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BIOMASS AND ALCOHOL PRODUCTION POTENTIAL OF OVER-RIPE PLANTAINS AND THEIR PEELS

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ABSTRACT

Procedures for alcohol and protein-rich biomass production from over-ripe plantains and their peels are described. Chemical analyses indicated a significantly ($P < 0.05$) higher content of moisture, crude fat and protein; as well as potassium, sodium, calcium, iron and magnesium in ripe plantains than in their peels. No significant difference ($P > 0.05$) was observed in the total sugars, reducing sugars and amylose contents of ripe and over-ripe plantains.

Alcohol yields of 14%, 12% and 8% were obtained from over-ripe plantains, over-ripe plantain/peels mix, and over-ripe plantain peels only respectively. Over-ripe plantain flour fermentation residue (OFR), mixed over-ripe plantain flour and peels fermentation residue (MPF) and over-ripe plantain peels fermentation residue (OPF) had protein contentsof 36.6%, 32.8% and 28.9% respectively.

Key Words: Over-ripe plantains, peels, alcohol, biomass.

INTRODUCTION

Farm wastes like surplus over-ripe plantains, cassava peels, plantain peels and corn cobs are important environmental pollutants with variable contents of carbohydrates (Mepba and Gokana, 1991).

In the 1960s, the recognition of a world-wide shortage of protein led to renewed attempts to solve this problem by large-scale production of biomass as a source of food protein. The major usage of microbial biomass in animal feeds is at present well-recognised (Reed, 1980; Solomon, 1987). Although considerable work had been done on green plantains (Hernandez, 1975; Agbo, 1980; Ogazi, 1989) information on product formulations with over-ripe plantains and their peels is scanty in available literature. This investigation was aimed at creating utility for seasonally surplus plantains and their peels through alcohol and protein-rich biomass production.

MATERIALS AND METHODS

Sample Source and Preparation

Bruised and cut pieces of fully matured green plantains were obtained from the Associated Agric. Farms, Bori, Rivers State. The plantains were stored at room temperature (35°C) for five days (Hernandez, 1975) and allowed to ripen and over-ripen as described in the prepared chart (Von Loeseck, 1960). Only the chemical (proximate minerals and sugars) content of ripe plantains and their peels was determined. Fermentation was effected on the plantains and their peels in their over-ripe state. *Saccharomyces cerevisiae var ellipsoideus* was obtained from Amalgamated Distilleries Nigeria Limited, Port Harcourt.

Ripe and over-ripe plantain pulp was separately cut into thin slices, blanched, dehydrated and pulverised (Mepba et al., 1990). The peels were similarly dried and pulverised but without prior blanching.

Analytical Determinations

The proximate contents of ripe plantain, ripe plantain peels, over-ripe plantain, over-ripe plantain peels and the freeze - dried fermentation biomass were analysed following standard AOAC (1984) methods. The fibre content of the freeze-dried fermentation biomass was determined by the Neutral detergent fibre procedure of Van Soest and Goering (1970).

Determination of Mineral Contents

Samples for mineral analyses were prepared according to AOAC (1984) methods, and minerals except potassium and sodium were assayed spectroscopically using atomic absorption spectrophotometer Model 460 (Perkin Elmer Corp., Atlanta GA). Potassium and sodium were determined by flame photometry procedures (AOAC, 1984).

Starch, total sugars, reducing sugars and amylose:

Total sugars and starch were determined by sugar anthronesulfuric acid method (Dimler et al., 1952) and amylose was assessed by modifying the iodine-potassium iodide procedures of Mcready et al. (1950). The reducing sugars were determined following the copper-reducing method of Somogyi (Pearson, 1980).

Fermention of over-ripe plantain flour and peels:

Pulverised samples of over-ripe plantains were reconstituted in water at levels of 27.3% (W/V), mixed and filtered through cheese-cloth to obtain juice. After repeated washings and filtrations the resultant juice was homogenized, acidified, buffered and sterilised (Mepba, 1981). *Saccharomyces cerevisiae var ellipsoideus* were innoculated at levels of 6 g/litre of substrate and fermentation conducted under controlled anaerobic conditions for seven days.

In another related experiment, samples of pulverised pulp and hydrolysed peels were mixed in a ratio of 4:1 and fermented as previously described. Pulverised samples of over-ripe plantain peels were acid hydrolysed following the method of Pancoast and Junk (1980) with slight modifications. Two hundred and fifty grammes of pulverised peels were dispersed in 750ml of 0.1M Hcl. The slurry was autoclaved at 120°C for 30minutes and then cooled. The pH was adjusted to 4.0 with 0.1M Na_2C0_3 prior to sugar determination and fermentation. Musts were filtered after seven days and the residues freeze-dried and chemically analysed. Wines obtained from fermenting units were distilled at atmospheric pressure and the distillates collected.

