SOME PHYSIOLOGICAL EFFECTS OF A MAINLY FRUIT DIET IN MAN*

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'Prove thy servants, I beseech thee, ten days; and let them give us pulse to eat and water to drink.'

Daniel 1:12

Fruit diets have recently received considerable attention in the lay press. Dietitians who were consulted were of the opinion that a diet consisting only of fruit is incomplete, being low in total protein, certain essential amino acids, fat, certain vitamins and minerals. People subsisting on a purely fruit diet for a considerable length of time should therefore develop various deficiency stigmata.

Our interest in this matter was aroused when a lady of 45 years of age consulted us and claimed that she had subsisted entirely on a fruit diet for the past 12 years. According to her she was feeling very well and enjoyed her strenuous daily programme as a teacher in physical education.

Her decision to change to a fruit diet was precipitated by loss of weight, progressive muscular weakness and tiredness. Out of despair, more than anything else, she decided to follow the suggestion of her husband to try a raw fruit diet.

Initially the weight loss continued, partly because she found it difficult to adjust herself to this type of diet; after 6 months she weighed only 31·3 kg. However, she then started to gain weight, and weighed 48·5 kg after 8 months on the diet. Ever since, her weight has fluctuated between 47·5 and 50 kg.

When she consulted us her weight was 49·0 kg and her height 158·5 cm. Clinical examination of the patient together with a number of relevant laboratory tests revealed no abnormality. She was subjected to different physical fitness tests, including tests for joint flexibility, the Harvard step-test, and dynamometric tests for grip, chest and back-muscle strength. These tests confirmed that the subject was in excellent health.

The story of the patient also interested us for a completely different reason. Many factors are almost certainly concerned in atherosclerosis. Among those considered, diet still occupies the dominant position. The question remains, however, which component of the diet bears the chief responsibility. Since the discovery that cholesterol is a major constituent of the atherosclerotic plaque, a large amount of evidence has accumulated, implicating a chronic high-fat intake and derangement of the blood lipids as the most important factors in atherogenesis. The question as to which lipid is the culprit is still unsettled. Most workers favour cholesterol, but there is some suspicion that another lipid or combination of lipids, and not necessarily cholesterol, might be the primary damaging agent.[1-9]

Although most research workers still favour a chronic excessive lipid intake as the most important single dietary factor in atherogenesis, attention has recently been focused on the chronic consumption of large quantities of refined sugar,[10-14] and it must be borne in mind that a fruit diet is essentially a high-sugar diet. Yudkin *et al.*[10-13] claimed that there is a better correlation between a chronic high intake of sucrose and atherogenesis than between a high fat intake and atherogenesis. According to these workers a moderate increase in dietary sugar did not only produce an increase in cholesterol, phospholipid and triglyceride in all their subjects, but also, in a substantial proportion of them, an increase in plasma insulin and platelet adhesiveness.[13,14] High-sugar diets apparently also affect the tolerance of human subjects to glucose.[13]

For the reasons outlined, it was decided to have a closer look at the physiological and biochemical effect of a fruit diet on human beings. This is a report of our observations on volunteers who lived for extended periods on a diet consisting mainly of fruit.

METHODOLOGY

Selection of Subjects

White and Bantu male and female volunteers were employed in the present project. These subjects were subdivided as follows:

A. Mental Patients from Weskoppies Hospital

1. *Experimental division.* This group consisted of 9 Bantu males, divided into 2 groups of 5 and 4 subjects. These groups were put on a fruit diet separately and at different times of the year. Their ages ranged from 20 to 54 years. The mental disease diagnosed in all these cases was that of schizophrenia. At the time when the fruit project was commenced, the Bantu patients had already been in hospital for about 3 months, during which time they were on the standard hospital diet. All these patients were in remission when they volunteered to participate in the project. They were still on tranquillizers in accordance with modern psychiatric practice. This medication continued for 24 weeks after which the patients were due to be discharged from hospital.

