



Full Length Research Paper

Cyanide reduction pattern of cassava (*Mannihot Esculenta*) as affected by variety and air velocity using fluidized bed dryer

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ABSTRACT

Detoxification of two cassava varieties (TMS30572 and TMS98/0581) by varying drying temperature and air velocity to produce cassava chips was studied at the Department of Food Science and Technology, Federal University of Technology Akure, Ondo; State Nigeria. Quantitative determination of total cyanide (HCN) in cassava chips was carried out using alkaline titration method. Results show that varieties and air velocity interactions highly significantly reduced ($P \leq 0.05$) the total cyanide content in the dried chips. Drying at temperature of 40 °C, air velocity of 2.03 m/s, 2.25 m/s, 2.45 m/s and 2.75 m/s reduced the cyanide content from 8.19 mg/kg to range between 2.53 mg/kg-1.07 mg/kg; at temperature of 50 °C at same air velocity gave result of 4.05 mg/kg-1.63 mg/kg; at temp of 60 °C same set of air velocity gave 6.75 mg/kg-1.01 mg/kg and temperature of 70 °C at same air velocity of 7.08 mg/kg - 1.87 mg/kg for TMS30572. TMS98/0581 at temperature of 40 °C, 50 °C, 60 °C and 70 °C and air velocity of 2.03 m/s, 2.25 m/s, 2.45 m/s and 2.75 m/s gave result of 7.43 mg/kg-3.04 mg/kg; 0.45 mg/kg-0.67 mg/kg; 0.68 mg/kg-0.59 mg/kg and 0.59 mg/kg respectively. It was noted that total HCN content in cassava chips can be substantially reduced by drying at temperature of 70 °C and air velocity of 2.75 m/s for TMS30572 and temperature of 60 °C and 70 °C at air velocity of 2.75 m/s. This study shows the importance of air velocity on drying for achieving a save level of HCN on dried cassava chips.

Keywords: Cyanide reduction, Drying, Air Velocity, Cassava Varieties.

INTRODUCTION

Cyanogenic glycosides account for approximately 90% of the wider group of plant toxins known as cyanogens. The major characteristic of these toxins is cyanogenesis, that is the formation of free hydrogen cyanide associated with cyanohydrins that have been stabilized by attachment of sugars (glycosylation) to form cyanogenic glycosides such as linamarin from cassava which is reported as the level of releasable hydrogen cyanide (Agbor-Egbe and Lape-Mbome, 2006).

Cassava (*Mannihot esculenta*), is a major staple food for Africa (Cardoso *et al.*, 2005), and many nations of tropical origin and America. It accounts for a higher food calories per unit weight compare to yam. It has being reported that about 70% of cassava production in Africa is used as food therefore it plays a major role in alleviating the African food crisis.

It has being reported that cassava is consumed majorly in its processed form due to its high hydro

cyanide content, in Asia about 40% produced is for direct human consumption with much of the remainder expected as chips and pellets and in Latin America and the Caribbean, about 35% to 40% of the cassava production is used for human consumption. The processed form includes cassava chips, meal, flour and starch.

Cassava cultivars classified as “bitter” or “sweet” contain varying amounts of cyanogenic glycosides. The cyanide level varies from about 75 to 350 ppm, but can be up to 1000 ppm or more depending on the variety, plant age, soil condition, fertilizer application, weather, and other factors (Gomez and Valdivieso, 1983; Fomunyam *et al.*, 1984; Aregheore and Agunbiade, 1991). Values from 15-400 mg/kg fresh weight of hydrogen cyanide in cassava roots have been reported for bitter varieties. Sweet varieties of cassava (low cyanide content) will typically contain approximately 15-

50 mg/kg hydrogen cyanide on a fresh weight basis. Sweet varieties of cassava can be processed adequately by peeling and roasting, baking or boiling, while bitter varieties of cassava (high cyanide content) require more extensive processing such as drying, fermentation etc.

Highly toxic hydrocyanic acid (HCN) is released from the cyanogenic glucosides during hydrolysis by the enzyme linamarase (present in the root peel of cassava).

