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EFFECT OF STORAGE AND COOKING PRACTICES ON THE TOTAL CYANIDE CONTENT OF TWO CASSAVA (*MANIHOT ESCULENTA* CRANTZ) CULTIVARS

Mulugeta Taye[1] and Eskindir Biratu[2]

[1] Awassa College of Agriculture, PO Box 5, Awassa, Ethiopia

[2] Ethiopian Health and Nutrition Research Institute
PO Box 5654, Addis Ababa, Ethiopia

ABSTRACT: Effect of different storage and cooking practices on the total cyanide content of the cultivars Amarokello white and Umbure was conducted using enzymatic assay. Total cyanide reduction varied between different storage methods resulting in a higher reduction in sundried flour (98.6–99.3%) compared to ground (1.9–51.4%), trench (6.1–49.1%) and refrigerator (4.0–29.7%). Cooking the root also brought about a wide range of total cyanide reduction in Amarokello white (73.0–98.2%) and Umbure (61.0–96.1%) cultivars. The highest total cyanide reduction was obtained when the roots were soaked, sundried and baked. The lowest total cyanide reduction in the two cultivars, however, was obtained when the roots were boiled without prior soaking. Soaking the cassava leaf in water before boiling led to a higher reduction. Boiling the leaf after sundrying with or without soaking resulted in the highest reduction of total cyanide in both Amarokello white (99.1–99.6%) and Umbure (96.0–97.5%) cultivars.

Key words/phrases: Cassava, cyanide, cyanogenic glucosides, storage methods

INTRODUCTION

Cassava *(Manihot esculenta* Crantz) (Euphorbiaceae) is a perennial root crop currently grown almost anywhere in areas between the latitudes 30°N and 30°S of the equator (Bokanga, 1996). It grows in a wide range of climatic conditions and performs better than most other crops under drought conditions (Cock, 1985). Cassava serves as a source of food for over 800 million people, as a feed, and as a major source of starch for industrial purposes (Nweke, 1996). The crop is particularly a major source of carbohydrate in many tropical countries. It is estimated that cassava provides 37, 12, and 7 per cent of the energy in the diet of tropical areas of Africa, America, and Asia, respectively (Key, 1987). At present, over hundred cultivars which vary in their morphology and cyanogenic glucosides content (10–470 mg per 100 g fresh root) are grown in the tropical world (Onwueme, 1978; Kay, 1987).

Cassava has been grown and used as food for about a century in different regions of Ethiopia. A survey conducted in different parts of southern and southwestern Ethiopia showed that cassava grows in an altitudinal range of 480–1800 m, annual temperature of 15–30°C and annual precipitation of 692–1470 mm (Mulugeta Taye, 1994). In the southern Ethiopia particularly in Amarokello area (Gedeo Zone) cassava is almost used as staple food. In Wolaita area (North Omo Zone), cassava roots are widely consumed after washing and boiling or in the form of bread and "injera" after mixing its flour with that of some cereal crops such as maize *(Zea mays)*, sorghum *(Sorghum bicolor)*, or tef *(Eragrostis tef)* (Mulugeta Taye, 1994). At present, over twenty local and identified cultivars which vary in their morphology, agronomic characters and cyanogenic glucosides content are cultivated in the southern and southwestern regions of Ethiopia (Mulugeta Taye, 1993).

The major factor that limits the use of cassava as food is the toxicity of hydrogen cyanide (HCN) which occurs as a result of the hydrolysis of cyanogenic glucosides (Rickard, 1985). This chemical is produced when the cyanogenics: linamarin and lotaustralin that are found in the ratio of 10:1, respectively, are acted upon by the extracellular enzyme linamarase following damage of cells during harvesting or processing (Conn, 1969; Onwueme, 1978). The cyanide present in cassava, therefore, may be considered to be of two types: (1) bound cyanide present as the cyanogenic glucoside (2) free cyanide present as the cyanohydrin; as free HCN which is a gas above 26° C (under alkaline conditions) and as CN^- (Bradbury and Holloway, 1988). The total cyanide which comprises both the bound and the free cyanide indicates the potential of the cyanogenic glucosides in the roots or leaves.

The cyanogenic glucoside occurs in all parts of the plant. It is found in higher concentration under the peel and around the fiber in the middle part of the root (Key, 1987). Its concentration, however, may be influenced by several factors including soil type, availability of soil moisture and time of maturity (Bradbury and Holloway, 1988). To show differences in the cyanogenic glucosides content of the different cultivars, growers traditionally use the term bitter (high cyanide content) and sweet (low cyanide content) in many cassava growing countries including Ethiopia. These terms, however, are often mistaken with taste.

