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Development and Production of Fermented Flour from Sweet Potato (*Ipomea Batatas* L.) as a Potential Food Security Product

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Abstract: The research investigated the possibility of producing acceptable fermented sweet potato (*Ipomea batatas* L.) flour. Raw sweet potato was size reduced, fermented (submerge) for 72 hours, drained, dried and milled to produce fermented sweet potato flour. The proximate composition of the final fermented flour was determined and compared with that of the raw sweet potato. The result revealed that the crude protein (4.27%) and carbohydrate (84.81%) contents of the fermented sweet potato flour were significantly higher ($P \leq 0.05$) than in the raw sweet potato which were 1.86% and 31.11% respectively. Also, the fat, crude fibre and ash contents of the fermented flour were significantly lower ($P \leq 0.05$) than in the raw sweet potato which were 0.21%, 0.06% and 1.78% for fermented sweet potato flour as against 0.59%, 0.73% and 2.52% for the raw sweet potato flour. During the fermentation period, the microbial profiles of the fermenting medium increases with increase in time while the pH of the medium decreases with time. Pasting properties of the flour showed that the peak viscosity was attained at 278.67 RVA with pasting temperature of 80.35 °C, pasting time of 5 minutes, final viscosity of 391.58 RVA and breakdown viscosity of 78.53 RVA. The study revealed the nutritional quality as well as the pasting characteristics of the fermented sweet potato flour that has a great influence and implication on its utilization as a food security crop.

Key words: Sweet potato, fermentation, proximate properties, pasting properties, food security.

1. Introduction

Sweet potato (*Ipomea batatas* L.) belongs to the family *Convolvulaceae*; and the name applied to perennial, trailing herbs of the morning glory family. The plant, which is native to tropical Americas, is cultivated on sandy or loamy soils throughout many warm regions of the world. Two main types are commonly cultivated, a dry, mealy type and a soft, light-to-deep yellow, moist fleshed type. It is a hardy crop that thrives in soil that cannot sustain yam production [1, 2].

In the tropics, sweet potatoes are consumed of marketed soon after harvesting because of their shelf life that can be as short as one week [3, 4]. Sweet potato is highly nutritious in terms of Vitamins A and C, and minerals such as calcium and potassium [5] than other root crops particularly the dark orange and yellow-fleshed varieties [3, 6].

In Nigeria, orange-fleshed sweet potato is widely processed into flour and found to attract higher prices by consumers than from other varieties [7, 8]. The crop is well patronized as a daytime snack in schools, offices and in homes [9]. It can also be eaten boiled, fried and in roasted form. In addition, it can be sliced, dried in the sun and ground to give flour that remains in good condition for a long time [10]; and as well be used as a dough conditioner in bread manufacturing

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and as a major raw material in snack and noodles production [11] as well as a stabilizer in the ice cream industry [12].

Sweet potato has been processed into prickles and consumed as lacto-juices by processing it with lactic acid bacteria as the fermenting organism and the juice produced has been reported to be very rich in minerals and vitamins [13, 14]. Sweet potatoe has also been processed into chips in much the same way as Irish potato [15, 16]; and used as a major source of raw material for feed production for piggery [17] in Asia particularly in countries like China and Japan etc. The crop also has large potential as a carbohydrate base in baby food production [18].

There is however little or no work done on the fermentation of sweet potato into flour suitable as meal for home consumption. This study therefore investigates the possibility of fermenting sweet potato into flour as a means of promoting food and nutrition security in the developing countries. It is believed that a successful development and production of good quality flour will eventually be promoted in the villages where sweet potatoes are grown in abundance. Eventually this product will assist in minimizing postharvest losses associated with sweet potato and ensure increased earnings by sweet potato farmers particularly in the developing countries in Africa. It will also lead to production of novel food products from sweet potato crops thus assisting in minimizing food insecurity problems particularly in most developing African countries where hunger, poverty and starvation are highly prevalent.

2. Materials and Methods

2.1 Raw Materials Used

Yellow-fleshed sweet potatoes were obtained from Ile-Epo market, Lagos, Nigeria.

2.2 Methods

2.2.1 Preparation of Fermented Sweet potato Flour

The sweet potatoes were washed to remove adhering soil particles and peeled. The peeled tubers were chipped into slices (4-5 mm) and soaked in portable water for a period of three days (72 hours). After this period has elapsed, the fermented chips were drained and dried in a cabinet drier (Mitchel, Model SM220H) at 65 °C for 9 hours and milled into flour (≤ 250 μm)

2.2.2 Proximate Composition of Raw Sweet Potato and Fermenting Flour

This was determined in the raw sweet potato and the fermenting sweet potato flour as described by AOAC [19]. Parameters such as moisture content, crude protein, crude fibre, ash, fat and carbohydrate were determined in the sample.

