HAITI PRODUCTIVE LAND USE SYSTEMS PROJECT

SOUTH EAST CONSORTIUM
FOR INTERNATIONAL DEVELOPMENT
AND
AUBURN UNIVERSITY

INCREASING THE MARKETABILITY OF MANIOC AND BREADFRUIT PRODUCTS BY IMPROVING PROCESSING TECHNIQUES

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ENGLISH EXECUTIVE SUMMARY

The perishability of fresh manioc roots and breadfruit places constraints on the marketing of these products. This study was made to investigate processing techniques to reduce these constraints.

MANIOC

The primary objective of this consultancy was to test the commonly held belief among manioc processors that the traditional manioc flatbread (*kassav* in Haitian Creole) cannot be made from dried manioc chips. As a result of this perception and other economic factors, manioc production and *kassav* processing are done on a very small-scale which constrains the development of urban markets for the product. Proving that the *kassav* could be made from dried manioc will allow the development of alternative marketing channels for manioc.

The study accomplished this objective. The consultant had traditional bakers produce *kassav* from manioc meal that had been removed from a traditional bakery, dried, then rehydrated and returned to the bakery. The results from a sensory evaluation of the product by a panel of Haitians demonstrate clearly that the product is tasty and accepted by Haitian people. The consultant also showed that *kassav* could be made from manioc meal made from dried manioc chips. This means that farmers could produce manioc chips, dry them and then ship them to cities whenever transportation is available (because the dried chips store well) and that meal made from such chips can be used to produce *kassav*.

Concern over the levels of cyanide in manioc products led to testing cyanide levels. Cyanide content in commercially available *kassav* ranged from 2.9 mg 100/g to 3.4 mg 100/g, while *kassav* made from dried manioc chips which had not been compressed to extract liquids (and some associated cyanide) contained 6.1 mg 100/g. Compressing the freshly grated manioc to extract liquids appeared to reduce cyanide levels. Since cooking is known to reduce the cyanide level of a product, tests were made to observe the reduction in cyanide levels obtained through cooking. The products tested included *kassav* and manioc flour porridge (a thick soup). Manioc flour is a by-product of *kassav* processing in Haiti and is used to make porridge. While cooking did reduce cyanide levels, the reduction was not sufficient to bring cyanide levels into a range comparable with those observed in products produced with traditional methods. These results indicate that manioc may have to be compressed at some point in order to reduce cyanide levels to those found in traditional, Haitian manioc products. This may most economically be done at the processor-level.

It is important to emphasize that there is no consensus on the safe levels of cyanide for human consumption. The International Institute of Tropical Agriculture considers "...a manioc cultivar innocuous or safe if the total cyanide content in mg HCN/kg fresh weight tuber is less than 50" (Mahungu, Yamaguchi, Almazan and Hahn). This corresponds to 20 mg 100/g dry weight. Thus, the cyanide levels found in Haitian manioc products, produced with the modified processes tested here, may not be considered high.

Given adherence to recommendations, contained herein, concerning cyanide content, processors should be encouraged to develop processing and marketing channels for *kassav* and manioc flour based on dried manioc chips.

BREADFRUIT

A Port-au-Prince processor indicated a desire to produce a fried breadfruit chip for the local and export markets. This study investigated the possibility of using sun-dried slices of breadfruit to produce fried breadfruit chips. The study showed that this would be possible if the thickness of the breadfruit slices could be controlled. Additionally, the study found that dried slices of breadfruit store quite well over a period of at least two months.

The applicability of flour made from dried breadfruit slices in other food manufacturing processes was also tested. Results indicate that breadfruit flour could replace 5 percent of the wheat flour in making bread. Based on these results, the study recommends that other applications of the flour, such as in sauces, soups, puddings, cakes, cookies and crackers, should be tested.

This study shows that with appropriate equipment for slicing fresh breadfruit, farmers can transform their highly perishable breadfruit into a relatively stable product with many potential uses at the farm and the food processing level. This could make a significant contribution toward the achievement of the PLUS project goal to increase farm income in a manner that supports conservation of natural resources. Farm income would increase as farmers either preserved for later use or sold more of their breadfruit harvest. The increased value flowing from breadfruit trees will increase the value of the trees to the farmers and should translate into enhanced conservation of the trees.

Processors should be encouraged to develop processing and marketing channels for breadfruit chips and breadfruit flour derived from dried breadfruit chips.

CREOLE EXECUTIVE SUMMARY

REZIME

Rasinn manyòk ak lam veritab pa konsève lontan apre yo finn rekòlte. Se yon pwoblèm lè pou yo vann. Etid sa a chèche teknik pou transfòme pwodwi sa yo pou rezoud pwoblèm sa a.

MANYOK

Premye objektif etid sa a se chèche konnen si moun k'ap fè kasav gen rezon lè yo panse kasav pa kapab fèt ak farinn manyòk seche. Kòm konsekans kwayans sa a mete ak lòt pwoblèm ekonomik, sa fè pwodiksyon manyòk ak kasav pa fèt an gran kantite. Sa anpeche mache kasav devlope lavil. Si kasav te kapab fèt ak manyòk seche, sa ta pèmèt devlope lòt jan pou vann manyòk.

