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CYANOGENIC GLYCOSIDE CONTENT OF FRESH AND PROCESSED PEELS OF FOUR IMPROVED GHANAIAN CASSAVA CULTIVARS

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Abstract

The cyanogenic glycoside levels of four relatively new Ghanaian cassava cultivars were determined spectrophotometrically. The mean values obtained were 393.8, 548.9, 702.1 and 424.7 p.p.m. for *Afisiafi*, *Abasafitaa*, *IITA9904* and *Tech Bankye*, respectively. The effects of sun-drying and a combination of soaking and sun-drying on the cyanogenic glycoside content were investigated. Soaking in water for 24 h followed by sun-drying for 24 h resulted in a 63 –74 per cent reduction in cyanogenic glycoside levels compared with 27 – 64 per cent reduction after sun-drying for 48 h. The results showed a significant reduction in cyanide potential of all the varieties following sun-drying and the combination of soaking and sun-drying ($P < 0.05$). The combination of soaking and sun-drying was more effective than sun-drying alone.

Introduction

Cassava peel can be utilized as supplementary feedstuff for livestock production owing to the finding that it exhibits high rumen degradability (Smith *et al.*, 1991). The periodic release of new improved and high-yielding varieties of cassava, coupled with the advent of large-scale production and processing of cassava in Ghana, has resulted in the generation of substantial quantities of cassava peel, which constitutes 8 per cent of the total dry weight of the cassava tuber (Devendra, 1977). It has long been recognized that many plants, including cassava, synthesize cyanogenic glycosides (Spencer & Seigler, 1983; McMahon *et al*., 1995; Cereda & Mattos, 1996; Thomson & Brimer, 1997; Jones *et al*., 2000; Wickham, 2001; Adindu *et al.*, 2003; Miller *et al.*, 2006). Tissue disruption brings cyanogenic glycosides into contact with hydrolytic enzymes resulting in the release of toxic hydrogen cyanide (Hruska, 1988; Vetter, 2000). Unfortunately, the presence of these cyanogenic glycosides, mainly linamarin and lotaustralin, makes cassava products potentially deleterious to animal health.

By inhibiting cytochrome oxidase in the mitochondria of cells, hydrogen cyanide causes a reduction in the utilization of oxygen by tissues. In animals, doses of HCN between 0.66 and 15 mg/kg body weight are reported to be lethal. Chronic sub-lethal dietary cyanide has reportedly caused impaired thyroid function and growth, neonatal deaths and lower birth rates (Obioha, 1972; Bokanga, 1994). For instance, the ingestion of fresh or processed cassava peel-based diets resulted in reduced growth rates in pigs, sheep, goats and African giant rats (Tewe *et al*., 1977; Tewe & Maner, 1981). Ingestion of cassava peel triggers detoxification mechanisms leading to an increase in serum and urinary levels of thiocyanate, a known inhibitor of the thyroidal uptake of iodine. Consequently, there is a significant reduction in the level of thyroxine, which is essential for normal growth and development of animals (Tewe *et al*., 1984). Cyanide levels above 30 p.p.m. are considered deleterious to animals (Tweyongyere & Katongole, 2002).

Different methods of processing, some more effective than others, have been found to reduce the cyanogenic glycoside content of plant parts. These include soaking (Cooke & Maduagwu, 1978), retting (Ayenor, 1985), freezing (Kuti & Konoru, 2006), ensiling (Obioha & Anikwe, 1982), fermentation (Tewe & Kasali, 1986), boiling (Longe, 1980), oven-drying (Tewe & Kasali, 1986), and parboiling and sun-drying (Salami, 2000). Little is known about the cyanide potential of the relatively new varieties of cassava which are currently cultivated and processed in Ghana. In order to assess the suitability of cassava peels from these cultivars as feed ingredients, their cyanogen concentrations must be determined. The present study was, therefore, undertaken to determine: 1) the cyanogenic glycoside content of four improved varieties of cassava, and 2) the extent to which sun-drying and a combination of soaking and sun-drying would reduce the cyanide potential of the peels.

Experimental

Four improved varieties of fresh cassava, namely *Tech bankye, Abasafitaa*, *Afisiafi*, and *IITA9904* were obtained from the Plant Genetic Resource Institute (Bonsu, Ghana). The cassava peels and pulp were stored at 4 ^{0}C.

