For How Long Should Chaya Leaves be Boiled?

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Introduction

Chaya (*Cnidoscolus aconitifolius*) or tree spinach is a nutritious, fast growing perennial shrub (*TN (http://edn.link/tn-53)* 53 (http://edn.link/tn-53)). It is one of many food plants that contain cyanogens, chemical compounds that can produce toxic hydrogen cyanide (HCN) when the food is consumed (Table 1). Hydrogen cyanide is produced when the plant cells are damaged, because an enzyme located in one part of the cell is then able to act on the cyanogen, which is kept in a different part of the cell. Microorganisms living in the intestines of animals also contain small amounts of enzymes which release HCN from cyanogens (Teles 2002).

Table 1: Cyanogen content of food plants		
Plant	**Approximate volume of 100 grams (raw)**	**Approximate cyanogen content (mg HCN/100 grams raw)**
cassava - root	120 mL[e]	1.5-100[a]
flax seed - meal	110 mL[e]	36-39[a]
giant taro - leaves	860 mL[e]	2.9-3.2[a]
bamboo – young shoots	160 mL[e]	10 - 800[a]
bitter Almond - kernels	210 mL[e]	470[a]
chaya - leaves	1200 mL	0.08-1.48[bc]; 27-42[d]
[a]FAO/WHO Expert Committee on Food Additives 2012; [b]Kuti and Konoru 2006; [c]Jaramillo *et al.* 2016; [d]Ross-Ibarra and Molina-Cruz 2002; [e]USDA 2015		

The provisional guideline for the maximum daily long-term intake of HCN is 0.02 mg HCN equivalents/kg body weight (FAO/WHO Expert Committee on Food Additives 2012). This corresponds to a daily intake of about 1.4 mg/day HCN equivalents for a 70 kg adult or 0.24 mg/day for a 12 kg child. Food processing techniques such as grinding, drying, fermenting, and cooking release HCN into the air or cooking water, reducing the amount of HCN in the plant that is consumed (Teles 2002). Surprisingly, freezing chaya has been shown to increase the amount of HCN produced (Kuti and Konoru 2006). Although raw chaya leaves produce much less HCN than cassava, consuming raw chaya could pose a risk, especially for young children. The risk is also greater for people lacking protein [in particular, the sulfur-containing amino acids methionine and cystine, found in eggs, fish, chicken, beef and pork] because they are less able to detoxify HCN (Teles 2002).

A very rough estimate of the HCN content of a food can be obtained by sealing food in an air-tight plastic bag with Cyantesmo paper (***EDN (http://edn.link/cyantesmo)*** 130 (http://edn.link/cyantesmo)). ECHO staff used this method to determine that boiling 80 grams of chaya leaves and stems for 20

minutes reduces their HCN content to levels too low to be detected by the Cyantesmo paper. Our aim was to use a more precise method to determine the extent to which shorter boiling times would reduce the HCN content of chaya leaves below the maximum daily long-term intake level of 0.02 mg HCN equivalents per kg body weight. Shorter boiling times require less fuel and may better maintain the nutrient levels of the plant.

Methodology

We obtained Cyantesmo paper from CTL Scientific

Figure 10. Color of Cyantesmo paper corresponding to 0.25 ppm cyanide. *Source: Danielle Hepler*

(http://www.ctlscientific.com/cgi/display.cgi?item_num=90604) and attached strips of the paper to rubber stoppers so the paper would hang just above the solution we wanted to measure. We created a standard color scale using glass flasks, to which we added potassium cyanide solutions that would release (respectively) 0.10, 0.25, 0.30, or 1.0 parts per million (ppm) HCN. We also added a drop of 18 molar sulfuric acid, as recommended in the Cyantesmo paper directions. We sealed the flasks with the rubber stoppers, and noted the color of the paper in each flask after 24 hours (Figure 10).

Chaya leaves were harvested at ECHO Florida during the months of February and March. They were shipped overnight to Pennsylvania and refrigerated for 2 days until the analysis could be completed. The leaves were chopped into 1.5 cm pieces and the volume of 10 grams of leaves (raw and cooked) was placed into each flask. Raw leaves were placed in glass flasks with 75 mL distilled water. The leaves to be cooked were placed into boiling distilled water and boiled for 5.0, 6.5, 7.0, 8.5 and 10 minutes. The cooking water was discarded and fresh distilled water was added. The leaves were mashed, a drop of 18 molar sulfuric acid was added, and the flasks were stoppered. The color change was evaluated after 24 hours (Figure 11) by comparing the Cyantesmo paper from each flask of leaves to the color scale obtained from the potassium cyanide solutions. All measurements were repeated at least 3 times. Safety measures for this method included use of disposable gloves, goggles, and a ventilated hood.

