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Full Length Research Paper

Soaking and drying of cassava roots reduced cyanogenic potential of three cassava varieties at Jimma, Southwest Ethiopia

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Detoxification of three cassava varieties (NR-44/72, NW-45/72 and NW-44/72) by traditional methods of processing to produce cassava flour was investigated at the college of agriculture, Jimma University during February to May, 2007. The total hydrogen cyanide (HCN) quantitative determination in cassava flour was carried out using a simple enzymatic picrate paper method. Results show that varieties, soaking time and their interactions highly significantly reduced ($P<0.01$) total HCN content (ppm) in the flour. Soaking of cassava chips in water for about 24 h prior to sun drying reduced the HCN from 108.37 to 10.83 ppm (reduced by 90%), from 66.45 to 13.33 ppm (reduced by 79.94%) and from 58.63 to 15.0 (reduced by 74.42%) for varieties NW-44/72, NR-44/72 and NW-45/72, respectively. It was noted that total HCN content in cassava flour can be substantially eliminated (by more than 80%) by soaking of cassava chips in water. This study highlighted the importance of soaking of cassava chips for at least 24 h prior to sun drying for a safe level of HCN in the flour. However, it is also important to develop new and improved processing techniques to reduce HCN substantially.

Key words: Cassava flour, soaking, total hydrogen cyanide.

INTRODUCTION

Cassava (Manihot esculenta Crantz) is one of the most important food crops in Africa. It is the third most important food in the tropics after rice and maize. It derives its importance from the fact that its starchy, tuberous roots are a valuable source of cheap calories, especially in developing countries where calorie deficiency and malnutrition are widespread. Cassava alone provides the major source of dietary calories for about 500 million people; many of them in Africa (Yeoh et al., 1998). Cassava contains the potentially toxic compounds like the cyanogenic glycosides. Both the roots and leaves contain cyanogenic glycosides, primarily as linamarin which liberate hydrogen cyanide (HCN) upon hydrolysis (White et al., 1998). These compounds can cause acute cyanide poisoning and death in humans and animals when consumed in sufficient quantities. There are over 5000 known phenotypically distinct cassava cultivars which all contain varying concentrations of the cyanogenic glycosides (Haque and Bradbury, 1999). The cyanogenic potential of known cassava cultivars ranges from less than 10 to more than 500 mg kg^{-1} as HCN on fresh weight basis (O'Brien et al., 1994). Consumption of cassava and its products is thought to cause cyanide poisoning with symptoms of vomiting, nausea, dizziness, stomach pains, weakness, headaches, diarrhea and occasionally death (Akintonwa et al., 1994). Cyanide intake from cassava can worsen goiter and cretinism in iodine deficient areas and is almost certainly the cause of konzo in eastern, central and southern Africa (Delange et al., 1994; Ernesto et al., 2002). Konzo is an irreversible paralysis of the legs of sudden onset that occurs particularly in children and women of child bearing age (Cliff et al., 1997). Tropical ataxic neuropathy is a chronic condition of gradual onset that occurs in older people who consume a repetitive cassava diet. It causes loss of vision, ataxia of gait, deafness and weakness (Howlett, 1994; Cardoso et al., 2005). These medical conditions caused by cyanide overload could be prevented by a considerable reduction in the per capita cyanide intake

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(Cardoso et al., 2005). It is therefore crucial to develop better strategies to reduce the cyanide content in cassava based products.

One of the strategies to reduce cyanide content of processed cassava is to improve processing methods used for conversion of roots to storable cassava products such as flour. A number of processing methods or a combination of them (peeling, slicing, soaking, retting, fermentation, boiling, drying, roasting, pounding, milling etc) are available that attempt to remove the poisonous principle as much as possible. In Africa, the major methods of flour making from cassava roots involves sun drying of peeled roots followed by crushing in a pestle and mortar and sieving. This method was proved to retain 25 to 30% of the original linamerin present (Cardoso et al., 2005). Another method like heap fermentation is also known to remove twice as much linamarin as does sun drying, but still 12 to 16% of linamarin is retained (Bradbury, 2004). Bradbury (2004) described that, in order to produce cassava flour of the WHO safe level (10 mg HCN equivalent per kilogram flour), cassava roots containing less than 32 ppm linamerin would be needed. In view of the importance of cassava as a major source of food to the local people in Ethiopia, fear of HCN toxicity still exists by these people. Hence, searching for and application of different post harvest practices that can significantly reduce HCN will have great role in promoting the wider production and consumption of cassava in Ethiopia. Although varieties have been improved for root yield, their cyanogenic potential and the quantity of HCN retained after processing is not known. The objective of this experiment was therefore to examine the effects of soaking and drying of cassava roots on total cyanide content of cassava flour of three varieties.