Etid sa a arive montre sa posib. Konsiltan an fè moun ki gen kasavri fè kasav ak farinn manyòk. Li pran farinn manyòk nan kasavri, li fè seche farinn nan, apre li remouye-l, li retounen-l nan kasavri pou fè kasav avè-l. Kèk ayisyen ki goute kasav ki fèt jan sa a di li gen bon gou e yo renmen li. Konsiltan an montre tou kasav kapab fèt avè moso manyòk seche. Sa vle di, peyizan yo ta kapab koupe manyòk an moso, seche yo, apre voye vann lavil kote gen mwayen transpò (paske moso manyòk seche kapab konsève pandan yon bon tan). Farinn ki fèt ak moso manyòk seche ta kapab sèvi pou fè kasav.

Yon lòt pwoblèm, se kantite yon pwazon ki rele siyani ("cyanure"), manyòk anmè genyen. Yo te teste tou kantite pwazon sa a nan kasav la. Kasav ki abitye vann sou mache a genyen ant 2,9 mg/100g a 3,4 mg/100g, alòs kasav ki fèt ak moso manyòk seche ki pat prese pou fè dlo soti nan manyòk ki ta graje (pwazon an soti ak dlo a) genyen plis siyani, 6,1 mg/100 g. Prese manyòk graje pou fè dlo soti sanble diminye kantite siyani an. Kòm anjeneral nivo siyani an bese nan yon pwodwi lè li kwit, yo te teste kantite siyani ki genyen nan kasav ak labouyi farinn manyòk (ki se pwodwi ki kwit). Farinn manyòk se yon pwodwi ki jwenn nan manyòk lè kasav ap fèt.
Nivo siyani bese vreman lè pwodwi yo kwit, men li pa rive menm jan ak nan kasav ki abitye fèt yo. Rezilta sa yo montre manyòk la ta dwe prese pou jwenn menm nivo siyani ki genyen nan pwodwi manyòk ki abitye fèt yo. Mwayen ki pi ekonomik pou fè sa, se ta nan kasavri yo menm.

Li enpòtan pou ta genyen yon antant sou nivo siyani ki pa danjere pou moun jwenn nan manje. Instit Entènasyonal pou Agrikilti Tropikal (IITA) konsidere "... yon varyete manyòk pa danjere si kantite siyani an pa depase 50 HCN/kg manyòk fre" (Mahungu, Yamaguchi, Almazan ak Hahn). Sa vle di 20 mg/100 g. manyòk seche. Kidonk, kantite siyani ki jwenn nan pwodwi ki fèt ak manyòk an Ayiti, jan ki te eseye nan etid sa a, ta dwe konsidere pa danjere pou moun manje.

Dapre rekòmandasyon ki soti nan etid sa a, sou kesyon kantite siyani, yo ta dwe ankouraje moun ki nan biznis fè kasav ak farinn manyòk sèvi ak moso manyòk seche pou fè pwodwi sa yo.

LAM VERITAB

Yon bizisman nan Pòtoprins te montre li enterese fè tranch lam veritab fri pou vann an Ayiti ak lòt bò dlo. Etid sa-a chèche wè si gen mwayen sèvi ak tranch lam veritab seche nan solèy pou pwodwi lam veritab fri. Anplis, etid sa-a montre li ta posib si yo ta kontwole gwosè tranch lam veritab yo. Etid sa montre tou moso lam veritab seche ka konsève pou plis pase de (2) mwa.

Etid sa te chèche tou si gen mwayen fè lòt pwodwi avèk moso lam veritab seche. Rezilta yo montre farinn lam veritab kapab ranplase 5 pou san farinn ble pou fè pen. A pati rezilta sa yo, etid la rekòmande pou teste farinn lam veritab pou fè lòt bagay tankou sòs, poudinn, gato, bonbon ak biswit sèk.

Etid sa a montre ak ekipman byen chwazi pou koupe lam veritab an tranch, peyizan kapab fè lam veritab ki gate rapid tounen yon pwodwi ki kapab konsève e ki kapab sèvi pou fè anpil bagay lakay peyizan ak nan biznis ki transfòme manje. Dekouvèt sa a ka pote yon diferans nan Pwojè PLUS ki vize pou ogmante lajan (revni) peyizan fè, au menm tan ki pèmèt konsève resous natirèl yo. Revni peyizan ap ogmante lè yo kapab sere nan rekòt lam veritab oubyen pou sèvi pi devan oubyen pou vann. Pye lam veritab t'ap genyen plis valè pou peyizan yo. Kòm konsekans, yo t'ap gen plis tandans pwoteje yo.

Yo ta dwe ankouraje bizismann angaje nan fè tranch lam veritab ak farinn ki fèt ak moso lam veritab seche, epi devlope mache pou pwodwi sa yo.

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INTRODUCTION

This report covers food technology studies made to assist in the development of new marketing channels for manioc and breadfruit produced by small-scale Haitian farmers participating in activities of the Productive Land Use Project. The report is divided into sections on manioc and breadfruit. Conclusions and recommendations on both products are provided in two final sections.

