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Sensory Analysis and Phytochemical Characterization of Aerial Yam and Water Yam

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Abstract
This work is focused on the sensory evaluation, phytochemical and proximate analysis of aerial yam and water yam. The raw unblanched and blanched samples were dried using convective hot air and solar dryer. The phytochemical composition and proximate compositions of the samples were carried out to determine the phytochemicals and proximate components of the samples. Sensory test, using a designed questionnaire, was done to determine the acceptability of flour produced from the dried products. The results revealed the presence of important phytochemicals such as tannin, flavonoid, glycoside, saponin, alkaloids in both water yam and aerial yam samples. Proximate analysis of the samples showed that water yam (68.25%) and aerial yam (62.25%) contain moderately high water contents in raw form. The moisture content of the dried aerial yam (9.75%) was also observed to be higher than that of the dried water yam (7.25%). Hedonic test results showed wide acceptability of the colour, aroma, texture and general appearance of blanched samples more than the unblanched samples of the yam species. The economic advantages of these yam species can be optimized by blanching. The information obtained from sensory, phytochemical and proximate analysis could help in generating data for design of dryers for making these flours. It could also help the process industries in making decisions on the handling, storage and distribution/exportation of these important agro-products.

Keywords: Aerial yam, water yam, hedonic, phytochemicals

1. Introduction

Dioscorea spp. popularly known as yam are starchy foods in the form of tubers produced in Africa, Caribbean, South Pacific, Americas, and Asia (Ayo et al., 2018). They are essential source of carbohydrate for many people of West Africa and other Sub-Saharan region (Obidiegwu et al., 2020). Yam are one of the most important tropical root crop after cassava and sweet potato grown in West Africa. There are about 600 different species of yam, however, only six are commonly grown as staple foods in tropical regions. They are *Dioscorea Bulbifera Dioscorea Dioscorea alata, Dioscorea rotundata, Dioscorea esculenta,* and *Dioscorea dumetorum* (Ayo et al., 2018). Amongst these, *Dioscorea bulbifera* is a member of this yam species considered as a wild species of yam native to Africa and Asia (Nwadike et al., 2022). It is cultivated due to its cheap source of nutrient to Humans and have been shown to possess a myriad of compounds that have been attributed to several health benefits (Kalu et al., 2021, Nwadike et al., 2020). They are reported to contain diosgenin, a pharmacologically active compound used as steroidal drugs all over the world (Daniel et al., 2017). Water Yam *(Dioscorea alata)* is the most widespread yam species. It is more important as food in West Africa and the Caribbean than in Asia and in America where it originated and has been competing with the most important species like *Dioscorea rotundata* (Oko & Famurewa, 2015). Water yam is popular and prevalent within Abakiliki agro-ecological zone of Ebonyi state, Nigeria where it is called "Mbala or Nvula" (Native names in Igbo land) (Oko & Famurewa, 2015). Water yam has low sugar content necessary for diabetic patients. Also, it contains nutrient which has benefits to the body, and it also contains dietary fibre which is important in the diet for the healing and health-promotion. It also contains a lot of minerals like calcium, potassium, iron, phosphorus and copper with high presence of vitamins C and E which have antioxidant properties, and lowers blood pressure levels (Ojimelukwe et al., 2021). Sequel to these findings, it is necessary to preserve this agro-product from spoilage by the use of drying and other processing techniques.

Phytochemicals are plant components, primarily secondary metabolites that have health promoting properties. They are alkaloid, flavonoids, tannin, diosgenin etc. They have been reported to be useful for human's health and wellbeing (Kalu et al., 2019). For instance, alkaloids are useful in medicine as anesthetic. They act as lifesaving drugs in some serious disorders like heart failure, cancer, malaria and diabetes (Heinrich et al., 2021). Flavonoids are reported to possess many useful properties ranging from anti-inflammatory, anti-microbial, anti -tumour and anti -allergic activities (Mohammad and Elham, 2013). While Tannins serves as a coagulant aid, anti-oxidant and anti-fungal activities (Nouioua-Wafa *et al*., 2016).

