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Development, nutritional quality and sensory attributes of noodles produced from cocoyam and wheat flour blends

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Abstract: The study investigated nutritional quality and sensory attributes of noodles produced from cocoyam root and wheat flour blends. Five different noodles were formulated as sample A – E with sample A 100 % cocoyam noodle as control. Proximate composition, mineral profiles, functional properties, antinutritional factors and cooking properties as well as sensory attributes of the cocoyam-wheat noodles were determined using standard analytical methods. Data obtained were subjected to ANOVA while Duncan Multiple range test was used to separate the mean where there is significant difference. Results showed that incorporation of wheat flour between 15 – 25 % with cocoyam flour to produce noodles improved its nutritional and functional qualities. Antinutritional factors of the cocoyam-wheat noodles significantly ($p<0.05$) reduced compare to 100% cocoyam noodle. The study shows that addition of 20 – 25 % wheat flour to cocoyam flour for the production of noodle increase its nutrition density, physicochemical and sensory acceptability.

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Keys: Antinutritional factors, cocoyam-wheat noodle, nutrition density, physicochemical, sensory acceptability

1. Introduction

Global economic meltdown has shown that there are needs for food enrichment and improvement in order to promote global food security at all times. *Colocasia spp* (cocoyam) is one of the roots and tubers commonly cultivated in West Africa for household purpose and as a source of income to many rural families. Roots and tubers with cereal grains are terms staple food because it's a food you will find at least once in a family menu per day in third world country. Hence, it is one of the foods that provide food security among the people of third world countries. Research has shown that most cocoyam breeds can be used for nutraceptical purposes especially for people with diabetic, gastrointestinal disorder, high blood pressure, glycemic tolerance people, etc while industrially its starch can be modified for other industrial uses and as binding and coating agent in pharmaceutical industries. Cocoyam contains vitamin, thiamin, riboflavin, niacin and minerals (calcium, phosphorus, e.t.c.) in reasonable amount (Owusu-Darko *et al*., 2014). These micro-nutrients give cocoyam roots nutritional advantages over other numerous roots and tubers.

Cocoyam, however, is gluten-free and contains high-quality phyto-nutrition profile comprising of dietary fiber which helps in regulating bowel health, lowering cholesterol levels and controlling blood sugar levels, antioxidants with a moderate quantity of minerals, and vitamins (Boakye *et al*., 2018). Cocoyam can be processed using different unit operations such as boiling, roasting, frying, milling and pounding to *fufu*, soup thickeners, porridge and specialty food for gastrointestinal disorders, among others. However, cocoyam roots contain antinutritional factors such as oxalate, phytate, tannins, amylase and trypsin inhibitors to mention but few. These antinutritional factors especially oxalate and phytate when present in food causes caustic effect, irritating and reduces absorption in the intestinal tract. It does also interfere with the bioavailability of calcium in the food (Coronell-Tovar *et al*., 2019). Processing of cocoyam to stable or consumable products is a way of reducing its post-harvest losses, antinutritional factors and increasing its potentials in food and industrial applications.

Noodle is generally becoming a staple food in developing countries and is typically made from unleavened dough of durum wheat flour mixed with egg or water and formed into sheets or various shapes, then cooked by steaming or boiling, and can also be made with flours from other cereals or grains (Gapalakrishman *et al*., 2011). Durum wheat is considered the best material for making high quality pasta products due to its unique gluten protein presence. Gluten is considered to be most significant factor related to wheat flour dough making and pastry quality because it contain gladin and glutenin which are responsible for its mould ability, elasticity and chewability, this in turn make wheat flour inevitable in pasta production (Animasahun *et al*., 2017). However, wheat flour has high glycemic index which causes food intolerant in many of its consumers. Roots and tubers have low glycemic index if used properly would contribute immensely to food security in a many ways due to increasing demand for food low glycemic index in lieu of high glycemic index foods. Food diversification and fortification of root and tubers especially the underutilized one will enhance the nutritional quality of its products.

Extrudation of starchy materials had become a widely used technique to obtain a wide range of product such as snacks, breakfasts, cereals products and semi-industrial special flours (Kuuku and Beta, 2014). There is dearth information on the application of extrusion cooking on processing of cocoyam-wheat flour, hence a need to explore the possibility of applying extrusion cooking for creating diversified consumption in cocoyam roots. It is therefore imperative that using cocoyam roots which has nutraceptical usefulness, high digestibility of its starches and low glycemic index of its starch with different food ingredients into noodles products could increase the nutritional value of its products. Therefore, the aim of the study was to examine nutritional quality and sensory evaluation of noodles produced from cocoyam-wheat flour blends.

