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Full Length Research Paper

Effect of lactic acid bacteria starter culture fermentation of cassava on chemical and sensory characteristics of fufu flour

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The effects of lactic acid fermentation of cassava on the chemical and sensory characteristic of fufu flour were investigated. Two strains of *Lactobacillus plantarum* were used as starter cultures for the fermentation of cassava to fufu for 96 h. The resultant wet fufu samples were dried at 65°C in a cabinet dryer for 48 h and analyzed for chemical and sensory characteristics. Fermentation caused a high reduction in the protein content of cassava, which ranges between 1.26 ± 0.02% for cassava with starter culture SL 14, and 1.14 ± 0.04% for cassava with starter culture SL 19. However, the unfermented cassava fufu flour has the highest protein content; this shows the influence of fermentation in reducing the proximate composition of cassava. The values of the sugar, starch and amylose contents show similar trends. The sugar contents ranges between 5.21 ± 0.04 to 4.41 ± 0.0%, with the unfermented sample having the highest value. When subjected to sensory evaluation, the traditional and starter-culture fermented cassava fufu flour were not significantly different in terms of color, odor, and texture, but the cassava fufu flour produced using starter culture SL19 had the highest overall acceptability (P<0.05).

Key words: Cassava, fermentation, *Lactobacillus plantarum*, chemical composition, sensory characteristic.

INTRODUCTION

Cassava, *Manihot esculenta* Crantz, is a perennial woody shrub with an edible root, which grows in tropical and sub- tropical areas of the world (Burrell, 2003). Cassava is one of the most important food crops in the tropics (Burrell, 2003). Cassava is a tropical root crop that serves as a food security and income generation crop for many millions of people in the developing world (Scott et al., 2002). Cassava is grown widely in Nigeria and in many regions of the tropics, where it serves as one of the basic food source for about 200 – 300 million people (FAO, 1991). In 1999, Nigeria produced 33 million tonnes making it the world's largest producer.

Cassava is the basis of many products, including food. In Africa and Latin America, cassava is mostly used for human consumption, while in Asia and parts of Latin America, it is also used commercially for the production of animal feeds and starch-based products (FAO, 1991). Cassava is normally processed before consumption as a means of detoxification, preservation and modification (Oyewole, 1991). Fermentation is an important processing method for the crop. The fermentation processes can be classified into solid state (without soaking, e.g. gari) and submerged (involving soaking in water, e.g. fufu). During fermentation of fufu, lactic acid bacteria, yeast and other bacteria contribute significantly to starch breakdown, acidification, detoxification and flavour development (Oyewole 1991).

Lactic acid bacteria are found to be useful in flavouring foods, in inhibiting spoilage bacteria and pathogens, in intestinal health and other health benefits related to blood cholesterol levels, immune competence and antibiotics production (Sandine, 1987). The roles of the lactic acid bacteria in the modification of the cassava fufu constituents are yet unknown (Oyewole, 1997). This research work was embarked upon to investigate the effect of lactic acid fermentation on the chemical and sensory

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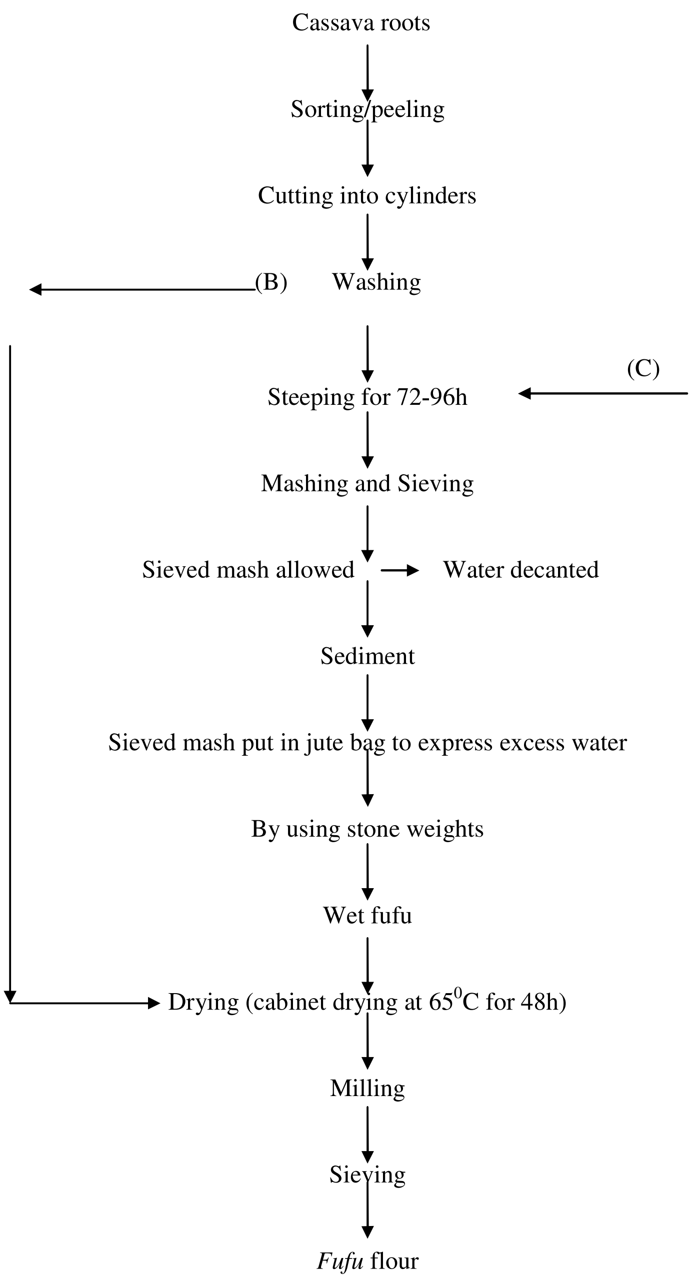

