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REMARKS

ON

THE USE OF BORAX AND FORMALDEHYDE AS PRESERVATIVES OF FOOD.

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SOME weeks ago, when I was giving evidence before the Food Preservatives Committee of the Local Government Board, I urged that the use of foreign substances as preservatives of food stuffs should be abandoned, and, if possible, replaced by a more wholesale use of the method of cold transport and storage. I took this view partly on general grounds, which were the following: (1) An antiseptic is inimical to the life of the organisms that cause putrefaction; it cannot, therefore, be harmless to the vital processes in the higher animals. (2) Numerous clinical observations have been recorded which show that dyspeptic and other troubles follow the use of foods which have been treated with commonly employed preservatives like borax. (3) Even if, as in the case of boric acid and borax, the poison is not cumulative, the continuous passage of foreign substances through the kidney cannot be beneficial to those organs.

It is perfectly true that most of us are probably taking small doses of antiseptics in our foodstuffs without any obviously bad results; those who suffer are peculiarly susceptible to such drugs, but, as such cases are by no means uncommon, it appeared to me of sufficient importance to recommend legislation in the direction I have indicated. If, on the other hand, trade influences are too strong, at least articles mixed with drugs should be labelled as such, and not sold as fresh foods. In this way those people who are peculiarly susceptible to any particular antiseptic could avoid it.

In any question of this kind one has to balance the good and the bad, that is to say, whether more harm will result from the products of putrefaction or from the antiseptic used to hinder or prevent putrefaction. But if the method of cold storage were made compulsory no such question could arise, for putrefaction would be prevented without foreign admixture. I was particularly questioned whether on physiological grounds there was any reason why the sterilising of milk by heat could give rise to any toxic material. This I answered unhesitatingly in the negative. The milk proteids are rendered somewhat more difficult of digestion by heat, as in the cooking of all albuminous foods. But most gastric juices are able to grapple with this difficulty. Of course, in cases of feeble digestion, raw or underdone meat and uncooked milk are preferable to foods which have been cooked too much, but there are no grounds for supposing that, in the case of milk, heating will split off from its proteid matter anything of the nature of a toxin.

The special ground on which I opposed the use of antiseptics arose from some experiments I had done with artificial digestive mixtures. These experiments were conducted to test the action of borax and formaldehyde on digestion. I selected these because they are the antiseptics most frequently employed as food preservatives. The experiments show that the antiseptics named act prejudicially on the digestive enzymes even in the doses which are employed as preservatives, and this furnishes an additional reason why their use should be prohibited. The following are the details of the experiments, the results of which I was briefly able to indicate before the Committee.

BORIC ACID AND BORAX.

My attention was first called to the use of these substances in milk some years ago by Professor F. J. Allen (Birmingham). He noticed many cases of malnutrition in infants fed on such milk, particularly if borax was the adulterant. The condition passed off when pure milk was used. On examining the matter, Professor Allen found that borax prevents the normal action of rennet. The process of milk digestion in the stomach may be briefly explained as follows:—Milk is subjected to the action of two ferments in the gastric juice; one of these is called rennet the other pepsin. The preliminary breaking down of the molecules of caseinogen (the chief albuminous constituent of milk) by rennet is evidenced to the eye by the formation of a curd; this appears to be necessary before the subsequent peptonisation by pepsin can be properly carried out.

In repeating these experiments I have limited myself to observing the influence of borax and boric acid on the action of rennet. The following will serve as typical of numerous experiments I have made; all show analogous results:

Fresh cow's milk was divided into portions of 100 c.cm. each.

To No. 1 nothing was added.

To No. 2 0.05 gram of boric acid was added.

To No. 3 0.1 gram of boric acid was added.

To No. 4 0.15 gram of boric acid was added.

These are quantities comparable to those used generally to keep milk sweet.

After the lapse of an hour, during which time the milk was well shaken with the acid, much was found to be undissolved, even in specimen No. 2. One cannot therefore say that any more boric acid had passed into solution in those specimens to which more of the solid had been added. Boric acid is a comparatively insoluble substance.

From all four specimens curds were taken and treated with a few drops of rennet extract. A well-marked curd occurred in all in less than a minute at 40° C.

The small amount of boric acid which will dissolve in milk in an hour will therefore not prevent, or even markedly hinder, rennet activity.

I kept the remainder of the specimens, 2, 3, and 4, for a few hours longer in order to test the matter again when all the boric acid had dissolved, but I found that still there was no hindering of rennet action.

