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Chemical and biological studies on banana fruit

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With 3 figures and 6 tables

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Banana "Musa Cavendishii" is one of the most popular fruit crops in Egypt, due to its nice and palatable taste and high nutritive value (1). The chemical composition of banana fruit was studied by many investigators (2–9). Nitrogen balance of the rats as affected by banana fruit in the diet was also studied (10). It was found that N-balance index of absorbed N was increased as the result of supplementing casein diet with banana protein. Addition of 9% fresh banana pulp as a supplement to a diet containing 10% casein's protein failed to affect significantly the growth of weanling rats fed ad libitum.

The possible uses of banana in animal feeding were studied by *Agot* (11) who found that proteins and fats were present in nutritionally insignificant amounts. Meanwhile vitamins, except B_{12}, were present in appreciable amounts and the starch content was as high as 20–32%. *Brassani* et al. (12) reported that in chicken feed, banana flour may replace up to 10% of the corn flour, while high percentage gave rise to growth depression.

This work is an attempt to study the biological characteristics of both the edible and nonedible portions of banana fruit, since they have received limited attention specially for the peel. Chemical evaluation of the above-mentioned components of the fruit was also carried out. The possibility of using the nonedible portion as animal feed was also explored.

Materials

Ripe fruit samples of the *Musa Cavendishii* banana "Hindi" used in this study were caught at random from different markets in Cairo. Green yellowish colour and flesh firmness were taken to indicate ripeness of fruits and their suitability for experimentation.

Methods

Preparation of samples

Preparation of fruits for chemical and biological analysis:

a) Edible portion (pulp):

A representative quantity of banana fingers were peeled and the edible portions were then thinly sliced. A portion of the fresh slices was spontaneously analysed for moisture, vitamins (ascorbic acid, thiamin and riboflavin) and sugar content. The other portion was dried under vacuum at 60 °C for 48 hours, then finely ground using a blender. The powdered samples were used for further analysis.

b) Nonedible portion (peel).

The peels were also cut into small slices after excluding solid tips and treated in the same manner as mentioned above for the edible portion.

I. *Chemical analysis*

Known samples were analysed for moisture content, ether extract, total ash (13), calcium and phosphorus (14), total nitrogen (15) and nonprotein nitrogen (16). The amino acid contents by the chromatographic technique (17), total sugars (18) and vitamins as given by *Person* (19).

II. *Biological evaluation of banana fruit*

Biological experiments were conducted to evaluate the biological value of fruit as follows:

a) Protein efficience ratio (P.E.R.).

b) Effect of banana on growth.

The method described by *Brassani* et al. (12) to determine the protein efficiency ratio was used using twelve weanling males and the same number of weanling females of albino rats with an average of 45 gm. All rats were fed for about one week on the stock diet till they weighed from 50–52 gm at the beginging of the experiment. The animals were then divided into 4 groups (A, B, C and D), each group contained three males and three females. Food and water were given ad libitum. Total body weight of each animal group was recorded for a period of 21 days.

III. *Effect of banana on growth rate*

The feeding assay was carried out to evaluate the effect of banana pulp and peel on growth. At the beginning of the assay the animals were distributed into 6 groups (A, B, C, D, E and F), each group consisting of four rats. The groups A, B and C were males while groups D, E and F were females.

Two experimental diets plus the stock diet were made up according to the following:

1. Stock diet (No. I).

2. Banana pulp diet (No. II).

It was made up using two equal weights of diet No. I (Stock) and dried banana pulp powder.

3. Banana peel diet (No. III).

Peel diet was made to contain 50% of diet No. I (Stock) and 50% of dried banana peel powder.

The animals were fed the test diets for a period of four weeks. Food and water were given ad libitum and the total body weights of each group was recorded daily.

Table 1. The composition of experimental diets used.

Component	Amount of diets in (g.)			
	Casein diet 1	Peel diet 2	Pulp 50% 3	Pulp 100% 4
Casein	6	3	3	–
Dried pulp	–	–	50	86
Dried peel	–	40	–	–
Hydrogenated fat	2.5	2.5	2.5	2.5
Corn oil	2.5	2.5	2.5	2.5
Vitamin mixture	1	1	1	1
Salt mixture	4	4	4	4
Corn starch	84	47	37	4
Total	100	100	100	100

In diets 2 and 3, 50% of the protein source, from casein.
In diet no. 4, 100% of protein source from banana pulp.

