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Comparative Study of Nutrient and Cyanic Acid Loss in Various Retting Techniques in Local Cassava Processing

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ABSTRACT

Cassava contains a good deal of compounds that are injurious to human health typical of which include cyanic acid. Their presence demands that cassava be processed by techniques that aim at reducing as much as possible these toxic compounds. However, the amount of carbohydrate lost in each of the several processing techniques of is found to vary according to the technique adopted and also according to the end product. In this study, the amount of carbohydrate lost in each of the several processing techniques of the cassava samples obtained in local markets in Ogun State Nigeria was determined using the Anthrone method and results showed that 35.70 g/kg of carbohydrate was lost from effluent of cassava milled after 24 hrs of retting for fufu, 24.25 g/kg of carbohydrate was lost from locally fermented cassava for 4 days and 30.25 g/kg was lost from effluent of fresh cassava milled for gari processing. Results also showed that 28.25 g/kg of carbohydrate was lost from boiled cassava tubers processed for tapioca whereas subsequent retting of cassava lost carbohydrate amounting to 11.24 g/kg on day 1, and 13.25 g/kg on day 2. The effluent of cassava retted for 3 days with mother liquor as source of inoculums gave 24.25 g/kg while unpeeled cassava retted for 4 days gave only 8.25 g/kg.

Keywords: Detoxification, Inoculums, Manihot Species, Carbohydrate, Cyanic Acid.

