

Full Length Research Paper

An assessment of the microbiological safety of dry yam (gbodo) processed in South West Nigeria

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The microorganisms involved in dry-yam (gbodo) and water used in parboiling from different source (well, pipe-borne, river, stream and pond) were investigated. There was predominance of *Staphylococcus aureus*, fungi and coliforms in the gbodo samples. Coliforms were also observed in all the parboiling water. In gbodo, the total viable bacterial count was generally high, ranging from 1.1×10^6 cfu/ml from Oyo processing area to 7.8×10^5 cfu/ml from Iseyin processing areas. A large percentage of the microorganisms involved in gbodo were fungi ranging from 8.5×10^5 cfu/ml in samples collected from Abeokuta to 1.2×10^6 cfu/ml in samples from Ibarapa. *S. aureus* was isolated from all the dry yam samples with counts ranging from 2.5×10^3 cfu/ml in samples collected from Iseyin processing area to 9.0×10^4 cfu/ml from Baruba processing area. The control sample prepared at the laboratory has a low microorganism' population compared with all the collected samples.

Key words: Gbodo, Microbiological safety, yam, parboiling water.

INTRODUCTION

Yam, *Dioscorea* spp., is the second most important root/tuber crop in Africa, after cassava, with production reaching just under one third the level of cassava (FAO, 1997). More than 95% (2.8 million ha) of the current global area under yam cultivation is in sub Saharan Africa, where the mean gross yields are 10 t/ha (FAO, 1996, 1997).

Yam is an important source of carbohydrate for many people of the sub Sahara region, especially in the yam zone of West Africa (Akissoe et al., 2003). It is cultivated throughout the tropics, and in many parts of the sub tropics and temperate zones (Kordylas, 1990). In West Africa and New Guinea, yam is one of the primary agricultural commodities (Coursey, 1983). There are over 150 species of yam grown throughout the world (Purseglove, 1991). Babaleye, (2003) reported that yam contributes more than 200 dietary calories per capital daily for more than 150 million people in West Africa and serves as an important source of income to the people.

As of date, the age-old traditional method is still being used for the processing of yam to dried yam (gbodo). The quality of the "gbodo" and "elubo" varies from processor to processor and from location to location (Akissoe et al., 2001; Hounhouigan et al., 2003; Mestres et al., 2004). Indeed, local consumers of yam flour (elubo) have preference for the product made from a particular area of south-west Nigeria (Bricas et al., 1997). Information is not available on the variations in gbodo production from different parts of the processing zones (especially variations in parboiling operation which can lead to variation in microbiological quality of gbodo). Thus, the safety of gbodo could be ascertained from the effect of source of water for parboiling on the pH and microbial constituents of gbodo.

MATERIALS AND METHODS

Raw materials

Yam tubers of the variety "ljedo" (*Dioscorea esculenta*) was purchased from Odo-oba in Oyo state. The yam tubers were of six to eight months old. The processing water from river, pond,

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Table 1. Moisture content and microbial analyses of gbodo samples from different processing areas.

Source of Gbodo	Moisture content (%)	Aerobic plate count (cfu/ml)	plate fungal count (cfu/ml)	Staphylococcus aureus (cfu/ml)
Abeokuta	9.48±1.22	1.7 x 10 ⁶	8.5 x 10 ⁵	3.4 x 10 ³
Ibarapa	10.31±0.9	1.2 x 10 ⁶	1.2 x 10 ⁶	4.3 x 10 ³
Iseyin	8.53±0.78	8.0 x 10 ⁷	7.8 x 10 ⁵	3.1 x 10 ³
Saki	8.47±0.65	4.4 x 10 ⁷	6.9 x 10 ⁵	7.9 x 10 ⁴
Oyo	7.84±1.24	1.1 x 10 ⁶	1.2 x 10 ⁶	2.5 x 10 ³
Baruba	7.79±0.39	5.4 x 10 ⁷	7.9 x 10 ⁵	9.0 x 10 ⁴
Control	7.15±0.28	1.2 x 10 ³	1.2 x 10 ³	2.5 x 10 ³

stream, well and Pipe borne/treated (Tap) water were obtained in Abeokuta.

Culture media and chemical

The culture media used are peptone water, Nutrient Agar (Oxoid), MacConkey agar and broth (Oxoid), Potatoe Dextrose Agar (Oxoid) and other chemicals were of analytical grade and were obtained from the laboratory of the Department of Food Science and Technology, University of Agriculture, Abeokuta, Nigeria.

Sampling of “gbodo”

Gbodo samples were collected from three major processors in South west of Nigeria. The samples were collected in sterile polythene bags and subsequently milled in a cleaned local plate mill and stored at -4°C before further analyses.

Processing of yam to dry-yam “Gbodo”

Yam tubers was processed to “gbodo” in the laboratory following the method described by Ige and Akintunde (1981) with some modifications. The white yam tubers were thoroughly washed with clean water to remove adhering soil and other undesirable materials from the yam and to reduce microbial growth on the final product. Peeling was done using a sharp knife. The peeled yam were sliced into size of 2 to 3 cm in thickness so as to hasten the process of drying. The sliced yam were parboiled at 50°C for 2 h in water baths, (Clifon, England), then left in the parboiling water for 24 h in order to become flabby, after which they were drained and dried at 60°C for minimum of 3 days in a cabinet dryer, the dried samples were weighed at intervals to obtain a constant weight. The dried yam were then packaged and stored before further analyses.