There have been significant underutilization of these yam species owing to poor knowledge of its medicinal, phytochemical, proximate, nutrient and sensory properties. This have led to the misuse, mishandling and wastage of these food product. There is therefore the need to carry out research to evaluate the phytochemical and proximate analysis as well as sensory evaluation of its dried flour. Study on these yam species especially the effect of blanching and other forms of pretreatment could uncover some inherent potentials in aerial yam and water yam. It could also suggest the best pre-treatment methods to improve the quality and acceptability of the flour produced from these yam species.

2.0 Materials and methods

2.1 Material collection and preparation

The aerial yam sample was sourced from Afor Opi market in Nsukka Local Government Area of Enugu State, while the water yam was sourced from Eke Awka market, Awka, Anambra State. The aerial yam and water yam were identified at the Department of Crop Science, Nnamdi Azikiwe University, Awka. The yams (Plate 1.1a and 1.1b) were washed with clean water and spread in open air to avoid spoilage. The water yam was peeled and cut into desired size while the aerial yam was cut without peeling because peeling tends to remove the mesocarp of the yam which is known to be medicinal.

Plate 1.1a: Aerial Yam sample

Plate 1.1b: Water yam sample

2.2 Blanching of the Samples

This experiment was carried out at the unit Operation Laboratory, Department of Chemical Engineering, Nnamdi Azikiwe University Awka. The drying of the samples was done with convective hot air dryer (Fig. 2.1) and solar dryer (Fig.2.2). In blanching for both convective hot air dryer and solar dryer, 2.0 mm of the sample was cut and 100g of the sample weighed into a bowel containing boiled water at 80^oC. The sample was left in the hot water for 10 minutes. The water was removed and the new weight of the sample taken. The sample was put in the dryer (convective and solar dryer) and allowed to dry to constant weight with the weight taken at 10 minutes interval. The unblanched sample were cut to the same size and the same weight (100g) was dried using both the convective hot air dryer and solar dryer until constant weight was achieved.

