XVIII. INVESTIGATION OF THE ANTI-SCORBUTIC VALUE OF FULL CREAM SWEETENED CONDENSED MILK BY EXPERIMENTS WITH MONKEYS.

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INTRODUCTORY.

EXPERIMENTS have already been made [Barnes and Hume, 1919] on the anti-scorbutic value of raw, dried and heated cow's milk and for some of these experiments monkeys were used. Reference is there made to the literature of the subject, but as far as is known no experimental observations are extant on the anti-scorbutic value of sweetened condensed milk.

It is probable from what is already known of the anti-scorbutic value of milk heated to 100°, or above, that unsweetened condensed milk has lost all or almost all of its anti-scorbutic property, since it is heated at a temperature above 100° in order to sterilise it. With sweetened condensed milk however the high concentration of sugar is depended upon as the preservative after the preliminary pasteurisation of the milk. Concentration is carried out below 55° and is conducted *in vacuo*. It therefore seemed of interest to examine some well-known brand of condensed milk from this point of view and Nestlé's was chosen for the purpose.

In the work already referred to [Barnes and Hume, 1919], the minimum dose of raw milk daily needed to protect monkeys of 2-3 kilos. weight from scurvy was found to be 100-150 cc. daily. It was therefore only necessary to establish the minimum daily dose of condensed milk which would protect the same or similar animals from scurvy, in order to be able to calculate the loss, if any, suffered by the condensed milk.

MATERIAL USED.

The material used consisted of two batches of milk, of which one batch was used in experiment 1 and the other in experiment 2.

By arrangement with the Nestlé Anglo-Swiss Condensed Milk Co., to whom the writer is indebted both for the gift of the material and for all details about it, the milk in each batch was absolutely uniform. Batch 1 was made

on June 7th, 1919, and the experiment was started in August, 1919; batch 2 was made on October 24th, 1919, and the experiment was started in February, 1920. In neither batch was any of the milk from stall fed cows.

The milk is condensed as follows:

Pooled full cream milk is first heated in a vessel with continuous inflow and outflow, the temperature of which is about 80°. It is computed that the milk remains at this temperature for about 3½ minutes. The sugar is next added; during this part of the process there is access of air. It then passes to a vacuum condenser where it boils at about 50° for about three hours and is drawn off when it passes a certain viscosity test. It is then cooled in bulk and during this part of the process there is again access of air.

Figures were provided by the Company giving the degree of condensation, which made it possible to calculate the amount of condensed milk equal to any given quantity of raw milk. These figures differ for every batch.

TECHNIQUE OF THE EXPERIMENTS.

The technique is fully set out in the paper already quoted [Barnes and Hume, 1919].

The basal diet consisted of boiled white rice and wheat germ and the ration of milk was relied on to provide sufficient vitamin A.

Both monkeys were male sooty mangabeys (*Cercocebus fuliginosus*) the anti-scorbutic needs of which had been previously ascertained. The one "Rags" had remained in health on a ration of 200 cc. of raw milk daily for 225 days, while the other "Toby" had developed scurvy after 77 days on a ration of 200 cc. dried milk; he was then cured on 200 cc. of raw milk, just scalded, daily. A ration of 200 cc. raw milk daily was therefore more than sufficient to provide anti-scorbutic for either of these monkeys, at a time when they weighed 2-3 kilos. In the course of the present experiments they grew to be monkeys weighing 5 and 4.5 kilos. respectively and were still growing; their anti-scorbutic needs might therefore be supposed to be greater and not less than in the preceding experiment.

EXPERIMENTAL RESULTS.

Experiment 1. This experiment was carried out with the June batch of milk. Both monkeys received the equivalent of 250 cc. of fresh milk daily, Rags for 188 days and Toby for 199 days.

In this period Rags grew from 3370 g. to 4190 g., an increment of 820 g., while Toby grew from 3560 g. to 4320 g., an increase of 760 g. Both remained in perfect health the whole time.

Experiment 2. This experiment was conducted with the October batch of milk. Toby received the equivalent of 200 cc. of fresh milk for 260 days and increased from 4320 to 5020 g., an increase of 700 g. He was in perfect

health at the close of the experiment but the rate of growth was slower than in the previous experiment.

Rags received the equivalent of 150 cc. of fresh milk together with 50 cc. of the same milk, autoclaved at 120° for one hour; this destroyed the anti-scorbutic in the added 50 cc. but made the vitamin *A* value of the ration the same as in the case of Toby. The animal increased in 246 days from 4190 to 4570 g. an increase of only 380 g., less than half the growth in the former shorter period, and not much more than half the growth shown by Toby on the same vitamin *A* ration. The two animals' rates of growth in the first experiment on identical rations were almost exactly the same: the animal however appeared to be in perfect health at the close of the experiment.

The lag in Rags' growth on the 150 cc. ration might be due to a slight anti-scorbutic insufficiency, but since in previous experiments [Barnes and Hume 1919], the minimum requirement for monkeys of 2 to 3 kilos. was found to be 100 to 150 cc. of raw winter milk a day, it cannot be definitely stated that any loss of anti-scorbutic potency is demonstrated in the condensed milk.

The loss, if any, is small and the same is also true with regard to vitamin *A*. The present experiments were not made with a view to testing this property, but save for the wheat germ, the milk provided the sole source of vitamin *A* in the diet. Previous experience [Barnes and Hume, 1919] has shown that about 200 cc. of autoclaved milk daily provide a supply of vitamin *A* which enables good growth in monkeys of 2-3 kilos. to take place.

A recent experiment of Hopkins [1920] has shown that the vitamin *A* value of butter is only destroyed on heating at 120° for four hours, when access of air is permitted. Recent experiments by Delf [1920, p. 227] suggest that the anti-scorbutic vitamin is also much more susceptible to heat when free access of air is permitted. Unpublished experiments by Zilva show that there is loss of anti-scorbutic potency in substances exposed to the action of ozone. Doubtless these observations give the explanation of the non-destruction of vitamins in the condensation of Nestlé's sweetened condensed milk, for though the milk is heated for a very considerable time, though at a low temperature, it is heated *in vacuo*.

One important point should however be made with reference to the use of sweetened condensed milks in infant feeding. The above experiments show that there is little if any vitamin destruction in such milk but it must be borne in mind that in the experiments the milk was reconstituted to have as nearly as possible the same fat and vitamin (assuming no destruction) content as raw milk. That is to say that it was diluted at most four times (one vol. condensed milk to about three vols. water) whereas instructions for the use of the milk for infants suggest a dilution of at the lowest eight times and at the highest very much more. So large an addition of water produces a dilution of the fat and vitamins to an extent likely to be dangerous, although the high

percentage of sugar gives an adequate calorie supply, a danger to which attention was drawn by Coutts [1911].

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