Sample collection

Samples (100 g) of gbodo were collected at different processing centers and stored in sterile containers.

pH determination

The pH was determined for each processing water sample using Jenway pH meter (Model 3015, Serial no. 1647, U.K).

Microbiological analysis

Microbiological analyses of gbodo and parboiling water were microbiologically analysed.. The microbiological procedures were

those recommended in the International Commission on Microbiological Specification for Foods (1996). Culture media were those of Oxoid and Difco. Microbiological analyses included total aerobic viable count, fungal count and coliform count.

Enumeration of microorganisms

Each sample container was cleaned externally with 70% ethanol to disinfect it. An appropriate serial dilution of all the samples was carried out and 0.1 ml of the selected dilution was spread on duplicate plates using sterile glass spreader. This technique was used for the enumeration of total aerobic viable count, coliform, fungal and staphylococcal counts on Nutrient Agar (Oxoid) and Eosin Methylene Blue (EMB) Agar (Oxoid). Potatoe Dextrose Agar (Oxoid) and Baird Parker Agar (Oxoid) supplemented with tellurite and egg yolk emulsion, respectively. All cultures were incubated at 37°C for 24 h except for coliform bacteria which was incubated at 37°C and 44°C for 24 h. Media used were prepared according to the manufacturers instructions.

Characterization of isolates

Isolates were stored on Nutrient agar slants at 4°C for further confirmatory tests which included IMVIC test, carbohydrate utilization, and reaction on TSI. Large, flat, irregular, wrinkled or smooth, ground-glass colonies, 4-6 mm in diameter were counted as *Bacillus*. Confirmation was as described by Yusuf et al. (1992). Confirmation of typical colonies of *S. aureus* on Baird-Parker agar was on the basis of the results of catalase, coagulase, phosphate production, nitrate reduction and carbohydrate utilization (Umoh et al., 1999).

RESULTS

Assessment of traditional dry yam-gbodo samples

Table 1 shows the mean variations in the population of microorganisms found in collected samples of gbodo and moisture contents from different processing areas. The mean moisture level of gbodo from Ibarapa is the highest (10.31%) while the ones from Baruba have the lowest moisture content of 7.79%. Gbodo sample from Abeokuta have the highest mean aerobic plate count of 1.71x10⁶ cfu/ml while the sample from Baruba have the lowest mean aerobic plate count of 7.79x10⁵ cfu/ml. The result indicates the predominance of *Staphylococcus* sp., and fungi in the collected gbodo samples. In gbodo

Table 2. Microbial analyses and pH of water from different sources before and after parboiling.

Source of Gbodo	Moisture content (%)	Aerobic plate count (cfu/ml)	plate	fungal count (cfu/ml)	Staphylococcus aureus (cfu/ml)
Abeokuta	9.48±1.22	1.7 x 10 ⁶		8.5 x 10 ⁵	3.4 x 10 ³
Ibarapa	10.31±0.9	1.2 x 10 ⁶		1.2 x 10 ⁶	4.3 x 10 ³
Iseyin	8.53±0.78	8.0 x 10 ⁷		7.8 x 10 ⁵	3.1 x 10 ³
Saki	8.47±0.65	4.4 x 10 ⁷		6.9 x 10 ⁵	7.9 x 10 ⁴
Oyo	7.84±1.24	1.1 x 10 ⁶		1.2 x 10 ⁶	2.5 x 10 ³
Baruba	7.79±0.39	5.4 x 10 ⁷		7.9 x 10 ⁵	9.0 x 10 ⁴
Control	7.15±0.28	1.2 x 10 ³		1.2 x 10 ³	2.5 x 10 ³

* = uncountable

- = no growth

samples collected (Table 1), the total viable count was generally high, ranging from 7.8×10^5 cfu/ml from Iseyin to 1.1×10^6 cfu/ml from Oyo processing areas. A large percentage of the microorganisms involved were fungi which are of high value in almost all the gbodo collected from the processing areas ranging from 8.5×10^5 cfu/ml in samples collected from Abeokuta to 1.2×10^6 cfu/ml in samples from Ibarapa. *S. aureus* were also isolated in all the dry-yam samples ranging from 2.5×10^3 cfu/ml in samples collected from Iseyin processing area to 9.0×10^4 cfu/ml from Baruba processing area. The control sample prepared at the laboratory has a low microorganism' population compared with all the collected samples. These show that the levels of contamination of the collected samples are high, even when compared international standards (ICMSF, 1996).

