Effect of Different Processing Methods on Cyanogenic Glycoside from Harvested Bamboo Shoot (Wa-bo)

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Abstract

Bamboo shoots have a long history of its utilization as food and medicine and rich in nutrient components such as proteins, carbohydrates, minerals, vitamins and bioactive compounds. Due to the presence of bioactive compounds phenols, phytosterols and dietary fibers, they play a vital role in health promotion as well as prevention of cardiovascular, cancer and chronic diseases. However, due to the presence of cyanogenic glycoside i.e. taxiphyllin, the shoots need to be eaten with caution. Cyanogenic glycosides are the bioactive plant products present in many food crops, derived from amino acids. Bamboo shoot contains cyanogenic glycosides compound, which can be broken down to hydrogen cyanide. Toxic levels of cyanogenic glycoside are estimated in terms of the quantity of free cyanide generated. Food processing procedures such as boiling, soaking, fermentation and drying reduce the levels of hydrogen cyanide. The main objective is to reduce the natural toxic compound (cyanogenic glycoside) from harvested bamboo shoot (Wa-bo) for food consumptions. In the present research work, harvested bamboo shoot *(Phyllostachys sp)* was boiled, soaked with water and dried to reduce hydrogen cyanide content by using hot air oven (20-240°C, GP 100). And the harvested bamboo shoot was also fermented with salt and water to reduce HCN content. The hydrogen cyanide (HCN) content was determined by Association of Analytical Chemists (AOAC) method for quantitative test (Alkaline Titration Method). The phytochemical examination and moisture content of harvested bamboo shoot was also determined. The factors affecting the reduction of HCN content of harvested bamboo shoot from Kamayut Township such as volume of water, boiling time, soaking time, fermentation time, drying time, and drying temperature were studied.

Keyword: Bamboo shoot, Cyanogenic glycosides, Processing Methods

Introduction

Cyanogenic glycoside is chemical compounds contained in foods that release hydrogen cyanide when chewed or digested. The act of chewing or digestion leads to the hydrolysis of the substances, causing cyanide to be released (http://www.intechopen.com/books/toxicology-new-aspects-tothis-scientific conundrum). Then toxicity of cyanogenic glycoside and their derivatives is dependent on the release of hydrogen cyanide. The toxicity of cyanogenic glycoside is associated with their ability to be hydrolyzed either spontaneously or in the presence of enzymes to produce cyanide as end products of their hydrolysis. Cyanogenic

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glycoside is a group of nitrile-containing plant secondary compounds that yields cyanide (cyanogenesis) following their enzymatic breakdown. Cyanogenic glycoside occurs in at least 2000 plant species, of which a number of species are used as food. They are amino-acid-derived constituents of plants produced as secondary metabolites. Cyanogenic glycoside is not toxic on its own (http://www.intechopen.corp/books/ toxicology-new-aspects-to this-scientific-conundrum). Hydrolysis of cyanogenic glycoside usually occurs when cyanogenic plants are chewed by herbivores or when the plants are disintegrated during processes, such as grinding, pounding or in the presence of water for example during soaking or fermentation. Symptoms of cyanide toxicity in humans have been reported to include vomiting, stomach ache, diarrhoea, convulsion, and in severe cases death. Fresh fruit and vegetables are an important part of a healthy diet, several fruits and vegetables consumed contain small amounts of natural toxins (http://www.intechopen.com/books/ toxicology-new-aspects-to this-scientific-conundrum).

Literature Review

Cyanogenic Glycoside

Cyanogenic glycoside is phytotoxins which occur as secondary plant metabolites in many plant species, of which a number of species are used as food in some areas of the world. Many plants are potentially toxic because they contain glycosides, principally linamarin. Among the cyanogenic plants most likely to be consumed by humans are the lima bean and cassava. Cyanogenic glycoside is planted secondary metabolites that release HCN gas when exposed to the hydrolyzing enzymes glycosidases. The glycosides degrade into cyanohydrin aglycone plus a sugar part (D-glucose). The aglycone may decompose and release hydrogen cyanide gas (www.foodsafety.govt.nz >industry>cyanide.htm).

