

Yams (*Dioscorea* spp.) for Production of Chips and French Fries¹

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INTRODUCTION

Local popularity of potato chips and French fries suggests that suitable substitutes for potato might be found among roots and tubers produced in Puerto Rico for a ready market. Fried plantain chips (platanutres) (2) have been available now for some years, and have become widely known. Sweet potato chips have been developed and sold commercially in several of the states. Instructions for their preparation are given by Boggens and Woodroof (1). Yam, well known and appreciated throughout the Island, should serve equally well for chips and fries. Trials made this year with different species and varieties of yam from the Federal Experiment Station collection indicate that some of them will yield acceptable chips and fries.

MATERIALS AND METHODS

Twenty-five cultivars of yam from five species of *Dioscorea* were selected for these tests. They represented varieties well known for their cooking characteristics, but of variable quality. Whole tubers in excellent condition were taken from storage and divided into three sections, young, medium and old portions. The young (lower) and old (upper) portions were peeled by hand and cut into thin slices (about 1.5 mm.) with a simple kitchen device. The two kinds of slices were fried separately in a household deep fat fryer until crisp at 375° F in commercial corn oil. During frying, the chips were agitated or separated mechanically to assure even cooking. When crisp, the chips were drained, then placed on absorbent paper towels and salted lightly.

After the chips were cooled, some were placed in cellophane bags and stored for 1 week. The remainder were panel-tasted and evaluated on the basis of the following characteristics:

Characteristic	Measurement
Cooking time	Minutes
Freedom from tendency to stick	Scale 1-3
Crispness	Scale 1-3

¹ Manuscript submitted to Editorial Board October 27, 1971.

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Characteristic	Measurement
Color acceptability	Scale 1-3
Agreeable flavor	Scale 1-3
Lack of bitterness	Scale 0-3

(A rating of 3 suggests the most desirable degree of the characteristic rated.)

These characteristics were rated again 1 hour later, and again after 1 week.

The center portion of the yam was cut into normal French fries (strips about 0.5-1 cm. wide and thick) and thin French fries (strips about 0.15 cm. thick and 0.3-0.4 cm. wide). These were fried until well-colored, then drained and placed on absorbent paper towels. Thick French fries were evaluated only while hot, as this is considered the normal way of eating them. Thin French fries had many of the characteristics of chips and were rated in the manner for that product.

A quality score was obtained for each variety of yam by adding the individual scores of the five rated characteristics. This score permitted rapid comparison of varieties. In addition they were rated for convenience in the kitchen (size, shape, waste). The ratings were: Not acceptable, poor, acceptable, good, or excellent as sources of fried foods.

As superior varieties became recognized, one of them, Farm Lisbon, was selected for tests with various cooking fats. With other kinds of chips, the type of fat influences flavor, color, and keeping qualities. Cooking temperature for each was reduced from 375° as necessary to avoid excessive smoking. The chips were cooked to a pleasant color, then rated by an informal panel.

RESULTS

Varieties of five species were tested (*D. alata*, *D. rotundata*, *D. esculenta*, *D. bulbifera* and *D. trifida*). Their characteristics, are noted in table 1. Many of these varieties are new to Puerto Rico, but are available from the authors.

All fries of the species *D. rotundata*, *D. esculenta*, and *D. bulbifera* contained bitter or acrid substances making them unacceptable for chips or fries. One variety of *D. trifida* yielded acceptable chips. The varieties of *D. alata* produced fries of varied quality. Forastero and Farm Lisbon, as well as a few other varieties, produced excellent chips.

Although some varieties received high quality scores, inadequacy with respect to a single characteristic sometimes downgraded final judgement. For example, the excellent yam Florido yielded rather pale, bland, accept-

able chips but these lacked the overall quality of some of the other varieties. Many varieties produced chips of an undesirable color, or with blotchy areas representing oxidized portions. Anthocyanin pigmentation discolored the final chips.

Yam varieties that produced good chips also were those that were rated

TABLE 1.—Principal characteristics of chips of yam (*Dioscorea* spp.) varieties (lower portion) and quality score