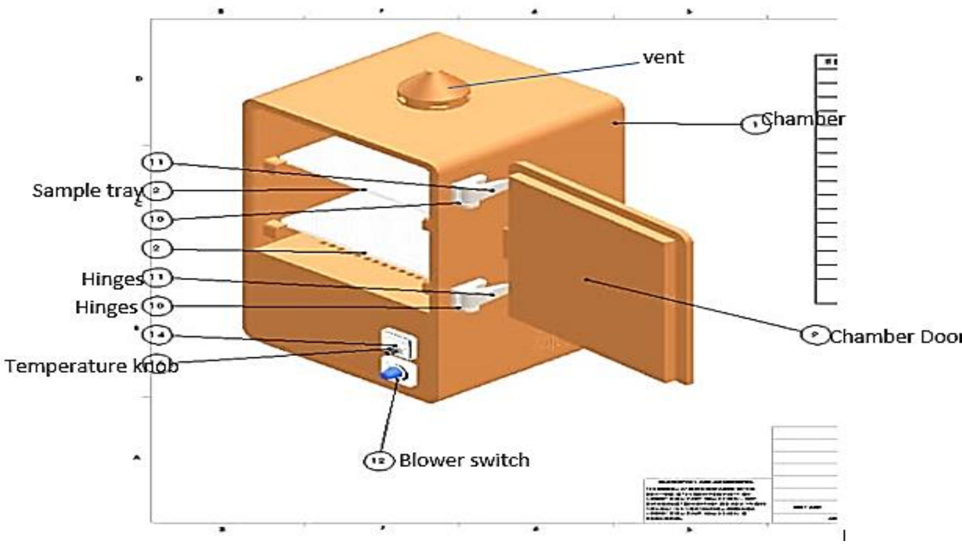


Fig. 2.1: A Schematic diagram of convective hot air dryer used

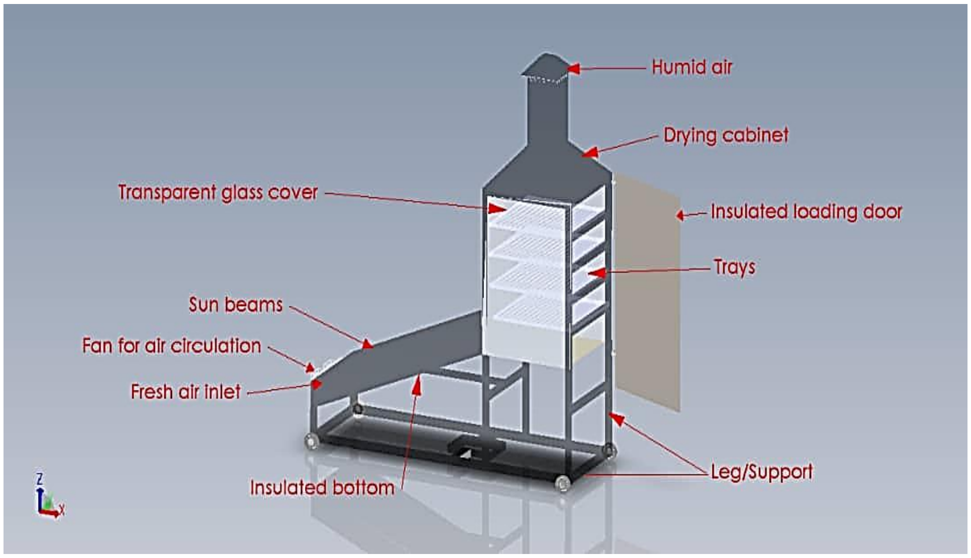


Fig.2.1: A Schematic diagram of solar dryer used

2.3 Phytochemical Analysis of the Samples

All the phytochemical analyses were carried out at the Material, Energy and Technology Laboratory, Project Development Institute (PRODA), Enugu state. The two different species of yam samples were prepared for qualitative phytochemical analysis as described by Harbone, (1998). The crude extracts of the samples were prepared using standard procedure (Falope et al.. 1999). The fresh yam samples were peeled with a sharp stainless knife. The yams were cut into 5mm diameter and pounded with a ceramic mortar and pestle. This was done to increase the surface area and reduce the size. About 5 g of each sample was weighed into four different 250ml conical flasks. 100ml of four different solvents was added to the samples (ethanol, water, butanol and hexane). The mixture was agitated at room temperature with a vibrator shaker at 500rpm. Each of the mixtures was filtered with a Whatman filter paper I at room temperature. Then, the extract was collected into sample bottles and kept in the refrigerator for further analysis. The samples were tested for the presence of alkaloids, flavonoids, tannin, glycosides, saponin, steroid and phenol/polyphenols the presence of flavonoids.

2.4 Proximate analysis

All the proximate analyses were carried out at the Material, Energy and Technology Laboratory, Project Development Institute (PRODA), Enugu. The method used is according to AOAC (2000). Moisture content, ash content, crude fibre, protein, fat and oil and carbohydrate were the proximate analysis carried out.

2.5 Sensory evaluation

The hedonic test was done according to Sukanya and Michael (2014). The dried water yam and aerial yam were milled into flour which was used in carrying out the hedonic analysis to determine the sensory attributes of the flour produced. Fifty (50) questionnaires were administered to respondents (mainly bakers) who serve as the panelists. They completed the questionnaires based on the flour samples presented to them. The flour samples were coded as follows

Flour A: Blanched Water yam for convective hot air dryer
Flour B: Un-blanched Water yam for convective hot air dryer
Flour C: Blanched Aerial yam for convective hot air dryer
Flour D: Un-blanched Aerial yam for convective hot air dryer
Flour E: Blanched Water yam for solar dryer
Flour F: Un-blanched Water yam for solar dryer
Flour G: Blanched Aerial yam for solar dryer
Flour H: Un-blanched Aerial yam for solar dryer

The questionnaire was based on 9-point Hedonic rating on water yam and aerial yam flour. The rating was summarized in overall like and dislike disposition. The hedonic scale ranking employed in the analysis of the samples were: Like extremely, Like very much, Like moderately, Like slightly, Neither like nor dislike, Dislike slightly, Dislike moderately, Dislike very much, Dislike extremely. To enable the ratings of the like and dislike to be made in a continuous manner, it was constructed as a bipolar scale with neutral at the center. This makes the positive and negative descriptors to be statistically symmetrical around the neutral hence, agreeing in general with other affective scales (Guest et al, 2007). The 50 panelists used were made of 34 females and 16 males. Majority of them (76%) were in the age bracket of 20 – 40 years and were people who work with flour.

