DETERMINATION OF POTASH ALKALI AND METAL CONTENTS OF ASHES OBTAINED FROM PEELS OF SOME VARIETIES OF NIGERIA GROWN MUSA SPECIES

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Potash alkali and metal contents of ashes obtained from peels of six varieties of Nigeria Musa species were investigated. The varieties of Musa species – *Musa paradisiaca* (plantain)*, Musa* 'Gross Michel' (Igbo banana), *M.sapientum L.* (paranta), *Musa* 'Wild Banana' (omini), Musa 'Red' (sweet banana), and *Musa* 'Fugamo' (somupeke), were investigated. The moisture, dry matter, ash and alkali contents; concentration of metals in the ashes and in the contents extracted with water from the ashes; and the ratio of potassium to other metals in the ashes and in the corresponding extracts were determined. Moisture contents ranged from 80.9 to 86.7%; dry matter content, 13.3 to 19.1%; ash content, 6.3 to 12.0%; alkali content, 69.0 to 81.9% of ash and 4.7 to 9.6% of dry sample. Samples ranged between 2.60 and 720mg/kg and in the corresponding extracts, BDL to 500.49mg/kg; ratio of concentration of potassium to other metals in the samples, 0.6 to 395; and in the extracts, 0.5 to 313. Gross michel showed the highest concentration of K (750mg/kg) while omini banana gave the lowest average value (112.70mg/kg).

Keywords: Ash; Potash; Potassium; Alkali; Metal concentrations; Musa species

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INTRODUCTION

Bananas and plantains have been said to be the 4th largest fruit crop of the world. The world production is estimated to be 28 million tons, in which tropical Africa alone produces about 9 million tons of banana annually (Morton, 1987). It has become a basic food crop for over 70 million people in Africa (IITA 2009). Over 50 species of Musa are in existence (Lheureux et al. 2007), in which the main group of edible bananas or plantains are derived from *Musa acuminate* and *Musa balbisiana* (Kayisu et al. 1981).

Potash has gained a world-wide domestic and commercial use in the flat glass, chemical, pulp and paper sectors (MCS, 1996). It is also used for production of local soap (Onyegbado et al. 2002) and traditionally used as a cleansing agent. The simplicity of potash chemistry and the easily available local and improved potash production technology (Babayemi et al. 2010) have lent the ash-derived potash a promising future as a sustainable source of raw material for potash-based industries. The potash contents of various plant materials have been reported (Kevin 2002; Afrane 1992; Nwoko 1980). The alkali contents of the ash-derived potash were said to be hydroxides of potassium and sodium (Onyekwere 1996; Kuye and Okorie 1990) or carbonates of potassium and sodium as reported by Taiwo and Osinowo (2001). Adewuyi et al. (2008) determined the potash yielding potentials of several African wood species, and compared the ash as well as alkali contents. Babayemi and Adewuyi (2010) assessed the effectiveness and economic significance of sustainable management of wood waste through potash production. From the available literature searched, information is lacking on the chemical content of different varieties of plantain and banana fruit peels. Ankrah (1974) reported potash content of ripe plantain peel and unripe plantain peel for the purpose of soap making (Onyegbado et al. 2002). Trace elements were observed in the fruit peels and trunks of *Musa paradisiaca* (Selema and Farago 1996).

There are reports on the chemical contents of the flesh of plantain or banana fruit: vitamin C (Hagg et al. 1995, 2007), volatiles (Shiota 1993), and fatty acid (Meechaota et al. 2007). Previous studies carried out on the chemical contents of plantain and banana fruit peels have been mainly on organic contents (Emaga et al. 2007); there is little or no report comparing both organic and inorganic chemical contents of the peels of plantain and banana varieties. The mid-ribs, the pseudo-stem and the stalk of some Nigerian grown Musa species were investigated for their physical, fibre, and chemical (cellulose) properties for their pulp and paper potentials (Omotoso and Ogunsile 2009); the peel is apparently unexplored.

Various parts of plantain and banana have been studied for various uses: alcohol production from ripe fruit, medicinal use for treatment of gastric ulcer, and the pseudo-stem as a source of fibre (INIBAP 2003). There is a large consumption of this fruit in Nigeria, either consumed as ‘dodo’ (fried ripe fruit), ‘dodo Ikire’ (from over-ripped fruit), chips (fried unripe fruit), or processed to produce plantain flour and local beer (Oladejo and Sanusi 2008). In all these stated uses there is little or no account of reuse or recycling of the waste peels, except for some insignificant use as animal feed. Due to their importance in Nigeria, plantain and banana have received the involvement of international and national institutes, Plantain and Banana Development Program (PBDP) activities, state Agricultural Development Program (ADP), universities faculty of agriculture, oil producing companies agricultural department, and hybrid delivery projects (Faturoti et al. 2007).

