

# Preparation of Yam (*Dioscorea alata* L.) Flakes<sup>1</sup>

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## INTRODUCTION

Yam (*Dioscorea alata* L.) of the variety known in Puerto Rico as "Florido" is grown in the mountainous region of the Island. This root crop is in great demand by consumers in both rural and urban areas. It is cultivated mainly to supply the fresh market. Due to the seasonal nature of this crop, supplies are greater from October to January and there are practically none from February to September.

Surplus root crops are generally used for manufacturing purposes. Economic methods have been developed through modern food technology for the preparation of processed products from starchy root crops such as white and sweet potatoes.

No successful attempt to process yam in the form of flour or flakes is reported in the literature, although methods for dehydration of potatoes are reported extensively. Barker et al. (1), Bowen (2), and Burton (3) described the method of producing powdered mashed potatoes by spray drying. Research for the development of precooked dehydrated products from potatoes (5,7,8,9,10,11,12,13) and sweet potatoes (6) has been conducted at ARS, USDA Eastern and Southern Regional Laboratories in Philadelphia and New Orleans. As a result of these developments, instant mashed potatoes are being produced now in large quantities and are widely accepted in both consumer and institutional markets.

Texture of the final product is one of the main problems in preparing powdered mashed potatoes of good quality. This may be controlled by reducing cell rupture through proper cooking and dehydrating processes. It generally is recognized that the texture factor is one of the major attributes of food quality affecting consumer acceptance.

This study was undertaken for the purpose of developing a method for preparing instant mashed yam of good quality and acceptance. Such a method would assure availability of a yam product throughout the year in an easily prepared form for consumer use.

## MATERIALS AND METHODS

Florido yam tubers harvested at Barrio Cañaboncito, Caguas, P.R. were used as raw material. The tubers were left until used in burlap bags at room

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temperature for 30 days or less. Each batch consisted of 20 pounds of fresh tubers with three replicates for each cooking period.

The yam tubers were lye-peeled for 3 minutes in a 20-percent boiling lye solution, following a method developed by Rivera-Ortíz and González (17). Residual lye was removed in a washing machine provided with water sprayers and nylon brushes. After this preliminary washing, the tubers were hand-scrubbed with nylon brushes to remove any remaining peel, then trimmed. The peeled and trimmed tubers were cut into  $\frac{1}{2}$ -inch slabs and steam-cooked at 40-pound steam pressure for four different periods of time, namely, 5, 10, 15, and 20 minutes. The cooked slabs were ground in a Hobart 800 Model grinding machine.<sup>3</sup> Water was added at this point to bring the pulp to an appropriate total solids content for dehydration (4). The mixture was mashed and finally dehydrated in a pilot-plant-size double drum dryer. Drum speed was adjusted to 2.5 r.p.m. with a clearance between drums of about 0.008 to 0.015-inch. Steam at 60-pound pressure was supplied to heat the drums.

The resulting sheets of dried yam were broken into flakes by forcing them through a  $1\frac{1}{2}$ -inch screen. The flakes retained by U. S. Standard Sieve No. 8 were put in tin cans in a room at 32-percent relative humidity. Dust that passed through the sieve was discarded.

Total solids content, blue-value index (BVI), shear press, and consistency or viscosity measurements were determined or taken on samples at different processing stages. Total solids content was determined by the conventional vacuum oven method (15); free starch or BVI by following the method of Mullins et al. (16) based on the appearance of a blue color due to a reaction between iodine and free starch.

Consistency or pastiness characteristics of the slurries prepared from yam flakes were determined by using the Brabender Amylograph-Viscograph. Samples were prepared by mixing 65 g. of yam flakes with 450 g. of distilled water for 30 seconds in a Waring Blendor at a moderate speed. The Brabender Amylograph-Viscograph bowl speed was adjusted to 75 r.p.m. (19). The sensitivity cartridge of 700 cm./g. was used. The heating cycle was initiated at 30° C. (86° F.). Temperature was increased at a constant rate of 1.5° C./min. for 40 minutes to 90° C. (194° F.). The temperature was maintained at 90° C. for 40 minutes (cooking temperature), and then cooled down at 1.5° C./min. for 40 minutes to 30° C.

