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Research Article

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A Comparative Quality Evaluation of White Yam (Dioscorea Rotundata) and Water Yam (Dioscorea Alata) Chips as African Fries

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Abstract

This study was conducted to evaluate the quality characteristics of Dioscorea rotundata and Dioscorea alata as alternative to potato in French fries production and effect of frying time on the quality index and acceptability of resultant yam chips. The yam chips were pretreated by blanching for 10minutes at 90°C, and soaking in 5% citric and sodium metabisulphite acid solution for a period of 30minutes. The treated blanched yam chips were deep fried at 170°C for 21 minutes, but the chips were withdrawn at intervals of 3minutes to determine the moisture content, textural properties and sensory attributes of the chips.

The proximate composition of the fried chips was evaluated using established procedures of the Association of Official Analytical Chemists (AOAC). The textural properties such as Peak force and deformation at break of the deep fried chips were determined using a Universal Instron testing machine.The fried yam chips were subjected to sensory analyses (colour, crispiness, mouthfeel, taste, overall acceptability) using a 9- point Hedonic scale. Data obtained were subjected to Analysis of Variance ANOVA and means separated by Duncan Multiple Range test.

The result of the proximate analysis on the two varieties of raw yam tubers showed that wateryam (D.alata) had a significant ($p>0.05$) higher moisture content (69.49%) and protein values (7.60%) than white yam (D. rotundata) having 64.84% and 4.55% respectively).D alata had a significant ($p>0.05$) high fibre content of 2.34 % compared to D rotundata which had 1.42%. On the other hand, D. rotundata, has greater amount of carbohydrate (26.70%) than D. alata with (20.18%).

A significant ($p< 0.05$) lower moisture content existed for the fried chips samples from 3 minutes to 18 minutes for both white yam (54.32-32.76%) and water yam (61.32- 31.03%).Frying time had a significant lowering effect on the moisture content of fried chips. White yam (D. rotundata) showed significantly ($p>0.05$) high force at peak than wateryam (D. alata), with values of 26.30N, and 7.30N respectively. Results showed that frying time had significant ($p>0$ 05) effects on the peak force and deformation at peak of the fried yam chips for the two varieties. The pre-treatments given to the yam chips produced from the two yam varieties, gave some desirable sensory characteristics. The sensory scores showed that fried white yam chips had a significant ($p>0.05$) highest score (7.14) compared to wateryam fried chips (6.39) at 21st minute frying time even in terms of colour, taste, mouthfeel and overall acceptability.

The use of yam as a substitute for potato in French fries production would make fries to be more affordable and promote its utilization in French fries production.

Keywords: Dioscorea rotundata, Dioscorea alata, French fries, Frying time, Proximate, Textural properties and Sensory attributes

Introduction

Yam (Dioscorea spp.) is a multi-species, tuber crop that is cultivated widely in the tropics and subtropics. Over 90% of world yam production occurs in the yam belt of West and Central Africa, with Nigeria alone accounting for about 71% of the world's total. Of the 600 known species of yams, only six are edible or food yams. Dioscorea rotundata and D. cayenensis (both known as Guinea yam) are the most popular and economically important yams in West and Central Africa where they are indigenous, while D. alata (referred to as water or greater yam) is the most widely distributed species globally. The crop is of major importance in the diet and economic life of people in West Africa, the Caribbean islands, parts of Asia, and Oceania. Yam is an elite crop, preferred over other root and tuber

crops of West Africa and a choice during ceremonies and festivities.