MATERIALS AND METHODS

The study site

The experiment was conducted in postharvest physiology laboratory of the department of Horticulture at Jimma University College of Agriculture and Veterinary Medicine (JUCAVM), Ethiopia during February to June, 2007.

Experimental materials, treatments and procedures

Cassava tubers were harvested, 12 months after planting from three varieties (NR-44/72, NW-45/72 and NW-44/72) grown at Jimma Agricultural Research Center which are known to be high yielding but with high cyanogenic potential (CNP) (50 to 100 ppm total HCN kg^{-1} of fresh tubers) (Table 1). The tubers were peeled, immediately washed with tap water and sliced. Cassava chips of the appropriate size were made from the sliced tubers and then subjected to four different soaking periods and sun drying treatments as follows: i) sun drying without socking; ii) 12 h socking and sun drying; iii) 24 h socking and sun drying; iv) 36 h socking and sun drying.

Following each of the aforementioned treatments, cassava flour was made using a laboratory grinder/mill. 500 g of the flour was used for the experiment. The laboratory experiment was laid out in a 3 × 4 factorial arrangement (three varieties with four soaking periods as indicated earlier; i to iv) in 'completely randomized design' with three replications.

Analysis of total HCN

Total HCN (ppm) in the flour was analyzed using the enzymatic picrate paper kit developed by Bradbury et al. (2004). The absorbance of the solution produced by immersing the exposed picrate papers to the sample in 5 ml distilled water for 30 min was measured at 510 nm using a spectrophotometer against the blank solution obtained by immersing picrate paper without exposure to the sample. The total HCN content in ppm was calculated as total HCN content (ppm) = 396 × absorbance.

Statistical analysis

Total HCN was subjected to analysis of variance. The significant treatment means were compared using Duncan's multiple range test (DMRT) at $P<0.01$. MSTAT–C statistical software package was used for the analysis.

RESULTS

The different soaking periods resulted in a highly significant ($P<0.01$) differences in the total HCN content in each of the varieties tested. Total HCN ranged between 10.83 to 40 ppm (Table 2). The lowest total HCN (10.83 ppm) in the flour was obtained when cassava chips were soaked in water for about 24 h prior to drying and milling in the variety NW–44/72 followed by NR-44/72 and NW-45/72 which resulted in 13.33 and 15.00 ppm, respectively. The commonly used method of cassava chips drying in the sun without soaking resulted in 11.6 ppm total HCN in NR-44/72 followed by 16.67 and 40.00 ppm total HCN in NW-44/72 and NW-45/72, respectively. In this study, the test varieties differed significantly ($P<0.01$) in their total HCN content. NR–44/72 appeared to show the lowest total HCN mean value (14.38 ppm) over the four processing methods followed by NW-44/72 and NW-45/72 which resulted in 16.04 and 27.92 ppm, respectively (Table 3). In addition, the mean performance of the different soaking periods over the three varieties was also highly significant ($P<0.01$). Socking of cassava chips in water for about 24 h gave the lowest total HCN mean value of 13.06 ppm over the three varieties followed by soaking for 12 h which resulted in 20.83 ppm (Figure 1). Analysis of percentage total HCN reduction in this study indicated also highly significant ($P<0.01$) range of variations for each of the soaking periods. It ranged between 31.77 to 90% total HCN reduction (Figure 2). Moreover, mean total HCN reduction of the varieties was highly significant. It varied from 52.38% in NW-45/72 to 85.20% in NR-44/72 (Table 3).

DISCUSSION

The considerable reduction in total HCN content of the

Table 1. Characteristic features of the test varieties at Jimma.

Variety	Yield potential (tones ha^{-1})	CNP (ppm)	Stem color	Origin/source	Year of introduction
NR-44/72	30-45	66.45	Red	Nigeria	1972
NW-45/72	30-50	58.63	Pale	Nigeria	1972
NW-44/72	40-50	108.37	Pale	Nigeria	1972

Source: Amsalu et al. (2008).

Table 2. Effect of variety and soaking time on the total HCN (ppm) content of cassava flour of the three different varieties.