Table 2. Chemical composition of both pulp and peel calculated on dry basis (g./100 g.)

Composition	Pulp	Peel
Crude protein (N × 6.25)	3.44	8.61
Total nitrogen	0.82	1.74
non protein nitrogen	0.26	0.34
protein nitrogen	0.55	1.38
Ether extract	2.29	7.21
Starch content	14.60	7.99
Total sugars	76.12	27.49
Pectin	2.30	3.40
Ash content	3.60	16.90
Phosphorus mg./100 g.	88.38	76.9
Calcium mg./100 g.	70.19	442.0
Iron mg./100 g.	0.47	1.65
Vitamin C. mg./100 g.	40.0	23.50
Vitamin B_1mg./100 g.	0.08	0.08
Vitamin B_2mg./100 g.	0.93	1.08
Moisture	75.7	88.0
Other substances	0.25	35.0

Results

I. *Chemical composition of both banana pulp and peel*

Tables 2, 3 and 4 show the determined values for the chemical composition of both banana pulp and peel. The obtained data gave remarkable differences in the ash content, nitrogen-containing substances, carbohydrates, vitamins and amino acid contents. The peel portion contained

Table 3. The amino acid contents of banana pulp and peel as comparing with the F.A.O. reference protein (g./16g. N).

Amino acids g./16g.N.	Pulp	Peel	F.A.O. reference
* Leucine + Isoleucine	2.32	1.20	9.0
* Phenyl alanine	3.08	1.23	2.8
* Methionine	0.00	0.74	2.2
* Valine	2.32	0.88	4.2
* Threonine	1.10	0.97	2.8
* Lysine	1.51	0.48	4.2
Cystine + Cystiene	5.00	3.99	
Tyrosine	2.90	3.44	
Histidine	2.32	2.78	
Alanine	2.09	0.65	
Serine	2.90	1.46	
Glycine	2.84	1.46	
Glutamic acid	5.29	2.09	
Aspartic acid	7.55	5.01	

* Essential amino acids.

Table 4. Essential amino acids content of banana pulp and peel as compared with F.A.O. reference protein (calculated g./16g.Nitrogen).

Amino acids	Pulp	Peel	F.A.O. reference protein
Total amino acids	41.22	26.77	–
Leucine + Isoleucine	2.32	1.20	9.0
Phenyl alanine	3.08	1.23	2.8
Methionine	0.00	0.74	2.2
Valine	2.32	0.86	4.2
Threonine	1.10	0.97	2.8
Lysine	1.51	0.48	4.2

higher values for ash, as well as calcium and iron than that of the pulp. Regarding the nitrogen-contianing substances, they were also higher in peel rather than in the pulp. Vitamins C, B_1 and B_2 proved to be present in both pulp and peel in fairly reasonable amounts. In this respect, vitamin C content in the pulp is twice that of peel, while B_1 and B_2 exist in nearly similar amounts in both banana pulp and peel.

The sugar contents were very much higher in pulp than in the peel. The determined starch in the pulp was twice as much as that of the peel.

The obtained data for the amino acid contents showed higher values for aspartic acid (18%) contributing the major fraction of amino acids present in both pulp and peel. Methionine was absent in banana pulp. The amino acid contents calculated for 16 gm. N are higher in pulp than that of peel (Table 3).

II. *Biological value of banana*

a) *Protein efficiency ratio (P.E.R.)*

Table 5 shows the P.E.R. value of banana diet in comparison with 6% casein diet. Results given in figure 1 and table 5, demonstrate that neither the pulp nor the peel proteins yielded good P.E.R. values when used at 6% protein level, which resulted in a significant reduction in weights of rats specially those receiving the peel diet. The P.E.R. of casein was + 0.5 whereas the other tested diets showed negative P.E.R. values amounted to – 1.75, – 5.58 and – 4.67 for the pulp diets and the peel diet respectively.

Table 5. Protein efficiency ratio of banana diets in comparison with casein diet.

