XC. THE ANTISCORBUTIC VALUE OF FRESH AND CANNED ENGLISH TOMATOES.

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THE juice of raw tomatoes is known to be powerfully antiscorbutic, and according to American observers it possesses also both the fat-soluble A and the water-soluble B vitamins [Hess, 1920]. According to Hess and Unger [1918], *canned* tomatoes also have an important antiscorbutic value even after a year's storage, and Hess states that the juice of canned tomatoes may be safely given as an antiscorbutic to young infants [Hess, 1920, p. 234]. Canned tomatoes have recently been introduced into the ration of the United States army "in lieu of an equal quantity of potatoes, not exceeding 20 % of the total issue" [Hess, 1920, p. 231]. The relative antiscorbutic value of raw tomatoes appears not to have been determined, but Hess and Unger fed to young guinea pigs, on an otherwise scorbutic diet, the juice of tomatoes which had been canned and stored for a year. The minimal daily ration necessary to ensure protection from scurvy was found to be 4 cc. It is of some interest to speculate how this value would compare with that of the fresh juice.

In 1920, a number of experiments were started at the Lister Institute to determine this point for the English tomato. For various reasons, the publication of the results was delayed. Some canned tomatoes were however stored at the laboratory temperature and these have recently been tested for any residual content of vitamin C, after an interval of nearly four years. The results of these and of the former experiments are now presented in detail for the first time¹.

1. *Raw fresh tomatoes.*

These experiments were carried out from August to October 1919. The pulp and flesh of fresh English tomatoes was squeezed through muslin on alternate days and fed to young guinea pigs in daily doses. The remainder of their diet was crushed oats and bran and autoclaved milk, as in numerous other experiments conducted at the Lister Institute by various workers in connection with researches upon the distribution of the antiscorbutic vitamin.

Groups of animals each receiving doses of 10 cc., 5 cc., and 2.5 cc. respectively were found to thrive well and exhibited no sign of scurvy at the post-mortem examination. Two animals (Nos. 575, 576), each receiving only 1.5 cc.

¹ The unpublished results have been quoted by the author [1921].

of the juice daily, remained also fairly active and their growth rate compared favourably with that of those receiving a higher ration, but both developed tenderness of the knee joints during the experiment and No. 575 became distinctly lame. Both these animals showed typical scorbutic lesions in the muscles and fascial tissues of the knees, and in both the tibiae were found to be distinctly brittle. The scurvy was however of a very mild character and in No. 576 it developed only during the last seven days of the experiment.

So far as these tests go, therefore, the minimum protective ration for a young guinea pig must lie between 1.5 and 2.5 cc. and may be estimated as about 2 cc. daily¹. The juice is therefore not as efficient as orange or lemon juice. It is of interest to note that raw tomatoes have recently been tested in S. Africa and the local product is decidedly inferior to the English fruit, the minimum protective dose under similar experimental conditions being about 4 cc. daily².

2. *Bottled tomatoes.*

A sample of bottled tomatoes was received from Messrs Chivers in January 1919, which, according to information supplied at the time, had been prepared on Oct. 4, 1918. The fruit was first plunged into boiling water for two minutes to loosen the skin, then peeled and immediately packed into bottles without the addition of water. The bottles were "processed" by standing in a water-bath which was gradually heated to 190° F. (87.8° C.) and which was maintained for 45 minutes at that temperature.

This sample was tested by Miss M. Rhodes at the Lister Institute from Feb. to July 1919. The juice was therefore four months old at the beginning and nine months old at the end of the experiments. Two animals receiving 20 cc. and two others receiving daily 10 cc. of the juice from these tomatoes remained in good health for 90 days (Feb. to May). Two others receiving only 5 cc. daily (June, July) developed well-defined scurvy and were chloroformed after 42 days. No other tests were made. It should be noticed that the juice fed to the animals from June 12-27 was fermenting during the last days of use. The condition of the animals improved somewhat when a new supply had been obtained (June 27) but this sample also began to ferment on July 7; in spite of this it had to be used until July 15. It does not seem likely that fermentation alone was responsible for the somewhat severe symptoms observed and it may be concluded that the minimum protective dose for this sample of bottled tomatoes lies between 5 and 10 cc. It is thus considerably higher than the minimum dose of 4 cc. found by Hess and Unger for their American brand. If we take the minimum protective dose of the fresh juice as 2 cc., then about three-quarters of its value has been destroyed by the bottling and subsequent period of storage.

¹ In 1921 the minimum ration was quoted as 1.5 cc. The article was written in S. Africa, and at the time of writing the results of the post-mortem examination of Nos. 575, 576 had not been received.

² An account of these experiments by Delf and Pullinger is still in the press.

3. *Canned whole tomatoes.*

(a) *Before storage.* In August 1919, sound fresh English tomatoes were selected and canned in the following manner. After plunging into boiling water for two minutes, the tomatoes were peeled and heated gently for about ten minutes in a shallow pan, by which time juice had formed although no water had been added. Tins were filled with the fruit and juice and partly sealed. They were then processed at 100° C. for five minutes and finally sealed. The cans were cooled quickly by plunging into cold water and were stored at laboratory temperature. Some of these were at once tested for vitamin content in the usual way.

Two animals receiving 5 cc. of the juice daily developed severe scurvy; two receiving 7.5 cc. had good health throughout the experiment but developed a tenderness of the knee joints. At the post-mortem examination, this was seen to have been caused by slight subcutaneous haemorrhages. Two other animals receiving 10 cc. daily remained in perfect health, and at the post-mortem examination no trace of haemorrhage could be seen. The minimum dose for complete protection thus lies between 7.5 and 10 cc. daily, and is probably nearer 7.5 cc., instead of about 2 cc. as in the case of the raw juice. Mere canning has thus reduced the original value by about three-quarters.