Cyanide is widely distributed in nature and is a normal constituent of blood, usually at low concentration: $<12\ \mu mol\ l^{-1}$ (Solomonson, 1981). Using improperly processed cassava can increase the cyanide content in the human body and eventually cause goitre, cretinism, paralysis, and neurological disorder (Delange and Ahluwalia, 1983; Rosling, 1987 cited in Bradbury *et al.*, 1991). As reported by Montgomory (1980) the lethal dose for human varies between 0.5–3.5 mg HCN$(kg)^{-1}$ body weight.

Several post-harvest practices which comprise mainly the storage and cooking methods considerably affect the cyanide content. A total cyanide reduction of 63–73% (Nambisan and Sundersan, 1985) and 70–80% (Gomez *et al.*, 1984) was reported when the tuberous roots were stored in the form of flour. A total cyanide reduction of 50 to 60% after storing for 48 hours on four cultivars was also reported (Aalbersberg and Limalevu, 1991). Cooke and Maduagwa (1978) and Aalbersberg and Limalevu (1991) reported that boiling the tuberous root resulted in a total cyanide reduction of 55% and 50–60%, respectively. Studies on the effect of cooking the leaf also showed a considerable reduction in total cyanide (Kalenga Saka, 1993).

However, in view of the importance of cassava as a major source of carbohydrates for several million people in the developing countries, quiet limited studies have been conducted to alleviate the cyanide problem. Evaluation and application of the different post-harvest practices, therefore will play an indispensable role to promote the production and utilization of cassava.

Thus, the purpose of this study was to examine the effect of different storage and cooking practices on the total cyanide content of two widely used cultivars.

MATERIALS AND METHODS

Cultivars and experimental site

Cassava roots and leaf samples were collected from two cultivars, namely, Amarokello white and Umbure grown for about fourteen months during the years 1994 and 1995 at Awassa College of Agriculture. Amarokello white is a local cultivar which was collected from Amarokella area/Gedeo zone while Umbure is a recently introduced and widely used cultivar that was collected from Wolaita area/North Omo Zone.

Storage experiment

In this experiment, about ten kilograms of fresh cassava roots were used in each treatment for both cultivars. The cassava roots stored at ambient conditions on the ground, in a trench, and in a refrigerator were cut into pieces without peeling. To prepare cassava flour the roots were peeled, cut into small pieces, sundried, and ground into flour using an electric grinder.

The treatments used in this experiment were:

i) Spreading the cassava roots on the ground for three and six days at 16-24° C; 34-47% RH;
ii) Burying it in a trench of 75 x 40 cm for three and six days;
iii) Sundrying it for nine days at an ambient temperature of 24-28° C; and
iv) Storing it in a deep refrigerator at -20° C for four weeks.

Cooking experiment

Cassava root

The term cooking in this study was used for both boiling and baking practices as used by Bradbury and Holloway (1988).

Three kilograms of cassava roots were collected randomly from a number of plants of each cultivar. The cassava roots were peeled and cut into small pieces for all treatments. The pieces dried at ambient temperature of 24-28° C for 48 hours were further shredded and ground into fine flour by an electric grinder and used for baking. Both boiling and baking were carried out in an electric auto-control dish and oven, respectively.

The treatments involved in this experiment were:

i) Boiling the cassava root without soaking in water for 20 minutes;
ii) Boiling it after soaking in water for 20 minutes;
iii) Boiling it without soaking in water for 40 minutes;
iv) Boiling it after soaking in water for 40 minutes;
v) Baking it at 200° C but after sundrying but without soaking; and
vi) Baking it at 200° C after soaking in water and sundrying.

Cassava leaves

The first four fresh leaves were collected from twenty plants of each cultivar. In all the treatments, the midribs of the leaves were removed and were boiled until they were soft. Some leaves were also dried at 24-28°C for two days.

The treatments involved were:

i) Boiling the leaf after soaking in water;
ii) Boiling it without soaking in water;
iii) Boiling it after soaking and sundrying; and
iv) Boiling it without soaking but after sundrying.

Chemical analysis

The total cyanide analysis was conducted using the enzymatic assay developed by Cook (1978). This method involves the extraction of cyanide using aqueous phosphoric acid, enzymatic hydrolysis of linamarin with the enzyme linamarase, and determination of total cyanide colorimetrically.

