IMPROVED METHOD FOR THE PROCESSING OF YAM INTO FLOUR AND SHELF STABLE COUSCOUS, WASAWASA, AS A CONVENIENCE FOOD

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Summary

Fresh yam was processed into *Wasawasa*, a traditional yam meal, by mechanically and sun drying the yam, milling into flour and reconstituting the flour with water into *wasawasa*. The colour and taste of the *wasawasa* produced from the mechanically dried yam was like that produced from fresh yam according to the traditional taste panellists. However, the aroma was not characteristic of the traditional *wasawasa*. The overall acceptability was good for the mechanically dried *wasawasa*. The colour of the sun dried product was not however appealing according to panellists. The microbial load of the *wasawasa* produced from the mechanically dried yam was very good but quite high for sun dried products but still fell within acceptable levels.

1. Introduction

Yam is an important staple food crop in Ghana and is cultivated commercially in the forest savannah transitional zone covering the northern parts of Ashanti, Brong-Ahafo, Volta and Eastern Regions and the southern parts of the Northern Regions. Even though there are several species of yam, only six species are important as staples and account for about 95% of all food yams grown. Of these, the three most extensively cultivated in Ghana are white yam, water yam and yellow yam (Hahn *et al*. 1995).

Nearly all the yams harvested in Ghana are used directly as food with very little processed. In a survey by Ellis et al. (2002) 96% of the respondents reported that they consumed yams as boiled slices, 24% as fried yam and 25% as pounded yam or fufu. Other yam dishes reported were roasted yam and yam porridge. Apart from consuming the tubers, yam has gained importance in recent years as a non-traditional export crop in Ghana.

Despite the importance of yam in Ghana, post-harvest loss of tubers has been estimated by Akorada (1992) at 30%, and the main method of storage is in storage barns (Ellis et al., 2002). Apart from storage and immediate use of the tubers for food, processing offers a means to curtail the post-harvest loss of the produce but this is carried out on a very limited scale in Ghana. Notably, it is only in recent years that yam tubers are being processed into fufu flour by a few companies for both the local and export markets. Processing of yam and other root and tubers, helps to extend the shelf life of the product, and also presents them in a convenience form which can readily be used for food preparation in the homes. Unlike cassava which has been traditionally processed for a long time into several indigenous products, indigenous yam products are hardly known to the general populace in Ghana.

As part of the IFAD/CONRAF/IITA project on ‘Poverty alleviation and enhanced food availability in West Africa through improved yam technologies’, this project was carried out under Activity 5.2b as on-farm testing of a yam processing technology which had been developed in the sub-region. The technology developed had been transferred from Institute Togolais de Recherche Alimentaire in Togo to the Food Research Institute of the Council for Scientific and Industrial Research, Ghana for dissemination to the general public.

2. Materials and methods

2.1 Transfer of technology

Mme Djake Amouzou from Institut Togolais de Recherche Alimentaire, Togo, visited the CSIR-Food Research Institute in Accra to introduce project personnel to the product wasawasa and give a detailed description of an improved procedure for the production of yam flour, and utilisation of the flour to produce wasawasa, a yam couscous.

2.2. Brief field study

A brief field study was conducted in Accra involving visits to three local markets to investigate the availability of traditionally produced yam flour in Ghana. The study involved informal interviews of traders selling yams and yam flour to find out whether waswasa is traditionally produced in the country and the method for its production.

2.3 Production of yam flour in the laboratory

Twenty tubers of yam were purchased from the open market and divided into five lots of four tubers each. Each group of yams were peeled, washed and treated as follows: The first group of yams were sliced and blanched immediately by immersing in boiling water and boiling for 5 min. The second group were sliced under water in a large bowl and blanched. The third group were sliced into water in a large bowl of water to which the juice from six lime fruits had been squeezed for ten minutes and blanched. The fourth group sliced under water in a large bowl into which the juice for six lime fruits had been squeezed and blanched. The last group were sliced and given no further treatment. Each group of yam slices were divided into two and one portion dried in a mechanical dryer at 60 ^{o}C for 8 h. The second portion was dried on a mesh in the sun (ambient temperature ca 30 ^{o}C) for 2 d.

