Effect of Whole-Root Chips Loading for Drying Cassava on Trays or Concrete Floor on Cyanide Losses

Authors: Guillermo Gómez and Mauricio Valdivieso, Utilization Section - Cassava Program, Centro Internacional de Agricultura Tropical, Apartado Aéreo 6713, Cali, Colombia.

ABSTRACT

Roots of varieties CMC-40 and CMC-84 from 15-month-old plants were used in this experiment. Three loadings for drying on trays (10, 15 and 20 kg m^{-2}) and two for concrete floors (10 and 12 kg m^{-2}) were studied. At these loading rates floor drying was more efficient in reducing cyanide than tray drying. Increasing the loading of chips on trays up to 20 kg m^{-2} resulted in higher cyanide losses than with lower loadings, especially with the high cyanide variety, CMC-84. Proportion of free cyanide in dried chips appeared to progressively increase as the loadings on trays were incremented. Floor and tray drying chips of the low-cyanide variety produced dried chips containing 100 ppm or less of total cyanide, on a dry matter basis. These levels were not reached with chips of the high-cyanide variety.

Introduction

Sun-drying, either on concrete floors or inclined trays, is the most widespread method of drying cassava chips for animal feed. Duration of the sun-drying process depends on several factors such as climatic conditions (ambient temperature, solar radiation, relative humidity, windspeed), the geometry, size and uniformity of the chips, initial moisture content of chips and loading rates of fresh chips per unit area of drying surface.

Cassava varieties differ widely in cyanide content of their root tissues (Gómez et al., 1980). Most cyanide in cassava is bound cyanide in the form of cyanogenic glucoside, linamarin (Conn, 1969; Nartey, 1978; Gómez et al., 1980). Once physical structure of roots is disrupted, cyanogenic glucoside is normally hydrolyzed by the enzyme linamarase, present in cassava tissues with highest concentration in root cortex or peel, forming hydrocyanic acid (Conn, 1969). The drying process is an efficient way of eliminating cyanide in cassava roots (Correia, 1947; Cooke and Maduagwu, 1978; Maduagwu and Adewale, 1981; Gómez, 1982).

Objective of this study was to ascertain the effect of several loading rates of fresh cassava chips of two cassava varieties (one a low-cyanide cultivar, CMC-40, and the other a high-cyanide cultivar, CMC-84) on cyanide elimination by the sun-drying process on a concrete floor and on inclined trays.

Materials and Methods

Roots of varieties CMC-40 and CMC-84 from plants harvested at 15 months of age, grown under identical conditions, were used in this experiment. Unwashed harvested roots were chopped through a Thailand-type chipping machine (Thanh, et al., 1979). Fresh whole-root chips were immediately weighed and spread on either concrete floor platforms (22 m^2 each) or inclined trays (1.5 m^2 each). Three (10, 15 and 20 kg m^{-2}) and two (10 and 12 kg m^{-2}) loading rates were studied for drying on trays and on concrete floors, respectively, for each variety. A total of 12 trays and three concrete platforms per variety at each loading rate were assayed. Samples of fresh and dried chips were taken from every two trays and from two equal sub-areas of each concrete platform so that six samples per treatment were analyzed.

Immediately after fresh chips were spread on the experimental drying surface a 60 g sample was taken, immersed in phosphoric acid, homogenized and filtered and the homogenate used for cyanide analyses by the enzymatic assay (Cooke, 1978); total and free cyanide were determined by this assay and bound cyanide (linamarin) was obtained by difference. Chipping and sampling operations were coordinated so as to keep the time elapsed between them to a minimum; the immersion of the sample in phosphoric acid took place approximately 15 minutes after the whole-roots were chipped. Chips were periodically turned during the drying period, manually on the trays and using a wooden rake on the floor. Meteorological conditions at the drying site were recorded throughout the experimental period. At the end of the drying period, samples of dried chips were taken, ground and analyzed for dry matter (DM) and cyanide contents. DM determination was performed by drying samples to constant weights at 60°C. All cyanide contents are expressed on a DM basis. The experimental information was statistically analyzed using the analysis of variance procedure (SAS, 1979) for each variety separately.

Results and Discussion

Meteorological conditions recorded at the drying site throughout the experimental period and duration of the drying periods for chips of each variety are summarized in Table 1. Because climatic conditions were more favorable (higher ambient temperature and solar radiation, lower relative humidity and higher windspeed) during the sun-drying period for chips of the variety CMC-84, they dried faster than those of the variety CMC-40. For each variety, chips spread either on trays or on a concrete floor at a loading rate of 10 kg m^{-2} required approximately the same time for drying; however, increasing the loading rate to 12 kg m^{-2} on the floor extended the drying period by about one day (Table 1).