2. *Control division.* A group of 15 Bantu male patients from Weskoppies Hospital who were admitted to the hospital at more or less the same time as the experimental group, served as controls. The controls were subdivided into the following groups:

(*a*) Five patients who had been treated for the same mental condition as group A_1, but whose medication had been stopped.

(*b*) Five patients whose clinical history corresponded closely to that of control group 2 (*a*) but who still received medical treatment.

(*c*) Five patients who suffered from various psychoses and whose medication consequently differed.

The control persons ate the ordinary hospital diet, and were included for the purpose of assessing the effect which different medical drugs and different mental diseases might have on the biochemical parameters being investigated.

B. Normal Healthy Subjects

This group originally consisted of 18 normal White male and female volunteers whose ages ranged from 23 to 64 years. These subjects included businessmen and -women,

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teachers, typists, housewives, etc. Only 8 of these volunteers, 6 females and 2 males, continued with the diet for 12 weeks or longer. The others supplemented their diet in different ways and the results are therefore not included in this report.

C. The Subject Referred to in the Introduction

At the time when the project began she had been on a fruit diet supplemented to a very small degree with nuts for about 12 years.

Selection of subjects was based on the history and a clinical examination. Special attention was given to general appearance, clinical complaints, blood pressure, weight and the condition of the skin. Blood cell counts and routine urine analysis were also done. These parameters were evaluated regularly during the experimental period.

The Diet

Under the term 'fruit diet' as used in this report, all possible varieties of fruit are included. The fruit could be eaten raw, stewed, dried or canned. Fruit juice was also allowed. The mental patients ate almost all the fruit raw. The normal volunteers ate most of their fruit raw, but a certain proportion was eaten as stewed or dried fruit, and as fruit juice.

In designing the diet for the project the daily diet consumed by the single volunteer served as guideline. Her minimum daily diet at the time consisted of 450 g of avocado, any other available fruit, and about 30 g of nuts. For the purpose of the project this diet was adjusted so as to supply a minimum of 2 400 calories, 50 g protein, 0·5 g calcium, and adequate amounts of iron and vitamins per day. At least 20% of the calories had to be supplied as fat so as to ensure adequate intake of calories, essential fatty acids, and fat-soluble vitamins. Every subject had to eat a minimum of 450 g of avocado per day to ensure an adequate intake of calories, fat and protein. In addition the fats in avocado are highly unsaturated. In general fruit is low in proteins and fats and has a high satiety value. To comply with the requisites outlined, subjects were allowed to supplement their diet by 70 g of nuts per day. The Bantu subjects ate only peanuts while the other subjects ate also cashew nuts and walnuts in similar quantities. Coconut was allowed, but only one subject ate small quantities.

The subjects could also eat tomatoes, carrots, cucumbers and lettuce. Coffee and tea with sugar but without milk were allowed. No restrictions were put on sugar, honey and salt.

In the case of the Bantu subjects the fruit and nuts were purchased and the food intake controlled by one of us to ensure that subjects complied with the minimum standards recommended. Inasmuch as no ceiling was set to the fruit intake, some subjects ate much more than the minimum amount suggested. A record was kept of the total food purchases per week. From these records the average daily food intake could be calculated.

The normal volunteers supplied their own food. This resulted in a greater variety in total food intake from subject to subject. To enable participants to comply with the minimum standards recommended, each subject was supplied with a guide for the recommended daily intake of fruit and nuts (Table I) as well as a list of the composition and calorie content of different varieties of fruit and nuts (Table II) from which a rough estimate of the adequacy of their diet could be made.[15] Each subject was asked to eat 20 portions of fruit per day supplemented by ¼-½ cup of nuts (about 70 g) and 2 or 3 cups of fruit, carrot or tomato juice. Two portions of fruit (about 450 g) had to be avocado for the reasons mentioned earlier. As already mentioned, a diet of this composition supplies about 2 400 calories per day, as well as most of the essential nutrients. Subjects were asked to keep a daily record of their food intake.