Figure 11. Raw chaya leaves turned the Cyantesmo paper dark blue, indicating ≥ 1 ppm cyanide. *Source: Danielle Hepler*

Results

Ten grams of chopped raw leaves had a volume of 120 mL, while ten grams of chopped, cooked leaves had a volume of 60 mL. As expected, all of the raw leaf samples had a color change indicating a HCN content of >1 part per million (> 0.02 mg HCN per 240 mL serving of chopped, uncooked leaves). After 5 minutes of boiling, the color corresponded to a HCN concentration of about 0.10 to 0.25 ppm (0.004 to 0.01 mg HCN per 240 mL serving of chopped, boiled leaves). From 7 minutes on, the color corresponded to an HCN concentration of <0.10 ppm. The blue color for the 0.1 ppm standard and for the boiled leaves varied from flask to flask. This variability probably occurred because the amount of HCN was near or under the lowest amount of HCN the Cyantesmo paper can detect (0.2 mg/L). The air leaving the flask while cooking and the cooking water also turned Cyantesmo paper light blue, but the color was not compared to the standard color scale.

Conclusion

Although the Cyantesmo paper method does not precisely measure the amount of HCN likely to be produced from a food, our results suggest that 5 to 10 minutes is sufficient to reduce the HCN to levels safe for consumption. Other reports show a slightly wider but similar range of 5 minutes (Gonzalez-Laredeo *et al.* 2003) to 15 minutes (Ross-Ibarra and Molina-Cruz 2002) of boiling time. Boiling for only 5 minutes would save on fuel, but extending the boiling time a little longer would provide a margin of safety, which seems prudent considering the wide variation in the amount of HCN in chaya (Table 1).

Findings of our study support the possibility of HCN being present after boiling, but at concentrations below those considered unsafe. It is possible that the chaya leaves we analyzed lost HCN while they were shipped and stored, or that our method did not measure all of the HCN present in the chaya leaves. That said, our

findings suggest that the boiling time to reduce HCN to safe levels is less than the 15-20 minutes reported in *EDN*130 for eliminating color change of the Cyantesmo paper.

Several questions remain.

1. Do HCN levels differ if the chaya leaves are in the water while it is brought to the boiling point?
2. How much HCN does the cooking water contain?
3. Does storage, chopping, baking, or frying change the HCN level of chaya leaves?
4. Does cooking chaya in an aluminum pot have adverse health effects? [We at ECHO have heard mention of this, but have not come across well-researched evidence.]
5. What factors explain the wide range in reported HCN values for chaya? To what extent are HCN values influenced by method of analysis, cultivar, young versus older leaves, and/or varying environmental factors?

References

FAO/WHO Expert Committee on Food Additives. 2012. *Safety Evaluation of Certain Food Additives and Contaminants.* Geneva: WHO Press.

González-Laredeo, R.F., M.E. Flores De La Hoya, M.J. Quintero-Ramos, and J.J. Karchesy. 2003. Flavonoid and cyanogenic contents of chaya (spinach tree). *Plant Foods for Human Nutrition* 58:1-8.

Kuti J.O., and B.H. Konoru. 2006. Cyanogenic glycosides content in two edible leaves of tree spinach (*Cnidoscolus* spp.). *Journal of Food Composition and Analysis* 19: 556-561.

Jaramillo C.J., A.J. Espinoza, H. D'Armas, L. Troccoli and L.R. de Astudillo. 2006. Concentrations of alkaloids, cyanogenic glycosides, polyphenols and saponins in selected medicinal plants from Ecuador and their relationship with acute toxicity against *Artemia salina*. *Revista de biología tropical* 64(3): 1171-1184.

Ross-Ibarra, J. and A. Molina-Cruz. 2002. The Ethnobotany of Chaya (*Cnidoscolus aconitifolius* ssp. Aconitifolius Breckon): A Nutritious Maya Vegetable. *Economic Botany* 56(4):350-365.

Teles F.F.F. 2002. Chronic poisoning by hydrogen cyanide in cassava and its prevention in Africa and Latin America. *Food and Nutrition Bulletin* 23(4): 407-412.

US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. 2015. *USDA National Nutrient Database for Standard Reference, Release 28*. https://ndb.nal.usda.gov/ndb (https://ndb.nal.usda.gov/ndb)

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