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RESEARCH ARTICLE

Dry Fufu Powder, an Alternative Method of Fufu Preservation for Availability and Easy Transportation

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ABSTRACT

Wet fufu mash contains a lot of water, is bulky and easily contaminated. This work produced dry fufu powder that solved the above problems. Traditional method of wet *fufu* production was used to produce wet mash, termed Xo. Eleven organisms were isolated from the system namely: *Bacillus subtilis, Staphylococcus aureus, Klebsiella aerogenes, Enterobacter aerogenes, Pseudomonas aeruginosa, Escherichia coli, Lactobacillus coryneformis, Candida tropicalis, Saccharomyces cerevisiae, Aspergillus sp and Rhizopus sp.* Three isolates did not ret the tubers; four caused partial retting while four retted the tubers. The four isolates that retted the tubers were grown in cassava medium. *Lactobacillus coryneformis* and *Saccharomyces cerevisiae* were able to utilize it in 24-48 hours. They were used as starter cultures to ret the tubers as single cultures and mixed cultures to produce wet fufu samples X1, X2 and X3 respectively. The wet fufu mashes produced were dispersed and dried at 65^{o}C for 72 hours. They were crushed, sieved, and assessed for their protein and cyanide contents. Their percentage crude protein content were 2.52, 9.96, 9.85 and 10.44% respectively and their cyanide contents were 0.880, 0.018, 0.016 and 0.012mg/g respectively. Sensory evaluation of the samples accepts all the samples with most preference to X3. The samples were aseptically packaged in cellophane bags and kept for six months without loosing their organoleptic qualities. To achieve long storage, wet mash can be oven-dried, crushed and sieved to fine fufu powder.

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INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is grown widely in Nigeria and in many regions of the tropics. It serves as one of the basic food sources for about 200- 300 million people (FAO, 1991). Nigeria produced about 33 million tones of cassava in 1999 and since then she is among the world's largest producers of cassava (Sobowale *et al*., 2007).

Cassava has been variously used in the production of different types of food in Africa, such as *garri, fufu, lafun, abacha, tapioca* etc (Okafor *et al*., 1998). It is normally processed before consumption due to the presence of toxic cyanogenic glycosides present in the fresh roots. The only most single method of processing is by fermentation which helps in the detoxification, preservation and modification of the food product (Oyewole, 1991). The fermentation process can be classified into solid state (without soaking, as in *garri*) and submerged fermentation (soaking in water, as in *fufu*) (Oyewole, 2002).

Fufu is a fermented white and soft cassava mash which can be as a wet mash or dry powder (Okoro, 2007). It is commonly consumed in the eastern and south – south zones of Nigeria. Traditional method of producing wet *fufu* mash and their improved versions still involve peeling, cutting (optional), soaking for 3-5 days, macerating and sieving, then settling and decanting excess water (Okpokiri *et al*., 1984; Obadina *et al*., 2006). Wet *fufu* mash is bulky due to its high water content and can be easily contaminated. Wet *fufu* mash when cooked and pounded into dough also cannot stay up to 10 days without contamination and spoilage.

Fufu is a very good source of carbohydrate (about 98%) and energy but very low in protein (about 2.0%). There is need to improve the processing and preservation methods to enhance storage and protein content of the

product. This will increase its transportation to other townships of Nigeria and even abroad as export. The use of starter cultures helped to increase the protein content of the product as there is need to produce food rich in protein to feed the increasing population of the world (Umeh and Odibo, 2013a & b; Fagbemi and Ijah, 2005).

Since *fufu* is widely demanded in Nigeria by the poor and the elite, there is great need to produce *fufu* that can be stored for a longer time and easily transported to other parts of the country and even abroad

MATERIALS AND METHODS

Source of cassava tubers

One year old cassava tubers of the specie TMS 30555 were harvested from the farm at the Nnamdi Azikiwe University Awka premises and immediately transported to the laboratory for processing. Culture media, chemicals and reagents used are obtained from the Applied Microbiology and Brewing Laboratory of the institution and were of analytical grade.

Method of *fufu* production

The method of wet *fufu* mash production by Oyewole (2002) was used to produce wet *fufu* mash in the laboratory. The tubers after harvest were peeled, cut into cylindrical portions (4-7 cm long) and washed with tap water. Three kg (3 kg) of the peeled cut tubers were soaked in 5liters of water for 4 days using plastic buckets with lid. The retting waters and tubers were monitored daily for retting ability and the presence of microbial flora. The isolated organisms were identified, characterized and their ability to singly ret the tubers checked. Four organisms retted the tubers and produce acceptable wet fufu mash. The four organisms were tested for their ability to grow in cassava medium within 28 – 48 hours. Two organisms utilized cassava medium and were used as starter cultures to ret the tubers as single cultures and as mixed cultures aseptically.

