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ROOT-CROPS PROCESSING RESEARCH AT THE UNIVERSITY OF THE WEST INDIES ST. AUGUSTINE, TRINIDAD

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INTRODUCTION

The nutritional requirements of man may be broadly classified as carbohydrate, protein, fat, vitamins and minerals, of which carbohydrate forms the greatest single item. Carbohydrate foods are basically starches and sugars. On a global scale, rice, wheat and other cereal grains form the bulk of our carbohydrate foods, nevertheless root-crops play an important role. Of the root-crops, white potato (Solanum tuberosum) records the greatest production (301 million metric tons per annum 1970) with cassava (Manihot esculenta) following (88.2 million metric tons); all others together account for a mere 25 per cent of the total world production of the major root-crops (Kay, 1973).

The advantages of cereal grains over root-crops are low moisture content (and therefore better keeping quality), longer shelf life, ease of obtainability, better nutritional value, relatively lower unit cost per edible portion. Traditionally grains are used wherever possible and this possibility for the Commonwealth Caribbean has been extended to the importation of cereal grains to a large extent. Total cereal imports for 1972 for the CARIFTA region were $139.3M (E.C.) of which $44.5M was intra-regional, while $94.8M was extra-regional (Sammy, 1974). Within reasonable limits we may assume that the extra-regional imports were for wheat and wheat-flour only. When we consider that at present wheat cannot be grown in the Caribbean, then it would seem that there is considerable potential for the development of a carbohydrate source to replace wheat. This will be in the areas of tropical cereals and root-crops.

Alexander (1967) indicated that the demand for starchy roots may be indirectly affected by:

1) limited ways of preparation
2) method of marketing and merchandizing
3) uncertainty about product quality; and
4) high wastage in preparation

It would seem to us that the way to remove these limitations would be by the development of processed products. A study of the resources spent on root-crops development will show that the greatest expenditure is on Agronomy, with very little on processing and utilization. This is clearly indicated by a study of the proceedings of the First and Second International Root-Crops symposia and the programme of the Third.

The First Symposium identified the importance of processing and utilization through a Study Group. At the Second Symposium two papers on processing were presented, while at the Third six papers were slated for presentation. Indications are that the study of processing and utilization are gaining momentum but not at a sufficient rate.

We are convinced that tropical root-crops will not be able to make any significant impact unless their usage is extended. This can only be done through research and development in processing and utilization. A greater proportion of the resources expended on root-crop research must therefore be channeled into processing and utilization.

Research on the processing of tropical root-crop was started at the University of the West Indies, Trinidad, in 1969 through participation in the Root-crop Programme of the Faculty of Agriculture. The Root-crop Programme at this time was financed through a grant from the Rockefeller Foundation. At present the Programme is financed through the International Development Research Centre (IDRC). Emphasis is placed on the root-crops - sweet potato (Ipomaea batatas) and yams (Dioscorea spp.), but some preliminary work is being done with breadfruit (Artocarpus communis).

The object of the research is to study the processing potentials of tropical root-crops having the greatest possibilities for commercial utilization and thus of greatest economic benefits to the "Caribbean Region". Work is being done in the following areas; preparation of "composite flours" for bread and baked goods, canning, instant products (pre-cooked drum-dried) and breakfast foods.

COMPOSITE FLOURS

The object is to study the baking potential of composite flours made from wheat flour by dilution with varying quantities of root-crop flours, using the baking methods in existence in Trinidad and Tobago. It is felt that any major changes in the baking industry would have to be gradual. Because of this we are searching for composite flours that would have baking properties and produce products similar to those obtained from wheat flour. The products obtained in the experiments were considered acceptable only when the taste panel recorded a 100 per cent acceptance. Studies have been conducted using composite flours containing sweet potato, yam and breadfruit flours.

Two studies were conducted using a composite flour containing sweet potato flour. One study was of two cultivars (049 and C9) grown in Trinidad and Tobago, for baking potential. (This work was published "Studies in Composite Flour - 1. The Use of Sweet-potato Flour in Bread and Pastry Making" by G.M. Sammy, in Trop. Agri. Trin., 47, (2) 1970). The other was a comparative study of seventeen sweet potato cultivars for bread-making potential. This work was presented as part of the Paper "The status of Composite Flour Research at the University of the West Indies" at the International Conference on the Production and Marketing of Composite Flour, Baking and Pasta Products" held in Bogota, Columbia, 23-27th October, 1972. From this first study it was found that of the two cultivars studies 049 had good baking properties for dilution up to 15 per cent for bread, 20 per cent for cakes and 30 per cent for cookies, while C9 had poor baking properties. Tables 1 and 2 summarises these baking properties. In the preparation of sweet potato flour, peeling was found unnecessary, while treatment with one per cent sodium metabisulphite improved the colour of the flour. Addition of one per cent glyceryl monostearate or monopalmate only slightly improved the baking properties. Addition of five per cent fish protein concentrate or cotton seed flour had little or no effect on the baking properties.

