CHEMICAL COMPOSITION AND POTENTIAL USES OF PROCESSING WASTES FROM SOME NIGERIAN CASH CROPS[1] /

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Resumen

Se incluye la composición aproximada de proteína cruda, fibra cruda, ceniza, sodio, potasio, fósforo y otros elementos menores de pulpa y pergamino de café, cáscara de cola, mucílago de la nuez de cola, pulpa del pseudofruto de marañón, pulpa de nues de cacao y cáscara de cacao. El alto contenido de humedad y fibra cruda pueden limitar el consumo directo por los animales de estos productos aunque el ensilaje de los mismos podría mejorar su valor alimenticio. Las cenizas son pobres en Mn, Cu y Zn pero ricas en Ca, N, K, Na, P, Fe y Mg; por esta razón, podrían utilizarse en la industria local de jabones o como fuente de fertilizante orgánico. Se sugiere su posible utilización como materia bruta para la producción de pectinas, jaleas y colorantes de alimentos.

Introduction

Cocoa, coffee, cashew and kola represent agricultural crops of significant economic importance to Nigeria. The income obtainable by the farmers from the sale of cocoa and coffee beans, cashew and kola nuts is still the main reason for cultivating the crops. However, large quantities of field processing wastes, such as pod husks and apple pulp are usually discarded and left to rot in farms and plantations all over the country. In addition, substantial amounts of coffee pulp with parchment and cocoa bean testa are left to waste in Nigeria Coffee Mills and Cocoa Processing Industries respectively. Cashew apple pulp is as yet not available as a distinct waste in Nigeria because the processing of cashew apple on commercial basis has not started. Some of the apples are only picked and sold to individuals who suck the juice and throw away the pulps. Certainly, large quantities of apples are still left behind to rot under the trees in the cashew farms. This observation supports the claim by Ohler (12) who reported that annually the greater part of about 2.5 to 5 million tons of cashew apples is left unused under the trees, and that this volume will increase sharply in the coming years with the increased area planted to cashew. The availability of these by-products in such quantities warrants efforts to develop profitable uses for them in order to provide extra income to the farmers.

Apart from the traditional use of alkaline ash from cocoa pod husk for the manufacture of crude soap (3), it has already been used to a limited extent for feeding farm animals (1, 2, 9), and as fertilizer and nematicide (6). Similarly, coffee pulp has been used as organic fertilizer or animal feed (5). The possibility exists however, that other available field or industrial wastes could be similarly used.

The chemical compositions of cocoa pod husk (3, 13), coffee pulp and parchment (5), kola pod husk and kola nut testa (14) and cashew apple (12) have been reported. However, very little information is available on the elemental composition of some of these processing wastes.

The objective of the present study, therefore, was to investigate the proximate and elemental composition of field or industrial processing wastes from cocoa, coffee, kola and cashew with the hope that the results would suggest ways in which they could be utilized profitably.

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Materials and methods

The cocoa pod husks used in this study were obtained from fresh cocoa pods of F_3 Amazon after the pulps and beans were removed The bean testa were obtained after fermentation of the beans. The fresh coffee berries of *Coffea canephora* (robusta) were depulped manually immediately after harvest. The coffee beans were air-dried until the parchment (endocarp) could be removed The kola fruits of *Cola nitida*, Vent. (Schott and Endlicer) were harvested and the pods opened with a knife The husk, testa and nuts were separated. These samples were obtained from experimental plots in Onigambari Headquarters and Owena Sub-station of Cocoa Research Institute of Nigeria. Cashew-apples (pseudo-fruit) were obtained from Iwo and Eruwa plantations. The juice was extracted with a Zyliss juice squeezer and the residual pulp air-dried. Except otherwise stated, all the analyses reported in this work were carried out on ground, oven-dried (65°C for 24 h) samples.

Proximate analysis for moisture, ether extract, crude protein, crude fibre, ash, nitrogen-free-extract were done according to the methods described in the official methods of Analysis of the Association of official Analytical Chemists (4).

Elemental analysis was donde by ashing 0.5 g portion of sample at 550°C in a muffle furnace. The ash was dissolved in 5 cm^3 of 4N-HCl and made up with distilled, deionized water to 100 cm^3. Sodium and potassium were measured on portions of this solution using a Corning 400 Flame photometer. The other elements were measured on a Perkin-Elmer Atomic Absorption Spectrophotometer (Model 703) using appropriate hollow – cathode lamps. Phosphorus was determined by an automated version of the molybdophosphate/ascorbic acid method using the Technicon Auto-analyzer modular equipment. The molybdophosphate was reduced with ascorbic acid and the absorbance measured with a Technicon Colorimeter equipment with a continuous flow cell and filter with a nominal wavelength of 660 nm.