In spite of the boric acid the milk went sour in a little over a day.

These experiments do not prove very much. They show, what was previously well known—namely, that boric acid by itself is a very inefficient antiseptic, and has but little if any inhibiting power over the unorganised ferment—rennet—selected for experiment. The cause of this feeble action both on organised ferments (micro-organisms) and unorganised ferments or enzymes is to be probably partly explained by its difficulty of solution.

I imagine it is for this reason that boric acid alone is seldom used as a preservative for milk; the preparation known as "glacialin" is what is usually employed. Glacialin is a mixture of boric acid and borax, and it can hardly be doubted that it is the borax which acts as the principal antiseptic. More interest and importance, therefore, must be attached to experiments with borax.

As before, the milk was divided into portions of 100 c.cm. each. At the end of two days the unadulterated milk had gone sour; the specimens to which borax was added were still sweet.

To No. 1 nothing was added.

To No. 2 0.05 gram of borax was added.

To No. 3 0.1 gram of borax was added.

To No. 4 0.15 gram of borax was added.

On testing samples of each with rennet at 40° C. half an hour after the borax had been added,

No. 1 coagulated in about 30 seconds.

No. 2 coagulated in about 2 minutes.

No. 3 and 4 did not coagulate at all.

These experiments show that 1 part of borax in 1,000 of milk completely inhibits rennet activity, and even smaller proportions will delay its action.

FORMALDEHYDE.

This substance is most efficient as an antiseptic, but I cannot agree with Mr. A. H. Allen¹ that it is the least objectionable of the preservatives of food. Its very efficiency in

counteracting ferment activities render it particularly objectionable. The aqueous solutions of formaldehyde are very irritating to the skin. I noticed this even with solutions containing only 5 parts in 10,000 of water; the skin is roughened after dipping the fingers into it for a few moments, and any little abrasions that may be present in the skin are rendered intensely painful. Cervello states that by painting the ear of a rabbit three times a day with it ulceration and gangrene are obtained within a week. From this it will be gathered that though formalin has but little taste, it can nevertheless not be harmless to the mucous membrane of the alimentary canal, which is far more easily injured than the external skin. Bruni has shown that in animals vomiting is produced by very dilute solutions.

If the drug is introduced into an animal by intravenous injection, the red corpuscles of the blood are disintegrated, respiration is disturbed and may stop, convulsions and coma may also supervene. Its power as an antiseptic is, however, so marvellous that the experiment has been tried of treating consumptive patients with air charged with its vapour. Physicians have not entirely relinquished this method of treatment, for it has been stated that by mixing the vapour with other substances the air may be rendered respirable; but it has been fully shown that an admixture of air with the vapour of formaldehyde only is so irritating, and after a short time so impossible, that more harm than good has been the result.

The experiments I have performed myself were to test the influence of formaldehyde in digestion. I could wish that they were more complete, but they at least show that substances treated with even weak solutions are rendered very indigestible. They may be divided into four categories: the influence of formaldehyde (1) on gastric digestion of proteid; (2) on the pancreatic digestion of proteid; (3) on the pancreatic digestion of starch; (4) on the curdling action of rennet. I will quote illustrative experiments under each of the four heads.

1. *Influence of Formaldehyde on the Gastric Digestion of Proteid.*—Artificial gastric juice was prepared by adding Benger's liquor pepticus to 0.2 per cent. hydrochloric acid in the proportion 1 to 5. Fibrin was taken as the proteid or albuminous matter to be digested. The fibrin was divided into a number of portions and placed in various strengths of formaldehyde for two or three days. Even the weakest solutions employed kept the fibrin perfectly free from decomposition, but in all cases it was rendered very hard. Equal quantities of each were subjected to the action of the same volumes of the artificial gastric juice in a warm oven at 40° C. The end of digestion was considered to be reached when all lumps had passed into solution. The following table gives the results:

Experiment A.

1. Fresh fibrin.	Digestion complete in 45 minutes.	
2. Fibrin placed in 0.05 per cent. formaldehyde for 2 days	Digestion complete in 65 minutes. In 3 hours. In 7 hours. In 24 hours. Hardly any digestion at end of 24 hours.	
3. " " 0.10 " " "		
4. " " 0.25 " " "		
5. " " 0.50 " " "		
6. " " 1.00 " " "		
7. " " 2.00 " " "		
8. " " 4.00 " " "		

Experiment B.

