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13th European Meeting of Meat Research Workers, Rotterdam 1967

# The Role of Sulphite in the Preservation of Meat Products: A Review.

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## Introduction

" - - - - - - - bring me some disinfectant sulphur and make me a fire so that I can fumigate the house"

The Odyssey. Trans. E.V. Reu, p.340

Elementary sulphur is still to be found on the shores of Sicily so it is not surprising that it was known to Homer. It is perhaps more surprising that he knew sulphur could be burned to make a disinfectant gas. We do not know when it was first observed that fruits, vegetables and meats left in a room during fumigation with sulphur dioxide did not deteriorate rapidly, but it seems very probable that sulphur dioxide has been used as a preservative in foods for centuries.

The modern approach to preservatives is highly critical, and rightly so. To gain acceptance a preservative must be:

(1) Acceptable biologically, using long term trials.
(2) Necessary for meeting important technological needs.
(3) Not conducive to deceptive practice.
(4) Beneficial on balance to the public.

Even after meeting these requirements, a preservative may well be limited to strictly defined products and amounts.

In this paper the data relating sulphites to these oriteria will be examined and discussed.

1) Biological Data.

1.1. Acute toxicity.

Little is known on the acute oral toxicity of sulphites mainly due to the practical difficulty of administering enough sulphite to cause death. Excessive doses induce vomiting in many species, including humans.

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|---|---|---|
| Oral LD 50 Rabbit | 600/700 mg/kg body weight measured as $SO_2$ | Ref.1 |
| Oral LD 50 Cat | 400/450 mg/kg body weight measured as $SO_2$ | Ref. 2,3. |

These figures may be compared with the acute toxicity levels for nitrates and nitrites which are traditional additives in meat.

mg/kg body weight

| | | | |
|---|---|---|---|
| Oral LD 50 Rat | 3236 | Potassium Nitrate | Ref. 4 |
| Oral LD 50 Rat | 85 | Potassium Nitrite | Ref. 4 |

Sulphites, therefore, have an acute toxicity between those of nitrates and nitrites.

It is interesting to note that sulphites were formerly used in human medicine as gastric antiseptics in doses between 0.3g and 0.6 g (The Dispensatory of the U.S.A. 1947)[5]. These must have been rather uncomfortable prescriptions, as according to Lafontaine & Goblet (1955)[6] doses of 0.4g sulphite trigger off the vomiting reflex in man. Lafontaine comments that this property probably explains why no case of acute poisoning by sulphite in humans was known to him.

1.2. Long term studies.

Fitshugh, Knudsen & Nelson (1946)[7] showed no-effect in rats fed 0.05% sodium bisulphite (307 p.p.m. as $SO_2$) for two years. At the 0.1% level of sodium bisulphite they noted inhibition of growth and some histropathological abnormalities. It must be remembered that the

itself and in these experiments it is very unlikely that sulphite had any direct effect on the animals. While there may have been some adverse effects due to destruction of thiamine, it now seems very probable that some toxicity developed due to storage of the sulphited diet. Bhagat and Lockett (1964)[8] demonstrated the development of toxicity in a sulphited diet during storage for 75 days.

Lockett and Natoff (1960)[9] found a no-effect level in rats over a two year test with sodium metabisulphite added to drinking water at 750 p.p.m. as $SO_2$. None of the histopathological symptons described by Fitshugh (1946)[7] at higher levels of sulphite was found.

Lockett and Natoff's technique avoided the extraneous influence of storing a sulphited diet and the levels of sulphite used in the drinking water were carefully controlled. The no-effect level of 750 p.p.m. as $SO_2$ in drinking water is equivalent to 1125 p.p.m. in the diet, as in these experiments the weight of water consumed was 1.5 times the weight of food.

Cluzan, Causeret and Hugot (1965)[10] also found no adverse effects on growth, mortality and histology of rats given 1200 p.p.m. potassium metabisulphite in the drinking water over a period of 20 months.