Fresh chips of variety CMC-84 contained higher ($P \leq .05$) levels of DM as well as of cyanide than those of variety CMC-40 (Table 2). The total cyanide levels in fresh chips of roots from the 15-months-old plants of the two varieties were similar to those found with the same cultivars when they were 12 months old (Gómez and Valdivieso, manuscript in preparation). Although most cyanide in root tissues, the peel cortex and parenchyma (Gómez and Valdivieso, 1983), was present as bound cyanide (~90% and 10% free), chipping of whole roots allowed rapid hydrolysis to occur, converting bound to free cyanide so that content of free cyanide in fresh chips increased to 29% and 18% ($P \leq .05$) for varieties CMC-40 and CMC-84, respectively, associated with a proportional reduction in the bound cyanide content.

Table 1. Meteorological conditions at the drying site and duration of drying periods.

Parameter	Drying period for variety	
	CMC-40	CMC-84
Average meteorological conditions		
Air temperature, °C	25.5	28.0
Solar radiation, cal g cm^{-2} h^{-1}	70	90
Relative humidity, %	76	72
Windspeed, km h^{-1}		
at 2 m above ground	4.1	4.6
at 0.3 m above ground	1.5	2.8
Duration of drying periods, h		
on trays	75	53 (56)*
on concrete floor at		
10 kg m^{-2}	77	53
12 kg m^{-2}	102	76

*Number in parenthesis is the drying time at the loading rate of 20 kg m^{-2} on trays.

Table 2. Dry matter and cyanide contents in fresh whole-root chips of cassava varieties CMC-40 and CMC-84.

Parameter	CMC-40	CMC-84
Dry matter, %	36.8 ± .6^{a}	40.7 ± .3^{b}
Cyanide contents, ppm DM basis		
Total	336 ± 14^{a}	706 ± 18^{b}
Bound	241 ± 12^{a}	577 ± 17^{b}
Free	95 ± 4^{a}	129 ± 3^{b}
Free-cyanide, % of total	29 ± .7^{a}	18 ± .4^{b}

a,bMeans in the same row bearing different superscript are different ($P < .05$). Each value is the mean of 30 samples ± the standard error of the mean.

Cyanide content of dried chips as affected by drying surface (trays vs floor) and loading rates of fresh chips per unit area are presented in Table 3. These results can be summarized as follows: (1) sun-drying either on trays or concrete floors produced chips with final DM content in the range of 91% to 95%; (2) chips dried on concrete floors showed lower ($P \leq .05$) total cyanide contents than those dried on trays, in both varieties; (3) increasing loading rates from 10 to 20 kg m^{-2} on trays allowed a more efficient ($P \leq .05$) cyanide elimination, as shown by the decrease in cyanide contents in dried chips at the higher loading

Table 3. Effect of sun-drying (on trays or concrete floor) and loading rates on the cyanide content in dried chips of two cassava varieties[1].

Parameter	Drying surfaces and loading rates ($kg\ m^{-2}$)						
	Trays				Floor		
	10	15	20	SEM[2]	10	12	SEM[2]
VARIETY CMC-40							
Dry matter, %	93.8	92.6	91.0	.31	92.5	94.9	.39
Cyanide content, ppm DM basis							
Total	71[a]	66[a]	58[a][3]	2.36	50[b]	29[c]	3.78
Bound (linamarin)	57[a]	50[a]	43[a]	.39	33[b]	11[c]	1.27
Free CN, % of total CN	20[a]	24[a]	26[a]	.96	35[b]	64[c]	4.48
Total CN eliminated, %	78[a]	77[a]	81[a,b]	1.23	82[b]	93[c]	1.72
VARIETY CMC-84							
Dry matter, %	91.0	91.0	91.4	.22	92.4	91.6	.33
Cyanide content, ppm DM basis							
Total	310[a]	189[b]	162[b,c]	16.45	107[d]	142[c]	8.27
Bound	279[a]	138[b]	103[c]	3.83	61[d]	91[c]	2.81
Free CN, % of total CN	10[a]	27[b]	37[c]	2.93	43[d]	36[c]	1.76
Total CN eliminated, %	58[a]	74[b]	77[b]	2.30	85[c]	77[b]	1.81

[1]Each value is the mean of six samples.

[2]Pooled standard error of the mean, for each drying surface.