2.2.3 pH Determination

The pH of the fermenting chips was determined from 0-4 days using a pH meter (Jenway, Model-3505) which has been previously adjusted with buffer solutions of pH 4 and 8.

2.2.4 Microorganism Determination

This was determined in the fermenting sweet potato using procedure described by Destroiser [20] and Sobowale et al. [21].

2.2.5 Pasting Properties

The fermented sweet potato flour was subjected to pasting properties determination using rapid visco analyzer (RVA) method as described by Adebowale et al. [22] for pasting temperatures, pasting time, peak viscosity, final viscosity etc.

2.2.6 Data Analysis

The data generated were subjected to analysis of variance using SPSS package version 10 and data were assessed by analysis of variance (ANOVA).

3. Results and Discussion

Table 1 shows the proximate composition of raw sweet potato and fermenting dried sweet potato flour. The moisture content was high in the raw sweet potato with a value of 63.19% and 8.87% in the corresponding dried fermented flour.

There was a reduction in the ash content in the raw tubers from 2.52% to 1.78% in the dried fermented

Table 1 Proximate composition of dried fermented sweet potato flour and raw sweet potato.

Parameter	Raw sweet potato	Dried fermented sweet potato
Moisture (%)	63.19[a]	8.87[b]
Ash (%)	2.52[a]	1.78[b]
Crude fibre (%)	0.73[a]	0.06[b]
Crude protein (%)	1.86[b]	4.27[a]
Fat (%)	0.59[a]	0.21[b]
Carbohydrate (%) (By difference)	31.11[b]	84.81[a]

Values are average of three determinations.
Values in the same row not followed by the same superscript are significantly different ($P < 0.05$).

flour. The crude fibre content was higher in the raw tuber, which was 0.73% than in the dried fermented flour that was 0.06%. However, the crude protein in the raw tubers was lower (1.86%) than that in the dried flour (4.27%). The fat content in the raw tuber was 0.59% while it was 0.2% in the dried fermented sweet potato flour. The carbohydrate content in the raw tubers was 31.11% as against 84.81% in the dried fermented flour.

The results of the proximate composition of the raw sweet potato and fermented dried sweet potato flour showed that considerable level of water has been removed as the sweet potato was processed from the raw tuber into fermented flour. Consequently, the moisture content in the fermented dried sweet potato flour was low enough for proper storage [20, 23].

In addition, there was a reduction in the ash content of the fermented dried sweet potato flour as compared with the starting raw sweet potato crop. It is believed that the processes of fermentation as well as drying may have contributed to reduced level of ash content in the fermented flour. It is however possible that some of the available minerals in the raw potato were utilized by the fermenting organisms in the sweet potato mash [24].

Heat produced during the drying operation (i.e. drying the fermented mash) could also bring about a reducing effect on some minerals such as calcium, phosphorus and iron, which are strongly adversely affected by heat, and this may resulted in the reduction in the ash content of the dried fermented sweet potato flour [23]. The crude fibre content of the fermented dried flour was also lower than that in the raw tuber, and this may be due to the activity of the fermenting organisms and on the processing technique employed as the peels were removed prior to fermentation. The peels may also contribute to the crude fibre of the sweet potato.

The crude protein was higher in the fermented dried sweet potato than in the raw sweet potato possibly due to the concentration effect of drying due to the removal of water [24].

The fat content in the fermented sweet potato was lower than in the raw sweet potato and this may be due to the processing technique used in which after fermentation of the sweet potato, it was pressed mechanically to remove water. During the process of removing water mechanically, fat and other water-soluble contents may be released and removed as well. Some microorganisms may also require some level of fat to thrive [24].

Generally, bacteria, yeast and mould require nutrients for growth and development [20, 24]. This may partially account for reduced level of ash content in the fermented flour as compared with the raw sweet potato and may also be partially attributable to process of peeling, washing, soaking in water and the entire fermentation process as well as dewatering of the chips.

The starch content in the dried fermented flour was much higher than in the raw sweet potato and this is likely due to the concentration effect of drying [20, 25].

