TECHNICAL NOTE: CASSAVA (PEELED-ROOT) FLOUR AS PARTIAL REPLACEMENT OF WHEAT FLOUR IN BREAD

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Previous reports have shown that it is possible to prepare acceptable bread containing up to 20% of either fresh cassava (Crabtree, Kramer & Baldry, 1978a, b) or dried cassava flour (Dendy, Clarke & James, 1970; Crabtree, Kramer & Baldry, 1978b). Higher levels of wheat flour substitution could be obtained by using cassava starch rather than flour (Kim & De Ruiter, 1968; Pringle, Williams & Hulse, 1969; Dendy, Clarke & James, 1970).

In most of these reports little attention has been paid to some factors such as the cassava cultivar used, the effect of plant age on root quality, the loading rate of cassava root pieces or chips per unit of drying surface area and its effects on cyanide losses, etc. which may affect the quality of the cassava product(s) and henceforth the results of the breadmaking evaluations.

The present note describes some preliminary observations on the effect of oven-drying at 60°C on cyanide elimination from peeled-root thin chips or thick slices, the chemical composition including the starch and sugar contents of the resulting cassava flour, and its evaluation in breadmaking. In addition, a few observations on the chemical composition and cyanide content of root peel, a byproduct of the cassava flour processing, were also obtained.

Processing for cassava flour preparation

Cassava roots from 8-month-old plants of a local cultivar (M Col 113) which is classified as a low-cyanide-containing variety (Gómez et al., 1980) were used in this study. The rcots were washed an peeled by hand with a knife. Peeled roots were immersed in water for approximately 30 min prior to being either cut with a machete into transverse slices of about 1-cm thickness or chipped in a Thai type chipping machine (Thanh et al., 1979). The dimensions of the chips were not regular and no attempt was made to select them by size. Th elength, width and thickness of the irregular chips varied from 5 to 10, 2 to 4 and .3 to .6 cm, respectively.

Fresh peeled-root slices or chips were immediately weighed on to load wired-bottom trays, each with an area of 0.54 m^2, with 10.8 kg per tray so that a loading rate of 20 kg m^{-2} was obtained. Four trays with fresh slices and four with chips were intercalated within the oven's cabinet and dried in the air-forced electrically heated oven (Despatch Model V-31, Despatch Industries, Inc. Box 1320, Minneapolis, Minnesota 55440); a temperature control thermostat was standardized and set at 60°C as the operating temperature. In addition, two trays with irregular root peel pieces, obtained by breaking the peels by hand, were also included in each drying and placed at the lower positions of the oven cabinet. The exact weight of root peel pieces per tray was not measured, but since root peel represented approximately 18% of total root fresh weight, the estimated load per tray was around 7.5 to 8 kg of fresh root peel giving a loading rate of about 14 to 15 kg m^{-2}.

Immediately after spreading the fresh slices, chips and peel pieces onto the trays, samples from each tray were taken for DM (dry matter), cyanide, starch and sugar analyses. DM content was determined by drying the samples to constant weight at 60°C; total and free cyanide were analyzed using the enzymatic assay (Cooke, 1978) and bound or glycosidic cyanide was estimated by difference. Aliquots of each sample were freeze-dried (Model S.B.5, Chemlab Instruments Ltd., Hornminster House, 129 Upminster Road, Hornchurch, Essex, U.K.) for subsequent analyses of total and reducing sugars by the method described by Cronin & Smith (1979) and starch by the acid hydrolysis method (Blake & Coveney, 1978). Samples of dried slices, chips and root peel were separately ground through a laboratory mill (Cyclone Sample Mill, UD Corporation, 1898 South Flatiron Court, Boulder, Colorado 80301) using a 0.5 mm steel screen. Dried ground samples were analyzed for the parameters which were determined in the fresh samples using the same methods as previously described. In addition, for each two trays a sample of the dried products was also analized for its proximal chemical composition by the AOAC (1970) methods.

Each tray was considered as an experimental unit and experimental data were compared using the t-test (Steel & Torrie, 1960). Two dryings were performed so that eight values of each parameter for either peeled-root slices or chips were statistically analyzed.