Results and discussion

The quantities of the by-products expressed on a fresh weight basis as obtained in the laboratory are shown in Table 1. From 498.33 g of fresh cocoa fruit, 385.65 g of cocoa pod husk were obtained after removing the beans, placenta and the mucilage, which on a wet-weight basis represented 77.39% of the weight of the whole fruit. The beans were fermented and the testa removed immediately after fermentation From 81.54 g of beans obtained after fermentation, 20.92 g constituted the bean testa which represented on wet-weight basis about 25.66% of the total bean weight and 4.33% of the whole fruit. The proportion of by-products of coffee, cashew, and kola in relation to the whole fruit were obtained as described for cocoa. It must be emphasized that although coffee pulp and parchment were separately removed from the fruit for analyses in the present study, *Coffea canephora* (robusta) is processed by the dry method in Nigeria. Consequently, both the pulp, parchment and dry matter from the mucilage come off together in the course of shelling and are available as such in the premises of the Coffee Mills. Furthermore, cocoa bean testa is not a field processing waste because it is not removed until after the beans have been roasted in the Cocoa Processing Industries.

Table 1. Percentage content of various components in freshly harvested fruits; the percentage moisture and dry matter of each component.

Component*	Proportion (%)	Moisture (%)	Dry Matter (%)
Coffee pulp (*C. canephora* Pierre)	44.30	75.45	24.55
Coffee parchment (*C. canephora* Pierre)	10.80**	5.66**	94.34
Kola pod husk (*C. nitida*)	46.80	82.90	17.10
Kola-nut testa (*C. nitida*)	14.98	89.20	10.80
Cashew-apple pulp (red)	77.60	85.40	14.60
Cashew-apple pulp (yellow)	77.80	84.20	15.80
Cocoa-bean testa (F_3 Amazon)	4.38	78.48	21.52
Cocoa pod husk (F_3 Amazon)	77.39	82.62	17.38

* Each value represents the mean of six determinations.

** Value expressed as g/100 g of dry sample.

The data in Table 1 show that fairly large proportions of each fruit constitute undesirable waste products in the economy of production of the fruits. The problems of disposal and contamination of the environment coupled with scarcity of fertilizers and animal feed in the country make it necessary to give more attention to these field and industrial processing wastes.

All the samples were high in moisture ranging from 75.5 g/100 g of fresh sample of coffee pulp to 89.2 g/100 g fresh sample of kola nut testa. The high moisture content may necessitate the drying of some of these materials, particularly cashew apple, at the farms before being transported for use.

Representative values of the proximate chemical composition of each processing waste are given in Table 2. The values for crude protein ranged between 5.6% in cocoa pod husk to 15.0% in coffee pulp

The crude fibre content of most materials were high and this coupled with the high moisture content may be the main drawback in direct use of these materials as animal feeds. However, some of these processing wastes have been successfully fed to farm animals with significant savings in feed cost per unit body weight gain, milk or egg production. Adeyanju *et al.* (12) and Hutagalung *et al.* (10) found that cocoa pod husk could economically make up to 25% of maintenance rations for sheep and goats, about 30% in the growing/finishing diets for pigs and 20% in poultry layer's mash without any serious deleterious effects. The results of various studies reported by Cabezas, Jarquin and Braham (5) suggest that coffee pulp could be a useful feedstuff for ruminants, swine and poultry. Coffee pulp could be profitably incorporated at levels between 20% and 30% of the ration of beef cattle, 20-40% of the concentrate for dairy cattle and 16% in swine ration without any detrimetal effect on weight gain, milk production and feed conversion. To obtain better results, one study recommends the gradual introduction of coffee pulp into the rations. Ogutuga (14) has suggested that the protein in kola pod husk or kola nut testa can be extracted and used as protein concentrate for animal consumption. Furthermore, Olubaja (personal communication) has observed that beef cattle were fed with fresh cashew apple at Upper Ogun cashew plantation without any significant deleterious effect. In view of these various feeding trials, the processing wastes could find some use as cheap substitutes for some ingredients in compounded feeds. However, because of the relatively low crude protein and high crude fibre content, they seem to be more suited for feeding ruminants (1, 2, 4). It has been suggested that breeding or specialized processing methods could be used to reduce the crude fibre content of the waste products and thus improve their feeding value. Furthermore, the processing wastes may be rendered more suitable for animal feeding by ensiling in pit silos. The use of coffee pulp silage as an animal feed has been discussed by Murillo (11). It was established that coffee pulp silage is not nutritionally worse than fresh coffee pulp, and that when coffee-pulp silage has been found wanting, it is probably due to the drying of the silage by sun exposure. The results of various feeding trials led Murillo (11) to conclude that ensiled coffee pulp produces better performance than

Table 2. Chemical composition of the processing wastes.

