Dietary Intakes of Vitamin C in Iceland

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It has been estimated that the caloric value of the food produced in Iceland is more than three times higher than that needed to satisfy the energy requirements of the inhabitants (Sigurjonsson, 1948). More than 80% (according to caloric value) is fish and fish products, of which the greatest part is exported. The home production of milk and dairy products is sufficient except that some butter is imported and there is a surplus production of meat. The cultivation of potatoes and other vegetables, although increasing, is not yet sufficient to allow a satisfactory consumption level. There is almost no cultivation of grain so that all cereals have to be imported. Apart from some fruits (especially tomatoes) grown in hot-houses the only native fruits are berries.

It is easily understood that formerly, when potatoes and other vegetables were scarce, the diet was apt to be low in vitamin C, and probably it has been milk, more than anything else, that has saved the population from scurvy. However, scurvy was common enough, but mainly among the poorer people on the coast where milk was scarce. Until the beginning of this century the doctors frequently mentioned scurvy in their annual reports, but since then it has become more and more rare and nowadays it is only exceptionally that a clinical case of scurvy is reported.

The disappearance of scurvy has been paralleled by an increasing cultivation and consumption of potatoes and other vegetables, together with an increased consumption of milk in the towns and seaside villages. The diet, however, is still rather poor in vegetables, and fruit is scarce; one might therefore expect that the dietary intake of vitamin C is still inclined to be somewhat low.

The present survey was designed to determine how much vitamin C is available in the average national diet, the amount of this vitamin contributed by the different foodstuffs and the proportion of the total intake derived from domestic sources.

METHODS

From the annual production estimates, kindly submitted by the Director of the Agriculture Organization in Iceland, and from the official trading reports of the Statistical Bureau (Hagstofa Islands, Reykjavik, 1936–45), the average annual supply of vitamin C-containing foodstuffs for the 5-year periods 1936–40 and 1941–5 was calculated. The results are given in Table 1.

The mid-year population for 1938 was estimated as 118,290 (arithmetical mean of the census populations in 1937 and 1938, the census being taken annually at the end of the year); this is taken as the average population during the period 1936–40.

Similarly, the mid-year population for 1943, estimated as 124,982, is taken to represent the average population for the period 1941–5.

In Table 2 the amounts of foodstuffs available are calculated in terms of average daily consumption per head of population. This table also shows the estimated amount of vitamin C thus supplied by each item, as well as the total intake derived from domestic and imported food. In addition, the second column shows how the vitamin estimates are arrived at, by giving the estimated amount of vitamin C available per

Table 1. *Total estimated yearly supplies of vitamin C-containing foodstuffs. Averages for the periods* 1936–40 *and* 1941–5, *expressed in metric tons*

Foodstuff	1936–40	1941–5
Domestic:		
Potatoes*	5,994	6,450
Swedes†	1,480	938
Carrots	18‡	26
Green vegetables	23‡	55
Tomatoes	53‡	97
Milk§	60,660	62,593
Total production consumed as such	34,930	34,620
Imported:		
Oranges	34	151
Lemons	44	85
Apples	62	494
Other fresh fruits	3	3
Dried fruits	62	773
Canned fruits	6	135
Jams, purées and syrups	39	158
Potatoes‖	941	1,432
Roots	41	5
Onions	123	175
Cabbages	80	8
Conserved vegetables (canned, dried and the like)	17	26

* The average potato crop for these two periods was estimated as 7992 and 8600 metric tons, but here 25% has been deducted to allow for seed potatoes and storage waste.

† Crop estimates were 1850 and 1172 metric tons; 20% has been deducted to allow for storage waste.

‡ These figures actually represent the production estimates of a single year, 1940, as no figures were available for the preceding years of this period.

§ The figures for milk consumed as such have been derived by deducting from the total for milk the amount corresponding to the estimated production of butter, cream, cheese and other milk products.

‖ 15% has been deducted for storage waste.

100 g. of each foodstuff 'as purchased', allowance having been made for kitchen waste and cooking losses. For domestic foods the estimates are based on actual determinations carried out by the author on samples of the respective foodstuffs using the 2:6-dichlorophenolindophenol method, the reduction of the dye being determined by means of a photoelectric colorimeter. The estimates of vitamin C in the imported foods, with the exception of dried fruits, are based on the tables of the British Medical Research Council (Accessory Food Factors Committee, 1945), although slight modifications have been made for potatoes and apples. The vitamin content of dried fruits was estimated with aid of the tables of Schulerud, Kanter & Rasmussen (1945).