Some differences were found in the average number of young per litter and in the proportion of males. The former effect was significant in the first generation but not in the second and Cluzan et al comment that they are unable to draw conclusions on this aspect without further studies. The growth of the young, maintained in the same way as their parents, was the same in the groups receiving sulphite as in the controls, during the three months it was recorded.

The following levels were proposed in 1962 by the Joint FAO/WHO Expert Committee on Food Additives[4] based on the no-effect level of 307 p.p.m. established by Fitshugh.

| | |
|---|---|
| Unconditional acceptance | 0 - 0.35 mg/kg body weight |
| Conditional acceptance | 0.35 - 1.5 mg/kg body weight (Calculated as $SO_2$) |

The FAO/WHO COmmittee reconsidered the limits for sulphites in 1965 and 1966 and decided to leave them unchanged. For a 70 kg. man the upper acceptable daily intake remains therefore at 105 mg. This may be compared with the daily intake of under 20 mg. calcuted by the U.K. Food Standards Committee in 1953[11].

If, however, the work of Lockett and Natoff is confirmed then the acceptable daily intake might be increased by a factor of 3.68 i.e. $\frac{1125}{307}$.

A monograph on the subject of sulphite in foods is due to be published shortly by the W..H.O.

1.3. Effect on thiamine

Sulphite is well-known to cause destruction of thiamine.

The thiamine content of pork sausage is given in the Manual of Nutrition (1966)[12] as 0.1 mg/oz. equivalent to 0.35 mg/100g. Assuming all this is lost on cooking in the presence of sulphite, we can calculate the effect on the daily consumption as follows:

Daily consumption of pork sausage in the U.K. per capita is 13 g., National Food Survey (1966)[13] the loss is therefore:

$$\frac{13 \times 0{,}35 \text{ mg}}{100} = 0.045 \text{ mg.}$$

Taking the daily requirement of thiamine per capita as 1.6 mg. the maximum loss due to sulphiting pork sausage is therefore 2.8% of the total.

Beef has only one fourteenth of the thiamine content of pork, McCance and Widdowson (1960)[14], and the consumption of beef sausage is less than that of pork sausage, i.e. 7.3 grams per day per capita. The loss of thiamine through sulphiting beef sausage is therefore around 1/20th that of pork sausage and may be ignored.

2. Technological needs.

2.1. In the U.K. the majority of people cook their sausages by frying. If pork or beef sausages are fried on the day of manufacture they will burst or even disintegrate in the pan. This applies to sausages both in natural and artificial edible casings.

2.2. Even if it were technologically possible, it is not practible in a highly industrialised country to sell sausages on the day of manufacture. Workers in meat factories expect to have week-ends and holidays free, like the rest of the public, so that a storage life of 3- 5 days is a necessity.

2.3. There is no merit in eating freshly slaughtered meat. In the case of beef the carcases should be aged for at least 10-14 days at 4°C - 6°C. before boning to attain tenderness and flavour. Pork does not improve significantly on ageing but equally, it certainly does not deteriorate when held for several days at chill temperatures. The effect of comminution is to distribute existing bacteria over an increased surface area of the meat so that bacterial action and oxidative discolouration become more pronounced. Both these undesirable effects are held in check by the use of 300 p.p.m. - 450 p.p.m. of sulphur-dioxide, as they are by refrigeration, although the latter is less effective regarding discolouration.

3. Deceptive practice.

It is probably true to say that the attitudes of Regulating Authorities in different countries towards the use of sulphites in meat products range from relectant acceptance to strong disapproval. The main objection felt is probably the alleged scope for deceptive practice. The following quotation from the Report of the Joint FAO/WHO Expert Committee on Food Additives (1962)[4] illustrates the anxieties felt.

> "Sulphite preserves colour and restores the redness of dullcoloured meat; it may thus serve to mask any putrefaction. Since it does not prevent putrefactive processes in meat, it may lead to deception regarding freshness and to possible injury from the consumption of tainted meat. For this reason sulfite should not be used for meat."