2. Material and Methods

2.1 Materials

The fresh mature cocoyam roots was obtained in a farm at Isale-Oyo, Oyo town and were processed immediately on its arrival at the food laboratory, Federal College of Education (Special) Oyo while wheat flour, salt, egg and vegetable oil used for this study were purchased at Ace supermarket Oyo, Oyo State. Carbon cellulose was purchased at an industrial chemical shop in Ojota, Lagos State, Nigeria.

2.2 Preparation of cocoyam flour

Freshly harvested, matured cocoyam roots of about three kilogram was sorted, washed in portable water, peeled and sliced to 2.0 mm thickness using manual kitchen slicer. The sliced were transferred into stainless pot that already has water diluted with ascorbic acid solution for about 5 min. The solute was removed, allow to drain at room temperature (28±2ºC) for 5 min, dried in an air oven (Model: DC 500; Serial number 12B154) at 55±5ºC for 48 hours, milled in a laboratory hammer mill (Fritsch, D-55743, Idar-oberstein-Germany), sieved using 350 µm screen, packed in a low density polyethene bag and store at room temperature (28±2ºC).

2.3 Formulation of cocoyam-wheat composite flour

The formulations of composite flour were done according to the method of Akinsola *et al*., (2018) with slight modification. The cocoyam root-wheat flour was mixed in proportion of 100 %; 90:10 %; 85:15 %; 80:20 %; 75:25 %, and coded as sample A, B, C, D and E. Sample B – E was blended using a Kenwood mixer (Model: HC 750D, Kenwood, UK) to produce homogenized composite flour. Sample A served as control and contained 100 % cocoyam flour while samples B, C, and D consist of cocoyam and wheat flour. The composite flours of the four samples with control sample were formulated equally to determine their nutritional quality and sensory property of their noodles, respectively.

2.4 Pasta formulation of cocoyam-wheat noodle samples

The noodles samples were prepared according to the method described by Gopalakrishnan et al. (2011) with slight modification using “Bellini pasta and Noodle maker BTPA 700”. Two hundred gram of each sample was weighed; 25g of carbon cellulose, 5 gm of salt was added to the weighed flour, mixed thoroughly. About 25 gm whole egg was beat inside the mixture and mixed thoroughly. The required quantity of water of about 50 to 55 ml was added, mixed thoroughly with 10 to 12 ml of oil to form dough. Other ingredients were added equally for the pasta production as shown in Table 1 below and a pasta-making machine [model: Dolly Mini P3, Italy] was used in this study. The dough which is relatively soft was forced into the holes in the die under pressure of approximately 6895 kpa. The extruded product from a twines were cut into uniform size, steamed for 3 min, and dried at 55±5ºC for 6 hr using hot air oven (Model: Genlab, DC 500; Serial number: 12B154). It was then allowed to cool, packed and stored in low density polythene nylon for further analysis.

Table 1: Cocoyam-wheat flour blends noodle formulation

Parameter, gm	Sample A	Sample B	Sample C	Sample D	Sample E
Cocoyam-Wheat flour	200	200	200	200	200
Carbon cellulose	25	25	25	25	25
Egg	25	25	25	25	25
Salt	05	05	05	05	05
Vegetable oil	10-12	10-12	10-12	10-12	10-12
Water, ml	50-55	50-55	50-55	50-55	50-55

Akinsola *et al.*, (2018) modified

2.5 Proximate composition of cocoyam-wheat noodle samples

Proximate analysis of the samples was carried out using Association of Official Analytical Chemistry (2012), carbohydrate content was determined by difference while gross energy value of each sample was determined by calculation from fat, carbohydrate and protein content using the Famakin *et al*. (2016):

Gross energy, KJ/100 gm (Dry matter) = (Protein x 16.7) + (Lipid x 37.7) + (Carbohydrate x 16.7)

2.6 Mineral profile of the pasta samples

The standard method described by Association of Official Analytical Chemists was used for mineral analysis of the samples (AOAC, 2012). The samples were ashed separately at 550 ^oC. The ash was boiled with 10 ml of 20 % hydrochloric acid in a beaker and then filtered into a 100ml standard flask. This was made up to the mark with deionized water. Mineral profiles (sodium, potassium, zinc, calcium, phosphorus, iron and magnesium) were determined from the resulting solution using an inductively-coupled plasma atomic emission spectrometer (ICPAES, TL 6000 USA). All values were expressed in mg/100g.

