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Cyanogenic Potentials of Some New Cassava Varieties as Affected by Harvest Age, Varietal Differences and Pre-treatment

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Abstract: *The cyanogenic potentials of three newly released cassava varieties (Ampong, Broni and Otuhia) were evaluated at different ages of harvest. The pH values and cyanide content of the flour produced from these cassava roots were studied to find out how they were affected by age, variety and pre-treatment. The pre-treatment method used were Chipping, toasting, chipping and steeping in citric acid, grating, and steeping in citric acid and toasting. Results obtained from the study showed that the cyanide content of the fresh roots were significantly affected by both age and variety while the pH and cyanide contents of the cassava flour were affected by age, variety and pre-treatment methods. The roots harvested at 14 months had the lowest cyanogenic potentials which is within the range of sweet cassava category. The cyanide content of the flour ranged from 2.48mgHCN$_{eqv}$/kg to 6.99mgHCN$_{eqv}$/kg which is within the range recommended as the maximum cyanide content level of cassava flour for safe consumption.*

Key words: *Cassava, cyanogenicglucoside, pH, pre-treatment, variety.*

I. Introduction

Cassava which is one of the most important staple foods in most West African countries is basically a major source of carbohydrate and contains other food nutrients such as fats, proteins, ash, moisture fibre, and some other trace elements in smaller quantities. Most of the cassava varieties arepotentially toxic when consumed in a raw state due to the presence of cyanogenicglucoside in the crop. Thecyanogenic potentials of cassava and its products aretherefore among the most important qualities that affect its use for production of derived food products[1]. While the pH value of the flour influences the taste of the derived food product, the cyanogenic potential of the cassava flour can be a limiting factor to its use for various food applications.

The toxicity of cassava is associated with its ability to release hydrogen cyanide from the stored cyanogenicglucosides[2]. The cyanide toxicity results from the conversion of the residual cyanogen in cassava to hydrogen cyanide inside the human body after consumption. The consumption of cassava with high cyanogen concentration can result to illness or even death depending on the concentration level. For the cassava roots to be safely used as food, it has to undergo various degrees of processing depending on the type of variety so as to eliminate or reduce the cyanogenic potential to a safe level of less than 10mg HCN equivalent per kg of cassava flour as recommended by the Food and Agricultural Organisation of the United Nations, World Health Organisation [3] and the African organization of standards [4].

Gomez et al.[5] reported that Cassava varieties grown under similar climatic conditions differ widelyinthecyanide content of the roots but thevariability is highly dependent on the age at harvest.

The objectives of this research work is therefore to evaluate the cyanogenic potentials of three newly released cassava mosaic disease (CMD) resistant cassava varieties and investigate the effects of various pre-treatment methods on the pH values and cyanide composition of the flour produced from these varieties.

II. Materials and Methods

2.1 Materials

The cassava tubers used for these studies were the newly released varieties planted on 25th march 2013 at the experimental farm of the Crop Research Institute Fumesua, Kumasi, Ghana and were harvested at 10 months; 12 months and 14 months after planting. The three cassava varieties used were *Ampong, Broni and Otuhia.*

2.2 Experimental design

A 3x3 factorial design in CRD (Completely Randomised design) was used for the evaluation of the effect of harvest age and varietal differences on the cyanide content of the fresh cassava roots while a 3x3x5 factorial design was used to investigate the effect of harvest age, variety and pre-treatment on the cyanide content and pH values of the processed cassava flour.The principal factors in the study were the harvest age, variety and pre-treatment.The data generated were statistically analysed using Genstat 12th edition.General Analysis of Variance (ANOVA) and mean separation were performed using Fischer's Least Significant Difference of means to determine significant differences at 5 % probability level.

2.3Processing of cassava flour

The cassava tubers were processed into flour at the Food and Post-Harvest Laboratory of Agricultural Engineering Department, Kwame Nkrumah University of Science and Technology Kumasi, Ghana.

