Mineral and Sensory Properties of 'Àmala' Produced from Yam and Cassava Flours Flavoured with Ginger Flour

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ABSTRACT

This study assessed the mineral and sensory properties of 'àmàlà' produced from yam (Dioscorea rotundata) and cassava (Manihot esculenta) flours flavoured with ginger (Zingiber officinale) flour. The three raw materials were individually processed into flour and mixture design generated by the design expert software version 12 was used to formulate a total of 13 runs. The results were compared with two controls; sample 1 (100% yam flour) and sample 2 (100% cassava flour). The samples were evaluated for mineral and sensory properties using standard operating procedures. The results obtained for the mineral analysis showed that the calcium, magnesium, zinc and iron contents ranged from 3.17-93.81 mg/100 g, 3.35-103.77 mg/100 g, 0.61-1.83 mg/100 g and 0.17-10.87 mg/100 g respectively. Sample 13 (55 yam flour: 30 cassava flour: 15 ginger flour) had the highest iron content. Major striking observation revealed that the addition of cassava flour to these flour samples improved the mineral content of these samples as the control, sample 1 (100% yam flour) had very little mineral content when compared to the rest of the samples. For the sensory evaluation of the 'àmàlà', sample 10 (50 yam flour: 30 cassava flour: 20 ginger flour) and sample 1 were the most preferred in terms of general acceptability amongst other samples on the 9-point Hedonic scale and of all the minerals analyzed in this work, only the iron content met the requirements for Recommended Dietary Allowance of iron for men and postmenopausal women.

INTRODUCTION

Àmàlà' is a traditional Nigerian cuisine originating from the Yoruba ethnic group in the western regions of the country. Crafted from yam and/or cassava flour, as well as unripe plantain flour, 'amàlà' is prepared by peeling, slicing, cleaning, drying, and blending yams into a flour known as 'elubo.' Notably, this 'elubo' serves as the base for making 'amàlà.' Recognized for its nutritional benefits, it boasts a higher protein content compared to other root tubers (Okigbo and Nwakammah, 2005). Furthermore, the carbohydrate and rich dietary fibre content in 'amàlà' contribute to the elimination of body waste, while also reducing the risk of heart conditions associated with elevated cholesterol levels. Additionally, the presence of vitamins and antioxidants in 'amàlà' plays a role in enhancing the immune system.

"Over the years, the production of 'amàlà' has predominantly relied on yam alone. However, research, Magallanes *et al*., (2017) indicates that yam flour lacks the sufficient mineral content necessary for 'amàlà' to be considered suitable for consumption by individuals who are obese or have high blood pressure. As a response to this, a composite of cassava and ginger flours has been introduced alongside yam flour. This combination can provide the essential requirements needed to address these health conditions and render 'amàlà' more fit for consumption.

Yam, the common name for certain plant species in the Dioscorea genus, yields edible tubers. Independently domesticated on three continents—Africa (*Dioscorea rotundata*), Asia (*Dioscorea alata*), and the Americas (*Dioscorea trifida*)—yams play a crucial role in the culinary landscape (Nora, 2019).

Yam flour, being gluten-free, serves as a viable option for individuals with gluten allergies (Okigbo and Nwakammah, 2005).

Cassava (*Manihot esculenta*) flour, a noteworthy substitute for wheat flour in various recipes, is rich in carbohydrates, vital vitamins such as Vitamin C, and essential minerals. With fewer than 120 calories per quarter-cup serving, cassava flour stands out as a lower-calorie alternative among gluten-free flours. Notably, cassava flour contains resistant starches, exhibiting properties akin to soluble fibre, which bypass digestion in the small intestine (Magallanes *et al*., 2017).