2.7 Determination of functional properties of the noodle samples

The functional properties of the cocoyam roots composite noodle samples determined included bulk density, water absorption capacity, swelling power by Onwuka (2005) while wettability index of the noodle samples were determined following the methods described by Okezia and Bello (1988). Least gelation capacity was determined using the method of Onwuka (2005).

2.8 Antinutritional factors of the pasta samples

Selected anti-nutritional factors such as alkaloid, phytate, oxalate and tannins was determination using method described by Nwosu (2013) while amylase and trypsin inhibitors of the noodle samples were determined as described by the method of Figueira *et al*. (2003) and Famakin *et al*. (2016), respectively.

2.9 Determination of cooking property of the noodle samples

The cooking properties such as cooking time, cooked weight, water uptake percentage and gruel solid loss of developed spaghetti were determined as described by Akinsola *et al*. (2018) method.

2.10 Sensory attributes of the pasta samples

Sensory attributes of cocoyam-wheat flour blends were determined as described by Akinsola *et al*. (2018). Twenty semi-trained panelists but familiar with indomine^{TM}, a similar product to the study samples were drawn from the College community. The panelists were asked to indicate their preference for the samples in term of appearance, chewability, colour, flavour, taste, texture and overall acceptability on 9-point Hedonic scale where 9 =like extremely and 1=disliked extremely. Each panelist sat in an enclosed cubicle designed for sensory evaluation and water was provided to rinse mouths before and after tasting each of the samples.

Statistical analysis

Data obtained were statistically analyzed using SPSS version 17.0, mean and standard error of means (SEM) of the triplicate analyses were calculated. The analysis of variance (ANOVA) was performed to determine significant differences between the means while the means were separated using the Duncan Multiple Range Test (DMRT) at $p< 0.05$.

3 Results

Table 2 shows the results of proximate composition of the cocoyam-wheat noodle samples. There was significant difference in sample A compared to other samples in term of moisture content, crude protein, crude fat, crude fibre and crude ash of the formulated noodles with an increase in value from sample A to sample E with values ranged from 9.26 - 10.11 %; 7.92 - 11.56 %; 1.42 - 4.83 %; 4.08 - 4.98 %; 3.67 - 4.65 %, respectively. Carbohydrate value of the noodle samples shows significant difference at $p<0.05$. There values ranged from 65.16 - 72.77 % in sample A – E, respectively. Statistical difference ($p<0.05$) were observed in the energy values of the samples which ranged from 1401.61 kJ in sample A to 1463.31 kJ in sample E, respectively. Carbohydrate values decreases from 72.77 % to 65.16 % while its total energy values increases from 1401.61 kJ to 14.81.35 kJ in sample A to sample E, respectively.

Table 2: Proximate composition of cocoyam-wheat noodle samples

Parameter, %	Sample A	Sample B	Sample C	Sample D	Sample E
Moisture content	10.11±0.00	9.26±0.11	9.38±0.04	9.36±0.22	9.32±0.14
Crude protein	7.92±0.41	9.64±0.30	10.56±0.02	11.02±0.10	11.56±0.33
Crude fat	1.45 ± 0.13	4.13±0.01	4.36±0.31	4.59±0.23	4.83±0.00
Crude fibre	4.08±0.21	4.41±0.12	4.75±0.10	4.86±0.01	4.98±0.31
Crude ash	3.67±0.02	3.81±0.00	3.94±0.31	4.06±0.15	4.15±0.10
Carbohydrate	72.77±.65	68.74±1.32	67.01±1.24	66.11±1.08	65.16±1.32
Energy, kJ	1401.61±2.35	481.35±1.57	1459.79±1.66	1461.11±1.09	1463.31±1.07

Values recorded as triplicate mean ± SD, while values with different superscripts within the same row are significantly different
at p<0.05. S.D = Standard deviation, Sample A = 100 % cocoyam noodles, Sample B = cocoyam-wheat (90-10) noodles, Sample
C = cocoyam-wheat (85-15) noodles, Sample D = cocoyam-wheat (80-20) noodles, Sample D = cocoyam-wheat (75-25) noodles.

Table 3 presented mineral profile of the cocoyam-wheat noodle samples. There was significant difference (p<0.05) in all the samples minerals determined. There values ranged from 81.42 - 129.15 gm/100 gm (Ca); 66.47 - 98.57 gm/100 gm (Mg); 58.16 - 131.19 gm/100 gm (P); 538.79 - 722.04 gm/100 gm (K); 17.51 - 56.36 gm/100 gm (Na), 2.93 – 3.22 gm/100 gm (Fe) and 1.98 – 2.61 gm/100 gm (Zn), respectively. The sodium potassium ratio of the noodle samples ranged from 0.03 – 0.08 while phosphorus calcium ratio ranged from 0.71 in sample A to 1.02 in sample E.