Table 2. *Vitamin C-containing foodstuffs; estimated vitamin C content, average daily consumption and estimated average daily intake of vitamin C/head of population*

Foodstuff	Estimated vitamin C content (mg./100 g.)	Average daily consumption/head 1936–40 (g.)	1936–40 Estimated vitamin C intake (mg.)	1941–5 (g.)	1941–5 Estimated vitamin C intake (mg.)
Domestic:					
Potatoes	9	138·8	12·49	141·4	12·73
Swedes	26	34·3	8·92	20·5	5·33
Carrots	4	0·4	0·02	0·6	0·02
Green vegetables	—	0·6	0·19	1·6	0·50
Tomatoes	20	1·2	0·24	2·1	0·42
Berries	—	?	?	?	?
Rhubarb	10	—	0·60	—	0·60
Syrups and jams	—	—	0·40	—	0·40
Milk consumed as such	1	809·0	8·09	758·9	7·59
Estimated intake of vitamin C from domestic foodstuffs			30·95	—	27·59
Imported:					
Oranges	41	0·8	0·33	3·3	1·35
Lemons	18	1·0	0·18	1·9	0·34
Apples	3	1·4	0·04	10·8	0·32
Other fresh fruits	—	—	0·01	—	—
Dried fruits	2	1·4	0·03	16·9	0·34
Canned fruits	5	0·1	0·01	3·0	0·15
Jams, purées and syrups	—	0·9	0·09	3·4	0·31
Potatoes	9	21·8	1·96	31·4	2·83
Roots	—	1·0	0·10	0·1	0·01
Onions	10	2·9	0·29	3·8	0·38
Cabbages	25	1·9	0·48	0·2	0·05
Conserved vegetables (canned, dried and the like)	—	0·4	0·05	3·9	0·53
Estimated intake of vitamin C from imported foodstuffs			3·57		6·61
Total estimated intake of vitamin C			34·52		34·20

Comments to Table 2

Potatoes. The estimated amount of vitamin C obtainable from 100 g. (allowance having been made for kitchen waste and cooking losses as in other similar studies) is near the average value found in autumn, but different varieties of potatoes vary to some extent in their vitamin content.

Swedes. Here also the estimated amount of vitamin C applies to autumn values.

Green vegetables. The estimate of production quoted in Table 1 is almost certainly too low. Also the amount of vitamin C obtained from 100 g. can only be estimated very roughly as this is a heterogeneous group; furthermore, some of the vegetables are eaten raw while others are cooked. In any case, however, the proportion of the total vitamin C intake obtained from this source is small.

Tomatoes. The values adopted here apply to raw tomatoes, as almost all the tomatoes are consumed raw.

Berries. Varying amounts of wild berries (*Vaccinium uliginosum*, *V. myrtilliforme* and *Empetrum nigrum*) are collected in autumn and eaten fresh. But the greater part is conserved as syrups and jams, the amounts of which are only roughly estimated, and are based on a dietary survey of some years ago.

Rhubarb. The estimate of vitamin C obtained from rhubarb also is only a very rough one.

Milk consumed as such. The vitamin C content of market milk in Reykjavik is usually about 1·0–1·5 mg./100 ml.; in the country the milk may contain about 2 mg./100 ml. when consumed fresh. As, however, a considerable amount of the milk is consumed after having been cooked, e.g. as milk soups, the average vitamin value is taken to be 1·0 mg./100 ml.

Imported foods. No allowance is made for waste during storage except for potatoes as mentioned above; the values for fresh fruits, therefore, are probably too high.

Apart from milk, some small amounts of vitamin C may be obtained from other animal foods, especially liver (from sheep and cattle) which may contain up to 20 mg./100 ml. when freshly cooked or fried. However, this source would, at best, only yield little more than 1 mg./head/day. Moreover, as fresh liver is only available in the autumn, and the greater part is conserved in various ways, no significant error will be caused by omitting this item from the table.

RESULTS

Table 3 shows the estimated average daily total intake of vitamin C and the proportions derived from different foodstuffs.