TABLE I. RECOMMENDED DAILY INTAKE FOR FRUIT AND NUT DIET

		Calories
2-3 cups fruit juice		300
20 portions* of fruit (including 2 or more of the following: dried fruit, oranges or orange juice, avocados)		1 500
¼-½ cup nuts		400
Total		2 200
Example of Daily Distribution		
Breakfast:	1 cup fruit juice	100
	4 portions of fruit	300
10.30 a.m.:	2 tablespoons of nuts	100
Lunch:	1 cup fruit juice	100
	6 portions of fruit	450
3.30 p.m.:	1 cup fruit juice	100
	2 tablespoons of nuts	100
Dinner:	7 portions of fruit	525
	2 tablespoons of nuts	100
9.00 p.m.:	3 portions of fruit	225
Total		2 100

*Portion quantities are given in Table II.

A fruit diet has a high satiety value due to its high crude-fibre and water content. This made it impossible for some of the volunteers to eat the recommended amount of food in 3 meals per day, hence some of them ate fruit in between meals to control their calorie and nutrient intake and their weight. As was the case with the Bantu subjects, some of the White subjects also consumed considerably more fruit than the minimum recommended.

RESULTS

Psychological and Social Impact

Most subjects, and especially the mental patients, accepted the fruit diet very well. The most critical period was from the third to the sixth week. Social and professional obligations made it sometimes very difficult for the normal volunteers to abide by the diet. On the other hand a fruit diet can be prepared in so many different and palatable ways that some of the normal volunteers experienced relatively little discomfort and embarrassment as a result of the diet. In this respect it should be stated that certain hotels and restaurants co-operated with the subjects inasmuch as they prepared delicious fruit meals on request. During the winter season it was more difficult to abide by the fruit diet as hot meals were preferred.

Some of the subjects who went on holidays or missions while still on the diet, experienced great inconvenience. They could not always obtain the fruit they wanted, and even if fruit was abundant, it was not always possible to prepare meals properly. This was an important reason why

so many of the normal volunteers deviated from the prescribed diet.

At a follow-up interview of the normal volunteers approximately 20 weeks after termination of the fruit project, practically every volunteer, including volunteers who did not complete the experiment, remarked that since the project, fruit had come to figure prominently in their daily diet.

Food Intake

The diet was planned to ensure a minimum intake of 2 400 calories and 50 g of protein per day. To compensate for the high satiety value of fruit the diet was supplemented by 70 g of nuts. The high-fat content of nuts and avocados enabled most of the participants to consume the recommended number of calories; some subjects consumed considerably more calories than the minimum number requested. The calorie and nutrient intakes are presented in Table III, and were calculated from standard tables.[15] The final analysis of the food consumed by the different groups showing the percentage of the total calories supplied by protein, fat and carbohydrate in the diet is summarized in Table IV.

TABLE IV. PERCENTAGE OF CALORIES SUPPLIED BY PROTEINS, FAT AND CARBOHYDRATE*

Subjects	*Protein*	*Fat*	*Carbohydrate*
Group A_1	8·0%	36·7%	64·8%
Group B	7·1%	37·6%	64·7%
Group C	5·6%	45·0%	52·0%

*The apparent discrepancies in the calculations are due to the way in which nutrient values are calculated.[15]

The diet supplied an average daily calcium intake of 650 mg. The average sodium intake per day was about 4 g (= 10 g NaCl) before the experiment, and this dropped to about 1 - 2 g (= 3 - 5 g NaCl) with the fruit diet. In the case of the Bantu the values for potassium were of the order of 3·0 and 9·0 g respectively. The change in potassium intake of Whites was less than in Bantu. However, the serum levels of these electrolytes as well as the potassium