Table 3: Mineral profile of cocoyam-wheat noodles samples

Parameter, gm/100gm	Sample A	Sample B	Sample C	Sample D	Sample E
Calcium	81.42±1.01	96.22±1.51	107.34±2.01	116.72±1.62	129.15±2.11
Iron	2.93±0.00	2.98±0.12	3.02±0.10	3.11±0.12	3.22±0.11
Magnesium	66.47±1.23	74.37±1.21	83.18±2.50	92.46±1.93	98.57±1.30
Phosphorus	58.16±0.72	91.28±1.83	98.50±2.21	118.03±3.70	131.19±2.43
Potassium	538.79±3.71	625.34±2.40	677.41±3.33	701.89±4.11	722.04±2.62
Sodium	17.51±0.55	33.78±1.11	41.26±0.61	49.11±1.40	56.36±1.05
Zinc	1.98±0.00	2.17±0.03	2.33±0.12	2.42±0.14	2.61±0.00
P: Ca	0.71±0.10	0.95±0.21	0.92±0.10	1.01±0.16	1.02±0.11
Na : K	0.03±0.00	0.05±0.00	0.06±0.01	0.07±0.00	0.08±0.01

Values recorded as triplicate mean ± SD, while values with different superscripts within the same row are significantly different
at p<0.05. S.D = Standard deviation, Sample A = 100 % cocoyam noodles, Sample B = cocoyam-wheat (90-10) noodles, Sample
C = cocoyam-wheat (85-15) noodles, Sample D = cocoyam-wheat (80-20) noodles, Sample D = cocoyam-wheat (7525) noodles.

Functional property of the cocoyam-wheat noodle samples was as shown in Table 4. Statistical difference at alpha 0.05 was not observed in the bulk density values of the noodle samples. There values ranged from 0.63 gm/cm^3 in sample E to 0.75 gm/cm^3 in sample A. Significant differences were observed in the swelling power and water absorption capacity (WAC) compare to sample A. There values ranged from 286.24 – 378.52 gm/cm^3 and 165.11 – 204.09 gm/cm^3 in sample A – E, respectively. Marginal statistical difference was observed in wettability index of the noodle samples compare to sample A. There values ranged from 5.88 sec in sample A to 5.63 sec in sample E while least gelation concentration (LGC) values varied from 15.13 gm/cm^3 in sample A to 16.71 gm/cm^3 in sample E. The LGC values of the formulated noodle samples were significant difference at alpha 0.05.

Table 4: Functional property of the cocoyam-wheat noodle samples

Parameter	Sample A	Sample B	Sample C	Sample D	Sample E
Bulk Density, g/ml	0.75±0.00	0.71± 0.01	0.68± 0.01	0.67±0.00	0.63±0.11
Swelling Power, g/cm^3	286.24±1.12	298.34± 4.20	316.28±3.22	345.11±1.46	378.52±2.31
WAC, g/cm^3	165.11±3.01	173.20±2.21	178.13±1.51	189.63±2.31	204.09±3.25
Wettability index, sec	5.88±0.04	5.82±0.10	5.76±0.20	5.68±0.13	5.63±0.21
LGC, g/cm^3	15.13±0.33	15.51±0.02	16.04±0.21	16.65±0.23	16.71±0.11

Values recorded as triplicate mean ± SD, while values with different superscripts within the same row are significantly different
at p<0.05. S.D = Standard deviation, Sample A = 100 % cocoyam noodles, Sample B = cocoyam-wheat (90-10) noodles, Sample
C = cocoyam-wheat (85-15) noodles, Sample D = cocoyam-wheat (80-20) noodles, Sample D = cocoyam-wheat (75-25) noodles.
WAC = Water absorption capacity, LGC = Least gelation concentration.

Table 5 shows the results of antinutritional factors of the cocoyam-wheat noodle samples. Statistical differences (p<0.05) were observed in all the selected antinutritional factors determined. There values decrease as wheat incorporation increases from 0 – 25 gm/100 gm. Alkaloid and oxalate contents of the noodle samples decrease from 3.85 – 2.78 and 5.21 – 3.42 in sample A – E, respectively. Phytate values ranged from 2.01 in sample E to 3.25 in sample A while tannins values ranged from 1.01 – 1.76 in sample A – E, respectively. Amylase and trypsin inhibitors values decrease from 3.62 – 2.35 AIU and 2.14 – 1.76 TIU in sample A – E, respectively. Incorporation of wheat flour into cocoyam flour for noodle making significantly reduces its antinutritional factors.