Each set of dried yam slices were milled in a hammer mill and packaged in polythene bags and sealed. Samples were taken for determination of colour and microbiological analysis.

2.4 Preparation of wasawasa

Based on the analysis of colour and the population of aerobic mesophiles and moulds in the differently treated yam flour samples, the best method was used for the production of yam flour for wasawasa preparation. Ten yam tubers purchased from the open market were peeled washed, sliced and dried in a mechanical dryer at 60 ^{o}C for 8 h. The dried yam slices were milled into flour in a hammer mill and used for the preparation of wasawasa

The yam flour produced in the laboratory and traditional yam flour purchased from the open market were used to prepare wasawasa by a traditional processor in the laboratory as follows; Two (2)kg of yam flour were intermittently sprinkled with water and skilfully kneaded to moisten the flour. Kneading was continued till the moistened flour began to form large granules (small balls) with diameters of about 2 mm. Kneading was continued till all the flour had formed these small balls. The granules were then steamed to obtain wasawasa.

2.5 Microbiological analysis

2.5.1 Enumeration of aerobic mesophiles and moulds

For all samples, 10 g of cassava dough were added to 90 ml sterile diluent containing 0.1 % peptone (Difco 0118-17, Becton Dickinson & Co, Sparks, USA) and 0.85 % NaCl with pH adjusted to 7.2 and homogenised in a stomacher (Lab Blender, Model 4001, Seward Medical) for 30 s at normal speed. From appropriate ten-fold dilutions, pour plates were prepared using Plate Count Agar (PCA Difco 0479-17-3, Difco Laboratories, Detroit, USA) for aerobic mesophiles, DeMan, Rogosa and Sharpe Agar (MRS, Merck 10660, Merck, Darmstadt, Germany) incubated anaerobically in an anaerobic jar with anaerocult A (Merck) for lactic acid bacteria and Malt Extract Agar (Merck 5398) containing 100 mg chloramphenicol (Sigma C-0378, Sigma Chemical Co, St Louis. MO, USA) and 50 mg chlorotetracycline (Sigma C-4881) per litre for yeasts and moulds. PCA plates were incubated at 30 ^{o}C for 3 d, MRS plates incubated at 30 ^{o}C for 5 d and MEA plates at 25 ^{o}C for 5 d.

2.5.2. Identification of moulds

Moulds were identified by morphological characteristics according to Samson et al. (1994). Isolates were inoculated at three points on Czapek Yeast Extract Agar (CYA) and Malt Extract Agar (Merck 5398) incubated in the dark at 25 ^{o}C for 7 d. Czapek Yeast Extract Agar contained g/l distilled water; 3.0, $NaNO_3$ (Merck 11,8598), 1.0, K_2HPO_4 (Sigma no P5504), 0.5, KCl, 0.5, $MgSO_4.7H_2O$ (Merck 11,5573), 0.01, $FeSO_4.7H_2O$ (Merck 11,4006), 5.0, yeast extract (Oxoid L21, Oxoid Ltd., Basingstoke, Hampshire, England), 30.0, sucrose (Sigma no S9378) and 20.0, agar (Merck 1.01614), pH 6.5. The colony diameter was measured after 5 d and colony characteristics observed. Morphological examination was carried out by staining and wetting a piece of the mould on a microscope slide with lactophenol (Merck), squashing the fruit bodies and teasing the mycelium to determine the general form of growth.

2.6 Colour measurements

The CIELAB L*, a* and b* of each of the dried slices of yam were determined using the Minolta Chromameter CR310 after they had been milled into flour. The hue angles h*, representing the degree of yellowness were calculated according to the formula $h^* = \tan^{-1} (b^* / a^*)$ (MacDougall, 1988).

2.7 Sensory analysis

A focus group interview was conducted amongst six persons three of whom were familiar with wasawasa and the other three who had never heard of the product. They were presented with wasawas prepared form the market sample of yam flour and wasawasa prepared from the yam flour produced in the laboratory. The samples were assessed informally for appearance, odour, taste and overall acceptability.

