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Biochemical changes that occur in plantain (unripe) and cassava peels during processing (sun-drying)

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BIOCHEMICAL CHANGES THAT OCCUR IN PLANTAIN (UNRIPE) AND CASSAVA PEELS DURING PROCESSING (SUN-DRYING)

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ABSTRACT: Cassava (*Manihot spp*) and green (unripe) plantain (*Musa spp.*, AAB group) peels are a cheap source of feed to ruminant livestock in Ghana. Since cassava and plantain availability in large quantity is seasonal, effective utilization of the peels can be obtained by sun-drying (processing) to increase its dry matter content and enhance its storability. A study was conducted to determine the effect of sun-drying on the chemical components of the peels with the view to enhance peel utilization by small scale ruminant livestock farmers in Ghana. The colour and texture of the peels changed appreciably after processing. The observed peel to pulp ratios (wet basis) were 53:47, 40:60, and 21:79; and 36:64, 27:73 and 15:85 (dry matter basis) for French-, and False-horn plantains and cassava, respectivley. Significant increases in dry matter content (15.14% to 94.00%, 17.51% to 91.00% and 30.02 to 87.64%) for French-, False-horn plantain and cassava peels, respectively, resulted from the processing ($P<0.05$). Sun-drying increased the acid detergent fibre (ADF), acid detergent lignin (ADL), and acid detergent insoluble nitrogen (ADIN). But decreased substantially reducing sugar, chlorine, and iodine concentrations (non significant, $P>0.05$) in the sun-dried peels. The treatment does not seem to influence the quality of feed in terms of energy and digestible organic matter.

INTRODUCTION

Inadequate and unbalanced feeding of ruminant livestock in Ghana an other West African countries have been reported (Tuah, 1989). The malnutrition results from over-reliance on natural grass lands whose productivity follows the natural rainfall and the erratic supply of crop by-products for livestock feeding. An estimated 7.5 million metric tonnes of agricultural by-products, amounting to 9.3 kg dry matter per tropical livestock unit, can be obtained if the agricultural by-products are properly utilized (Tuah, 1989). These changes in nutritional status of livestock result in very irregular growth and marked fluctuations in seasonal weights (Wilson, 1987).

The change in small ruminant production pattern from free roaming and grazing, to confinement for a greater part of daytime (from about 6.00 a.m. to 3.00 p.m.) plus grazing for an average of 3 hours per day (from about 3.00 p.m. to 6.00 p.m; Apori, 1992) has increased the importance of off farm crop residues like cassava and plantain peels as animal feed resource. However, less is known of the chemical constituents of these feeding stuffs. Available research (Krauss, 1921; Devendra, 1977; Adegbola and Asaolu, 1985) suggests that the feeding value of cassava peels for ruminant livestock was equivalent to that of maize, based primarily on energy and crude protein content as well as digestibility and short term growth experiments. Other studies (Tuah, 1989) have relied on the crude protein content and *in-vitro* dry matter digestibility of plantain peels (Eggleston, Swenner, and Akoni, 1991), whole plantain fruit and pulp (Swennen and Vuylsteke, 1987), and on whole cassava root energy and crude protein content or nutrient digestibility (Olaloku, Egbuiwe, and Oyenuga, 1971) to assess root and fruit nutritive value.

Cassava and plantain are seasonal crops. Therefore one of the problems of feeding cassava and plantain peels to ruminants is the fluctuating supply. This fluctuating supply problem could be solved by processing (air drying, sun-drying, dehydration) peels into forms that can be stored. The processing will reduce the high moisture content, incidence of molding or side reactions capable of producing indigestible products, instability index, volume of material and enhance packaging.

The objective of my work was to determine the biochemical changes which occur with the sun-drying of cassava and plantain peels as practised by most small scale ruminant livestock farmers in Ghana to prolong shelf-life. The results obtained will help to characterise cassava and plantain peels as a feedstuff, explain production performance of livestock on these feed resources, and provide basic information to help optimise the utilization of these off-farm crop residues.