Dioscorea rotundata Poir (white yam) is a species of yam native to Africa which produces edible tubers and has economic importance (Omonigho and Ikenebomeh, 2000) [1]. It is one of the most important cultivated yams popular and most consumed in Cameroon (Lape and Treche, 1994) [2]. It has a long shelf-life which does not affect its cooking and organoleptic qualities and can be available all year round. Water yam (Dioscorea alata), on the other hand, is the most economically important yam species which serve as a staple food for millions of people in tropical and subtropical countries. D. alata is a crop with potential for increased consumer demand due to its low sugar content necessary for diabetic patients. Water yam (Dioscorea alata) has been a lesser choice compared to white and yellow yams. Yam tubers consist of about 21% dietary fiber and are rich in carbohydrates, vitamin C, and essential minerals. Yams generally have high moisture content; the dry matter is composed mainly of starch, vitamins, sugars and minerals. Yam is an excellent source of starch, which provides calorific energy. It also provides protein three times more superior than the one of cassava and sweet potato. Nutrient content varies with species and cooking procedures. The most common cooking methods of yam in the Western and Central Africa are boiling, roasting and frying. Processing of the tubers into a more stable product will increase shelf life and availability, and enhance its utilization.

In recent years, French fries have become popular in fast food restaurants in many tropical and, developing countries where yams are also produced in large quantities. This is as a result of consumer's growing interest and preference in convenience foods. Potatoes, which are used for French fries production, are not locally available in many of these countries thus making them an expensive food.

The use of yam as a substitute for potato in French fries production, will not only make the fries more affordable, but will also help to reduce post-harvest losses and increase its utilization (Quansah et al. 2010) [3]. The quality of French fries depends on the properties of the raw materials as well as the processing conditions. Some attributes of French fries of much importance to the consumer is the color, texture and oil absorption. The potential utilization of yam for French fries production and distribution using convenience packaging has been studied by Tortoe, Quansah [4].

One potential problem in processing of yam into chips or fries is the discolouration and darkening of the product and this is undesirable for the quality of the finished product. This has been attributed to enzymic browning reactions as a result of the presence of water soluble phenolic substances in yam[5]. Various approaches have been employed in preventing browning of yam during processing. These approaches include inactivating the phenolase (by blanching, use of inhibitors), rendering the conditions unfavourable to enzyme action (lowering pH),minimizing contact with oxygen and use of antioxidants [5,6].The objectives of this study however, was to compare the quality evaluation of Dioscorea rotundata and Dioscorea alata as alternative to potato in French fries production.

Materials and Methods

Materials

White yam (Dioscorea rotundata), and water yam (Dioscorea alata) were obtained from a local market in Lagos, Nigeria.

Methods

Proximate analysis of raw materials

The proximate analyses of the raw materials were carried out using established procedures of the Association of Official Analytical Chemists (AOAC, 2010) [7]. Specifically, parameters such as crude protein, crude fibre, ash, fat, and percent carbohydrate were determined. Also, percent total solids were determined.

Processing of Yam

The yam tuber was manually peeled using stainless steel knife, washed, and chipped into sizes of 10mm thickness, 10 mm width, and 60 mm in height. The yam slices were blanched for 10 minutes at 90^{o}C, and treated with 5% food grade Sodium metabisulphite and citric acid for a period of 30minutes. The treated blanched yam slices were drained off the solution, salted using sodium chloride, and deep fried at 170^{o}C for 3-21minutes. The fried chips were then drained off the adhering oil, cooled and packaged in High density polyethylene bags.

Determination of Textural properties of Deep fried chips

The textural properties of the deep fried chips were determined using a Universal Instron testing machine(Testometric M500). Parameters such as peak force and deformation at break were majorly determined.

Moisture loss during frying

During frying of the chips from the different yam varieties, the chips were withdrawn at intervals of 3minutes to determine the moisture content of the chips.

Organoleptic qualities of fried chips

The different fried chips were subjected to organoleptic tests using semi-trained panelists in the Institute based on established procedures. A 20 member panelist was used to evaluate the fried chips using 9-point hedonic scale ranging from 1(representing 'dislike extremely) to 9 representing (extremely acceptable). Parameters determined were taste, after taste, mouth feel, color, appearance, crispiness, and overall acceptability.

