STUDIES ON THE ABSORPTION OF CAROTENE IN MAN

TSUYUKO KAWAGUCHI AND AKIJI FUJITA

Biochemical Laboratory, Kitasato Institute, Minato-ku, Tokyo

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The chief source of vitamin A of the Japanese is carotene, especially β -carotene. It is therefore important to know the absorbability of carotene in order to determine the vitamin requirement of the Japanese but studies concerning the matter have scarcely been performed in Japan. A survey of the literature shows that this problem has not been fully established in other countries and the results of various investigators are scarcely in accord. According to the view of the authors, it seems to be highly questionable whether carotene, especially β -carotene in feces, has been accurately measured. The authors have conducted a detailed study of carotene absorption in Japanese using an assay method which had been established by the authors for determining β -carotene in feces.

EXPERIMENTAL

Methods

1. Subject.

The experimental subject was a 46-year-old, healthy female, weighing 46 kg and 152 cm in height. Exercise was limited to light house work and heavy manual labor not permitted.

2. Method of β -Carotene Determination

The total quantity of feces for 24 hours was measured, mixed well, a suitable aliquot (about 3 g) was taken, ground well, extracted with 3 ml methanol and filtered through a sintered-glass filter. The residue was extracted several more times with methanol to make a total volume of about 10 ml. The same process was repeated with benzene until the filtrate became clear (usually 20–30 ml). The benzene layer was evaporated off leaving a volume of about 10 ml. To this was added 10 ml of 5 per cent KOH-ethanol and mixed well. After standing for about 10 minutes, 10 ml of water was added, the solution shaken well and the benzene layer collected. This was washed two times with an equal volume of 60 per cent methanol and then twice with 20 ml water. The benzene layer which had now become clear was evaporated off, the residue was dissolved in 3 ml petroleum ether and 1 ml of the solution was used for chromatography. For this purpose calcium hydroxide columns, 0.7×15 cm, were used. One ml of the carotene solution was placed on the column and developed with petroleum ether only. Approxi-

mately 20 ml was required. First, α -carotene flowed down and after an interval, β -carotene followed. The β -carotene fraction was taken in a test tube, diluted with a suitable quantity of petroleum ether and the optical density was measured with the Beckman spectrophotometer (450 m μ , 1 cm). The conversion factor for calculating the β -carotene concentration, *f*, *i. e.*, ($\bar{r}$ /ml)/*E* was taken as 3.84. Under these conditions, the added β -carotene was practically completely recovered. No special treatment for saponification was found necessary.

3. Basal Diet.

The basal diet was made up as similar as possible to the normal daily diet of the subject. The daily intake was 2000 Calories with 70 g protein and almost no carotene was contained. Though there were some variations according to the season and course of the study, the diet was approximately that shown in Table I.

4. Experimental Diet.

Food containing carotene to be tested was administered at one meal, lunch. Test samples containing margarine or oil were incorporated in mashed potato and given. Strained pumpkin was sweetened with sugar and given in place of Irish potato. When margarine was added to this, the margarine was mixed in during the process of straining. Care was taken to use margarine which did not contain carotene.

TABLE I
Composition of the Basal Diet.

Time	Menu	Ingredients	Weight	Cal.	Protein
Breakfast	Bread	Bread	g 150	376	g 10.5
		Margarine	10	74	—
	Fruit Tea	Apple	100	46	0.3
		Black tea	Small	—	—
		Sugar	10	40	—
Lunch	Pickled squid (1) Cooked vegetable	Squid	100	79	17.0
		Irish potato	150	117	2.8
		Dried onion	100	25	1.4
		Sugar	10	40	—
		Soy bean sauce	10	—	—
	(2) Mashed potato	Irish potato	150	117	2.8
		Margarine	30	222	—
		Radish	20	3	—
	Pickle				
	Rice	Boiled rice	320	448	6.7
Dinner	Soup	Tofu (Bean curd)	50	32	3.0
	Boiled fish	Miso (Bean paste)	20	31	2.5
		Spanish mackerel	100	110	20.0
		Sugar	5	20	—
		Soy sauce	10	—	—
	Vegetable	Cabbage	100	13	1.4
	Pickle	Radish	20	3	—
	Rice	Boiled rice	320	448	6.7
Total			(1)	1,905	72.3
			(2)	2,127	72.3