Cyanide in cassava exist in three forms such as glucosides (linamarin and lotaustralin), cyanohydrin and free hydrocyanic acid (HCN), they constitute a major limitation to the use of cassava both as food for human and animal (White *et al.*, 1998). The World Health Organisation (WHO) has set the safe level of cyanogens in cassava flour at 10 ppm or 10 mg HCN /kg, while in Indonesia the acceptable limit is 40 ppm (FAO/WHO, 1991; Damardjati *et al.*, 1993; Djazuli and Bradbury, 1999; Cardoso *et al.*, 2005)

Consumption of cassava and its products that contain large amounts of cyanogens may cause cyanide poisoning with symptoms of vomiting, nausea, dizziness, stomach pains, weakness, headache, exacerbates goitre and diarrhoea and occasionally death (Mlingi *et al.*, 1992; Mlingi and Bainbridge, 1994; Akintonwa *et al.*, 1994; Delange *et al.*, 1994; Onabolu *et al.*, 2001; Ernesto *et al.*, 2002; Simeonova and Fishbein, 2004; Cardoso *et al.*, 2005).

Cassava tubers are processed by a wide range of methods to reduce their cyanide content, improve palatability and conversion of fresh root into stable products. The methods include peeling, chipping, grating, soaking, boiling fermenting and drying (Onabolu *et al.*, 2002; Obilie *et al.*, 2004; Amsalu *et al.*, 2008).

Cassava has moisture content of 60-70%, coupled with solubility of its cyanogenic glucoside, drying (dehydration) result to substantial reduction in the toxin. Traditionally drying is carried out using radiation from the sun (sun drying), this result to variation in the product hence poor quality of the final product. It facilitates continuous fermentation process; although cost effective, it is slow and encourages growth of mould and other microorganisms leading to aflatoxicosis and mycotoxic infection. Due to poor properties of sundried cassava, there is need for quicker drying methods to eliminate microbial infection, high quality end products and optimal cyanide detoxification

Drying is a unit operation targeted at removing nearly all water present in foodstuff. Cassava is dried when moisture within first move to the surface and then is removed into the surrounding air as water vapour and it is associated with water present in cassava root for prolonged shelf life thereby hindering both biochemical and microbial activities.

Onayemi and Oluwakomi (1987) reported that a wet cassava chip exposed to heated air undergo progressive loss of weight due to removal of water in three forms: first is the free water, the absorbed and finally the chemically

bound water; while energy requirement for the removal of water increase in that order that is the extent of moisture removal depend on temperature, air velocity and humidity of the drying air.

MATERIALS AND METHODS

Two varieties; TMS 30572 and TMS 98/0581 were used for the study. The method of peeling washing, draining, chipping and drying at various temperature and air velocity that is a four by four factorial were used to obtain the cassava chips from the two cassava varieties. The hydrogen cyanide content was determined.

Analysis of total HCN

Total HCN (ppm) in the flour was analyzed using the alkaline titration method as obtained from AOAC (1990). 4 g of sample ground to pass No. 20 sieve of each sample for both varieties was soaked in a mixture of distilled water (40 ml) and orthophosphoric acid. The samples were each thoroughly mixed and stored then left at room temperature overnight. This was done to set free all bounded hydrocyanic acid. The resulting sample (mixture) was then transferred into distillation flask and a drop of paraffin (antifoaming agent) was added to the broken chips. The flask was then fitted to other distillation apparatus and distilled. About 45 ml of the distillate was collected in the receiving flask containing 4 ml of distilled water and 0.1 g of Sodium Hydroxide pellets. The distillate was then transferred into 50 ml volumetric flask and make up to mark with distilled water, 1.6 ml of 5 % Potassium Iodide was added and titrated against 0.01M Ag(NO₃)₂. End-point is indicated by faint but permanent turbidity. The total HCN content in mg/kg was calculated as total

$$HCN \text{ content} = \frac{13.5 \times TV}{M}$$

Where;