Figure 1. Traditional method of fufu production showing one stage method (Oyewole, 1991). (B) Showed the production of unfermented fufu flour. (C) Showed the stage of inoculation with SL14 and SL19 *L. plantarum* strains.

characteristics of cassava fufu flour.

MATERIALS AND METHODS

Production of fermented fufu flour

Cassava roots of the local white variety were obtained from a local farm around Abeokuta. The roots were from 10 – 15 months old plants. One stage method of fufu preparation was used during this investigation (Figure 1). Peeled cassava tubers (3 kg) were cut into cylindrical pieces and steeped in water (4 l) for 96 h. The resulting soft fermented cassava roots were hand pulverized and sieved using sieve of about 1.00 mm aperture. The sieved mash was allowed to sediment for 12 h before the top water was decanted. The sedimented mash was then placed in a jute bag to express the water. The resulting wet product, fufu, was further dried in a single layer at 65^{o}C for 48 h in a cabinet dryer. The dried fufu cake was then milled to powder.

For the production of unfermented cassava flour, peeled cassava roots were cut into thin chips and washed properly to remove dirt. The chips were then dried in a cabinet dryer at 65^{o}C for 48 h. The dried chips were then milled and sieved to get the unfermented cassava flour.

Isolation and evaluation of *Lactobacillus plantarum* as a starter culture

The cassava roots were fermented for three days. At 0 h and 24 h intervals and 5 g of fermenting roots was taken under aseptic conditions. The sample was homogenized with 50 ml of sterile distilled water. These was serially diluted and plated on MRS agar in duplicate and incubated for 2 - 3 days at 30°C under anaerobic condition. Random isolates from colonies growing on the plates were streaked on fresh MRS agar to purify the isolates. About ten isolates were picked during each isolation period. These colonies were transferred and purified on MRS agar and maintained in MRS broth. The Preliminary identification tests were done according to Sharpe (1979). The isolates were Gram stained and tested for catalase reaction. The rod and coccal cells that were catalase negative and gram positive were selected and labeled.

Isolated *Lactobacillus plantarum* strains (SL14 and SL 19) were selected for this investigation. The culture were grown on an MRS slant for 18 h. Grown cells were harvested by adding 10 ml of sterile distilled water followed by aseptic agar surface scrapping under vigorous shakings (Adeyele, 1986). 3 kg of cassava roots were weighed into sterilized buckets and washed with many volumes of sterile distilled hot water. Four liter of the water was added to the sterilized tubers before inoculating with 10 ml of the culture. The roots in the water were then covered and labeled. It was allowed to ferment for 96 h, and other unit operation followed as described under traditional production of fufu flour (Oyewole, 1991).