TABLE II. COMPOSITION AND CALORIE CONTENT OF THE DIFFERENT VARIETIES OF FRUIT AND NUTS*

Food and description†	*Portion (household measure)*	*Weight g*	*Calories*	*Protein g*	*Fat g*	*Total carbohydrate g*	*Calcium mg*	*Iron mg*	*Vitamin A IU*	*Thiamine mg*	*Riboflavin mg*	*Niacin mg*	*Vitamin C mg*
Apples: Raw	1 medium	150	76	0·4	0.5	19·7	6	0·3	90	0·04	0·03	0·2	5
Dried	½ cup	28	78	0·4	0·3	20·8	5·5	0·4	—	0·03	0·03	0·3	3
Apple juice	1 cup	249	124	0·2	—	34·4	15	1·2	90	0·05	0·07	Trace	2
Apricots: Raw	3 medium	114	54	1·1	0·1	13·8	17	0·5	2 990	0·03	0·05	0·9	7
Dried	½ cup	37	98	1·9	0·1	25·1	32	1·8	2 785	Trace	0·06	1·2	5
Avocados	1 cup,cubes	152	372	2·6	40·1	7·8	15	0·9	430	0·10	0·20	1·7	24
Bananas	1 large	150	88	1·2	0·2	23·0	8	0·6	430	0·04	0·05	0·7	10
Carrots, raw	1 cup, grated	110	45	1·3	0·3	10·2	43	0·9	13 200	0·06	0·06	0·7	7
Cherries	1 cup, pitted	154	94	1·7	0·8	22·8	28	0·6	960	0·08	0·09	0·6	13
Coconut	½ cup, shredded	13	86	0·5	6·0	8·2	7	0·5	—	Trace	Trace	Trace	—
Dates	½ cup	44	126	1·0	0·3	33·5	32	0·9	25	0·04	0·04	1·0	—
Figs: Raw	3 small	114	90	1·6	0·5	22·3	62	0·7	90	0·06	0·06	0·6	2
Dried	½ cup	42	113	1·7	0·5	28·7	78	1·2	35	0·06	0·05	0·7	—
Grapefruit, raw	½ medium	285	75	0·9	0·4	19·0	41	0·4	20	0·07	0·04	0·4	76
Grapefruit juice	1 cup	246	87	1·2	0·2	22·6	20	0·7	20	0·09	0·05	0·5	99
Grapes	1 cup	153	84	1·7	1·7	17·7	20	0·7	90	0·07	0·05	0·3	5
Grape juice	1 cup	254	170	1·0	—	46·2	25	0·8	—	0·09	0·12	(0·6)	Trace
Guavas	1 medium	80	49	0·7	0·4	12·0	21	0·5	180	0.05	0.03	0·8	212
Lemons	1 medium	100	20	0·6	0·4	5·4	25	0·4	—	0·03	Trace	0·1	31
Lemon juice	1 cup	246	59	1·0	0·5	18·9	34	0·2	—	0·11	0·01	0·3	122
Mangoes	1 medium	200	87	0·9	0·3	22·7	12	0·3	8 380	0·08	0·07	1·2	55
Muskmelon: Cantaloup	1 cup, diced	145	30	0·9	0·3	6·7	25	0·6	4 960	0·07	0·05	0·7	47
Melon	1 wedge	150	49	0·8	—	12·8	(26)	(0·6)	60	0·07	0·04	0·3	34
Olives, green	10	65	72	0·8	7·4	2·2	48	0·9	160	Trace	—	—	—
Oranges	1 medium	215	70	1·4	0·3	17·4	51	0·6	(290)	0·12	0·04	0·4	77
Orange juice	1 cup	246	108	2·0	0·5	27·1	47	0·5	(460)	0·19	0·06	0·6	122
Pawpaws	1 cup, cubes	182	71	1·1	0·2	18·2	36	0·5	3 190	0·06	0·07	0·5	102
Peaches: Raw	1 medium	114	46	0·5	0·1	12·0	8	0·6	880	0·02	0·05	0·9	8
Dried	½ cup	40	106	1·2	0·2	27·7	17	2·7	1 300	Trace	0·08	2·1	7
Peanuts, shelled	2 tab'espoons	18	100	4·8	8·0	4·2	14	0·4	—	0·06	0·02	3·0	—
Pears	1 medium	182	95	1·1	0·6	23·9	20	0·5	30	0·03	0·06	0·2	6
Pineapples	1 cup, diced	140	74	0·6	0·3	19·2	22	0·4	180	0·12	0·04	0·3	33
Pineapple juice	1 cup	249	121	0·7	0·2	32·4	37	1·2	200	0·13	0·04	0·4	22
Plums	2 medium	120	58	0·8	0·2	14·8	20	0·6	400	0·08	0·04	0·6	6
Prunes	4 medium	24	54	0·5	0·1	14·2	11	0·8	380	0·02	0·03	0·3	1
Raisins	½ cup	40	107	0·9	0·2	28·5	31	1·3	20	0·06	0·03	0·2	Trace
Strawberries	1 cup	149	54	1·2	0·7	12·4	42	1·2	90	0·04	0·10	0·4	89
Tangerines	2 medium	228	70	1·2	0·4	17·6	(54)	(0·6)	(680)	0·12	(0·04)	(0·4)	50
Tomatoes	1 medium	150	30	1·5	0·4	6·0	16	0·9	1 640	0·08	0·05	0·8	35
Tomato juice	1 cup	242	50	2·4	0·5	10·4	(17)	(1·0)	2 540	0·12	0·07	1·8	38
Watermelon	1 wedge	462	60	1·0	0·4	14·7	15	0·4	1 265	0·10	0·11	0·3	13