Statistical Analysis

Data obtained were subjected to statistical analysis using SPSS (Statistical Package for the Social Sciences) Version 16 for PC Windows. All data were subjected to Analysis of Variance (ANOVA) with the mean values separated by Duncan's Multiple Range Test (DMRT) at 5% level of significance.

Results and Discussion

The result of the proximate analysis on the two varieties of yam showed that wateryam (D.alata) had a significant ($p>0.05$) higher moisture content (69.49%) and protein values (7.60%) than white yam (D. rotundata) having 64.84% and 4.55% respectively). These values were in agreement with previous works carried out by Oyenuga, and Onwuka and Ihuma (2007). There was no significant difference in the crude fat content of the two varieties, D alata (0.54%) and D rotundata (0.50%) considered in this study. D alata had a significant ($p>0.05$) high fibre content of 2.34 % compared to D rotundata which had 1.42%. These values show that the D. alata variety can be regarded as more nutritious in terms of the protein and fibre contents. On the other hand, D. rotundata, has greater amount of carbohydrate (26.70%) than D. alata with (20.18%).

Table 1: Comparison of Proximate composition of D. alata and D. rotundata

Component (%)	D. alata	D. rotundata
Moisture	69.49[a]	64.84[b]
Crude protein	7.60[a]	4.55[b]
Crude fat	0.54[a]	0.50[a]
Crude fibre	2.34[a]	1.42[b]
Ash	2.75[a]	2.25[b]
Carbohydrate	20.18[a]	26.70[b]

Means values in the same row with the different superscript are significantly different ($p<0.05$).

Moisture Lossduring Deep Frying of Raw Yam Chips

Frying was both a cooking and a dehydration process, and it involves simultaneous heat and moisture transfer process in which heat is transferred by the hot oil into the yams during frying and provided enough energy for vaporization of moisture from the yam chips; while oil is absorbed simultaneously [8].During frying process, it is observed that some chemical, physical and sensory characteristics of foods are usually modified. The chemical changes that occurred during this process include gelatinisation of starch, denaturation of protein, enzymes inactivation and flavour development while the physical changes include softening of tissue, decrease in moisture content, increase in oil content, formation of colour, crust and shrinkage and swelling of the product [9].

Figure 1 showed the effect of frying time on moisture content of raw yam chips. Results indicated that the moisture content of fresh D. rotundata (white yam) and D. alata (water yam) was 73.84% and 80.19% respectively. A significant ($p< 0.05$) lower moisture content existed for the fried chips samples from 3 minutes to 18 minutes for both white yam (54.32-32.76%) and water yam (61.32- 31.03%). This implies that the frying time is inversely proportional to the moisture content which means that frying time had a significant lowering effect on the moisture content of fried chips. This is in consonance with the work of Manjunatha, who reported an exponential decrease of moisture content of Gethi (Dioscorea kamonensis Kunth) with frying time at varying temperatures [9].