Treatment of peels

Samples of the cassava peels were sun-dried for 48, 96 and 144 h, or soaked in water for 24 h and sun-dried for 24 h.

Extraction of cyanide from cassava pulp and peels

Samples of the different cassava peels or pulp were grated. Cyanide extraction was carried out using a modified method of Chew (1972). Briefly, about 2 g of the grated tissue were placed in 100-ml Kjedahl flask and treated with 10 ml portions of 0.05 ml phosphate buffer (*p*H 6.0). After the addition of 1 ml of 2 per cent mercuric chloride, the flask was sealed and incubated over night (17 h) at room temperature. Hydrated stannous chloride (0.5 g) was then added.

Cyanide analysis

Cyanide was measured as described by Freidstein & Klendosshoj (1957). Briefly, 0.1 ml of the cyanide extract was added to the outer compartment of the Conway diffusion dish and 1.0 ml of 01 *N* NaOH was placed in the inner compartment. About three drops of 10 per cent H_2SO_4 were added to the outer compartment. The top was tightly sealed and the dish swirled gently to mix the solution in the outer compartment. The dish was incubated at room temperature for 4 h. After the incubation period, 0.1 - 0.5 ml of the solution in the centre well was transferred into a test tube. After the addition of 1 ml of phosphate buffer, *p*H 9.9, and 0.5 ml of 0.25 per cent chloramine-T, the mixture was allowed to stand for 3 min. An aliquot of pyridine-barbituric acid solution was then added and the mixture incubated at room temperature for 10 min. Cyanide was then measured spectrophotometrically.

Statistical analysis

Statistical analysis was performed using the analysis of variance test of the SPSS software. Differences of $P < 0.05$ were considered significant.

Results and discussion

The cultivars used for the study were selected on the basis of their approval for use by farmers, and their current use in cassava processing industries in Ghana. Since nitrogen fertilizer, soil type, moisture, and temperature affect the cyanogenic glycoside content of plant parts (Wheeler *et al.*, 1990), care was taken to ensure that the cassava varieties used in the study were grown in the same location under the same environmental conditions, and harvested at the same time.

The values obtained for the cyanogenic glycoside content of the fresh pulp and peels of

all the four varieties are shown in Fig.1. Although cassava peel was the primary focus of the study, it was also of interest to investigate the cyanide potential of the fresh pulp since literature values for these cultivars are not readily available. The results of the study show that variation in cyanogenic glycoside content exists among the cassava cultivars examined. This is consistent

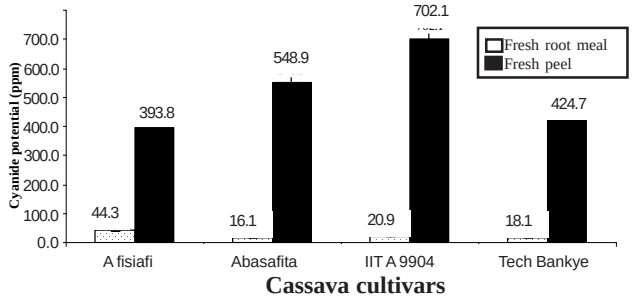


Fig. 1. Cyanide levels of the pulp and fresh peels of four cassava cultivars

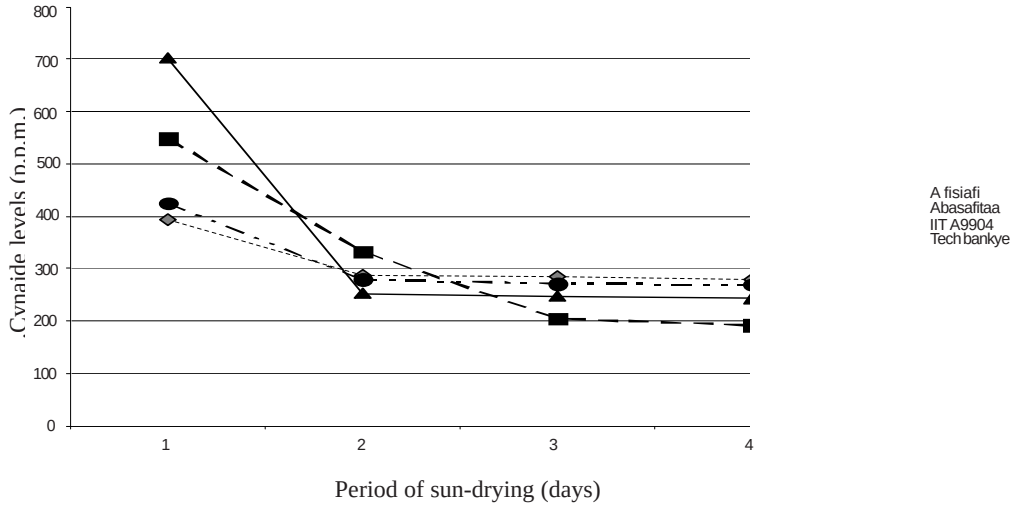
with the finding that polymorphism in cyanogenic glycoside content exists in certain plants (Gleadow & Woodrow, 2000). The reasons for the observed differences in cyanogenic glycoside content may include differences in the expression of biosynthetic enzymes, such as the UDP-glucose-ketone cyanohydrin â-glucosyltransferase, as well as the availability of valine and leucine, precursors of the aglycones for linamarin and lotaustralin (Hahlbrock & Conn, 1970; Zilg & Conn, 1974).