*From *Composition of Foods*.[15]
†Vegetables such as tomatoes and carrots were allowed.
Note: Parentheses indicate imputed value.

TABLE III. MEAN DAILY INTAKE OF THE DIFFERENT GROUPS ON A FRUIT AND NUT DIET

Group	*Cal.*	*Protein g*	*Fat g*	*Carbohydrate g*	*Ca g*	*P mg*	*Fe mg*	*Na mg*	*K mg*	*Vit. A IU*	*Thiamine mg*	*Riboflavin mg*	*Niacin mg*	*Vit. C mg*
A_1	2 760	55	113	450	0·81	1 110	23	136	8 970	15 930	2·6	2·67	33	1 250
B	2 630	46	110	420	0·53	1 065	19	102	8 420	47 560	2·2	1·9	29	1 120
C	2 300	32	115	300	0·43	770	13	89	7 750	15 300	1·8	1·9	17	500

concentration per kg body-weight did not show a statistically significant change during the experimental period. Vitamins, and especially vitamins A and C, were consumed in excess of the daily allowances, since guavas, oranges and pawpaw contain large quantities of vitamin C, while pawpaw, mangoes and carrots supplied large quantities of vitamin A. However, in contrast to excess preformed vitamin A, excess carotene does not in itself appear to be injurious.

The single subject (group C) consumed almonds and walnuts instead of peanuts and consequently her niacin intake was lower than that of the experimental groups. Her total calorie intake was also lower than that of the other subjects because she consumed less fruit than the other subjects, and no sugar or honey. On the other hand, her fat intake was higher than that of the other subjects due to the high intake of avocado, i.e. often up to 800 g per day.

Physiological and Clinical Impact

None of the subjects experienced any ill-effects. In general, the mental patients did very well on the diet. Their interpersonal relationships, co-operativeness and interest in their surroundings were excellent.

Physical performance. A considerable number of the normal subjects claimed that their physical condition improved while they were on the diet. Some were convinced that their stamina increased and that their ability to undertake strenuous physical tasks and to compete in sport improved. These observations were completely subjective, and even though some of the evidence sounded convincing, such observations are likely to be prejudiced by the novelty of a 'new diet'. On the other hand McKechnie *et al.*[16] recently reported that the elimination of sucrose from the diet of marathon runners for one week before a race impaired the performance of the athletes and reversed the normal tendency for blood glucose to rise during such a race. Pruett[17] made similar observations in men during prolonged work stress. The excellent physical condition of the one subject in group C should also be kept in mind.

Most subjects reported an increase in the frequency of bowel movements and especially in urine production. Some were so worried about the increase in diuresis that they sought advice in this respect. The pH of the urine invariably changed from acid to alkaline.