National and international production of plantain and banana is ever booming, while local and domestic consumption are on an increase; but national and international programs for management of the resulting waste peels are rare, perhaps because information is lacking on the resources inherent in the waste peels; consequently, a huge amount of waste peels is dumped daily, especially in Nigeria. A geometric increase in the generation of solid waste in Nigeria calls for a sustainable management options in which reuse and recycling top the list (Babayemi and Dauda 2009). These and several other reasons prompt this study. Hence this investigation aims at determining and comparing the alkali and metal contents of the peels of six Nigeria grown plantain and banana varieties.

EXPERIMENTAL

Sample Collection

Fresh plantain (*Musa paradisiaca)* peels were collected from a food canteen in Bells University of Technology, Ota, Nigeria; while five varieties of banana – *Musa* 'Gross Michel' (Igbo banana), *M.sapientum L.* (paranta), *Musa* 'Wild Banana' (omini), *Musa* 'Red Banana' (sweet banana), and *Musa* 'Fugamo' (somupeke) were purchased from road-side sellers in Ibadan in Oyo state and Ota in Ogun state, Nigeria. The peels from the different varieties were oven-dried separately and stored in sample bags.

Moisture Content (MC) and Dry Matter Content (DM)

The moisture content was determined using the method suggested by Miroslav and Vladimir (1999).

$$MC = \frac{(M_1 - M_2)}{M_1} X100 \quad (1)$$

where M_1 = initial weight, and M_2 = weight after drying. Likewise, the dry matter content was defined (Vladimir 1999) as follows:

$$DM = \frac{M_2}{M_1} X100 \quad (2)$$

Ash Content (AC)

A known weight (M_3) of each oven-dried sample was placed in a porcelain crucible and ashed in muffle furnace set at 500^{o}C for 15 hours; it was cooled in a desicator, and the final weight (M_4) was determined using electronic balance (Vladimir 1999). The ash content was calculated as follows:

$$AC = \frac{M_4}{M_3} X100 \quad (3)$$

Alkali Content (Alk)

A known weight (2g) of the ash of each variety was dissolved in 250cm^3 of distilled water. The solution was thoroughly shaken and allowed to settle for about 30 minutes. 25cm^3 of the clear portion was pipetted and titrated against 0.1M HCl using methyl orange indicator (Adewuyi et al, 2008). Replicates were obtained, and the average titres were used to calculate the alkali content of the ash and as a percentage of the dry sample.

Analysis of Metals

With a slight modification to the method described by Miroslav and Vladimir (1999), 0.5g portions of oven-dried and ground samples were weighed into porcelain crucibles and ashed in a muffle furnace at a slowly increasing temperature up to 600^{o}C for 2 hours. The samples were removed and cooled in a desicator. 10ml of 6M HCl were added to each portion and heated on a steam bath for 15 min, after which 1mL of HNO_3 was added and heated for an hour to ensure complete dissolution. 10mL of distilled water were added, cooled and filtered into 50mL volumetric flasks and made up to mark with distilled water. Metals were analyzed using an atomic absorption spectrophotometer at the wavelengths 766.5nm, 589.0nm, 285.2nm, 422.7nm, 324.7nm, 248.3nm, 213.9nm, and 283.3nm for K, Na, Mg, Ca, Cu, Fe, Zn, and Pb, respectively.

To determine the water extractable metals, the above procedure was repeated for each sample, but the parts involving digestion with acids were omitted.

Ratio of K to Other Metals

The ratio of the concentration of K to that of each metal in the sample and in the extract was calculated to establish any possible relationship in the proportion of K and other metals.

Statistical Analysis

Using the Pearson worksheet function, correlations were made between various parameters to identify any useful relationships which may be a guide in the qualitative and quantitative selection of materials, and in the purification of extract alkali in the subsequent experiments.

RESULTS AND DISCUSSION

Moisture, Dry Matter, Ash, and Alkali Contents

The results of moisture content, dry matter, ash, and alkali contents of the samples are shown in Table 1. The results ranged from 80.9 to 86.7%, 13.3 to 19.1%, and 6.3 to 12.0% ash content; 69.0 to 81.9% for moisture, dry matter, ash and alkali contents, respectively, as percentage of the ash; and 4.7 to 9.6% alkali content was observed for dry peel.

