CCXXII. THE DISTRIBUTION OF THE VITAMIN B COMPLEX.

III. FRUITS.

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Most of the previous work on the distribution of vitamin B in fruits was carried out before the differentiation of the complex into the antineuritic vitamin B₁ and the antidermatitis vitamin B₂, and as a rule the results of the older experiments give only rough indications of the presence of both constituents of the complex. These have been summarised by Sherman and Smith [1931].

In the work described in the present paper, apple, banana, orange and tomato, the fruits in most common use in this country, were tested for their vitamin B₁ and vitamin B₂ content respectively. Vitamin B₄ [Reader, 1929; 1930, 1, 2] has not been tested for independently. As it was not being supplied in the basal diet used for the vitamin B₁ tests, these indicated the content of vitamin B₁ and B₄ combined.

This work is a continuation of that on the vitamin B₁ and B₂ content of foodstuffs previously carried out in this laboratory [Aykroyd and Roscoe, 1929; Aykroyd, 1930; Chick and Copping, 1930; Roscoe, 1930, 1931]. A comparison is given in this paper of all the results hitherto obtained.

METHODS.

The methods employed were those described in the previous papers [Roscoe, 1930, 1931], in which the growth of young rats is used as criterion.

In the vitamin B₁ estimations the diets contained unpurified caseinogen and the vitamin B₂ was supplied as autoclaved yeast extract (F5A). For the vitamin B₂ estimations purified caseinogen was used and vitamin B₁ was provided as Peters's antineuritic concentrate from yeast (YE) [Peters, 1924; Kinnersley and Peters, 1925].

The fruits were prepared by peeling, coring or removing the pips, and then mincing. The water content of the pulps so obtained was reduced by exposing to the air in thin layers at 37°. The fruits were bought from time to time throughout the experiments. No particular variety was adhered to.

The reduced pulps were incorporated in the diets in varying percentages (reckoning from the dry weights), but the rats were only allowed to consume

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enough of these diets to provide a given amount of the fruit each day, the remainder of their requirements being satisfied with a vitamin-free diet.

THE VITAMIN B₁ CONTENT OF CERTAIN FRUITS (Table I).

Table I. *Vitamin B₁ content of certain fruits as demonstrated by weight increase of rats during 5 weeks on diets containing various percentages of the fruit pulps.*

(Vitamin B₂ supplied as autoclaved yeast extract (F5A).)

Material tested	Amount eaten daily		No. of rats	Increase in weight in 5 weeks (averages, g.)
	Wet weight g.	Dry weight g.		
Orange	2.5	0.25	4	50
	5.0	0.5	1	85
Tomato	6.25	0.5	4	38
	12.5	1.0	4	82
Banana	2.3	0.5	2	No growth
	4.6	1.0	4	51
Apple	5.5	1.0	4	32
	11.0	2.0	4	66

The amounts referred to in the following paragraph are the dry weights consumed daily.

Orange proved a rich source of the antineuritic vitamin; rats eating as little as 0.25 g. gained 50 g. in weight in 5 weeks, those eating 0.5 g., 85 g. *Tomato* was about half as good as orange; rats receiving 0.5 g. gained 38 g., those with 1.0 g., 82 g. *Banana* was one-quarter as rich as orange; with 1.0 g. the increase in weight was only 51 g. *Apple* was even poorer; with as much as 2.0 g. the increase in weight in 5 weeks was only 66 g.

In Table II the results obtained with these fruits, together with the values for the other foodstuffs previously published, are tabulated in the order of their vitamin B₁ potency. The amounts shown are the dry weights needed by

Table II. *The vitamin B₁ content of various foodstuffs (dry weights).*

Material	Daily dose needed to promote increase in wt. of 50-60 g. in 5 weeks g. dry wt.		Potency (yeast = 100)
Yeast (brewer's)	0.05	< 0.25	{ 100 50
Wheat germ	0.1		
Liver (ox)	< 0.5	0.25-0.5	10-20
Watercress	< 0.3		
Lettuce	0.3		
Orange	0.25		
Etiolated cabbage	0.3-0.5		
Carrot	0.25-0.5	0.5-1.0	5-10
Spinach	< 0.5		
Green cabbage	< 0.95		
Turnip	0.5-1.0		
Tomato	0.5-1.0		
Egg-yolk	0.5-1.0	1.0-2.0	2.5-5.0
Onion	0.5-1.0		
Meat (ox muscle)	1.0-1.5		
Banana	1.0		
Potato	1.0-2.0		
Apple	1.0-2.0		

young rats, when given as sole source of vitamin B₁, to produce an increase in weight of 50–60 g. in 5 weeks. These values have been used to calculate the vitamin B₁ potency in terms of that of yeast. Yeast being taken as 100, the materials are placed in groups with potencies of over 20, 10–20, 5–10 and 2·5–5, respectively.