TV = titre value

M = mass of sample

Experimental materials, treatments and procedures

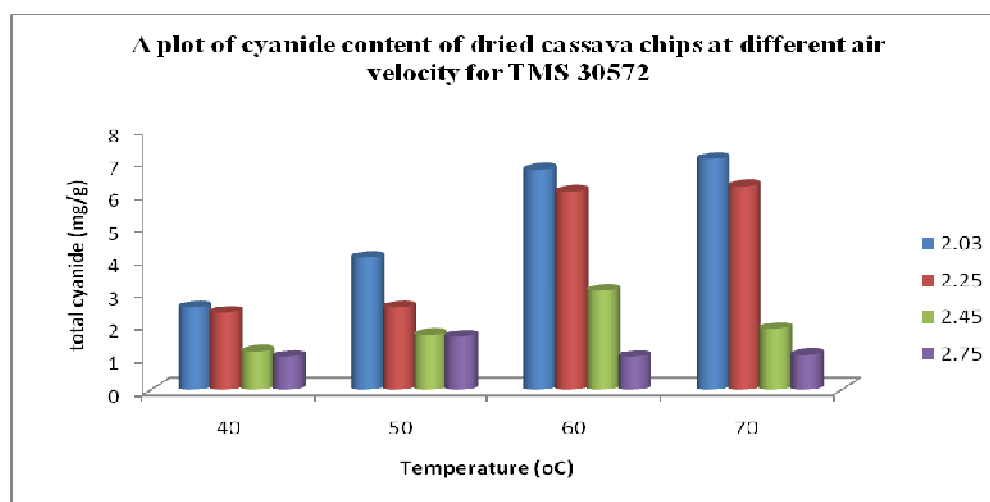
Cassava tubers were harvested, 12 months after planting from two varieties (TMS 30572 and TMS 98/0581). The tubers were peeled, immediately washed with tap water and drained. Cassava chips of the appropriate size were made from the sliced tubers and then subjected to four different drying temperature and air velocities. Following the aforementioned treatments, dried cassava chips was used for the experiment.

Statistical analysis

Total HCN was subjected to analysis of variance. The

Table 1. Cyanide content of dried cassava chips (TMS 30572) at specific air velocity (m/s) and different temperature

Temperature	Cyanide content mg/kg			
	2.03m/s	2.25m/s	2.45m/s	2.75m/s
40	2.53 ^a ±0.01	2.37 ^a ±0.02	1.18 ^a ±0.02	1.01 ^a ±0.02
50	4.05 ^b ±0.13	2.53 ^b ±0.02	1.68 ^b ±0.02	1.63 ^b ±0.06
60	6.75 ^c ±0.05	6.08 ^c ±0.02	3.04 ^d ±0.02	1.01 ^a ±0.01
70	7.08 ^d ±0.02	6.24 ^d ±0.01	1.87 ^c ±0.02	1.07 ^a ±0.11

**Figure 1.** Effect of air velocity (m/s) on the cyanide content (mg/kg) of dried cassava chips.

significant treatment means were compared using Duncan's multiple range test (DMRT) at $P < 0.05$. SPSS (17.0) – Statistical Package for Social Sciences was used for the analysis.

RESULT

The total HCN for both varieties at different temperatures and air velocities, here significantly different from each other ($P \leq 0.05$) in the total HCN content in each of the varieties tested. The total cyanide contents for fresh cassava tested were 7.96 mg/kg and 8.43 mg/kg for TMS30572 and TMS98/0581 respectively. Total HCN ranged between 0.59 to 7.43 mg/kg for both varieties (Table3).

