg/100g), са изузетком укупних фенола (3,79-1,83), али су сви били у оквиру прихватљивих граница. Узорак са 60% WY и 40% AB био је оцењен као најприхватљивији од стране панела оцењивача (7,02±0,38).

Кључне речи: водени јам, суплементација хране, оџоџо, брза храна, дубоко пржење

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