1. Fresh fibrin		Digestion complete in 30 minutes. In 60 minutes. In 95 minutes. In 3 hours. In 5 hours. Had not digested at 6 hours, when the observation was stopped.
2. Fibrin placed in 0.05 per cent. formaldehyde for 3 days	...	
3. " " 0.01 " " "	...	
4. " " 0.25 " " "	...	
5. " " 0.50 " " "	...	
6. " " 0.10 " " "	...	

These experiments show that a percentage of 0.5 renders gastric digestion almost impossible; and that a percentage of over 0.05 considerably delays it.

2. *Influence of Formaldehyde on the Pancreatic Digestion of Proteid.*—These experiments were conducted in a corresponding way and led to a corresponding result. The fibrin, after a two-days' stay in various strengths of formaldehyde solution, was subjected to the action of artificial pancreatic juice at 40° C., and the time of digestion noted. The artificial pancreatic juice was made by mixing Benger's liquor pancreaticus with 1 per cent. solution of sodium carbonate in proportion of 1 to 4.

The results are even more striking than in the case of gastric digestion. It will only be necessary to quote one illustrative experiment:

1. Fresh fibrin		Digestion completed in 30 minutes. In 95 minutes.
2. Fibrin previously placed in 0.05 per cent. formaldehyde	...	
3. " " 0.10 " " "	...	No trace of digestion at end of 24 hours.
4. " " 0.25 " " "	...	
5. " " 0.50 " " "	...	
6. " " 1.00 " " "	...	
7. " " 2.00 " " "	...	
8. " " 4.00 " " "	...	

3. *Influence of Formaldehyde on the Pancreatic Digestion of Starch.*—A 1 per cent. solution of starch was prepared and divided into portions of 5 c.cm. each. To some of these were added 2 drops of formaldehyde of various strengths, and to all a few drops of Benger's liquor pancreaticus. All were placed in the warm bath at 40° C., and the time noted when the starch had disappeared—that is, owing to its conversion into dextrin and sugar, it ceased to give a blue colour with iodine. In the specimens to which no formaldehyde had been added the starch reaction was lost in one minute. In those to which formaldehyde had been added the time was prolonged to three to six minutes, according to the strength of the reagent added; even so weak an addition as 2 drops of a 0.1 solution of formaldehyde increased the digestion time to three minutes.

4. *The Action of Formaldehyde on the Rennet-curdling of Milk.*—The proportion in which formaldehyde is stated to be used in the milk trade is roughly 2 drops of formalin (40 per cent. formaldehyde) per fluid ounce.

In all cases such an addition to milk greatly delays rennet action. Various specimens of milk I have tested differ in the amount of delay. In some cases the amount added is sufficient to completely inhibit the action of the ferment; but in all cases the curd when it does form is very slow in making its appearance, and is never firm as it is in unaltered milk. Much smaller doses of formaldehyde have a similar though less marked effect; thus a few drops of a 0.2 per cent. solution of formaldehyde per ounce of milk raised the time of onset of curdling from 20 seconds to 1½ minute.

I have thought it desirable to publish my results as the question is now prominently before the public, and every additional piece of evidence has thus some value. Similar experiments have been published previously by others, for example, by Rideal and by Boyce, and although there are some differences of detail both of method and results between these experiments and my own, they all tend in the same general direction.

These experiments appear to me to prove conclusively the injurious effect produced by even minute quantities of certain preservatives on the activity of the enzymes concerned in ordinary digestion, and to furnish a cogent reason why the use of these substances should be prohibited for the preservation of food materials.

It will be noticed that all my experiments were performed *in vitro*; they require to be amplified by experiments *in vivo*. Artificial digestion experiments, however, as a rule form a very good guide to what occurs in natural digestion.

REFERENCE.

1 *Commercial Organic Analysis*, vol. iv.

THE RAINFALL IN THE WEST AND EAST.—At a recent meeting of the Royal Meteorological Society Mr. W. Marriott read a paper on Rainfall in the West and East of England in Relation to Altitude above Sea Level, in which he discussed the mean monthly and annual rainfall for the ten years 1881-90 at 309 stations, grouped according to altitude. The western stations were considered to be those which drained to the west, and the eastern stations those which drained to the east. A general increase in the annual amount of rain was observed as the altitude increased, and the rainfall was considerably greater in the west than in the east. The monthly rainfall in the west appeared to be subject to a much greater range than in the east; in the west the maximum at all altitudes occurred in November, but in the east generally in October. In the west the spring months April, May, and June were very dry, and in both west and east there was a very great increase in the rainfall from June to July.