5. *Metabolism Experiment.*

The carotene-deficient diet was given every day (the method of preparation differed every day though the ingredients were the same) and the total feces excreted the following day was collected. The feces was weighed, mixed well and a small aliquot was taken for determining the carotene content. Even with this carotene-deficient diet, the carotene content of the feces was never zero but measurable quantities were demonstrated. This diet was continued for several days. Food containing carotene was then given at lunch time and the carotene content of the feces excreted the following day measured. The carotene content of the feces of the basal diet was subtracted and the difference, which was the real quantity excreted, was subtracted from the quantity of carotene ingested and this value was assumed to be the quantity absorbed. The percentage absorption was calculated from the quantity absorbed and the quantity taken. The carotene excretion was measured every day until a constant value was obtained. Data in which the effect of food taken before was apparent, were omitted as were those obtained at times of diarrhea.

6. *Absorption of Pure Carotene Solution.*

Two mg (α , 80 γ , β , 1680 γ) crystalline carotene (prepared from benzene-dissolved carotene by evaporation under reduced pressure) was dissolved in 2 ml olive oil. This was absorbed on about 10 g of bread and given at lunch time.

7. *Carrot Diet.*

When cooked carrot was given, the carrot was sliced in about 5 mm sections and seasoned with soy sauce and sugar and when grated carrot was given, raw carrot was grated with a radish-grater.

8. *Pumpkin Diet.*

The pumpkin was boiled and strained. In the experiment, the rind was removed in some cases and included in the others.

9. *Dried Seaweed Diet.*

Ten g dried seaweed "Asakusanori" (produced at Omori), *i. e.*, 3½ sheets, was placed in an oven at 80° for 3 minutes, cut into about 1 cm² pieces, seasoned with a small quantity of salt and sodium glutamate, soaked in hot water and taken.

10. *Spinach Diet.*

The leafy part of the spinach was boiled and strained.

Results

1. *Absorption of Pure Carotene.*

Table II shows the results of the experiment with the oil solution of carotene. Absorption of β -carotene is high and without correction for the β -carotene in the basal diet, it is 84 per cent and with correction, it becomes 98 per cent. With a suspension of carotene, instead of the oil solution, absorption was poor. Whether this was due to the mode of administration is not clear but on the third day after cessation of administration of the suspension, a small quantity of carotene was found in the feces in a crystalline form. It is therefore suggested that carotene is poorly absorbed in a crystalline form.

TABLE II
Absorption of Oily Solution of Pure Carotene.

I, Basal diet. II, I + Carotene in 2ml olive oil containing 1680 γ β -carotene.

Diet	Date	Daily feces	β -Carotene excreted	Absorption
		<i>g</i>	γ	<i>per cent</i>
I	May	1	238	
		12	252	
			245^b	
		13	280 (35) ^a	98
II		14	276 (31)	98
		15	287 (42)	97.5
		16	258 (13)	99.3
			275^b (30)^b	98^b

^a The parenthesized figures indicate the corrected amount of excreted β -carotene.

^b Average. (Same in the following tables).

2. Carotene Absorption from Carrot Diet.

The results of the cooked carrot diet are shown in Table III and the

TABLE III
Carotene Absorption from Cooked Carrot.

I, Basal diet. II, I + 50 g cooked carrot containing 2652 γ β -carotene. Supplemented with 20 g fried bean curd.