Hydrogen Cyanide

The hydrogen cyanide is the major toxic compound causing the toxic effects. When edible parts of the plants are macerated, the catabolic intracellular enzyme B-glycosidase can be released, coming into contact with the glycosides. This enzyme hydrolyzes the cyanogenic glycosides to produce hydrogen cyanide, glucose and ketones or benzaldehyde. Hydrogen cyanide is a volatile compound which evaporates rapidly in the air at temperatures over 28°C and dissolves rapidly in water (http://en.m.wikipedia.org> wiki>hydrogen cyanide).

Bamboo shoot *(Taxiphyllin)*

The cyanogenic character of bamboo among cyanogenic plants is due to the presence of taxiphyllin, which is decomposed quickly by the action of heat. Taxiphyllin is structurally p-hydroxylated mandelonitrile tiglochinin (www.researchjournal. co.in>assignments). On hydrolysis, taxiphyllin yields glucose and hydroxybenzaldehyde cyanohydrins which further decompose to hydroxybenzaldehyde and hydrogen cyanide. Cyanide content of bamboo shoot ranged from 1000 to 8000 mg/kg hydrogen cyanide. Although cyanide content of bamboo shoots is much higher than that of cassava root, the cyanide content in bamboo shoots decreases substantially following processing (http://www.intechopen.com/books/ toxicology-new-aspects-to this-scientific-conundrum).

Methods of Hydrogen Cyanide Reduction

Food processing procedures such as boiling, soaking, fermentation and drying reduce the levels of hydrogen cyanide. Processing methods, such as peeling, drying, grinding, soaking, boiling or cooking, soaking and fermentation have been reported by several studies to cause a significant reduction in the cyanogenic glycosides of processed foods (http://www.foodstandards.gov.au).

Cyanogenic glycoside found in fresh bamboo decomposes quickly when placed in boiling water, rendering the bamboo shoots safe for consumption. During boiling, significant amount of cyanogens are leached into cooking water, Duration of boiling and amount of water used for boiling greatly affect the reduction of cyanogenic glycoside. Soaking is a simple traditional practice which is followed in the processing of food. Soaking is quite effective in eliminating cyanogens particularly in most plant species which have low content (http://www.intechopen.com/books/ toxicology-new-aspects-tothis- scientific-conundrum). Drying is an appropriate processing method for removal of cyanogenic glycoside in food plant. Oven drying at 60°C for brief 8hr drying periods leads to very high reduction of cyanogen content up to 95% of the initial cyanide content (www.worldbamboo.net >wbncx>Sessions). Fermentation is carried out in tanks or other suitable fermentation vessels for 3-4 days. Fermenting should not be less than 2days to ensure adequate cyanide detoxification. During fermentation, hydrogen cyanide which is easily soluble in water can be reduced by 99.96% (http://www.intechopen.com/books/ toxicology-new-aspects-tothis-scientific-conundrum).

Materials and Methods

Raw Materials

Harvested bamboo shoot (Wa-bo) was purchased from, Kamayut Township, Yangon Region. Sodium hydroxide, ammonium hydroxide, potassium iodide and silver nitrate are analar grade (JDH chemicals Ltd. China, BDH chemicals Ltd. England, AJAX chemicals Australia). They were purchased from Shwe Ma Chemical Shop, Pabedan Township, Yangon Region.

Methods

Boiling, soaking, fermentation and drying methods (hot air oven, 20-240°C, GP 100) were used to reduce the hydrogen cyanide (HCN) content. The determination of HCN content was analyzed by alkaline titration method for quantitative test (A.O.A.C.-915.03, 936.11) and phytochemical examination for qualitative test. The moisture content of the harvested bamboo shoot was determined by thermo gravimetric analysis.