3.0 Results and Discussion

3.1 Phytochemical analysis

The result of the qualitative phytochemical analysis of the two yam species is given in Tables 3.1 and 3.2. According to Table 3.1, flavonoids, tannin and polyphenol are absent in water yam sample irrespective of the solvent used. Glycoside, alkaloids, steroid and saponin were found to be present in the different solvents used though in varying concentrations. It could be seen that alkaloids and sponin were moderately soluble in ethanol while glycoside was seen to be very soluble in ethanol. Glycoside and saponin were found to be highly soluble in aqueous solution as shown in Table 3.1. In aerial yam analysis, glycoside was found to be present in different concentrations in all the solvents. Saponin and tannin were moderately abundant in water solvent while steroids were insignificantly present in the solvents.

Flavonoids have been reported to affect the heart and circulatory system, and are used as spasmodytics and diuretic (Lorena et al., 2023). Also, some traditional crops and plants are known for the management of diabetes mellitus. It is also known that the medicinal properties of crop and plant samples have been attributed to the active ingredients present in the phytochemical analysis of the samples. The flavonoids and polyphenols are well-known oxidants (Zhang et al., 2015). In terms of the phytochemical analysis, aerial yam is considered to be of more importance because of the presence of flavonoids, polyphenols and tannin among others.

Table 3.1: Phytochemical constituents of Water Yam

S/N	PARAMETER	ETHANOL	WATER	BUTANOL	HEXANE
1	Alkaloids	+	-	++	+++
2	Flavonoids	-	-	-	-
3	Tannin	-	-	-	-
4	Glycoside: Cyanogenic	+++	+++	+	+
	Cardiac	++	-	++	-
5	Steroid	-	-	+	-
6	Polyphenol	-	-	-	-
7	Saponin:	+	+++	-	-
		+	+++	-	-

KEY: -: Absent, +: Insignificantly present**,** ++: Moderately present**,** +++: Abundantly present.

Table 3.2: Phytochemical constituents of Aerial Yam

S/N	PARAMETER	ETHANOL	WATER	BUTANOL	HEXANE
1	Alkaloids	+	-	+	+++
2	Flavonoids	+	++	+	-
3	Tannin	-	+++	-	++
4	Glycoside:	++	+++	+	+
	Cyanogenic	+++	+	+	-
	Cardiac				
5	Steroid	-	-	+	+
6	Polyphenol	++	-	+	+
7	Saponin: Frothing	-	+++	-	-
	Emulsion	+	+	-	-

KEY: -: Absent, +: Insignificantly present**,** ++: Moderately present**,** +++: Abundantly present.

3.2 Proximate Analysis

The proximate analysis of the food samples was done to determine their different compositions. As expected, the moisture content of the raw water yam was highest with 68.25% (Table 3.3). Water yam is a food sample that is known to contain large quantities of water. The moisture content of the water yam decreased from 68.25% to 7.25% after drying while that of aerial yam decreased from 62.25 to 9.75%. This is expected because the major aim of drying is to reduce the moisture content which will subsequently increase the shelf life (Onu et al, 2017). The ash content is the inorganic component remaining after the removal of water and incineration of organic compounds. The ash content of dried water yam (DWY) was 7.50% while that of the (DAY) aerial water was 1.75% . The ash (Table 3.3) content was relatively unchanged after drying especially for water yam. The ash content of the aerial yam increased from 1.75 to 3.75%. The crude fibre is the indigestible part of the main food sample. The crude fibre of both water yam and aerial yam decreased after drying from 4.25 and 5.25 to 2.50 and 1.50% respectively. Nwabanne (2009) in the analysis of fermented ground cassava reported fibre content values ranging from 5.10 to 5.40%.

All the samples have low fats and protein content which is in agreement with the results reported by Luther et al (2003) for different food samples. The fat content decreased from 2.4 and 3.1% to 0.6 and 0.3 for aerial water yam and aerial yam, respectively after drying. The protein content increased from 1.71 and 0.83% to 3.2 and 3.16% for water yam and aerial yam sample, respectively after the drying. The aerial yam had more carbohydrate content than water yam. From Table 3.3, it could be seen that the carbohydrate content increased from 16.21 to 78.89% from water yam and from 27.29 to 81.07% for aerial yam. Nwabanne (2009) explains that the difference in drying rates of food samples is as a result of the difference in the chemical compositions of the samples.