It will be seen that the orange is as good a source of vitamin B₁ as any of the substances tested, except yeast and wheat germ. Its potency lies between 10 and 20 and is equal to those of the green leaf vegetables, liver and carrot. Tomato has a potency of between 5 and 10, equal to those of turnip, egg-yolk and onion. Banana and apple have potencies between 2·5 and 5, equal to those of meat and potato.

THE VITAMIN B₂ CONTENT OF CERTAIN FRUITS (Table III).

Orange, tomato and banana all proved to be equal sources of this vitamin. In each case rats receiving 1·0 g. daily increased in weight by about 30 g. in 5 weeks and those receiving 2·0 g. by about 60–70 g. *Apple* was again the

Table III. *The vitamin B₂ content of certain fruits as demonstrated by weight increase of rats during 5 weeks on diets containing various percentages of the fruit pulps.*

(Vitamin B₁ supplied as antineuritic yeast concentrate (YE).)

Material tested	Amount eaten daily		No. of rats	Increase in weight in 5 weeks (averages, g.)
	Wet weight g.	Dry weight g.		
Orange	10·0	1·0	4	29
	20·0	2·0	5	69
Tomato	12·5	1·0	2	No growth
	25·0	2·0	4	67
Banana	4·6	1·0	4	35
	9·2	2·0	4	62
	18·4	4·0	3	102
Apple	5·5	1·0	2	34
	11·0	2·0	4	47
	22·0	4·0	4	66

poorest of the fruits tested; rats receiving 1·0 g. increased in weight 34 g. in 5 weeks but 4·0 g. were needed to produce 66 g. increase.

In Table IV these fruits are placed in order of their vitamin B₂ contents, together with the other foodstuffs previously tested. The amounts needed to promote an increase in weight of 50–60 g. in 5 weeks are given and from these have been calculated their potencies when yeast is taken as 100.

The fruits tested do not stand very high as regards their vitamin B₂ content; it was lower than the vitamin B₁ content. Orange, tomato and banana are equal to wheat germ and onion, poorer than the green leaf vegetables, root vegetables, meat and milk, but richer than the cereals, pulses or potatoes. Apple has a content equal to that of the cereals.

In Table V are shown the vitamin B₁ and vitamin B₂ potencies, respectively, of the various foodstuffs, when the fresh weights needed to promote

Table IV. *The vitamin B₂ content of various foodstuffs (dry weights).*

Material	Daily dose needed to promote increase in wt. of 50-60 g. in 5 weeks g. dry wt.	Potency (yeast = 100)
Yeast (brewer's)	0.1	{ 100 80
Liver (ox)	0.12	
Egg-white	0.3-0.6	20-40
Watercress	0.4	
Green cabbage	0.4	
Spinach	0.4	
Milk (cow's)	0.7	10-20
Meat (ox muscle)	0.5-0.75	
Lettuce	0.6	
Etiolated cabbage	0.4-0.8	
Carrot	0.5-1.0	
Turnip	1.0	
Egg-yolk	1.0	5-10
Wheat germ	1.0-2.0	
Onion	1.6	
Orange	1.0-2.0	
Banana	1.0-2.0	
Tomato	< 2.0	
Peas (dried)	2.0-3.0	2.5-5
Wheat (whole)	2.0-3.0	
Apple	2.0-4.0	
Potato	2.0-4.0	
Maize (whole, white)	2.0-3.5	< 2.5
Millet	> 4.0	
Maize (whole, yellow)	> 4.0	
Rice	> 4.0	

Table V. *The vitamin B₁ and B₂ potencies of various fresh foodstuffs.*

The potencies have been calculated by comparing the amounts of the fresh materials needed to promote 50-60 g. growth in young rats during 5 weeks, with the amount of fresh yeast needed (i.e. as source of vitamin B₁, 0.05 g., as source of vitamin B₂, 0.1 g.).