I. INTRODUCTION

Cassava(*manihot sp)*, an extremely important food in Africa with origin from South America is a staple food in the tropics and in Africa as a whole. Its production and processing at the moment is still largely done by manual labour. It is therefore not a surprise that initiatives has been taken by Agronomists to develop new varieties which are higher yielding and disease resistant (FIIRO, 2006). Its importance relates to the fact that cassava roots can be processed into 100 different foods (Ekenayake, 2001). Two major varieties are recognized in cassava – *manihot utilisima* pohl and *manihot esculenta*. *Manihot utilisima* is popular for its edible tubers and leaves used to feed farm animals like goats and rabbit while *manihot esculenta* contains higher concentrations of cyanic compounds which are poisonous. The poisonous nature of some varieties of cassava (bitter cassava) is the result of two cyanogenic glycosides – linamarin and lotaustralin (Coursey, 1982). These are hydrolyzed by linamarase enzyme which is released when cassava cells are ruptured to liberate free hydrogen cyanide which is lost into the air as well as a bound residual glycoside (Coursey, 1982). Hydrogen cyanide is a strong poison and for adults, lethal dose is 60mg/day (Hahn, 1989). A higher dietary intake of fresh or inadequately processed bitter cassava may lead to chronic cassava toxicity characterized by goiter, ataxic neuropathy etc. and in addition, respiratory difficulties may occur and occasionally death (Osuntokun, 1994). Reducing the cyanide content in bitter cassava is a function of processing technique, the best being soaking in water, followed by grating and frying (Mahunga, Yamaguchi, Almazan and Hahn, 1987). Okigbo (1980), showed that for sweet cassava, the hydrogen cyanide (mg/kg fresh tissue) content of the seed is zero, seedlings is 285, roots is 126 and mature leaves is 468 whereas bitter cassava contains HCN (hydrogen cyanide) up to the tone of 7.5 for the seed, 245 for the seedlings, 185 for the roots and 310 for the mature leaves. Many African countries have employed several methods for the detoxification of cassava for food products. Five methods have so far been studied by Mahunga et al (1987). In all the methods however, HCN content were reduced by as much as 69.85 % to 100 %. The two most effective methods, involve complete submersion of the peeled tubers in water either for 3 to 4 days with detoxification results between 99.8 % to 100 % or peeling, grating and retting between 18hrs and 3 days, shredding, sun drying and frying with detoxification range of 90.8 % to 99.0 %. Another method requires boiling the tubers for a long time, rinsing in warm water and pounding in a mortar for fufu with a loss of cyanide of about 80.1 % only (Mahunga *et al.*, 1987). The least effective method is sun drying of peeled, chipped, cassava and subsequent processing into fufu where cyanide loss is lowest at 69.85 %. These processing techniques however lead to loss of nutrients like protein, carbohydrates and minerals. The initial source of potential loss of nutrient is during the peeling process (FIIRO, 2006) where a loss of 30 – 40 % can occur if inexperienced peelers are used, but with experienced peelers, loses can reduce to 20 – 25 %. The next major source of loss of nutrient is during grating and retting. These two processes leaves behind, effluents rich in nutrients. The ORSTOM group has been working on solid fermentation process for improving protein and carbohydrate content of cassava and other tropical starch substrates. (Saucedo, Lousane, Navarro, Roussos and Rainbault, 1992). This is as a result of the chronic loss of nutrients during processing. Because of its acidic, bacterostatic and bactericidal properties, fermentation prevents microorganisms from breaking down vegetal materials. Solid substrate fermentation has been a batch process utilizing natural heterogeneous materials for detoxification as described by Rainbault and Girand (Rainbalt *et al.*, 1993). This has been focused of physical and enzymological characteristics of cassava starch media – amylase product (Ramirez, de Stouvend and Rainbault, 1994). Saucedo et al, [8] in a study at ORSTOM laboratory Montpellier on the growth and alcohol fermentation of cassava starch in solid state, found that fermentation can be carried out using a highly promising amylolytic yeast and more recently, Soccol, Iloki, Marin and Rainbault, (2004) obtained a good result with the rhizopus fungi of special interest in traditionally fermented foods. Fermentation of cassava causes vast changes in the physicochemical and functional properties of the final product and attempt is being made to analyze the extent to which the nutritional values change with processing (Saucedo et al, 1992). White and yellow cassava flour—products (garri) derived from cassava specie (*Manihot* spp.) roots, sampled from fifteen locations in Igbesa, Ogun State Nigeria, were subjected to analysis for cyanic acid contents. The alkaline titration method of the Association of Official Analytical Chemists (AOAC) (1970) was adopted. The g*ari* flour was also processed from mashed cassava roots which had been subjected to various retting techniques for time periods of between 2 to 4 days. It was discovered that the cyanic acid levels were influenced significantly by the following factors; source, type (whether yellow or white), method of fermentation and the length of fermentation of the cassava (Ukhun and Nkwocha, 1989). In this study, the effluents from several processing techniques were studied and quantified in terms of their carbohydrate content to give an insight into what stands to be lost during the processing of cassava using any of the techniques.