Table 5: Antinutritional factors of the cocoyam-wheat noodle samples

Parameter	Sample A	Sample B	Sample C	Sample D	Sample E
Alkailoid	3.85±0.11	3.19±0.01	2.88±0.01	2.84±0.11	2.78±0.12
Oxalate	5.21±0.00	4.62±0.16	3.71±0.02	3.68±0.21	3.42±0.11
Phytate	3.25±0.00	2.77±0.02	2.38±0.11	2.16±0.12	2.01±0.00
Tannins	1.76±0.03	1.14±0.00	1.09±0.12	1.03±0.03	1.01±0.01
Amylase inhibitor, AIU	3.62±0.02	3.09±0.21	2.82±0.10	2.63±0.03	2.35±0.00
Trypsin inhibitor, TIU	2.14±0.11	1.78±0.20	1.83±0.11	1.81±0.10	1.76±0.11

Values recorded as triplicate mean ± SD, while values with different superscripts within the same row are significantly different
at p<0.05. S.D = Standard deviation, Sample A = 100 % cocoyam noodles, Sample B = cocoyam-wheat (90-10) noodles, Sample
C = cocoyam-wheat (85-15) noodles, Sample D = cocoyam-wheat (80-20) noodles, Sample D = cocoyam-wheat (75-25) noodles.
AIU = amylase inhibitor unit, TIU = trypsin inhibitor unit.

Cooking property of the cocoyam-wheat noodle samples was as shown in Table 6. Statistically difference at alpha p≤0.05 was observed among the cooking time of the samples which ranged from 2.55 to 3.34 min in sample A – E especially in sample C – E compared to sample A and B. cooking weight of the noodle samples shows no significant difference at p≤0.05 between sample A – B while there are significant difference in sample C – E compared to sample A. cooked weight values varied from 16.28 gm in sample A to 18.14 gm in sample C. There was significant difference in sample A to other samples with values ranged from 52.76 gm/100 gm (sample A) to 60.59 gm/100 gm (sample E). Gruel solid loss shows no significant difference (p<0.05) between samples except sample E. There values ranged from 4.48 gm/100 gm – 4.75 gm/100 gm in sample A – E. Table 2 shows that gruel solid loss decrease marginally as wheat flour substitution increase from 0 – 25 gm/100 gm.

Table 6: Cooking property of the formulated noodle samples, 100gm

Parameter	Sample A	Sample B	Sample C	Sample D	Sample E
Cooking time, min	3.34±0.20	3.11±0.11	2.93±0.33	2.76±0.01	2.55±0.43
Cooked weight, gm	16.28±1.22	16.43±1.30	17.18±1.12	17.69±0.50	18.14±0.63
Water uptake, gm/100gm	52.76±2.11	53.18±1.54	54.71±1.2	60.23±2.11	60.59±1.41
Gruel solid loss, gm/100gm	4.75±0.13	4.71±0.32	4.64±0.20	4.52±1.02	4.48±0.80

Values recorded as triplicate mean ± SD, while values with different superscripts within the same row are significantly different
at p<0.05. S.D = Standard deviation, Sample A = 100 % cocoyam noodles, Sample B = cocoyam-wheat (90-10) noodles, Sample
C = cocoyam-wheat (85-15) noodles, Sample D = cocoyam-wheat (80-20) noodles, Sample D = cocoyam-wheat (75-25) noodles.

Sensory evaluation of the noodles produced from cocoyam-wheat flour blends was as shown in Table 7. There were significant differences (p<0.05) for all the sensory attributes determined. Sample A had the least mean score (5.81) while sample E that have 20 % wheat flour incorporation had highest (6.78) mean score. Chewability, colour and flavour scores ranged from 5.79 – 6.02; 5.13 – 7.01 and 5.18 – 6.88, respectively. Statistical differences were observed in all the noodle samples compare to sample A in term of taste and texture. Sample C had the highest mean score (6.62) for taste while sample E had the highest mean score (6.03) at alpha 0.05. Sample E of the formulated noodle samples had the highest overall acceptability mean score of 7.21 and significant difference at alpha 0.05 to other noodle samples especially sample A, the average scores of the samples ranged from4.61 in sample A followed by B, C, D and E, respectively.