MATERIALS AND METHODS

Three batches (10 bunches per batch) of green (unripe) French-, and False-horn plantains with mean weights of 14.75 and 8.8 kg/bunch, respectively, and three batches (300 kg per batch) of cassava were peeled at about two hours after harvesting, between 26 November and 20 December, 1992. The plantain and cassava were harvested within the Cape Coast district (Coastal savanna ecological zone) of the Central Region of Ghana. Peels of each batch were weighed, shredd-ed, bulked, fresh composite sample taken, and the remainder sun-dried for six days. Part of the fresh composite samples were used for dry matter determination, and the remainder oven dried at 50°C for 48 hours, milled to pass through a 2.0-mm sieve in a Christy and Norris hammer milling machine, mixed thoroughly and 150 g kept in 250-cm^3 air tight plastic bottles at 4°C in a referigerator prior to analysis. The average temperature, sunshine hours, and relative humidity during the study period were 26.5°C, 7.45 hours, and 80.8%, respectively. Samples of peels being dried were taken at the end (6.00 p.m.) of each day's drying when peels were being collected for overnight storage to make dry matter deter-minations. At the end of the sixth day of drying, a composite sample of dried material was also milled and stored like the fresh samples.

Peel samples were analysed for dry matter (% DM), crude protein (% CP), crude ash, and pH, using AOAC (1970) methods. Acid detergent fibre (% ADF), acid detergent insoluble nitrogen (% ADIN), and acid detergent lignin (% ADL) were determined using the analytical procedures described by Van Soest (1967).

The metabolizable energy (MJ/kg DM) for ruminants (MEr) was determined by use of the Hohenheimer Futterwert-Test (HFT) using rumen liquid as elaborated by Menke et al. (1979) in *in-vitro* studies as follows:

$$\mathbf{ME = 1.06 + 0.1570\ GP + 0.0084\ XP + 0.0220\ XL - 0.0081\ NA}$$

$$(R^2 = 94;\ Sy.X = 2.92)$$

where: **GP** is the gas production (ML) in 24 hours from 200 mg of feed sample (dry matter); and **XP**, **XL**, and **XA** are the crude protein, lipid, and ash, respec-tively, of feed sample (g/kg DM).

With respect to minerals, 1.0 g of samples were wet digested in duplicate with a mixture of nitric and perchloric acids in a ratio of 5:1 in a Kjeldahl flask and digest made up to 100 mL with de-ionised water. Calcium (Ca), magnesuim (Mg), manganese (Mn), zinc (Zn), copper (Cu) iron (Fe), and nickel (Ni) concentrations (mg/kg DM) in the prepared digests were determined using Perkin-Elmer 1100 Atomic Absorption spectrophotometer (AAS), soduim (Na) and potassium (K) by flame photometry, available phosphorus (P) by colorimetry (Pye Unicam PU 8600 UV/VIS spectrophotometer), free chlorine (Cl), iodine (I), and sulphate (SO_4) by use of a HACH kit., following procedures recommended by the American Public Health Association (APHA., 1987). Reducing sugar content of samples were estimated using the Folin-Wu method (1961).

The chemical components data obtained for fresh and sun-dried peels were compared statistically using the Analysis of Variance (ANOVA) for complete randomised design (CRD, Steel and Torrie, 1960) and means were separated by Scheffe's test (1980).

RESULTS AND DISCUSSION

An average peel to pulp ratio for French-, False-horn plantains and cassava of 53:47, 40:60, and 21:79 (wet basis), and 36:64, 27:73 and 15:85 (dry matter basis), respectively, were obtained. This current values of peel to pulp ratio for plantain peels (wet basis) compares favourably with earlier results reported by Eggleston, Swennen, and Akoni (1991). However, the peel to pulp ratio of 15:85 (dry matter basis) for cassava was higher than values earlier obtained by Adegbola and Asaolu (1986) of 8:92 and 10:90.

The pattern of increase in dry matter and other variations in chemical constituents of False-horn, French plantain and cassava peels resulting from six days of sundrying (processing) are shown in Figure 1 and Table 1. From Figure 1, farmers needed to dry shreded plantain peels for four days at temperture of 26.5°C, 80.8% relative humidity, and 7.45 sunshine hours, to attain dry matter content of 87.0% and above. At that level of dry matter, where moisture content is less than 13%, the peels can be stored. This is because the water activity of the peels will be low, and incidence of mold (*Aspegillus spp*) growth which is a problem of stored products with high moisture content (>13%) in the tropical hot environment will be reduced to a minimum as suggested by Muller (1992).

