IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 17, Issue 12 Ser. 1 (December 2023), PP 54-59
www.iosrjournals.org

Methaemoglobin Complex And Cyanogenic Glucoside Effects On Parboiled And Roasted Irish Potato (Solanum Tuberosum) Tubers .

[1]okenwa, Jude C.[*], [2]ugwuanyi Rose .C, [3]babatunde Olanrewaju M
[4]onukwuli Chimezie O.

[1, 2] Department Of Science Laboratory Technology, Institute Of Management And Technology, Enugu, Enugu State Nigeria
[3]federal Polytechnic N'yak Shendam, Plateau State, Nigeria.
[4]eastern New Mexico University Portales New Mexico, Usa.

Abstract
The importance of Irish Potatoes (Solanum tuberosum) as a global crop that can be transformed into many products impacting several health dimensions cannot be over emphasized. This research determined the cyanogenic glucosides of raw, parboiled and roasted Irish potatoes (Solanum tuberosum); and the pH effects on the cyanogenic glucosides of the processed Irish potato using a colorimeter through the formation of cyanomethemoglobin. The results show a variation in the cyanogenic glucoside concentration at various pHs. The highest cyanogenic glucoside concentration of 1.18 ± 0.2316 mg/kg was recorded in raw potatoes at pH 8.6 while the lowest cyanogenic glucoside concentration of 1.05 ± 0.0600 mg/kg was recorded in parboiled Irish potato at pH of 8.6 For processed samples of Solanum tuberosum with Methaemoglobin complex; roasted Irish potatoes has the highest value of cyanide concentration of 1.12 ± 0.0289 mg/kg at pH of 8.6, followed by parboiled potatoes at 1.05 ± 0.0600 mg/kg at pH of 8.6. The highest mean cyanide concentration (0.83 mg/kg) was recorded at pH 8.6 (basic medium) while the lowest mean cyanide concentration (0.74 mg/kg) was recorded at pH 5.8 (acidic medium). The values obtained for the various methods used in processing Irish potatoes were in tandem with recommended standard by World Health Organization (WHO) and International Standard Organization (ISO). The values are lower than the maximum accepted standard of 10 mg of HCN /10 kg body weights. This research summarizes critical information on nutritional profiles of Irish potatoes and their processed products and describes the state of the science relative to the influence of in-home and common commercial processing on nutritional quality and potential impacts on human health.

Keywords: *Irish Potatoes; cyanogenic glycoside; Modified, Methaemoglobin Complex.*

Date of Submission: 08-12-2023 Date of Acceptance: 18-12-2023

I. INTRODUCTION

Apart from the colder regions of the world, Irish potato (*Solanum tuberosum*) is grown nearly in the whole world. It has remained for centuries an important staple food for many tropical regions (Ogunjobi *et al*., 2005). *Solanum tuberosum* is the fourth largest yielding crop plant in the world, producing nearly 300 million metric tons of tubers per annum (Jones *et al.,* 1996).

Irish potato (*Solanum tuberosum*) is an edible tuber from the *Solanum tuberosum* plant which is actually native to South Africa. They are also referred to as "white potato" and their tubers are also rich source of starch worldwide (Smith *et al.,* 2001). They rank with wheat and rice as one of the most important staples in the human diet (Camire *et al*. 1997).

Food modification and or processing industry is one of the most important industry all over the globe, however, by-products of such industrial activity that are mainly organic material must be handled in appropriate manner to avoid any environmental violence (Schieber *et al.,* 2001). Potatoes, not only in terms of their easy preparations, combining the healthiness of cereals and characteristic chemical composition of vegetables; therefore is important that they are included in human diet. Nutritional value of potatoes is determined and found to contain nutrients such as protein, starch, fat, minerals, group of polyphenols, which guarantee proper antioxidant activity of this vegetable and anti nutritive factor such as cyanogenic glucosides (Schieber *et al.,* 2001).