Breadmaking

Dried peeled-root slices and chips were ground and the resulting flour used for breadmaking. The levels of substitution of wheat flour by cassava flour were 10, 15, 20 and 25%. The bakers flour used was about 78% extraction and 12% protein content. The breadmaking formula for 100 g of wheat/cassava flour blend included 6 g sugar, 4 g shortening, 4 g pressed yeast and 2 g salt. The volume of water to be added to the flour blend was increased as the ratio cassava flour/wheat flour increased, and varied between 63 to 65 g. The water addition was controlled so as to give a dough of suitable consistency.

Bread was baked from the wheat/cassava flour blends using a laboratory-type Hobart mixer equipped with a hook blender, by a straight-dough method with

90-min fermentation at 30°C and 80% relative humidity. Then, the dough was maintained at room temperature for 15 min, molded mechanically into loaves of 370 g and allowed to ferment for approximately 55 min. The loaves were baked for 25 min at 195°C in a stationary cabinet oven with thermostats for controlling both top and bottom temperatures. The loaf height, weight and volume were measured 24 hr after breadmaking. The specific volumes of the baked loaves were determined by seed displacement. The loaves were scored, using a scale from 0 to 10, for shape, crust appearance and crumb texture.

A few bread samples, one for each of the cassava flour levels at 0, 15 and 20%, were analyzed for their cyanide (Cooke, 1978) content.

Results and discussion

The proximal chemical composition, the starch and sugar contents of cassava flour prepared by oven-drying (60°C) peeled-root slices and chips is summarized in Table 1. The moisture, starch, crude fibre and ash contents found in the cassava flour samples analyzed fell within the range of specifications for commercial cassava flour following official standards (Ingram, 1975). The crude protein content of cassava flour obtained in this study is slightly higher than values reported for parenchyma (peeled-root) tissue of roots of most of the known cassava cultivars (Barrios & Bressani, 1967; Gómez & Valdivieso, 1983; Gómez, personal communication). Generally, cassava flour tends to have similar protein content than that of sweet potato flour (De Carvalho et al., 1981) but lower than potato flour (Yañez et al., 1981).

The peeled roots of the local cultivar M Col 113 contained low cyanide levels (135 ± 29 mg kg^{-1} DM, Table 2) confirming previous results (Gómez et al., 1980); most of the cyanide was present as bound cyanide and only 12 ± 4% was found as free cyanide. Drying of cassava slices and chips considerably reduced the cyanide content present in the fresh material, but at the same drying temperature (60°C), loading rate (20 kg m^{-2}) and drying period (20-22 hr), the cyanide losses were affected by the geometry and size of the cassava peeled-root pieces. Thus, oven-drying of chips allowed a 72 ± 7% elimination of either total or bound cyanide, whereas in 1-cm thick slices only 49 ± 16% of the initial cyanide content was lost. These results clearly demonstrate the effect of cassava root piece shape and size on cyanide elimination. However, dried slices and chips showed cyanide levels which were low enough to be acceptable as a human food. The amount of total cyanide eliminated was almost entirely accounted for by the hydrolysis of the cyanogenic glucoside, as has also been observed in some drying experiments with whole-root chips (Gómez, Valdivieso & Salcedo, 1983).

The results of the breadmaking evaluations are summarized in Table 3. The inclusion of cassava flour at levels of 10 and 15% of the wheat/cassava flour blends resulted in bread quality similar to that of the wheat flour. Higher levels (20 and 25%) of cassava flour inclusion led to a slight increase in water absroption but notably to lower loaf specific volumes and loaf scores as compared to the results with levels of substitution of 10 and 15%. The level of 15% cassava flour inclusion gave a bread quality which was the closest to that obtained with the wheat flour. These results indicate that cassava flour prepared as described in this study could be incorporated in wheat/cassava flour blends at levels of 10 and 15% and satisfactory bread quality could be obtained.

Only three samples of bread (0, 15 and 20% cassava flour) were analyzed for their cyanide content and the results showed total cyanide values of 3.5, 2.5 and 1.9 mg kg^{-1} DM, respectively. The free cyanide proportions of the three bread samples were 53, 74 and 92%, respectively. These results suggest that elimination of the residual cyanide of cassava flour may continue further under the moisture and temperature conditions of the fermentation process used. Since most of the promising cultivars produce roots with higher cyanide concentrations than those of roots of local cultivars, research on cyanide elimination and the effects of residual cyanide content in cassava flours on bread quality and nutritional aspects merits special attention.