The latter study showed that bread-making potential varies with different cultivars. There seemed to be a direct relationship between crude protein content and the baking potential. Tables 3 and 4 give summarised results. Further to the laboratory studies, one hundred pound batches of composite flour made up of 15 per cent sweet-potato flour and 85 per cent wheat flour were given to two local bakeries for baking trials. Bread of the pan-loaf and butter-bread types were readily produced, and proved to be highly acceptable by a consumer acceptance test. However, the preparation of "hops" which is a crusty loaf, proved difficult at a 15 per cent dilution. Addition of 0.5 per cent "Emplex" (a Patco Product of sodium and calcium Stearoyl - 2 Lactylate), strengthened the dough and permitted the production of acceptable "hops". Straight dilution without additive for the production of "hops" was below 10 per cent.

The work on composite flour with yam flour and breadfruit flour has not yet been published. Experimental results have shown that yam composite flour produces a fully acceptable loaf at a dilution of up to 25 per cent. The quality and storage life is better, for a loaf made with 25 per cent dilution as compared with a loaf made with 100 per cent wheat flour (white). Table 5 gives the summarised results.

Bread made from breadfruit composite flour had poor baking qualities as compared with sweet-potato and yam. The highest dilution for an acceptable loaf was 5 per cent. Table 6 summarises the results.

CANNING

Studies have been carried out on the canning of sweet-potato (049) and yam (Lisbon, coconut and oriental - D. alata), portuguese (D. rotundata), cush cush (D. trifida) and chinese (D. esculenta) in brine. They were canned as $\frac{1}{4}$ and $\frac{1}{2}$ inch cubes (diced) and as chunks. Further, sweet potato was canned as small whole potatoes unpeeled.

The canned cubes and chunks showed considerable starch leaching and, especially with the sweet potato, disintegration. The leaching was so heavy that after one month storage the total liquor in the can became a pasty mess.

Blanching of the cubes before filling, and the addition of 0.1 to 0.5 per cent calcium chloride give little improvement. The canning of small (2.4-4.0 cm dia.) whole unpeeled sweet-potato in brine gave a good product with little or no starch leaching. The canning liquor remained relatively clear after six months of storage. The skin of the potato posed no problem as it was easily removed before serving. This product had a high acceptability on a random taste-panel of 150 consumers.

"INSTANT PRODUCTS"

The idea here is to prepare a pre-cooked instant type product similar to that marketed for Irish potato (Solanum tuberosum). A brief description of the process is as follows: the tubers or roots are cooked, mashed into a paste and drum-dried. The main problems encountered with yams were high blue-values (200 to 1,200) and difficulty in scraping the product clean off the drum. The high blue-value was an indication of large number of raptured starch cells. This was solved somewhat by passing the cooked yam pieces first through a meat mincer and then mixing

to the required consistency using a "K" beater (Hobart). This reduced the amount of free starch from broken cells to an acceptable level. To assist the scraping of the product from the drum dryer 0.1 to 0.5 per cent glyceryl monostearate was added. With these modifications an acceptable product was produced. There was some difficulty with discoloration of the final product. It is known that the stem-end of cooked yam becomes discoloured, varying from light reddish brown to brown, while the rose-end remains white to off-white. However, this problem was overcome by judicious blending of stem and rose ends to give an acceptable off-white product.

Experimental results have shown that pre-cooked yam flakes may be produced with equal facility from a variety of yams such as lisbon, coconut, and oriental (D. alata); protuguese (D. rotundata) cush cush (D. trifida) and chinese (D. esculenta). The flakes produced from the chinese yam had poor texture on reconstitution, and developed a bitter taste after two weeks of storage. The flakes prepared from the other varieties were all acceptable.

It is gratifying to report that from this work a semi-commercial size pilot plant was set up in Barbados to test market "instant yam" made from D. alata. The test proved successful and steps are being taken to set up a commercial-size plant.

Preliminary experiments have indicated that an "instant" sweet-potato, similar to the yam product is possible. Intensive research is continuing in order to work out the various parameters affecting the final product. The results obtained thus far are encouraging.

BREAKFAST FOOD

Because of the North American influence in the West Indies imported convenience breakfast foods are well established among the upper and middle class of our society, and are fast filtering down to the lower level. Most breakfast foods have a carbohydrate base. There is therefore no reason why convenience breakfast foods cannot be made from root-crops. The object of this research is to produce breakfast foods from root-crops or with a root-crop base to replace those imported. Experiments are being carried out on two types of products, the flake type, similar to corn flakes and an instant porridge.