Blood pressure. Both the systolic and diastolic blood pressure of the subjects fluctuated somewhat while they were on the special diet, but only in the case of the systolic pressure did a statistically significant decrease occur. Four of the subjects were mildly hypertensive; in all four the pressure, especially the systolic pressure, decreased.

Body-weight. The actual body-weight of each subject at the time the project was commenced and the subsequent changes which occurred during the experimental period are presented in Figs. 1 and 2. The results for groups A_1 and B are presented separately because of the difference in their dietary pattern preceding the experiment. The expected normal weight for each subject, based on sex, height, age and build of the subject was calculated, using the table of the Metropolitan Life Insurance Company. The results are shown in brackets in Figs. 1 and 2. From these figures it is clear that most subjects lost weight initially. The greatest loss occurred during the first 3 weeks.

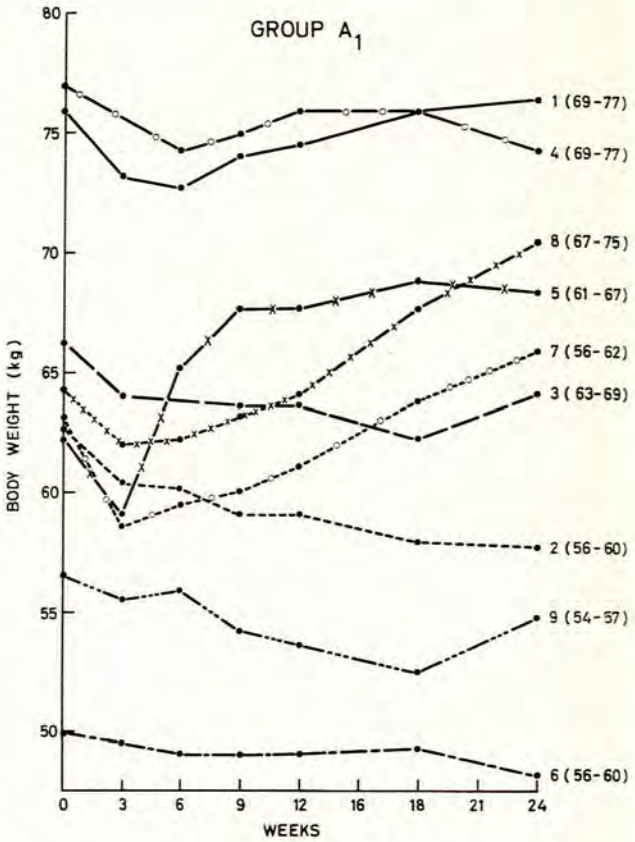

Fig. 1. Changes in the body-weight of the Bantu subjects (group A_1).

The average initial weight loss after 6 weeks was about 1·97 kg for group A_1 and about 3·63 kg for group B. The average initial weight of group A_1 was 61·52 kg; after 12 weeks it levelled off at 60·80 kg. In group B the average initial weight was 68·83 kg; this dropped to 64·15 kg after 18 weeks. Case No. 7 was excluded for the average, because she was unable to eat the recommended amount of fruit and consequently did not regain her initial weight. After the initial loss, the weights of the subjects of group B levelled off at figures which corresponded more or less with the calculated theoretical normal weights.

Haematology. No statistically significant changes in blood cell counts, haemoglobin concentration, red cell sedimentation rate and serum iron level (determined in some of the cases only) were obtained.

DISCUSSION

Diet Followed

The diet followed by the subjects can be regarded as being a high-sugar, relatively high-fat, low-protein one (Table III). The total calorie, vitamin and electrolyte intakes were adequate. The average gross protein intake was 50 g per day, supplying about 7·5% of the total calorie intake.

