# Deodorization of Fermented Cassava

Nwokanma S. Ohochuku[1]

In Nigeria, one of the methods for processing cassava (*Manihot esculenta* Crantz) for food is to ferment the roots in cold water and sieve it for cooking cassava fufu. Aqueous fermentation of cassava tubers is associated with an odor that is objectionable to many. This odor has been removed by treatment with hydrogen peroxide. The use of alkali and carotenoids is also discussed.

The importance of cassava roots as a main source of staple food in the tropics has been stressed (Nestle, 1973), and it has been estimated (Philips, 1974) that by 1980 it would provide 37% of the calories consumed in Africa especially as it forms a valuable reserve against famine in regions where it is intensively cultivated (Cock and Howeler, 1978 ).

There are various methods of processing cassava tubers into food products (Lancaster et al., 1982). One of the main processes involves cold water fermentation and sieving the softened pulp. The sieved mass containing approximately 50–65% water is usually stored in that condition and from it portions are taken and cooked into fufu, which is eaten with soup or stew. The sieved mass and the fufu made from it (irrespective of the cassava variety) possess an inherent odor objectionable to many. Investigations (Ballantine & Ohochuku, 1983) showed that this odor arises from the butanoic acid produced (along with acetic and propanoic acids) during fermentation. Fermentation with molding continues during storage, thus increasing the intensity of the odor and inducing discoloration of the mass and the fufu made from it. These effects increase the dislike for the product.

The objective of this work is to remove the odor from the fermented mass so as to popularize its consumption. The treated mass could be dried to give cassava flour with longer storage life and could be used in times of need. The net effect would be an overall increase in cassava fufu consumption and a drive toward mechanized production of this odorless cassava flour.

## MATERIALS AND METHODS

For the experiments on deodorization, cassava tubers of the white variety were used because the other varities (the yellow and red core) needed only drying of the fermented mass to become odorless. The tubers were peeled, cut, washed, and submerged in cold water at ambient temperature until fermentation occurred as indicated by the softening of the tuber. The white pulp was extracted and mashed in a basket dipped in a basin of water (i.e., sieving). After sedimentation, the supernatant water was decanted and the sediment transferred to a cotton bag in which it was mechanically pressed to give a wet mass with a water content of 30–40%. A fermentation period of 48 h in place of the usual 96 h and a maximum recovery of carbohydrate from tubers that had developed woody fibers were achieved by slicing tubers to pieces approximately 15 mm thick.

**Treatment Procedures.** *Air Blowing.* The pressed mass (30–40% water content) coarsely powdered by sieving it with the traditional home sieve was thinly spread on a cloth covering a 1-$m^2$ perforated top of an aluminum surface. The aluminum surface formed the top of a wooden box fitted with a copper coil through which water at 50–55 °C was circulated. Air was blown through the coil to heat it up and escaped through the perforations, thereby drying the flour. Oven-drying and sun-drying were also practiced. In all the cases flour of 18–20% moisture content was obtained. Dried untreated samples from the white variety were also fried in a rice pan until it lost its objectionable odor.

*Alkaline Treatment of the White Tuber Variety.* Since a carboxylic acid is responsible for the bad off-odor of the fermented tubers, we decided to neutralize it with base, thereby converting it into an odorless salt.

In this respect, trial titrations with 50 g of the pressed sample in 100 $cm^3$ of water were performed with 0.1 M $NaHCO_3$ solution by using a methyl orange indicator. From the titration result, the quantity of 0.1 M base needed to neutralize a 10-kg sample (the unit that was worked with) was calculated and 90% of this volume was added to the 10-kg sample being stirred in 20 L of water. More base was added in small volumes until the pH of the suspension rose to 7.5 as measured with an M & B Rota pH indicator paper. The pH of the slurry was then adjusted to 6.5 with dilute acetic acid. The acidic slurry gives white fufu with no stale oil odor while the slurry that has a pH of 6.5–7.0 by base neutralization only gives a dull white fufu possessing the odor of stale oil. Treatment with aqueous ammonium hydroxide was similar, but 0.1 M ammonium hydroxide solution was used in place of bicarbonate solution and the titration was checked mainly with pH indicator.

After the treatment, the suspension was allowed to sediment, supernatant water decanted, and more water stirred in again. After the second decantation, the sediment was transferred into a bag, pressed to 30–40% water content, and sun-dried or hot air dried to a moisture content of 18–20% to give cassava flour.

*Hydrogen Peroxide Treatment of the White Variety.* Ten kilograms of the pressed mass in 20 L of water was stirred with 3 M $H_2O_2$ (1 L of 10% w/v 30-volume $H_2O_2$ solution). Stirring was continued for 1 h after which the remaining procedure of washing, pressing, and drying was the same as that of the alkaline treatment. In situ deodorized fermentation was carried out by submerging peeled tubers in 5% aqueous solution of hydrogen peroxide, to see whether fermentation could take place without producing the objectionable odor.