Cyanide occurs naturally in plant foods in form of cyanogenic glycosides which releases hydrogen cyanide upon hydrolysis. Additionally, cyanogenic glucosides are a group of widely occurring natural

substances which upon enzyme hydrolysis, produce hydrogen cyanide, glucose, ketones, or benzaldehyde (Berngner *et al.,* 2002; Onyesom *et al.,* 2008). According to Vetter (2000), over 2600 species of plants produce cyanogenic glucosides. Thus, the toxicity of some foods is attributed to the presence of CN^-, which halts cellular respiration by acting as a non competitive inhibitor for an enzyme in mitochondria called cytochrome oxidase (Ajaelu *et al.,* 2008). Moreover, it has been reported that high exposure to this potent poison in humans may cause nausea, vomiting, diarrhea, dizziness, weakness, mental confusion, and convulsions followed by terminal coma and literally death (Cipollone *et al.,* 2005; Ussie *et al.,* 2007). Another study has also shown that most cases of cyanide poisoning in humans are caused by the consumption of unprocessed or partially processed foods that contain cyanide. However, many research works revealed that processing methods play a significant role in reducing the level of cyanide contents in foods (Iglesias *et al.,* 2002; Komolafe and Arawande, 2011). Similar studies recommended that Irish Potatoes should not be consumed without processing because the active biochemical contents which includes cyanogenic glycosides in a raw potato can cause ingestion of bacteria or food borne illness that could be detrimental to human health (Nestel *et al.,* 2007).

Therefore, the cyanogenic glucoside present in the Irish potatoes was given an insight in this work to understand it's concentration upon processing using various methods.

II. MATERIALS AND METHODS

Collection and Preparation of Irish Potato Samples

Apparently healthy tubers of *Solanum tuberosum* (Irish potato) was used for this project work. The tubers of the Irish were identified by a taxonomist, purchased from the market at Nasarawa State, Nigeria. The Blood of a healthy Rabbit were purchased from Keffi main market in Nasarawa State.

The entire reagents used were of analytical grade and were used without further purification. All samples were washed to remove sand and other debris, before they were peeled.

Sample Preparation

Raw potato mash

The raw potatoes were washed with clean water in order to get it free of sand and other earthy materials. They were peeled and grated and further processed using AOAC, 2001 method.

Roasted potato mash

Irish potatoes that have undergone dry heating via hot charcoal flame were peeled and grated using a manual grater and a mash of the roasted potatoes was developed. It was mixed with deionized water for cyanide extraction.

Parboiled potato mash

Peeled potatoes that were partially boiled were grated using manual grater and a mash of the parboiled samples was developed. It was mixed with deionized water for cyanide extraction.

Extraction of Liquor

The grated sample (5 g) of the raw potato that was steeped into a deionized water was kept for 24 hours and its liquor was extracted. Similar procedure was carried out on the parboiled and roasted Irish potatoes samples and their respective liquor were extracted using the method by Ajaelu *et al.,* 2008.

Preparation of Buffer Solutions Phosphate and Borate buffers at pH of 5.6 – 7.8 with ionic strength 0.05 mol/dm3 and pH of 8.0 – 9.0 with ionic strength 0.05 mol /dm3 were prepared respectively using the method of Howard and Denton (2014).

The Preparation of Hemoglobin was carried out according to the method of (Beetlestone and Irvine, 1964).

The Preparation of Methemoglobin was carried out according to the method of (Beetlestone and Irvine, 1964).

Determination of Cyanogenic glycoside of the processed Potatoes

In the determination of cyanide contents in the processed potato samples was done according to method by Ajaelu *et al*., 2008.

Statistical Analysis

Values were recorded in triplicates, and statistical Analysis of data was carried out using analysis of variance (ANOVA) and Duncan's Multiple Range Test for the estimation of means. The "t" value was tested at 95% confidence interval.

III. RESULT AND DISCUSSION

Table 1: The Mean Concentration of the Stock Methemoglobin Produced.