Tubers from each of the three cassava varieties were divided into five portions, then washed and peeled. Each of the portions was subjected to a distinct pre-treatment prior to drying in a mechanically ventilating cross flow dryer pre-set to a temperature of 70°C. The pre-treatment were carried out in the following ways. For the first pre-treatment (T1), the tubers were chipped to a size of $10\times 10 \times 50$mm as recommended by Fioreze and Morini[6].

The second pre-treatment (T2) involved grating the tubers with mechanical grater, dewatering by placing under a load for about 15h, screening and then toasting in a toasting pan for 6min[7]. The third samples (T3) were chipped to size of $10 \times 10 \times 50$mm and steeped in citric acid solution (20%m/v) for 12hours[8].

For the fourth samples (T4), the cassava tubers were dewatered after grating, and kept under load for 15hours. The fifth samples (T5) were sliced and steeped in citric acid solution (20%m/v) before screening and toasting for 6min using a toasting pan. The pre-treated samples were dried to a constant weight in a mechanically ventilating cross flow dryer.

The dried samples were ground into fine flour with a laboratory mill and the excess fibres were removed by passing the flour through a 250µm sieve in accordance with the recommendations of the African Organization for Standardization[4].

2.4 Determination of the cyanogenic potential of the cassava samples

The cyanide content of the cassava samples was determined using the AOAC official titration method of [9]. Twenty grams (20g) of the Cassava sample was weighed into a Kjeldahl distillation flask. Two hundred milliliter (200ml) of distilled water was added into the sample and the mixture was allowed to stand for 3 hours. It was then distilled until 150ml of the distillate was obtained. Twenty milliliters (20 ml) of 0.02M sodium hydroxide was added to the distillate and the volume diluted to 250 ml in a volumetric flask using distilled water. 8ml of 6M ammonia solution and 2ml of 5% potassium iodide (KI) were added to 100 ml of the aliquot. This was titrated with a 0.02M silver nitrate (AgNO3) until an end point of faint but permanent turbidity (which is easily recognized especially against black background) was obtained.

The hydrogen cyanide content of the sample was then obtained using the following formula:

Cyanide content ($mgHCN_{eqv}$ /kg) = $0.54(V_0-V_1) \times (250/100) \times (1000/M) - 1350(V_0-V_1)/M$

Where M = mass in grams of the test sample

V_0 = Volume in millimeter of silver nitrate solution used for the titration proper

V_1 = Volume in millimeter of the silver nitrate solution used for the blank test.

2.5 Determination of the pHvalues of the cassava flour

The pH values give a measure of the acidity or alkalinity of a product. The pH values of the cassava flour were determined using EUTECH 510 pH meter. Five grams (5.0g) of the cassava flour sample was weighed into a beaker previously washed with distilled water. Twenty five millilitres(25.0ml) distilled water was measured into the beaker containing the sample and the content was intermittently stirred for about 20 minutes before allowing the mixture to stand for about 30 minutes. The sensor of the Eutech pH meter was then dipped into the settled mixture in the beaker and the pH value read out in the digital output meter.

III. Results and Discussions

3.1 The hydrogen cyanide content of the fresh cassava roots

The cyanogenic potential of any particular cassava variety partly determines the type of pre-treatment and processing the roots will undergo to make it safe for consumption. Fresh cassava roots with very high cyanogenic potential are expected to go through more elaborate processing than those with low cyanogenic potential.