The percentage change in the compositions between the raw and dried samples was equally evaluated. The percentage change was calculated on wet basis in accordance with Luther et al, (2003) and shown in Table 3.4. For water yam, the moisture content showed a percentage decrease of 89.38% after drying. A similar trend was obtained in the ash content, crude fibre and protein contents. However, an increase was observed in protein and carbohydrate contents with 300 % and 386.67 % respectively. For aerial yam, the moisture content, crude fibre and protein showed a decrease of 84.42, 71.43 and 73.73 % respectively. However, ash content showed an increase of 117.14%.

Table 3.3: Proximate analysis of the yam samples

Sample	Water Content	Ash Content	Crude fibre	Fats content	Protein content	Carbohydrate content
RWY	68.25±0.35	7.25± 1.06	2.50± 0.71	2.40± 0.28	1.71± 0.18	16.21 ± 0.93
RAY	62.25± .35	3.75± 1.06	1.50 ± 0.00	3.10± 0.14	0.83± 0.18	27.29 ± 0.13
DWY	7.25 ± 0.35	7.50± 1.41	4.25±0.35	0.60± 0.28	3.20± 0.06	78.89 ± 0.95
DAY	9.75 ± 0.35	1.75± 0.35	5.25± 0.35	0.30± 0.14	3.16± 0.36	81.07 ± 0.66

Where; RWY: raw water yam, RAY: raw aerial yam, DWY: dried water yam and DAY: dries aerial yam

Table 3.4: Percentage differences between the raw and dried samples

Sample	Water Content (%)	Ash Content (%)	Crude fibre (%)	Fats content (%)	Protein content (%)	Carbohydrate content (%)
Water yam	89.38	3.33	41.18	-300	46.56	-386.67
Aerial yam	84.42	-117.14	71.43	-933.33	73.73	-197.07

3.3 Statistical analysis of the proximate analysis

The one-way analysis of variance (ANOVA) was evaluated to determine whether the changes obtained in the mean values of the proximate analysis between the raw and dried yam samples were statistically significant. The p-value was set at 0.05 that is, at 95% confidence level. The results were given in Tables 3.5 and 3.6. For the water yam in Table 3.5, the variations observed in the mean values of moisture content, fats, protein and carbohydrate of both raw and dried samples were not statistically significant since their significant values of 0.00, 0.024, 0.008 and 0.00 respectively are all less than 0.05. This means that these compositions were affected by the drying process. However, the changes observed in mean values of the ash content and crude fiber are not statistically significant since their significant values of 0.860 and 0.089 respectively are all greater than 0.05, the *p*-value. This implies that the changes in their mean values were not affected by the drying process.

The one-way ANOVA of the aerial yam is shown in Table 3.6. The changes observed in the mean values of moisture content, crude fiber, fats, protein and carbohydrate of the raw and dried sample of aerial yam were not statistically significant since their significant values of 0.00, 0.004, 0.003, 0.015 and 0.000 respectively were all less than 0.05. This means that these compositions were affected by the modification of the samples. However, the change in the mean value of the ash content is not statistically significant since its significant value of 0.127 is greater than the p-value. This implies that the change in its mean value was not affected by the drying process. It is concluded that the drying process caused changes in the proximate parameters of the yam samples which resulted in an appreciable change in their nutritive and calorific values

Table 3.5: One-way ANOVA for water yam

Parameter	Sum of squares	Df	Mean square	F value	p-value
Moisture content	3721.00	1	3721.00	29768.00	0.000
Ash content	0.63	1	0.63	0.04	0.860
Crude fibre	3.06	1	3.06	9.80	0.089
Fats	3.24	1	3.24	40.50	0.224
Protein	2.21	1	2.21	116.52	0.008
carbohydrate	3929.41	1	3929.41	4475.79	0.000

Table 3.5: One-way ANOVA for aerial yam

Parameter	Sum of squares	df	Mean square	F value	p-value
Moisture content	1756.25.25	1	1756.25.25	22050.00	0.000
Ash content	4.00	1	4.00	6.40	0.127
Crude fibre	14.063	1	14.063	225.00	0.004
Fats	7.840	1	7.840	392.00	0.003
Protein	5.406	1	5.406	65.98	0.015
carbohydrate	22891.75	1	22891.75	12576.93	0.000