Table 7: Sensory evaluation of the noodles produced from cocoyam-wheat flour blends

Attributes	Sample A	Sample B	Sample C	Sample D	Sample E
Appearance	5.81±0.03	5.98±0.02	6.23±0.10	6.78±0.02	6.65±0.21
Chewability	5.79±0.10	5.41±0.05	5.66±0.13	5.53±0.14	6.02±0.00
Colour	5.14±0.01	5.13±0.11	5.72±0.12	7.01±0.11	6.83±0.04
Flavour	5.18±0.02	5.67±0.13	6.88±0.01	6.83±0.00	6.22±0.13
Taste	6.18±0.11	5.59±0.01	6.29±0.11	6.62±0.13	6.10±0.11
Texture	5.63±0.21	5.53±0.12	5.74±0.00	5.99±0.21	6.03±0.20
Overall acceptability	4.61±0.10	5.81±0.21	6.31±0.03	6.85±0.11	7.21±0.17

Values recorded as triplicate mean ± SD, while values with different superscripts within the same row are significantly different
at p<0.05. S.D = Standard deviation, Sample A = 100 % cocoyam noodles, Sample B = cocoyam-wheat (90-10) noodles, Sample
C = cocoyam-wheat (85-15) noodles, Sample D = cocoyam-wheat (80-20) noodles, Sample D = cocoyam-wheat (75-25) noodles.

4. Discussions

4.1 Proximate composition of the formulated noodle samples

Moisture content of the samples indicated good storage stability, avoidance of lump and mould formation during storage period, hence greatly increase storage ability of the sample. Moisture content of the noodles produced from cocoyam-wheat flour blends were relatively low and statistically difference compare to the control sample. Akinsola *et al*. (2018) and Zakpaa *et al*. (2010) reported a moisture safe level of 8 -13 % for good storage of solid composite flour while Koua *et al*. (2018) reported that low moisture content than 10 % is generally accepted as a standard value for dry food product with a better shelf life. These postulations indicate that the lower the moisture content of a food product, the better its storage ability. Protein content of the noodle samples increase as wheat flour incorporation increases. This may be as a result of protein (gladin and glutenin) found in wheat grains. This result agreed with the work of Idowu and Akinsola (2017) who work on adding wheat flour to orange fleshed sweet potato to produce pasta product. Statistical differences were observed in the protein content of the samples as wheat flour addition increases. Research has shown that proteins play a major role in immune booster, cell division and repairment, and growth. The protein content of the noodle samples fall below recommended daily intake of 13 – 14 gm/100gm according to Anigo *et al.* (2009) while fat content of the noodle samples can provides more than 28.4 % energy recommended by FAO/WHO (2012) as fat allowance contribution in food. Fat, apart from adding more energy values to food, its also provides fat soluble vitamins (ADEK), insulate organs, protects internal tissues and other cell biochemical activities (Akinyemi *et al*., 2020).

Crude fibre of all the noodle samples falls within the range of 2.5 – 5.0 gm/100gm as reported by some workers (Akinsola *et al*., 2022; Famakin *et al*., 2016). Crude fibre especially dietary fibre plays a vital role during and after consumption and digestion of food because it does prevent constipation; allow good movement of abdominal contraction. According to Soetan and Olaiya (2013), dietary fibre play good role in glucose adsorption, reduces risk of hyperglycemia and help in reducing body weight. Ash content of the noodle samples indicates the presence of mineral salts in the food products and a good tool in ionic (acid-base) balancing of body fluid system (Ibeanu *et al*., 2016). The study shows increase in total energy content of the noodle samples compare to control sample (sample A) as wheat flour incorporation increases. The products will provides enough energy per 100 gm and effect protein sparing ability of carbohydrate in the food product. Carbohydrate, apart from providing energy, its contribute effectively to muscles coordination, blood and Kreb's circle activities and also acts as mild laxative (Akinsola *et al*., 2018; Sushma *et al*., 2016). The increase in carbohydrate and energy content of the noodle samples may be as a result of wheat flour addition from 0 – 25 % which agreed with the work of Animashaun *et al*. (2017).

4.2 Mineral profile of the formulated noodle samples

Mineral profile of the noodle product formulated from cocoyam root and wheat flour was as shown in Table 3. Statistical differences at alpha 0.05 were observed in all the selected minerals determined. Calcium content of the samples ranged from 81.42 – 129.15 mg/100gm. Calcium has been shown to perform many biochemical processes and stabilize protein reactions in the body. Its deficiency in food can cause osteoporosis and other related nutritional diseases in the body. Iron and magnesium content ranged from 2.93 – 3.22 mg/100gm and 66.47 – 98.57 mg/100gm in sample A – E, respectively. In foetus and child development, iron has been shown to work against impair physical and cognitive development and reduce morbidity in child bearing. It availability in food activate many enzymes including ferritin and hemosiderin (Pharmics, 2019) while Ibeanu *et al*. (2016) reported that magnesium is an important element in cells constituents and bone formation and utilization during Kreb's circle activities.