Diet	Date	Daily feces	β -Carotene excreted		Absorption
			Determined	Corrected	
		<i>g</i>	γ	γ	<i>per cent</i>
I	Jan.	9	257		
		10	239		
		11	265		
			254		
II		12	2,240	1,990	25
		13	3,130 ^a	2,880	9
		14	1,920	1,670	37
		15	2,230	1,980	25
		16	2,150	1,900	28
			2,334	2,084	21

^a Diarrhea

results with raw grated carrot are shown in Table IV. It can be seen in Table III that the excretion of β -carotene with the basal diet is 254 γ and when this is corrected, the percentage absorption of β -carotene is 21. A

comparison was made of the β -carotene content between raw and cooked (1 g for 8 minutes) sliced carrot and only a loss of 3.5 per cent was found by the process of cooking.

Table V shows that the absorption of β -carotene from raw grated carrot was 21 per cent. The absorption from grated carrot cooked for 3 minutes was 48 and when this was supplemented with 10 g margarine, the absorption was 46 per cent. The β -carotene excreted with the basal diet in this experiment was 247 γ and the percentage absorption were calculated from this. From the results, it can be seen that absorption is poor with raw grated carrot, that the absorption rises 2.4 times by cooking and there is a slight but not significant drop in absorption with addition of margarine.

3. Carrot Absorption from Pumpkin Diet.

Table V shows the results of the experiment with the pumpkin (strained including rind) and Table VI, the results obtained with the squash (strained, peeled). It can be seen in Table V that the absorption of β -carotene, after correction for the carotene of the basal diet, was 53 per cent. With addition of 30 g margarine, the adsorption was 69 and with addition of 30 g olive oil, it was 64 per cent. In other words, the addition of margarine or oil increased the absorption of carotene but margarine had a slightly greater effect. In Table VI, the β -carotene excreted in the feces with the basal diet was 246 γ and when the values are corrected for this, the percentage absorption becomes 35 and with addition of 10 g margarine or 10 g olive oil, the absorption is 38, and 39 per cent respectively. In this case, the addition of oil had little effect on the absorption.

TABLE IV
Carotene Absorption from Grated Carrot.

I, Basal diet. II, 50 g raw grated carrot (β , 2100 γ), mixed with 100 g mashed potato. III, 50 g grated carrot, cooked 3 minutes, mixed with 100 g mashed potato. IV, III + 10 g margarine.

Diet	Date	Daily feces	β -Carotene excreted		Absorption
			Determined	Corrected	
		<i>g</i>	<i>γ</i>	<i>γ</i>	<i>per cent</i>
I	June 10 11	85	242		
		95	252		
			247		
II	14 15	108	1,945	1,698	19
		104	1,890	1,643	22
			1,917	1,670	21
III	16	86	1,340	1,093	48
	17	80.5	1,375	1,128	46
	18	81	1,320	1,073	49
			1,345	1,098	48
IV	19	97	1,367	1,120	47
	20	88	1,425	1,178	44
			1,396	1,149	46

TABLE V
Carotene Absorption from Pumpkin (strained).

I, Basal diet. II, 300 g pumpkin (strained, including rind) (β , 873 γ).
III, II + 30 g margarine. IV, III + 30 g olive oil.

Diet	Date	Daily feces	β -Carotene excreted		Absorption
			Determined	Corrected	
		<i>g</i>	γ	γ	<i>per cent</i>
I	Feb. 17	108	692 ^a		
		65	225		
		19	265		
			245		
II	20	82.5	677	432	51
		21	615	370	58
		22	674	429	51
			655	410	53
III	23	79.5	565	320	63
		24	549	304	65
		25	435	190	78
			516	271	69
IV	26	69	568	323	63
		27	558	313	64
		28	549	304	65
			556	313	64

^a Carotene given up to February 14, switched to basal diet on 15th, no bowel movement on 16th.

TABLE VI
Carotene Absorption from Squash (strained).

I, Basal diet. II, I + 150 g squash (inner meat only, cooked, containing 3240 γ β -carotene). III, II containing 3200 γ β -carotene + 10 g margarine.
IV, I containing 3170 γ β -carotene + 10 g olive oil.