Variety	Drying without soaking	Socking for 12 h	Socking for 24 h	Socking for 36 h	Variety mean
NR-44/72	11.67^{cd*}	14.17^{bcd}	13.33^{bcd}	18.33^{bcd}	14.38^{b}
NW-45/72	40.00^{a}	33.33^{a}	15.00^{bd}	23.33^{b}	27.92^{a}
NW-44/72	16.67^{bcd}	15.00^{bcd}	10.83^{d}	21.67^{bc}	16.04^{b}
mean	22.78^{a}	20.83^{a}	13.06^{b}	21.11^{a}	19.45^{a}

CV (%) = 21.64; *Means followed by the same letter are not significantly different from each other.

Table 3. Mean percent reduction of total HCN in three cassava varieties.

Variety	CNP (ppm)	Mean HCN after processing (ppm)	Reduction of HCN (%)
NR-44/72	66.45	14.38^{b}	78.36
NW-45/72	58.63	27.92^{a}	52.38
NW-44/72	108.37	16.04^{b}	85.20
$LSD_{0.01}$		4.8	

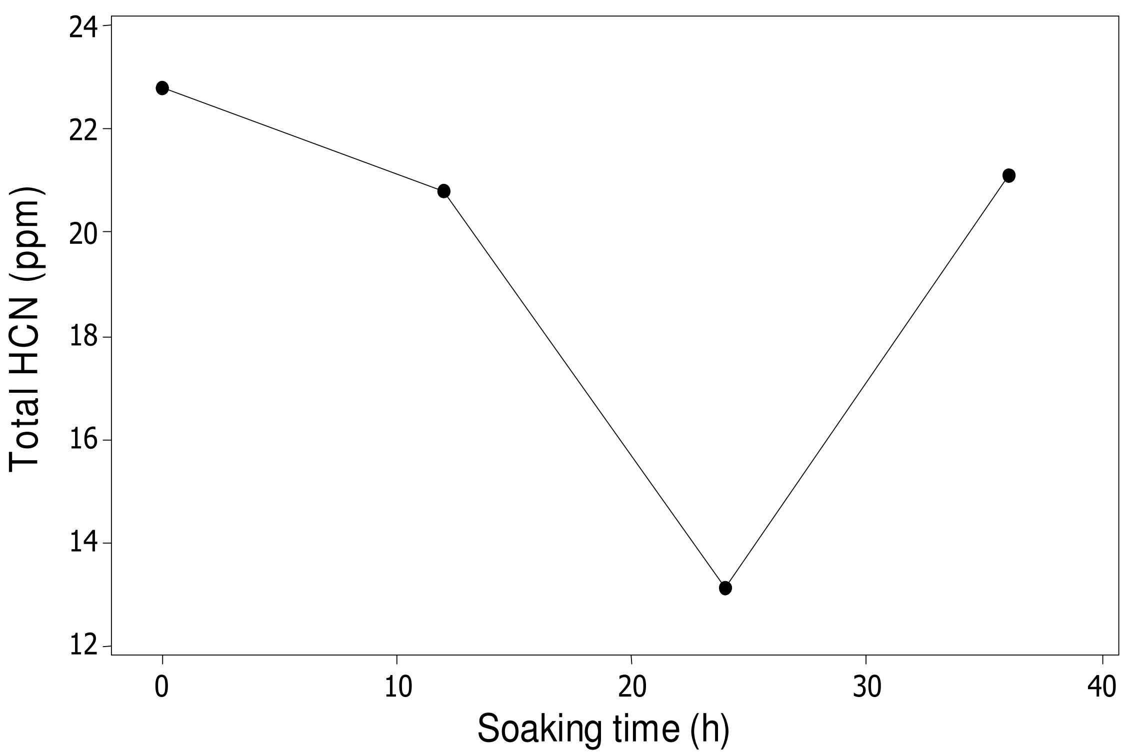

Figure 1. Effect of soaking time on mean total HCN (ppm) content of the three cassava varieties.