Effect of parboiling on microbial load and pH

Table 2 Shows the changes in the microbial load and pH of all sources of processing water before after parboiling. There was a general decrease in the microbial load of the water from different sources after parboiling. Also, there was decrease in the pH after parboiling. The total aerobic viable count ranges from 1.1×10^5 to 7.0×10^6 cfu/ml before parboiling and it reduced to the range of 1.3×10^3 to 1.7×10^5 cfu/ml after parboiling. The fungal count also reduced from the range of 1.0×10^3 to 1.3×10^4 cfu/ml before parboiling to the range of 1.2×10^2 to 7.8×10^2 cfu/ml after parboiling. The *staphylococcus aureus* ranges from 1.4×10^5 to 2.5×10^5 cfu/ml before parboiling to the range of 2.8×10^2 to 2.4×10^3 cfu/ml after parboiling. There was simultaneous decrease in the pH of the water from 5.76 – 5.49 (river water); 4.78 – 4.21 (tap water); 6.01 – 4.75 (well water); 6.07 – 5.30 (stream water) and 5.75 – 5.25 (Pond water) after parboiling.

Microbial analyses and pH of water after 24 h steeping

The microbial analyses of gbodo parboiled with different water sources after 24 h steeping are shown in Table 3. The result indicates an increase in the microbial load as compared to the microbial load before steeping. There was increase in the predominance of coliforms bacteria ranging from 2.0×10^3 to 8.0×10^3 cfu/ml; fungi in the ranges of 2.4×10^5 to 9.7×10^5 cfu/ml and total aerobic viable count at the range of 2.8×10^7 and 5.8×10^7 cfu/ml. The pH was decreased to the range of 4.02 to 4.60.

DISCUSSION

All the dry-yam gbodo collected from different processing areas had high microbial counts while their moisture content were within the range of recommended value for flour samples of 7-13% (Christensen and Kaumann, 1973). There is a linear relationship between the incidence of different types of microorganisms and moisture content of samples, as gbodo is a rich carbohydrate source for yeast and mould growth (Uraih and Ogbadu, 1980). The presence of *S. aureus* could be as a result of processors handling (WHO, 1992; Adams and Moss, 1999).

The microbial load of river, stream and pond were so high above the acceptable limit as given by the International Commission on Microbiological Specification for Food (ICMSF) while that of tap and well were not so high but also above the acceptable limit, especially coliform count. The counts of total bacteria, fungi and coliform for the different sources of water reduced by about 10^1 when taken immediately after parboiling, thus, indicating the destructive effect of the parboiling temperature and time on some of the microorganisms present in all the water samples, as most of them were

Table 3. Microbial analyses of water from different sources after 24 h steeping.

Water sample	Total aerobic viable count (cfu/ml)	Fungal count viable count (cfu/ml)	Coliform count (cfu/ml)	pH
River	4.7 x10 ⁷	8.0 x10 ⁵	6.5 x10	4.43
Tap	2.8x10 ⁷	3.4x10 ⁵	2.0x10 ³	4.02
Well	3.4x10 ⁷	2.4x10 ⁵	-	4.22
Stream	4.5x10 ⁷	6.6x10 ⁵	8.0x10 ³	4.49
Pond	5.8x10 ⁷	9.7x10 ⁵	11.2x10 ³	4.60

- = no growth

thermolabile. Coliform presence is an indication of faecal contamination (Tahir and Oyawole, 1993). The presence of coliform in pipeborne (tap) water should be of concern because previous reports also reported microbial quality of tap water supplied to some communities in Nigeria is poor with coliform counts exceeding recommended level (Tahir and Oyawole, 1993). The coliform count for well water was not prominent. The increase in the microbial load during steeping could have been due to the fact that microorganisms that have been inhibited by parboiling temperature and time (50°C for 2 h) were resuscitated at the lower temperature of the steep water. The presence of *S. aureus* in all the samples may be as result of its presence on the palm of the handler and it can present a risk at high count. The *S. aureus* isolated are alpha haemolytic and likely to be human biotypes and more enterotoxigenic than animal biotype which are often beta haemolytic (Bergdoll, 1979). A study of complimentary food preparation and handling in Eastern Nigeria also confirmed the presence of enteric pathogens. The exotoxin of *Staphylococcus* spp. is associated with food poisoning and spores of pathogens with handlers (Ehiri et al., 2001).

The presence of fungi in a food product is undesirable, especially *A. flavus* and *A. niger* which are sporadic (Adegoke, 2004). Toxigenic strains of *A. flavus* have been known to produce aflatoxin, a potent hepatotoxic and carcinogenic agent (Uraih and Ogbadu, 1980). *A. niger* also produce protecatenic and oxalic acids which are toxic metabolites (Avdesh and Prakash, 1968). These fungi have been implicated in food poisoning illness (Yusu et al., 1992) and are also known as spoilage microorganisms. Proper and hygienic processing of gbodo with the use of good quality water like pipeborne/tap water and well water as well as treatment of other sources of water like, river water is of utmost importance to make gbodo/elubo an internationally acceptable food. The coliforms could include strains of *E. coli* which is heat stable form, as the virulence factor of enterotogenic *E. coli* (ETEC) strains produce two types of enterotoxin of which one is heat stable (ST), that is, it can withstand 100°C/15 min (Adegoke, 2004).

In order to make these products gbodo to be acceptable in the international market, it is therefore recommended that, treated water or well water be used to process gbodo to obtain a minimal microbial load in the yam flour.

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