PROCEEDINGS

OF THE

CARIBBEAN FOOD CROPS SOCIETY

TENTH ANNUAL MEETING
PUERTO RICO

1972

VOLUME X

THE PROCESSING OF YAM FLAKES IN BARBADOS

E.G.B. Gooding
Barbados Sugar Producers' Association (Inc.)*

The processing of foods in the Caribbean is, of course, nothing new. Sugar and rum have been processed from the raw agricultural material, sugar cane, for centuries; more recently citrus juices have been locally processed, and currently there is a great deal of activity, especially in Puerto Rico, Jamaica and Trinidad, to process more and more of the local food crops. However, there are always the twin problems of limited markets and the high prices that the farmers expect for their products.

In Barbados we do not have the abundance of exotic fruit that are found in some other islands, though we are learning to grow vegetables, and there has been a good deal of thought given by the Government and the Sugar Producers' Association - both of whom are anxious to increase the extent of agricultural diversification - to the possibility of processing as a way of extending the potential market for foodcrops.

About a hundred locally grown foodcrops and fruit have been screened. Consideration was given to the technical feasibility of processing, what process or processes were suitable, viz canning, freezing or dehydration, whether the product was likely to be acceptable and to find a market, and, not least, what would be the probable economics of such a project. Barbados did not come out particularly well when these several factors were examined. The items commonly processed such as carrots or beans were too costly when grown under our conditions to begin to compete with the imported products, and the more exotic tropical fruits do not grow well or in any quantity in our climate. However, we do grow certain tropical root vegetables both well and cheaply. Barbados is perhaps the only place that grows yams (Dioscorea alata) on a plantation scale, and at the time these calculations were made they could be obtained, ex field, at 3 to 4 cents per pound--though the price is higher now. Further there was a fairly good export trade in yams. It is estimated that the U.K. market alone takes over 10,000 tons of fresh yams per year and Barbados was already supplying a portion of that. Yams are tiresome things to prepare for cooking, so we thought that an instant yam might indeed find a market. Yams are extremely costly on the U.K. market, selling at 7 to 10 pence per lb., equivalent to 36 to 48 EC cents or 18 to 24 US cents roughly: we calculated we could get them into U.K. retailers at a lower cost with convenience built in as a bonus.

On the technological side we anticipated no very serious trouble. Yam is a tuberous starchy vegetable, and dehydration techniques have been commercially practiced for decades with Irish potatoes. Our analyses showed the reducing sugar content of mature yams to be low (ranging from 0.2 to 1.3% of the dry weight_; this meant that non-enzymic browning in the stored product should not be a great problem (3). The fat content was low (0.03 - 0.25%) and carotenoids absent, so we believed that packing in air would not permit any great extent of oxidative rancidity (by contrast with sweet potatoes where breakdown of carotenoids leads to a mixture of ketones and aldehydes with strongly offensive odours and flavours within a few weeks unless oxygen is excluded from the pack).

We examined the relative merits of the air-lift process and drum drying process and decided to go for the latter. The early experimental work was started in 1969, initially in conjunction with the Chemical Engineering Department of the University of the West Indies in Trinidad. Thanks are due to Dr. George Sammy and his colleague, Mr. William Steele, for the help they gave at that time and which demonstrated that it should, in fact, be technically possible to produce the type of product we were seeking. After a while, however, we transferred the work to the research headquarters of the Barbados Sugar Producers' Association, where we installed a small (8" x 8") single drum dryer with applicator rolls, specially designed for us by Messrs. Richard Simon & Co. Ltd., of Nottingham, England.

Every stage in the process was, of course, carefully examined both for its effect on the product and for any wastage which might be encountered at that point. What was needed in the product was a thin flake of as high a density as possible which would reconstitute very quickly to a mashed yam of good, not sticky, texture. The latter implied little or no free starch, viz the rupture of cells must be kept to a minimum - quite a tall order for a multi-stage process.