Table 2 shows the microbial activity in the fermenting sweet potato chips. Total viable count increased from 0 to 72 hours of processing from 4×10^2 to 82×10^6 cfu/g, yeast and mould count also increased from 0 cfu/g at zero hour to 64×10^6 cfu/g at 72 hour. Lactic acid bacteria count also increased from 0 at zero hour to 96×10^6 cfu/g at 72 hour. However, there was no coliform growth between the 0 hour and 72 hours of fermentation.

Table 2 Microbial population of fermented sweet potato.

Fermentation Days (Hrs)	Total viable count (cfu/g)	Yeast/mould count (cfu/g)	Coliform count (cfu/g)
0	4×10^2	Nil	Nil
24	17×10^3	5×10^3	Nil
28	36×10^5	28×10^5	Nil
72	82×10^6	64×10^6	Nil

Values are average of three determinations.

The microorganisms responsible for the fermentation of the root and tuber crops were identified to be mainly lactic acid bacteria, yeast and mould; with lactic acid bacteria being the predominant micro-organisms [13, 14, 26, 27]. Lactic acid bacteria as well as some yeast and mould e.g. *Geotricum candida* have been reported to be primarily responsible for the fermentation of starchy crops such as cassava into some commonly consumed fermented products such as “Gari”, “Lafun” and Fufu [25, 28] which are widely eaten in some countries of West Africa [22].

Fig. 1 depicts the pH profile of the fermenting sweet potato, which shows that the pH reduces from 6.32 at 0 h to 4.11 at 72 h of fermentation.

The pH changes in the fermenting sweet potato showed that as the time of fermentation increases, the isolated microorganisms, i.e. lactic acid bacteria, yeast and mould as well as the total viable count increased while the pH value decreased from day 0 to day 4. Previous workers on fermented tubers such as cassava have reported that lactic acid as well as some flavouring compounds such as aldehydes [22, 29] was produced during fermentation and that the pH reduction in the fermenting root and tuber crops was essentially due to the presence of lactic acid bacteria [21, 22, 30, 31].

Table 3 shows the pasting properties of dried fermented sweet potato flour. The peak viscousity in the flour was 278.67 RVA at peak time of 5 minutes. The breakdown viscousity was 78.83 RVA, trough viscousity was 199.83 RVA, the final viscousity was 391.58 RVA, set back viscousity was 191.75 RVA and the pasting temperature was 80.35 °C.

The peak viscosity obtained upon reconstituting the fermented sweet potato flour was quite high and lower than that reported for sweet potato starch [32], which may be because of other constituent present in the sweet potato flour apart from starch. The set back and break down viscosity were also high. It clearly shows that the fermented flour upon gelatinization will not readily retrograde particularly if it is intended for a dough-like meal. The peak time also was low and similar to that reported for sweet potatoes starch showing that the starch in the fermented sweet potato flour imbibes water readily gelatinize readily, and within few minutes a dough-like meal can be obtained, which is a desirable quality attribute particularly in terms of convenience for the ultimate consumers of the product. Also, the final viscosity obtained for the dried fermented sweet potato flour was quite high and was comparable to that of the fermented cassava flour [22, 28]. This shows its potential high suitability for meal as this is a desirable quality attribute for dough-like meal which often involves reconstitution of the flour in water, cooking with steaming until smooth dough of desired consistency is obtained [22, 28]. The dough can be ultimately consumed with soups, stews as desired.

4. Conclusion

This study has revealed the potentials and possibilities of utilizing fermented sweet potato flour as meal. This product could serve as an alternative to the popular fermented cassava flour that is conventionally utilized domestically in form of meal. The process technology involved required minimum processing equipment of fermentation vessels, peeling and chipping equipment as well as a solar/tray/cabinet