Boiling Method for Hydrogen Cyanide Reduction

The raw material was peeled, washed and cut into 0.5cm thick. Then, 100g of sample and 400m1 of water were placed in a 1000m1 round bottom flask and boiled on the electric stove at 100°C±2 for 60min. The reduced amount of HCN content was also analyzed with changed in water volume and boiling time at every 15mins.

Soaking Method for Hydrogen Cyanide Reduction

The raw material was peeled, washed and cut into 0.5cm thick. Then, 100g of sample and 400m1 of water were placed in a plastic container for 24hr at room temperature (27ºC). The reduced amount of HCN content was also analyzed with changed water volume and soaking time at every 6hrs.

Oven-Drying Method for Hydrogen Cyanide Reduction

The raw material was peeled, washed and cut into 0.5cm thick. Then, 300g of sample placed on the steel trail with a bed of aluminum foil and put in an oven at 100°C. The reduced amount of HCN content in the harvested bamboo shoot was analyzed with changed of drying time at every l hr from 3hrs and drying temperature.

Fermentation Method for Hydrogen Cyanide Reduction

The raw material was peeled, washed and cut into 0.5cm thick. Then, 500g of sample, 10g of salt and 400m1 of water were placed in a plastic container for 3days at room temperature (27ºC). The reduced amount of HCN content was also analyzed with changed water volume and fermentation time at an interval 1day.

Results

Table (1) Effect of Volume of Water on Reduction of HCN from Harvested Bamboo Shoot by using Boiling Method

Sr. No	Treatment (Volume of Water, ml)	Reduction of HCN from Harvested Bamboo Shoot	
		Content (mg)	Reduction (%)
1.	Unprocessed (raw)	13.86 ± 0.37	-
2.	400	8.892 ± 0.37	36
3.	600	7.848 ± 0.44	43
4.	800	6.984 ± 0.27	50
5.	1000*	5.58 ± 0.27	59
6.	1200	5.94 ± 0.34	52

* the most suitable condition, ± SD of three replicates

Table (2) Effect of Boiling Time on Reduction of HCN from Harvested Bamboo Shoot by using Boiling Method

Sr. No	Treatment (Boiling time, min)	Reduction of HCN from Harvested Bamboo Shoot	
		Content (mg)	Reduction (%)
1.	Unprocessed (raw)	14.41 ± 0.42	-
2.	30	7.74 ± 0.38	46
3.	45	6.804 ± 0.43	52
4.	60	5.652 ± 0.44	60
5.	75*	4.932 ± 0.38	65
6.	90	5.148 ± 0.44	64

* the most suitable condition, ± SD of three replicates

These experiments were carried out at Industrial Chemistry Department, University of Yangon.

Table (3) Effect of Volume of Water on Reduction of HCN from Harvested Bamboo Shoot by using Soaking Method

Sr. No	Treatment (Volume of Water, ml)	Reduction of HCN from Harvested Bamboo Shoot	
		Content (mg)	Reduction (%)
1.	Unprocessed (raw)	15.012 ± 0.54	-
2.	400	8.496 ± 0.27	43
3.	600	7.704 ± 0.32	49
4.	800*	7.02 ± 0.39	53
5.	1000	7.2 ± 0.16	52

* the most suitable condition, ± SD of three replicates

Table (4) Effect of Soaking Time on Reduction of HCN from Harvested Bamboo Shoot by using Soaking Method

Sr. No	Treatment (Soaking Time, hr)	Reduction of HCN from Harvested Bamboo Shoot	
		Content (mg)	Reduction (%)
1.	Unprocessed (raw)	14.688 ± 0.28	-
2.	6	8.856 ± 0.32	40
3.	12	8.172 ± 0.27	44
4.	18	7.704 ± 0.63	48
5.	24	7.236 ± 0.49	51
6.	30*	6.156 ± 0.38	58
7.	48	6.192 ± 0.27	58