The steps in the process as finally developed in the laboratory were:

1. Selection of Raw Material

Great care has to be taken in selecting raw material for processing. There seems to be the idea in the Caribbean that we should have processing plants to handle any unsaleable stuff that the market has rejected or been unable to take.

We examined our three most commonly grown cultivars, Crop (White) Lisbon Coconut Lisbon and Oriental. Coconut Lisbon and Oriental had the best shaped tubers and gave lower preparation losses; however, Oriental (an early maturing yam) consistently had lower solids

* Present address: Caribbean Development Bank, Bridgetown, Barbados.

content than the others, 16-17% compared with 23-24%. Since the whole purpose of the dehydration process is to obtain the solids, this weighed heavily against Oriental; put another way, it took 11 pounds of Oriental to give 1 pound of dehydrated product, against about 8 pounds of Crop or Coconut Lisbon.

It was important that the yams be fully mature at harvest; not only did this lead to the highest possible solids content but gave very much lower reducing sugar contents; some 50 determinations (2) showed averages for immature yams to be about 7% on the dry weight basis but only about 1% for mature tubers.

A problem that at one time appeared to be serious was enzymic pinking, resulting from the action of polyphenolases when exposed to the air in the peeled or cut yams. When the tuber was subsequently cooked these areas became purplish to black and severely affected the quality of the product. An extensive investigation seemed necessary. We found that all tubers showed some pinking immediately upon cutting for about half an inch inwards from the stem end and most tubers quickly became pink at the toe or distal end. The areas around wounds quickly became pink if they were not already so when the tuber was sliced. Some tubers became pink over the whole cut surface; others did not. There were striking differences between cultivars; we found 50% of Coconut Lisbon, 30% of Crop Lisbon and only 20% of Orientals to behave in this manner. Part of the explanation seems to be that there is a higher concentration of polyphenolase enzymes near meristematic regions, such as the growing tips or where wound calluses are being formed, but this clearly is not all, and we never completely solved the problem - though in actual factory practice this phenomenon was less important than at first feared.

As mentioned earlier, it was important for cells to remain unbroken and so not liberate starch. The different cultivars were checked for liability to cell breakage during the various stages of the process by estimating the relative quantities of starch liberated by the 'blue value' technique (4); no differences were found.

The colour of the product is, of course, important. Most yams are apt to become slightly grey on cooking. With Coconut Lisbon the worst in this respect, with Oriental best.

On balance Crop Lisbon was chosen as the most suitable yam for the process.

2. <u>Washing</u> by soaking and scrubbing

3. <u>Peeling</u> by immersion in boiling 10% caustic soda solution for 10 minutes. This was studied in some detail by Steele in Trinidad (5) who was able to show not only its effectiveness but also the very limited and sharply defined penetration of the alkali, and that the uptake by the part of the tuber that was to be eaten was virtually nil. The skin, loosened by this treatment, could be about completely removed by brushing under jets of water. The losses incurred by lye peeling were measured by Steele who showed them to be about exactly the same as those incurred in the kitchen, viz about 20% of the total weight for large tubers and 30% for small ones.

4. <u>Trimming</u> by hand could not be avoided. It was at this point that the pinking showed up most seriously. However, in actual practice it was decided to use the technique long employed for controlling enzymic pinking of potatoes - viz to immerse the peeled or cut pieces on 0.1% sodium sulphite solution. This gave good results. Trimming losses plus peeling losses averaged 30 to 40% of the total quantity of yams handled - very high, but largely dependent on the irregular shape of the tubers and the poor condition - bruises, punctures and so on - of a high proportion of them.

5. <u>Cutting</u>. It was necessary to cut the tubers into pieces small enough to cook quickly and uniformly. In Trinidad 1 cm. cubes were used, but the losses due to sloughing off of the outer layers were high, ranging from 8-21% (4). Using slices instead of dice reduced this loss to 6-8%, still too high. Cooking in steam instead of water brought these losses to less than 5% (5).