Protein source	rats number		Average rat wt. at the begining (g.)	Average rat wt. changes (g.)	P.E.R.
	before expr.	after expr.			
Casein	6	6	52.0	+ 1.66	0.5
Peel 50%	6	3	52.1	–15.16	–4.67
Pulp 50%	6	5	52.8	– 8.23	–1.75
Pulp 100%	6	5	53.1	–11.16	–5.58

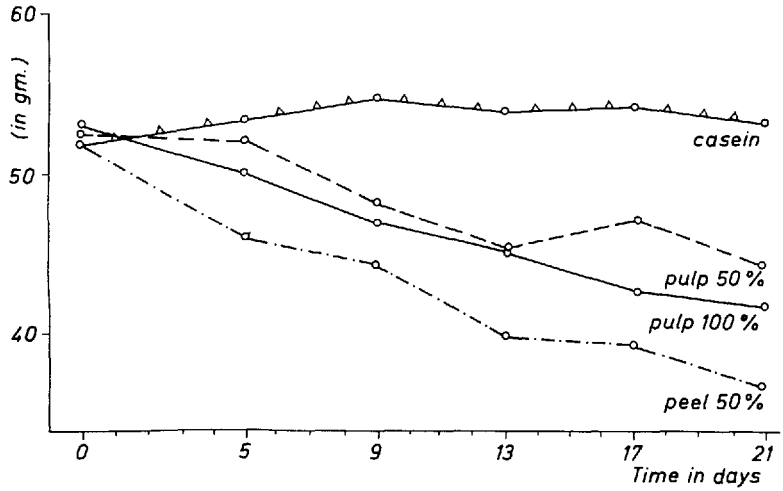

Fig. 1. Average weight changes of rats for banana diet comparing with casein diet.

b) *Effect of banana on growth*

Figures 2 and 3 summarise the results obtained in the growth experiment. The results elucidate that the incorporation of the stock and the pulp diet apparently raised the body weight for male and female rats respectively. On the other hand the incorporation of the stock diet to the peel diet resulted in a slight increase amounting to 6% in both male and female groups. However the body weight changes were too small for the peel diet when compared with the groups given the stock diet only, which showed high increase in the body weight for male and female rats respectively (Table 6).

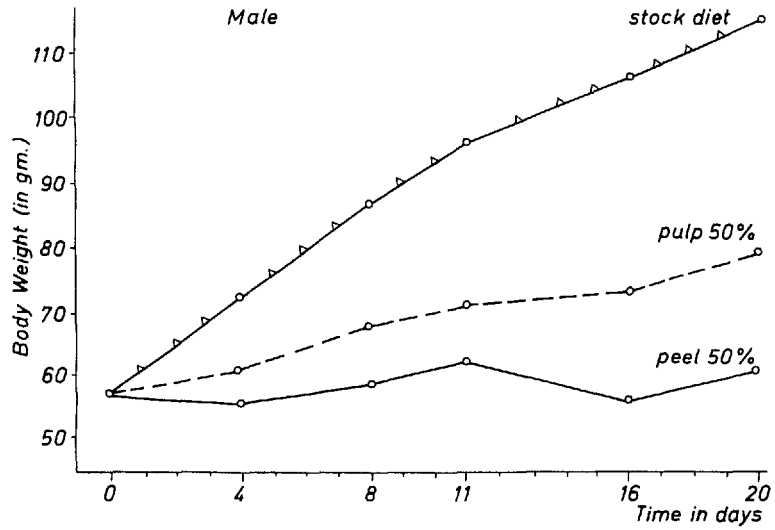

Fig. 2. Effect of banana diets and stock diet on the growth rate of male rats.

Table 6. The effect of banana pulp and peel replaced by 50% of stock diet on the growth rate of male and female rats in comparison with stock diet.

	Male rats			Female rats		
	Stock diet	Pulp 50%	Peel 50%	Stock diet	Pulp 50%	Peel 50%
Average rat wt. (g.);						
- at the beginning	56.75	57.5	57.5	51.75	51.25	51.50
- at the end	115.5	76.2	60.6	116.25	76.0	50.0
Rat wt. changes due to diet consumed (g.)	+ 58.75	+18.75	+3.6	+64.5	+24.75	+3.5
Rat wt. changes %	103.5	32.6	6.3	124.6	48.3	6.8
Rat wt. changes due to banana consumed (g.)	-	+5.33	−3.52	-	−23.91	−21.96

Discussion

This work was interested to investigate the chemical and biological characteristics of both the edible and nonedible portions of banana fruits.