Diet	Date	Daily feces	β -Carotene excreted		Absorption
			Determined	Corrected	
		<i>g</i>	γ	γ	<i>per cent</i>
I	July 3	90	240		
		4	252		
			246		
II	5	85	2,350	2,104	35
		6	2,355	2,109	35
			2,353	2,106	35
III	7	88	2,244	1,998	38
		8	2,220	1,954	39
			2,232	1,976	38
IV	9	78	2,160	1,914	40
		10	2,230	1,984	37
			2,195	1,949	39

4. Carotene Absorption from Dried Seaweed Diet.

As can be seen in Table VII, the daily ingestion of 10 g dried seaweed containing 2060 γ β -carotene is somewhat excessive for the test subject. The

TABLE VII
Carotene Absorption from Dried Seaweed.

I, Basal diet. II, I + 10 g dried seaweed containing 2060 γ β -carotene.

Diet	Date	Daily feces	β -Carotene excreted		Absorption
			Determined	Corrected	
I	Feb. 5 6	<i>g</i>	γ	γ	<i>per cent</i>
		90.5	316		
		61	237		
			277		
II	7	82.2	2,220	1,943	6
	8	87.7	2,102	1,825	11
	9	102	2,292	2,015	2
	10	70	1,930	1,653	20
	11	90	2,340	2,063	0
			2,177	1,900	8

β -carotene content of the feces with the basal diet was 277 γ and when the value during administration of dried seaweed is corrected for this, the percentage absorption is 8. There is a fluctuation from day to day, but the percentage absorption is considered about 10. The absorption of carotene in dried seaweed was thus found to be very poor.

This experiment was repeated on August 7 and 10 g dried seaweed containing 1710 γ β -carotene was administered. Diarrhea, however, occurred from that day and the absorption of β -carotene was 4 per cent and the experiment was obliged to be discontinued.

5. Carotene Absorption from Shellfish (*Tapes philippinarum*) Diet.

It has been reported by Kawaguchi that vitamin A is scarcely found in *Tapes philippinarum* and other shellfish and only carotene is found as a vitamin A source. This finding being different from that of other animals, an experiment was carried out concerning the absorbability of this carotene. The chromatographic findings and the ultraviolet absorption spectrum of the carotene fraction coincide well with those of β -carotene. In this experiment, 200 g of cooked shellfish was administered. This was quite a large quantity for the test subject to take at one time but the β -carotene contained in it was only 120 γ . The feces become soft on the third day of the experiment and on the fourth day there was diarrhea with several bowel movements a day so the experiment was stopped. The β -carotene content of the feces with the basal diet was 252 γ and following administration of the shellfish the β -carotene content rose to 338 γ but with correction for the basal diet, the value became 136 γ and the percentage absorption became negative. The quantity of carotene given in this experiment is however small and the value of the basal diet is large compared with the experimental value so this study is not

considered accurate. It is suggested, however, that there is very little absorption of carotene.

TABLE VIII
Carotene Absorption from Tapes philippinarum.

I, Basal diet. II, I + 200 g shellfish, cooked 3 minutes, containing 120 γ β -carotene.

Diet	Date	Daily feces	β -Carotene excreted		Absorption
			Determined	Corrected	
I	March 12 13	<i>g</i>	γ	γ	<i>per cent</i>
		86	241		
		73	264		
			252		
II	14	70	360	108	- 3
	15	140.5 ^a	392	140	- 3
	16 ^b	108.5 ^a	412	160	-15
			388	136	- 0

^a Soft stool. ^b Discontinued because of diarrhea on the 17th.

TABLE IX
Carotene Absorption from Spinach (strained) and the Effect of Tocopherol.