Determination of the cyanide levels for the peels of the four varieties showed that *IITA9904* had the highest cyanide potential of 702.1 p.p.m. while *Afisiafi* had the lowest mean cyanide potential of 393.8 p.p.m. The values obtained for *Afisiafi* and *Tech bankye* were not significantly different from each other. These findings are comparable to those reported for fresh peels of Nigerian cassava varieties by Tewe and Lyayi (1989). The values obtained for the fresh pulp were much lower than those of the peels, ranging from 16.2 to 44.3 p.p.m. for *Abasafitaa* and *Afisiafi* respectively. Since the values for all four cultivars fall within the range for sweet varieties (15-50 p.p.m.), the pulp can be processed adequately by cooking and should be safe for human consumption. The observation that cyanide potential of the peels far exceeded those of the pulp was consistent with the findings of Adegbola & Asaolu (1986). There was no correlation between the cyanide potentials of the peels and the pulp.

As shown in Fig. 2, sun-drying resulted in a substantial decrease in the cyanide potential of the peels of all four cultivars. The *IITA9904* variety showed the highest reduction in its cyanide potential after 2 days of sun-drying. There was a sharp decline in the cyanide levels of *Afisiafi, Tech bankye* and *IITA9904* within the first 2 days of sun-drying. This was probably due to a temperature-induced activation of linamarase, which, subsequently, hydrolyzed the cyanogenic glycosides. The hydrogen cyanide produced is extremely volatile, vaporizing at temperatures above 28 ºC (Wickham, 2001). After 2 days, there was no further reduction in their cyanogenic glycoside levels.

In contrast, the cyanogenic glycoside level of the *Abasafitaa* continued to decline until the fourth day. There was no correlation between the initial and final cyanogenic glycoside levels of the peels of the four varieties subjected to sun-drying. These findings are consistent with those of Tweyongyere & Katongole (2002) who studied other cassava varieties. The effectiveness of sun-drying appeared to be cultivar-dependent. Thus, the cyanide potential of *Afisiafi* decreased by 29.2 per cent while that of *IITA9904* decreased by 65.2 per cent. These differences may be due to genetic variations in the intracellular concentration or distribution of linamarase.

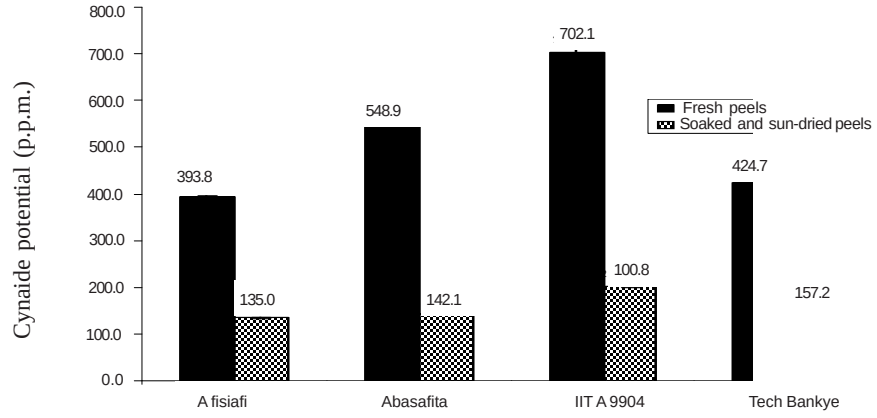
The effects of the combined treatment of soaking and sun-drying on the peels of all four cassava varieties are illustrated in Fig. 3. The