The cyanide content of the three cassava varieties harvested at 10 months, 12 months, and 14 months are presented in table 1.The harvest age andvariety interaction on the cyanide concentration indicates significant differences ($p\leq 0.05$) between the samples. The cyanide content of *Broni* variety harvested at 14 months of age (38.34$mgHCN_{eqv}$/kg) significantly differed ($p\leq 0.05$) from the rest of the samples with the exception of *Ampong* variety harvested at 14 months with cyanide content of 42.17$mgHCN_{eqv}$/kg. The cyanide content of *otuhia* variety harvested at 10 months of age which had a value of 91.45$mgHCN_{eqv}$/kg was significantly higher (p>

0.05) than the rest of the samples.The harvest age × variety interaction also showed that cyanide content of *Ampong,Broni* and *Otuhia* varieties when harvested at 14 months were less than 50mgHCN$_{eqv}$/kg hence making them fall within the sweet or non – toxic class while those harvested at 10 and 12 months ranged from 51.61 mgHCN$_{eqv}$/kg to 91.45mgHCN$_{eqv}$/kg which is within the category of average toxic cassava roots. The two categories of the cyanide content implies that the roots harvested at 10 and 12 months require minimal processing while those harvested at 14 months require very minimal or no special processing before use.

Table 1 Effects of harvest age and variety on cyanide content of fresh cassava roots

Sample code	Age (months)	Variety	HCN (mg/kg)
A_{10}	10	Ampong	87.22
B_{10}	10	Broni	76.24
O_{10}	10	Otuhia	91.45
A_{12}	12	Ampong	56.34
B_{12}	12	Broni	51.61
O_{12}	12	Otuhia	58.69
A_{14}	14	Ampong	42.17
B_{14}	14	Broni	38.34
O_{14}	14	Otuhia	46.16
cv %			4.00
Lsd			4.13

A, B, O=Ampong,Broni and Otuhia respectively, subscripts 10,12,14 are harvest ages in months

3.2 The pHand Hydrogen Cyanide Content of pre-treated Cassava flour

Results of the analysis of variance on the data obtained from the pH and cyanide analysis of the flour indicates that the effect of age, variety and pre-treatment as well as the interaction were significant on the hydrogen cyanide content and the pH values of pre-treated cassava samples.

The interactions of harvest age, variety and pre-treatment presented in Table 2 below indicates that the cyanide content of flour from *Otuhia*variety harvested at 10 months with chipping pre-treatment (O_{10} T_1) having a value of 6.99mgHCN$_{eqv}$/kg was higher($p \leq 0.05$) than the value from all other samples while the flour from Broni Variety harvested at 14 months with citric acid and toasting pre–treatment ($B_{14}T_5$) had lower ($P \leq 0.05$) cyanide content (2.48mgHCN$_{eqv}$ /kg) than other samples. The three factor combinations generally produced cassava flour with cyanide contents in the range of 2.48mgHCN$_{eqv}$/kg to 6.99mgHCN$_{eqv}$/kg which is below the FAO/WHO [3] recommendation of 10mgHCN$_{eqv}$/kg maximum cyanide content in cassava flour for safe consumption.

The pH values of 6.960 and 6.970 from *Broni*Variety harvested at 10month and *Otuhia* Variety harvested at 14 months with chipping pre-treatment (B_{10}T1 and O_{14}T1 respectively) were significantly higher ($p \leq 0.05$) than the pH values of other samples while the flour samples from Ampong (5.473) and Otuhia varieties harvested at 10months and pre-treated by steeping chipped roots in citric acid (A10T3 and O10T3) had pH values of 5.473 and 5.500 respectively which were lower ($p \leq 0.05$) than the pH values of all other samples.

Table 2 Effects of age, variety and pre-treatment on pH and cyanide content of cassava flour

