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Potential of Soaking and Sun-Drying in Detoxifying Toxic Cassava Root Tubers

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Abstract: Root tubers of cassava (*Manihot esculenta* Crantz) have cyanogenic glucosides which liberate hydrogen cyanide (HCN) on hydrolysis in quantities that can be toxic to humans. As a result, several techniques have been used to detoxify the tubers including among others, soaking, sun-drying and fermentation which has been found to be the most effective. However, fermentation is associated with the growth of potentially mycotoxigenic moulds (fungi) which compromise the quality of the processed product hence suggesting the use of alternative mould free processing techniques like soaking and sun-drying. Therefore, this study investigated the potential of soaking and sun-drying in detoxifying root tubers of a toxic cassava variety, "Rutuga", (interpreted as "strangler") of cyanogens (total HCN, free HCN and bound HCN) in South Western Uganda. The cyanogens were determined by a standard titration method. The results indicated that soaking peeled cassava root tubers in cold distilled water for 4 days removed about 78% of bound HCN while sun-drying of peeled cassava chips for 5 days removed about 74% of free HCN. However, both methods are less effective in removing total HCN (soaking, 47%; sun-drying, 43%) due to the ineffectiveness of soaking and sun-drying in removing free HCN (21%) and bound HCN (3%) respectively. Hence a mixed approach employing both methods would be more appropriate in detoxifying cassava of total HCN.

Keywords: Cassava Root Tubers, Cyanogens, Soaking, Sun-Drying

1. Introduction

Cassava belongs to the genus *Manihot*, and family Euphorbiaceae. *Manihot* comprises 98 tropical species with *M. esculenta* Crantz being the only commercially cultivated species [1]. Cassava is the main source of dietary energy for low income consumers in several parts of tropical Africa as well as the major urban areas [2-5]. It was established in Uganda during the 19th century and became a valuable crop for food security [6]. However, cassava is a cyanophoric plant producing toxic cyanogenic glucosides, linamarin (93%) and lotaustralin (7%) present in the leaves and roots of the plant [7-9]. These two cyanogenic glucosides (CGs) liberate hydrogen cyanide (HCN) and acetone cyanohydrin on hydrolysis (cyanogenesis) especially when linamarin in the vacuole gets into contact with linamarase enzyme in the cell walls during damage of cassava plant tissue [8]. The compounds, acetone cyanohydrin, CGs (bound HCN) and HCN (free HCN), are referred to as cyanogens. The cassava plant can release hydrogen cyanide (free HCN) in quantities that are toxic to humans thus causing death with lethal dose ranging between 0.5 and 3.5 mg/kg body weight when taken by mouth [8]. As a result some farmers in Africa have abandoned the cultivation of toxic cassava varieties [4]. However, fatalities from cassava poisoning are rare due to the low levels of HCN in cassava food products processed by the traditional methods [10].

Cassava roots are processed into various food products by a range of traditional methods such as fermentation, soaking or sun-drying which reduce the levels of cyanogens in the cassava products with less than 2% of cassava processed through factories [8, 6]. For example, sun-drying is one of the most common methods for processing products in Africa and sun drying of peeled cassava roots precedes the making of cassava flour in Africa [11]. Studies in Uganda have also found fermentation to be very effective in reducing cyanide levels in cassava root tubers [12, 13]. According to Bradbury [14], heap fermentation is known to remove twice as much linamarinin cassava as sun drying does. However, studies have indicated that different moulds that grow on cassava during fermentation may negatively impact on the value of the product. For instance, the growth of potentially mycotoxigenic fungi, Aspergillus, Cladosporium, Fusarium and Penicellium species on the fermented cassava can lead to mycotoxin formation [11] which compromises the safety of the processed cassava. As a result, safe processing techniques such as sun drying and soaking would be better processing alternatives as they are free from growth of moulds. Unfortunately, there is little information on the extent to which sun-drying and soaking can detoxify root tubers of toxic cassava varieties in Uganda. Accordingly, this study investigated the potential of soaking and sun-drying in detoxifying root tubers of a toxic cassava variety, "Rutuga", interpreted as "strangler", of total HCN, free HCN and bound HCN (cyanoglycosides).