For cassava peels, farmers will have to dry for at least six days under average experimental temperature (26.5°C), relative humidity (80.8%), and sunshine hours (7.45 hours) to attain dry matter content of 87% and above which will be

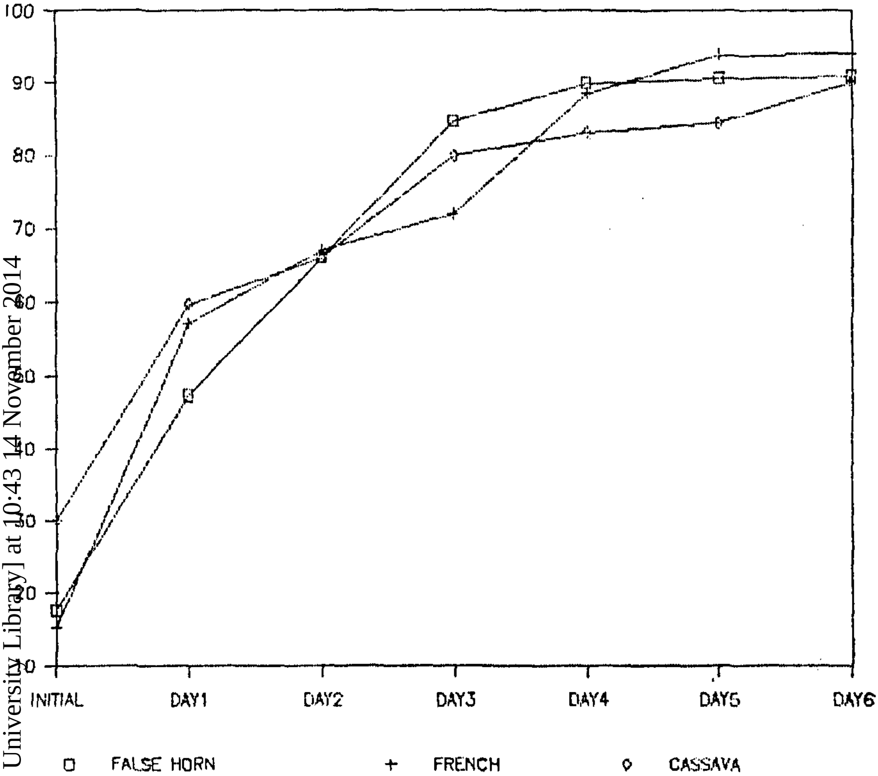

FIGURE 1. Changes in DM content (%) of peels.

ideal for storage. Sun-drying led to darkening of peels (browning effect) which was more pronounced with plantain peels. The darkening might be due to oxidation of pigments, like tannins and phenolic compounds by enzymes (oxidases like tyrosinase, phenolase, etc.) in tissues of peels. Nonenzymatic reactions between the Cl, I, Fe, and other peel constituents could have also caused darkening (browning effect) during the sun-drying process (Hodge, 1976;1967). This could have accounted for the reduction (Table 1) in I and Cl levels associated with the sun-drying process.

Generally results obtained (Table 1) indicated that processing (sun-drying) significantly ($P<0.05$) increased the percentage dry matter, tended to increase the

TABLE 1. Chemical Composition of Fresh and Sundried French-, False Horn-Plantain, and Cassava (*Manihot Ultilissima* L.) Peels (on dry matter basis).