After retting the tubers were washed, mashed in clean water and sieved remove the fibers and the vascular bundles. The mixture was allowed to settle and excess water decanted. The wet *fufu* mash was transferred into a clean jute bag and the remaining water pressed out. The resulting wet *fufu* mash was spread and dried in the oven at 65^{o}C for three days, ground, sieved and packaged in airtight cellophane bags.

All the fufu powder samples produced were tested for total cyanide and protein content and analyzed organoleptically by 10 panelists for colour, taste, texture and general acceptability and the results obtained confirmed statistically.

Method of analysis

Determination of the retting ability of the tubers

The retting ability of the tubers was determined manually using the method of Umeh and Odibo (2013b).

Total cyanide content of the samples

The method used by Okafor *et al*. (1998) was used. Standard cyanide curve was prepared. One gram of the dry fufu powder was dissolved in 100 ml of water and allowed to settle. Twenty milliliters of the filtrate was pipetted into a 100 ml flask. Ten milliliters of alkaline sodium picrate solution were added in the flask and mixed. Ten milliliters of the mixture was transferred in a test tube. The tubes were incubated in a water bath set at 94^{o}C for 5 minutes and allowed to cool at room temperature. Absorbance of the mixtures was read from a Jenway 6405UV/V Spectrophotometer at 540 nm after using distilled water to zero the spectrophotometer. The absorbance was the average of two readings. Then the concentrations of potassium cyanide in the sample were calculated from the standard cyanide curve.

Isolation, characterization and identification of the microorganisms

The pour plate method as described by Collee and Miles (1989) was used to determine the microbial counts in the retting water. Characterization and identification of the bacterial isolates was carried out as stipulated by Krieg and Holt (1984). The methods of Banett *et al.* (1990) were used to isolate, characterize and identify the fungal isolates.

Estimation of protein content

Crude protein content of the four different fufu powders produced were determined by the micro Kjeldahl method of Pearson (1976) and calculated using a protein conversion factor of 6.25.

Sensory evaluation of the fufu flour

The method of Fagbemi and Ijah (2005) was used to prepare the fufu dough. Ninety gram of the different fufu powders were stirred in 150 ml of boiling water. The fufu dough was allowed to cook for 20 minutes with intermittent stirring. After cooking the resulting doughs were evaluated for colour, taste, texture, and general acceptability by 10 panelists who are conversant with the organoleptic qualities of fufu–dough. The scores were analyzed statistically using the Kruskal – Wallis test.

RESULTS

The daily changes in the microbial counts of the retting water were presented in Table 1. On the zero day only the heterotrophic bacteria were present in the retting water. Subsequently the total microbial counts increased with increase in retting days. Table 2 showed the morphology and biochemical properties of two yeasts isolated, Table 3 presents the morphology and biochemical properties of two moulds isolated, While Table 4 showed the morphological and biochemical characteristics of the six isolated bacteria and one lactic acid bacteria. Ability of the different isolates to ret the tubers as well as their growth in cassava medium was as shown in Table 5. Only four isolates were able to ret the tubers completely and two were able to grow quickly in a mineral salt medium containing cassava water as a carbon source within 24-48 hours. Table 6 showed the result of the crude protein and cyanide content of the dry fufu powder. The sample produced using the mixed culture gave fufu powder with highest crude protein content and lowest cyanide content (10.44% and 0.12mg/g) respectively. Table 7 presents the statistical analysis of the organoleptic qualities of the samples with the X3 most preferred.

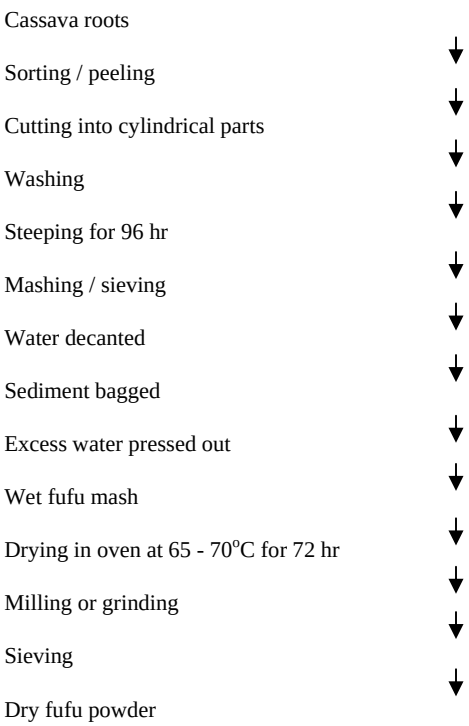

Fig. 1: Method of fufu powder production (Oyewole, 2002).

