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Carbohydrate and Protein Composition of Banana Pulp and Peel as Influenced by Ripening and Mold Contamination

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ABSTRACT

The effects of firewood-obtained ash and a fruit mold, Botryodiplodia theobromae, *on the total proteins and some carbohydrate constituents of the banana fruit were investigated. A slight decrease in moisture content of the ash-ripened peel was recorded. Fruit infested with the mold showed a complete loss of glucose and fructose and a drastic reduction in total sugars. Cellulose was found to remain fairly constant during ripening while the starch content fell as ripening progressed. Low levels of proteins were recorded both in the peel and pulp of fruit.*

INTRODUCTION

The banana fruit is utilized by livestock and is eaten as fresh fruit by man when ripe. However, in Nigeria, the peel constitutes a valuable fodder for goats and sheep (Oyenuga, 1968). In view of the nature of the carbohydrates and presence of some digestive enzymes, which facilitate ripening, banana (when completely ripe) is highly digestible and is often prescribed for children and patients with digestive disorders. In some Nigerian tribes, the fruit is an important ingredient in the preparation of concoctions such as 'afoforo', used in traditional medicine for treating coughs in children. Despite the importance of the fruit to man and his livestock, many reports on its spoilage (Greene & Goss, 1962; Meredith, 1960, 1961; Lukezic *et al.*, 1967) have not mentioned loss of nutritional value. Spoilage also means reduction in quality and marketability.

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The mature green fruit, after harvest, undergoes two main methods of ripening processes in Nigeria, natural and ash-ripening. The ashes (obtained from burnt firewood or charcoal) normally employed accelerate ripening, which would be slower in fruits allowed to ripen naturally. Such ash-treated fruits, however, appear to be relatively pale yellow in colour.

Botryodiplodia theobromae was the only mold encountered on the ash-ripened fruit (Adisa, 1983). This therefore indicates that the ash discourages the occurrence of other spoilage molds when banana is under storage. The ash-ripening practice for banana and plantain fruits is an old indigenous method for accelerating fruit ripening in Nigeria. This practice, unknowingly to the local fruit dealers, is also a short-term fruit preservative technique.

This work is based therefore on investigations of the effects of ash and *B. theobromae* on the total proteins and some constituent carbohydrates of the fruit.

MATERIALS AND METHODS

A bunch of mature green banana fruits (Cameroon variety) was harvested from the Botanical Nursery of the Department of Botany and Microbiology, University of Ibadan. The banana fruits were treated as follows: a batch was covered with a fiber sack and allowed to ripen naturally; another batch was similarly treated, but sprayed with ash obtained from burnt firewood, while the third batch had individual fingers of banana inoculated with *B. theobromae* (2 drops of 5×10^4 spores/ml) maintained on 2% malt extract agar for 4 days. All treated fruits were kept in three incubators, for each experiment, set at 28°C (± 1°C) and stored for 7 days.

The determination of the different food constituents was carried out on alternate days. The total proteins in the peel and pulp were estimated by the Kjeldahl method while the proximate determination of moisture content, glucose, fructose, maltose, sucrose, starch and cellulose of peel and pulp was determined using standard methods (AOAC, 1970). The total sugars were estimated by employing the method of Pearson (1973). There were five replicates for each set of experiments.

RESULTS AND DISCUSSION

The ash employed in accelerating ripening of fruits has no appreciable effect on the proximate chemical composition of the fruit except for a slight decrease in the moisture content of peel. Ash-ripened peel had a dry matter

TABLE 1

Proximate Determination of Total Proteins and Some Carbohydrates of Ash-Ripened and Naturally Ripened Banana Peel when Stored for 7 Days at 28°C (±1°C)