Potency	Vitamin B ₁	Vitamin B ₂
More than 100	Wheat germ	Liver (ox)
100	Yeast (brewer's)	Yeast (brewer's)
20-100	Liver (ox)	Wheat germ
	Egg-yolk	Egg-yolk
10-20		Meat (ox muscle)
		Egg-white
		Watercress
		Peas (dried)
		Wheat (whole)
		Spinach
		Maize (whole, white)
		Green cabbage
5-10	Meat (ox muscle)	Milk
	Watercress	Lettuce
	Orange	Etiolated cabbage
	Lettuce	Carrot
	Spinach	Banana
	Etiolated cabbage	
	Carrot	
	Banana	
2.5-5	Potato	Potato
	Green cabbage	Apple
	Tomato	Orange
	Turnip	Tomato
	Apple	Turnip
Less than 2.5	Onion	Onion

50–60 g. growth in 5 weeks are compared with the amount of fresh yeast needed.

It is noticeable that with a few exceptions the materials tested do not vary widely in their content of vitamins B_1 and B_2 respectively. Yeast, wheat germ, liver and egg-yolk have potencies of both vitamins greater than 20, but all the remaining foods lie between 2.5 and 20, with the exception of onion which is lower.

A general similarity is also exhibited in the distribution among the food-stuffs of the two vitamins, the materials when placed in order of value forming two very similar series (see Table V). There are however marked exceptions. Liver and meat have a considerably higher proportion of vitamin B_2 than of B_1 (vitamin B_1 potency/vitamin B_2 potency = $1/4$), and the green leaf vegetables, egg-yolk, banana and turnip a slightly higher proportion ($1/2$), that is, these take higher places in the vitamin B_2 series than in the vitamin B_1 series. On the other hand, wheat germ has a much higher proportion of vitamin B_1 than of B_2 ($8/1$), and orange and the whole cereals a slightly higher ($2/1$); these, therefore, take higher places in the vitamin B_1 series.

Egg-white is unique in that it is the only known natural source of vitamin B_2 without vitamin B_1 . No natural source of vitamin B_1 without vitamin B_2 is known.

These results may be compared with those of previous investigators. Apples have always been found to be poor sources of "vitamin B" [Weatherby and Waterman, 1928]. Oranges were here found to be richer in the antineuritic vitamin, than had been thought, about 4 cc. of juice, not 10 cc. [Sherman, 1926], being sufficient for normal growth when vitamin B_2 was being adequately supplied; 20 cc., not 10 cc. [Willimott, 1928], were needed, however when the juice was the sole source of vitamin B_2 . Tomatoes, as previously shown [House, Nelson and Haber, 1929], were here found to be rather poorer than oranges in vitamin B_1 . Bananas were tested for their vitamin B_1 and B_2 contents separately by Eddy [1927]. The present assays do not agree with his. This may be due to the fact that Eddy based his estimations on weight maintenance for both vitamins, whereas the weight of rats can be maintained without vitamin B_2 if vitamin B_1 is supplied. On this basis the vitamin B_2 potency was found by him to be considerably higher than the vitamin B_1 potency, whereas in this work it was lower. In Eddy's work also 6 g. of fresh banana when given as source of vitamin B_2 were found to support nearly normal growth, here more than 17 g. were needed.

SUMMARY.

1. The vitamin B_1 content of orange was the highest of the fruits tested, being one-fifth that of yeast (dry weights) and equal to that of the green leaf vegetables or liver. The value of tomato was rather less than one-tenth that of yeast, banana one-twentieth and apple still lower.

2. The vitamin B_2 content of the fruits tested was lower. The value of

orange, tomato and banana was rather less than one-tenth and of apple about one-twentieth that of yeast (dry weights).

3. The vitamin B₁ and B₂ potencies of all the foodstuffs tested in this laboratory have been calculated taking yeast as standard. These are tabulated in order of magnitude, firstly comparing dry weights and secondly fresh weights.

4. A large number of the foodstuffs tested had the same proportion of vitamin B₁ to vitamin B₂ as had yeast. Liver, meat, the green leaf vegetables and egg-yolk were richer in vitamin B₂ than in vitamin B₁, while the reverse was true of wheat germ, orange and the whole cereals.

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