Ginger (*Zingiber officinale*), a flowering plant renowned for its rhizome or ginger root, serves dual roles as a spice and folk medicine. Studies, Murad *et al*., (2018) suggest that ginger may contribute to a reduction in body mass index (BMI) and blood insulin levels. Moreover, ginger has demonstrated the ability to significantly decrease LDL (bad) cholesterol, total cholesterol, and blood triglyceride levels, thereby mitigating the risk of heart disease (Murad *et al*., 2018). The anti-inflammatory and antioxidant properties of ginger further positions it as a preventive measure against cancer (Dugasani *et al*., 2010).

MATERIALS AND METHODS

Tubers of cassava were sourced from Nnamdi Azikiwe University farmers association, Awka, Anambra State. Tubers of white yam (*Dioscorea rotundata*) and fresh gingers were bought from Eke Awka Market, Awka South Local Government Area Anambra State and validated by the Department of Crop Science, Nnamdi Azikwe University, Awka. At the period of purchase, wholesome produce free of insect infestation or any physical damage was purchased.

Research Design

The composite flour mixture was generated using Mixture design D- Optimal from Design Expert 12 statistical software. The design key is as shown on Table 1. The experiment had a total of 13 runs and 2 controls (Table 2). The mixture components, A (Yam flour), B (Cassava flour), C (Ginger flour) was summed up to 100.

Table 1: Design key

Factors	Unit	Name	Low	High
X1	G	Yam flour	50	60
X2	G	Cassava flour	30	40
X3	G	Ginger flour	10	20

Table 2: Design of experiment for composite flour

Run	Component 1 A:Yam flour g	Component 2 B:Cassava flour G	Component 3 C:Ginger flour g
1	100	0	0
2	0	100	0
3	55	35	10
4	50	40	10
5	50	30	20
6	53.33	33.33	13.34
7	51.67	36.66	11.67
8	50	40	10
9	51.67	36.66	11.67
10	50	30	20
11	60	30	10
12	60	30	10
13	55	30	15
14	56.67	31.67	11.66
15	50	35	15

METHODS

Production of yam flour

The yam tubers were thoroughly inspected for wholesomeness. They were washed properly in order to get rid of sand and other extraneous materials. The washed yam was peeled using a kitchen knife and sliced to 1 mm thickness. The yam slices were washed after which the sliced yam was steeped into boiled water for 3 minutes. The parboiled yam slices were dried in oven at 70ºC for 17 hours. The yam chips were milled using Mouliner 1000W blender to get flour and finally sifted with standard sieve BSS 44 to get uniform particle size (Nojimu *et al*., 2003).

Production of cassava flour

Mature wholesome cassava tubers were chosen from the lots. They were properly washed in order to get rid of sand and other extraneous materials. The tubers were peeled, sliced to 3 mm thickness and washed. The washed tubers were soaked in water for 3 days for fermentation at 35ºC to take place, to remove hydrogen cyanide in it. After fermentation, the slices were removed from the water, rinsed, further sliced to 1 mm thickness and dried in an oven at 70ºC for 11 hours. The cassava chips were milled into flour using Mouliner 1000 W blender. The flour was sifted with BSS 44 standard sieve size to get uniform particle size (Achidi *et al*., 2008).

Production of ginger flour

The ginger roots were washed, peeled and sliced into thin slices of 1 mm. They were dried in an oven at 70ºC for 13 hours and milled into flour using Mouliner 1000W blender and sieved with BSS 44 standard sieve size to get fine flour (Ravindran, 2016).

Production of 'Àmàlà'

The flour samples were weighed with regards to the runs. Water was made to boil and the flour was reconstituted into the boiling water to form a thick paste of desired consistency.

Mineral Analysis of 'Àmàla'

Calcium, magnesium, Zzinc and iron were analyzed using Atomic absorption spectrophotometer (Varian Australia Pty Ltd.) according to (AOAC, 2010).