Preliminary work has indicated that both types of products are possible from sweet-potato. The study includes fortifying the products with soya beans and other legumes in order to increase the protein content. Table 7 gives a summary of the formulations and process conditions.

Future research on the processing potention of root-crops will expand on the breakfast foods to include puffed products and milled products. High protein pre-weaning mixes for children using locally produced legumes and root-crops as the carbohydrate base are also being considered. Other root-crops to be included would be dasheen, eddoes, tannia, (aroids).

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TABLE 6. Effect on Baking Properties of Composite Flour (Breadfruit and Wheat Flour) with different Proportions of Breadfruit (Home Baking).

% Breadfruit Flour	0	5	10	15	20
Loaf Volume:					
ml/g bread	3.3	3.3	3.1	3.0	2.5
ml/kg flour	5865	5850	5540	5128	4385
Shape:					
Colour:					
crust	light brown	light brown	light brown	light brown	light brown
crumb	white	white	off-white	off-white	off-white
Texture:					
crust	smooth	smooth	smooth	slightly rough	rough (cracks)
crumb	good(even cells)	good(cells even)	very fair (cells uneven)	fair(cells uneven)	poor
Taste:	good	good	slight off-flavour	off-flavour	off-flavour

TABLE 7. Formulation for Flake type breakfast foods using sweet-potato flour as the bas

Experiment No:	11	12	13	15	16	18	19
Ingredients (% dry weight)							
Sweet-potato flour	94	82	13	50	50	50	50
Rice flour	-	-	-	44	34	22	12
Wheat flour (white)	-	-	-	-	-	20	35
Corn (maize) flour	-	12	-	-	10	-	5
Skim milk powder	4	4	4	4	4	-	-
Salt	2	2	2	2	2	3	3
Soya flour (whole)	-	-	12	-	-	-	-
Water (gms)	40	40	40	40	40	40	40

Processing Conditions	Range
% Dough moisture	32-41%
% Moisture after drying	13-16%
Roller spacing for pressing flakes (cold) (inches)	0.003
Toasting temperature °C	210
Toasting time (Sec)	105-120
Moisture content of finished product(%)	2-4

TABLE 4. Properties of Sweet-Potato Tubers and Flour made from them.

Cultivar	Tuber Shape	Colour		Moisture		Flour Bulk-Density g/ml	Crude Protein %	Total Sugar %	Reducing Sugar %	Fat %	Fibre %	Ash %
		Skin	Flesh	Tuber	Flour							
A13/56/11	Bulbous	yellow	light orange	68	2.7	0.472	4.1	9.5	3.0	0.56	3.72	1.40
02/62	Cylindrical	reddish	white	70	3.1	0.506	4.1	7.9	2.4	0.16	2.47	1.46
08/589	Bulbous	white	white	71	3.2	0.618	3.8	8.2	1.0	0.60	1.46	2.07
C9/9	Cylindrical	white	white	65	2.8	0.494	3.8	6.1	1.2	0.27	2.39	2.03
02/59	Bulbous	reddish	white	67	2.5	0.542	3.6	7.9	1.2	0.61	2.85	1.62
Austin Canner	Bulbous	yellow	orange	69	3.4	0.508	3.6	8.2	1.5	0.81	3.41	2.19
B13/56/11	Bulbous	yellow	orange	68	2.3	0.442	3.1	12.0	2.0	0.90	4.31	2.07
Centennial	Cylindrical	deep orange	deep orange	72	2.1	0.498	3.3	10.4	1.3	0.39	1.66	2.15
049	Bulbous	reddish	white	70	3.9	0.486	3.0	6.3	3.2	0.41	1.82	1.71
28/59	Bulbous	reddish	white	68	2.2	0.564	3.0	6.9	1.4	0.46	1.04	1.29
A7/63/22	Bulbous	dark red	pale yel.	69	2.3	0.548	2.9	7.9	3.0	0.17	1.64	1.94
A16/15	Bulbous	orange	orange	66	3.2	0.466	2.6	4.7	2.7	0.54	2.32	1.70
I 62	Cylindrical	reddish	white	70	2.3	0.596	2.6	6.5	3.0	0.31	2.26	1.04
03/62	Bulbous	white	white	71	2.5	0.518	2.4	5.6	2.9	0.52	2.35	1.64
Sunny side	Bulbous	orange	pale orange	69	3.4	0.550	2.1	9.1	1.4	0.85	2.45	1.93
C9	Cylindrical	white	white	68	3.2	0.494	2.8	7.1	0.7	0.62	1.62	1.74
A 28/7	Bulbous	reddish	white	66	2.6	0.504	2.6	4.5	1.0	0.53	2.62	1.17

* On dry wt basis

TABLE 5. Effect on Baking Properties of Composite flour with Different Proportion Yam Flour (Baked under 'Home Condition')