Component*	Average composition (dry matter %)**				
	Total Ash	Crude Protein (% Nx 6.25)	Crude Fibre	Ether Extract	Nitrogen free Extract
Coffee pulp	5 70	15.00	23.8	3.75	42.71
Coffee parchment	1 74	10 05	24.69	0.48	51 78
Kola pod husk	5 97	6.25	12 24	0 95	68 01
Kola nut testa	7.63	10 31	10 20	0 87	62 47
Cashew-apple pulp (red)	2.45	9 69	13.25	4.65	59.35
Cashew-apple pulp (yellow)	4.70	8.44	11 90	6 35	56.96
Cocoa-bean testa***	7.77	13 13	14 84	2.28	53.56
Cocoa pod husk	10.97	5.63	28 2	3.54	39.82

* The varieties analyzed were those indicated in Table 1

** Each value represents the mean of six determinations.

*** Not a field processing waste (see text).

dehydrated pulp, due possibly to its better palatability, better digestibility, and lower content of caffeine and tannins. The ensiling process involves simple technology and can be effectively used by both farmers and processors. This means that these processing by-products could be stored during the harvesting season and used later as fresh or dehydrated silage.

Some compounds such as tannins, caffeine, theobromine and other polyphenols present in these processing wastes could adversely affect the voluntary feed intake, digestion and metabolism of the animals. Furthermore, the different pesticides applied during the development of the fruits may also have similar adverse effects on perfomance of the animals. The effects of caffeine and tannins, as well as their interaction on farm animals fed with coffee pulp have been reported by Bressani (5) and shown to decrease palatability, reduce digestibility of coffee pulp protein and increase urine output. Chlorogenic acid has also been shown to cause increased motor activity in ruminants and rats with the ultimate effect of decreasing weight gain and feed conversion efficiency. It has been reported however, that the distribution of these polyphenols in the fruit varies and there are more in the beans, nuts and testa than in the husks or pulps (8, 9, 16). The possible effects of these polyphenols and pesticides should be taken into consideration in the use of these processing wastes as animal feed. Murillo (11) has reported that, tannis and caffeine decreased significantly during ensiling in pit silos. Both compounds are water soluble hence, they could be lost in the draining liquid. Thus, ensiling could prove to be of some benefit in reducing the adverse effects of these polyphenols on animals fed with the processing wastes.

Table 3 shows the elemental composition of the different field and industrial processing wastes.

Coffee pulp contained the lowest amount of potassium being 1.2 g/100 g of dry sample while kola pod husk contained the highest (5.1 g/100 g of dry sample). Ankrah (3) has discussed the use of cocoa pod husk as an ingredient in traditional soap making in Ghana. This is due to the high potassium content of other processing wastes reported in this paper suggests that they could be similarly utilised for soap making.

The ashes of the processing wastes were poor sources of manganese, copper and zinc but rich in calcium, phosphorus, sodium, iron and magnesium.

It should be expected, however, that the compositional values reported in this paper will change according to variety of crop, location, season and agricultural practices. The organic matter of these waste products contains high amounts of nitrogen and potassium (Table 3).

Since the organic matter content of tropical soils is rapidly depleted because of high year-round bacteriological activity, the possible use of these processing wastes as organic fertilizer could be an invaluable gain to Nigerian farming.