Sensory Evaluation of 'Àmàlà'

The processed flour was subjected to sensory evaluation. The flour was stirred in boiling water to make paste for each sample. A 9 point Hedonic scale was used in measuring the intensity and the acceptability of the pastes' colour, taste, aroma, mouldability, texture and general acceptability. A panel consisting of 25 judges including students and staff of the Nnamdi Azikwe University, Awka were used as semi trained panelists to evaluate the flour samples using the questionnaire provided for scoring different parameters using a 9-point Hedonic scale with the following rating: 9 - Like extremely, 8 – Like very much, 7 – Like moderately, 6 – Like slightly, 5 – Neither like nor dislike, 4 – Dislike slightly, 3 – Dislike moderately, 2 – Dislike very much and 1 – Dislike extremely (Iwe, 2010).

RESULTS AND DISCUSSION

Mineral composition of 'Àmàlà' samples

The mineral composition of the 'àmàlà' samples is shown in Table 3. The Calcium results of these samples ranged from 3.17 – 93.81 mg/100g with sample 5 (50 yam flour: 30 cassava flour: 20 ginger flour) having the highest calcium content. Omohimi *et al*., (2017) on the study of the proximate and mineral compositions of different yam chips, flakes and flours reported that the value of calcium in the yam flour samples to range from 16.1 – 25.9 mg/100 g. According to Kemi *et al*., (2010), calcium is an important element for bone formation. Adults aged 19 to 64 need 700 mg of calcium a day. In this study, the calcium proportion in these samples are low, this means that the diet should be modified with foods with high calcium levels.

The Magnesium content of the 'àmàlà' samples ranged from 3.35-103.77 mg/100 g. Sample 5 (50 yam flour: 30 cassava flour: 20 ginger flour) had the highest magnesium content. Omohimi *et al*., (2017) on the study of the proximate and mineral compositions of different yam chips, flakes and flours reported the magnesium content of yam flour to range from 31.1 – 36.0 mg/100 g which is low compared to the value of this study. The Recommended Dietary allowance (RDA) of Magnesium in adults aged 19-51 years is 200-400 mg daily for men and 310-320 mg for female. This goes further to show that the amount consumed per serving is not enough to meet the RDA.

The zinc content of the 'àmàlà' samples ranged from 0.61-1.83 mg/100 g. Sample 10 (50 yam flour: 30 cassava flour: 20 ginger flour) had the highest zinc content among other samples. From the study carried out by Omohimi *et al*., (2017) on the study of the proximate and mineral compositions of different yam chips, flakes and flours, it was recorded that the zinc content of yam flour samples ranged from 0.65-0.85 mg/100g which is slightly different from the results of this study. Zinc is a mineral that is essential for cell development and replication. RDA for zinc is 8 mg/day for females and 11 mg/day for males (Mason, 2008). From this research, the 'àmàlà' samples did not meet the Recommended Dietary Allowance (RDA).

Iron is an important mineral for red blood cell formation. The results showed that the iron content ranged from 0.17-10.87 mg/100 g, this is slightly different from the results reported on the study of the proximate and mineral composition of different yam chips, flakes and flours by Omohimi *et al*., (2017) which ranged from 7.61-11.49 mg/100 g. According to Mason (2008), the recommended dietary allowance of iron for men and postmenopausal women is 8 mg/day while 11, 15, and 30 mg/day were recommended for adolescents, premenopausal and pregnant women respectively. Our results showed that these 'àmàlà' samples can adequately supply iron in the diet except the control sample 1(100% yam flour) which had low iron content. Sample 13 (55 yam flour: 30 cassava flour: 15 ginger flour) had the highest iron content.