Table 1: Daily changes in the microbial counts of the retting water

Days	Heterotrophic bacterial count x10^6cfu/ml	Yeast count x10^6 cfu/ml	Mould count x10^6cfu/ml	Lactic acid bacterial count x10^6cfu/ml
0	27.0	nd	nd	nd
1	40.0	30.5	28.5	29.0
2	51.0	40.0	46.0	30.5
3	55.5	46.5	53.0	39.5
4	65.0	50.0	56.0	48.0

Key: nd – not determinable

DISCUSSION

Fufu, a fermented cassava food product widely consumed in Nigeria, had suffered deterioration and contamination by microorganisms due to its high moisture content. Most of these organisms accompany the product from the fermentation system, storage containers, surrounding air and even human handling. The wet product is very bulky and cannot be stored for a long time without spoilage. Its transportation and distribution to other areas that do not produce it is very cumbersome and most times contamination and spoilage occur in transit.

Also, the food product is very low in protein and sometimes high in cyanide due to the methods of fermentation. It is an energy giving food and therefore need to be improved in both storage and nutritive value.

This work is carried out to find the best method of processing, preserving and storing this food product as well as increasing its nutritive value. Starter cultures isolated from the fermenting system were used to ret the tubers and after fermentation the tubers were mashed to produce wet fufu mash.

The wet mash was oven dried to produce the dried fufu powder which if well stored can last long time without deterioration and contamination. The fufu powder is less bulky and can be easily transported from one part of the country to the other and even exported abroad to serve Nigerians that are in the Diaspora. By this it can increase our income and exchange.

Many microbes had been reported to be responsible for cassava fermentation to fufu (Okafor *et al*, 1998; Oyewole, 1991; Oyewole, 2002; Fagbemi and Ijah, 2005; Umeh and Odibo2013 a & b). In this work, eleven organisms were isolated; [*Bacillus subtilis, Staphylococcus aureus, Klebsiella aerogenes, Enterobacter aerogenes, Pseudomonas aeruginosa, Escherichia coli, Lactobacillus coryneformis, Candida tropicalis, Saccharomyces cerevisiae, Aspergillus sp and Rhizopus sp.*]; seven bacterial isolates and four fungal isolate (Tables 2, 3 and 4). Microbial counts of these organisms in the retting water increased daily with increase in retting days (Table 1). This is in agreement with the findings of Fagbemi and Ijah, (2005). The increase in counts may be as a result of favorable conditions which enable them to multiply (Fagbemi and Ijah, 2005). The multiplication of coliforms, especially in the early and intermediate days of fermentation is a characteristic of mixed acid fermentations (Davis *et al*., 1980). It was also observed that the fungal and lactic acid bacterial counts were very small on the zero days and is considered as not determinable (nd) (Table 1). Among the eleven isolated organisms, four were able to cause complete retting of the tubers; four caused partial retting while three did not ret the tubers (Table 5). Two of the organisms (*Lactobacillus coryneformis* and *Saccharomyces cerevisiae*) that ret the tubers were able to utilize cassava as a carbon source in 24-48 hr while others needed 48-72 hr to start growth in the cassava medium (Table 5). The two organisms (*Lactobacillus coryneformis*

Table 2: Morphology and biochemical properties of the yeast isolates

		Sugar fermentation					Sugar assimilation					
Culture characte-ristics	Cell morphology	Glucose	Maltose	Galactose	Dextrose	Manitol	Glucose	Maltose	Galactose	Dextrose	Manitol	Probable organism
Cream white smooth & flat	Oval Budding cells,pseudo-hyphae	+	+	+	+	-	+	+	+	+	-	*Candida tropicalis*
Smooth cream white to tan, hairy	Budding cells	+	+	-	-	+	+	+	-	-	-	*Saccharo-myces cerevisiae*

Table 3: Morphological characteristics of the mould isolates

Young culture morphology	Old culture morphology	Microscopy	Texture	Days	Probable organisms
Whitish with yellow reverse	Blue-green to dark-green	Double branching septate hyphae, short conidiophores	Powdery and velvety	3-4	*Aspergillus sp*
Dense grayish cottony	Green to brown to black filling the plate	Oval non-septate hyphae with sporangiophores	Fluffy and cottony	2-3	*Rhizopus sp*.