Sample code	Variety	Pre-treatment	Age (months)	HCN(mg/kg)	pH
$A_{10}T1$	Ampong	T1	10	6.40	6.6833
$A_{10}T2$	Ampong	T2	10	4.10	6.4433
$A_{10}T3$	Ampong	T3	10	4.56	5.473
$A_{10}T4$	Ampong	T4	10	3.14	6.4167
$A_{10}T5$	Ampong	T5	10	3.00	5.6933
$A_{12}T1$	Ampong	T1	12	6.14	6.7133
$A_{12}T2$	Ampong	T2	12	3.98	6.5333
$A_{12}T3$	Ampong	T3	12	4.38	6.6433
$A_{12}T4$	Ampong	T4	12	2.97	6.54
$A_{12}T5$	Ampong	T5	12	2.91	5.8933
$A_{14}T1$	Ampong	T1	14	5.97	6.8867
$A_{14}T2$	Ampong	T2	14	3.93	6.5933
$A_{14}T3$	Ampong	T3	14	4.32	5.77
$A_{14}T4$	Ampong	T4	14	2.82	6.6867
$A_{14}T5$	Ampong	T5	14	2.77	5.9233
$B_{10}T1$	Broni	T1	10	5.34	6.96
$B_{10}T2$	Broni	T2	10	3.92	5.92
$B_{10}T3$	Broni	T3	10	3.98	5.9533
$B_{10}T4$	Broni	T4	10	2.97	6.09
$B_{10}T5$	Broni	T5	10	2.70	5.8367
$B_{12}T1$	Broni	T1	12	5.18	6.8467
$B_{12}T2$	Broni	T2	12	3.86	5.9533
$B_{12}T3$	Broni	T3	12	3.92	5.99
$B_{12}T4$	Broni	T4	12	2.67	5.9867
$B_{12}T5$	Broni	T5	12	2.58	5.8033
$B_{14}T1$	Broni	T1	14	5.14	6.72
$B_{14}T2$	Broni	T2	14	3.83	5.9733
$B_{14}T3$	Broni	T3	14	3.88	6
$B_{14}T4$	Broni	T4	14	2.61	6.0267
$B_{14}T5$	Broni	T5	14	2.48	5.9033
$O_{10}T1$	Otuhia	T1	10	6.99	6.9033
$O_{10}T2$	Otuhia	T2	10	4.52	5.8
$O_{10}T3$	Otuhia	T3	10	4.61	5.5
$O_{10}T4$	Otuhia	T4	10	3.07	5.95
$O_{10}T5$	Otuhia	T5	10	2.97	5.7033
$O_{12}T1$	Otuhia	T1	12	6.90	6.91
$O_{12}T2$	Otuhia	T2	12	4.13	5.8633
$O_{12}T3$	Otuhia	T3	12	4.40	5.5967
$O_{12}T4$	Otuhia	T4	12	2.97	6.0233
$O_{12}T5$	Otuhia	T5	12	2.91	5.91
$O_{14}T1$	Otuhia	T1	14	6.81	6.97
$O_{14}T2$	Otuhia	T2	14	4.02	5.8633
$O_{14}T3$	Otuhia	T3	14	4.38	5.62
$O_{14}T4$	Otuhia	T4	14	2.93	6.05
$O_{14}T5$	Otuhia	T5	14	2.88	5.98
cv (%)				2.20	0.3
L.s.d				0.14	0.03156

CV=Coefficience of variation,L.s.d.=Least significant difference.A,B ,O=Ampong,Broni and Otuhia cassava varieties subscript 10,12 and 14 = ages in months, and T1 to T5=pre-treatments

IV. Conclusion

The cyanide content of fresh *Ampong*, *Broni* and *otuhia* cassava tubers harvested at 14 months were lower($p \leq 0.05$) than those harvested at 10 months and 12 months.These varieties can therefore be classified as sweet or non-toxic when harvested at 14 months since the values were lower than 50 $mgHCN_{eqv}/kg$ fresh weights identified as threshold for non-toxic fresh cassava tubers.

The three cassava varieties produced flour with low cyanide content of2.48 $mgHCN_{eqv}/kg$ to6.99$mgHCN_{eqv}/kg$. These values are below the WHO/FAO [3] recommendation (of cyanide content not greater than 10 $mgHCN_{eqv}/kg$ dry matter of cassava flour) and hence could be safely consumed by humans without any fear of cyanide toxicity.

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