Table 3: Mineral analysis of the 'Àmàlà' samples

Sample	Calcium	Magnesium	Zinc	Iron
S1	$3.17^{o} \pm 0.01$	$3.35^{o} \pm 0.01$	$0.61^{m} \pm 0.00$	$0.17^{m} \pm 0.00$
S2	$57.31^{n} \pm 0.01$	$56.70^{n} \pm 0.00$	$1.53^{g} \pm 0.00$	$9.82^{g} \pm 0.03$
S3	$66.85^{m} \pm 0.03$	$82.63^{j} \pm 0.01$	$1.40^{k} \pm 0.00$	$10.54^{c} \pm 0.01$
S4	$67.13^{l} \pm 0.00$	$82.00^{m} \pm 0.00$	$1.33^{l} \pm 0.00$	$8.75^{k} \pm 0.00$
S5	$97.81^{a} \pm 0.01$	$103.77^{a} \pm 0.00$	$1.83^{b} \pm 0.00$	$8.80^{i} \pm 0.00$
S6	$69.11^{i} \pm 0.00$	$95.76^{e} \pm 0.01$	$1.51^{h} \pm 0.00$	$10.06^{f} \pm 0.01$
S7	$67.88^{j} \pm 0.00$	$82.57^{k} \pm 0.00$	$1.50^{i} \pm 0.00$	$9.62^{h} \pm 0.00$
S8	$67.42^{k} \pm 0.00$	$82.03^{l} \pm 0.00$	$1.47^{j} \pm 0.00$	$8.75^{k} \pm 0.00$
S9	$73.60^{h} \pm 0.00$	$83.00^{i} \pm 0.00$	$1.50^{i} \pm 0.00$	$8.78^{j} \pm 0.00$
S10	$93.25^{b} \pm 0.12$	$103.75^{b} \pm 0.06$	$1.85^{a} \pm 0.00$	$8.50^{l} \pm 0.00$
S11	$85.03^{f} \pm 0.06$	$85.30^{f} \pm 0.00$	$1.60^{d} \pm 0.01$	$10.33^{d} \pm 0.00$
S12	$85.10^{e} \pm 0.00$	$85.00^{g} \pm 0.00$	$1.58^{e} \pm 0.01$	$10.83^{b} \pm 0.01$
S13	$90.72^{c} \pm 0.00$	$97.83^{c} \pm 0.00$	$1.62^{c} \pm 0.00$	$10.87^{a} \pm 0.00$
S14	$83.73^{g} \pm 0.00$	$83.94^{h} \pm 0.00$	$1.53^{g} \pm 0.01$	$10.10^{e} \pm 0.00$
S15	$86.30^{d} \pm 0.00$	$97.14^{d} \pm 0.00$	$1.55^{f} \pm 0.00$	$8.35^{l} \pm 0.00$

Values of are mean ± standard deviation of triplicate determinations. Values in the same column bearing different superscript differed significantly ($p < 0.05$). S2 = 100 g cassava flour, S3 = 55:35:10 of yam flour, cassava flour and ginger flour, S4 = 50:40:10 of yam flour, cassava flour and ginger flour, S5 = 50:30:20 of yam flour, cassava flour and ginger flour, S6 = 53.33:33.33:13.34 of yam flour, cassava flour and ginger flour, S7 = 51.67:36.66:11.67 of yam flour, cassava flour and ginger flour, S8 = 50:40:10 of yam flour, cassava flour and ginger flour, S9 = 51.67:36.66:11.67 of yam flour, cassava flour and ginger flour, S10 = 50:30:20 of yam flour, cassava flour and ginger flour, S11 = 60:30:10 of yam flour, cassava flour and ginger flour, S12 = 60:30:10 of yam flour, cassava flour and ginger flour, S13 = 55:30:15 of yam flour, cassava flour and ginger flour, S14 = 56.67:31.67:11.66 of yam flour, cassava flour and ginger flour, S15 = 50:35:15 of yam flour, cassava flour and ginger flour..

Sensory properties of 'Àmàlà' samples

The appearance of 'àmàlà' as shown in Table 4 ranged from 1.80 - 6.92. Samples 10 (50 yam flour: 30 cassava flour: 20 ginger flour) and 1(100% yam flour) had the highest score of 6.92 while sample 7 (51.67 yam flour: 36.66 cassava flour: 11.67 ginger flour) and sample 2 (100% cassava flour) had the least score of 1.80.