MANIOC

Introduction and Objectives of the Manioc Study

Manioc or cassava (*Manihot esculenta*) is a root crop widely grown and consumed in Haiti. It is eaten in the form of a pancake or flatbread, called *kassav* in Haitian Creole, and as porridge or thick soup prepared from manioc flour. Manioc flour is a by-product of *kassav* production. The traditional way of preparing *kassav* involves washing the manioc root, followed by peeling, grating, compressing to remove some of the liquid released during grating, grinding, then baking on a hot plate. Any manioc meal not processed into *kassav* is further ground into manioc flour.

In Haiti, it is believed that *kassav* can only be made in a continuous process, i.e., that freshly grated, still moist manioc meal must be used. This, coupled with their short shelf-life, implies that fresh manioc roots must be delivered to the facility producing the final product. Shipment over long distances is difficult because of transportation problems, partially associated with the perishability of the roots. *Kassav* processing generally takes place near manioc production areas in very small scale processing centers. Small scale generally implies higher per unit costs than could be achieved with larger scale facilities. Higher costs tend to constrain the growth of the market for *kassav* which in turn has constraining effects on the growth of the production and processing sectors of the industry.

One possible way to break this low productivity cycle is to transform the raw product in a way that would allow it to be stored longer and shipped over longer distances. For example, it would be desirable if *kassav* could be prepared from dried manioc roots. This would allow for a more efficient marketing channel. Farmers in distant rural areas could transform their perishable manioc roots into sun-dried manioc chips, a less-perishable intermediate product having a long shelf life. Later, the dried chips could be sent to processing plants in cities. This will not only relieve farmers of the constraints of storage and transportation, but also allow the final product to be completed in larger scale facilities in or near towns and cities. This should result in lower *kassav* production costs and higher profits for processors. Ultimately, these higher profits will be shared with consumers in the form of lower prices for the finished product and with producers in the form of higher prices for the raw product. Thus, the primary objective of this study of *kassav* processing is to establish whether or not *kassav* can be produced from dried manioc chips.

A secondary objective of this study was to test whether one of the traditional processing steps, namely, compressing the grated manioc roots to extract liquids released by grating, could be eliminated. The compression step requires heavy equipment and thus raises the cost of manioc processing. Eliminating this step was investigated by testing cyanide levels in cooked products. Since cooking is known to reduce the cyanide level of a product, it was hypothesized that the typical cooking processes would reduce the cyanide content of the finished products to safe levels. The products tested included *kassav* and manioc flour porridge. *Kassav* is cooked at the processing plant, while porridge is cooked by the consumer.

The cyanide content of manioc varies with variety. Two types of manioc are known. One is called "sweet manioc" which contains low levels of cyanide and can be readily consumed without treatment while the other is called "bitter manioc" which contains higher levels of cyanide ranging from 6-1200mg/100g, depending upon the variety. *Kassav* is typically made from bitter manioc. It is not clear what the cyanide level of manioc consumed in Haiti is. Cyanide in manioc is in two forms:

- bound cyanide present as glucosides such as linamarin and lotaustralin; and
- free cyanide present as cyanohydrin and hydrocyanic acid (HCN).

Cyanohydrin, an organic cyanide compound, is formed when linamarin is attacked by the enzyme linamarase which is present in manioc roots and released when the cell structure is disrupted. Cyanide is widely distributed in nature and is a normal constituent of blood, usually at very low concentrations < 12 uM/L. The body has natural defense mechanisms to detoxify low levels of cyanide. The lethal dose taken orally by human is 0.5-3.5 mg/kg body weight or approximately 30-210mg of HCN for an adult weighing 60 kg.

"There is no consensus as to how much cyanide concentration is safe for human consumption" (Mahungu, Yamaguchi, Almazan and Hahn, pp. 11). The International Institute of Tropical Agriculture considers "...a manioc cultivar innocuous or safe if the total cyanide content in mg HCN/kg fresh weight tuber is less than 50" (Mahungu, Yamaguchi, Almazan and Hahn, pp. 11). This corresponds to 20 mg 100/g dry weight. However, previous studies of various traditional manioc products have shown cyanide content of these products to be in range of 2-3 mg 100/g. Since people in West Africa as well as in the Caribbean have been consuming manioc products for numbers of years without apparent ill effect, this concentration may be considered a safe and acceptable cyanide level in food. Information regarding cyanide content of manioc products in Haiti is limited. Thus, a secondary objective of this study was to test the cyanide content of manioc products produced from dried manioc chips and of various traditional Haitian manioc products. This investigation was limited to testing a few sample products.

Description of Commercial *Kassav* Preparation

A *kassav* processing plant at Rivière Froide, Port-au-Prince was visited four times to observe how *kassav* is prepared. The process starts by peeling manioc roots using a spoon as a peeler. Peeled roots are washed, then stacked together until the workers finish peeling the batch of roots to be processed. The next step is grating. Grating is done using a grating machine attached to an electric motor or powered by a diesel engine. Grated manioc is packed in coarse jute bags, placed under a press, and excess juice or water is removed by compression which is done by mechanically assisted manpower. The compressed manioc mass is passed thru a sieve (or screen) to remove large pieces of skin or fiber to obtain a uniform particle size. This still-moist manioc meal is sprinkled with salt and put into a circular shaped mold (about 15 cm diameter and about 2 cm high), tapped lightly and baked on a hot plate heated by burning tree branches. The baked product, called *kassav,* is a porous flatbread with a bland taste and slightly chewy texture.