3.4 Sensory Evaluation

The result of the sensory attributes of the flour produced from aerial yam and water yam are shown in Figs. 3.1-3.4. As shown in Fig. 3.1 for appearance, Flour A has the highest preference of 453, followed by Flour C with total preference of 430, whereas Flour G has the least preference of 296. For colour preference (Fig. 3.2), Flour A (426) has the highest preference, followed by Flour C (420) with the least preference being Flour D (318). From Fig. 3.3, Flour A (436) has the highest texture preference, followed by Flour D (432), whereas Flour B (303) has the lowest texture preference. According to Fig. 3.4, Flour A (428) was the most accepted in consideration of aroma factor followed by Flour C (426), whereas the least preferred was D (330).

A combination of the factors that contribute to the preference of flour is presented in Fig. 3.5. From Fig. 3.5, Flour A and Flour C have the highest preference. The overall best score in all the tested categories indicated that the flours obtained from the blanched products were more acceptable than other flours obtained from unblanched products. The flour obtained from blanched water yam was the most acceptable followed by that obtained from blanched aerial yam. In terms of the drying method, the flours obtained from the hot air dryer was more acceptable than the flours obtained from solar dryer. This may be due to the combination of speed and temperature that was employed which resulted in the lowest drying time and the distorted colour of the products.

Analysis of variance test was used to test the difference between the mean of the different flours, to know whether there is a significant difference. The result is presented in Table 7.0. According to Table 7.0, Flour A has a mean of 435.75, Flour B has a mean of 329.75, Flour C has a mean of 427.00, Flour D has a mean of 335.50, Flour F has a mean of 317.50, Flour G has a mean of 316.25 and Flour H has a mean of 327.50.

Furthermore, the mean of the observations were plotted against the factors and the result is shown in Fig. 3.6. From the means plot (Fig. 3.6), it could be observed that Flour A has the highest mean of 435.75, followed by Flour C with a mean of 427.00. Flour G has the least mean of 316.27. Thus, we can say that Flour A (Blanched water yam for hot air dryer) is more preferred in terms of its Appearance, Colour, Aroma and Texture, followed by Flour C (Blanched aerial yam for hot air dryer). Flour G (Blanched aerial yam for solar dryer) is less preferred.