I, Basal diet. II, I + 60 g spinach (leafy part strained) containing 2360 γ β -carotene. III, II containing 2538 γ β -carotene + 6 g margarine. IV, II containing 2500 γ β -carotene + 6 g margarine + 10 mg α -tocopherol. V, II containing 2380 γ β -carotene + 6 g margarine + 100 mg α -tocopherol.

Diet	Date	Daily feces	β -Carotene excreted		Absorption
			Determined	Corrected	
I	March 30 31 April 1	<i>g</i>	γ	γ	<i>per cent</i>
		75	255		
		80	252		
		72	250		
			253		
II	2	95	1,866	1,613	33
	3	78	1,824	1,571	33
	4	80	1,815	1,562	34
			1,835	1,582	33
III	5	82	1,795	1,542	39
	6	78	1,883	1,630	36
	7	75	1,762	1,509	41
			1,813	1,560	39
IV	8	81	1,709	1,456	42
	9	80	1,733	1,480	41
	10	73	1,606	1,353	45
			1,683	1,430	43
V	11	87	1,565	1,312	45
	12	83	1,646	1,393	41
	13	76	1,611	1,358	43
			1,607	1,321	43

6. Carotene Absorption from Spinach Diet.

The effects of fat, tocopherol and cyanocobalamin on the absorption of carotene when 60 g strained spinach containing 2340 γ β -carotene is administered, are listed in Tables IX and X. As shown in Table IX, the daily

TABLE X

Carotene Absorption from Spinach (strained) and the Effect of Vitamin B₁₂.

I, Basal diet. II, I + 50 g spinach (leafy part, strained) containing 3430 γ β -carotene. III, II containing 3430 γ β -carotene + 5 γ B₁₂. IV, II containing 3220 γ β -carotene + 5 γ B₁₂ + 6 g margarine.

Diet	Date	Daily feces	β -Carotene excreted		Absorption
			Determined	Corrected	
		<i>g</i>	<i>γ</i>	<i>γ</i>	<i>per cent</i>
I	April 17	57.5	226		
	18	142	197		
	19	93	304		
			262		
II	20	96	2,610	2,348	33
	21	100	2,480	2,218	37
	22	90	2,530	2,268	36
			2,540	2,278	35
III	23	93	2,410	2,148	39
	24	86	2,500	2,238	37
	25	97	2,465	2,203	38
			2,456	2,194	38
IV	26	93	2,330	2,068	41
	27	100	2,520	2,258	36
	28 ^a	140	2,570	2,308	35
			2,473	2,211	37

^a Soft stool.

excretion of β -carotene with the basal diet was 253 γ , the corrected value for absorption after administration of spinach was 33 per cent, the absorption with addition of 6 g margarine was 39 and the absorption with the additional supplementation of 10 and 100 mg α -tocopherol was 43 and 43 per cent respectively, *i. e.*, absorption rose with addition of margarine, rose somewhat higher with further addition of tocopherol though there was little difference whether 10 or 100 mg tocopherol was added.

The β -carotene content of the spinach in this experiment was 41.2 γ /g. When cooked for 3 minutes, the value dropped 3.3 per cent to 39.8 γ /g and with straining, there was a decrease of 5 per cent to 39.3 γ /g. It can be seen that the loss by cooking is small.

Table X shows the results when the spinach was supplemented with 5 γ B₁₂ and in the case when 6 g margarine was added in addition to B₁₂. The β -carotene content of the feces with the basal diet was 262 γ and the corrected percentage absorption with the spinach diet was 35. A corrected value of 38 and 37 per cent were obtained with B₁₂ supplementation and B₁₂ plus

margarine supplementation respectively and it can be seen that those had almost no effect.

DISCUSSION

1. Absorption of Carotene in Food.

The above findings are summarized in Table XI. It can be seen that

TABLE XI
Summary of Carotene Absorption.
Mag, Margarine ; Toc, Tocopherol ; Olo, Olive oil.