	Concentration Determined X 10^{-4} ± S.E in (mg/L)
1	1.690 ± 0.00
2	1.690 ± 0.00
3	1.690 ± 0.00

S.E = Standard error. The mean concentration of stock methemoglobin is 1.690 x 10^{-4} ± 0.00 mg/L.

Table 2: Concentration of Cyanogenic glycoside (mg/kg) of raw *Solanum tuberosum* at pH 5.6-9.0

pH	Mean Concentration x 10^{-4}	S.D x 10^{-6}	C.V	S.E
5.6	0.48	0.0959	0.2011	0.0610
5.8	0.76	0.2975	0.3924	0.0830
6.0	0.64	0.1382	0.2161	0.0870
6.2	0.71	0.2850	0.4022	0.0890
6.4	0.81	0.2272	0.2792	0.0830
6.6	1.07	0.0556	0.0519	0.0370
6.8	0.86	0.0791	0.0915	0.0530
7.0	0.78	0.1679	0.2165	0.1120
7.2	0.79	0.3291	0.4185	0.0630
7.4	0.81	0.0586	0.0734	0.0390
7.6	0.82	0.5259	0.6445	0.3270
7.8	0.85	0.3166	0.3709	0.1010
8.0	0.74	0.0965	0.1304	0.0630
8.2	0.76	0.1246	0.1633	0.0831
8.4	1.11	0.1250	0.1137	0.0832
8.6	1.18	0.2316	0.1967	0.1501
8.8	1.00	0.3799	0.4176	0.2312
9.0	0.79	0.05007	0.6294	0.0104

S.E = Standard error, C.V= Coefficient of variation, S.D= Standard deviation

Physicochemical Composition of Raw and Modified Irish Potato

The pH value of both modified Irish potatoes decreased significantly ($P \leq 0.05$) throughout the modification period as shown in Table 5, with roasted potato having a higher cyanogenic value of 1.12 compared to parboiled potato with a value of 1.05 . The pH values ranged between 5.6 ± 0.02 and 9.0 ± 0.01 before and during modification. The mean cyanaogenic glycoside value increased significantly ($P \leq 0.05$) throughout the modification process, as shown in table. In this study, the concentration value of cyanogenic glycoside both modified potatoes was observed to reduce during and after processing with time, as compared to the unprocessed one. Potato as a major staple food plays an important role to combat mineral deficiencies through its relative high nutritional content. Therefore, potato by-products based silage may be used as a substitute for concentrates as an energy source in growing and finishing diets for man and livestock.

Table 3: Concentration of Cyanogenic glycoside (mg/kg) of roasted *Solanum tuberosum* at pH 5.6-9.0

pH	Mean Concentration x 10^{-4}	S.D x 10^{-6}	C.V	S.E
5.6	0.64	0.0455	0.0709	0.3030
6.0	0.65	0.3869	0.5856	0.2253
6.2	0.65	0.0387	0.0568	0.2253
6.4	0.66	0.5583	0.8508	0.2223
6.6	0.68	0.1976	0.2116	0.3223

6.8	0.93	0.2950	0.4692	0.1317
7.0	0.63	0.1256	0.1840	0.1703
7.2	0.69	0.6644	0.8412	0.4041
7.4	0.79	0.0563	0.0685	0.0343
7.6	0.82	0.0970	0.1033	0.0571
7.8	0.94	0.1304	0.1169	0.0753
8.0	1.12	0.1176	2.1145	0.2760
8.2	1.01	0.3113	0.2858	0.2027
8.4	1.11	0.1682	0.1446	0.1030
8.6	1.02	0.0289	0.0428	0.0183
8.8	0.61	0.2772	0.4541	0.1241
9.0	0.60	0.3017	0.5086	0.2011