It is striking that the average intake of vitamin C was almost exactly the same in the two periods, 1936–40 and 1941–5. In both cases the amounts derived from potatoes (home-grown and imported) and milk were much the same, these two items together

Table 3. *Estimated average daily total intake of vitamin C and proportions derived from different foodstuffs*

Period	Average total vitamin C intake (mg./head/day)	Percentage of intake derived from				
		Potatoes	Swedes	Milk	Fresh fruit	Domestic foodstuffs
1936–40	34·5	42	26	23	2	90
1941–5	34·2	45	16	22	6	81

supplying about 65% of the total intake in the first period and 67% in the second. Much fewer swedes were grown during the second period because of damage caused by the larvae of *Chortophilia brassica* especially in the southern part of the country. The effect of this on the vitamin C intake was counterbalanced by greater imports of fruits and other foodstuffs; thus in 1941–5 19% of the vitamin C intake was derived from imported food against 10% in 1936–40.

Seasonal variation

There is a considerable seasonal variation in the vitamin C intake. This is caused partly by changes in the vitamin content of some foodstuffs, chiefly potatoes, and partly by seasonal variations in the composition of the diet. From the figures obtained for the average daily intake, therefore, it cannot be inferred that the average daily intake/head of vitamin C is at a uniform level of about 34 mg. throughout the year. Green vegetables, for instance, are available only during summer and autumn and at that time potatoes contain more vitamin C than is quoted in the tables, whereas in late winter and spring the vitamin C content of potatoes may be as low as 4–5 mg./100 g. Further, the consumption of swedes, which are one of the major sources of vitamin C, is almost entirely confined to the half year from September to February, so that the amount of vitamin C derived from swedes during this period is about twice as much as indicated in Table 2. Allowing for this, it may be assumed that during autumn and early winter the average daily intake of vitamin C amounts to 40–50 mg./head/day, whereas in late winter and spring, when swedes are no longer available and potatoes are of less value, it is reduced to about 20 mg. and even lower. Now, if the average intake during spring is about 20 mg., it follows that lower values will be quite common and, allowing for a reasonable spread around the mean, it may be assumed that in not a few households the intake will be reduced to 15 mg. and, in some cases, even to about 10 mg. That this is so is supported by the results of a dietary survey carried out some years ago (Sigurjonsson, 1943). Corroborative evidence from extensive blood

analyses is not yet available, but, from a few assays made in early spring, it seems that plasma values of about 0·1–0·2 mg. of vitamin C/100 ml., and even lower, are at least not rare.

DISCUSSION

Workers in the field of nutrition, who believe that the minimum daily requirement of vitamin C is 75–100 mg. for adults, will undoubtedly consider the results here presented as evidence of a serious shortage in vitamin C and consequently expect the population to be in a permanent state of deficiency. But what really is the minimum intake of this vitamin needed for perfect health?

Before the war the standard laid down by the League of Nations Health Organization (1938), allowing an intake of 30 mg./day for adults, was commonly accepted, at least in Europe. Later there has been a tendency to raise the standard; thus the daily allowance recommended by the U.S.A. National Research Council (1945) is 75 mg. for adults and some investigators consider the optimum intake to be about 100 mg. It is true that the term 'optimum intake' sometimes appears to be used in a different sense from that of minimum requirement intake, but really this is misleading because the lowest intake necessary to obtain optimum results should be regarded as the minimum requirement. The higher claims are based mainly on measurements of the vitamin C content of blood plasma or serum, but such measurements do not reveal any obvious level representing the limits of normality.

It has been shown by Fincke & Landquist (1942), among others, that a daily intake of well over 100 mg. of vitamin C is required to keep the blood saturated. Though few will maintain that a state of saturation is required for optimum health and nutrition, it is quite common to see the lower limit for a satisfactory plasma level put at 0·7 or 0·8 mg./100 ml. Thus Brown, Fincke, Richardson, Todhunter & Woods (1943), in grouping their material, adopt the classification of Neuweiler (1939) and accordingly take plasma values below 0·4 mg. as definitely scorbutic though not indicating clinical scurvy, values of 0·4–0·8 mg. as evidence of deficiency, and 0·8–1·0 mg. is taken by them as a good normal value. Also Fincke & Landquist (1942) seem to regard 0·8 mg./100 ml. as an index of adequate nutrition. McDevitt, Dove, Dove & Wright (1944) regard values of 0·7–1·0 mg. as satisfactory, of 0·5–0·7 mg. as suboptimal and values below 0·5 mg. as indicative of deficiency. It appears that an intake of about 60–80 mg. daily is required to keep the plasma level at 0·7–0·8 mg./100 ml. These figures for the minimum normal blood values are, however, entirely arbitrary, and it has not been shown conclusively that persons with a plasma level of, say, 0·2–0·4 mg./100 ml. or even lower, are in any way worse off than those with a level at 0·7 mg.*