Source	β -Carotene content	Supplement	Carotene absorption
	γ		per cent
Pure carotene crystal (suspension)	1,620	0	58
"	1,620	Mag 30 g	47
Pure carotene oil solution	1,680	Olo 2 g	98
Cooked spinach	2,652	0	21
Grated " (raw)	2,100	0	21
" " (cooked)	2,100	0	48
" " "	2,100	Mag 10 g	46
Pumpkin (strained)	873	0	53
"	873	Mag 30 g	69
"	873	Olo 30 g	64
Squash (strained)	3,240	0	35
	3,200	Mag 10 g	38
	3,170	Olo 10 g	39
Spinach (strained)	2,360	0	33
"	2,538	Mag 6 g	39
"	2,500	{ Mag 6 g	43
		{ Toc 10 mg	
"	2,380	{ Mag 6 g	43
		{ Toc 100 mg	
"	3,430	0	35
"	3,430	B ₁₂ 5 γ	38
"	3,220	{ B ₁₂ 5 γ	37
		{ Mag 6 g	
Dried seaweed	2,060	0	8
Shellfish (<i>Tapes philippinarum</i>)	120	0	0

the percentage absorption of β -carotene with ordinary diet is 20–40 and when the food is strained, so that it is more readily absorbed and with the addition of oil or tocopherol, the absorption rise to 60 per cent or more. The absorption with dried seaweed was less than 10 per cent and with shellfish almost zero. It is true that in the case of the latter two, the quantity was much greater than that usually taken and resulted in softening of the feces and diarrhea and the absorption may have dropped below normal due to this but it can be said that absorption is poor.

If these values can be applied to the Japanese is general, the normal per-

centage absorption of β -carotene in food would be about 30 and it would therefore be necessary to take 3 times the anticipated amount for proper nutrition.

2. Carotene Requirements.

In Sheffield, Hume *et al.* (1) have studied the vitamin A requirement in young adults using carotene alone as the source of vitamin A. They fed the test subjects a carotene-deficient diet and conducted preventive and therapeutic experiments. It was assumed that the minimal daily requirement was 1500 i.u., provided that all of the β -carotene was absorbed and in consideration of individual differences and margin of safety, it was stated that the requirement would be 2 times the above value, *i. e.*, 3000 i.u. It was found on the basis of the carotene content of the feces that the percentage absorption of carotene is not 100 and in view of this, it was concluded that the daily requirement would be 4000 i.u. in the case of pure carotene, 5000 in the case of homogenized carrot, 7500 in the case of cabbage or spinach and 12,000 i.u. in the case of cooked diced carrot. Calculation of the percentage absorption from these values gives 75, 60, 40 and 25 respectively and these figures are quite close to the results obtained by the authors.

3. Absorbability of Carotene in Man Reported in the Literature.

The values given in the literature vary as do the methods of determination, (3, 5, 8, 10-13, 17, 21, 24, 27, 32, 33). Of these, the method of determination is not presented in some (1, 8) and coloring substances other than carotene may have been measured in some studies using chromatography (1, 3, 7, 9). Kreula (2) has used alumina chromatography but has developed with petroleum ether alone so it is considered that it is a weakly activated alumina and as α - and β -carotenes are not separated with this adsorbent, it is assumed that he did not fractionate the carotene components. Hara and Nakano (21) have used alumina but have not separated carotene fractions. It has been reported that alumina causes isomerism of carotenoids and in the case of feces, where many types of pigment are present, Ca(OH)_2 is more suited for separating the fractions of carotene than alumina. James *et al.* (10) have conducted a detailed study with Ca(OH)_2 chromatography but used 25 per cent benzene-petroleum ether for developing, so the isolation of each carotene fraction is believed inadequate. The isolation of non-carotene pigments, therefore, is also considered inadequate. From these facts, it is suggested that the results of carotene absorption experiments presented in the literature require reinvestigation.