Physico-chemical properties of alcohol from over-ripe plantain and over-ripe plantain peels:

Total alcohol in the ferments was measured by direct reading of hydrometer at 30°C following the method of Berry (1979) and on distillates by weighing using a pychometer (AOAC, 1984). Total titratable acidity, volatile acidity, specific gravity and pH of ferments were determined by standard methods (AOAC, 1984).

Statistical Analysis

Statistical analysis of data was carried out according to standard procedures (Steel and Torrie, 1980) using 5% level of significance.

RESULTS AND DISCUSSION

Analytical determinations

The proximate analysis of ripe and over-ripe plantains and their respective peels is shown in Table 1. Ripe and over-ripe plantains had a significantly ($P < 0.05$) higher content of moisture, crude fat and protein than ripe and over-ripe plantain peels. No significant ($P > 0.05$) difference was observed in the moisture, crude fat, crude fibre, protein and ash contents of the ripe and over-ripe plantain peels. These results support the claims of osmotic withdrawal of nutrients from the peel to the pulp at climactric and senescence (Wade and Brady, 1970) and protein synthesis at senescence (Bray et al., 1970).

Table 2 shows data on the mineral contents of ripe, over-ripe plantains and their peels respectively. No significant difference ($P > 0.05$) was observed in the potassium, sodium, calcium, iron and magnesium contents of ripe and over-ripe plantain peels. The results compare favourably with those obtained for Lacatan by the United Fruit Company (1970). It also lends support to the claim of non-translocation of mineral contents during the climacteric and senescence stages of fruit ripening (Duckworth, 1966).

In Table 3, the starch, total sugars, reducing sugars and amylose contents of ripe, over-ripe plantains and their peels are compared. Ripe plantain had a significantly ($P < 0.05$) higher starch content than over-ripe plantains, ripe plantain peels and over-ripe plantain peels. No significant ($P > 0.05$) difference was observed in the total sugars, reducing sugars and amylose contents of ripe and over-ripe plantains. No significant differences ($P > 0.05$) were also observed in the starch, total sugars, reducing sugars and amylose contents of ripe and over-ripe plantain peels. This result is consistent with that of Lustre et al. (1976) that in the post-climacteric stage the banana pulp becomes over-ripe with a reduction in starch content.

Similarly, following degradation of cell wall polysaccharides and withdrawal of moisture from the peel,

Table 1. Moisture, Crude Fat, Crude Fibre, Protein, Ash and Carbohydrate Contents of Ripe, Over-Ripe Plantains and their Peels⁺.

Classification	Moisture	Crude Fat	Crude Fibre	Protein	Ash	Carbohydrate (By Difference)
Ripe Plantain	64.2b*	1.0b	0.7a	3.2b	1.3b	29.7
Ripe Plantain Peel	61.1a	0.1a	4.1b	1.8a	2.0b	31.0
Over-ripe Plantain	66.2b	0.9b	0.6a	3.3b	0.5a	28.4
Over-ripe Plantain Peel	59.3a	0.1ab	4.8b	1.8a	2.1b	31.8

+ Expressed as percent fresh weight of samples

* Means with different subscripts within the same column are significantly ($P < 0.05$) different.

Table 2. Mineral contents of Ripe, Over-Ripe Plantains and their Peels+

Classification	Potassium	Sodium	Calcium	Iron	Magnesium
Ripe Plantain	420b*	340b	160b	120b	240b
Ripe Plantain Peel	140a	120a	40a	40a	120a
Over-ripe Plantain	421b	350b	170b	110b	240b
Over-ripe Plantain Peel	140a	130a	40a	50a	120a
Plantain (Lacatan)++	420	350	170	120	250

\+ Expressed as parts per million (ppm) fresh weight of samples.

* Means with different subscripts within the same vertical column are significantly different ($P < 0.05$).

++ Data from the United Fruit Company, New York (1970).

Table 3. Starch, Total Sugars, Reducing Sugars and Amylose Contents of Ripe, Over-Ripe Plantains and their Peels+.

Classification	Starch	Total Sugars	Reducing Sugars	Amylose
Ripe Plantain	3.2b*	15.1b	11.2b	2.2b
Ripe Plantain Peel	0.5a	7.2a	5.1a	0.9a
Over-ripe Plantain	0.8a	13.4b	12.1a	2.1b
Over-ripe Plantain Peel	0.2a	6.0a	4.7a	0.4a

\+ Expressed as percent fresh weight of samples.

* Means with different subscripts within the same vertical column are significantly ($P < 0.05$) different.

there is conversion of starch to sugars with an increasing level of sugars in the post climacteric pulp (Singh <u>et al.</u> 1976, Martin and Segundo, 1977).