S.E = Standard error, C.V= Coefficient of variation, S.D= Standard deviation

Table 4: Cyanogenic glycoside (mg/kg) of parboiled *Solanum tuberosum* at pH 5.6-9.0

pH	Mean Concentration x 10^{-4}	S.D x 10^{-6}	C.V	S.E
5.6	0.74	0.0455	0.0709	0.303
5.8	0.71	0.0064	0.9031	0.0630
6.0	0.68	0.0003	0.5060	0.0020
6.2	0.77	0.3494	0.4535	0.2021
6.4	0.67	1.1026	0.5988	0.6490
6.6	0.93	0.1744	1.5988	0.1010
6.8	0.87	0.0826	0.1876	0.0524
7.0	0.86	0.0985	0.0948	0.0651
7.2	0.81	0.1141	0.1141	0.0671
7.4	0.95	0.2024	0.1406	0.1250
7.6	0.82	0.1443	0.2132	0.0831
7.8	0.86	0.1954	0.1559	0.1152
8.0	0.77	0.2620	0.2268	0.1561
8.2	0.94	0.2220	0.1678	0.1581
8.4	0.98	0.0357	0.3651	0.0224
8.6	1.05	0.0600	0.0692	0.0441
8.8	0.84	0.3113	0.3722	0.1814
9.0	0.69	0.2161	0.3222	0.1270

S.E = Standard error, C.V= Coefficient of variation, S.D= Standard deviation

Table 5: Mean Concentration of Cyanogenic glycoside (mg/kg) of raw and modified *Solanum tuberosum* at pH 5.6-9.0

pH	**Raw**	**Parboiled**	**Roasted**	**Mean per pH**
5.6	0.78	0.74	0.64	0.54
5.8	0.76	0.71	0.58	0.58
6.0	0.64	0.68	0.65	0.57
6.2	0.71	0.77	0.65	0.55
6.4	0.81	0.67	0.66	0.59
6.6	1.07	0.93	0.68	0.80
6.8	0.86	0.87	0.93	0.74
7.0	0.78	0.86	0.63	0.69
7.2	0.79	0.81	0.69	0.69
7.4	0.81	0.95	0.79	0.78
7.6	0.82	0.82	0.82	0.73
7.8	0.85	0.86	0.94	0.88
8.0	0.74	0.77	1.12	0.81
8.2	0.76	0.94	1.01	0.60
8.4	1.11	0.98	1.11	0.93
8.6	1.18	1.05	1.12	0.97
8.8	1.00	0.84	0.61	0.80
9.0	0.79	0.67	0.60	0.73
Mean cyanide concentrations per sample	0.83	0.81	0.74	

Table 6: Highest and lowest cyanogenic Glycoside concentration with respect to pH

Sample/Process	Highest concentration (mg/kg)	pH	Lowest Concentration (mg/kg)	pH
Raw.	1.18 ± 0.2316	8.6	0.48 ± 0.0959	5.6
Parboiled	1.05 ± 0.0600	8.6	0.67 ± 0.2160	6.4
Roasted	1.11 ± 0.1682	8.4	0.60 ± 0.3017	9.0