Greenwood-Barton (8) had earlier suggested the use of cocoa pod husk as fertilizer in cocoa planta-

Table 3. **Elemental composition of the processing wastes.**

	Average Composition (mg/100 g of dry sample)**									
Component*	**Nitrogen**	**Na^+**	**K^+**	**Ca**	**P**	**Fe**	**Mg**	**Mn**	**Cu**	**Zn**
Coffee pulp	2.4	98.0	1.2	286.0	120.0	18.0	65.0	0.0	2.8	3.4
Coffee parchment	1.5	86.0	1.3	172.0	72.0	7.0	39.4	0.0	12.0	13.5
Kola pod husk	1.0	58.3	5.1	500.0	170.0	14.0	21.6	4.0	0.0	3.2
Kola-nut testa	1.7	29.2	4.7	650.0	180.0	38.0	23.6	4.0	3.2	7.0
Cashew-apple pulp (red)	1.6	858.0	2.7	412.8	160.0	16.4	568.0	1.3	3.7	5.1
Cashew-apple pulp (yellow)	1.4	741.3	2.5	362.7	158.0	14.7	567.2	1.5	3.3	3.3
Cocoa-bean testa***	2.1	47.1	4.4	600.0	320.0	10.0	16.8	8.0	0.0	2.4
Cocoa pod husk	0.9	131.7	4.8	164.0	90.0	4.0	5.6	2.0	3.0	3.4

* The varieties analysed were those indicated in Table 1.

** All values were expressed as mg/100 g of dry sample except values for nitrogen and potassium which were expressed as g/100 g of dry sample.

*** Not a field processing waste (see text). Each value represents the mean of six determinations.

tions, but feared that it might serve as a reservoir for the fungus *P. palmivora* the causal agent of black pod disease of cocoa. However, Egunjobi (6) has shown, that the use of cocoa pod husk as soil amendment resulted in an increase of 122% in maize yield, 59% reduction in soil population of the nematode, *Pratylenchus brachyurus* and tolerance by maize to other diseases like leaf streak. The increase in growth and yield of maize, as well as, reduction in soil population of *Pratylenchus brachyurus* were directly correlated with the levels of cocoa pod husk amendment. The effects of cocoa pod husk in the soil persisted beyond the first maize cropping and probably beyond the second one. The results of Egunjobi (6) suggest that besides controlling certain nematodes and improving nutrient status of the soils, cocoa pod husk probably aslo improves the soil structure.

The value of cocoa pod husk as an organic fertilizer for maize has been further established recently by Oladokun and Olukotun (personal communication) who obtained bumper harvest after application of dried and powdered cocoa pod husk to maize plots. Suárez de Castro (14) has indicated that 45 kg of dried coffee pulp is equivalent, on the basis of its chemical composition, to 4.5 kg of an inorganic fertilizer 14-3-37 or to 9 kg of 7-1.5-18.5. This reflects the high potassium content of coffee pulp. Various other experiments have indicated that coffee pulp is a valuable organic fertilizer particularly for the coffee tree. The present work has similarly shown that, on the basis of the elemental composition of these processing wastes, they may be useful as organic fertilizers. This is particularly important in the case of cocoa bean testa and kola nut testa in which high amounts of theobromine and caffeine respectively may drastically limit their use as animal feed. Handling could be a problem in the use of some of these waste products as fertilizer because of the high moisture content. In cases where transportation costs permit, the fresh material could be applied directly to the soil. Alternatively, they may be dried and milled before application.

Ogutuga (14) has indicated that kola pod husk and also kola nut testa contain high amount of pectin which can be extracted and used in jam and jelly production. The preparation of pectin and jam from cocoa pod husk has also been reported (15). Furthermore, Awolumate (CRIN Annual Report, 1981) has studied the chemical composition of a greyish-brown mucilage extracted from cocoa pod husk. The characteristic sugar composition of the mucilage suggests a strong similarity to pectin, and consequently, may provide an alternative source of industrial raw materials for the production of jams, jellies, and similar types of foods. Bressani (5) has also reported that coffee-berry mucilage is very rich in pectic substances, which could yield pectins. However, recovery is made difficult by the large volumes of water involved in pulping and washing operations and recycling or use of coffee pulp as the raw material was therefore suggested. It seems therefore, that the possibilities of obtaining pectin from these sources are promising.

In another study, Awolumate (unpublished data) has successfully extracted a colouring matter from the outer pericarp of fresh cocoa pod husk. Although the major anthocyanin pigments and flavonoids have not been identified, the compound is readily soluble in water/acetone to form a golden yellow solution. Furthermore, Ogutuga (14) has also obtained a reddish extract from red kola nuts. It was observed that the colour became deeper when the compound was extracted with 1% HCl in methanol. Both coffee pulp (5) and cashew apple skin (7) are known to contain a considerable amount of polyphenols. Since most food colours currently being used in the country are imported, further investigation into the colouring matters of these field and industrial processing wastes appears economically justifiable.