RESULTS

As indicated in Table 1, the different storage methods showed a wide range of differences in the total cyanide reduction in both Amarokello white and Umbure cassava cultivars.

Table 1. The influence of some storage methods on the total cyanide content of cassava roots.

	Cassava cultivars			
	Amarokello white		Umbure	
Sample treatments	Total cyanide [mg(100g)$^{-1}$]	Percentage reduction	Total cyanide [mg(100g)$^{-1}$]	Percentage reduction
Fresh	2.12 (0.06)*		1.43 (0.04)	
A	2.08 (0.02)	1.9	1.34 (0.04)	5.9
B	1.04 (0.04)	51.4	0.97 (0.02)	32.4
C	1.99 (0.01)	6.1	1.15 (0.03)	19.9
D	1.08 (0.03)	49.1	1.39 (0.01)	23.5
E	0.03 (0.01)	98.6	0.01 (0.01)	99.3
F	2.03 (0.02)	4.0	1.91 (0.02)	29.7

Numbers indicated in brackets are the standard deviations.
A, The root spread on the ground for 3 days; B, Spread on the ground for 6 days; C, Buried in the trench for 3 days; D, Buried in the trench for 6 days; E, Sundried flour; and F, Put in deep refrigerator for 4 weeks.

The lowest total cyanide reduction was obtained when the fresh cassava roots were stored for three days on the ground in both Amarokello white and Umbure cultivars compared to any other treatments. The total cyanide reduction in the trench for three days was also low in both Amarokello white and Umbure cultivars. Tuberous roots that were stored in deep refrigerator at -20° C also showed a higher retention of total cyanide, but with some variations between the cultivars.

Spreading the tuberous roots on the ground and in the trench for six days resulted in an increase in total cyanide reduction in both cultivars. Sundrying resulted in the highest total cyanide reduction.

Signs of deterioration starting from the third day were observed on the ground and in the trench but were absent from those cassava roots stored in the refrigerator and from flour.

Cooking the cassava roots also brought about a wide range of differences in total cyanide reduction in both Amarokello white (73-98.2%) and Umbure (61.0-96.1%) cultivars (Table 2). Among the treatments, the cassava roots soaked in water prior to boiling and baking showed a considerable reduction in their total cyanide content on both cultivars.

Table 2. The influence of some cooking practices on the total cyanide content of cassava roots.

	Cassava cultivars			
	Amarokello white		Umbure	
Sample treatments	Total cyanide [mg(100g)$^{-1}$]	Percentage reduction	Total cyanide [mg(100g)$^{-1}$]	Percentage reduction
Fresh	2.14 (0.06)		1.47 (0.04)	
A	0.58 (0.02)	73.0	0.58 (0.03)	61.0
B	0.19 (0.01)	91.1	0.18 (0.02)	88.0
C	0.23 (0.02)	89.3	0.18 (0.04)	88.0
D	0.16 (0.02)	92.4	0.13 (0.01)	91.1
E	0.30 (0.01)	86.1	0.31 (0.01)	78.8
F	0.04 (0.02)	98.2	0.06 (0.04)	96.1

Numbers indicated in brackets are the standard deviations.
A, The root boiled without soaking for 20 minutes; B, Boiled after soaking for 20 minutes; C, Boiled without soaking for 40 minutes; D, Boiled after soaking for 40 minutes; E, Baked after sundrying but without soaking; and F, Baked after soaking and sundrying.

Baking sundried flour at 200° C after soaking the cassava roots resulted in the highest total cyanide reduction in the cultivars Amarokello white (98.2%) and Umbure (96.1%) compared to cases where the cassava had not been presoaked. The lowest total cyanide reduction was obtained when the cassava roots were boiled without soaking for 20 minutes in both cultivars. On the other hand, boiling for 20 minutes after soaking resulted in a considerable reduction which was nearly the same as that resulting from boiling for 40 minutes.

Table 3 shows the total cyanide reduction between the leaf treatments. It varied between 85.3–99.6% in Amarokello white and 80.9–96.0% in Umbure cultivars. Leaves that were boiled without soaking showed a lower cyanide reduction in both cultivars (Table 3). However, boiling the leaf with and without soaking after sundrying showed a considerable reduction in both Amarokello white (99.1–99.6%) and Umbure (96.0–97.5%) cultivars.