IV. DISCUSSION

In this research work, the complex of cyanomethemoglobin formed was used to evaluate the cyanogenic glycoside of raw and the modified Irish potatoes. The raw Irish potatoes extract serves as the control. The modifications were done by methods earlier described. Tables 3.1-3.4 show the variations in the cyanogenic glycoside concentrations of each sample at different pHs while Table 5 shows the summary of the mean cyanogenic glycoside concentration for the entire samples under study at a particular pH and the mean cyanogenic glycoside concentration of each sample at the pH range of 5.6-9.0. The investigation was carried out with pH varying from 5.6 to 9.0 at 0.2 intervals. The variations in the concentrations as determined and recorded in the Tables 2 - 5 were likely as result of variation in the degrees of temperature which varied in direct proportion to the quantity of heat energy gained by the system and the pH perhaps, causing Cyanogenic glycosidal to be converted to hydrocyanic acid (which is a toxicant in Irish potatoes). This observation is in line with the report of Adindu *et al.,* 2003. From the results display in Table 5, the highest mean cyanogenic glycoside concentration was recorded in raw potato to be 0.83 mg/kg and the lowest mean concentration was found in roasted potato at 0.74 mg/kg. The mean concentration value discovered for parboiled potato was 0.81 mg/kg which is closed to 0.83 mg/kg recorded for raw potatoes**.** Generally, the mean cyanogenic glycoside concentrations with respect to pH variations appeared relatively low at the acidic medium and high at the basic medium as observed in Table 5. This can be adduced to the fact that at lower pH, dissociation of the complex mixture to yield cyanide is not favorable, which resulted in less free cyanide ions in the solution. This effect is tandem as was reported by Koenig, 2015. The major differences observed in the mean cyanide concentrations determined for the raw Potatoes (0.83 mg/kg) and in the roasted sample at 0.53 mg/kg as in Table 5 is probably due to the residual concentration of alkaloid in the unprocessed sample and considerably low in parboiled potatoes due to the fact that boiling (which usually requires more water, large volume of heat and longer processing time) is one of the traditional methods of reducing alkaloid toxicity dominant in foods (Abiona *et al.,* 2005). Thus, from the data in Table 2 - 4, it could be inferred that the variations in the mean cyanide concentrations determined for the raw Potatoes and from the modified samples are due to several changes in the processing condition such as temperature, concentration and pH but most especially, the temperature. This agrees with the findings of Anon *et al.,* (2010). This result also agrees with the work done by Ajaelu *et al*., (2008)**.**

V. Conclusion

Irish Potato is in abundant and are being modified to suit one's need without considering the toxins level when consumed. From this research, the variation in the concentration level of cyanogenic glycosides level of various modified forms of Irish potato and at different pH has been discovered. The raw potatoes and those that were modified through different processing measures; all developed from the same specie of irish potatoes from the same geographical region under the same climatic condition were found to have different levels of cyanogenic glycosides concentration. The highest cyanogenic glycoside appeared in raw potato at pH 8.6 (1.18 $\pm$ 0.0231 mg/kg) followed by roasted Irish potato at pH 9.0 (1.11$\pm$0.1682 mg/kg) and lastly by parboiled Irish potatoes at 6.4 pH (1.05 $\pm$ 0.0600 mg/kg). From the result, it can as well be generally concluded that high concentrations appeared more frequently in basic medium of the solution than its populations in the acidic medium. Comparing with the accepted standards of World Health Organization, 2012 and International Standard Organization, 2008), 10 mg/kg and 0.5-3.5 mg/kg respectively; it is thereby opined that Potatoes may be consumed when modified without creating any risk associated with cyanide to human health.

Conflicts of Interest

The authors declare no conflicts of interest.

Funding

The authors declare that we did not receive any fund and or sponsorship from any agency as this research was privately sponsored.

REFERENCE

[1]. Abiona, O.O., Sanni L.O., And Bamgbose, O. (2005). An Evaluation Of Microbial Load, Heavy Metals And Cyanide Contents Of Water Sources, Effluents And Peels From Three Cassava Processing Locations. Journal Of Food, Agriculture And Environment. 3(1): 207-208.

[2]. Adindu, M.N., Olayemi, F.F., And Nze-Dike, O.U. (2003). Cyanogenic Potential Of Some Cassava Products In Port Harcourt Markets In Nigeria, Journal Of Food Composition And Analysis. 4(16) 1 – 21.

[3]. Ajaelu, J.C., Bamgbose, J.T., Atolaiye, B.O. And Adetoye, A.A. (2008). The Use Of Methemoglobin In Estimating The Cyanogen Potential Of Cassava And C Assava Products. African Journal Of Biotechnology. 7(10):346 - 348.

[4]. Anon, K., Naim, R., Kisay, L., Park, J., Qaisar, M., & Zulfiqar, A. B. (2010). Precipitation Chelation Of Cyanide Complexes In Electroplating Industry Wastewater.International Journal Of Environment. 5(1): 45-46.