Phosphorus and potassium contents of the formulated noodle samples ranged from 58.16 mg/100gm in sample A to 131.19 mg/100gm in sample E. Phosphorus is an essential mineral in many body biochemical reactions. For instance, it plays an important role in the generation of ATP, maintenance of homeostasis, nucleic acids production (Penido, 2012). The Ca : P molar ration in this study ranged from 0.71 – 1.02. According to Koua *et al*. (2018), this indicated good absorption of dietary calcium available while less than 0.5 indicates poor calcium intake from the food. The result of this molar ration constitutes a good advantage and indicates good absorption of calcium in the formulated noodle samples. As reported by Eleazu *et al*. (2013) potassium is a crucial element in osmosis fluid balance, heart rhythm, nerve impulsion regulation and cell metabolism. Sodium and zinc content of the formulated noodle samples ranged from 17.15 – 56.36 mg/100gm and 1.98 – 2.61 mg/100gm in sample A – E, respectively. Sodium has been shown by some field workers (Pharmics, 2019) as an important tool in fluid and acid-base osmostatic balance, coordinate muscle and glucose absorption. The molar ration of K : Na ranged from0.03 – 0.08. The potassium content of all the noodle samples were higher that sodium content which according to Chen *et al*. (2010) indicates good health promoter by reducing incidence of hypertension.

4.3 Functional property of the noodle samples

Table 4 shows the functional property of the formulated noodle sample. Functional property of food materials reflect its complex interactions of starch composition, water affinity, structure and cell conformity. It's also determines uses for different food development and acceptability. Bulk density (BD) of the noodle samples shows no statistical different at $p<0.05$. This may be as a result of using standard sieve (350 µm screen) to obtain same flour particle size. The study BD is of low value; this is an indication of close compact of its flour particles which invariably may increase energy and nutrient density of the food. Low BD may also be an advantage in the food product packaging and transportation cost. Swelling power (SP) and water absorption capacity (WAC) of the noodle samples shows significant differences at alpha 0.05 in all the samples. There values ranged from286.24 – 378.52 gm/cm^3 and 165.11 – 204.09 gm/cm^3 in sample A – E, respectively. SP is related to the association binding within starch granules and apparently the strength and character of micelle network in relation to amylase content of the flour (Adebowale *et al*., 2005). It also indicates the presence of amylase and amylopectin activity in the flour or its food product and water absorption index of starch based flour during heating. Yellavila *et al*. (2015) reported that it is a measure of hydration capacity because it measure swollen starch granules and their entrapped water while WAC is the ability of flour to absorb water and swell for improved consistency in the food. The study WAC of the noodle samples shows an increase in WAC compare to control sample. The high WAC may be due to the addition of wheat protein to the samples during formulation with the exception of control sample. According to some field workers (Sushma *et al*., 2016), high WAC seen in this study indicates it usefulness in pastry product development as more dry matter could be added to the mixture. This by implication means more nutrients would be available in the noodle products.

Wettability index of the formulated noodle samples ranged from 5.88 sec in sample A to 5.63 sec in sample E. wettability index or time indicates the actual time required for a flour sample to get wet; it also shows hydrophilic property and ease of dispersion of flour on water will get wetted or absorbed which indicate good cooking property of the formulated noodle samples. Least gelation concentration (LGC) of the noodle samples ranged from 15.13 gm/cm^3 in sample A to 16.71 gm/cm^3 in sample E. LGC indicates the lowest protein concentrate at which gel formation remains in the sample, may be as a result of high protein hydrolysis during noodle preparation and formulation. Akinsola *et al.* (2022) reported that gelling properties of food sample can be attributed to the relative ratio of protein, carbohydrate, lipids and interaction between their components.

4.5 Antinutritional factors of the formulated noodle samples

Antinutritional factors of the formulated noodle samples is as shown in Table 5.significant differences were observed in all the samples compare to control sample. Antinutritional factors has been reported by many field workers (Tadele, 2015; Akande *et al*., 2010) as anti agent in both macro and micro nutrients availability and absorption in intestinal abdomen of man due to its reactive nature of forming bond to nutrients and make it unavailable to man intestinal uses. Alkaloid and oxalate contents of the noodle samples range from 3.85 in sample A to 2.78 n sample E and 5.21 in sample A to 3.42 in sample E, respectively. The presence of these factors in the food products may interfere with the bioavailability of other nutrients and may affect man health when consumed beyond certain threshold (Boakye *et al*., 2018). Amandikwa *et al*. (2012) reported that drying has been established to be efficient in reducing its content in food as shown in this study.