[3]Means in the same row bearing different superscripts are different ($P < .05$).

rate; (4) a similar effect ($P \leq .05$) was observed on concrete floor drying (10 vs 12 kg m^{-2}) with the chips of variety CMC-40, but not with those of variety CMC-84; (5) the proportion of free cyanide in chips dried on concrete floors was higher ($P \leq .05$) than those of chips dried on trays; (6) in most cases total cyanide eliminated during the drying process accounted for 74% to 93% of the initial cyanide content and (7) dried chips of variety CMC-84 contained considerably higher cyanide levels than those of variety CMC-40, especially in chips dried on trays.

Data from this study demonstrate that the sun-drying process, especially on concrete floors, eliminates most (74% to 93%) of initial cyanide content of fresh whole-root chips (Table 3); chips of variety CMC-84 dried on trays at a loading rate of 10 kg m^{-2} lost only 58% of their initial cyanide content. In general, most remaining cyanide in dried chips is still found as the cyanogenic glucoside. It has been suggested (Cooke and Maduagwu, 1978) that sun-drying would lead to greater losses of cyanide than oven-drying because of longer drying times and at moisture contents and temperatures at which endogenous linamarase is active.

A maximum content of 100 ppm of hydrocyanic acid has been set as one of the quality standards for the importation of dried cassava chips or pellets to the European Economic Community (Anonymous, 1977). All dried chips of the low-cyanide variety, CMC-40, showed total cyanide concentrations less than 100 ppm, but dried chips of the high-cyanide variety, CMC-84, especially those dried on trays, had higher cyanide contents than this established limit. Little information exists as to the maximum cyanide content which can be safely ingested. This depends not only on cyanide content of dried cassava chips but also on level of inclusion of cassava meal in animal feed diets. Research in progress at CIAT (Gómez, personal communication) would suggest that cassava meal containing approximately 300 ppm of total cyanide and present in diets for broilers (0-4 weeks) up to a level of 30% does not produce any apparent adverse effects on animal performance. Further studies are needed to elucidate the toxic level of cassava cyanide for animal feeding.

Acknowledgment

The authors thank Déborah de la Cuesta and Teresa Salcedo for help in laboratory analyses, to Eduardo Granados for collaboration in statistical analyses, and to Christopher Wheatley for editing the manuscript.

References

Anonymous. Cassava export potential and market requirements. Geneva. Int. Trade Centre. UNCTAD/GATT. 1977. 65 p.

Conn, E.E. Cyanogenic glycosides. J. Agric. and Food Chem. 17. 1969. 519-526.

Cooke, R.D. An enzymatic assay for the total cyanide content of cassava (*Manihot esculenta* Crantz). J. Sci. Food Agric. 29. 1978. 345-352.

Cooke, R.D. and Maduagwu, E.N. The effects of simple processing on the cyanide content of cassava chips. J. Fd. Technol. 13. 1978. 299-306.

Correia, F.A. Acido cianídrico en algunas variedades de mandioca. Bragantia VII. 1947. 15-22.

Gómez, G. Cassava, cyanide and animal nutrition. In proceedings of a workshop on "Cassava toxicity and tyroid: research and public health issues," Ottawa, Canada, May 31-June 2, 1982. International Development Research Centre. In press.

Gómez, G. and Valdivieso, M. Changes in cyanide content of cassava tissues as affected by plant age and variety. 6th Symposium of the International Society for Tropical Roots Crops. Lima, Perú, 21-26 February 1983.

Gómez, G., De la Cuesta, D., Valdivieso, M., and Kawano, K. Contenido de cianuro total y libre en parénquima y cáscara de raíces de diez variedades promisorias de yuca. Turrialba 30(4). 1980. 361-365.

Maduagwu, E.N. and Adewale, A.F. Loss of hydrocyanic acid and its derivatives during sun drying of cassava. In Terry, E.R., Oduro, K.A. and Caveness, F. eds. Triennial root crops. Symposium of the international society for tropical root crops, 1st., Ibadan, Nigeria, 1980. Tropical root crops: research strategies for the 1980's. Proceedings, Ottawa, Canada. International Development Research Centre. Series IDRC-163e. 1981. pp 149-151.

Nartey, F. Manihot esculenta (Cassava). Cyanogenesis, ultrastructure and seed germination. Munksgaard, Copenhagen, Denmark. 1978. 262 p.

S.A.S. User's Guide. 1979 Edition. S.A.S. Institute Inc., Raleigh, N.C., U.S.A. 1979. 494 p.

Thanh, N.C., Muttamara, S., Lohani, B.N., Rao, B.V.P.C., and Burintratikul, S. Optimization of drying and pelleting techniques for tapioca roots. International Development Research Centre - Asian Institute of Technology. Final Report No. III. Bangkok, Thailand, 1979. 119 p.