Table 1 shows the total HCN (mg/kg) composition of dried cassava chips (TMS 30572) subjected to various drying temperature (40, 50, 60 and 70 °C) and air velocity (2.03, 2.25, 2.45 and 2.75 m/s) respectively. From the table, at temperature of 40 °C the total HCN reduces as the air velocity increases from 2.03 m/s to 2.75 m/s; air velocity of 2.75 m/s gave total HCN of 1.01 mg/kg, 1.18

mg/kg at 2.45 m/s, 2.37 mg/kg at 2.25 m/s while the highest value of 2.53 mg/kg occurred at 2.03 m/s. it also show that at temperature of 50 °C the highest HCN content of 4.05 mg/kg was recorded at a speed of 2.03 m/s while the least value 1.63 mg/kg occurred at air velocity 2.75 m/s. Temperature of 60 °C resulted to cyanide content ranging from 1.01 mg/kg to 6.75 mg/kg, it also shows that the HCN content drops rapidly as the blower speed increases from 2.03 m/s to 2.75 m/s. Air speed of 2.03m/s gave the highest HCN content of 7.08 mg/kg at temperature of 70 °C while the lowest is 1.07 mg/kg at air velocity of 2.75 m/s. The result shown on Table 1 indicates that for a particular temperature, the HCN content of dried cassava chips reduces as the air velocity increases which can be attributed to rapid moisture loss due to hydrolysis of linamarin as size reduces and the increase in blower speed aid the process. The samples at different drying temperature and specific air velocity shows that significant difference occurs among the total HCN but at air velocity 2.75 m/s, no significant difference occurs among dried samples at 40, 60 and 70 °C (1.01, 1.01 and 1.07 mg/kg respectively). Comparing the data on Table 1, it can be seen

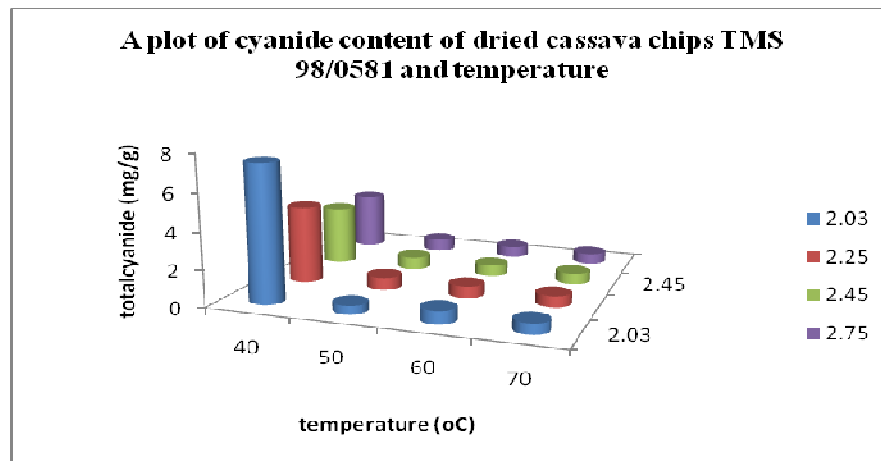


Figure 2. Effect of air velocity (m/s) on the cyanide content (mg/kg) of dried TMS 98/0581 cassava chips.

Table 3. Cyanide content of dried cassava chips from two varieties (TMS 30572 and TMS 98/0581) at specific air velocity (m/s) and different temperature

Temperature	Cyanide content mg/kg			
	2.03m/s	2.25m/s	2.45m/s	2.75m/s
40	2.53 ^c ±0.01	2.37 ^c ±0.02	1.18 ^d ±0.02	1.01 ^d ±0.02
50	4.05 ^d ±0.13	2.53 ^d ±0.02	1.68 ^c ±0.02	1.63 ^c ±0.06
60	6.75 ^e ±0.05	6.08 ^f ±0.02	3.04 ^e ±0.02	1.01 ^d ±0.01
70	7.08 ^f ±0.02	6.24 ^g ±0.01	1.87 ^d ±0.02	1.07 ^d ±0.11
40	7.43 ^g ±0.01	4.21 ^e ±0.01	3.21 ^e ±0.01	3.04 ^d ±0.06
50	0.45 ^a ±0.10	0.68 ^b ±0.02	0.67 ^a ±0.29	0.67 ^a ±0.05
60	0.68 ^b ±0.02	0.65 ^b ±0.01	0.63 ^a ±0.06	0.60 ^a ±0.09
70	0.59 ^b ±0.01	0.59 ^a ±0.02	0.59 ^a ±0.01	0.59 ^a ±0.03

*Means followed by the same letter are not significantly different from each other.

seen that at air velocity of 2.75 m/s, the lowest HCN content were observed at temperature of 40, 50, 60 and 70 °C which are 1.01 mg/kg, 1.63, 1.01 and 1.07 mg/kg.