Table 1. Moisture Content (MC), Dry Matter Content (DM), Ash Content (AC), and Alkali Content (Alk)

Species	MC (%)	DM(%)	AC(%)	Alk(% of ash)	Alk(% of dry peel)
Musa 'Gross Michel' (Igbo banana)	86.1	13.9	10.4	70.1	7.3
M.sapientum (paranta)	80.9	19.1	10.3	69.0	7.1
M. paradisiacal (plantain)	81.9	18.1	6.3	74.4	4.7
Musa 'Wild Banana' (omini)	86.7	13.3	7.7	81.9	6.3
Musa 'Red' (sweet banana)	83.2	16.8	8.6	70.4	6.0
Musa 'Fugamo' (somupeke)	85.7	14.3	12.0	79.8	9.6

Omini banana gave the highest moisture content of 86.7% (perhaps this is responsible for its usual thick and soft peels) and highest alkali content of 81.9%. The omini variety may then be of economic advantage over the others for potash production. The paranta variety gave the least moisture content of 80.9% and the least alkali content of 69.0%. The correlation between moisture content and alkali content (% of ash) gave a correlation coefficient of 0.3753, showing that little or no relationship existed between the two parameters. Further study is suggested to establish if actually the abundance of water in the matrix of fresh peel of Musa species is a function of alkali metal content of the peel.

Correlation between ash content and alkali content (% of the dry peel) gave a correlation coefficient of 0.893, implying a high relationship between the two parameters. Ash content may then be used as indicator of alkali-yielding potentials of different varieties of Musa species. Correlations between dry matter content and ash content and between moisture content and alkali content (% of dry peel) gave correlation coefficients of 0.0648 and 0.1863 respectively implying little or no relationships.

The moisture content in this study ranged from 80.9 to 86.7%, which perfectly agreed with those obtained by Ankrah (1974) in which the range of 78-94% was observed. Ash content in this study ranged from 6.3 to 12.0%, while those observed by Adewuyi et al. (2008) ranged from 1.25 to 8.80% for some African wood species, and Taiwo and Osinowo (2001), 10.54 to 18.20%, for various agro-wastes. The results obtained in this study are similar to these reported values. For alkali content, the range of 69.0 to 81.9% was observed in this study; Adewuyi et al. obtained a range of 4.50 to 96.50% for wood species; and Taiwo and Osinowo, 12.40 to 56.73% for various agro-wastes. The results agree with those observed by Adewuyi et al. and have closer range to that of Taiwo and Osinowo.

Table 2. Concentration (mg/kg) of some Metals in the Sample

	Musa 'Gross Michel' (Igbo banana)	*M.sapientum* (paranta)	*M. paradisiaca* (plantain)	*Musa* 'Wild Banana' (omini	Musa 'Red' (sweet banana)	*Musa* 'Fugamo' (somupeke)
K	513.40	330.10	374.90	112.70	720.00	350.20
Na	37.40	113.50	191.80	187.60	109.00	61.60
Mg	7.60	49.90	105.80	109.20	174.60	270.60
Ca	31.20	31.20	30.10	20.10	30.10	23.40
Cu	20.10	20.10	4.10	2.60	3.20	11.20
Fe	1.30	26.40	8.80	30.90	5.90	15.10
Zn	2.90	20.90	31.10	10.10	21.10	12.10
Pb	2.80	3.50	3.10	5.30	6.10	8.60

Concentration (mg/kg) of Metals in Samples and Extracts

The concentrations of metals in the samples (Table 2) ranged from 2.60 to 720mg/kg. The range of concentration of K was from 112.70 to 720mg/kg; Ca, 23.40 to 31.20mg/kg; Cu, 2.60 to 20.10mg/kg; Fe, 1.30 to 30.90mg/kg; Zn, 2.90 to 31.10mg/kg; and Pb, 2.80 to 8.60mg/kg. Red banana had the highest K level (720mg/kg) and omini had the least (112.70mg/kg); the highest Na level was found in plantain (191.80mg/kg) and the least was found in gross michel (37.40) mg/kg); the highest level of Mg was observed in fugamo (270.60mg/kg) and in gross michel, the least, (7.60mg/kg). The dominating alkali metal in the sample was K, except in omini, where Na dominated. K, Na, and Mg seemed to be in higher concentrations than the others. The K observed in this study ranged from 112.70 to 720mg/kg. These values are very close to the observation of Onyegbado et al. (2002); they reported 126.10ppm for Plantain peels; Selema and

Farago (1996) observed 38600mg/kg for *Musa pardisiaca*, which is higher than the observed value.