[5]. AOAC (2005) Official Methods Of Analysis. 19th Edition, Association Of Official Analytical Chemists, Washington DC.

[6]. AOAC (Association Of Official Analytical Chemists) (2001). Official Methods Of Analysis. Revised Edition, Washington D.C.
[7]. Berngner, V., Giner R.M., Grane-Tarnel N. & Arazola G. (2002). Chromatographic Determination Of Cyanoglycosides Prunasin And Amygdalin In Plants Extract Using A Porous Graphitic Carbon Column. Journal Of Agriculture And Food Chemistry. (3):77.
[8]. Beettlestone, J.G., & Irvine, D.H. (1964). Reactivity Differences Between Hemoglobin Part IV. The Thermodynamics Of Ionization Of Some Vertebrate Hemoglobin. Journal Of Chemical Society. 9(77): 5090 - 5095.
[9]. Camire, M.E., Violette, D., Dougherty, M.P. And Mclaughlin, M.A. (1997) Potato Peels Dietary Fiber Composition: Effect Of Peeling And Extrusion Cooking Processes. Journal Of Agriculture And Food Chemistry, 45, 1404-1408. Https://Doi.Org/10.1021/Jf9604293.
[10]. Cipollone, R., Paolo, V., Emanuela, F., & Paolo, A. (2005). Cyanide Detoxification By Recombinant Bacterial Rhodanese. International Journal Of Environmentment, 5 (3):815-912.
[11]. Howard, B. & Denton, I.C. (2014). Mild Method For Removal Of Cyanogens From Cassava Leaves With Retention Of Vitamins And Protein. Journal Of Food Chemistry, 6, 67.
[12]. Iglesias, C. A., Sanchez, T. & Yeoh, H. (2002). Cyanogen And Linamarase Activities In Cassava Breeding Program. Journal Of Food Composition And Analysis, 15: 379-387.
[13]. Jones, A., Dukes, P. D And Schalk, J.M (1986). Breeding Vegetable Crops, In M. J. Bassett (Ed.) Sweet Potato Breeding.1- 35pp.
[14]. Koenig, B. (2015). Effect Of Carbonization Temperature On The Structure And Properties Of Carbon Fibres Prepared From Poly (Phenyleneisophthalamide) Precursor. Journal Of Fibres And Polymers; 1(6) 8 1629-163
[15]. Komolafe, E. & Arawande, A. (2011). Total Cyanide Content Of Garri Flour Produced In Delta State. Journal Of Food Security, 5(5): 162-168.
[16]. Nestel, P. S., Masai, C., Cipollone, R., Paula, T., Frances C.O. & Paola V. (2007). Food Intake And Growth In Enzymatic Detoxification Of Cyanide: Clues From Pseudomonas Aerugonsa Rhodanese. Journal Of Molecular Microbiology And Biotechnology,15(2-3): 1999-2112.
[17]. Ogunjobi, A.A, Adebayo-Tayo, B.C And Ogunshe, A. A (2005). Microbiological, Proximate Analysis And Sensory Evaluation Of Processed Irish Potato Fermented In Brine Solution, African Journal Of Biotechnology, 4(12):1409-1412.
[18]. Onyesom, I., Okoh P & Okpokunu, O. (2008). Levels Of Cyanide In Cassava Fermented With Lemon Grass (Cymbopogon Citratus) And The Organoleptic Assessment Of Its Food Products. World Applied. Sciences Journal 4 (6): 860-863.
[19]. Ussie, M.D., Alfred, G.O.D., & Abdul-Rasaq, A. A. (2007). Targeting Different End Uses Of Cassava: Genotypic Variations For Cyanogenic Potentials And Pasting Properties, International Journal Of Food Science And Technology, (567), 54.
[20]. Vetter, J. (2000). Plant Cyanogenic Glycosides. Toxicon. Journal Of Food, Agriculture And Environment, 38 (1): 11–36.