Figure 2 shows the total cyanide content of dried cassava chips (TMS 98/0581) indicating that HCN reduces as temperature increases. HCN content ranges from 0.59 mg/kg to 7.43 mg/kg. Temperature of 40, 50, 60 and 70 °C at constant air velocity of 2.03 m/s has total cyanide content of 7.43, 0.45, 0.68 and 0.59 mg/kg respectively which are significantly different from each other. It shows that as temperature increases from 40 °C to 70 °C the HCN content was observed to reduce drastically. Air velocity of 2.25 m/s gave HCN values of 4.21, 0.68, 0.65 and 0.59 mg/kg for the same set of temperature and significant difference occur among the dried cassava chips. The least total HCN was observed at 70 °C (0.59 mg/kg). Pairing total cyanide content

recorded at air velocity of 2.03 m/s and 2.25 m/s indicates that as air velocity increases the cyanide content of the dried chips reduces. The HCN content of cassava chips subjected to drying at different temperature and air velocity of 2.45 m/s were 3.21, 0.67, 0.63 and 0.59 mg/kg, there was no significant difference between samples dried at temperature of 50, 60 and 70 °C but significant difference occur between them at 40 °C. Air velocity of 2.75 m/s used for drying chips gave the least value 0.59 mg/kg. The result on Table 2 shows that drying at temperature of 50, 60 and 70 °C and air velocity of 2.75 m/s can be used to achieve low HCN content.

Comparatively significant difference occurs among the two varieties (TMS30572 and TMS 98/0581). From Table 3 the HCN value for TMS30572 ranges from 2.53 mg/kg to 7.08 mg/kg while 0.59 mg/kg to 7.43 mg/kg for

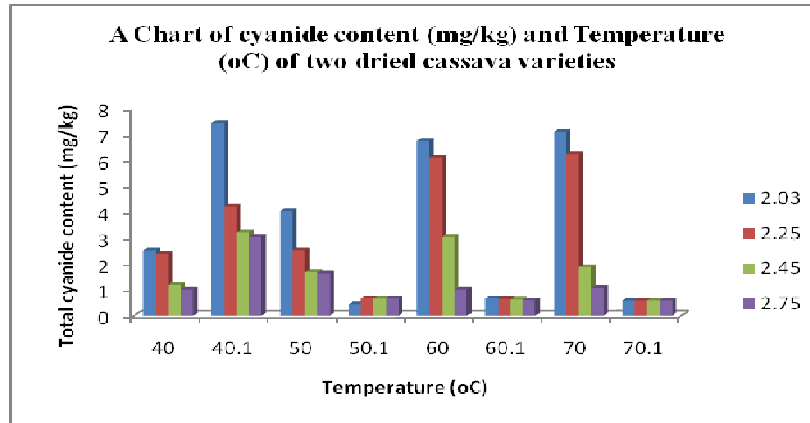


Figure 3. The two cassava varieties (TMS30572 and TMS98/0581)

TMS 98/0581 at air velocity of 2.03 m/s. Air velocity of 2.45 m/s for both varieties shows there is no significant difference between total cyanide contents of dried chips at 60 °C for TMS30572 and 40 °C for TMS98/0581. It can be concluded that high air velocity is required to aid temperature for even and rapid circulation of hot air to achieve reduced cyanide content in dried chips of both varieties.

The plot of cyanide against air velocity at constant temperature comparing both varieties show that temperature has much effect on variety TMS98/0581 with the least values occurring at 70 °C; highest HCN was seen at temperature of 40 °C.

Figure 1 shows effect of air velocity at a particular temperature on the cyanide content of dried cassava chips (TMS30572). The figure shows that at temperature of 40 °C, total HCN reduces as air velocity increases, reduction occurs gradually. The figure also shows that as temperature increased alongside air velocity the HCN value of the dried cassava chips reduced rapidly.