Experiment 1. Preparation and Evaluation of *Kassav* Made from Dried, Compressed Manioc Meal

The objective of this experiment was to determine if *kassav* can be prepared from dry manioc meal. Compressed manioc meal (manioc which has been grated and compressed to remove some of the liquid released during the grating process) was obtained from the *kassav* processing plant at Rivière Froide, Port au Prince. In order to test the effect of drying temperature, the manioc meal was divided into 3 groups. One batch was sun dried on a concrete roof top and required about 1-2 days to dry. The second and third group were dried at 60°C and 80°C , respectively, using a drying oven at Quisqueya University, Port-au-Prince. After one week, the manioc meals thus prepared were taken back to the Rivière Froide plant and reconstituted with water (about 40-43% moisture content). The bakers of the facility then used the material to bake *kassav* using exactly the same process they employ for their products. The *kassav* were evaluated on the spot by cassave processors as well as nineteen people at the SECID office at Petion-Ville using a five point scale questionnaire asking their preference for *kassav* products. The *kassav* used as a control in the evaluation were obtained from the *kassav* processing plant on the day the treated *kassav* were cooked. Note this means that the control and the treated *kassav* were made from different batches of manioc roots.

Results and Discussion: Experiment 1.

The apparent difference among the three meals was color. The sun dried meal had a light color. The meal dried at 60°C appeared slightly yellowish brown while the one dried at 80°C was darker than the others. In any case, all three meals congealed well and made good *kassav* when baked on a hot plate. Unlike the case of the meals, there was no conspicuous difference in color among the finished *kassav* made from meals dried at different temperatures. The results clearly indicated that *kassav* can be made from dried manioc meal. We asked people at the *kassav* processing plant to sample the products. After tasting, they indicated that they liked the products and commented that the products tasted exactly like traditional *kassav*.

The results of a sensory evaluation administered at the SECID office showed a similar response and acceptability. Nineteen people (18 are Haitian) evaluated the products. The results (Table 1) shows that *kassav* made from the meals dried at 80°C and 60°C had a higher score than the one made from sun dried meal and the control. The score of *kassav* made from sun dried meal was also higher than the control. The control was the commercial *kassav* purchased at the Rivière Froide manioc processing plant in Port-au-Prince. It is not clear why *kassav* made from the meals dried at higher temperatures (60°C and 80°C) scored higher than the one made from sun dried meal and the control. In any case, the results of this study (Table 1) demonstrated clearly that *kassav* can be made from dried meal, and the product is tasty and accepted by Haitian people.

Table 1.
Sensory evaluation of *kassav* prepared from meals dried at various temperatures and traditionally prepared commercial *kassav*

Sample	Drying temperature	Mean Score
Meal, sun dried	20°-27°C	2.94^b
Meal, oven dried	60°C	4.11^c
Meal, oven dried	80°C	4.00^c
Traditional *kassav*		2.11^a

Mean scores with the same superscript are not significantly different at the 5% level. A 1-5 scoring scale was used by the panelists, one indicating the least preferred. Nineteen panelists took part in the test.

Experiment 2. Preparation of *Kassav* from Uncompressed Manioc Chips

In Experiment 1, manioc meal was prepared from grated and then compressed manioc roots. For farmers with limited resources, chopping manioc roots into chips then sun drying is the simplest and the most economical way to preserve manioc. Manioc chips, when properly dried, can be stored for several months. The chips can be milled easily to meal by a grinding mill. The question addressed by Experiment 2 was whether *kassav* can also be made from dried manioc chips. This would allow elimination of both grating and compressing at the farm level. Thus, for use in Experiment 2, peeled manioc roots were simply chopped into chips and sun dried. The dried chips were brought back to Tuskegee University. The dry chips were ground to meal. Sufficient water was added to adjust the moisture content to about 40-45%. The moistened meal was then baked on a cast iron skillet to make *kassav*.

Results and Discussion: Experiment 2

The manioc meal, made without compressing to remove any liquid, congealed easily on a hot skillet to form *kassav*. Its appearance resembled those prepared at the Rivière Froide manioc processing plant at Port-au-Prince. These results showed that *kassav* or flat manioc bread can be prepared from dried manioc chips without a compressing step. This means that a new system for marketing manioc is technically possible. Farmers can make manioc chips, dry and store them, and then ship them to cities whenever transportation is available for later processing into *kassav*.

Experiment 3. Cyanide Content of Manioc and Manioc Products

The problem with manioc is its cyanide content which must be reduced to a safe level during processing. Manioc is a common staple that has been consumed by people in Haiti for many years. Thus, in the absense of conflicting data, one would suppose that the traditional Haitian manioc products are safe for consumption. However, when making a change in traditional production processes, it is imperative to know how the cyanide concentrations of the modified products compare to those of traditional products. Thus, the objective of this experiment was to gather initial indications of cyanide levels in traditional products and those made with the modified processing sequence tested by this study. These results should be consided only indicative since the study tested only a very limited number of samples.