4. Discussion on Carotene Absorption

In this study, the quantity of carotene excreted in the feces subtracted from the quantity ingested was presumed to be the quantity absorbed and the ratio of the quantity absorbed to the quantity ingested to be the absorbability, whereby the decomposition of carotene in the digestive tract was not taken into consideration. If carotene is decomposed in the digestive tract, the absorbability would be still smaller. Kreula (5, 6) has reported that there is no loss in carotene by incubating at 37° for 24 hours or storing for 8 days at 20°, but Ishii *et al.* (20) state that in experiments using artificial gastric juice, 24 per cent of the carotene contained in spinach, 18 per cent contained in

the carrot and 27 per cent contained in dried seaweed is decomposed. In the study by the authors, the percentage absorption was: spinach, 33-43; carrot, 21.48 and dried seaweed, 8. The decomposition in the case of dried seaweed, is therefore greater than the absorbability and the greater part of the absorption in the case of spinach and carrot would be due to decomposition. It is therefore assumed that Ishii's value are much higher than actually occur in nature. Be that as it may, there is no accurate method for determining the carotene broken down in the intestines so this factor was disregarded in this study.

5. *Excretion of Carotene with Carotene-Deficient Diet.*

Carotene is often observed in the feces of mice raised on a carotene-deficient diet by Kemmerer *et al.* (11), Ramasarma (12), and Russel *et al.* (13). The daily excretion in the feces is about 0.5-2 γ . The absorption spectrum of this substance is clearly different from that of carotene, indicating it to be a non-carotene pigment. This shows the non-specificity of the quantitative method of carotene determination. James *et al.* (10) studied the excretion of carotene in 8 adults given a carotene-deficient diet and found the excretion of 83-315 γ . He however has failed to state whether the absorption spectrum was examined and it is not clear whether the substance studied is identical with carotene. The authors have found that there is excretion of 250 γ carotene a day with a carotene-free diet and the absorption spectrum of the carotene fraction showed absorption maxima at 450 and 475 m μ , closely resembling β -carotene in pattern. The chromatographic findings also coincided so that the major part is assumed to be β -carotene. The object of this study being to examine the absorbability of carotene in food, it is more convenient to omit the influence of non-food carotene and the quantitative determination of carotene is easier and more accurate by so doing. The correction for the carotene excreted with the basal diet was therefore made. The question of whether the small quantity of carotene contained in the basal diet is absorbed equally well as in the case of the basal diet plus carotene-rich foodstuff, was considered but as can be seen in Table VIII, the carotene excreted in the feces would be greater than the quantity taken, if correction for the carotene in the basal diet is not made, so it is believed that this correction is rational.

6. *The Effect of Fat, Tocopherol and B₁₂ on Carotene Absorption.*

It has been shown that the absorption of carotene is promoted by the presence of fat in animals (5, 14) and man (3, 4, 15). It has also been found that α -tocopherol plays an important role in the utilization of carotene in the body, especially in growth (16-18) and in the formation of vitamin A in the liver (15). It has also been reported that the injection of vitamin B₁₂ in mice accelerates the utilization of carotene with promotion of growth and increase in deposition in the liver (19).

Under the conditions of this experiment, the addition of fat, tocopherol or vitamin B₁₂ had some accelerating effect on the absorption of carotene but the effect was not great.

SUMMARY

The absorbability of β -carotene was studied in an adult, Japanese female under various conditions and with various kinds of food. The following values, in per cent, were obtained: pure carotene suspension, ca. 60; oil solution of pure carotene, 98; carrots cooked in the ordinary manner, 21; pumpkin, 35–53; and spinach, 33–35.

There is some increase in the absorbability with the addition of margarine or olive oil but under the conditions of the experiments, the increase was insignificant.

Supplementation of vitamin B₁₂ or tocopherol resulted in some increase but the difference was not marked. The absorption with dried seaweed was 8 per cent and in the case of shellfish (*Tapes philippinarum*) there was scarcely any absorption. It is suggested that the seaweed and shellfish are poor sources of carotene.

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