	Percentage of Yam Flour in Composite Flour of Yam & Wheat Flour						
	0	5	10	15	20	25	30
Loaf volume:							
ml/g	3.3	3.4	3.5	3.6	3.5	3.3	3.1
ml/kg flour	5860	5940	6160	6380	6165	5850	5500
Shape:	normal	normal	normal	normal	normal	slightly fallen	fallen
Colour:							
crust	light brown	lightbrown	light brown	light brown	light brown	light brown	light brown
crumb	white	white	white	white	white	white	off-white
Texture:							
crust	smooth	smooth	smooth	smooth	smooth	slightly rough	rough (few cracks)
crumb	good(cells even)	good(cells even)	good(cells even)	good(cells even)	good(cells even	very fair (cells uneven)	fair(cells uneven)
Taste:	good	good	good	good	good	good	good

TABLE 3. Comparative Study of Flour Made From Different Sweet-Potato Cultivars for Bread-making

Loaf Properties of Bread from "Composite Flour" with 15 per cent Sweet-Potato Flour and 85 per cent Wheat Flour.

Cultivar	Volume		Shape of Loaf	Colour		Texture		Taste
	ml/kg Flour	ml/kg Bread		Crust	Crumb	Crust	Crumb	
Wheat flour	5830	3.3	Normal	Brown	White	Smooth	(Even cells)	Good
A 13/56/11	6380	3.6	normal	light brown	yellowish	smooth	good(cells even)	good
02/62	6270	3.5	normal	light brown	off-white	smooth	good(cells even)	good
08/58/9	6160	3.5	normal	brown	white	smooth	very good(cells even)	good
C9/9	6160	3.5	normal	brown	off-white	smooth	good (cells even)	good
02/59	5940	3.4	normal	brown	off-white	smooth	coarse(uneven cells)	good
Austin Canner	5940	3.4	normal	dark brown	light yellow	smooth	good(cells even)	good
B 13/56/11	5885	3.3	normal	golden brown	golden yellow	smooth	coarse	slightly sweetish
Centennial	5830	3.3	normal	dark brown	golden yellow	smooth	coarse(large uneven cells)	slight off flavour
049	5720	3.3	normal	brown	off-white	smooth	good(cells even)	good
28/59	5720	3.3	normal	brown	off-white	smooth	fair(small cells, dense)	slight off flavour
A 7/63/22	5530	3.1	normal	brown	buff	smooth	coarse(few large cells)	good
A 16/15	5520	3.1	normal	brown	golden yellow	smooth	coarse(few large cells)	good slight off flavour
I 62	5500	3.1	normal	brown	off-white	smooth	fair(small cells dense)	good
03/62	5060	3.0	normal	brown	greyish	rough	fair(small cells dense)	off-flavour
Sunny side	5060	3.0	slightly fallen	brown	light yellow	slightly rough	coarse (soggy)	off-flavour (poor mouth feel)
C9	4290	2.4	fallen	brown	light grey	rough (many cracks)	coarse(uneven cells)	off-flavour
A 28/7	3960	2.3	fallen	light brown	off-white	rough (many cracks)	coarse(uneven cells)	off-flavour

TABLE 1. Effect of Different Proportions of Sweet-potato and Wheat Flour on Characteristics of Loaves Baked under "Controlled Conditions".

	Cultivar								
	"049"						"C9"		
Sweet Potato Flour %	0	5	10	15	20	25	5	10	15
Loaf Volume:									
ml/g bread	4.6	4.2	4.3	4.3	3.7	2.8	4.0	3.8	2.7
ml/kg flour	7429	7214	7286	7357	6333	5000	7000	6428	4571
Shape:	stable	stable	stable	stable	slight fall	fallen	stable	slight fall	fallen
Colour:									
crust	pale brn.	pale brn.	brown	brown	brown	brown	pale brn.	brown	brown
crumb	white	l. grey	l. grey	light grey	light grey	light grey	light grey	l. grey	light grey
Texture:									
crust	smooth	smooth	smooth	smooth	rough few cracks	rough many cracks	smooth	rough few cracks	rough many cracks
crumb	cells even (good)	cells even (good)	cells even (good)	cells even (good)	cells uneven (v. fair)	cells uneven (fair)	cells even (good)	cells uneven (v. fair)	cells uneven (fair)
Taste:	good	good	good	good	fair	poor	good	fair	poor

TABLE 2. Effect of "Composite Flour" with Sweet-Potato on Pastry Quality.

		Cultivar	
Product	%Sweet Potato Flour	"049"	"C9"
Roti (unleavened Bread)	15	good	poor
Sponge Cake	20	good	poor
Raisin bread	20	good	poor
Pancakes	20	good	poor
Doughnuts	20	good	poor
Sweet cream biscuits	15	poor	poor

Good means acceptable as compared with product made from wheat flour
Poor means unacceptable