At the levels under consideration sulphite does not restore the redness of dull coloured meat, as was shown by Krol and Moerman (1959)[16] who caused meat to become discoloured by holding it at 22°C. for 16 hours and then treated it with 300 p.p.m. as $SO_2$ and minced it. They conclude that sulphite does not possess the ability

to restore colour to discoloured meat. A slight improvement in colour was noticable for a brief period after mincing but Krol and Moerman point out that this was in all probability attributable to the oxygenisation of part of the myoglobin. This improvement took place whether sulphite was added or not.

The present Writer confirms Krol and Moerman's conclusions and considers there is no scope for deceptive practice using concentrations of sulphite within the permitted range (not greater than 450 p.p.m. as $SO_2$). In the course of hundreds of trials with both pork and beef sausage containing from 300 p.p.m. - 400 p.p.m. of $SO_2$, the Writer has always observed gradual deterioration of the colour during the normal period of storage, which varies from 3-5 days in the temperature range 5°C - 20°C. Under U.K. conditions the colour and general appearnace of sulphited sausage is, indeed, a very sensitive index of its freshness.

4. Benefits to the Public

The Public Health Authorities in many countries are concerned by the occurrence of Salmonellae in meat and, short of irradiation, there is no known means at present of eliminating them from uncooked meat.

If we cannot eliminate Salmonellae completely, then we must aim to restrain their multiplication. A direct experiment on the effect of sulphites on the growth of Salmonellae was carried out by a working group of the Dutch organisation T.N.O. and reported by Moerman (1960)[17].

This group found that using sulphite equivalent to 300 p.p.m. $SO_2$ there was no growth of S. typhimurium in inoculated minced meat stored at 15°C for 66 hours or at 20 - 25°C for 6 hours. Where growth took place it was much slower in the presence of sulphite than without.

In our own Laboratories, Dyett and Shelley (1966)[18] found similar results using the normal flora of sausage. Coli-aerogenes bacteria were present in small numbers in all samples but multiplied rapidly in sulphite-free sausage.

In the same paper Dr. B.C.Hobbs is quoted as follows: "Sausagemeat with and without the addition of not more than 450 p.p.m. of sulphur dioxide was inoculated with Cl. welchii, Salmonella typhimurium of Staphylococcus aureus and incubated at 20° or 30°. Total viable counts were made and also separate counts on more selective media of the organisms added. The results showed that both the spoilage and the inoculated pathogenic organisms grew well on the sausagemeat without preservative. However, in the sausagemeat containing $SO_2$ the growth of spoilage organisms and the added inoculum was checked for at least 24 hours, and in some cases the pathogens died out completely.
It seems, therefore, that the addition of 450 p.p.m. of sulphur dioxide to sausagemeat during preparation does, in fact, serve a useful purpose in suppressing growth for 1 -2 days."

The annual food poisoning statistics prepared by the U.K. Ministry of Health [19] provide striking confirmation of the value of sulphite in sausage. In a communication to "The Lancet", Hannan and Dyett (1965)[20] wrote:

"For three years 1962, 1963 and 1964, out of all the incidents known to be associated with the consumption of meat products only 7 (some 2½%) were associated with sausages. This compares with the consumption of many thousands of millions of sausages in Britain during that period. In fact, more incidents were attributed both to eggs and to milk.

Evidence obtained in our laboratories shows that this position may well be due to the enlightened approach of the authorities in the United Kingdom in permitting the addition of a modest amount of metabisulphite preservative to sausages. In the presence of 450 p.p.m. of this substance, calculated as sulphur dioxide, there is a strong inhibition of mesophilic organisms including salmonellae and other food-poisoning types. Normal spoilage organisms on the other hand are inhibited to a much smaller degree, and there is, as a consequence, a strong natural protection in that the sausages will tend to become sour and unpalatable before they become injurious."

Discussion of Advantages and Disadvantages of Sulphites as Preservatives/

Few doubts should remain on the safety of sulphites within the accepted ranges. Sulphites are officially approved in many countries for dried fruits, fruit drinks, wine, vegetable products and gelatine. In the U.K. orange juice distributed by the Ministry of Health for consumption by babies contains 300 p.p.m. sulphite as $SO_2$. In their widespread use and relative freedom from toxic hazards, sulphites are unique among preservatives.