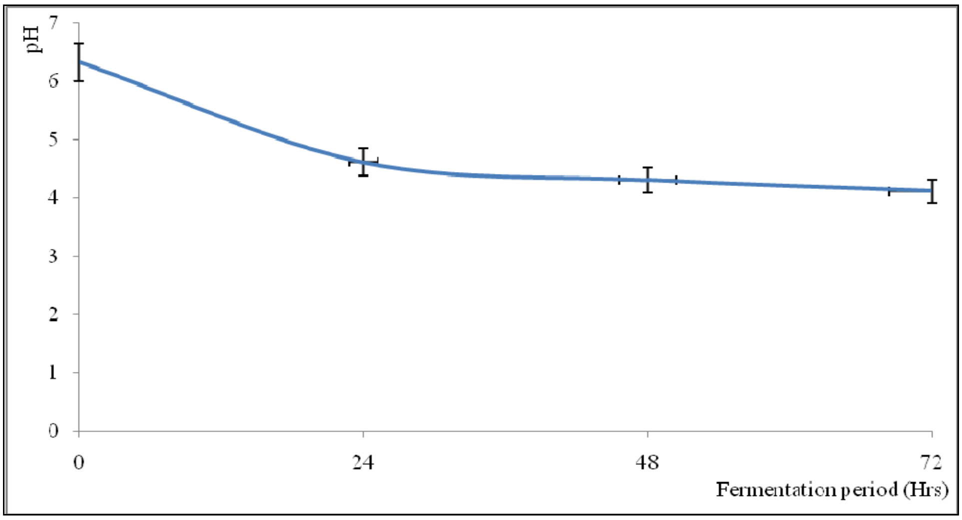

Fig. 1 pH profile of fermenting sweet potato chips.

Table 3 Pasting properties of fermented sweet potato flour.

Parameter	Value
Peak 1 (RVA)	278.67
Trough 1 (RVA)	199.83
Breakdown (RVA)	78.83
Final viscosity (RVA)	391.58
Set back viscosity (RVA)	191.75
Peak time (mins)	5.10
Pasting temp (°C)	80.35

dryer as well as a hammer mill to pulverize the fermented dried chips into flour of desirable particle size. The fermented sweet potato flour could be introduced in the menu-list in places where hunger, food and nutrition insecurity are highly prevalent.

Further research in the areas of the effect of the processing variables like soaking time, size of soaked materials and drying temperatures is currently being carried out as this will help in optimize the processing parameters with the sole aim of product that would be acceptable by the consumers. In addition, isolation and characterization of microorganisms responsible for the fermentation of the sweet potato chips is also being investigated.

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References

[1] D. Zhang, W.W. Colins, M. Andrade, Genotype and fertilization effects on trypsin inhibitor activity in sweet potato, Hort. Science 33 (2) (1998) 225-228.

[2] J.A. Ikeorgu, Root and tuber crops of Nigeria, Production challenges and future, in: Agronomy in Nigeria, Department of Agronomy, University of Ibadan, Nigeria, 2000.

[3] V. Ravindran, G. Ravindran, R. Sivakanesan, S.B. Rajagieru, Biochemical and nutritional assessment of tubers from 16 cultivars of sweet potato (*Ipomea batatas* L.), J. Agric. Food Chem. 43 (1995) 2646-2651.

[4] H.H. Yeoh, J. Tojama, T. Kobayashi, M. Yoshimoto, O. Yamakawa, Trypsin inhibitor activities in sweet potato varieties in sweet potato varieties, in: Proceedings of the 12th ISTRC Symposium, 2000, pp. 228-230.

[5] J.A. Wolfe, Sweet Potato, an Untapped Food Resources, Cambridge University Press, New York, U.S.A., 1992, p. 643.

[6] L. Palomar, Formulation and evaluation of sweet potato and cassava chiffon cake, in: G. Scott, S. Wiersemma, P. Ferguson (Eds.), Product Development for Root and Tuber Crops, International Potato Centre (CIP), Lima, Peru, 1992, pp. 41-50.

[7] M.O. Akoroda, T. Edebiri, J.N. Egeonu, Z.A. Bello, K.M. Yahaya, The status of sweet potato improvement and promotion in Nigeria, in: Proceedings of the 13th ISTRC Symposium, 2007, pp. 158-161.

[8] O.S. Odebode, Sweet potato flour for pasta production, J. Science and Technology 25 (1) (2010) 34-38.

[9] S.R. Indrasari, S. Wibomo, P. Wheatley, C.C. Infansyah, Improved Utilization of Sweet Potato in Snack Food Home Industries in Cirebon (West Java) Focusing on (a) Kremes Traditional Snacks Food and (b) the Potential

Utilization of Sweet Potato Flour in a Range of Food Products, Final Report to UPWARD Research Institute for Rice, Sukamando, Indonesia, 1995.

[10] C. Wheatley, G.J. Scott, R. Best, S. Wieresema, Adding value to root and tuber crops, A manual on product development, Centro International de Agriculture Tropical (CIAT) Cali, Colombia, 1995, p. 168.

[11] P. Dai, C. Wheatley, S.S. Antarlima, Participatory small scale improvement for small scale sweet potato flour production in East Java, Indonesia by Research Institute for Legume and Tuber Crops, Indonesia (RLET), International Potato Centre, P.O. Box 929 Bogor, Indonesia, 2009, pp. 1-9.

[12] V. de R. Amante, Processing of sweet potato into bakery products, in: E.T.J. Rasco, V. de R. Amante (Eds.), Selected Research Papers, July 1993-June 1994, South Asia Program for Potato Research and Development (SAPPRAD), 1995, pp. 122-126.