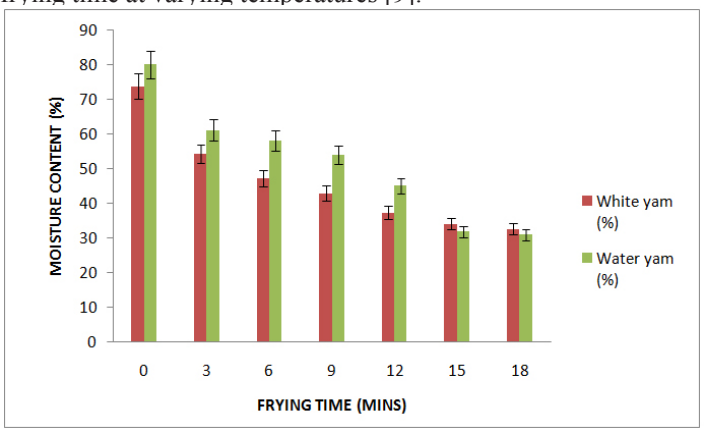


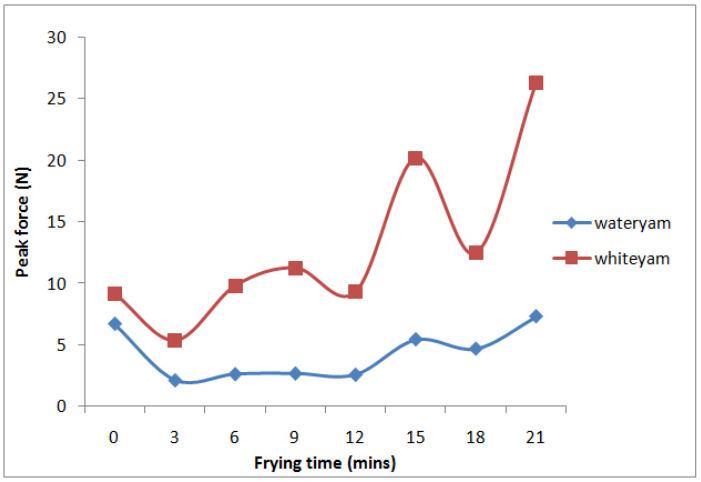
Figure1: Effect of Frying Time on Moisture Content of Raw Yam Chips

Textural properties analysis

Textural quality is an important attribute for the acceptability of fries and it is influenced by both raw materialssuch as starch content, size of starch granules, cell wall polysaccharides, nonstarch polysaccharides, pectin substancesand process conditions such as frying time and temperature. It is a quality index for consumer acceptability of fried chips and fries.Hardnessis one of the textural characteristics that depends on physical and chemical changes such as release of intracellular materials, starch gelatinization, dehydration, and crust formation, breakdown of adhesive forces between cells, water evaporation, and tissue expansion [10].

The peak force is the force, at which a sample cracks, crumbles or shatters and this is also known as fracturability. It is a measure of hardness of the chips because it is the peak force of the first compression of the product [11,12]. It is the first break in the force-deformation curve. The frying time had significant ($p>0$ 05) effects on the textural properties of the fried yam chips, and these effects were also noticed between the two yam varieties considered in this study.

Fried white yam(D. rotundata)chips showed significantly ($p>0.05$) high force at peak than wateryam (D. alata), with values of 26.30N, and 7.30N respectively. This could be as result of lower moisture content of fried white yam chips as compared with wateryam fried chips. Result indicated that greater force was required to break the yam chips from D. rotundata (white yam) than was required to break D. alata (water yam). The study indicated that as the frying time increases, the peak force increased, though a sharp decrease was observed at the twelfth and eighteenth minutes of frying for white yam as shown in figure 1. The initial rise of the peak force from 3minutes to 9 minutes could be attributed to lower moisture content which resulted into starch gelatinization and softening of the tissue. However, there were no significant difference between the moisture content of fried chips at the 15th and 18th minutes but at the 12th minutes a sharp decline in the peak force was observed.



It has been generally reported that textural properties of fried starch based products are influenced by gelatinization of starch during the process, sugar content and the strength of the cell wall [13].

The effect of frying time on deformation at peak and deformation at break for fried water yam chips was presented in Figure 2. The deformation at peak ranged from 3.824 to 13. 057mm with the highest value obtained from frying time of 21minutes. This result indicated an increasing trend of deformation at peak with increasing

frying time. In the same vein, the deformation at break increased with frying time up to 15 minutes before a sharp reduction occurred at the 18 minutes of frying.