A feature of the action of sulphites is their very low toxicity towards cell cultures. Thompson (1962)[21] studied the effects of sulphites on three lines of cell cultures. Two of these lines, mouse liver cells and strain L cells grew readily in the presence of 500 p.p.m. $NaHSO_3$ in the medium. A third type, He La, grew in the presence of 100 p.p.m. but more slowly than the control. This apparent selectivity of action against bacteria, yeasts, and probably virus, Lynt (1966)[22] compared with low toxicity towards animal and human cells provides further confirmation of their suitability as preservatives in food products.

We may therefore ask why many authorities disapprove of their use in meat products while accepting their use in other foods.

The only indisputable disadvantage of the use of sulphites in comminuted meat products, in the Writer's view, is the loss of thiamine. This has been shown above the represent 2.8% of the total thiamine intake in the U.K. In considering whether or not this is significant it should be remembered that thiamine is derived from a number of different sources, the most important in the U.K. being bread and flour, meat (especially pork), potatoes and other vegetables. In order to ensure an adequate daily intake, thiamine is added to bread by Government regulations. The level of thiamine fortification was decided at a time when sulphite was in general use in sausage and presumably took account of this factor.

Pork in forms other than sausage is one of the richest sources of thiamine and it would be both unnecessary and unwise to permit the addition of sulphite to uncomminuted pork meat.

There is clearly a good margin of safety in the daily intake of thiamine in the U.K. since an important section of the public excludes pork altogether from their diet for religious reasons, apparently without ill effect. The fractional loss of thiamine through sulphiting of fresh sausage seems therefore a small price to pay for the notable advantages.

The technological advantages should not be seen as accruing only to the manufacturer. The use of sulphite makes sausages available in the shops at all times and reduces wastage. Unnecessary wastage of food is not only indefensible in the time of a world shortage but adds to the cost of the goods reaching the public.

Abuse of sulphite in meat products by using high concentrations can be as readily detected in countries permitting specified lower amounts of sulphite as in those countries where sulphite is prohibited. In the U.K. abuse of sulphite is negligible.

The most compelling reason for the use of sulphite in comminuted meat products remains its inhibiting action against Salmonellae and other pathogens. Under U.K. conditions, where refrigeration in the home and in shops is by no means universal, there can be no doubt that sulphites are a powerful defence against food poisoning and unless means can be found for eliminating Salmonellae from raw meat it seems vital to continue the use of sulphites.

Even in frozen comminuted meat products sulphites play a beneficial role. While no multiplication of Salmonellae can take place during distribution of frozen meats, multiplication can readily occur in the home if the goods are stored after thawing and if sulphites are not present.

In inoculation experiments with Salmonella anatum at a level of 5000 per gram, frozen comminuted meats left 24 hours to defrost at 21°C. showed 90% reduction in viable counts at 22°C and 37°C when 200 p.p.m. $SO_2$ were present compared with controls without sulphites. It is possible that freezing and thawing increases susceptibility of Salmonellae to $SO_2$ Hamill (1967)[23].

It appears that the use of sulphites in comminuted meat products as practised in the U.K. is beneficial to the public on balance. Similar regulations and benefits apply in Australia and New Zealand. Sulphites are only permitted in uncooked meat products containing cereal, where the technological problems are pressing. Sulphites are not permitted, for example, in cooked meat pies where the process destroys any vegetative pathogens, and where the outside pastry forms its own edible package.

The most recent figures of food poisoning issued by the U.K. Ministry of Health[24] provide, perhaps, the strongest evidence one could expect. Out of the 70 known family and general outbreaks of food poisoning in the U.K. in 1965 associated with meat products, the number involving sausage was nil.

While the use of sulphites in comminuted meat products is particularly applicable to U.K. conditions, it may be of value to other countries who also lack a continuous'cold chain' from the meat factory to the domestic larder.

## SUMMARY

The safety and general acceptability of sulphites as preservatives in comminuted meat products is reviewed. Their advantages and disadvantages are discussed and it is concluded that as practised in the U.K. the use of sulphites is beneficial to the public and may be of value to other countries.

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