Chemical analysis

The pH of the samples was determined according to the method of AOAC (1984). 10 g of the sample was added to 50 ml of distilled water and stirred for 10 min. The pH of the sample was determined by dipping the electrode of the Kent pH meter in the mixture. Duplicate determinations were made in all cases. The pH meter was calibrated using pH 4.0 and 7.0 buffers. Total titratable acidity expressed as percentage lactic acid was determined by titrating 25 ml of the decanted homogenate samples used for pH determination against 0.1 N NaOH to pH 8.30. The volume of the 0.1 N NaOH used was noted and duplicate determination was made (Pearson, 1973). Moisture content of the samples was determined by oven air method (AOAC 1984). Ash was determined using method described by Pearson (1973). 5 g of each sample was burnt over a Bunsen burner until smoke ceases (Pre-charred) and was ashed in the muffle furnace at 550°C until a white ash was obtained for 6 h. Protein content of the samples was determined by the semi micro-Kjeldahl method using a factor of 6.25 as described by Pearson (1973). Fat was determined using the Soxhlet extraction method, as described by Oyeleke (1984). 5 g of each sample was extracted with hexane for 6 h. Crude fibre was determined using the method described by Pearson (1973). Starch content determined as follows: To the residue from sugar analysis, 15 ml of perchloric acid was added and 9 ml of distilled water. This was allowed to stand for 1 h and was then diluted to 100 ml with distilled water and then filtered.1 ml of the filtrate was used for the analysis. The development of colour was done by adding 0.5 ml, 5% phenol to the extract and then mixed, this was followed with 2.5 ml concentrated sulphuric acid and vortexed. It was allowed to cool and then the absorbance was read at 490 nm. The methods described by Juliano (1972), and William et al. (1958) were used for amylose content determination.

The Mineral contents were determined by the procedure of AOAC (1984). Calcium, magnesium, iron, copper and zinc were determined using the atomic absorption spectrophotometer. Potassium and sodium were determined by using the flame photometer, while phosphorous was determined by calorimetric method using ammonia molybdate.

Table 1. Characteristics of *Lactobacilli* isolated during the fermentation of cassava.

Representative strain	**SL14**	**SL19**	**SL04**	**SL09**
No. of Isolates	**8**	**4**	**4**	**5**
Colony Characteristics	Cy	White	Grey	White
Cell morphology	Rods	Rods	Rods	Rods
Gram's staining	+ve	+ve	+ve	+ve
Endospore	+ve	+ve	+ve	+ve
Catalase	+ve	+ve	+ve	+ve
Fermentation of:				
L-Arabinose	+	+	+	-
Ribose	+	+	+	+
D-Xylose	+	-	-	-
Galactose	-	+	+	+
D-glucose	+	+	+	+
D-fructose	+	+	+	+
D-mannose	+	+	+	+
Rhamnose	-	-	-	-
Dulcitol	-	-	-	-
Inositol	-	-	-	-
Mannitol	-	-	-	+
Sorbitol	-	-	-	-
Identity	LP	LP	LP	LP

LP = *Lactobacillus plantarum*.

Sensory evaluation

Sensory evaluation of the samples was carried out by eight-man trained panel of people familiar with the product. Evaluations were made on a five point hedonic scale in respect of color, odor and texture with score "5" having excellent attributes similar to "normal" and "1" indicating high characteristic difference from "normal" (Larmond, 1977). Panelists independently examined and scored the samples. Average scores were subjected to statistical analysis of variance and means were separated by Duncan Multiple Range Test.

RESULTS AND DISCUSSION

A total of twenty one lactic acid bacteria were isolated at 24, 48, 72, and 96 h, during the natural fermentation of cassava for fufu production. Except for *Lactococcus mesenteriode*s isolated at 24 h of fermentation, all the lactic acid bacteria isolated were strains of *Lactobacillus plantarum*, categorized into four groups (Table 1) based on morphological and cultural characteristics. The result is similar to that of Oyewole (1991) who found out that most of the lactic acid bacteria involved in cassava fermentation are of the *L. plantarum* group.

Table 2 shows the final pH, total titratable acidity, moisture content and other proximate chemical contents of the cassava roots at the end of 96 h fermentation. The pH of the unfermented cassava changes from 6.75 to 7.08 with a corresponding change of TTA from 0.07 to

Table 2. Effect of lactic acid fermentation on the chemical composition of fufu flour.

Parameter	Type of fermentation (96 h)			
	No fermentation	**Traditional fermentation**	**Fermented with *L.plantarum* SL14**	**Fermented with *L.plantarum* SL19**
M.C. (%)	6.68±0.22	1.61±0.04	6.57±0.48	6.71±0.61
Protein (%)	1.65±0.04	1.61±0.04	1.26±0.02	1.14±0.04
Fat (%)	0.35±0.02	0.25±0.05	0.24±0.03	0.25±0.04
Fibre (%)	1.66±0.02	0.77±0.01	0.87±0.00	0.87±0.03
Ash (%)	1.31±0.07	0.61±0.04	0.55±0.55	0.54±0.01
pH	7.08±0.01	6.25±0.08	6.45±0.02	6.11±0.03
TTA (%)	0.08±0.02	0.04±0.00	0.04±0.02	0.05±0.01

Values are means ± Standard deviation.