Materials and Method

All the manioc and manioc products were obtained in Haiti, mainly at Port-au-Prince. Total cyanide was determined by the AOAC method (Association of Official Analytical Chemists, 1985, Washington, D. C.) as follows:

1. 10-20g samples were weighed and placed in an Erlenmeyer flask.
2. 100mL of water were added and stood for 2 hours
3. The sample was transferred to a distillation tube and steam distilled. Tecatur's nitrogen distillation apparatus, Model 2002, was employed.
4. The distillate was received in an flask containing 20mL of 2.5% NaOH. About 150 mL distillate were collected.
5. To the distillate, 8mL of 6N NH_4OH was added, followed by 2 mL of 5% KI.
6. The distillate was then titrated drop by drop with 0.02 N $AgNO_3$ solution. The

end point had a faint but persistent white turbidity.

7. At the end point, titer value was read, then calculated into mg HCN/100g sample (dry weight)
8. All the analyses were made in duplicate

Results and Discussion: Cyanide Content of Manioc and Manioc Products

The materials used and the results of analyses are summarized and shown in Table 2.

Table 2.
Cyanide content of manioc and manioc products

Sample	Description of Sample	Cyanide Content mg/100g dwt
1	Manioc chips, sun dried	17.0
2	Manioc meal, made from grated manioc, not compressed to remove some of the moisture in the product	14.7
3	Manioc meal made from grated manioc, compressed to remove some of the moisture in the product and sun dried	6.4
4	Manioc meal made from grated manioc, compressed to remove some of the moisture in the product and oven dried at 80°C	6.5
5	Manioc meal made from grated manioc, compressed to remove some of the moisture in the product and oven dried at 60°C	6.8
6	*Kassav*, a commercial product made at Rivière Froide, Port-au-Prince, Haiti.	3.4
7	*Kassav* made from manioc chip meal. Not compressed. *Kassav* was prepared at Tuskegee (see Exp. 3)	6.1
8	*Kassav*, a commercial product purchased at Port-au -Prince by Dr. S. L. Louis of Tuskegee University	2.9
9	*Kassav*, a commercial product purchased at Port-au -Prince by Dr. S. L. Louis of Tuskegee University	2.9
10	Manioc flour from a commercial processor in Port-au-Prince	3.12
11	Manioc flour made from uncompressed, dried manioc chips	9.11
	*Manioc materials (samples 1-7) were from Rivère Froide manioc processing plant, Port au Prince.	

The results show that uncompressed manioc samples, namely, samples 1 and 2, had 17 and 14.7 mg/100g HCN, respectively. The cyanide content was lower for Samples 3, 4 and 5, indicating that compressing of manioc meal after grating probably reduced the cyanide content. Some cyanide compounds are water soluble and are leached out when compressed tightly. The cyanide content of commercial *kassav* consumed in Haiti (samples 6, 8 and 9) and *kassav* (sample 7) which was prepared at Tuskegee from manioc chips were not considered high although the latter appeared higher than samples 6, 8 and 9. It is important to note that the manioc constituting sample 7 was not compressed to remove any liquid at any time during the processing.

The cyanide concentration of sample 1 (manioc chips) and sample 2 (meal from uncompressed manioc) are 17 and 14.7mg, respectively, which may not be considered high enough to produce a lethal effect in humans. However, caution is needed not to consume large quanities of manioc products if they contain this level of cyanide. Cyanide content of manioc product depends on manioc variety and the method of processing. The fact that the control sample *kassav* (sample 6 of Table 2) and the treated sample *kassav* (sample 7 of Table 2) came from different batches of manioc roots may explain some of the diffenence in cyanide level between these two samples. It is recognized that manioc from different farms or produced under different production practices may have different levels of cyanide (Ayres). Processes such as soaking, maceration, compressing and cooking decrease cyanide content of resulting manioc products. Depending upon storage forms and storage conditions, cyanide content may decrease during storage.

Experiment 4. The Effect of Cooking on the Cyanide Level of Manioc Products

Cooking may significantly decrease the cyanide level in food. The purpose of this experiment was to determine how much cyanide reduction would occur as a result of cooking. Two samples of porridge were used. One was made with manioc flour obtained from Jeanty's plant, a processor and distributer of manioc flour to communities in Port-au-Prince. The other sample was made with the flour made from unpressed manioc chips. The manioc chips were brought from Port-au-Prince to be prepared into flour at the Food Science Laboratory at Tuskegee University. Ten grams of manioc flour was mixed with 100mL of water and heated to obtain the appropriate viscosity, then simmered for 10-30 min. The samples were analyzed for cyanide as described in Experiment 3. Analysis was done in duplicate. Results are shown in Table 3. Additional evidence of the effect of cooking was observed in the diffence in cyanide levels between uncooked manioc meal (sample 2 of Table 2) and the cooked *kassav* made from this meal (sample 7 of Table 2).