3. Results and discussion

3.1 Microbial contamination of yam flour during processing

The population of aerobic mesophiles and moulds on yam slices after they had been dehydrated by various pretreatments and drying are shown in Table 1. Mechanically drying yam slices at the elevated temperature of 60 ^{o}C resulted in products with reduced levels of microbial population as compared to sundrying. In the mechanically dried products, the population of aerobic mesophiles ranged from a level of 10^3 to 10^4 cfu/g whilst in the sundried products, the population of aerobic mesophiles were at levels of 10^7 and 10^8 cfu/g. Also with respect to the population of moulds, the mechanically dried samples recorded levels ranging between 80 and 4.0 x 10^2 whilst the sundried products had population levels ranging between 10^2 to 10^4 cfu/g. At the elevated temperature during mechanical drying, loss of moisture from the samples would be faster hence microbial growth in the samples during dehydration would be reduced drastically as the water activity is reduced to levels which will not support the growth of the various types of microorganisms. The differences in population of aerobic mesophiles in the mechanically dried samples as compared to the sundried samples were much more pronounced that in the differences in the population of moulds in the two sets of samples. This could be attributed to moulds being able to survive at a much lower levels of water activity than bacteria, hence the more rapid loss of water in the mechanically dried samples, had less effect on the total mould counts in the two sets of samples than on the aerobic mesophiles.

The various pretreatments including blanching did not appear to have much effect on the microbial population and analysis of variance did not show any significant difference between the counts of the samples at $P > 0.05$. However it is noted that the reason for carrying out the pretreatments was to improve the colour of yam flour but one would have expectedthat blanching will reduce the initial microbial load on the sliced yams but this did not appear to have been the case.

Table 1. The population of aerobic mesophiles and moulds in cfu/g in yam flour produced by different treatments and methods.

Sample	Aerobic mesophiles	Moulds[#]
Sundried		
1b	1.8×10^{7}	1.6×10^{2}
2b	8.4×10^{7}	4.3×10^{4}
3b	3.1×10^{7}	1.4×10^{3}
4b	1.0×10^{8}	6.0×10^{3}
5b	1.1×10^{8}	nd*
Mechanically dried		
Fresh yam flour		
1a*	4.8×10^{3}	4.0×10^{2}
2a	4.7×10^{3}	1.8×10^{2}
3a	3.0×10^{3}	2.1×10^{2}
4a	2.9×10^{4}	8.0×10
5a	3.7×10^{3}	1.2×10^{2}
After six months storage		
1a	1.6×10	1.7×10
2a	6.6×10^{3}	9.3×10^{3}
3a	9.0×10^{2}	8.0×10^{2}
4a	5.4×10^{4}	4.5×10^{3}
5a	1.5×10	1.7×10

not determined because colony covered the whole plate

*1 Peeled, washed, sliced, blanched and dried.
2 Peeled, washed, sliced under water, blanched and dried.
3 Peeled, washed, sliced into limewater, blanched and dried.
4 Peeled, washed, sliced under limewater, blanched and dried.
5 Peeled, washed, sliced and dried.
a Mechanically dehydrated at 60 °C in a hot air drier.
b Sundried

[#] Moulds identified after six months storage

- *Aspergillu nidulans*
- *Fusarium oxysporum*
- *Rhizopus stolonifer*
- *Sclerotium rolfsii*
- *Mucor* spp