*Carotene Treatment.* $\beta$-Carotene (all-trans from B. D. H. England), carotenoid extracts from carrot, and yellow cassava tubers were used to deodorize samples of the ferment from the white cassava variety. Finely grated carrots (500 g) were extracted with 5 L of water. The extract was diluted to 20 L with water to give a treatment

Department of Chemistry, University of Science and Technology, P.M.B. 5080, Port Harcourt, Nigeria.

[1]Present address: College of Education, P.M.B. 5047, Port Harcourt, Nigeria.

0021-8561/85/1433-0220$01.50/0 

Table I. Summary of Results of Treatment and Opinion Poll

| | untreated | treated | | |
|---|---|---|---|---|
| | | $H_2O_2$ | $NaHCO_3$ | carotene |
| (1) stage of odor loss | nil | after sun- or oven-drying | immediately after treatment | after sun-drying or on storing for 90 days after oven-drying |
| (2) color and quality of fufu | odorous and of same color and good quality as the local one | white, odorless, and of very good quality | same as the untreated sample but odorless | same as $NaHCO_3$-treated sample |
| (3) shelf life | long | shelf | life | |
| (4) sampling result: opinion pool | sample easily identified as cassava product; did not attract any recommendation for increased production | erroneously identified as sermovita; only recognized as cassava product by mastication; highly recommended for large-scale production | 15% of people interviewed detected the sample as cassava product from its color; there was complete identification of sample as cassava product after mastication; highly recommended for production | |

solution. Finely grated yellow cassava tubers were similarly treated to obtain a treatment solution. In the case of the β-carotene, a 150-mg sample was dissolved in 20 L of water.

Ten-kilogram portions of the white fermented mass was stirred in each of the treatment solutions for 30 min after which each set was transferred into cotton bags and pressed to masses of 60–70% solid content. Drying was in direct sunlight or with hot air in the presence of sunlight.

**Test for Free Acid in Flour.** A total of 100 g of the flour was extracted with redistilled petroleum ether (bp 60–80 °C). The residue recovered after distilling off the petroleum ether was checked for the odor of butanoic acid and also with litmus paper for acidic property.

**Cooking of Fufu.** Additional water is added to the pressed mass and mashed by hand to obtain a mass that can be rolled into balls of approximately 100 mm in diameter. These balls are put into a pot of boiling water immediately after rolling. Boiling is continued for about 10 min. The partly cooked balls are removed, pounded in a morter, rolled again into balls, and added to the same boiling water in the pot. Boiling is continued, the duration of this second cooking depending on the degree of the first cooking but generally it is approximately the same time. Cooking times each of 20 min have been reported (Ekandem, 1961; Lancaster et al., 1982). The fufu is then pounded again after the second cooking. Undercooked fufu is whitish and tastes like raw starch, while overcooked fufu has a dull color and is difficult to cut.

A method analogous to the cooking of "eluba lafun" (Ekandem, 1961; Lancaster et al., 1982) was adopted to the cooking of the flour from treated sample. In this method, a cup measure of flour and two cup measures of water were stirred in a pot. The suspension was put under low heat with constant stirring with a wood spoon until the fufu was cooked.

**Tests for Residual Treatment Chemicals.** From the observations and results noted during the treating stages, it became necessary to check for only residual hydrogen peroxide because this method with the bicarbonate treatment process appeared to be practicable. The analysis of residual hydrogen peroxide was carried out according to the standard method for traces of this chemical. The residual hydrogen peroxide was checked with a 10-g flour sample in 100 $cm^3$ of water. After the addition of 10 $cm^3$ of 10% KI, 3 $cm^3$ of acetic acid, and 1 $cm^3$ of 1% ammonium molybdate solution, the iodine liberated was titrated with 0.01 M $Na_2S_2O_4$.

**Water and Moisture Content.** A total of 10 g of the pressed mass was loosely and thinly spread on a pan and dried in a vacuum oven at 65 °C to constant weight. A similar procedure was used for the moisture content of the flour.

**Sampling.** An opinion poll was conducted in the University Campus and in four towns by using cooked fufu from untreated and treated flour (i.e., the bicarbonate and peroxide samples). In each area the three samples of fufu were shown to 100 people as samples made from different food sources. The people were requested to identify the probable source of each sample. They were allowed to smell or taste portions of the sample and to suggest which of the samples would be most liked by consumers if all were made from fermented cassava.

## RESULTS AND DISCUSSION

The untreated mass from the white tuber variety retained its inherent odor on drying, owing to the residual butanoic acid in the flour and its intense odor even in trace amounts (2 drops of butanoic acid in 100 $cm^3$ of water produces an intense odor). An ether extract of the flour from this white variety was found to possess the bad odor and also to be acidic, showing the presence of the acid(s) in the dried flour.