Table 3. Effect of lactic acid fermentation on the carbohydrate content of the fufu flour.

Type of fermentation	Amylose (%)	Sugar (%)	Starch (%)
No fermentation	19.80±0.18	5.21±0.04	76.86±0.45
Traditional fermentation (96 h)	21.30±0.74	4.64±0.65	75.75±0.45
Fermented with *L. Plantarum* SL 14 (96 h)	21.10±0.03	4.60±0.14	70.28±0.45
Fermented with L. *Plantarum* SL 19 (96 h)	21.24±0.00	4.41±0.00	70.72±0.44

Values are means ± Standard deviation.

Table 4. Effect of lactic acid fermentation on the mineral content of fufu flour.

Parameters	No Fermentation	Traditional Fermentation For 96 h	Fermented with *L. Plantarum* SL14 for 96 h	Fermented *L. plantarum* SL19 for 96 h
Ca (%).	0.044	0.086	0.088	0.100
Mg (%)	0.054	0.010	0.007	0.009
K (%)	1.107	0.125	0.125	0.107
Na (ppm)	94.01	88.71	61.70	65.71
Mn (ppm)	3.80	2.43	2.01	2.08
Fe (ppm)	19.98	10.98	10.87	10.12
Cu (ppm)	1.54	0.50	0.41	0.40
Zn (ppm)	8.98	5.03	4.38	4.90
P (%)	0.06	0.02	0.01	0.01

0.08%. The chemical composition of the fufu flour shows that the unfermented cassava sample has the highest values in all parameters examined, with a crude protein content of 1.65 ± 0.04%. This means that fermentation of cassava roots caused reduction in protein content. The fat, fibre and ash contents followed similar trends. The values of the inoculated cassava fufu samples were not significantly different in all parameters examined.

Table 3 shows the changes in sugar, starch and amylose content of the fufu flours. The sugar content values ranges between 5.21 ± 0.04 to 4.41 ± 0.0%. The cassava inoculated with starter culture strain SL 19 has the lowest value, while the unfermented fufu flour has the highest value. The starch content showed similar trend with the unfermented fufu flour having the highest value of 76.9 ± 0.5%. The amylose content of the unfermented sample was low with value as 19.8 ± 0.18%, while inoculated starter culture strain SL 14 fufu flour has the highest value of 21.2 ± 0.0%.

The mineral contents of the cassava fufu flours were shown in Table 4. The values of the unfermented fufu flour were different from the fermented samples in all the parameters examined. The values of cassava inoculated with starter culture strains and those traditionally fermented were lower as compared with the unfermented fufu flour. The result of the sensory evaluation is shown in Table 5. There were no significant difference (P>0.05) in odor, texture and color, and the overall acceptability of

Table 5. Effect of Lactic acid fermentation on the sensory characteristics of cooked fufu flour.

Measurements	Traditional Fermentation (96 h)	Fermentation with *L. plantarum* SL14 (96 h)	Fermentation with *L. plantarum* SL19 (96 h)
Texture	4.6a	4.6a	4.4a
Odour	4.4a	4.4a	4.3a
Colour	4.5a	4.4a	4.6a
Overall acceptability	4.5a	4.5a	4.6a

Means with same letters in the same column are not significantly different (P>0.05).

the lactic fermented fufu with starter culture strains and the traditionally fermented fufu flour.

Conclusion

The incorporation of starter culture (*L. plantarum*) has little or no effect on the chemical properties of fufu flour. The proximate analyses of the traditional and starter culture fermented fufu flour samples showed little variation in values as compared to the unfermented fufu flour. However, the addition of starter culture to cassava during steeping has effects on the pasting properties of the resultant fufu samples. Also, addition of starter culture strains reduced the characteristic odour in fufu, thereby enhancing the wider acceptability of the fufu samples as compared to the traditional fufu samples. In order to enhance the potentials of lactic acid fermentation, there is need for further research on its preservation, technology transfer, technology improvement and its social-economic implications. Traditional lactic acid fermentation processes will be greatly improved with the development and application of quality and safety systems.

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