II. Experimental

5.0 kg of cassava tuber of the same species were chosen for each processing technique, and 2 litres of water were used in each case. The effluents were collected in 2litre plastic containers and labeled accordingly. All techniques were set the same day and as soon as the effluents were generated. Analyses of the carbohydrate content were carried out using the Anthrone method (Jayaraman, 2006). The carbohydrate was dehydrated by the concentrated tetraoxosulphate (vi) acid present in the Anthrone reagent to form furfural which condensed with Anthrone to form a blue coloured complex which is measured spectrophotometrically. 4 mls of Anthrone reagent was added to 1.0ml of both samples and standard, thoroughly mixed and covered with marble and kept in boiling water bath for 10mins., cooled and measured at 620 nm using 1.0 ml of water and 4 mls of Anthrone as blank. The procedure was repeated severally and average values obtained for each sample. A survey of cassava products prepare for consumption tagged "ready-to-eat" (RTE) cassava-based snack foods was undertaken in 2008 to determine the levels of total hydrocyanic acid present. This analysis was carried out to respond to the information revealed to the New South Wales Food Authority of the detection of high levels of cyanic acid compounds in an RTE cassava-based snack food. 374 samples of RTE cassava chips available in the Australian market place were analyzed. It was found that a significant variation in the levels of total hydrocyanic acid was found in 317 samples which tested positive for cyanic acid. The levels of hydrocyanic acid observed were in the range of 13 to 165 mg of HCN equivalents per kg (with a mean value, 64.2 mg of HCN eq/kg for positive samples). Cyanogenic glucosides in cassava contains as much as 80 % of Linamarin or even higher. It is a ß-glucoside of ethyl-methyl-ketone-cyanohydrin and acetone cyanohydrin. Under high pressure and temperature, the Linamarin ß-linkage can only be broken. Even mineral acids can also achieve same, while enzymatic break seem to occur easily. An endogenous cassava enzyme like Linamarase can break this ß-linkage. The enzymatic reaction operates under optimum conditions at 25ºC, at pH 5.5 to 6.0. Linamarin is also found in all parts of the cassava plant including the leaves and stem, but high concentrations occur on the root and leaves. If the substrate and the enzyme are mixed together, a good detoxification can be achieved. All cassava plant species are known to contain various amounts of cyanide. Toxicity is as a result of free cyanide (CN^-) which has already been reported, (Cereda and Mattos, 1996), while toxicity caused by glucoside has not yet been observed or reported. The cyanic acid contents were determined in the samples according to the argentometric method (Association of Official Analysts, 1984) procedure 9113 – based upon final titration of the cyanide by iodo-silver. S1 = Cassava, milled after 24hrs of retting for gari processing. S2 = Cassava, retted locally for 3 – 4 days for fufu processing, S3 = wet milled cassava for gari processing, S4 = cassava, boiled for processing tapioca, S5 = cassava, retted for 1day after boiling for tapioca processing, S6 = cassava, retted for 2days after boiling for tapioca processing, S7 = cassava retted for 18 hrs-3 days with mother liquor as inoculums and S8 = unpeeled cassava retted for 4 days for fufu processing.

III. RESULTS AND DISCUSSION

Analysis of the carbohydrate content of peels from various retting techniques in local cassava processing has been carried out to ascertain the extent of loss of nutrient and results are shown:

Table 1. Result carbohydrate loss under different processing techniques

Sample mg/100 ml	Conc. (mg) in 1000ml	% Carbohydrate in 100 g sample	% Wt. of Carbohydrate lost in 1000 g sample	% Wt. of Carbohydrate lost in 5000 g sample
S1	17.85	3.57	35.7	178.5
S2	12.0	2.475	24.75	123.5
S3	15.13	3.025	30.25	151.25
S4	14.03	2.825	28.25	141.25
S5	5.62	1.124	11.24	56.20
S6	6.63	1.325	13.25	66.25
S7	12.13	2.425	24.25	121.25
S8	0.413	0.825	8.25	41.25

The results of cyanic acid content of the cassava samples removed as a result of the different processing technique is as shown below:

Table 2. Result of cyanic acid loss under different processing techniques Control cyanic acid content = 56.4 mg/kg

Sample mg/100 ml	Conc. (mg) in 1000ml	% Carbohydrate 100 g sample	Conc. of cyanic acid mg/kg	Conc. of cyanic acid removed mg/kg	% Cyanic acid loss
S1	17.85	3.57	28.4	28.03	49.65
S2	12.0	2.475	2.80	53.62	95.04
S3	15.13	3.025	16.4	40.04	70.92
S4	14.03	2.825	27.6	28.82	51.06
S5	5.62	1.124	8.40	48.03	85.11
S6	6.63	1.325	3.54	52.86	93.72
S7	12.13	2.425	0.80	55.64	98.58
S8	0.413	0.825	4.60	51.83	91.84