This paper has shown the relative richness of coffee, kola cashew and cocoa processing wastes in both crude protein, nitrogen-free-extract, major cations and trace elements. Therefore, these materials may have useful industrial applications. However, because of the relatively high price paid for beans and nuts, there has been little interest in the industrial utilization of these field and industrial processing wastes. The present studies have further indicated possibilities that these processing wastes could be used as a relatively cheap source of organic fertilizer, animal feed or as raw materials for the isolation of specific substances.

Abstract

The proximate composition of crude protein, crude fibre, ash, sodium, potassium, phosphorus and other trace elements of coffee pulp and parchment, kola pod husk, kola nut testa, cashew-apple pulp, cocoa-bean testa and cocoa pod husk are reported. The samples are high in moisture and crude fibre hence they may be of limited use for direct animal feeding but ensiling could improve their feeding value. The ashes are poor sources of Mn, Cu, and Zn but rich in Ca, N, K, Na, P, Fe and Mg. Therefore, they could be useful in the local soap industry or as sources of organic fertilizer. Possible uses as raw materials for the production of pectin, jam and food colours are suggested.

Literatura citada

1. ADEYANJU, S. A., OGUTUGA, D. B. A., ILORI, J. A. and ADEGBOLA, A. A. Cocoa husk as maintenance rations for sheep and goats in the tropics. Nutrition Reports International 11:351-357. 1975.

2. ADEYANJU, S. A., OGUTUGA, D. B. A., ILORI, J. A. and ADEGBOLA, A. A. Potentialities of cocoa husk in livestock feed. **In** Proceedings of the Fifth International Cocoa Research Conference, Ibadan, Nigeria, 1975. pp. 505-510.

3. ANKRAH, E. K. Chemical studies of some plant wastes from Ghana. Journal of the Science of Food and Agriculture 25:1 229-1 232. 1974.

4. ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS. Official methods of analysis. 11th ed. Washington, D. C. 1970.

5. BRAHAM, J. E. and BRESSANI, R., eds. Coffee pulp: composition, technology and utilization. Ottawa, Canada, 1979. 95 p. (IDRC-108e).

6. EGUNJOBI, O. A. On the possible utilization of discarded (*Theobroma cacao* L.) pod husk as fertilizer and nematicide. **In** Proceedings of the Fifth International Cocoa Research Conference Ibadan, Nigeria, 1975. pp. 541-547.

7. EXTRACTION OF tannis from cashew skin. Planters' Chronicle (India) 59(7):124-1964.

8. GREENWOOD-BARTON, L. H. Utilization of cocoa by-products. Food Manufacture 40: 52-56. 1965.

9. HAINES, C. E. and ECHEVERRIA, A. J. Cocoa pod as substitutes in tropical dairy rations. Foreign Agriculture 19:99-101. 1955.

10. HUTAGALUNG, R. L., and CHANG, C. C. Utilization of the cocoa by-products as animal feed. Proceedings of International Conference on Cocoa and Coconuts, Kuala Lumpur, Malaysia, 1978, 1980. pp. 447-456.

11. MURILLO, B. Coffee pulp silage, **In** Braham, J. E. and Bressani, R., eds. Coffee pulp: composition, technology and utilization. Ottawa, Canada, 1979. pp. 55-61. (IDRC-108e.

12. OHLER, J. G. Cashew. Amterdam, Koninklijk Inst. voor de Tropen, Dept. of Agricultural Research. Communication 71. 1979. pp. 77-214.

13. OGUTUGA, D. B. A. Some physical and chemical characteristics of the pod husk of F_3 Amazon Trinitario and Amelonado cocoa in Nigeria. Ghana Journal of Agricultural Science 8:115-120. 1975.

14. OGUTUGA, D. B. A. Chemical composition and potential commercial uses of kola nut, **Cola** *nitida* Vent (Schott and Endlicher). Ghana Journal of Agricultural Science 8:121-125. 1975.

15. OGUTUGA, D. B. A. Preparation of pectin and jam from cocoa pod husk. **In** Proceedings of the Fifth International Cocoa Conference, Ibadan, Nigeria, 1975. pp. 578-581

16. SOMORIN, O. Caffeine distribution in *Cola acuminata, Theobroma cacao* and *Coffea arabica*. Journal of Food Science 39:1 055-1 056. 1974.

17. SUAREZ DE CASTRO, F. Valor de la pulpa de café como abono. Santa Tecla, El Salvador, ISIC, 1960. (Boletin Informativo. Suplemento No. 5).