Table 4 summarizes the chemical proximal composition, the starch and sugar contents as well as the cyanide concentration of dried root peel pieces. Dried peel contained higher levels of crude protein, crude fibre and cyanide than the corresponding cassava flour (Gómez & Valdivieso, 1983; Gómez et al., 1980). Root peel contains a sizable amount of starch (58.3 ± 2.9% on a DM basis) and sugar levels slightly higher than those of the corresponding root-parenchyma tissue. Root peel however, constitutes only 15 to 20% of the total root fresh weight.

The cyanide concentration of root peels was higher than that of the parenchyma (Gómez et al., 1980) and oven-drying eliminated approximately two-thirds of total and bound cyanide. However, the final cyanide content of dried peel was four times the maximum permissible hydrocyanic acid level set as a quality standard for cassava products to be used as animal feeds (cited by Ingram, 1975). The chemical composition and notably the cyanide content of dried peels suggest that further research is needed to ascertain their potential nutritional value as animal feed. This is of special relevance because the root peel of most of the promising cassava cultivars contain considerably higher cyanide levels than the parenchyma (Gómez et al., 1980).

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Table 1. Composition of cassava (peeled-root) flour

Constituent	%
	on a DM basis
Dry matter	98.2 ± 1.3
Crude protein	4.8 ± 1.3
Ether extract	1.2 ± .2
Crude fibre	3.1 ± .4
Ash	3.0 ± .2
Starch[a]	78.7 ± 2.4
Reducing sugars[a]	1.4 ± .4
Total sugars[a]	4.9 ± 1.0

[a] Each value is the mean of 16 samples ± SE and each remainder value is the mean of 8 samples ± SE.

Table 2. The effects of cassava peeled-root piece shape on cyanide elimination by oven-drying at 60°C and at a loading of 20 kg m^{-2}

Parameter	Slices	Chips	
	—— on a DM basis ——		
Cyanide in fresh chips[a]			
Total (mg kg^{-1})	—— 135 ± 29 ——		
Bound (mg kg^{-1})	—— 118 ± 26 ——		
Free (% of total)	—— 12 ± 4 ——		
Cyanide in dried chips[b]			
Total (mg kg^{-1})	61 ± 5	39 ± 10	** [c]
Bound (mg kg^{-1})	53 ± 5	33 ± 9	**
Free (% of total)	12 ± 2	14 ± 2	*
Cyanide losses as			
% of initial contents			
Total	49 ± 16	72 ± 7	**
Bound	49 ± 16	72 ± 7	**

[a] Each value is the mean of 16 samples ± SE.

[b] Each value is the mean of 8 samples ± SE.

[c] Values were different at $P < .05$ (*) or $P < .01$ (**).

Table 3. Bread assessment of wheat/cassava flour blends

Parameter	Cassava flour level (%)				
	0	10	15	20	25
Water absorption (%)	63	63	63	65	65
Loaf characteristics					
Height (cm)	12.3	12.3	13.5	12.2	11.2
Volume (ml)	1593	1523	1535	1480	1435
Weight (g)	319	320	311	327	325
Loaf specific volume (ml/g)	5.0	4.8	4.9	4.6	4.4
as % of control	100	96	98	92	88
Loaf score					
0-10 scale	9	8	8.5	7.5	6
as % of control	100	89	94	83	67

Table 4. Chemical composition and cyanide contents of dried cassava (cv. M Col 113) root peel[a]

Component	%	
	on a DM basis	
Dry matter	94.2 ± .8	
Crude protein	9.1 ± 1.9	
Ether extract	2.0 ± .6	
Crude fibre	12.0 ± 2.1	
Ash	5.0 ± .4	
Starch	58.3 ± 2.9	
Reducing sugars	2.3 ± .4	
Total sugars	6.8 ± 1.8	
Cyanide in dried chips		
Total ($mg\ kg^{-1}$)	444 ± 39	(1273 ± 308)[b]
Bound ($mg\ kg^{-1}$)	273 ± 29	(998 ± 248)
Free (% of total)	39 ± 3	(22 ± 2)
Cyanide losses as		
% of initial contents		
Total	64 ± 8	
Bound	72 ± 5	

[a] Each value is the mean of four samples ± SEM.

[b] Values in parentheses correspond to fresh root-peel samples.