3.2 The species of moulds present in yam flour

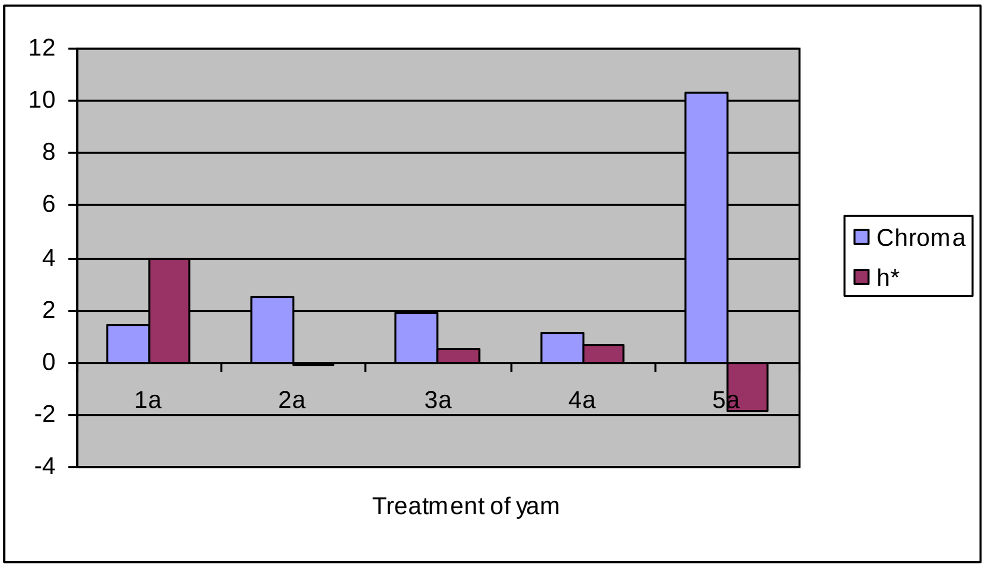
Various types of moulds were isolated from the yam chips. One type of mould grew rapidly on MEA and attained a diameter of about 6 cm after 7 days. The colonies were yellowish green with whitish margins and the colony reverse brownish. They had smooth-walled brownish conidiophores with greenish conidia heads which were columnar and bi-seriate. The vesicles were globose and the rough-walled conidia also globose. This type of mould was tentatively identified as *Aspergillu nidulans.* A second type of mould had aerial mycelium which was floccose which became whitish with age and was more intense near the surface of the medium. The colony reverse was purple in colour. They had septate micro-conidia borne on phialides on branched conidiophores in false heads which were variable in shape. The chlamydospores were hyaline and smooth-walled and this mould was tentatively identified as *Fusarium oxysporum*.

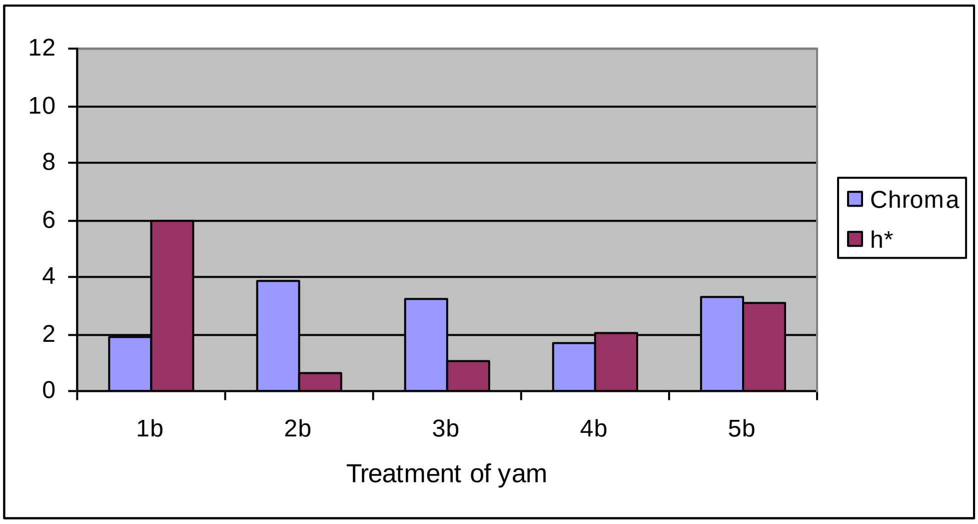
The third type of mould had a whitish colony which turned grayish-brown with time. They had irregularly shaped sporangiophores with smooth or slightly rough walled stolons whci had no chlamydospores and were opposite branched rhizoids. Their dark brown sporangia were globose to subglobose and columella globose, subglobose or ovoid. The zygospores which were brownish-black were warted with unequal suspensors. They were tentatively identified as *Rhizopus stolonifer*.