Food constituents	*Fresh weight estimated on alternate days (g/100g)*							
	Ash-ripened peel				*Naturally ripened peel*			
	1	*3*	*5*	*7*	*1*	*3*	*5*	*7*
Proteins	1·4[a] ± 0·03[b]	1·4 ± 0·03	1·5 ± 0·02	1·7 ± 0·03	1·9 ± 0·04	1·7 ± 0·02	1·9 ± 0·04	1·8 ± 0·04
Glucose	0·5 ± 0·01	1·5 ± 0·01	2·3 ± 0·02	2·4 ± 0·02	0·6 ± 0·02	1·2 ± 0·02	2·0 ± 0·03	2·4 ± 0·02
Fructose	1·4 ± 0·01	1·9 ± 0·01	5·1 ± 0·1	5·9 ± 0·1	1·4 ± 0·02	2·9 ± 0·02	4·0 ± 0·03	6·2 ± 0·5
Sucrose	0·3 ± 0·01	1·5 ± 0·01	2·1 ± 0·03	2·5 ± 0·02	0·4 ± 0·01	2·0 ± 0·01	2·5 ± 0·01	2·6 ± 0·01
Maltose	0	0	0	0	0	0	t[c]	t
Starch	1·9 ± 0·1	1·6 ± 0·1	1·2 ± 0·1	1·2 ± 0·1	1·8 ± 0·1	1·4 ± 0·1	1·3 ± 0·05	1·2 ± 0·06
Cellulose	8·3 ± 1·1	8·5 ± 1·0	8·3 ± 1·0	8·5 ± 1·0	8·5 ± 0·9	8·3 ± 0·9	8·5 ± 0·8	8·4 ± 0·9
Total sugars	5·0 ± 0·3	15 ± 1·9	24 ± 2·1	24 ± 2·1	4·1 ± 0·3	17 ± 0·9	28 ± 1·9	29 ± 2·2
Dry matter	12 ± 1·0	10 ± 0·6	10 ± 0·7	9 ± 0·6	12 ± 1·0	12 ± 1·0	11 ± 1·0	11 ± 1·0

[a] Data are means of triplicates.

[b] Standard error.

[c] t = traces.

TABLE 2

Effect of Ripening Stage on Some Carbohydrate Constituents and Total Proteins of Banana Pulp Stored for 7 Days at 28°C (±1°C)

Food constituents	*Fresh weight at 7 days of storage immediately after harvest (g/100 g)*							
	0[a]	*1*	*2*	*3*	*4*	*5*	*6*	*7*
Proteins	2·2[b] ± 0·01[c]	2·3 ± 0·01	2·3 ± 0·01	2·5 ± 0·01	2·4 ± 0·01	2·2 ± 0·01	2·3 ± 0·01	2·2 ± 0·01
Fructose	1·1 ± 0·01	1·5 ± 0·01	1·5 ± 0·01	2·0 ± 0·01	3·0 ± 0·01	3·9 ± 0·05	5·0 ± 0·05	5·0 ± 0·04
Glucose	1·6 ± 0·01	1·6 ± 0·01	2·3 ± 0·01	3·0 ± 0·01	4·6 ± 0·03	5·1 ± 0·03	5·5 ± 0·03	6·5 ± 0·05
Sucrose	3·1 ± 0·02	4·5 ± 0·02	7·2 ± 0·04	9·0 ± 0·5	10 ± 0·5	11 ± 0·6	12 ± 0·6	12 ± 0·7
Maltose	0	0	0	0	t[d]	t	t	t
Starch	34 ± 2·5	33 ± 2·0	26 ± 2·0	15 ± 1·3	15 ± 1·4	13 ± 1·0	11 ± 0·6	10 ± 1·0
Cellulose	9·6 ± 1·0	9·5 ± 1·0	9·3 ± 1·0	9·2 ± 1·0	9·3 ± 1·0	9·2 ± 1·0	9·0 ± 1·0	9·1 ± 1·0
Total sugars	8·6 ± 1·0	11 ± 1·0	15 ± 0·6	21 ± 1·6	21 ± 2·1	24 ± 2·0	36 ± 2·1	40 ± 2·5

[a] Freshly harvested mature green.