Figure 2 shows the plot of cyanide content of dried TMS98/0581 chips against temperature. The chart shows that increase in air velocity at low temperature has effect on the HCN content of the chips. It also shows that as temperature increases change in air velocity has little or no significant effect on the HCN content of dried cassava chips. At temperature of 70 °C from the chart air velocity has no significant effect on the HCN of the dried chips.

DISCUSSION

The remarkable reduction in total HCN content of the cassava chips recorded in this experiment might be due to enhanced hydrolysis process of cyanogenic glucosides by the enzyme linamarase. The significant contribution of increasing air velocity speed from 2.03 m/s to 2.75 m/s was apparent to induce hydrolysis as cyanide content in

the fresh cassava chips 8.19 mg/kg for TMS30572 and 8.43 mg/kg for TMS98/0581 were reduced to range between 7.43 mg/kg to 0.59 mg/kg and 7.08 mg/kg to 1.07 mg/kg respectively. Similar results were previously reported by Kemedirim *et al.*, (1995), Mulugeta and Eskinder (1999), Tivana and Bvochora (2005), Kobawila *et al.*, (2005) reported that *Lactobacillus* spp. is often time found to be associated with cassava tubers thus it might have significantly contributed to the observed total HCN reduction in this study. It can also be concluded that the higher the moisture content of the cassava the greater the loss in the cyanide content during drying. This was demonstrated by both varieties; TMS30572 has moisture content ranging between 62-67 % and TMS98/0581 67 - 69.5 %. The first variety retained the highest total cyanide while the other variety retained the lowest. Also cutting of cassava tubers into small chips might create easy access for contact between the enzymes and cyanogenic glycosides resulting in higher hydrolysis. Gomez *et al.*; 1984, Tivana and Bvochora; 2005 also gave similar reports. It might also be as a result of rate of moisture removal from an agricultural product which depends on their drying temperature, velocity and relative air humidity, variety and maturity and product sizes (Cock, 1985; Ade-Omowaye *et al.*, 2002) Kudra, 2004 stated that, wind is a fundamental factor during processing of cassava chips. This investigation pointed out that the retained HCN level in the cassava chips obtained after processing is very safe for human consumption especially for TMS 98/0581 since the HCN levels are very near to the WHO safe level of 10 ppm. Tivana and Bvochora (2005) also reported that cassava chips with 25 ppm HCN may be used to prepare a cassava flour meal without disorder to human health which is in agreement to the findings. Although different countries have different safe levels of HCN; the WHO has set a safe level of cyanogens in cassava flour as 10 ppm (FAO/ WHO, 1991). For example, the acceptable limit in Indonesia is 40 ppm (Adindu *et al.*, 2003; Cardoso *et al.*,

2005). In this study, this was apparent for the variety TMS 98/0581 which resulted in 0.59mg/kg after drying at temperature of 70 °C and air velocity of 2.7 5m/s. This investigation highlighted the importance of using high air velocity for drying cassava chips during cassava chips processing while drying with circulated air, the main role of this air is to pick up water vapour on the surface of the product (cassava chips). This means that the higher the speed of air the faster the rate of moisture removal resulting to rapid reduction in total cyanide content of the chips as demonstrated by both varieties as air velocity increases (Table 3). However, the result shows the importance of developing further processing techniques to reduce total HCN in the product.

CONCLUSION

The different air velocities and temperature used to obtain the dried cassava chips significantly affect the cyanide content of the different cassava varieties samples. The dried chips from TMS98/0581 at temperature of 70 °C had the least HCN level of 0.59 mg/kg. It also shows the importance of using improved method or technic to reduce HCN substantially.

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How to cite this article: Famurewa J.A.V. and Emuekele P.O. (2014). Cyanide reduction pattern of cassava (*mannihot Esculenta*) as affected by variety and air velocity using fluidized bed dryer. *Afr. J. Food Sci. Technol.* 5(3):75-80