Table 3. Influence of some cooking practices on the total cyanide content of cassava leaves.

	Cassava cultivars			
	Amarokello white		Umbure	
Sample treatments	Total cyanide (mg/100g)	Percentage reduction	Total cyanide (mg/100g)	Percentage reduction
Fresh	44.50 (0.3)		32.42 (0.5)	
A	4.20 (0.01)*	90.6	4.12 (0.03)	87.3
B	6.54 (0.02)	85.3	6.19 (0.02)	80.9
C	0.18 (0.02)	99.6	0.81 (0.03)	97.5
D	0.41 (0.02)	99.1	1.30 (0.02)	96.0

Numbers indicated in brackets are the standard deviations.
A, The leaf boiled after soaking; B, Boiled without soaking; C, Boiled after soaking and sundrying; and D, Boiled without soaking but sundrying.

DISCUSSION

The considerable retention of total cyanide in cassava roots stored for three days on both the ground and in the trench of both Amarokello white and Umbure cultivars was attributed to slow hydrolysis of cyanogenic glycosides by the linamarase enzyme. These results were similar to the report of Aalbersberg and Limalevu (1991) who observed a higher retention of total cyanide in cassava roots of four cultivars after 48 hours of storage. The greater total cyanide retention in the refrigerator was possibly due to the low temperature which arrested the activity or denatured the enzyme. On the other hand, a considerable reduction in total cyanide in the sundried flour might be related to cutting of roots into small pieces. Cutting of cassava roots into small pieces might create easy access for contact between the enzyme and the cyanogenic glucosides causing eventually higher hydrolysis. This practice appeared to be quite effective in removing a lot of cyanide from cassava roots. Similar results were also reported by many workers including Gomez *et al.* (1984) who obtained a reduction of 70–80% total cyanide after 48 hours of sundrying, Nambisan and Sundaresan (1985) who reported 63–73% reduction when 1 cm cube of the cassava root was sundried for 18 hours while Gomez and Valdivieso (1985) reported a cyanide reduction (82–94%) in leaves after 2–3 days.

A considerable reduction in total cyanide also occurred when the cassava roots and leaves were cooked. The improved total cyanide reduction in the tuberous roots due to soaking prior to boiling at 20° C and 40° C might be explained as a result of enhanced hydrolysis processes of cyanogenic glucosides by the enzyme as reported by Bokanga (1996). Moreover, the contribution of soaking in water was quite apparent on those roots that were sundried after soaking and baked at 200° C. The high temperature (200° C) might not have contributed to the total cyanide loss since high temperature is believed to decrease the activity of the enzyme and/or the conversion of cyanohydrin to HCN (Bokanga, 1996). In this study, the lowest total cyanide reduction that was obtained when the tuberous roots were boiled for 20 minutes in both cultivars was higher than that of Cooke and Madagawa (1978) who reported a reduction of 55%, Aalbersberg and Limalevu (1991) who indicated about 50–60% reduction but lower than that of Gomez and Valdivieso (1985) who reported 80–98% total cyanide reduction.

Soaking the leaf prior to boiling also showed slightly higher total cyanide reduction than the unsoaked leaves in both cultivars. The high temperature used for boiling might have decreased the enzymatic activity and/or the conversion of cynohydrin to HCN. The result obtained in this study, however, was relatively lower than results reported earlier: 99.4% (Gondwe, 1974), 98% (Essers, 1989) and 95.8–99.7% (Kalenga Saka, 1993). These differences could possibly be due to the differences in the cultivars, the methods of analyses used, and the time taken for cooking. Sundrying after soaking and without soaking, however, showed little difference in total cyanide reduction, but it was greater than the result obtained by boiling either before or after soaking. The result indicated that cutting the leaves into pieces could have contributed to hydrolysis of the cyanogenic glucosides. Cutting leaves to pieces gives more access and easy contact between the cyanogenic glucosides and the enzyme as reported by Kalenga Saka (1993).

The storage and cooking experiments showed a wide range of differences in the total cyanide content on both Amarokello white and Umbure cultivars. Storing the cassava roots in the form of flour after sundrying ensures a considerable total cyanide reduction rather than storing in the ground, trench or in the refrigerator. Unlike the ground and the trench, the sundried flour can also be stored for many days without deteriorating. Moreover, soaking both the tuberous roots and the leaves prior to cooking minimizes considerably the total cyanide content. Cooking the roots and leaves after soaking and sundrying also reduces considerably the total cyanide content.

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