6. <u>Cooking</u>. The purpose of cooking was not only to give the product a "cooked" flavour, but also to hydrolyse the protopectins of the middle lamellae that bind the cells together, to such an extent that the cells would easily separate unbroken from each other in the subsequent processes, and not become fractured and liberate starch. The effect of cooking procedures on this by measuring the blue values of the mashed product was examined and cooking in water for 20-30 minutes gave satisfactory results.

7. <u>Mashing</u>. When the cooked yam was mashed in a Hobart Mixer, no matter how gently, there was quite severe rupture of cells. The blue values rose and the finished material was

sticky. Evidently this had previously been found for potatoes in the USA, for the USDA researchers had had better results by ricing their potatoes (1), subjecting them to shear forces which simply pushed the cells over each other instead of "bashing" them apart. Whereas mechanical mashing gave blue values of 80 to 120, riced yam had blue values of 0-17. However, the drum dryer would not accept riced yam - it would not cling to its surface - so it was then necessary to homogenize the riced material. This was done in a dough mixer. This did lead to some damage to the cells, raising the blue values to about 40; but this is still low.

8. Drying proved to be very critical. It was found in some of the earlier experiments that blue values were extremely high, 250 to 400, and the reconstituted product was more like a sticky soup than mashed yam. Experiments using a hot plate of known temperature showed that this resulted from the high surface temperature causing explosive escape of water from the cells; 150°C seemed to be critical, though in fact rather higher drum temperatures could be used, presumably because the inner layers of adhering cells had a cushioning and cooling effect on those outside. Microscopic examination showed a close relationship between ruptured cells and blue values.

Peripheral speed and retention time were of course important; with our laboratory sized machine we found we could dry from a mash of about 80% water content to 2% with a retention time of 5.7 seconds and steam pressure 60 lbs./sq./inch.

Of course, we didn't get there all at once. In potato drying there is a delicate relationship between the consistency of the mash, peripheral speed, and drum temperature, on the thickness of the film which adheres to the drum. So far we have never got this to happen with yam. In all the early experiments, whatever we did, the product was too moist. Examination of the material on the drum showed it to have short whiskers when it approached the scraper blade; under the microscope these appeared as pieces of vascular tissue surrounded by parenchyma that had never been in close contact with the hot drum and which were, therefore, still very wet indeed. Eventually we moved the last of the applicator rolls close to the drum to act as a pressure roll and physically push these whiskers into the mat on the drum surface; after this we had no more trouble of this kind.

The product came off as a thin sheet, about 6 thousandths of an inch thick; the rate of output was in the range of 3 to 4 lbs. per square foot of heating area or about 2.5 lbs. per square foot of total drum space.

9. The product broke up into flakes, almost like soap flakes, though the density was only 0.2 to 0.25 g/ml. They could be very gently broken further to increase the density to about 0.35 but any milling increased the blue values severely. The blue values were normally in the region of 150 (170 was the upper limit for satisfactory texture), and moisture content 2.0 to 4.0%.

Reconstitution was by adding the flakes, gently with stirring, to 3 1/2 times their weight of hot (not quite boiling) salted water; the product closely resembles fresh mashed yam and can be made into very attractive dishes, for example by browning off under the grill or as yam and cheese or yam and fish pies and so on.

10. Storage behaviour. We have now had the opportunity to run storage tests over nearly two years, and, as anticipated, browning at ambient temperatures has not been a problem. Some of the more acute tasters could detect a trace of oxidative deterioration after 6 months, but families given material 14 months old could not tell they were eating a processed material.

11. Packaging. The Tropical Products Institute in London carried out tests of moisture uptake and advised MXDT cellulose/polythene pouches in cardboard cartons as a retail pack, but in fact the material has kept very well in 200 gauge polythene, though the moisture content has risen to 12% in the 12 months, which must be getting almost dangerous from the microbiological standpoint.

12. Additives. Owing to the low reducing sugar content we thought no sulphur dioxide need be added, and were proved right. We tried Glyceryl monostearate at a level of 5% of the dry matter in the mash and this brought the blue values down to 90 and gave a product with improved texture. The addition of dried skim milk at levels of up to 10% of the product gave what many tasters thought was a better flavoured product.

