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Assessment of copper residue in cocoa pods and beans in cocoa growing areas in the central region of Ghana

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ABSTRACT

Copper concentrations in cocoa pods and beans in samples of cocoa collected between February and March 2000 from eleven cocoa growing towns in the central Region of Ghana were determined. In all a total of three hundred samples were taken randomly from preselected farms. Copper fungicides were applied in ten of the farms and the eleventh farm where there was no application of copper fungicide served as a control. Analysis for copper was done using atomic absorption spectrometer. The concentration of copper in the pods ranged from 0.02 to 0.39mg kg^{-1} with an average of 0.22mg kg^{-1} while the range in the beans was 0.01 to 0.22mg kg^{-1} with an average of 0.13mg kg^{-1}. The pod thickness ranged from 0.60 to 1.20cm with an average of 0.90cm. The ratio of copper levels in the cocoa pods to the levels in the beans ranged from 1.33 to 2.67. Averagely, the concentration of the copper in cocoa fruit indicated a higher accumulation of the element in the pods than in the beans with 62% of the total copper concentration in the cocoa fruit contained in the pod while 38% was observed in the beans. A positive significant ($P<0.05$) correlation existed between concentration of copper in the beans and cocoa pods. Similarly, a positive significant correlation existed between the beans copper concentration and pods thickness as well as pods copper concentration and pod thickness ($P<0.05$).

Key Words: Cocoa Pods, Cocoa Beans, Copper fungicides, atomic absorption spectrometer, Central Region,

INTRODUTION

Ghana is the second largest world supplier of cocoa after Cote d'Ivoire. Since 2001, the volume of cocoa produced in the country has grown at unprecedented rates (at a yearly average of 11% between1994–99 and 16% in the following 2000–03 interval) [1].

Cocoa capsids are some of the most destructive pests of cocoa in West Africa. A single capsid produces up to 36 pricks from sucking within 24hours. It was estimated that capsids caused annual losses of about 70,000 tons of cocoa pods in the whole of West Africa cocoa growing region [2]. One fungal disease alone is thought to cause a loss of crop amounting overall to some 10 per cent, rising in some localities to 80 percent and if uncontrolled could seriously damage the economies of several countries [3]. Farmers are progressively integrating fertiliser use and application of fungicides. The level of copper in cocoa fruit is of interest due to the application of copper fungicides such as Kocide 101 (cupric hydroxide 77%), Copper Nordox (cuprous oxide), Champion (Cupric Hydroxide 77%), Ridomil (Copper Oxide 60%) and Caocobre Sandoz (50% Copper Oxide) to combat the attacks of various cocoa diseases. However in many cases hazardous residues are left, becoming a permanent danger to quality of food, environment and consumers' health and for that purpose their determination is a priority goal [4]

Traditionally, raw cocoa beans are sometimes eaten for their flavonoids, which studies by Eric Ding, et. al., suggest improve cardiovascular health**.** Flavonoids are degraded by processing and cooking the cocoa bean, so eating chocolate bars and cakes will not offer the same potent benefits [5]. Cocoa pod husks are useful, after removing the beans; they are dried, crushed and mixed with other poultry feeds. Husks are used as organic fertilisers and in liquid soap making. They are burnt to ash, dissolved in water and boiled, then filtered to get liquid soap. The liquid that comes out with pulp is used to make cocoa juice, wine and jam [6]. The bitter stimulant (hot chocolate beverage) was made of crushed, ground cocoa pods, beans, and nibs with added spices native to the tropics in the local area [7].

Cocoa beans are used traditionally for their medicinal powers to heal fevers, coughs, and pregnancy discomforts such as morning sickness. A raw cocoa powder when dissolve in hot water is believed to cure cough and also to fight tooth decay. The raw cocoa powder dissolved in hot water and mixed with honey is thought to cure asthma. Again, the hot solution of the raw cocoa powder and hot water mixed with ginger is used locally to treat sore throat. Because of their nutritional value cocoa bean shells and the pod husk are used as animal feed materials for livestock such as cattle. Meat from such animals can be a source of copper for the consumers system.

The objective of this research was to determine the level of copper residue in the cocoa fruit since copper accumulation can lead to Wilson disease. Wilson disease a genetic disorder that prevents the body from getting rid of extra copper. In Wilson disease, copper builds up in the liver, brain, eyes, and other organs. Over time, high copper levels can cause life-threatening organ damage [8]. Excessive copper intake can cause nausea, vomiting, stomach pain, headache, dizziness, weakness, diarrhea, and a metallic taste in the mouth. Copper toxicity is rare but can cause heart problems, jaundice, coma, and even death [9].

EXPERIMENTAL SECTION

Random sampling techniques were adopted to select cocoa farming communities and farms where copper fungicides had been applied in each community. Samples of cocoa fruits were collected from Jukwa (Ju), Twifo Manpong (TM), Edumfa (ED), Wawase(WW), Brase (BRA), Brema Ahumase(BA), Bisease (BI), Effutuakwa(EFF), Dominase (DO),Ajumako Kokoben(AK),

and Abura Dunkwa(AD). In all eleven cocoa farms in different villages/town in Central Region were analysed. In Edumfa no copper fungicide was applied.