Phytate and tannins of the formulated noodle samples range from 3.25 in sample A to 2.01 in sample E and 1.76 in sample A to 1.01 in sample E, respectively. Phytate form stable complexes with mineral ions like Ca, Fe, Mg, Zn and lower their intestinal absorption while tannins form insoluble complexes with protein and reduces its biological values (Akande *et al*., 2010; Banso & Adeyemo, 2007). Statistical differences were observed in both the amylase and trypsin inhibitors at alpha 0.05. There values decrease from 3.62 – 2.35 AIU and 2.14 – 1.76 TIU in sample A – E, respectively. This study shows that addition of wheat flour from 0 – 25 % significantly reduce all the selected antinutritional factors determined. According to Ologhobo et al. (2003), trypsin inhibitors in large quantity cause hypertrophy and hyperplasia of the pancreas while Nwozu (2011) who reported lethal doses of some selected antinutritional factors in his study as 50-60 mg/kg for phytate, 30 mg/kg (tannin), 10 mg/kg (cyanogenic glycoide), 2-5 g/kg (oxalate) and 2.50 g/kg (trypsin inhibitor). All the antinutritional values obtained in this study were far less than those lethal doses reported by Nwozu (2011) which indicated that all the sample flours nutrients and micronutrients will be available and well absorbed by man intestinal abdomen.

4.6 Cooking property of the noodle samples

Cooking property of the noodle samples formulated from cocoyam root and wheat flour as in table X. cooking parameters such as cooking time, cooked weight, gruel solid loss and % water uptake were determined. Statistical differences were observed in cooking time and water uptake of the noodle samples while cooked weight and gruel solid loss shown significant difference (p<0.05) at 15 – 25 % wheat flour incorporation. Short cooking time with small loss of solid gruel in cooking water is a good sign of quality noodles. Cooking time of all the samples were significantly less than control sample. Addition of wheat flour may have caused this scenario because presence of gladin and glutenin can caused discontinuity in the starch network thereby resulting in quick water uptake which leads to cooked time reduction. There exist a relationship between cooked weight and water uptake of the noodle formulated samples. These results are in line with Akinsola *et al.* (2019) where high water uptake indicates high degree of hydration in the noodle samples which give the product a good eating quality. Gruel solid loss significantly reduces as wheat flour addition increases from 0 – 25 %. This result was not in agreement with the work of Yadav *et al.* (2013) who study suitability of wheat flour blends with sweet potato, colocasia and water chestnut flours for noodle making.

4.7 Sensory attributes of the noodle samples

Table 7 shows the sensory property of the formulated noodle samples produced from cocoyam root and wheat flour. Significantly differences were observed at alpha 0.05 among the formulated noodle samples observed in term of sensory attributes determined. The mean score for all the sensory attributes (appearance, Chewability, colour, flavour, taste, texture and overall acceptability) determined ranged from 5.81 – 6.78; 5.41 – 6.02; 5.13 – 7.01; 5.59 – 6.62; 5.53 – 6.03; 4.61 – 7.21, respectively. Appearance, colour, flavour and texture almost always determined acceptability of any food products. In term of appearance, sample D is most preferred while sample E is most preferred in term of Chewability. Sample D is the most preferred in term of colour while sample C is best like in term of flavour. Taste and texture goes to sample D and E, respectively. Sample E is the most accepted to the semi-trained panelists. Sample E chewability and texture may have influence the decision of the panelists. Chewability and texture of food products is a good index for food product acceptability especially when it has to do with people that have similar pedigree to the main raw material used for the formulation of such food product. Sample D and E are most acceptable (6.85; 7.21) to the semi-trained panelists which indicates good product development of the formulated noodle samples.

Conclusion

The study examines the potential of producing noodle product from the blends of cocoyam and wheat flour. Noodle produced shows good functional, pasting and sensory properties compare to 100 % cocoyam noodles. Moreover, its nutrition property in term of protein and micronutrients increases considerably compares to control sample. The formulated cocoyam-based noodle have potentials suitable for the management of protein-energy-malnutrition and micro nutrients deficiency especially in the rural areas and among low wages earners because of its nutrition and micro nutrients improvement over 100 % cocoyam based noodle. The study revealed that incorporation of 20 – 25 % wheat flour into cocoyam based noodle will enhance its nutritional quality with acceptable sensory attributes in term of flavour, taste and texture. However, the sensory attribute results shows that noodles produced with 25 % of wheat flour addition had a good sensory acceptability when compared with other samples.

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