2. Materials and Methods

2.1. Sampling, Processing and Analysis of Cyanide in Cassava

The study area and the sampling of the root tubers of the toxic cassava variety "Rutuga" are fully described in Andama and Lejju [13]. The study employed traditional processing techniques for making of dried cassava chips for production of cassava flour [13]. These include sun drying peeled root tubers cut into small slices at temperature range of 28 to 40°C for 5 days. Soaking peeled root tubers in cold distilled water for 4 days followed by sun drying at temperature range of 28 to 40°C for 5 days. The root tubers were purposively soaked in distilled water to eliminate aquatic fermentation [13]. Hence the root tubers were detoxified by soaking alone. The processed cassava samples as well as fresh tubers were analysed for HCN in the Government Analytical Laboratory (GE058/07), Kampala by the standard titration method [15] fully described in Andama and Lejju [13]. The contribution of soaking in detoxifying the cassava root tubers was obtained by getting the difference in the amount of HCN removed by sun-drying from that removed by soaking and sun-drying.

2.2. Data Analysis

The proportions of cyanogens removed by soaking and sun-drying were summarized in multiple bar graphs drawn using Microsoft Excel 2007 computer package.

3. Results and Discussion

The initial concentrations of HCN in the processed and fresh root tubers are presented in Andama and Lejju [13]. Percentage of HCN removed by soaking and sun-drying are presented in Figure 1.

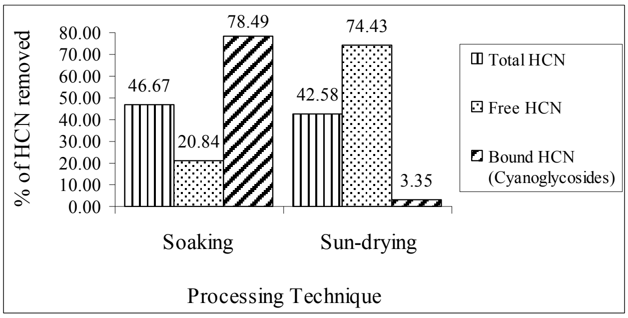

Figure 1. *Percentage of HCN removed by the processing techniques.*

Soaking peeled root tubers in distilled water removed more total HCN (46.67%) than sun-drying (42.58%). However, the amounts of the total HCN removed by the two methods were below average (50%). Nevertheless, sun-drying removed significantly high free HCN (74.43%) than soaking which removed only 20.84% of free HCN. On the other hand, soaking removed significantly greater percentage of bound HCN (cyanoglycosides) (78.49%) than sun-drying (3.35%). Gas bubbles were observed on the second and third days of soaking of the root tubers in distilled water. The gas bubbles reduced on the fourth day of soaking. The gas bubbles are due to liberation of free HCN from cyanoglycosides (bound HCN) on hydrolysis in water. Soaking is very effective in removing bound HCN (cyanoglycosides) by dissolution in water. Linamarin and acetone cyanohydrin (cyanoglycosides) are soluble in water and water sets free all the bound hydrocyanic acid [11, 15]. Hence there is leaching of the cyanogens when roots are soaked in water [16].

In addition, sun-drying was very efficient in removing free HCN mainly by volatization since HCN is highly volatile. Westby [11] reported that free HCN is volatile at 25.7°C and so is rapidly volatilized at tropical ambient temperatures. According to Dufour [10], the efficiency of the final sun-drying is important in removing residual volatile cyanogens. The efficiency may be improved through having different sizes and shapes of cassava pieces [8], especially crushing the cassava into smaller sizes and pieces. Sun drying peeled root tubers cut into small slices at temperature range of 28 to 40°C for 5 days was poor at removing bound HCN (cyanoglycosides) as the cyanoglycosides have relatively higher boiling than free HCN. The results of a study by Westby [11] showed that linamarin is stable and resists boiling in acid while acetone cyanohydrin has a boiling point of the order of 82°C. The sun-drying of the tubers in this study only removed 3.35% of bound HCN leaving 96.65% of bound HCN much higher than the 25-33% of linamarin retained in cassava flours processed by sun drying of peeled roots followed by crushing in a pestle and mortar and sieving [17].

Therefore, cyanogenesis was very low (3.35%) under sun-drying of cassava tubers while it was very high (78.49%) when tubers were soaked. The high level of retained bound HCN in the sun-dried tubers may lead to toxicity especially when food prepared out of such cassava product is consumed by people as the bound HCN will be hydrolyzed into free HCN. Also, consumption of the soaked cassava tubers without reducing the toxic free HCN further could cause toxicity problems to people.

4. Conclusions

Soaking root tubers in cold distilled water for 4 days removed about 78% of bound HCN while Sun-drying of chips for 5 days removed about 74% of free HCN. However, both methods are less effective in removing total HCN (soaking, 47%; sun-drying, 43%) due to the ineffectiveness of soaking and sun-drying in removing free HCN (21%) and bound HCN (3%) respectively. Hence a mixed approach of both methods would be appropriate to detoxify cassava of total HCN.

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