Species	Variety	Cooking time	Quality characteristics ¹					Quality score ²		
			Freedom from tendency to stick	Crispness	Color acceptability	Agreeable flavor	Lack of bitterness	After 1 hour		After 1 week
								Lower portion	Upper portion	Lower portion
		<i>Minute</i>								
<i>D. alata</i>	Morado	8	1	3	3	3	3	13	12	8
<i>D. alata</i>	Ashmore	8	3	3	2	2	3	13	13	11
<i>D. alata</i>	Vino Purple	5	3	2	1	1	3	10	11	9
<i>D. alata</i>	Purple Lisbon	7	2	3	1	1	3	10	10	8
<i>D. alata</i>	Macorís	5	3	2	1	1.5	3	10.5	11	9
<i>D. alata</i>	Florido	5	2	3	2	2	3	12	13	11
<i>D. alata</i>	Yellow Lisbon	7	3	2	2	2	3	12	15	10
<i>D. alata</i>	Bottleneck	6	3	1	2	3	3	12	15	10
	Lisbon									
<i>D. alata</i>	Oriental	5	3	2	1	1	3	10	10	8
<i>D. alata</i>	Seal Top	7	3	3	2	2	3	13	13	12
<i>D. alata</i>	Smooth Statia	5	3	2	1	1	3	10	—	9
<i>D. alata</i>	Farm Lisbon	7	2	3	3	3	3	14	14	12
<i>D. alata</i>	Feo	7	3	3	3	3	3	15	15	14
<i>D. alata</i>	Gordito	7	3	3	2	2	3	13	—	12
<i>D. alata</i>	Hawaii	5	3	2	1	2	3	11	11	9
	Branched									
<i>D. alata</i>	Forastero	10	3	3	3	3	3	15	15	11
<i>D. alata</i>	Hunte	7	3	3	3	3	3	15	11	11
<i>D. alata</i>	Vino Blanco	6	3	3	1	1.5	3	10.5	12	9
<i>D. rotundata</i>	Guinea Blanco	7	3	3	3	2	1	12	10	9
<i>D. rotundata</i>	Guinea Peludo	5	3	3	3	1	1	11	9	8
<i>D. bulbifera</i>	Gunda (Sharp Angled)	7	3	2	2	1	2	10	—	8
<i>D. bulbifera</i>	Gunda (round)	5	3	1	1	1	0	6	—	7
<i>D. esculenta</i>	Papa	6	3	3	3	1	1	11	10	10
<i>D. esculenta</i>	Pana	5	3	2	2	1	0	8	10	7
<i>D. trifida</i>	Mapuey Largo	6	1	3	3	2	3	12	12	11

¹ A rating of 3 suggests most desirable degree of characteristic rated.

² Sum of quality characteristic ratings; highest scores indicate highest overall quality.

highly for cooking characteristics. Tubers of these have white, compact flesh with minimum graininess, and have a low tendency for flesh oxidation. The capacity of a yam to yield a good chip thus can be predicted for *D. alata* varieties.

Chip quality sometimes was higher and sometimes lower in the upper portions of the yam (table 1). Quality did not deteriorate in 1 hour. Quality decreased after a week, however, chiefly through loss of crispness in some and flavor changes in all varieties. These changes were not uniform. The best chips were those sealed very carefully in minimum-sized packages. Antioxidants were not applied to the chips (a normal commercial practice).

TABLE 2.—Principal characteristics of French fries of yam (*Dioscorea* spp.) varieties (center portion) and quality score

Variety	Quality characteristics ¹						Quality score
	Cooking time	Freedom from tendency to stick	Crispness	Color acceptability	Agreeable flavor	Lack of bitterness	
	<i>Minutes</i>						
Morado	7	2	1	2	2	3	10
Ashmore	10	3	3	2	2	3	13
Vino Purple	5	3	2	1	1	3	9
Purple Lisbon	7	3	1	1	1	3	9
Macorís	3	3	1	1	1.5	3	9.5
Florida	6	3	1	2	2	3	11
Yellow Lisbon	8	3	1	2	2	3	11
Bottleneck Lisbon	7	3	2	3	3	3	14
Oriental	4	3	0	1	1	3	8
Seal Top	8	3	2	2	2	3	12
Smooth Statia	4	3	1	1	1	3	9
Farm Lisbon	8	3	1	3	3	3	13
Feo	7	3	2	3	3	3	14
Gordito	9	3	2	2	3	3	13
Hawaii Branched	6	3	1	1	1	3	9
Forastero	5	3	2	2	3	3	13
Vino Blanco	6	3	1	1	1	3	9
Guinea Blanco	8	3	3	3	1	0	10
Guinea Peludo	6	3	3	3	2	2	13
Gunda (sharp angled)	—	—	—	—	—	—	—
Gunda (round)	—	—	—	—	—	—	—
Papa	5	3	2	3	1	1	10
Pana	5	3	2	3	1	2	11
Mapuey Largo	7	3	2	3	2	3	13

¹ A rating of 3 suggests most desirable degree of characteristic rated.

² Sum of quality characteristic ratings; highest scores indicate highest overall quality.

Thus some deterioration in quality was expected. The best varieties, however, retained considerable quality even after the 1 week holding period.

Hot French fries were often very good (table 2). The varieties that yielded excellent chips also yielded excellent French fries. Quality of French fries is obviously highly correlated to chip quality. These crisps are a good product, both interesting and appetizing. Their characteristics are not reported in detail here.