Concentrations of metals extracted with water (Table 3) ranged from 63.30 to 500.49mg/kg for K; 33.80 to 137.50mg/kg for Na; 5.90 to 205.00mg/kg for Mg; 0.90 to 24.50mg/kg for Ca; 2.20 to 12.80mg/kg for Cu; BDL to 1.60mg/kg for Fe; 2.60 to 29.10mg/kg for Zn; and 2.20 to 7.10mg/kg for Pb. These showed that a certain percentage of the metals went into solution when extracted with water, except Fe in paranta, omini, and lady finger, where extremely little or none went into solution. This indicates that potash extract from ashes is not only the salt (carbonate) of K or Na. The compounds of other metals that are highly soluble in water (especially chlorides and nitrates) may also be present in the potash.

Table 3. Concentration (mg/kg) of some Metals in the Extract

Metals	*Musa* 'Gross Michel' (Igbo banana)	*M.sapientum* (paranta)	*M. paradisiaca* (plantain)	*Musa* 'Wild Banana' (omini	Musa 'Red' (sweet banana)	*Musa* 'Fugamo' (somupeke)
K	70.00	92.80	70.30	63.30	500.49	324.90
Na	35.30	95.00	134.40	137.50	37.30	33.80
Mg	5.90	45.00	51.80	95.90	152.50	205.00
Ca	14.50	24.50	24.20	0.90	24.50	22.40
Cu	11.00	12.80	3.40	2.20	3.10	10.20
Fe	0.90	BDL	1.40	BDL	1.60	BDL
Zn	2.60	13.10	29.10	2.80	20.10	10.80
Pb	2.20	2.40	2.90	3.80	5.10	7.10
BDL: below detection limit						

The results of the ratio of K to those of other metals are shown in Tables 4 and 5. They showed the degree of domination of the presence of K over other metals. This has a significance of helping in choosing an appropriate method or procedure for separating and purifying the ash-derived alkali, knowing in what proportion or the percentage each metal is present.

Table 4. Ratio of Concentration K to those of other Metals in the Sample

	Musa 'Gross Michel' (Igbo banana)	*Musa sapientum* (paranta)	*Musa paradisiaca* (plantain)	*Musa* 'Wild Banana' (omini	Musa 'Red' (sweet banana)	*Musa* 'Fugamo' (somupeke)
K/Na	14	3	2	0.6	7	6
K/Mg	68	7	4	1	4	1
K/Ca	16	11	12	7	24	15
K/Cu	26	16	91	43	225	31
K/Fe	395	13	43	4	122	23
K/Zn	117	16	12	11	34	29
K/Pb	183	94	121	23	118	41

Table 5. Ratio of K Concentration to other Metals in the Extracts

	Musa 'Gross Michel' (Igbo banana)	*Musa sapientum* (paranta)	*Musa paradisiaca* (plantain)	*Musa* 'Wild Banana' (omini	Musa 'Red' (sweet banana)	*Musa* 'Fugamo' (somupeke)
K/Na	2	0.8	0.5	0.5	13	10
K/Mg	12	2	1	0.7	3	2
K/Ca	5	4	3	70	20	15
K/Cu	6	7	21	29	161	32
K/Fe	78	-	50	-	313	-
K/Zn	27	7	2	23	25	30
K/Pb	32	39	24	17	98	46

Correlations

Correlations between the concentrations of K and metals ranged from 0.0032 to 0.6585 for the samples, and 0.0326 to 0.6072 for the extracts (Table 6). There were little or no correlations. K and Fe in the samples, K and Mg in the extracts exhibit some level of relationships.

Table 6. Correlations between K concentration and other metals in the sample with the corresponding extracts, respectively

	Sample			Extract	
	Equation	Correlation coefficient (R^2)		Equation	Correlation coefficient (R^2)
K/Na	y = -1.5325x + 579.24	0.2289		y = -2.3637x +373.42	0.4118
K/Mg	y = 0.1283x + 384.87	0.0035		y = 1.9241x + 8.6327	0.6072
K/Ca	y = 29.017x – 403.06	0.4593		y = 8.6057x + 27.76	0.1955
K/Cu	y = 1.4001x + 385.91	0.0032		y = -7.0426x + 237.08	0.0326
K/Fe	y = -14.002x + 606.51	0.6586		y = 496.83x -432.2	0.5198
K/Zn	y = 2.7822x +357.46	0.0218		y = 4.7712x + 124.54	0.071
K/Pb	y = -0.4129x + 402.24	2×10^{-5}		y = 72.174x – 95.716	0.5503

CONCLUSIONS

1. The results showed that potash from the fruit peels of Musa species is a very good source of the much needed alkali as a raw material for various alkali-based products.
2. The levels of alkali and several trace metals in the fruit peels of different varieties of Musa species varied, and ash-derived potash contains a percentage of some other water-soluble compounds apart from potassium carbonate.

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