The low level of starch and sugars in the peels is explained by their high ligno-cellulose contents which on acid-hydrolysis could yield fermentable sugars (Lipinski, 1978; Akobundu and Eke, 1987).

Fermentation of over-ripe plantain flour and peels:

Although treatment and direct fermentation of raw over-ripe plantain pulp and peels may yield similar results, dehydration and pulverisation of pulp and peel is advocated by these authors. Dehydration and milling enhanced bulk storage, shelf stability and utility of an otherwise perishable commodity. Acid-hydrolysis of peels was important to the yield of fermentable sugars (Akobundu and Eke, 1987). Fermentation was conducted under controlled anaerobic conditions because at low atmospheric pressure, carbon dioxide inhibits yeast multiplication, while complete inhibition results at seven atmosphere pressures of carbon dioxide (Amerine et al., 1980).

The physicochemical properties of alcohol from over-ripe plantains and their peels are summarised in Table 4. Percentage alcohol yield in over-ripe plantains, over-ripe plantains and peels mix (4 : 1), and over-ripe plantain peels was in the ratio of 7 : 6 : 4 respectively. These values are consistent with levels of fermentable sugars in the units and competitive micro-organisms endemic in the substrates (Amerine et al. 1980). Over-ripe plantains had higher level of fermentable sugars than the peels. The results obtained for over-ripe plantains and the over-ripe plantains and peels mix are consistent with those obtained in grape fruit fermentations (Amerine et al. 1980). The levels of total acidity, volatile acidity, specific gravity and pH are consistent with the content of alcohol in each unit. Those values compare favourably with those of Anuna et al. (1990).

The chemical composition of biomass from over-ripe plantain and their peels are compared with microbial biomass from filamentous fungi, algae and bacteria (Table 5). OFR had a significantly ($P < 0.05$) higher content of moisture and protein than OPF while a significantly ($P < 0.05$) higher content of fibre and ash was recorded in OPF.

The protein contents of OFR and MPF biomass fell within the range reportedfor filamentous fungal biomass but below the levels for algal and bacterial biomass (Kihlberg, 1972). OPF had a slightly lower level of protein than the values obtained by Kihlberg (1972) for filamentous fungi.

CONCLUSION

Possible uses of surplus plantain which would have resulted in losses have been established. Dehydration and pulverisation of fruit pulp and peels enhanced bulk storage, shelf stability and utility of an otherwise perishable product. Chemical analysis was important in the estimation of nutrient contents of the fermentation substrates (over-ripe plantain and over-ripe plantain peels). A significantly ($P < 0.05$) higher content of moisture, crude fat and protein; as well as minerals was recorded in ripe and over-ripe plantains than their respective peels.

The economic losses and environmental problems posed by seasonally surplus plantains and their peels could be solved through alcohol and biomass production.

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Table 4. Physicochemical Properties of Alcohol from Over-Ripe Plantain and their Peels.

Properties	Over-Ripe Plantains	Over-Ripe Plantains and Peels (4:1) Mix	Over-Ripe Plantain Peels
Alcohol (% Vol.)+	14 ± 0.3	12 ± 0.1	8 ± 0.1
Total Acidity (% Citric)	0.8 ± 0.1	0.8 ± 0.01	0.9 ± 0.01
Volatile Acidity % (acetic)+	0.28 ± 0.01	0.03 ± 0.01	04 ± 0.1
Specific gravity	1 ± 0.01	1 ± 0.01	1 ± 0.01
pH++	2.7	2.9	3.0

\+ Values are Means and Standard deviations from Means.
++ Direct reading from the pH meter (Berry, 1979).

Table 5. Comparison of Chemical Content of Over-Ripe Plantain and their Peels Biomass with Microbial Biomass from Filamentous Fungi, Algae and Bacteria.

Products	Moisture	Crude Fat	NDf %	Protein	Ash	Carbohydrate (By Difference)
1. OFR	55.3b*	0.8b	0.7a	36.6c	1.4a	5.2
2. M.P.F. (4:1)	54.8b	0.1a	3.6b	32.8b	1.8a	7.0
3. OPF	48.2a	0.04	6.6c	28.9a	4.1a	10.1
4. Filamentory Fungi+	-	-	-	31-50	-	-
5. Algae+	-	-	-	47-56	-	-
6. Bacteria+	-	-	-	72-83	-	-

1. OFR = Over-ripe plantain flour fermentation residue.
2. MPF = Mixed over-ripe plantain flour and peels fermentation residue
3. OPF = Over-ripe plantain peels fermentation residue

* Means with different subscripts within the same vertical column are significantly different ($P < 0.05$).
\+ Data from Kihlbeg (1972).