Table 4: Morphological and Biochemical Characteristics of the Bacterial isolates

Colony morphology	Gram stain	Spore	Motility	Urase	Catalase	Citrate	MR	VP	Indole	H_2S	Gelatine	KCN	Coagulase	Glucose	Lactose	Maltose	Sucrose	Manitol	Probable organisms
Slimy mucoid dry, white. Yellow when old	-ve short rods in chains & singles	-	-	+	+	+	-	+	-	-	-	+	-	-	AG	A	A	A	*Klebsiella aerogenes*
Cream, rough, opaque and circular	+ long,rods in chains	+	+	-	+	+	+	-	-	-	-	-	-	AG	-	-	-	-	*Bacillus subtilis*
Cream,smooth raised, circular	+ ve coci in clusters	-	-	-	+	+	-	-	-	-	-	-	+	A	-	-	-	-	*Staphylo-coccus aureus*
Smooth, mucoid and circular	-ve short rods,+ve capsules	-	+	-	+	+	-	+	-	-	-	+	-	A	A	-	A	-	*Entero-bacter aerogenes*
Blue to dirty green low convex colonies	+ve rods	-	+	-	+	+	-	-	-	-	-	+	-	AG	-	-	-	-	*Pseudo-monas aeruginosa*
Cream white nonviscous flat colonies	-ve shot rods	-	-	-	-	-	-	-	+	-	-	-	-	A	A	-	A	A	*Escheri-chia coli*
Gray to white on TJA	+ve rods	+	-	-	-														Lactob-cillus cory-neformis

Key: A = acid; AG = acid and gas; TJA = Tomato juice agar used to grow *Lactobacillus species*

Table 5: Ability of the organisms to ret the tubers and grow in Cassava medium

Organisms	Retting ability	growth in cassava medium (24 hrs)
Aspergillus sp	-	-
Bacillus subtilis	+ +	+
Candida tropicalis	+ +	+
Enterobacter aerogenes	+	-
Escherichia coli	-	-
Klebsiella aerogenes	+	-
Lactobacillus coryneformis	+ +	+ +
Saccharomyces cerevisiae	+ +	+ +
Staphylococcus aureus	+	-
Rhizopus sp	-	-
Pseudomonas aeruginosa	+	-

Key: - no retting, no growth; + partial retting and partial growth; + + complete retting and full growth

Table 6: Percentage crude protein and Cyanide content of the fufu powder

Samples	Crude protein content (%)	Cyanide content (mg/g)
Xo	2.52	0.880
X1	9.96	0.018
X2	9.85	0.016
X3	10.44	0.012

Key: Xo-sample from traditional method; X1–sample with *Lactobacillus coryneformis* alone; X2–sample with *Saccharomyces cerevisiae* alone; X3– sample with mixed culture

cultures and they provide a high protein content and most acceptable fufu powder. Fagbemi and Ijah (2005) used *Candida utilis* and *Saccharomyces cerevisiae* isolated from 'burukutu' to enrich fufu and got similar results in protein content. Some of the organisms isolated from the traditional method (Xo) were not able to ret the tubers or caused partial retting. This is in line with the findings of Okpokiri *et al*. (1985) and Okolie *et al*. (1992) that submerged fermentation over four days by traditional method usually produces a mash and retting water which contain a foul odour resulting from uncontrolled fermentation, undesirable organisms and poor storage techniques. These unwanted organisms may result in variations in the quality of the fufu produced (Ogumbawo *et al*., 2004). This is the reason why it is necessary to use starter cultures in retting to eliminate the effect of the unwanted organisms. The starter cultures also help a lot in the mode of reduction of cyanogenic glycosides at various stages of fermentations (Sobowale *et al*., 2007; Umeh and Odibo, 2013 a).

Cyanide content of the retting water was increasing with increase in retting days, while that of the tubers was decreasing. The cyanide content of the tubers during the traditional method decreased from 2.8-0.880 mg/kg while that of mixed culture of the starter cultures decreased from 2.8-0.012 mg/kg. This supports the report of Fagbemi and Ijah (2005) that there could be a high reduction in cyanide content using starter cultures.

The percentage crude protein content of the fufu powder produced was determined. It was found that the crude protein of X3 was highest (10.44%), followed by that of X1 and X2 (9.96% and 9.85%) respectively, while the Xo had the least protein (2.52%) as seen in Table 6.

Table 7: Statistical analysis of the organoleptic qualities

Parameters	Xo	X1	X2	X3
Colour	4.0	4.3	4.4	4.8
Taste	3.0	4.4	4.8	5.0
Texture	3.3	4.5	4.5	4.8
General acceptability	4.1	4.8	4.6	5.0

Retting inference: 5- excellent, 4- very good, 3- good and 2- bad

This shows that the use of starter cultures can help a lot in improving the protein content of fufu (Umeh and Odibo, 2013a).

All the 10 panelists preferred the X3 fufu dough in all the tested qualities (Table 7). All the four samples of fufu powder were able to last for six months without loosing their qualities and protein content. It is therefore recommended to use the starter cultures in producing wet fufu mash before preserving to dried form. This will help to get a high protein fufu powder that can be stored for a long time, less bulky to carry and easy to be prepared into fufu dough.

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