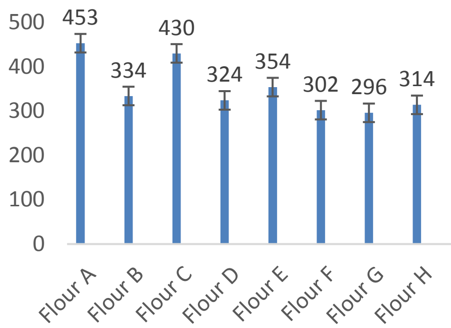


Fig. 3.1: Appearance preference of different Flours

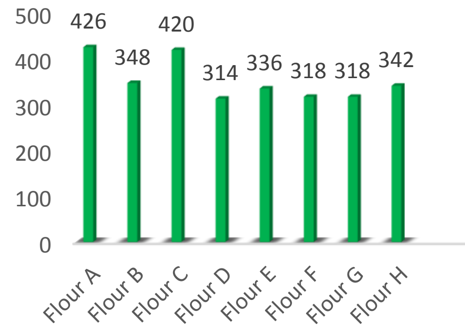


Fig. 3.2: Colour preference of the different Flours

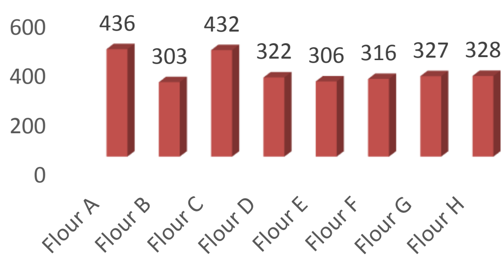


Fig. 3.3: Texture preference of the different Flours

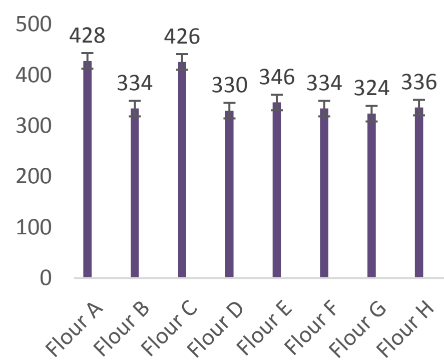
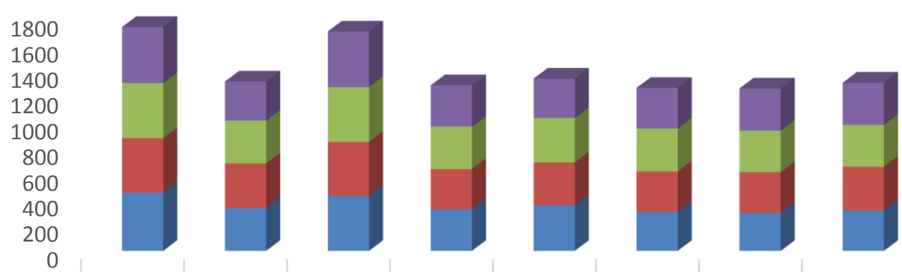


Fig. 3.4: Aroma preference of the different Flours



	Flour A	Flour B	Flour C	Flour D	Flour E	Flour F	Flour G	Flour H
Texture	436	303	432	322	306	316	327	328
Aroma	428	334	426	330	346	334	324	326
Colour	426	348	420	314	336	318	318	342
Appearance	453	334	430	324	354	302	296	314

Fig. 3.5: Overall Flour preference of the different Flours

Table 3.6 Descriptive Statistics of the Flour samples

Flour sample	Mean	Std. Dev.	Minimum	Maximum
Flour A	435.75	12.28	426.00	453.00
Flour B	329.75	19.02	303.00	348.00
Flour C	427.00	5.29	420.00	432.00
Flour D	322.50	6.61	314.00	330.00
Flour E	335.50	21.00	306.00	354.00
Flour F	317.50	13.10	302.00	334.00
Flour G	316.25	14.01	296.00	327.00
Flour H	327.50	11.47	314.00	342.00
Total	**351.47**	**48.84**	**296.00**	**453.00**

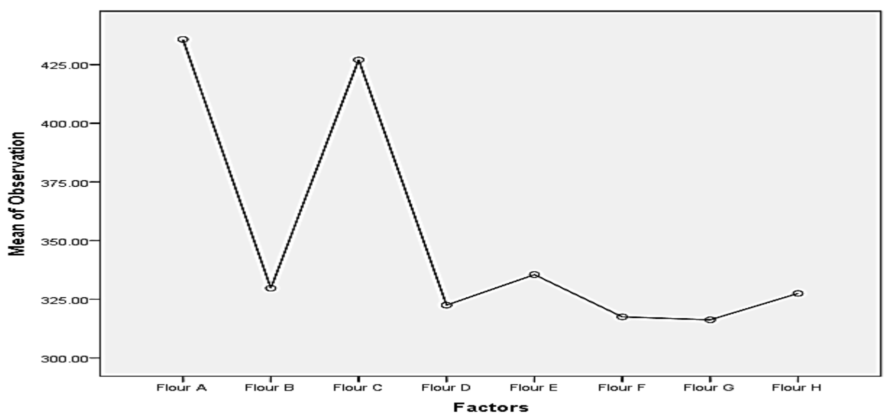


Fig. 3.6: Mean Plot of the different Flours.

Conclusion

The result indicated the presence of flavonoids, tannin and polyphenol in water yam irrespective of solvent used. Glycoside, alkaloids, steroids and saponin were found to be present in the different solvents used in varying concentrations. It also showed the presence of flavonoid, glycoside and tannin in aerial yam. The proximate analysis confirms that water yam (68.5%) and aerial yam (62.25%) contains predominantly water in its raw forms. It also showed that other proximate compositions are present in varying quantities. The Hedonic test results showed wide acceptability of the colour, aroma, texture and general appearance of both blanched and unblanched samples of the yam species. However, the blanched yam species dried with convective hot air dryer were more acceptable than the solar dried samples.

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