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REVIEW ARTICLE

Effects of processing methods of cassava (*Manihot esculanta*) leaves on detoxification of cyanogenic compounds: A short review

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ABSTRACT

Leaves of Manihot esculanta are rich in proteins as well as consist with carbohydrate, beta carotene, vitamin C, B1, B2, and other micro and macro nutrient elements which could be used to fulfill the nutrient requirement of humans to a certain extent. Nutrient profile of cassava leaf is determined by the cultivar, part of the plant, maturity period and harvesting period of leaves, soil fertility level, and the drying temperature. The nutrient availability is limited by the presence of high amount of anti-nutrients; fiber, cyanide, tannin and phytin. Moreover, presence of cyanogenic compounds results cynogenic toxicity which leads to chronic and acute health disorders. As reported, the cyanogenic toxicity of cassava leaves can be reduced by using several processing methods. This paper reviews the current literature evidences on the use of cassava leaves as a nutrient source of the human being and the efficient detoxification methods among the traditional processing methods.

Keywords*: Cassava, cyanogenic toxicity, cassava leaves*

INTRODUCTION

Cassava *(Manihot esculanta)* is *a* perennial shrub with bulky storage roots and belongs to family Euphorbiaceae. It is used as a starchy food among the population mainly in subtropical and tropical areas. This crop was introduced to Sri Lanka in 1786. As cassava has an ability to grow in different stressful environmental conditions, it has become the major staple food crop in many regions. Due to the higher availability and lower production cost, cassava is grown in Sri Lanka basically for the consumption purpose. However, after harvesting cassava roots, the leaves can be considered as a byproduct that does not make a commercial competition in the food market (Oresegun *et al.,* 2016; Piero *et al.,* 2016; Dissanayake *et al.,* 2018). One of the objectives of this review is to emphasize the nutritional values and negative health effects of the cassava leaves given by the cyanogenic toxicity. Furthermore, it is noteworthy to review the effect of processing methods of cassava leaves on detoxification.

Nutritional composition of cassava leaves

The cassava leaf meal is a good source of nutrients because cassava leaf contains high amount of protein, carbohydrate, beta carotene, vitamin C, B1, B2 and other micro and macro nutrients (Eggum, 1970; Fasuyi *et al.,* 2005; Bayata, 2016). The mineral content of the cassava leaves act as a potential source for human and animal feed (Wobeto *et al.,* 2006; Morgan, 2016).

30 - 40% of protein is recorded in the lush crop of dried cassava leaves (Ravindran and Ravindran, 1988). Essential amino acids, except Methionine and Lysine, are present in adequate quantities in cassava leaf and the amino acid content is comparable with the animal protein and leguminous plant proteins (Eggum, 1970; Fasuyi *et al.,* 2005; Ojimbo *et al.*, 2017). The recorded amount of protein in cassava leaves is higher than that of the non-legume plants. The amino acid profile can full fill the nutrient requirement of human. According to the literature, use of cassava leaves with different food pattern has been suggested as a solution to malnutrition among the population (Zekarias *et al.,* 2019).

The levels of protein, beta carotene and vitamin C, and other nutrients available in cassava leaves depend on the cultivar, part of the plant, harvesting period, soil fertility, age and the drying temperature (Wobeto *et al.,* 2006). According to the study of Wobeto *et al.* (2006), twelve months matured leaves have reported the highest amount of crude protein levels (35.90 g 100 g^{-1} of dry weight) with compared to the leaf maturity of 15 and 17 months. Moreover, 12 months matured cassava leaves reported the highest amount (137.38 g 100 g^{-1}) of beta carotene. Furthermore, availability of vitamin C was the highest amount (181.90 g 100 g^{-1} of dry weight) in the sample of leaves at the age of 17 months. The analysis revealed that the protein amount in cassava leaves changed at three different stages of their maturity. Crude protein and carbohydrate composition also changed from higher to lower value, from the youngest to mature leaves (Wobeto *et al.,* 2006).

The nutrient availability of cassava is limited by the presence of high amount of anti-nutrients, fiber, cyanide, tannin and phytin in the leaves (Fasuyi *et al.*, 2005; Oresegun *et al.,* 2016). The chemical composition of the cassava leaves also varies from variety to variety (Ravindran and Ravindran, 1988).

Toxicity of cassava leaves

Cassava has cyanogenic potential due to the presence of three types of cyanogens: linamarin, aceytohydrine and free cyanauric acid (HCN). Linamarin is the main cyanogenic compound present in cassava (Jansz and Uluwaduge, 1997; Fukushima *et al.,* 2016). The enzyme linamarase, which degrades cyanide into HCN, is present in cassava roots and leaves. When the cells are damaged the linamerin and other cyanogenic compounds are exposed and the enzyme linamarase releases the cyanuric acid by degrading the cyanogenic glycosides (Shama and Wasma, 2011; Tivana *et al.,* 2014).

Cyanuric acid is very toxic to human and the toxicity can be exposed either by ingestion or inhalation during the processing. According to the cyanuric acid content of the cassava, three types of toxicity levels can be identified: very toxic variety with more than 100 mg HCN kg^{-1} of pulp, moderately toxic variety with

50-100 mg HCN kg^{-1} of pulp and non- toxic variety with less than 50 mg HCN kg^{-1} of pulp. As per the World Health Organization (WHO), the maximum permissible level of hydrogen cyanide intake is 10 mg HCN kg^{-1} body weight. Intake of hydrogen cyanide, exceeding the maximum permissible level, may cause the death (Moriasi *et al.,* 2013; Ojimbo *et al.,* 2017).