* After this was written the author's attention was called to the important paper published by a committee of the British Medical Research Council on the vitamin C requirement of human adults (Vitamin C Subcommittee of the Accessory Food Factors Committee, Medical Research Council, 1948). The experiments on human volunteers there reported showed that so long as the diet did not contain more than 20 mg. of vitamin C daily, the average plasma level was below 0·1 mg./100 ml., and that at the intake level of 70 mg. daily the average plasma level was 0·55 mg./100 ml. though it seems from the accompanying graph that on some occasions it rose to above 0·7 mg./100 ml. The 'minimal protective dose', as measured by the criteria of the presence of scurvy, was found to be in the region of 10 mg. daily, though it was felt that tests of physical fatigue left some doubt whether 10 mg. was an optimal dose. It was concluded that so long as there is no evidence to support the view that an intake of more than 30 mg. daily has beneficial effects, there is no basis for recommending an intake higher than that amount.

In the present survey it was shown that in Iceland the average intake of vitamin C/head/day during the most favourable season probably is within the range of 40–50 mg. which would correspond to a plasma level of about 0·4–0·6 mg./100 ml. This, according to the classification of Brown *et al.* (1943), as cited above, would indicate a state of deficiency even in the most favourable season and, during a great part of the year, i.e. when the average intake is from 20 to 30 mg., the blood would accordingly show 'definitely scorbutic' values. One would expect, were this true, that there would be unmistakable signs of vitamin C subnutrition in this country. This, however, is not apparent when the general state of health is considered. The infant mortality is low, usually between 30 and 40/1000 live births, the general death rate is just below 10/1000 population, and the physical development of the children may be considered good. Clinical scurvy is almost never seen, though opinions may differ about the incidence and frequency of the so-called 'latent scurvy'. Some doctors believe that this ill-defined state of hypovitaminosis is not infrequent in spring time. That this may be so appears not unlikely considering that in many single cases the intake at that time may fall below 15 mg. and probably even to about 10 mg. daily. It is commonly accepted that a daily intake of 10 mg. of vitamin C is sufficient to prevent clinical scurvy, therefore it would appear likely that, by analogy with other nutritional essentials such as minerals and protein the requirements of which are more easily determined, double that amount, i.e. about 20 mg., would be sufficient to ensure normal nutrition. It has also been shown that 20 mg. daily and even less, will cure severe cases of scurvy (Barnes, 1947; Kalk & Brühl, 1942).*

In general, the results of this survey may be taken as evidence in support of the view that 30 mg. daily of vitamin C is an adequate allowance for adults and leaves a reasonable margin of safety. Although 20 mg. may be sufficient in most cases, it is probably too low as an average intake for a group of individuals; it may be concluded, therefore, that the Icelandic diet is apt to be short in vitamin C in spring time, though this does not lead to serious consequences. The same is apparently the case in many other countries which, nevertheless, enjoy a high standard of health. Thus in Norway, according to Hagtvet (1945), the average content of vitamin C in blood serum of 722 healthy subjects fell from 0·93 mg./100 ml. in August-September to 0·16 mg. in June; in Denmark the average serum values for 6196 members of working-class families fell from 0·9 mg./100 ml. in August to 0·1 mg. in June (Andersen & Normann, 1945).

SUMMARY

1. A survey, based on estimates of production of home foods and on statistics of imported foods, showed that the average daily intake of vitamin C/head in Iceland was 34·5 and 34·2 mg. in the 5-year periods 1936–40 and 1941–5.

2. The seasonal variation was considerable, and it is shown that in the autumn and early winter the average intake was probably within the range of 40–50 mg., whereas in spring time it was about 20 mg. or less.

3. The most important sources of vitamin C in Iceland are potatoes and milk, which

* See also the footnote above, p. 279.

together provided about two-thirds of the total intake; swedes provided, in the two periods, 26 and 15%, respectively, of the intake. The total amount of vitamin C derived from imported foodstuffs was 10% of the total intake during 1936–40 and 19% during 1941–5.

4. The population as a whole does not show obvious signs of deficiency of vitamin C, but cases of hypovitaminosis or 'subclinical scurvy' may occasionally occur in spring time. It is concluded that the standard of requirement of vitamin C accepted by the League of Nations Health Organization (1938), i.e. 30 mg. daily for adults, is fully adequate.

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