The taste of the 'àmàlà' as presented in Table 4 showed that the score ranged from 2.28 - 6.16. The aroma of the 'àmàlà' samples ranged from 3.24 - 6.20. Samples 10 (50 yam flour: 30 cassava flour: 20 ginger flour) and 1 (100% yam flour) had the highest score as they were liked slightly on the 9-point Hedonic scale.

The mouldability of the 'àmàlà' samples ranged from 1.44 – 7.20. Samples 7 (51.67 yam flour: 36.66 cassava flour: 11.67 ginger flour) and 2 (100% cassava flour) are significantly different ($p < 0.05$) from the rest of the samples as they had the lowest score and were disliked extremely on the 9-point Hedonic scale.

On overall acceptability, the result of the 'àmàlà' samples ranged from 2.08 – 7.16. Samples 10 (50 yam flour: 30 cassava flour: 20 ginger flour) and 1(100% yam flour) were liked moderately on the 9-point Hedonic scale. Samples 8 (50 yam flour: 40 cassava flour: 10 ginger flour) and 12 (60 yam flour: 30 cassava flour: 10 ginger flour) were liked slightly as they scored 6 on the 9-point Hedonic scale. Sample 2 (100% cassava flour) which was one of the controls used for this experiment was disliked very much on all parameters, this was because cassava is gluten-free which resulted to a watery paste hence less appealing.

Table 4: Sensory evaluation result of 'Àmàlà'

Sample	Appearance	Taste	Texture	Aroma	Mouldability	General Acceptability
S1	$6.92^{a}\pm 2.00$	$6.16^{a}\pm1.62$	$6.60^{a}\pm1.08$	$6.20^{a}\pm1.53$	$7.20^{a}\pm1.00$	$7.16^{a}\pm1.07$
S2	$1.80^{f}\pm1.19$	$2.28^{f}\pm1.60$	$1.92^{f}\pm1.58$	$3.24^{c}\pm2.26$	$1.44^{h}\pm1.19$	$2.08^{g}\pm1.15$
S3	$5.12^{cd}\pm1.81$	$4.76^{bcde}\pm2.33$	$5.24^{bcd}\pm2.08$	$5.40^{ab}\pm2.74$	$4.76^{cde}\pm1.85$	$5.24^{bcde}\pm2.11$
S4	$4.56^{d}\pm2.33$	$3.88^{e}\pm1.86$	$4.16^{e}\pm2.15$	$5.24^{ab}\pm2.28$	$3.60^{fg}\pm2.24$	$4.56^{def}\pm2.36$
S5	$4.64^{d}\pm1.89$	$4.28^{de}\pm1.88$	$4.56^{de}\pm2.16$	$5.16^{ab}\pm2.37$	$4.92^{cd}\pm2.12$	$4.84^{cde}\pm1.97$
S6	$5.04^{d}\pm1.81$	$4.84^{bcde}\pm1.86$	$5.48^{abcd}\pm1.69$	$5.56^{ab}\pm1.92$	$6.08^{b}\pm1.38$	$5.56^{bcd}\pm1.53$
S7	$1.80^{f}\pm1.19$	$2.28^{f}\pm1.59$	$1.92^{f}\pm1.58$	$3.24^{c}\pm2.26$	$1.44^{h}\pm1.19$	$2.08^{g}\pm1.15$
S8	$6.00^{abc}\pm1.63$	$5.88^{ab}\pm1.36$	$6.00^{ab}\pm1.26$	$5.96^{ab}\pm1.70$	$6.40^{ab}\pm1.14$	$6.24^{ab}\pm1.74$
S9	$4.56^{d}\pm1.98$	$4.52^{cde}\pm2.40$	$4.76^{cde}\pm2.13$	$5.08^{ab}\pm2.14$	$4.28^{def}\pm2.37$	$4.72^{cde}\pm2.17$
S10	$6.92^{a}\pm1.00$	$6.16^{a}\pm1.62$	$6.60^{a}\pm1.08$	$6.20^{a}\pm1.53$	$7.20^{a}\pm1.00$	$7.16^{a}\pm1.07$
S11	$5.72^{bc}\pm2.21$	$6.04^{a}\pm1.95$	$5.64^{abcd}\pm1.66$	$5.44^{ab}\pm2.08$	$6.16^{ab}\pm1.97$	$5.76^{bc}\pm1.98$
S12	$6.68^{ab}\pm1.99$	$5.48^{abcd}\pm2.04$	$5.92^{ab}\pm1.96$	$5.52^{ab}\pm2.00$	$6.04^{b}\pm2.13$	$6.24^{ab}\pm2.01$
S13	$3.40^{e}\pm2.00$	$4.00^{e}\pm2.10$	$2.92^{f}\pm1.89$	$4.68^{b}\pm2.58$	$2.68^{g}\pm2.25$	$3.56^{f}\pm2.24$
S14	$6.00^{abc}\pm1.71$	$5.56^{abc}\pm1.80$	$5.76^{abc}\pm1.56$	$6.08^{ab}\pm1.73$	$5.56^{bc}\pm1.53$	$5.96^{b}\pm1.37$
S15	$4.08^{de}\pm2.08$	$4.76^{bcde}\pm2.22$	$4.08^{e}\pm2.23$	$4.76^{b}\pm2.39$	$3.76^{ef}\pm2.07$	$4.40^{ef}\pm1.78$