The Present Situation

It now seemed that we had a product which was in itself good, with economics that should make it saleable. The next steps were twofold; (i) to examine the technical problems of scaling up, and (ii) to test the market. On this point a fruitful collaboration took place between the Barbados Sugar Producers, the Barbados Government and the

British Government, the eventual outcome of which was that the Barbados Government formally requested aid towards developing the project, and this was accepted by the Ministry of Overseas Development. Some time was spent with the engineers of the Tropical Products Institute in London and with Richard Simon and Co., the makers of the drum dryer; within months pilot scale equipment was installed and working at Wildey, Barbados, with an experienced food technologist, Mr. Roderick Wood, in charge, under the aegis of the Barbados Agricultural Development Corporation, a Government agency. Although there was a late start last year, over 10,000 lbs. of the product was made, most of which was tested in local hotels, hospitals, school meals and other institutions. Very much more is being produced this year for market testing abroad. A great deal has been learned about the technology of larger scale production.

CONCLUSION

It is too early to tell whether this yam will be a commercial success or not, but a great deal was done in a short time. One of the more striking aspects of the story is that all this work was done by two people working part time; first Mr. Steele and his assistant in Trinidad, and in Barbados one technologist and his assistant. This could not have been done without a great deal of cutting of corners and the application of existing knowledge. This was essentially a practical exercise, not academic: no knowledge was sought just for the sake of acquiring knowledge. The vision of the product was before us from the beginning and we were ruthless in following only the tracks that led us towards the goal. I think it is important to stress this: in these countries of ours which need to develop rapidly it is vital to see the required end and work towards it; while the alertness of mind engendered by University research is essential, it must also be tempered by a disciplined approach.

LITERATURE CITED

1. Cording, J., Willard, M.J., Eskew, R.K., and Sullivan, J.F. (1957) Advances in the Dehydration of Mashed Potatoes by the Flake Process. Food Tech. XI. 4, 99.
2. De Whalley (ed.) (1964), ICUMSA Methods of Sugar Analysis, p. 25; Elsevier, Amsterdam.
3. Gooding. E.G.B. (1960). The Storage Behaviour of Dehydrated Foods. Recent Advances in Food Science, 11, 22.
4. Mullins, W.R. et al. (1955) Estimation of Free Starch in Potato Granules and its Relation to Consistency of Reconstituted Product. Food Tech. IX 8, 393-395.
5. Steele, W. (1970) Personal communications

- o 0 o -

CHLOROPHYLL IN CITRON (CITRUS MEDICA L.)

L.E. Cancel, Milagros R. de Montalvo, and José M. Rivera
Food Technology Laboratory, Agr. Exp. Station, Univ. Puerto Rico, Puerto Rico

SUMMARY

The variation in chlorophyll content were determined for citrons at different stages of maturity and at different depth in the mature-green fruit.

Citrons at different stages of maturity were obtained from a commercial farm at Adjuntas, Puerto Rico. Four stages of maturity were obtained; immature green, mature green, turning ripe, and ripe. On examination of the endocarp of the fruits it was found that the immature green was of a greenish tint, the mature green was greenish yellow, the turning ripe was completely yellow, and the ripe fruit was whitish yellow or cream.

Spectrophotometric determinations were made at different depth of the fruit. The results of the spectrophotometric studies showed that the chlorophyll content was highest in the immature green fruit, with the green mature following closely. The chlorophyll content of the turning ripe is substantially lower than the first two stages of maturity, but in the same way larger than in the ripe fruit. The chlorophyll content of the citron diminishes considerably between tissue layers at different depth of the fruit. Nevertheless the tissue of the immature and mature-green fruit contain a good amount of green pigment at greater depths of the fruit. Since the green color is characteristic of quality in the candied citron it is advisable to used the immature and mature green fruit for this purpose.