Though the consumption of lower cyanide amount is not lethal long term intake of cyanide could cause severe health effects on human (Bayata, 2019). Hence, the consumption of non-detoxified cassava leaves and roots cause acute intoxication and chronic health disorders such as goiter, dwarfism and the tropical ataxic nephropathy (Bayata, 2019). Some other studies reveal that the lethal consumption dose of cyanuric acid is 0.5 to 3.5 mg kg^{-1} body weight. Several studies reveal that intaking of cassava with cyanide concentration leads to iodine deficiency disorders as thiyocyanate inhibits iodine uptake by the thyroid gland (Moriasi *et al.,* 2017; Muleta and Mohammad, 2017). Therefore, it is noteworthy that many countries have developed fermented cassava food products as a solution to cyanide toxicity of cassava (Fasuyi *et al.*, 2005; Kobawila *et al.,* 2005).

According the investigation conducted by Fasuyi *et al.* (2005), the average amount of HCN was reported to be 52.9 mg 100 g^{-1} in different varieties of cassava leaves. Moreover, the average tannin composition of cassava leaf was reported as 9.7 mg 100 g^{-1} whereas its average phenol content is reported as 192.0 mg 100 g^{-1}. Studies have also shown that cassava contains higher amount of tannin and phytin than the other legumes and cereals (Fasuyi *et al.,* 2005).

Cyanide concentration present in the plants is associated with the age of the plant and with some genes those are involved in the cyanogenesis pathway (Moriasi *et al.,* 2017). Hence, these genetic differences affect the different cyanide concentrations in different varieties (Moriasi *et al.,* 2017). According to the literature, traditional cooking methods of cassava leaves can be used for detoxification of cyanogenic toxicity. Moreover, due to the fear of losing vitamins and other nutrients in cassava leaves, people are used to prepare the cassava leaves under mild heat treatments. This may cause severe health problems due to the ingestion of cyanide.

Effects of processing methods on detoxification of cassava

In Sri Lanka, people in rural areas mostly consume cassava leaves in their meals. They generally cook sliced leaves by tempering for 5 to 6 min. This processing method can decrease bound cyanide level to 540 mg kg^{-1} and free cyanide level to 119 mg kg^{-1}. However, the free and bound cyanide levels may not be in the safe limit (Priyadarshani *et al.,* 2004). Another method of processing of cassava leaves is slicing, pounding leaves and cooking for 2 h. This method of cooking can lead to reduce the bound cyanide level to 5.9 mg kg^{-1}. Also, the cyanide level reported with the leaves treated with boiling water is also 5.9 mg kg^{-1} (Priyadarshani *et al.,* 2004). The same amount of protein is present in the samples of fresh cassava and boiled cassava leaves. It is worthy to mention that the protein content of the cassava leaves is not affected by the boiling process (Priyadarshani *et al.,* 2004).

According to Fasuyi *et al.* (2005), cassava leaves are subjected to different traditional processing methods such as sun drying, oven drying, steaming and shredding. Sun drying after shredding of cassava leaves has showed the effective way of processing of cassava leaves and cyanogenic potential has been decreased from 56.5 to 1.6-1.8 mg 100 g^{-1}. Further, oven drying of cassava leaves is reported as the least effective method for the cyanogenic detoxification. However, the above reported processing methods are not efficient for reduction of tannin and phytin levels in cassava leaves. Further to this, shredding with sun-drying of the cassava leaves can rupture the cassava leaf cells and bring out the linamerase enzyme. Linamerase hydrolyses the cyanogenic compounds and leaves volatile HCN. In the case of oven drying of the cassava leaves, the enzymes get denatured with the effect of higher temperature and thus, oven-drying processing method is inefficient in detoxification (Fasuyi *et al.,* 2005).

Boiling effect on the cyanogenic content of the cassava leaves has been investigated (Ojimbo *et al.,* 2017) and it is based on altering the surface area of the leaves and pounding and soaking the leaves or combination of those two practices prior to cooking. Hence, boiling and pounding the leaves can reduce the cyanogenic compounds. Area/volume ratio of the unpounded leaves may inhibit the enzymatic reaction in contrast to the pounded leaves. Pounding of leaves leads to rupturing the cells stimulating the enzymatic reaction by direct contact with the substrate and the enzyme (Ojimbo *et al.,* 2017).

The use of traditional methods such as soaking, boiling, chipping, fermentation, cooking, steaming, drying and roasting lead the enzyme linamerase to expose to the cyanogenic compounds in cassava leaves. This enzymes can release free cyanide (HCN and cyanouric acid) and detoxify by dissolving HCN and escaping into air (Piero *et al.,* 2016). Though the traditional processing methods can reduce the cyanide content to a certain level it may not remove the all toxicity. Genetic engineering has proven to remove the cyanogenic toxicity to a greater extent (Salvador *et al.,* 1988; Piero *et al.,* 2016); however, this needs further studies

CONCLUSIONS

Majority of the population in rural areas are adding cassava leaves for their main meals daily. Cyanogenic toxicity of cassava leaves and the excessive ingestion of cyanogenic compounds cause severe health effects. However, traditional processing methods of cassava leaves can detoxify the cyanogenic compounds. Those methods can rupture the cells and make the enzymes activate to breakdown the cyanogenic compounds. Among the processing methods, sun-drying, pounding and boiling of cassava leaves are the most effective methods for detoxification.

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