(b) *After storage, from Aug. 1919 to May 1923.* The remaining cans were tested from May to August 1923 at University College, London by the courtesy of Prof. Drummond. The experiments were conducted as far as possible in the same way as those previously performed at the Lister Institute. Difficulties were encountered in the labour involved in feeding the rather large daily doses of the juice and the supply of the canned fruit came to an end somewhat prematurely, but some indication was obtained of the residual value of the juice after nearly four years' storage. The cost of these experiments was defrayed by a grant from the Food Investigation Board.

Three animals each receiving a daily ration of 7.5 cc. of the juice developed typical symptoms of scurvy during life, and when examined after death showed characteristic though not severe scorbutic lesions. In one case, haemorrhages around the knees were partly absorbed and this animal if kept longer would doubtless have become a case of typical chronic scurvy. Four animals were given a higher ration. Two of these had 10 cc. daily throughout the experiment. Of these, one soon developed severe scurvy and was killed after 35 days; the other showed no sign of scurvy and at the post-mortem examination, after 65 days, no haemorrhages were found, although the muscles were dark in colour. Two other animals received at first 2.5 cc. daily (for 16 days) and then 12.5 cc. daily (for 52 days), representing an average of 10 cc. each daily for the whole period. These both had good health, one never showing scorbutic symptoms and the other developing definite but not severe tenderness of the joints and a little lameness during the course of the experiment. At the post-mortem after 68 days of experiment, the former was found to have

a slight haemorrhage in the small intestine and the latter had two small haemorrhages in the intercostal muscles. These animals were therefore practically protected for 68 days, but showed signs of the onset of scurvy. For a longer time (*e.g.* 90 days as in the earlier experiments) probably 10 cc. would be insufficient but not much below the necessary minimum for protection. Storage has thus caused slow but progressive deterioration in vitamin content, the stored product having lost rather more than four-fifths of its original raw value as against a loss of about three-quarters of the original raw value when freshly canned.

4. *Tomato purée canned.*

In August 1919, ripe English tomatoes of good quality were made into a purée by being first heated slowly in an open pan until they just boiled (about 20 minutes) and then being strained through muslin. The pulp was then returned to an open pan and simmered at about 90° C. with frequent stirring until after one or two hours the resulting thick pulp weighed about one-third of the original fresh weight of the fruit, and occupied about half the original volume. This pulp was distributed into cans which were then sealed except for the vent, processed at 100° C. for five minutes and finally the vent was also sealed. The cans were then cooled quickly and tests were started the next day to determine the antiscorvy value of the resulting preparation, fresh cans being opened for the purpose every five days.

Very little protection from scurvy was given by a ration of 2.5 cc. of the purée daily, animals on this ration developing severe scurvy in 46 days. With a daily ration of 5 cc., active and healthy animals were produced. In one case on this ration, the only sign of scurvy was found in a few small haemorrhages in the intercostal muscles; in another, slight haemorrhages were found over the muscles of both knees and ribs although the general condition was good. A daily ration of 10 cc. gave perfect protection from scurvy. The minimal daily ration giving protection from scurvy in the case of this purée lies therefore between 5 and 10 cc. and may be estimated as about 7.5 cc. Allowing for the concentration during the preparation, this represents about 15 cc. of the fresh juice. It has been shown that 2 cc. of the raw juice would give protection and thus the double process of canning and concentration has so reduced the vitamin value, that from this point of view there is no longer any advantage in making the purée. By concentrating more rapidly in an atmosphere devoid of oxygen, the loss could no doubt be considerably reduced. The methods employed were those recommended at the time by the Canning Kitchen and are presumably in frequent use.

The foregoing results are summarised in the following table. They show conclusively that such routine examination of canned goods as is carried out at the present time does not give any criterion of the food value as far as vitamins are concerned [*cf.* Savage, 1923]. They also suggest that it would be a protection to the interests of the public, if the date of manufacture were

stamped on all canned goods, a course which has been frequently urged hitherto in vain. Storage probably always involves further slow deterioration in vitamin content even when it is claimed, that by use of chemical preservatives, the fruit can be kept for years with flavour unimpaired.

Table showing comparative antiscorvy value of fresh and preserved tomatoes.

	Minimal protective daily dose for guinea-pigs	Average
Pulp of fresh raw English tomato	1.5-2.5 cc.	2 cc.
Bottled tomatoes (Chivers), after 4-6 months' storage	5 cc.-10 cc.	7.5 cc.
Tomatoes canned whole, 1-2 months old	7.5-10 cc.	8.5 cc.
Tomatoes canned whole and stored 3½-4 years	> 10 cc.	—
Tomato purée canned	5-10 cc.	7.5 cc. purée (equivalent to 15 cc. original juice)

SUMMARY.

(1) The minimal daily ration of raw fresh juice of English tomatoes protecting young guinea pigs from scurvy has been shown to lie between 1.5 and 2.5 cc.; it is thus not quite as effective an antiscorbutic as fresh orange or lemon juice. Attention has been called to the inferior value of the locally produced S. African tomato.

(2) A sample of bottled tomatoes (supplied by Chivers) which had been stored for six months was found to have lost about two-thirds of its original value.

(3) By canning, a loss of nearly three-quarters of the original value was sustained. After storage for nearly four years, a further but smaller loss was found to have taken place.

(4) Canned tomato purée had lost about seven-eighths of the value of the original juice. The concentrated juice is bulk for bulk but little superior to the canned unconcentrated juice, when prepared as described in this communication.

REFERENCES.

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