* the most suitable condition, ± SD of three replicates

Table (5) Effect of Drying Time on Reduction of HCN from Harvested Bamboo Shoot by using Drying Method

Sr. No	Treatment (Drying Time, hr)	Reduction of HCN from Harvested Bamboo Shoot	
		Content (mg)	Reduction (%)
1.	Unprocessed (raw)	14.22 ± 0.27	-
2.	3	8.82 ± 0.27	38
3.	4	7.128 ± 0.49	49
4.	5*	5.868 ± 0.54	58
5.	6	5.724 ± 0.48	59

* the most suitable condition, ± SD of three replicates

These experiments were carried out at Industrial Chemistry Department, University of Yangon.

Table (6) Effect of Drying Temperature on Reduction of HCN from Harvested Bamboo Shoot by using Drying Method

Sr. No	Treatment (Drying Temperature, °C)	Reduction of HCN from Harvested Bamboo Shoot	
		Content (mg)	Reduction (%)
1.	Unprocessed (raw)	14.184 ± 0.43	-
2.	60	8.064 ± 0.27	43
3.	70	7.488 ± 0.27	47
4.	80	7.02 ± 0.39	50
5.	90	6.876± 0.48	52
6.	100*	5.94 ± 0.21	58
7.	110	5.976± 0.32	57

* the most suitable condition, ± SD of three replicates

Table (7) Effect of Volume of Water on Reduction of HCN from Harvested Bamboo Shoot by using Fermentation Method

Sr. No	Treatment (Volume of Water, ml)	Reduction of HCN from Harvested Bamboo Shoot	
		Content (mg)	Reduction (%)
1.	Unprocessed (raw)	14.94 ± 0.34	-
2.	400	8.28 ± 0.16	44
3.	600	7.74 ± 0.27	49
4.	800	6.948 ± 0.32	53
5.	1000*	5.616 ± 0.43	62
6.	1200	5.688 ± 0.37	61

* the most suitable condition, ± SD of three replicates

Table (8) Effect of Fermentation Time on Reduction of HCN from Harvested Bamboo Shoot by using Fermentation Method

Sr. No	Treatment (Fermentation Time, day)	Reduction of HCN from Harvested Bamboo Shoot	
		Content (mg)	Reduction (%)
1.	Unprocessed (raw)	15.372 ± 0.44	-
2.	3	5.652 ± 0.65	63
3.	4	4.932 ± 0.37	67
4.	5	4.464 ± 0.40	70
5.	6*	4.176 ± 0.37	72
6.	7	4.176 ± 0.48	72

* the most suitable condition, ± SD of three replicates

These experiments were carried out at Industrial Chemistry Department, University of Yangon.

Discussion

The initial content of HCN in the harvested bamboo shoot (Wa-bo) was determined by using alkaline titration method. The observation of qualitative test for cyanogenic glycoside in the harvested bamboo shoot is presence (reddish brown). The moisture content of the harvested bamboo shoot is 87%.

Boiling method for cyanogen reduction will be more efficient when small sized pieces boiled in large volume of water. The highest concentrations are detoxified by the boiling for two hours (www.worldbamboo.net >wbncx>Sessions). Present analysis shows that the maximum amount of HCN content was reduced to 65% with 100g of bamboo shoot and 1000ml of water volume for 75min by using boiling method and the content of HCN did not reduce more than 75min of boiling time. The results are shown in Table (1) and (2). The hydrogen cyanide of bamboo shoot could be reduced due to boiling and soaking at extent depending upon the treatment and species (https://www.organicfacts.net/health-benefits/other/health-benefits-of-bamboto-shoots.html). The decrease in cyanogen also depends on temperature, time and soaking medium in which the material is soaked (www.worldbamboo.net >wbncx>Sessions). The most suitable amount of HCN content was reduced to 58% in 30hr with 100g of material and 800ml of water volume by using soaking method. The results are shown in Table (3) and (4). Table (4) shows that the HCN content did not reduce with more than soaking time 30hr.