3.3 Discolouration of yam flour during processing

One of the main problems which will affect the promotion of wasawasa at people who are not familiar with the product is the dark colour of the traditional product. To improve the colour, the Volarization project had developed a procedure in which after peeling, the yam tuber is sliced under water, then blanched before it is sundried. The results of the colour analysis of the yam flours showed that though samples which were sundried had a higher degree of brightness, they also had a higher degree of h* which is interpreted as a degree of yellowness which would obviously mask the whiteness of the flour and was interpreted as an indication of enzymatic browning of the product. The higher level of brightness seen in the sundried samples could be attributed to the bleaching effect of the ultra violent wavelength in the sunlight. In the sundried samples, the sample with the lowest h* value was the one produced using the method developed by the Volarization project, i.e. sliced under water and blanched and this sample also had the highest level of brightness amongst all the sundried samples confirming that slicing under water and blanching the slices before sundrying improves the colour over the traditional process of merely peeling yam tubers, cutting them into thin slices and drying the slices in the sun.

Apart for the mechanically dried product which was not blanched, all the mechanically dried samples had lower levels of brightness than their corresponding sundried products. However in the mechanically dried products, the levels of h* were much lower in all cases than in the corresponding sundried products and in the sample which was not blanched, a negative value was obtained for h*. Undoubtedly, the mechanically dried sample which was produced by simply peeling slicing and immediately dehydrating at 60 ^{o}C gave the best results because it had the highest value for brightness 10 and a negative value for yellowness. It could therefore be conclude that in the case of mechanically drying of yam slices, blanching the slices before draining was disadvantageous with respect to the colour of the slices. This is probably because blanching caused the slices to take up water and gelatinise the starch which prolonged the drying process to the detriment of the colour obtained. This was the method which was selected for the production of yam flour for the preparation of wasawasa.





<u>Legend</u>
Chroma - degree of brightness
h* - degree of yellowness

<u>Treatment of yam tuber</u>
1 - Peeled, washed, sliced and blanch
2 - Peeled, washed, sliced under water and blanched
3 - Peeled, washed, sliced into limewater and blanched
4 - Peeled, washed, sliced under limewater and blanched.
5 - Peeled, washed and sliced
a - Mechanically dehydrated at 60 ^{o}C
b - Sundried.

Fig 1. The effect of treatment on the colour of yam slices during processing into flour

3.4. Organoleptic qualities of wasawasa

Two clear patterns emerged from the informal organoleptic assessment of the traditional and improved wasawasa. The traditional processors who were familiar with the traditional product, found the colour of the improved wasawasa better than the traditional product and the taste very close to freshly boiled yam but still preferred the traditional product because they claimed that the improved product did not have the typical aroma and taste associated with wasawasa. However panellists who were not familiar with wasawasa, showed a great preference for the improved product and commented generally that though they wouldn't eat the traditional product because of its unattractive colour and partially fermented odour, the improved wasawasa was acceptable to them because it had the taste and colour of freshly boiled yam. The closeness of wasawasa produced from yam flour produced by mechanically dried yam slices to freshly boiled yam means that it will be easy to promote wasawasa especially in areas where freshly boiled yam is popular and the traditional wasawasa is unknown.

4.0 Conclusion and Recommendations

It can be concluded from the results that *Wasawasa* made from yam flour produced by mechanically dried yam slices tasted just like freshly boiled yam, microbiologically healthy and organoleptically acceptable. This can therefore set the stage for further work to be done on improving and setting the parameters for making wasawasa in large quantities which would eventually lead to preservation of yam. *Wasawasa* made from sun dried yam flour were not however desirable but further work need to be done to improve the product.

References

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Table 2. Moisture content of dried yam slices after six months storage

Sample	Percentage moisture
Sundried	
1a	12.66
2b	13.24
3b	13.27
4b	13.34
5b	12.63
Mechanically dried	
1a*	10.3
2a	9.22
3a	9.77
4a	9.90
5a	9.61

not determined because colony covered the whole plate

*1 Peeled, washed, sliced, blanched and dried.
2 Peeled, washed, sliced under water, blanched and dried.
3 Peeled, washed, sliced into limewater, blanched and dried.
4 Peeled, washed, sliced under limewater, blanched and dried.
5 Peeled, washed, sliced and dried.

a Mechanically dehydrated at 60 ^{o}C in a hot air drier.
b Sundried