Values are mean ± standard deviation. Values in the same column bearing different superscript differed significantly ($p < 0.05$). S1 = 100g yam flour, S2 = 100g cassava flour, S3 = 55:35:10 of yam flour, cassava flour and ginger flour, S4 = 50:40:10 of yam flour, cassava flour and ginger flour, S5 = 50:30:20 of yam flour, cassava flour and ginger flour, S6 = 53.33:33.33:13.34 of yam flour, cassava flour and ginger flour, S7 = 51.67:36.66:11.67 of yam flour, cassava flour and ginger flour, S8 = 50:40:10 of yam flour, cassava flour and ginger flour, S9 = 51.67:36.66:11.67 of yam flour, cassava flour and ginger flour, S10 = 50:30:20 of yam flour, cassava flour and ginger flour, S11 = 60:30:10 of yam flour, cassava flour and ginger flour, S12 = 60:30:10 of yam flour, cassava flour and ginger flour, S13 = 55:30:15 of yam flour, cassava flour and ginger flour, S14 = 56.67:31.67:11.66 of yam flour, cassava flour and ginger flour, S15 = 50:35:15 of yam flour, cassava flour and ginger flour..

CONCLUSION

This study revealed that 'àmàlà' produced from composite flours of yam, cassava and ginger can compete favourably with 'àmàlà' produced from yam only. Analytically, these composite flours had a significant effect on the mineral and sensory properties of the 'àmàlà'. Of all the mineral analyzed in this work, the iron content met the requirements for Recommended Dietary Allowance (RDA) of iron for men and postmenopausal women which is 8 mg/day. This proves that the 'àmàlà' is highly recommended for men and postmenopausal women. Moreso, this further creates the need for more researches of other food raw materials that can be used to enrich 'àmàlà'. This study also showed that 'àmàlà' sample produced with yam flour alone do not meet the needed mineral requirement for the body. Hence, the need to always fortify yam flour with flours that will complement in the lacking minerals or give an increase to mineral insufficiency so that it meets the needs of individuals that are obese or has high blood pressure. This study also showed that 'àmàlà' can be flavoured with ginger up to 20% which had the highest acceptability in the study competing favourably with àmàlà produced with 100 percent yam as they both had same highest acceptability. Therefore, production of 'àmàlà' from blends of yam and cassava flour flavoured with ginger (Sample 10;50 Yam flour: 30 Cassava flour: 20 Ginger) should be encouraged as cassava and ginger are affordable, readily available and has been proved in this study to fortify 'àmàlà'.

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