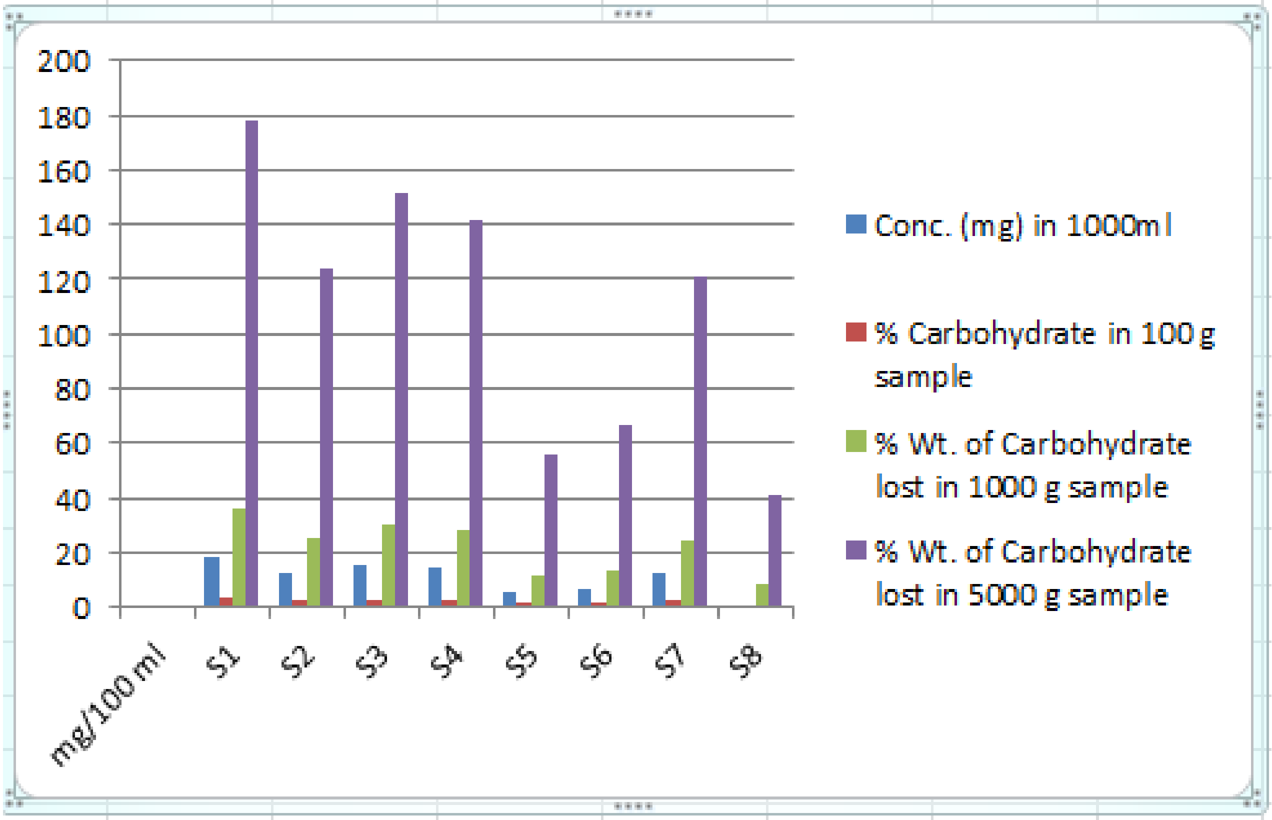

Fig. 1. Bar chart showing the percentage nutrient loss under different processing technique