Results and Discussion: Effect of Cooking on the Cyanide Level of Manioc Products

The commercial manioc flour had a low initial level of cyanide (3.12 mg) while manioc flour made from chips not compressed during processing had a higher initial cyanide concentration of 9.11 mg. The cyanide content of both tested products decreased with

Table 3. The effect of cooking on cyanide content of manioc products		
Sample	Cooking time (min)	Cyanide content mg/100g
Porridge made from manioc flour (from Jeanty's).	0	3.12
Porridge made from manioc flour (from Jeanty's).	10	2.40
Porridge made from manioc flour (from unpressed manioc chips).	0	9.11
Porridge made from manioc flour (from unpressed manioc chips).	10	7.20
Porridge made from manioc flour (from unpressed manioc chips).	30	5.20
Porridge made from manioc meal made from grated manioc, not compressed (sample 2 of Table 2).	0	14.7
Kassav made from manioc chip meal. Not compressed (sample 7 of Table 2).		6.1

cooking time. The differences in cyanide levels between uncooked and cooked products appears to be significant. These observations agree with other reports that cyanide content decreases with cooking. This indicates that some cyanide compounds present in the samples might have been lost because of evaporation, indicating that cooking can indeed reduce cyanide in manioc products. However, if the products are intended for youngsters especially infants, it is recommended that the products be made from manioc flour which is made from manioc roots which have been grated and compressed during processing. Processors should be encouraged to sample their products for cyanide content at different stages of the production process to understand where cyanide levels are high so that appropriate remediative action can be taken to insure that the cyanide level in the final product is safe for human consumption.

BREADFRUIT

Introduction and Objective of the Breadfruit Study

Breadfruit (*Artocarpus altilis* Fosb.), a native of Polynesia, is now grown widely in tropical zones of Asia, Africa and the West Indies. It is high in starch (65%) and also contains some protein (4.5%). This is a climacteric type fruit so it has a high post-harvest respiration rate and a short storage life. After peeling, it is served in a boiled or fried form or sometimes pounded into a paste which is fried in small spherical shapes or used to make a sauce for other types of foods. There is substantial demand for this fruit in Haiti.

The profitability of this fruit will increase if it could be stored in a stable form, transported to distant markets, then processed. Low temperature storage such as provided by a cooler or freezer is not feasible for farmers in rural areas because of financial considerations and lack of electricity. A simple and low cost way of preserving breadfruit is slicng followed by sun drying. The resulting dried chips can be stored for a long time. Later the chips can be sent to cities for processing and used as an additive or ingredient for various value-added food products. Thus, the objectives of this study of breadfruit processing were to determine dried breadfruit chip composition and to investigate the possibility of using dried breadfruit chips to make snack food and bakery products.

Materials and Method

Thinly cut (manually) and sun dried breadfruit chips were brought back to the Food Science Laboratory at Tuskegee University from Port-au-Prince for experiments. The dry breadfruit chips appeared stable and no spoilage or off flavor were observed after 2-3 months of room temperature storage. Two experiments were conducted to determine how to utilize breadfruit chips. One study was to prepare deep-fat fried breadfruit chips, and the other to prepare breadfruit bread.

Experiment 5. Fried Breadfruit Chips

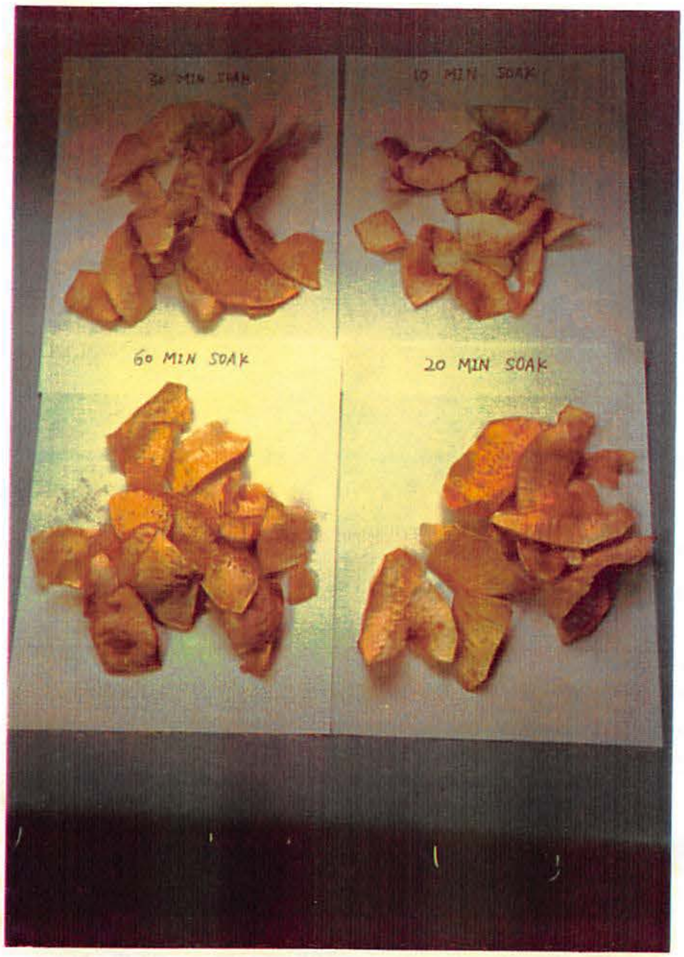
To prepare a potato-chip-like product from dried breadfruit chips, breadfruit chips were soaked in a sufficient amount of water to rehydrate them and then fried. The soaking times were 10, 20, 30 and 60 min. After soaking excess water was drained and wiped from the chips using a paper towel. The chips were then deep fat fried in cooking oil at 165°C for 1, 2, 3 and 5 min. The appearance, color, and texture of the deep fat fried chips were evaluated in the lab. Also the composition of breadfruit chips was analyzed and the results are presented in Table 4.