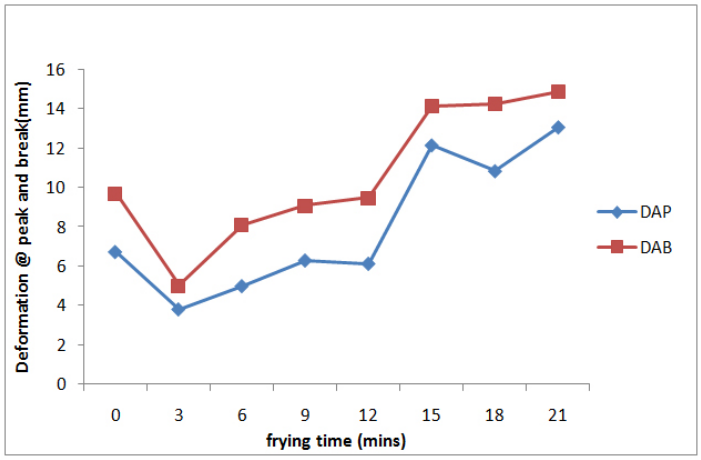


Figure 2: Effect of Frying Time on Textural properties of Water Yam Chips

KEY: DAP - Deformation at peak, DAB - Deformation at break

The effect of frying time on deformation at peak (DAP) and deformation at break (DAB) for white yam was indicated inFigure3. The deformation at peak for white yam ranged from 1.826 -5.928mm. As the frying time increases the deformation at peak and break increases from 3 mins to 12 mins but a decreasing trend was observed from 15 mins to 21 minutes. This might be due to starch gelatinization, increased oil uptake and swelling of the chips. This is revealed in the moisture content of fried chips which showed no significant difference at the 15th and 18th minutes (fig 1). This was corroborated by Nourian and Ramaswamy,(2003) who recorded similar trend in fried potato fries [14].

The deformation at break (DAB) for white yam and water yam were 6.099mm and 14.830mm respectively, showing that there was more deformation caused on the fried water yam than the fried white yam chips. This might be attributed to the structural and varietal difference of the yam involved in the study. The structural degradation which is as a result of low moisture content and prolonged frying time of 15 minutes was explained by deformation at peak and break. The reduction from 15 to 21 minutes might be as a result of higher extent of gelatinization and crust development. A similar trend was reported by Pedreschi and Moyano (2005) who studied the oil uptake and texture development of fried potato slices.

Yam varieties have varied physicochemical properties that affect their product development applications. These observed differences in peak force and deformation at peak and at break might be as a result of varietal difference. This was also asserted by Otegbayo who recorded varying values in the dry matter content, starch content, pectin and fat contents among six different D rotundata varieties [15]. Additionally, it has been reported that starch properties such as swelling index, gelatinization temperature/time, and pasting properties of yam products vary with different varieties (15,16).

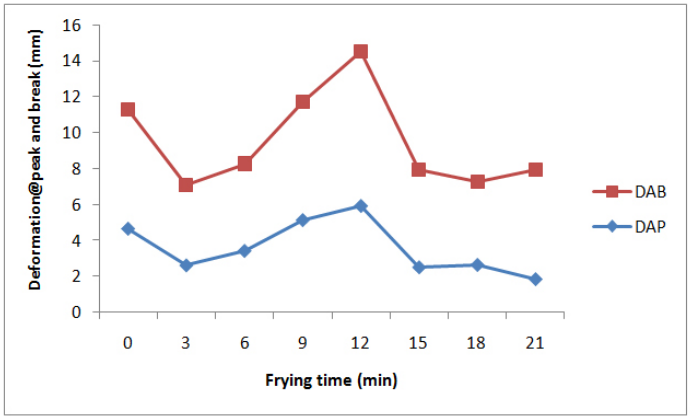


Figure 3: Effect of Frying Time on Textural properties of White Yam Chips

Sensory Evaluation of DeepFried Yam Chips

The pre-treatments given to the yam chips produced from the two yam varieties, gave some desirable sensory characteristics. The heat treatment that was given to the raw yam chips ie blanchingthat positively influenced the sensory attributes of the resulting Deep-fried yam chips. Sensory scores obtained in this study indicated that D. rotundata was more preferred in terms of colour, taste mouthfeel, and overall acceptability. The frying time of 21 minutes gave the best results, indicating that it was at that frying time that it was most preferred by consumers. The white yam (D. rotundata) was also more acceptable in terms of crispiness and textureparameters as compared to wateryam(D. alata). Crispiness is an important attribute desirable by consumers and a quality index of all fried products.This study showed that fried white yam chips had a significant ($p>0.05$) highest score (7.14) compared to wateryam fried chips (6.39) at 21st minute frying time.The overall acceptability for wateryam fried chips ranged from 5.29 - 6.39 with the highest value obtained in 21st minute frying time while, on the other hand white yam had its overall acceptability ranging between 6.64 - 7.43 with the significant highest value in the 21st minutes frying time.