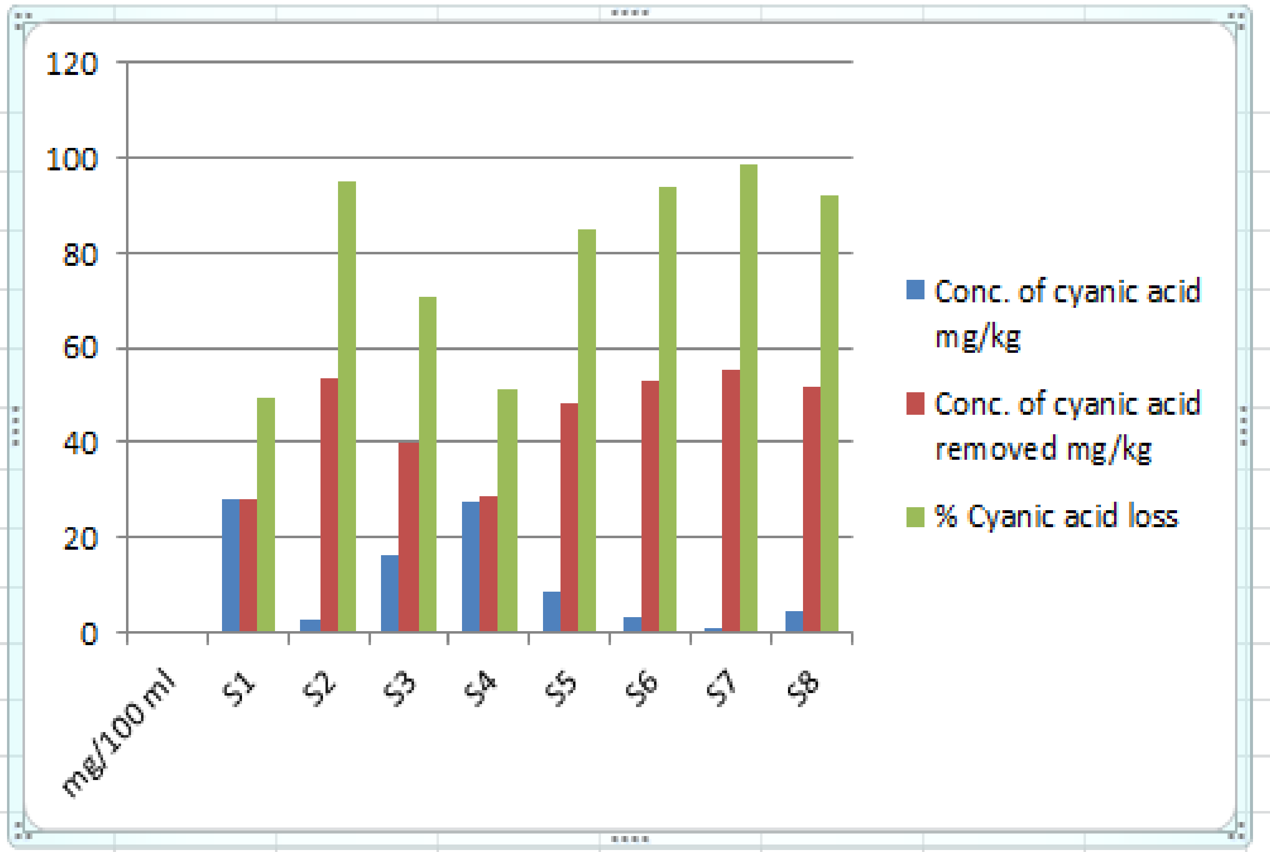

Fig. 2. Bar chart showing the percentage cyanic acid loss under different processing technique