The results, shown in Table 4, indicate that breadfruit is a high carbohydrate food, containing 62% starch. It also contains appreciable amount of protein at 3.81% and, like most fruits and vegetables, is low in fat. It may be considered a carbohydrate rather than a protein food.

Table 4. Proximate composition of breadfruit chips	
Moisture	19.72%
Protein	3.81%
Fat	1.13%
Ash	1.39%
Starch	62.80%

Results and Discussion: Deep fat fried breadfruit chips.

The fried breadfruit chips had a light yellowish brown color, crispy texture and a bland taste. Longer soaking time seemed to make a better product than shorter soaking time, but the difference was not clear. The problem arose due to the uneven thickness of the chips. Some parts of individual slices were thin while other parts remained thick. This created uneven cooking conditions. The thinly sliced parts cooked quickly and turned brown because of excessive cooking while the thick parts remained uncooked; hence, the products were not uniform in texture. The thick parts remained tough and not crunchy. The results indicate clearly that breadfruit must be cut thinly at the same thickness to ensure making of good quality chips. This is a difficult task for farmers since they probably do not have access to a slicing machine which can cut at adjusted thickness and obtain chip of uniform size and thickness. The deep fat fried chips presoaked at different times are shown in Picture 1.



Picture 1. Deep fat fried breadfruit chips presoaked in water at various times.

Experiment 6. Breadfruit Bread

Breadfruit chips were first dried at 60°C over night, then ground to flour. The flour thus prepared was used to replace wheat flour at 5, 10 and 20% of the total amount needed to make bread. The formula of bread is shown as follows:

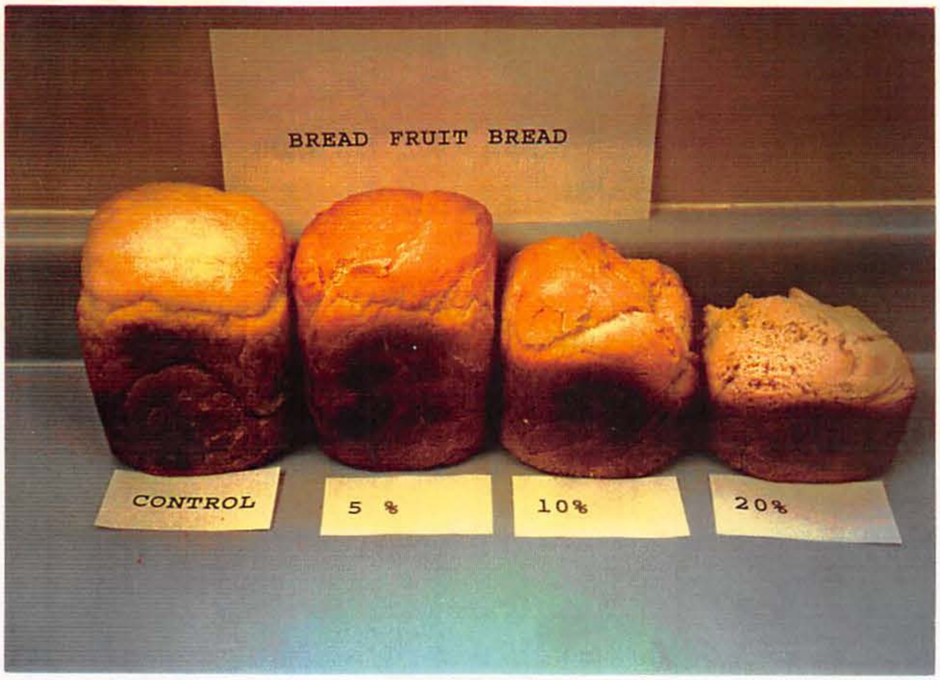
White Bread....All Purpose Flour Control Bread

2 cups of all purpose flour
2 tablespoons sugar
1/2 teaspoon salt
1 tablespoon margarine
1 tablespoon milk
3/4 cup lukewarm water
1 teaspoon active dry yeast