[13] H. Smita, P.M. Parmanick, R.C. Ray, Lactic acid fermentation of sweet potato (*Ipomea batatas* L.) into pickles, J. Food Process and Preser 31 (1) (2007) 83-107.

[14] S.H. Panda, R.C. Ray, Lactic acid fermentation of beta-carotene rich sweet potato (*Ipomea batatas* L.) into Lacto juice, Plant Foods Human Nutr. 62 (2) (2007) 65-70.

[15] F. Brigato, F.G. Oliveira, F.P. Collares-Quieroz, Optimization of the deep frying process of sweet potato chip in palmolein or starch, American Journal of Food Tech. (2010) 105-107.

[16] V. Hagenimana, C. Omo, Feasibility, acceptability and production costs of sweet potato based products in Uganda, Program Report, Program 6, 2010, pp. 95-96.

[17] G.H. Scott, Sweet potato as animal feed in developing countries, Present patterns and future prospects, in: A paper presented at the FAO Expert Consultations on the Use of Roots, Tubers, Plantains and Bananas in Animal Feeding, Held at the Centro International de Agricultura Tropical (CIAT) Cali, Colombia, Jan. 21-25, 1991.

[18] A.M. Nandutu, N.K. Howell, Nutritional and rheological properties of sweet potato-based infant food and its preservation using anti-oxidants, African Journal of Food, Agriculture, Nutrition and Development 9 (4) (2009) 76-1090.

[19] A.O.A.C., Official Method of Analysis, 15th ed., Washington DC, Association of Official Analytical Chemist, 1990.

[20] N.W. Destrosier, The Technology of Food Preservation, 4th ed., BS Publisher and Distributor, India, 2004, pp. 340-363.

[21] A.O. Sobowale, T.O. Olurin, O.B. Oyewole, Effect of lactic acid bacteria starter culture fermentation of cassava on chemical and sensory characterization of fufu flour, African Journal of Biotech. 6 (16) (2007) 1954-1958.

[22] A.A. Adebowale, L.O. Sanni, S.O. Awonorin, Effect of textural modifiers on the physico-chemical and sensory properties of dried fufu, Food Science Technology Int. 11 (2005) 373-382.

[23] A.I. Ihekeronye, P.O. Ngoddy, Integrated Food Science and Technology for the Tropics, Macmillan Publishers, 1985.

[24] K.P. Talaro, A. Talaro, Foundation in Microbiology, 4th ed., Publisher McGraw Hill College, 2002.

[25] L.O. Sanni, A.A. Adebowale, S.O. Tata, Proximate, functional, pasting and sensory qualities of instant yam flour, in: A paper presented at the 14th ISTRC Symposium, Central Tuber Crop Research Institute, Trivandrum, Keralala State, India, 2006.

[26] O.B. Oyewole, S.A. Odunfa, Characterization and distribution of lactic acid bacteria in cassava fermentation during fufu production, J. Appl. Bacteriol. 68 (1990) 145-152.

[27] A. Sanni, J. Morlon-Guyot, J.P. Guyot, New efficient amylase producing strains *of Lactobacillus plantarum* and *Lactobacillus fermentum* isolated from different Nigerian traditional fermented foods, International Journal of Food Microbiology 72 (2001) 53-62.

[28] A.O. Sobowale, O.B. Oyewole, Effect of lactic acid fermentation of cassava on functional and sensory characteristic of fufu flour, J. of Food Process and Preser 32 (4) (2008) 560-570.

[29] A. Brauman, S. Keleke, M. Malonga, E. Mlambi, F. Ampe, Microbiological and biochemical characterization of cassava retting, a traditional lactic acid fermentation of foo-foo (cassava flour) production, Applied and Environmental Microbiology, 1996, pp. 2854-2858.

[30] O.B. Oyewole, Lactic fermented foods in African their benefits, Food Control 8 (1997) 289-297.

[31] S.A. Odunfa, O.B. Oyewole, African fermented foods, in: B.J.B. Wood (Ed.), Microbiology of Fermented Foods, 2nd ed., Blackie Academic & Professional, 1997, pp. 713-752.

[32] A.O. Oladebeye, A.A. Oshodi, A.A. Oladebeye, Physico-chemical properties of starch of sweet potato (*Ipomea batatas*) and red cocoyam (*Colocasia esculenta*) cormels, Pakistan Journal of Nutrition 8 (4) (2009) 313-315.