To determine some of the textural characteristics of yam, shear press measurements were taken on 1, peeled-yam slabs of raw material chosen at

<sup>3</sup> Trade names are used in this publication solely for the purpose of providing specific information. Mention of trade names does not constitute a guarantee or warranty of the equipment by the Agricultural Experiment Station of the University of Puerto Rico or an endorsement over other equipment not mentioned.

TABLE 1.—*Pilot plant processing yields of prepared yam flakes*

Cooking period	Weight before cooking	Weight after cooking	Difference in weight	Water lost in dehydration
<i>Minutes</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Percent</i>
5	14.58	15.25	+0.67	79.73
10	13.83	14.08	+ .25	75.60
15	15.50	15.25	- .25	75.00
20	15.00	15.25	+ .25	80.84

random, 2, on cooked yam slabs, and 3, on mashed yam prepared as for a sensory evaluation. An individual 50-g. sample was used for each set of measurements. The Texture Test System Model TP-1 (Food Technology Corporation), adjusted to 1-minute stroke was employed to make the analyses. For shear-press measurements of peeled raw yam slabs and cooked yam slabs, the Standard Compression Cell was employed with a 3,000-pound proving ring set at a range of 600 pounds (20 percent). For mashed yams, the Universal Cell was employed, with a  $\frac{1}{8}$ -inch orifice plate inserted and a snugly fitting piston. A 300-pound proving ring was applied, with the range set for 60 pounds (20 percent). The temperature of mashed yam was maintained at  $82 \pm 2^\circ$  F. for these measurements. The area under the curve of the time-force curves was measured with a planimeter and the maximum force applied read directly from the chart.

A sensory evaluation of mashed yam was made by a trained, 10-member panel using a hedonic scale of 6 points (18) in which 1 stands for "like very much" and 6 for "dislike." The criteria applied in the evaluation were appearance, flavor, texture, and overall acceptability. Four samples at a time were presented to the panel per sitting. These samples of mashed yam (110 g.) were prepared by mixing with 50 strokes of a fork, 23 percent of yam flakes with 73 percent of tap water at  $180^\circ$  F. ( $81^\circ$  C.) (18), 3 percent of olive oil, and 1 percent of table salt.

### RESULTS AND DISCUSSION

For the preparation of flakes from starchy root crops, the tubers must be peeled, precooked, cooled down and cooked prior to dehydration. In preliminary work conducted during the course of these investigations, a dark discoloration always appeared in the precooked slabs during the cooling down period irrespective of the precooking treatment. The precooking step thus was eliminated from the experimental procedures for that reason. The yam tubers, however, must be kept under water during the interval between lye-peeling and cooking to avoid the discoloration. Lye-peeled yam tubers lost an average of 16.15 percent in weight during the peeling process, which represents peel weight.

In experiments carried out to determine optimum conditions for cooking yam slabs, cooking periods of less than 5 minutes resulted in uncooked yam whereas periods of more than 20 minutes resulted in overcooked or broken slabs.

Pilot plant-processing yields are shown in table 1. An increase in weight occurred in yam slabs cooked for 5 and 10 minutes. This probably is due to the vapor condensation observed on slab surfaces followed by absorption, helped by the softening of the yam tissues. Samples cooked for 15 minutes reached a temperature sufficiently high to evaporate condensation on the yam slabs and a loss in weight was noted. However, an increase in weight

TABLE 2.—*Pastiness characteristics of mashed yam; BVI and total solids content of yam flakes*

Cooking period	Mashed yam			Yam flakes	
	Gelatinization temperature	Viscosity 90° C.	Viscosity after 40 minutes cooking at 90° C.	BVI	Total solids
<i>Minutes</i>	<i>°C.</i>	<i>Brabender units</i>	<i>Brabender units</i>		<i>Percent</i>
5	66.4	137	248	200	94.11
10	63.0	273	243	239	93.99
15	60.3	278	197	273	94.15
20	59.5	295	177	244	93.12

was noted again in yam slabs cooked for 20 minutes which became very soft. The water absorption that increased this weight probably was due to the swelling of starch granules and to a partial gelatinization. Partial gelatinization at the 20-minute cooking period was greater than in the other cooking periods, as demonstrated by gelatinization temperatures found in the Brabender analyses.