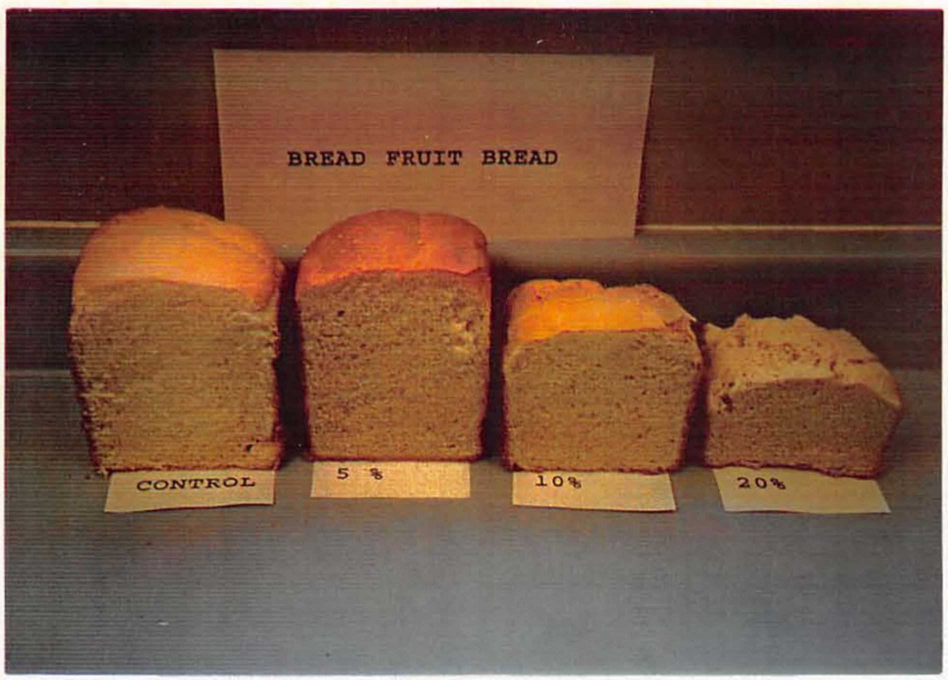
All the ingredients were mixed then baked in a Sanyo automatic bread maker. It took 3 hours to bake one loaf of bread. The breads thus prepared were compared on color, loaf volume, shape, aroma and taste by staff and students at the Food Science Laboratory at Tuskegee University. The breads prepared are shown in Pictures 2 and 3.

Results and Discussion: Breadfruit bread.

Breadfruit flour can replace wheat flour to make bread. Pictures 2 and 3 show clearly that we cannot use too much breadfruit flour in bread because it reduces the loaf volume and makes the bread texture appear more compact and less spongy. The reason for this is that breadfruit is a low protein ingredient which lacks gluten, a key protein essential for successful bread making. Therefore, adding too much breadfruit does not promote the formation of the soft, spongy structure characteristic of good bread. However, replacing wheat flour at the 5% level appears acceptable and does not impair the bread quality and characteristics. As a matter of fact, the 5% breadfruit bread had a comparable loaf volume and retained a desirable texture and good taste with some breadfruit flavor. In short, the product was judged highly acceptable. Other than bread, breadfruit flour can also be used in other food products such as sauces, puddings, cakes, cookies and crackers, etc.



Picture 2. Breads incorporating various levels of breadfruit flour



Picture 3. Cross section of breads incorporating various levels of breadfruit flour

CONCLUSIONS

1. *Kassav*, a traditional Haitian manioc flatbread, can be made from dried manioc meal. *Kassav* made from dried manioc meal was organoleptically acceptable. *Kassav* can be made from manioc meal made from dried manioc chips.
2. Manioc can be stored in the form of chips. Dried manioc chips are stable and can be stored easily. Manioc chips can be made into meal or flour by grinding.
3. Cyanide content of manioc and manioc products analyzed was not high. However, manioc root, grated but unpressed, still contained a substantial level of cyanide: 14-17mg/100g.
4. Processing steps such as compressing and cooking reduced cyanide content of manioc products.
5. A potato chip like product could be made from dried breadfruit chips if thickness of the chip can be controlled. Further study is needed to investigate appropriate processing conditions.
6. Breadfruit flour can replace up to 5% of wheat flour in bread making.

RECOMMENDATIONS

1. Analyze the cyanide content of varieties of manioc grown in Haiti. High cyanide varieties should not be recommended to make manioc chips. Manioc processors should be aware of the variety, production location and level of cyanide in the manioc they process.
2. In the absence of more complete information on the level of cyanide considered safe for human consumption, manioc products should not be sold to the public unless they contain cyanide equal to or less than the levels found in traditional manioc products, namely, 3.4 mg/100g dry weight.
3. Given adherence to the two preceeding recommendations, processors should be encouraged to develop processing and marketing channels for *kassav* and manioc flour based on dried manioc chips.
4. Conduct a study to determine the effect of storage time on cyanide content as well as the quality of manioc chips. The chips should be stored at least six months or longer at various conditions (certain temperatures, humidity, light, packaging, etc).
5. The addition of manioc flour in other food products should be explored.
6. Additional study should be made to determine the appropriate processing techniques to be used by farmers or village-processors to convert raw, whole breadfruit into chips appropriate for quick drying and further processing.
7. Breadfruit flour appears to be an excellent carbohydrate ingredient that can be used in various food products.
8. Processors should be encouraged to develop processing and marketing channels for breadfruit chips and breadfruit flour derived from dried breadfruit chips.

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