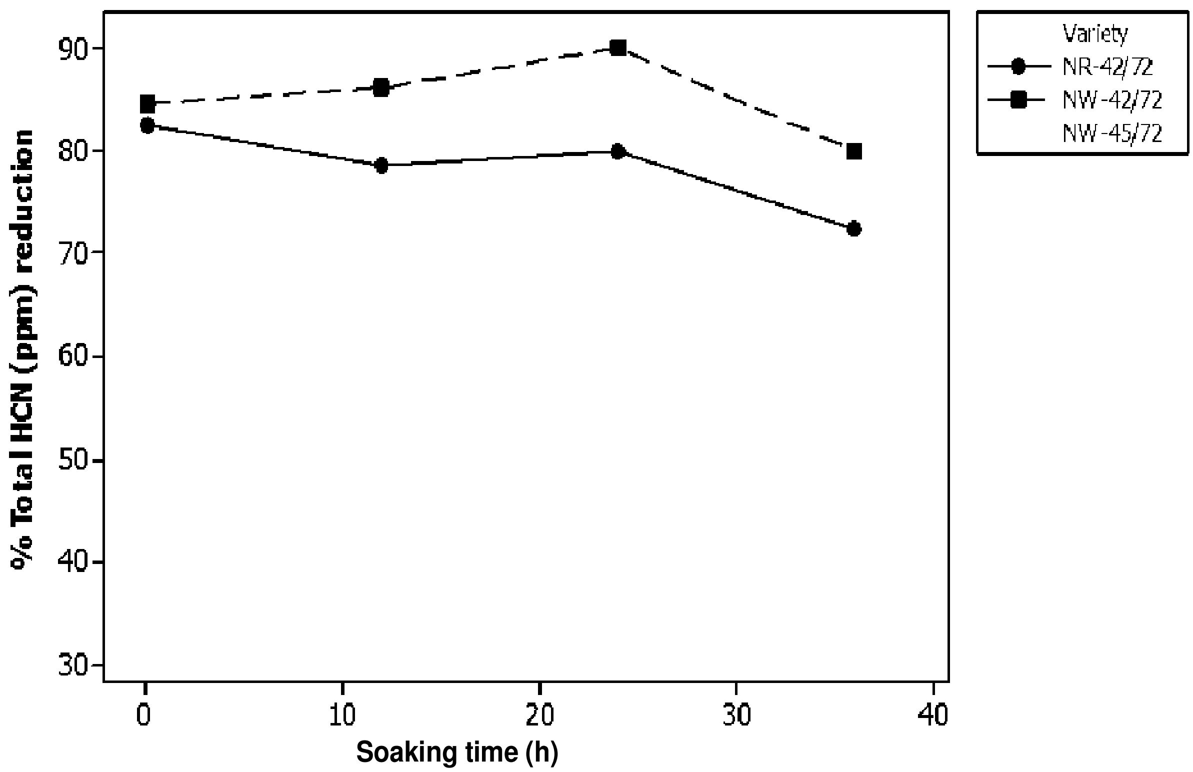

Figure 2. % Total HCN (ppm) reduction of the three cassava varieties at different soaking.

cassava flour recorded in this experiment might be explained as a result of enhanced hydrolysis process of cyanogenic glucosides by the enzyme linamarase. The significant contribution of socking of cassava chips in water for 24 h was apparent to induce hydrolysis. Similar results were reported previously by Mulugeta and Eskinder (1999), Tivana and Bvochora (2005), Kemedirim et al. (1995) and Kobawila et al. (2005). The probable justification for total cyanide reduction by hydrolysis in sliced and socked cassava chips could be due to bacteria produced linamarase (Kobawila et al., 2005). According to Kobawila et al. (2005), Lactobacillus spp. is most of the time found associated with cassava tubers and hence it might have significantly contributed to the observed total HCN reduction in this study as well. On the other hand, cutting of cassava tubers into small pieces (chips) might create easy access for contact between the enzyme and cyanogenic glycosides resulting in higher hydrolysis. Similar results were also reported by many workers including Gomez et al. (1984) who obtained a reduction of 70 to 80% after 48 h of sun drying and Tivana and Bvochora (2005) who obtained 95.41% reduction by heap fermentation followed by sun drying. Although heap fermentation is important in reducing HCN; levels were reported to be above the WHO safe level (FAO/WHO, 1991). This investigation pointed out that the retained HCN level in the flour obtained after processing is very safe for human consumption since the HCN levels are very near to the WHO safe level of 10 ppm. Tivana and Bvochora (2005) also reported that cassava flour with 25 ppm HCN may be used to prepare a cassava flour meal without disorder to human health which is in agreement to the findings. Although different countries have different safe levels of HCN; the WHO has set a safe level of cyanogens in cassava flour as 10 ppm (FAO/ WHO, 1991).

For example, the acceptable limit in Indonesia is 40 ppm (Cardoso et al., 2005). In this study, this was apparent for the variety NW-44/72 which resulted in 10.83 ppm after socking for 24 h. This investigation highlighted the importance of socking cassava chips for at least 24 h prior to sun drying during cassava flour making. However, it is quite important to develop further processing techniques to reduce total HCN in the product.

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