Period of sun-drying (days)

Fig. 2. A time-course of the effect of sun-drying on cyanide levels in cassava peels.

greatest magnitude of cyanogenic glycoside level reduction occurred in the *IITA9904* cultivar (from 702.1 to 200.8 p.p.m.). However, the *Abasafitaa* variety had the lowest cyanide level in its peels after the combined treatment of soaking and sun-drying (135.0 p.p.m.). There was a significant difference in the cyanogenic glycoside level among the four varieties after the combined treatment ($P < 0.05$). It is evident that the combination of soaking and sun-drying was more effective in reducing the cyanogenic glycoside levels of all the peels than the sun-drying alone (Fig. 4).



Cassava cultivars

Fig. 3. The effects of a combination of soaking and sun-drying on the cyanide levels of cassava peels

The combined treatment caused a reduction of 63.0-74.1 per cent in cyanide levels of the cassava peels. Soluble free cyanide is extracted into the water during soaking but bound cyanide is only negligibly reduced (Cooke & Maduagwu, 1978). Greater cyanide detoxification might have been achieved if soaking had been prolonged.

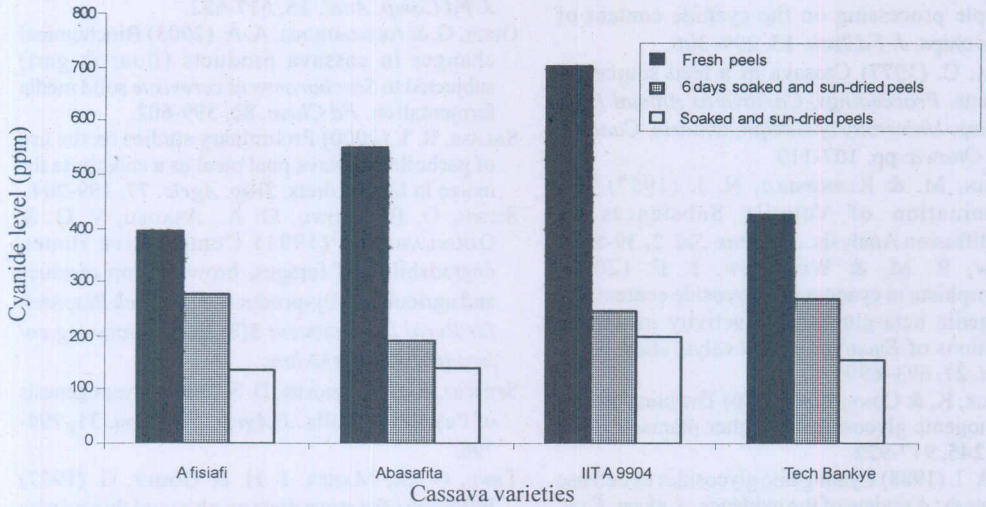


Fig. 4. Comparison of the effectiveness of sun-drying and a combination of soaking and sun-drying on the cyanide level of the cassava peels

However, soaking was only carried out for 24 h to prevent the growth of pathogenic microorganisms. When compared to sun-drying, the combined treatment appears to be a better option for processing of the cassava peels for use as animal feed. However, the lowest value obtained, 135.0 p.p.m. for *Afisiafi,* was three-fold higher than the non-deleterious level of 30 p.p.m. (Tweyongyere & Katongole, 2002). It must be noted that Tewe *et al.* (1984) reported a significant reduction in serum thyroxine levels and stunted growth in growing pigs fed cassava peel diets containing 96 p.p.m. total cyanide.

Conclusion

The study provides useful information on the potential toxicity of four relatively new Ghanaian cassava cultivars. The cyanogenic glycoside levels in the fresh peels of all four varieties were found to be extremely high. Processing by a combination of soaking and sun-drying greatly reduced the cyanide potential of the peels, and was more effective than sun-drying alone. Peels (especially those of *Afisiafi* and *Abasafitaa*) processed in this manner should be less toxic to animals when used as feed ingredients, but may not be sufficiently detoxified.

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