In the case of the yellow and red varieties, the odor was totally lost on sun-drying or hot air blowing in the presence of sunlight. Oven-dried samples became odorless on storing for 90 days or spreading it under the sun. The deodorization accompanying drying in the presence of sunlight of the colored varieties is attributed to the carotenoid content of these varieties. Maravalhas (1964) and Guimaraes and Barros (1971) have shown that the pigmentation in these varieties results from the presence of carotenoids in the tubers. The pigmented tubers contain approximately 230 mg of carotenoids/100 g of tuber (Oduro, 1982). Since the white and colored varieties differ mainly in their level of carotenoid contents, it is being proposed that the carotenoids must have reacted with the acids present in the fermented mass during sun-drying to produce the odorless flour.

The participation of the carotenoids in the deodorization gains support from the fact that either the yellow tuber extract or β-carotene or the aqueous carrot extract was able to deodorize the white mass. Also, the residue from the petroleum ether extract was found to be acidic but possessed no odor of tuber fermentation as observed in the flour from the untreated white variety. In addition, dilute $H_2SO_4$ hydrolysis of the residue from the petroleum ether extract possessed the odor of tuber fermentation, thus showing the liberation of the acid from its ester. This result then suggests that the carotenoids reacted with oxygen (probably via epoxidation) and the product combined with all the residual butanoic acid to form esters. If this hypothesis for the deodorization is correct, then the slow rate of deodorization of fufu flour with oven-drying might be explained as resulting from the slow rate of reaction of butanoic acid and the carotenoid epoxides in the absence sufficient sunlight. Unfortunately, acetylation of $\beta$-carotene with acetic acid using an ether-washed cassava flour medium with ethanoic acid in presence of sunlight failed to produce a pure product when examined by proton magnetic resonance spectroscopy. Side reactions accompanying the exposure of carotene to sunlight gave a mixture that was difficult to separate.

Alkali treatment of the white mass removed the bad odor by converting the acids to the odorless water-soluble salts. The treated samples were dried to odorless flour. Hydrogen peroxide treatment of the white variety gave a mass still possessing a faint odor, but on sun- or oven-drying, the odor was completely lost and an odorless flour was obtained. The elimination of the odor by $H_2O_2$ treatment is not understood; the more likely proposal would be that the residual peroxide in the sample being dried enhanced the reaction proposed above between the residual acid with the small amount of carotenoids in the white variety to produce an odorless flour by engaging most of the unsaturated centers in the carotenoids. In situ deodorized fermentation failed; fermentation did not take place even after 2 weeks. The medium must have been unfavorable to bacteria causing the fermentation.

In the alkali treatment, the bicarbonate process is preferred because of its convenience over the ammonia process. The contamination of the surrounding atmosphere with ammonia fumes disqualified the ammonia process; moreover, residual sodium salts of the $C_2$ to $C_4$ acids in such a food sample would be more tolerated than their ammonium salts. The carotenoid process is fast as it does not require extra washing with water after treatment as is the case with the alkali and peroxide processes. The use of locally produced material (carrot) makes it less costly than the other processes. The hydrogen peroxide process is highly recommended as it gives a flour with improved color and no residual peroxide (see below).

The fufu prepared from the treated wet mass (alkali treatment) by the rolled ball double cooking method and from the treated flour by the eluba lafun method were good and odorless. The fufu from the hydrogen peroxide treatment was whiter than the one from alkali treatment. This may be due to the bleaching action of $H_2O_2$. The fufu made from the bicarbonate and carotenoid processes were good and looked similar except that the use of excess carotenoid imparts a violet odor to the fufu.

The analysis for residual $H_2O_2$ showed that there was no residual $H_2O_2$ in the dried flour. This result was expected since the treated mass was wahsed several times by decantation, which should remove much of the chemical and the residue decomposed during drying. No analysis was conducted for residual bicarbonate since the treated mass was acidic at the end of treatment. Also, no analysis for sodium ion of the alkali-treated flour was made since it was estimated that the concentration of sodium in this product would be approximately equal to that in bread baked with baking powder.

The result of opinion poll is shown in Table I. In general, the $H_2O_2$-treated sample attracted more recommendation for production because of the extra white texture of the fufu from it. The $NaHCO_3$- and carotene-treated samples were equally highly recommended.

In general, it would be said that the program of deodorization was successful. The three processes are very practicable. The bicarbonate process is recommended for home processing for immediate consumption where no facility for drying is available since the treated wet mass could keep for a month or more if well stored. The $H_2O_2$ method ranks first to the bicarbonate and carotenoid process because of its simplicity and superior product and, if mechanized, cassava fufu would be enjoyed by quite a lot more people and increased tuber production would be more meaningful since more tubers would be fermented, treated, and preserved as flour for consumption in times of need. The cassava flour resulting from the hydrogen peroxide treatment is superior in quality to any of the flour from cassava tubers reported so far by a survey of processing techniques by Lancaster et al. (1982), and the cassava fufu cooked from it is good and attractive.

**Registry No.** *All-trans-$\beta$*-carotene, 7235-40-7; hydrogen peroxide, 7722-84-1; sodium bicarbonate, 144-55-8.

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Received for review December 5, 1983. Accepted September 6, 1984.