Performance of all varieties tested and their final ratings are summarized

TABLE 3.—*Advantages and disadvantages, rating of kitchen convenience, and final judgement of yam (Dioscorea spp.) varieties as French fries and fried chips*

Variety	Advantages	Disadvantages	Kitchen convenience ¹	Rating
Morado	—	Stickiness	Fair	Acceptable
Ashmore	—	Poor color	Good	Poor
Vino Purple	—	Purple color	Fair	Not acceptable
Purple Lisbon	—	Purple color	Fair	Not acceptable
Macoris	—	Poor color, bitter	Fair	Not acceptable
Florida	—	—	Excellent	Acceptable
Yellow Lisbon	Good flavor	Poor shape	Good	Excellent
Bottleneck Lisbon	—	Very poor shape	Poor	Excellent
Oriental	—	Poor flavor	Good	Not acceptable
Seal Top	—	—	Excellent	Acceptable
Smooth Statia	—	Poor color	Excellent	Not acceptable
Farm Lisbon	Excellent flavor	Poor shape	Poor	Excellent
Feo	Good color and flavor	Poor shape	Poor	Excellent
Gordito	—	—	Fair	Acceptable
Hawaii Branched	—	Poor color	Fair	Poor
Forastero	Excellent color, flavor, crisp- ness	—	Good	Excellent
Hunte	Good flavor	—	Fair	Very good
Vino Blanco	—	Poor shape	Fair	Poor
Guinea Blanco	Good color and crispness	Bitterness	Good	Not acceptable
Guinea Peludo	Good color and crispness	Bitterness	Good	Poor
Gunda (sharp angled)	—	Acrid taste	Fair	Not acceptable
Gunda (round)	—	Acrid taste	Fair	Not acceptable
Papa	—	Bitterness	Excellent	Not acceptable
Pana	Good color	Bitterness	Excellent	Not acceptable
Mapuey Largo	—	Stickiness	Fair	Acceptable

¹ Kitchen convenience is an estimate closely related to ease of peeling, low waste, and moderate size of tuber.

in table 3. Some of the best varieties have unacceptable shapes for agronomic purposes. As a source of fries, the variety Forastero is excellent. This variety combines agronomic vigor with excellent cooking and processing characteristics. Its shape is good, and can probably be adapted to machine harvesting. Forastero is often seen in the Mayagüez markets, especially toward the end of the yam season.

Cooking fat influenced quality of yam chips of the variety Farm Lisbon (table 4). Neither lard nor hydrogenated vegetable oil produced very good chips. Nevertheless, when the two were mixed in proportions of 40:60, respectively, (as recommended by González, et al. (3) for fried plantain chips), the chips were of excellent flavor. The mixture of lard and hydro-

TABLE 4.—Ratings of four cooking fats in terms of their effects on chips of *Dioscorea alata* variety Farm Lisbon

Medium	Quality characteristics ¹							
	Cooking temperature	Cooking time	Freedom from tendency to stick	Crispness	Hardness	Appearance	Flavor	Net value
	Degrees F.	Minutes						
Corn oil	375	4	3	1.5	2	3	2.5	3
Hydrogenated vegetable shortening	325	5	2	2	2	2	1.5	2
Lard	300	5	2	2	2	2	2	2
40% lard + 60% hydrogenated vegetable oil	350	5	2	2	2	3	3	2.5

¹ A rating of 3 suggests most desirable degree of characteristic rated.

genated vegetable oil was preferred by half the panel members over corn oil as a cooking fat.

DISCUSSION AND CONCLUSIONS

Although the principal purpose of these tests was to evaluate a number of yam varieties being grown in the Federal Experiment Station collection for their potential use as chips and fries, superior varieties known already in Puerto Rico were found to be excellent sources of chips. Among those is the variety Forastero, for example. Frequent bitterness of Guinea Blanco and a bland product from Florido, do not recommend these otherwise excellent yam varieties for chips.

A high quality yam chip can be prepared for marketing with little additional study. The chief necessity is an antioxidant to avoid flavor changes

in the fat of the cooked product. We intend to conduct a search for such an antioxidant this coming season. The chip also can be improved by thinner slicing, and adjusting the cooking time as necessary.

As new varieties of yam are added to the federal collection, additional selections will be made for potential use in this manner. Our experience thus far suggests these should be white and dense-fleshed varieties of *Dioscorea alata*.

SUMMARY

Tubers of 25 varieties of yam (*Dioscorea* spp.) were peeled, sliced, and cooked in corn oil at 375° F.

Chips were evaluated freshly cooked and after 1 week of storage. They were rated for crispness, hardness, flavor, and appearance. Species of yam other than *D. alata* usually did not yield good chips. The Puerto Rican variety Forastero (*D. alata*) yielded one of the best chips. The quality of hot French fries was related closely to chip quality. Among cooking fats, corn oil and a mixture of lard and hydrogenated vegetable oil gave best results. These results can be commercialized with little modification.

RESUMEN

Tubérculos de 25 variedades de ñame (*Dioscorea* spp.) se pelaron, se cortaron en rodajas y se cocieron en aceite de maíz a 375° F. Las rodajas fritas u hojuelas se evaluaron inmediatamente después de cocerse y después de 1 semana de almacenamiento. Se observó su dureza, tostadura, sabor y apariencia. De ninguna de las especies, con excepción de *D. alata*, se lograron hojuelas fritas de calidad aceptable. Con la variedad puertorriqueña Forastero (*D. alata*) se obtuvo una de las mejores. La calidad de las papas fritas (estilo francés) calientes estaba estrechamente relacionada con la calidad de las hojuelas fritas. Entre los aceites para cocinar, solamente el aceite de maíz y una mezcla de manteca con aceite vegetal hidrogenado dieron resultados excelentes. Con poca modificación, las técnicas serían útiles para uso industrial.

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