Urinary Output

The increased diuresis noticed by the subjects was almost certainly the result of the large fluid and potassium content

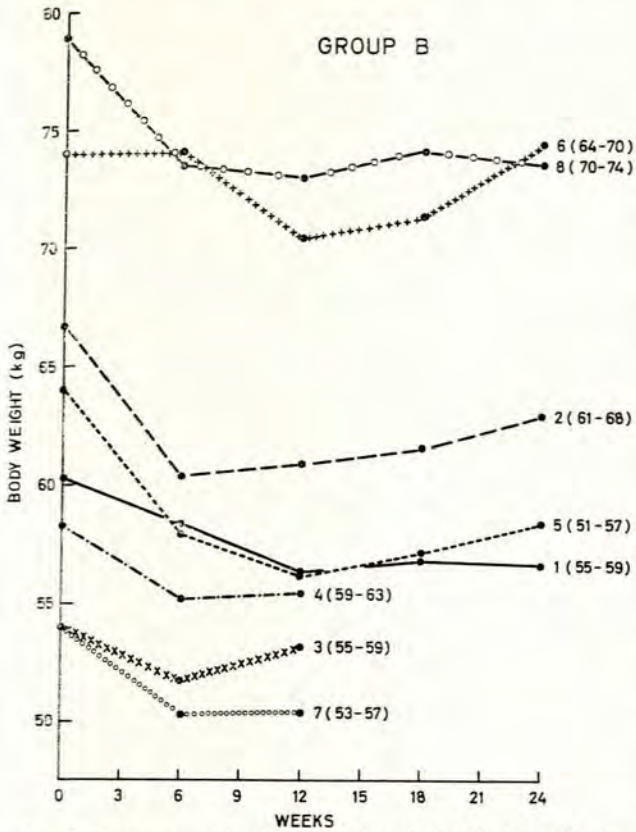

Fig. 2. Changes in the body-weight of the White subjects (group B).

of fruit. In addition most of the normal White subjects drank 2 - 3 glasses of fruit and carrot juice per day. According to theoretical calculations[15] the fruit diet increased the average daily water intake from 2 500 to 3 600 ml/day. An ordinary diet supplies about 1 ml H_2O per calorie, while the fruit diet supplied about 1·35 ml per calorie. On the other hand Dalderup *et al.*[19] reported an increase in urinary output by adult male rats kept on a high-glucose or lactose diet. A high-fructose diet produced only a transient increase in urinary output, while sucrose had no effect. It should also be mentioned that diets which favour weight loss, generally produce an initial loss in weight largely due to loss in body water.

According to Dalderup *et al.*[19] the faecal excretion of their animals on a high-monosaccharide or disaccharide diet decreased. This is in sharp contrast with the experience of our subjects. The discrepancy is probably due to the difference in the diets consumed by the animals of Dalderup *et al.*[19] and our subjects. In the case of the human-type diet supplied to the animals the carbohydrate content of the diet was raised by adding iso-calorically 15% refined monosaccharide or disaccharide to the diet, while in the present experiment the subjects consumed the sugars in the natural form together with large quantities of crude fibre. The diet also had a high fat content, and contained a considerable amount of potassium.

Blood Pressure

The blood pressure of the subjects showed a tendency to decrease. Three factors may have contributed to this decrease, namely the very significant reduction in sodium intake, the very significant increase in potassium intake, and the loss of weight.[20-24]

Body-Weight

The weight loss by the Bantu subjects in the early stages of the experiment (Fig. 1) was probably due to slow adaptation to the new and, especially to the Bantu, strange diet. In the early stages this may again be partly due to loss of body water. Dalderup *et al.*[19] noticed a similar adaptation period in rats that subsisted on a human-type diet to which additional monosaccharide had been added.

A similar but more pronounced loss in weight occurred in the other subjects. A few of these who were mildly overweight, found in this diet an excellent incentive to reduce, and consequently showed a greater decrease in weight than the others. An interesting aspect of the diet was the tendency for the weights to level off more or less at the 'theoretically ideal' weight for the subject. This may partly explain why some lost more weight than others. The comparatively mild degree of weight loss in the early phases of the experiment indicates that the diet was at least adequate in as far as it was able to produce a weight approximately equal to the calculated normal weight for each subject. On the other hand, body-weight alone is not a complete proof that a diet is adequate in every respect.

SUMMARY

The effect of a nut-supplemented fruit diet on the general sense of well-being, blood pressure and body-weight of human volunteers is described and discussed.

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