Table 2: Mean Sensory Scores of Fried Yam Chips

	Sensory Scores								
	Frying Time (Mins)	**Colour**	**Taste**	**After - Taste**	**Crispiness**	**Texture**	**Flavour**	**Mouth - Feel**	**Overall Acceptability**
*ATY	3	6.29^{a}	5.43^{a}	5.57^{a}	4.57^{a}	5.07^{a}	5.36^{c}	5.71^{b}	5.29^{c}
	6	5.64^{a}	5.29^{a}	5.29^{a}	4.93^{a}	5.43^{a}	5.36^{c}	5.14^{c}	5.86^{b}
	9	5.43^{a}	6.07^{a}	5.86^{a}	5.43^{a}	5.79^{a}	5.71^{b}	5.86^{bc}	6.00^{b}
	12	5.79^{a}	6.14^{a}	6.21^{a}	5.29^{a}	5.64^{a}	6.21^{ab}	6.14^{a}	6.07^{b}
	15	5.21^{a}	6.07^{a}	5.86^{a}	5.57^{a}	5.93^{a}	6.07^{b}	5.86^{b}	6.07^{b}
	18	4.57^{a}	6.43^{a}	6.57^{a}	6.00^{a}	6.14^{a}	6.43^{ab}	6.43^{a}	6.07^{b}
	21	6.21^{a}	6.14^{a}	6.14^{a}	5.93^{a}	6.21^{a}	6.71^{a}	6.07^{a}	6.39^{a}

*HTY	3	7.86^{c}	6.36^{a}	6.29^{c}	5.71^{a}	6.21^{bc}	6.07^{ab}	6.21^{a}	6.86^{c}
	6	7.07^{a}	7.00^{b}	6.79^{b}	6.43^{c}	7.07^{a}	6.50^{bc}	6.79^{a}	7.00^{ab}
	12	7.00^{a}	6.43^{a}	6.50^{bc}	6.07^{ab}	6.29^{bc}	6.50^{bc}	6.71^{a}	6.93^{a}
	15	7.43^{b}	7.36^{a}	7.14^{a}	6.36^{c}	6.79^{b}	6.43^{bc}	7.07^{a}	7.00^{ab}
	18	7.29^{a}	6.64^{a}	6.14^{c}	6.64^{d}	6.71^{b}	6.00^{ab}	6.50^{a}	6.64^{c}
	21	7.29^{a}	7.29^{b}	7.21^{a}	7.14^{e}	7.43^{a}	7.36^{c}	7.07^{a}	7.43^{a}

Values in the same column with the same superscript are not significantly different at 5% probability level.
*ATY- D alata*HTY- D rotundata

Conclusion

The outcome of this study revealed that yam like potatocould be used for the production of quality and acceptable French fries. However, blanching at 90^{o}C for 10 minutes, and citric acid and metabisulphite treatments employed in the study help to inhibit enzymatic browningin the product also improve the sensory attributes of the produced yam chips. Frying time which is a critical processing factor for fried chips exhibited a significant effect on the overall acceptability of the resultant fries. It is one of the quality parameters of the fries as determined by moisture content, fracturability and the deformation at break. The study showed that fried white yam chips have better frying characteristics than the fried water yam chips. Thus the fries from white yam (D. rotundata) were crispier than those made from wateryam (D. alata) also more accepted on the sensory scale than the fried chips from D alata.

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