Component	False Horn Peels Fresh	False Horn Peels Sundried	French Peels Fresh	French Peels Sundried	Cassava Peels Fresh	Cassava Peels Sundried
			%			
Dry matter	17.51	91.00	14.15	94.00	30.02	87.67
Crude protein	9.30	9.00	9.00	9.20	4.00	3.90
Crude lipid	4.60	4.40	4.30	4.60	1.00	0.80
Acid detergent fibre	11.02	13.26	12.41	13.56	17.37	19.82
Acid detergent lignin	4.2	6.40	4.60	7.30	5.1	8.5
Acid detergent insoluble nitrogen	0.89	1.15	1.34	1.50	0.79	0.99
Reducing sugar	62.02	47.50	65.00	47.50	64.52	52.02
Crude ash	13.80	13.70	13.00	13.60	4.00	4.00
Digestibility of organic substance	71.2	70.10	71.40	70.10	73.60	73.70
Metabolizable energy for ruminants (MJ/kgDM)	10.2	10.30	10.30	10.10	11.00	10.90
Protein to energy ratio (g/MJME)	9.10	9.00	8.70	9.10	3.64	3.58
pH	6.70	5.50	6.50	5.40	4.70	4.60
			mg/kg			
Potassium	51868	61791	60457	58145	8919	8774
Calcium	1719	1919	1549	1887	5548	6246
Phosphorus	2139	1854	2665	1179	588	596
Magnesium	1303	1304	1477	1392	1033	1112
Sodium	686	691	1022	684	2435	2401
Manganese	31.87	36.31	21.44	32.49	56.44	56.58
Iron	223	333	657	517	225	251
Copper	3.71	3.11	5.11	3.08	1.34	3.09
Zinc	15.46	17.62	26.89	21.56	20.11	21.60
Nickel	128	119	121	123	126	123
Iodine	475	255	675	350	1180	905
Chlorine	130	75	185	110	350	255
Sulphate	1000	600	9000	7500	8500	8000

All chemical composition values are on dry matter basis.
mg/kg: milligram/kilogram dry matter of feed.

acid detergent fibre, lignin, insoluble N, and Ca, but substantially decreased reducing sugar, Cl, and I concentrations of peels. Numerical variations (non-significant P<0.05) observed between parameters measured for fresh and sun-dried peels could be due to loss of easily digestible nutrients arising from mechanical and fermentation processes (Reed and Van Soest ,1985). The increases in acid detergent insoluble N (ADIN) could have resulted from polymerization of protein with carbohydrates (Maillard reaction) as a result of heat created by the fermentation process (Reed and Van Soest, 1985). Another reason could be the reduction in protein solubility as drying reduces the solubility of some nitrogeneous compounds and result in increases in the ADIN concentration as reported by Mercher and Satter (1983). Increases in acid detergent lignin contents could have resulted from formation of insoluble compounds or products from reactions between some nitrogenous substances and soluble carbohydrates, which were measured as part of the ADL during analysis (Van Soest, 1982).

The crude protein levels of plantain peels (Table 1) were similar to earlier values obtained by Tuah (1989), while the cassava peel crude protein contents were lower than values of 5.7% to 6.5% as reported by Osei and Twumasi (1989), and Ademosun and Asaolu (1986). The slight differences could be due to difference in cassava varieties and age at harvesting of samples used in the various studies. Adegbola and Asaolu (1986) reported of non-significant differences (P>0.05) between the crude protein, reducing sugar, and fibre contents of fresh and sun-dried cassava peels, like that observed in this study.

Implications of Study for Small Ruminant Livestock Production

The crude protein content of plantain peels suggest that the peels can provide the minimum rumen nitrogen requirement for effective functioning of rumen microbes (Preston and Leng, 1987). However, the low S estimated as SO_4 in False-horn peels, makes the N to S ratio of 73:1 and 132:1 higher than the recommended N:S ration of 10:1 (Bull, 1979; Moir, 1979) to be maintained in rumen for efficient microbial recycling of S and N. The low crude protein content of cassava peels, coupled with high S content above maximum tolerable level of 0.4% (NRC, 1980, Table 3) for sheep leads to low N:S ratios of approximately 4:1 and 5:1, respectively, for fresh and sun-dried cassava peels. Such low ratios might result in inefficient microbial recycling of S and N for small ruminants fed cassava peels as basal or complete feed. There is, therefore, the need to supplement diet of small ruminants on cassava peels with protein supplements high in N and low in S, whilst livestock on plantain peels (False-horn) may be supplemented with high S containing protein feeds.

The observed pH values suggest that the sun-drying process tended to increase the acidity of peels. Since pH levels of feed materials influence palatability the drying process may reduce palatability of the peels when used as feed material.