[b] Data are means of triplicates.

[c] Standard error.

[d] t = traces.

TABLE 3

Proximate Determination of Total Proteins and Some Carbohydrate Constituents of *Botryodiplodia theobromae*-infected Banana Fruit Stored for 7 Days at 28°C (±1°C)

Food constituents	*Fresh weight estimated on alternate days (g/100 g)*							
	1	*3*	*5*	*7*	*1*	*3*	*5*	*7*
	Peel				*Pulp*			
Proteins	2·0[a] ± 0·01[b]	1·8 ± 0·01	2·0 ± 0·01	2·0 ± 0·01	2·1 ± 0·01	2·0 ± 0·01	2·2 ± 0·01	2·1 ± 0·01
Glucose	0·7 ± 0·01	2·0 ± 0·01	0	0	2·0 ± 0·01	6·0 ± 0·04	12 ± 1·0	0
Fructose	1·1 ± 0·01	0	0	0	1·5 ± 0·01	2·7 ± 0·03	0	0
Sucrose	0·5 ± 0·01	1·5 ± 0·01	2·5 ± 0·04	4·5 ± 0·1	5·5 ± 0·1	7·0 ± 0·1	0	0
Maltose	0	2·7 ± 0·05	3·0 ± 0·04	3·0 ± 0·05	0	0	0	0
Starch	1·9 ± 0·01	1·8 ± 0·01	1·5 ± 0·01	1·3 ± 0·01	33 ± 2·1	31 ± 2·1	16 ± 1·4	15 ± 1·3
Cellulose	8·2 ± 1·0	6·0 ± 1·0	4·2 ± 0·3	2·0 ± 0·05	8·6 ± 1·1	5·0 ± 0·4	3·3 ± 0·1	1·7 ± 0·5
Total sugars	4·2 ± 0·2	12 ± 0·6	30 ± 1·3	12 ± 0·4	11 ± 0·7	25 ± 1·1	16 ± 1·0	3·5 ± 0·1

[a] Data are means of triplicates.

[b] Standard error.

content per 100 g of 9·1 to 11·7 g as against 11·3 to 12·1 g in naturally ripened peel (Table 1). However, the ash acts like a 'catalyst' because its addition to the peel surface hastens ripening when compared with the naturally ripened peel.

The effect of the mold *B. theobromae* on the food constituents shows a general decrease or complete loss of some. Cellulose, which was found to remain approximately constant during ripening in the peel and pulp (Tables 1 and 2), was drastically reduced (Table 3). This depletion of cellulose is likely to be due to the cellulolytic activity of the mold. *In vitro* and *in vivo* studies (Adisa & Fajola, 1983) showed that the organism produces high quantities of cellulases. The complete loss of fructose and glucose, both in the peel and pulp due to infestation by the mold, is an indication of the loss in nutritional value. The complete loss of sugars in fruits of tomato (Hasija & Batra, 1979), cucurbits (Singh & Choham, 1977) and watermelon (Chopra *et al.*, 1974), due to fungal infestation, has been reported. The utilization of the sugars serves as an alternative carbon source for respiratory substances by the organism. The starch content of peel and pulp fell considerably as ripening progressed with the decrease more pronounced in the pulp than in the peel. The decrease could be attributed to hydrolysis to sugars during ripening.

The protein contents are slightly higher in the pulp than in the peel while those of ripe and unripe fruits are constant (Tables 1 and 2). Although the values recorded for proteins were low, the sum total of the values of other food substances recorded show that the banana peel cannot be regarded as 'waste' as is the current practice in Nigeria. Bananas and plantains are cultivated in French West Africa for cattle feeding, the animals browsing on the leaves as well as the fruit (Oyenuga, 1968). The large amount of banana peel being produced and wasted in Nigeria could be more economically fed to livestock. More serious attention should be given to this aspect of husbandry.

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