Although banana contains some of necessary nutrients, specially carbohydrates, vitamins and minerals which make banana an edible food stuff, but it seems possible therefore that banana is not suitable food to be utilized by itself as a sole diet, as its protein content is apparently the factor restricting its use. The fact has been experimentally proved in rats having received banana alone and compared with rats taking banana mixed with their diets. Animals administrated banana alone exhibited

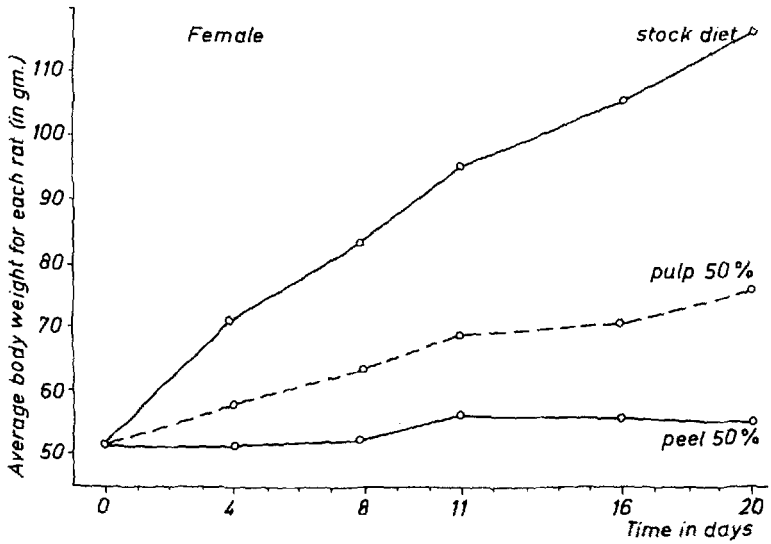

Fig. 3. Effect of banana diets and stock diet on the growth rate of female rats.

some symptoms characterised by emaciation, loss of weight (fig. 1), rough hair etc., whereas those receiving banana mixed with their food showed gradual increase in the body weight. The slight increase in the body weight of the control group given the casein diet, may be attributed to the relatively low level of protein used, which was not sufficient for tissue synthesis.

The negative P.E.R. values of banana diets may be due to the vast protein deficiency particularly in the essential amino acids (table 4). It is quite evident that with the exception of phenylalanine, banana fruit is proved to be vastly deficient with regard to the indispensible amino acids.

These results are in agreement with those of *Siliciano* and *Nasset* (10), who reported that the addition of 9% fresh fruit pulp of banana failed to effect significantly the growth of weanling rats fed ad libitum. They also found that dried banana when given as supplements to a diet containing 10% of protein from casein failed to affect the nitrogen balance of adult rats. *Agot* (11) also reported that banana peel is not digested readily, due to the presence of higher tannin content.

It is obvious from both animal assays (a and b) that although banana acquires fairly high caloric value, yet it cannot be considered as a source of plant protein in the diet especially for the vulnerable groups. This was emphasised by *Davidson* and *Passmore* (20), who reported the existence of proteins deficiency (Kwashirkor) in children in East and West Africa who eat large amounts of banana as a staple diet.

It is recommended therefore to use banana pulp together with other food stuffs for human consumption and banana peel mixed with diets of animals.

Summary

Chemical and biological evaluation of both the edible and nonedible portion of banana fruit was carried out. The possibility of using the nonedible portion (peel) as animal feed was also explored.

The results showed a remarkable difference concerning the chemical composition of both the edible and nonedible portions. The amino acid contents were proved to be vastly deficient with regard to the indispensable amino acids with exception of phenylalanine which was found in good amounts in the edible portion (pulp).

The biological results demonstrated that neither the pulp nor the peel portions yielded good P.E.R. values when used at 6% protein level. The P.E.R values showed negative values which amounted to – 1.75, – 5.85 and – 4.67 for the pulp and peel diets respectively.

Incorporation of the stock diet to the peel diet resulted in a slight increase which amounted to 6% in both male and female rat groups.

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