The average total solids content of fresh Florido yam was 28.0 percent and the total solids of yam slurries to be dehydrated ranged from 16.4 to 18.6 percent. The total solids of yam flakes given in table 2 averaged 93.84 percent which left an average of 6.16 percent moisture content. This moisture level is sufficiently low to assure long shelf-life for yam flakes. This also is the recommended level in white potatoes (4).

Fresh yam had a BVI of or nearly zero indicating no broken cells. Further processing caused cell rupture and a consequent increase in this value. The BVI of cooked samples averaged 14 for the four cooking periods; the slurries averaged 19. The value in the yam flakes tended to be higher, ranging from 200 to 273 as shown in table 2. The highest damage incurred by cells occurred during the dehydrating process.

TABLE 3.—*Texture characteristics of yam slabs, and of mashed yam prepared for sensory evaluation*

Cooking period	Maximum force			Area under the curve
	Raw yam	Yam after cooking	Mashed yam	Mashed yam
<i>Minutes</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Square inches</i>
5	248	105	39	1.08
10	275	65	42	1.22
15	249	62	38	1.28
20	225	38	43	1.54

TABLE 4.—*Sensory evaluation of mashed yam using 6-point hedonic scale<sup>1</sup>*

Attribute	Cooking period (minutes)			
	5	10	15	20
	Scores			
Appearance	2.4	3.0	2.6	2.8
Flavor	2.9	3.2	2.9	3.2
Texture	3.1	3.2	2.8	3.2
Overall acceptability	3.0	3.2	2.8	3.1

<sup>1</sup> 1 = "like very much" to 6 = "dislike."

Consistency measurements of mashed yam taken by using the Brabender Amylograph-Viscograph are presented in table 2. The gelatinization temperature of mashed yam decreased as the cooking period of the yam slabs increased, suggesting a certain degree of gelatinization during cooking. An increase in viscosity at 90° C. was noted with the increase in the cooking period of the yam slabs. Longer cooking periods meant greater cell rupture during dehydration as explained above in relation with BVI determinations. This resulted in increasing the viscosity at 90° C. On the other hand, except for the 5-minute cooking period, viscosity after 40 minutes cooking at 90° C. decreased with the increase in the cooking period. The constant temperature during cooking resulted in a thinning down of starches due to a progressive fragmentation and solubilization of the swollen starch granules (14). Probably the gelatinization of the samples cooked for 5 minutes was incomplete at 90° C. and continued during the constant temperature cooking.

Shear-press maximum forces for fresh yam varied, indicating differences in the firmness of the raw material (table 3). In cooked yam, this value decreased with the cooking time, while no definite trend was observed in mashes prepared from reconstituted flakes as for sensory evaluation. The areas under the curves determined for these mashes increased with the increase in the cooking period.

As presented in table 2, the degree of free starch available in the yam flakes was larger the longer the slabs were cooked prior to dehydration. As the free-starch content increased, the final product got stickier resulting in an increased value of the areas under the curves.

Table 4 shows the results of sensory evaluations. No marked differences were found among the samples, as they were all scored as "like moderately." This means that mashed yam of acceptable quality can be prepared from Florido yam.

### SUMMARY

Dehydrated yam flakes to be prepared as instant mashed yam were produced from lye-peeled tubers steam-cooked for periods of 5, 10, 15, and 20 minutes. The longer the cooking period, the higher the damage suffered by the cells, as evidenced by the free starch available in the flakes. Mashings prepared from the reconstituted flakes showed an increased degree of stickiness in samples with higher levels of free starch. All samples were found acceptable.

### RESUMEN

Se prepararon hojuelas deshidratadas de ñame para usarse en la confección de ñame majado instantáneo. Los tubérculos que se usaron para las hojuelas fueron pelados con soda cáustica y cocinados al vapor por períodos de 5, 10, 15 y 20 minutos. Mientras más largo fue el período de cocción mayor el grado de destrucción del tejido celular, así demostrado por la cantidad de almidón libre que contenían las hojuelas. El grado de pegajosidad aumentó con el incremento en el almidón libre en las muestras de ñame majado que se prepararon con las hojuelas reconstituídas. Todas las muestras fueron aceptables.

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