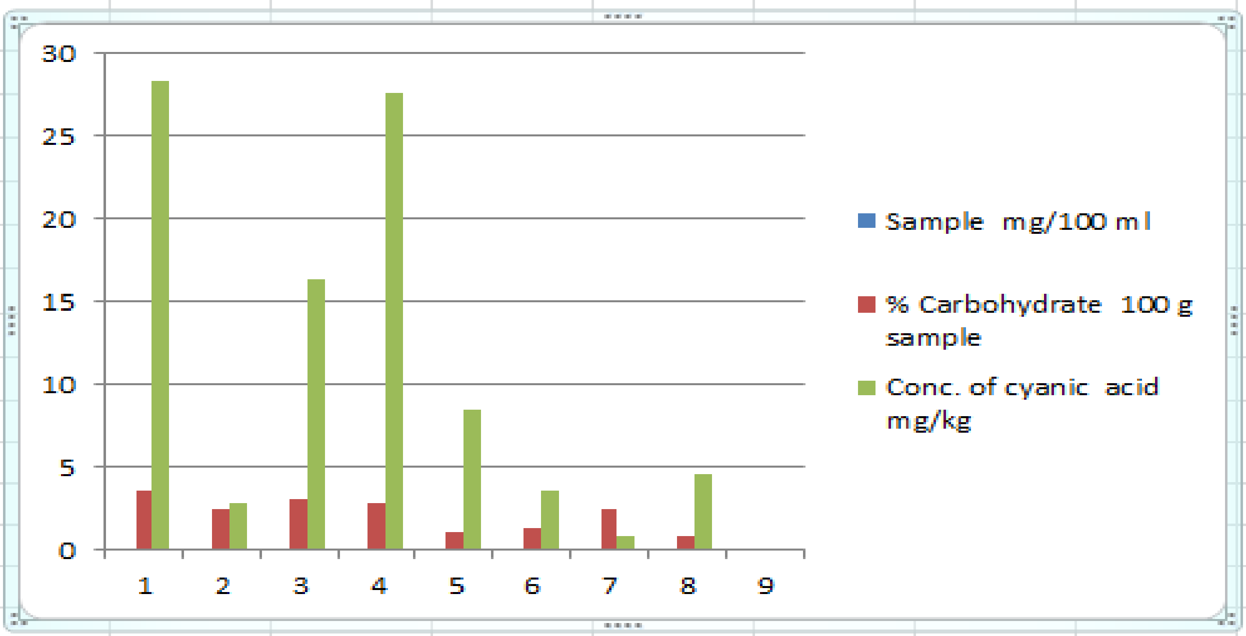

Fig. 3. Bar chart showing the comparison cyanic acid and carbohydrate loss under different processing techniques.

Discussion

The results observed show that as much as 3.75 % of carbohydrate is lost from the milled cassava after 24hrs of retting, followed closely by wet milled cassava amounting to 3.025%. Cassava boiled for processing tapioca lost 2.825% a well as 1.124% and 1.325% after first and second days of retting. Locally retted cassava for 3-4days gave 2.475% while effluent from cassava retted for 18hrs to 3days with mother liquor as source of inoculums gave 2.425%. Finally, unpeeled cassava retted for 4days gave barely 0.825%. The percentage cyanide loss under different processing technique shows that cassava retted for 18 hr. to 3 days with mother liquor as inoculums gave higher results and closely followed by the cassava retted locally for 3 – 4 days for fufu production devoid of the presence of mother liquor. The next high value was the cassava retted for 2 days after boiling for tapioca processing. Only the cassava samples milled after 24 hrs. of retting for gari processing S1 and cassava boiled for processing as tapioca had very low values showing that the cassava samples retained a lot of their cyanic acid content. This shows that even though each processing technique leaves behind some amount of carbohydrate, the extent to which some techniques lose carbohydrate could be minimized so as to conserve wealth.

IV. CONCLUSION

Although the essence of fermentation is to reduce to the barest minimum, the amount of cyanic acid compounds present, the extent to which most nutritional values are lost during processing of cassava should be a course of concern especially where a large consignment is involved. Carbohydrates tend to be more soluble in water when boiled with the result that a reasonable amount is lost in processing cassava for tapioca by boiling and fermenting for a day or two. It is reasonable to adjudge that even though the traditional method of retting cassava for 4 days leaves behind little more cyanic compounds than other techniques, it remains the best method for anyone who would want to retain the carbohydrate level as much as possible. It can therefore be recommended that for effective removal of cyanic acid from cassava, it should be retted at least for 3 – 4 days for processing of fufu, boiled and retted for at least I day for tapioca processing, retted for 3 – 4 days using mother liquor as inoculums or retted for at least 4 days without prior peeling.

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