The cocoa pods were split and beans removed and dried by spreading on concrete surfaces and regularly turned for one month. The dried pods and beans were ground in a stainless steel blender separately and stored for analysis. 2.5 g of each of the pod and bean were weighed in acid washed porcelain crucibles, heated gradually to and maintained at 250°C for 2 hours, and thereafter heating continued at 450°C for 16 hours in an muffle furnace. The ashed products were then wetted with deionized distilled water, treated with 5 cm^3 concentrated HNO_3, evaporated to dryness on a steam bath, and returned to the furnace at 450°C for 1 hour. The resulting ash was then digested with 5 cm^3 of redistilled 6M HCI and made up to 25cm^3 with deionized distilled water. The resulting solutions were analysed for Cu using Atomic Absorption spectrometer (AAS) Shimadzu model 6401F at wave lengths of 324.8nm All the samples were prepared in replicates of four. To determine the suitability of the sample preparation and analysis method, samples of cocoa beans and pods were spiked with 1µg g^{-1} sample of Cu. All the spiked samples were quadruplicated and subjected to the same preparation and analysis procedures as the unspiked samples.

RESULTS AND DISCUSSION

Recovery and reproducibility studies

The percentage of copper recovered in the reproducibility studies ranged from 96.3 ± 0.220% to 99.3.± 0.24%. The standard error is less than 0.5, suggesting that the method employed to analyse copper is reproducible.

Table 1 Mean concentration of copper in cocoa pods and beans, (mg/kg), and width of pod (cm)

Sample Site	Pod	Bean	Width of Pod/cm	Pod/Bean
DO	0.28 ± 0.01	0.18 ± 0.01	0.75	1.56
TM	0.24 ± 0.02	0.09 ± 0.01	0.90	2.67
BRA	0.16 ± 0.01	0.12 ± 0.01	1.20	1.33
AD	0.24 ± 0.02	0.16 ± 0.01	0.90	1.50
JU	0.16 ± 0.01	0.08 ± 0.01	1.20	2.00
EFF	0.26 ± 0.01	0.16 ± 0.01	0.80	1.63
WW	0.18 ± 0.01	0.16 ± 0.01	1.00	1.13
BI	0.18 ± 0.01	0.13 ± 0.01	1.00	1.38
BA	0.39 ± 0.02	0.15 ± 0.20	0.60	2.60
AK	0.26 ± 0.01	0.22 ± 0.03	0.80	1.18
ED	0.02 ± 0.01	0.01 ± 0.01	0.70	2.00

Table 2 Statistical Relationship between values

Sample	MEAN	STD	t=2.516
Pod (mg/kg)	0.22	0.09310	
Bean (mg/kg)	0.13	0.05676	P<0.05
T - test Cocoa Pod Thickness with			
Pod copper concentration	t=9.166	P<0.05	
Beans copper concentration	t =10.839	P<0.05	

Table 3 USA recommended daily intake of Copper

AGE	recommended daily (mcg) intake	mg
0-6month	200	0.20
7-12	220	0.22
1-3	330	0.33
4-8years	440	0.44
9 - 13 years	700	0.70
14-18years	890	0.89
19 years and older	990	0.99
pregnant females	100	1.0
breastfeeding females	1300	1.3

NB: 1mcg=.001mg

The concentration of copper in the pods ranged from 0.02 to 0.39mg kg^{-1} with an average of 0.22mg kg^{-1} while the range in the beans was 0.01 to 0.22mg kg^{-1} with an average of 0.13mg kg^{-1}. The concentration of the copper in cocoa fruit indicated a higher accumulation of the element in the pods than the beans. 62% of the total copper concentration of the cocoa fruit was contained in the pod while 38% percent was in the beans. The pod thickness ranged from 0.5 to 1.20cm, with an average of 0.88mg kg^{-1}. As observed, the greater the thickness of the pod the lower the copper level and vice versa (Table 1). This may be due to the fact that during spraying fungicides may be absorbed directly on the pods. The greater the thickness of the cocoa pods the lower the levels of copper observed, leading to less subsequent translocation of copper in the beans. The ratio of copper level in the pod to the copper level in the bean ranged from 1.33 to 2.67 mg kg^{-1}. The pod copper concentration to the bean copper concentration ratio provides an index of the element's absorption and distribution in the components of the cocoa fruit. The higher this ratio the lower the absorption and translocation of copper in the beans and greater in the pod and vice versa (Table1). The ratio indicated that higher efficient translocation of absorbed copper into the beans sampled follows the deceasing order of WW>AK>BRA>BI>AD >DO>EFF>JU>BA>TM. Application of copper fungicides increased copper levels by 8 to about 20 times in the pod and16 to 22 times in the beans.

There was variability in the concentration of copper in the fruit but this variability is very small in the beans (standard deviation = 0.05676) compared with variability in the concentration of copper in the pods (standard deviation = 0.09310). The results in Table2 showed a significant ($P<0.05$) positive correlation existed between concentration of copper in bean and cocoa pod. Similarly, a positive significant correlation existed between the beans copper concentration and pods thickness as well as pods copper concentration and pod thickness ($P<0.05$).

CONCLUSION

The analysis method used in the present study was found to be suitable for the determination of copper in cocoa beans and pods.

The levels of copper in the pods were high than the levels observed in the cocoa beans. The mean values observed were 0.22 and 0.13 mg kg^{-1} for the pod and the beans respectively compare with the recommended intake of copper for healthy adult men and women in North

America is 0.9 mg/day[10] and the World Health Organization recommends a minimal acceptable intake of approximately 1.3 mg/day [11]

It is obvious from the result that farmers who eat the raw beans or use the powdered dry cocoa beans and pods from these farms as beverages, medicine or any alternative raw use of the fruit are not at risk. But compare to USA recommended daily intake (Table 3) children between 0-1year from DO, TM, EFF,AD, BA and AK are at risk if they are exposed to any of the known traditional uses of cocoa pods. The mean copper concentrations in the cocoa pod and beans were lower than mean concentration of available copper (0.265 mg kg^{-1}) observed in the soils analysis from the same farms [12].

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