Drying methods such as sun, oven, freeze and superheated steam can be employed for the reduction of hydrogen cyanide (www.worldbamboo.net >wbncx>Sessions). The efficiency of cyanide removal during drying is dependent on moisture content of the material. Table (6) displays that the maximum content of HCN from bamboo shoot (200g) was reduced to 58% at 100°C for 5hr by using oven-drying method and the results are shown in Table (5) and (6). When prolong drying time, the appearance of resultant dried bamboo shoot was turned into charred substance. Fermentation is one of the ancient methods of food preservation and widely use in many cultures. Fermentation decreases the taxiphyllin content by lowering the pH through microbial activity (www.worldbamboo.net >wbncx>Sessions). Table (8) shows that the optimum content of HCN from bamboo shoot (500g) was reduced to 72% during 6days with 1000ml of water volume by using fermentation method and the results are shown in Table (7) and (8). The HCN content did not change in 7 days of fermentation time.

Conclusion

Bamboo shoots are a well-known vegetable for their nutritional value but they have very high content of hydrogen cyanide content, which needs processing for safe consumption. The simple processing methods such as boiling, soaking, fermentation and drying are effective for HCN reduction. The most suitable reducing content of HCN from harvested bamboo shoot (500g) is 72% with 1000ml of water volume and 10g of salt for 6days of fermentation time by using the fermentation method.

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References

- Bamboo Botanicals, 2017 **From** http://www.bamboobotanicals.ca/html/ bamboo-care/soil-for-bamboo.html
- Cyanogenic Glycoside- Information Sheet, Joint FAO/WHO Expert Committee on Food Additives(JECFA) in 1993, International Programme on Chemical Safety (IPCS) in 2004 **From** www.foodsafety.govt.nz >industry>cyanide.htm
- Cyanogenic Glycosides in Cassava and Bamboo Shoots Techanical Report Series, No.28, Food Standard Australia, New Zealand, July 2004 **From** https://www.foodstandards.gov.au >28
- Cyanide Poisoning, Veterinary Toxicology, 2012 Retrieved July 7,2017 **From** www.sciencedirect.com >article>pii
- Islamiyat Folashade Bolarinwa, Moruf Olanrewaju Oke,Sulaiman Adebisi Olaniyan and Adeladun Stephen Ajala, A Review of Cyanogenic Glycosides in Edible Plants, Department of Food Science and Engineering, Ladoke Akintola University of Technology (LAUTECH), P.M.B. Ogbomoso, Oyo State, Nigeria **From** http://www.intechopen.com/books/toxicology-new-aspects-tothis-scientific-conundrum Association of Official of Analytical Chemists (A.O.A.C.- 915.03, 936.11), (2000), International, vol 1,chp 11.
- Kanchan Rawat, C. Nirmala and M.S.Bisht, Processing Techniques for Reduction of Cyanogenic Glycoside from Bamboo Shoots, Dept. of Botany, Panjab University Chandigrah-160014, Centre for Science Education, North Eastern Hill University,Shillong-793002, India Retrieved August 16, 2016 **From** www.worldbamboo.net >wbncx>Sessions
- Reduction of Cyanide of Bamboo Shoot due to a Traditional Manipuri Method of Processing, 17.7.2016, S.GIRI SINGH, Department of Biochemistry, Manipur College, Imphal-795 008, INDIA **From** - www.thebioscan.com>journalpaper>
- Reduction of Cyanide of Bamboo Shoot due to a Traditional Manipuri Method of Processing Interesting Benefits of Bamboo Shoots, 2016, Organic Information Services Pvt Ltd. **From** https://www.organicfacts.net/health-benefits/other/health-benefits-of-bamboto-shoots.html