The acid detergent lignin (ADL) concentration of fresh plantain peels (Table 1) suggested that it might not be a limitation to digestibility. This might be the reason for the high *in-vitro* dry matter digestibility (IVDMD) values of 84.58% for False-horn and 73.63% for French-plantain peels reported by Tuah (1989). The IVDMD values of 52.55% and 67.5% for two cassava varieties could be due to the acid detergent lignin (ADL) content of cassava peels which was at the threshold value at which ADL concentration tends to reduce the digestibility of most tropical feeds (Becker, 1992). The increased ADL content in dried cassava peels (Table 1) suggested that the dried peels fed alone may have slow rate of degradation, reduced feed passage through the gastro-interstinal tract and feed intake. Becker (1992) reported that the ADL constituent of feed, at 5% to 15% may reduce the digestibility of most tropical feedstuffs. Generally the energy content of the peels is fairly high, with plantain peels containing at least 10.0 MJ/kg DM. The protein to energy ratios (Table 1) are below the minimum recommended value 10.7 g/MJME (Close and Menke, 1986) and have to be compensated by an additional protein source in order to obtain efficient utilization of feed nutrients from the peels.

With respect to minerals elements, most constituent levels were within recommended requirements for sheep (Table 1, NRC, 1980). The K content of plantain peels was double the maximum tolerable level of 3% of feed dry matter for sheep and cattle. With such high concentration animals fed plantain peels as basal diet or complete feed will have depressed Mg absorption and utilization which can predispose livestock to hypomagnesaemic tentany. High K containing feedstuffs as plantain peels may also reduce energy utilization and weight gain in lambs as earlier reported by Jackson, Kroman, and Ray (1971). Based on the K concentration, it might be advisable to ensure that plantain peels do not constitute more than 50% of the daily feed dry matter intake of the sheep and goats on it. Another way is to increase the Na and Cl intake of animals on plantain peels. This is because the chlorine requirement and metabolism in the animal is directly tied up to the K concentration (Church and Pond, 1982). This will reduce the physiological stress imposed on ruminant livestock fed with plantain peels as basal diet or complete feed.

The Ca content of plantain peels were lower than the P levels. This lead to Ca:P ratios of 0.8:1, 0.9:1, 0.6:1, and 1.6:1 for fresh and sun-dried False-horn-, and French-plantain peels, respectively. These low Ca:P ratios, lower than the recommended Ca:P ratio range of 1:1 to 2:1 can predispose intact and castrated male sheep to incidence of urinary calculi if fed plantain peels for a longer period of time. This suggested that Ca biased mineral supplements should be given to small ruminant livestock (sheep and goats) normally fed plantain peels when in confinement. The cassava peels were however adequate in Ca but lower in P, thus giving a high Ca to P ratios of 9.4:1 in fresh and sun-dried peels. This suggested that for animals on cassava peel-biased feeds, mineral supplements rich in P should be supplied to them. A proper combination of cassava and plantain peels could also be employed in feeding small ruminant livestock to circumvent the problem of mineral imbalances.

The concentrations (mg/kg DM) of iodine in all peels, Fe in French plantain, SO_4 in French plantain and cassava peels were above tolerable levels (Table 1, NRC, 1980), while Na was low in False-horn- and sun-dried French-plantain peels when compared to recommended requirements (NRC, 1980). The high I content of feedstuff might cause hyper activity in ruminant livestock, which will in turn result in reduced growth and other productive activity.

CONCLUSION AND RECOMMENDATIONS

The results obtained suggested the need for specificity in feed supplementation to ruminant livestock on plantain and cassava peels as basal or complete feed based on the deficiencies or excesses in feed nutrients that have to be corrected.

Sun-drying of plantain and cassava peels may be done to reduce the high water content of freshly pared plantain and cassava peels in order to increase their shelf-life and enhance storability

Further study should be undertaken taking into consideration parameters like age at harvesting of plantain fruits and cassava roots, eologicai zones of country where plantain and cassava production are feasible, and the quantification of the amount of 5-hydroxytryptamine (5-HT) in plantain peels, since this is a toxic component which is capable of causing hallucinations as has been identified in the peels of banana which belong to *Musa spp* species inwhich plantains belong (Kochhar, 1981).

A feeding trial in which the identified nutritional deficiencies of the peels have been corrected should preceed recommendations for the technology adoption in feeding practices.

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