Effects of some food preservatives on the behavior of nitrite in processing meat products

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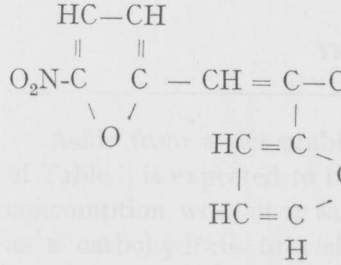
In recent years various food additives are employed in processing meat products, and it has been observed in our laboratory that in aqueous model system most of them manifest various effects on the behavior of nitrite in the treatment of keeping for 72 hours at 4° C and cooking for one hour at 75° C, especially in the presence of ascorbate. As for the effects of phosphates on the behavior of nitrite in processing meat products and on the color of meat products, the results of experiments with cooked sausage were given in the previous papers (1, 2).

At present in Japan, four food preservatives, i.e., sorbic acid (SA), sodium sorbate (NaS), potassium sorbate (KS) and 2- (2-furyl) - 3- (5-nitro- 2-furyl) -acrylamide (AF 2) are permitted to use in processing meat products, but their contents in meat products are limited by law to be less than 0.2 % in each case of SA, NaS and KS, and less than 5 ppm in case of AF 2. AF 2 is a new food preservative synthesized by Saikachi (3) in Japan, which is a nitrofuran derivative and has the following structural formula.



2- (2-furyl) - 3- (5-nitro - 2-furyl)-acrylamide (AF 2)

AF 2 is reported to be less toxic but obviously more effective in antibacterial activity as compared with two other nitrofuran derivatives of nitrofurazone and nitrofurylacrylamide which were formerly permitted in Japan to use as food preservatives (4—10), and AF 2 is now widely employed as a food preservative in our country.

Since any detailed studies of the effects of food preservatives on the behavior of nitrite in processing meat products seem to have not so far been performed, an investigation on this point was undertaken in the present work with the samples of aqueous model system and cooked sausage.

EXPERIMENTAL

1. Experiments on aqueous model system

Each test solution was prepared by dissolving 0.1 % of SA, NaS and KS each or 0.025 % of a 1:49 mixture of AF 2 and soluble starch corresponding to 5 ppm of AF 2 in a veronal buffer solution of pH 5.0 or 0.6 containing 0.01 % sodium nitrite coexisting or not coexisting with 0.1 % of sodium ascorbate.

Each test solution was cooked for one hour at 75°C just after preparation and the amount of nitrite in each test solution before and after cooking was determined colorimetrically by the method described in the previous paper (11) (outlined in Fig. 1).

Test solution 2 ml
↓ ferricyanide solution (pH 7, 0°C)
10 mM K_3 Fe $(CN)_6$ solution : 3 ml
veronal buffer of pH 7.0 : 25 ml
distilled water : 25 ml
let stand for 30 min at 0°C
↓ 0.1 M Pb-acetate solution (pH 5) 10 ml
let stand for 10 min at room temperature
make up to 200 ml with distilled water
filter
Filtrate 5 ml
↓ Orange I reagent 5 ml
keep at 30° C for 30 min
cool with running tap water for 10 min
measure the absorbance at 479 mμ

Fig. 1. *Colorimetric method for the determination of nitrite coexisting with various food additives in aqueous model system*

2. Experiments on cooked sausage

Each cooked sausage sample was prepared by removing connective tissue and fat as far as possible from beef chuck at 4 days after slaughter, comminut-

Table 1. *Curing ingredients used for the preparation of cooked sausage*

Sample number	*Curing ingredients*			
	NaCl	$NaNO_2$	*Na-ascorbate*	*Food preservatives*
	%	%	%	%
control	2.0	0.02	—	—
1	2.0	0.02	—	Sorbic acid 0.2
2	2.0	0.02	—	K-sorbate 0.2
3	2.0	0.02	0.1	—
4	2.0	0.02	0.1	Sorbic acid 0.2
5	2.0	0.02	0.1	K-sorbate 0.2

ing and mixing with the curing ingredients combined in each proportion given in Table 1 in a silent cutter, stuffing into a Krehalon (vinylidene chloride-vinyl chloride co-polymer) casing each, cooking for one hour at 75°C, then cooled with running tap water and ice water for 30 minutes respectively.

Since it has been found in the experiments on aqueous model system that AF 2 exhibits no effect at all on the behavior of nitrite at the concentration of 5 ppm, and as it is also well known that NaS is not so stable as SA and KS and not practically used in processing meat products, only two food preservatives of SA and KS were employed in the present experiments on cooked sausage.

The amount of nitrite in each cooked sausage sample before and after cooking was determined colorimetrically by the method proposed in the previous paper (12) (outlined in Fig. 2).

Sample 2 g
↓ H_2O 10 ml
homogenize for 3 min
↓ H_2O
150 ml
↓ 0.5 M Na-diethylbarbiturate aqueous solution 5 ml
heat in a water bath at 80° C for 90 min (pH 9.0 ± 0.2)
cool with running tap water for 10 min
and ice water for 30 min, respectively
↓ 1 N HCl solution 2 ml
↓ 10 mM $K_3Fe(CN)_6$ solution 3 ml
keep at 0° C for 30 min (pH 7.0 ± 0.1)
↓ 0.1 M Pb-acetate solution 10 ml

let stand for 10 min at room temperature
↓ H_2O
200 ml
filter
Filtrate 5 ml
↓ Orange I reagent 5 ml
keep at 30° C for 30 min
cool with running tap water for 10 min
measure the absorbance at 479 mμ

Fig. 2. *Colorimetric method for the determination of nitrite coexisting with various food additives in meat products*

In addition, the figures for pH, water-holding capacity (WHC) and color formation value (CFV) of cooked sausage samples were determined by the methods described in the previous papers (1, 2).

RESULTS AND DISCUSSION

1. Effects of food preservatives on the behavior of nitrite in aqueous model system

The results of experiments in the effects of food preservatives on the behavior of nitrite in aqueous model system are given in Table 2.

According to the results in Table 2, any decomposition of nitrite could not be observed in all test solutions just after preparation.

Nevertheless, after cooking for one hour at 75° C the decomposition of nitrite apparently took place by the addition of SA, NaS and KS even in the absence of ascorbate, and since no change in pH value was brought about at all in all test solutions by cooking-treatment, all these three sorbate food preservatives seemed to exert undoubtedly themselves certain actions on the decomposition of nitrite.

This action of decomposing nitrite increased with decreasing pH value, and in particular in the test solutions of pH 5.0 the amount of nitrite decomposed by SA was distinctly larger than those decomposed by NaS and KS even though the pH values of these test solutions were quite the same.

Ascorbate promotes the decomposition of nitrite in general, and in the present experiments too, the amounts of nitrite decomposed by SA, NaS and KS in the presence of ascorbate were evidently larger than those in the absence of ascorbate. When SA and KS are employed together with ascorbate, however, special attention should be given to the fact that SA, as clearly shown in the test solutions of pH 5.0, tended to promote the decomposition

Table 2. *Effects of food preservatives on the behavior of nitrite in aqueous model system*

Test solution Concentration of food additive					$NaNO_2$ found (ppm) Just after preparation at O° C	
pH[a])	$NaNO_2$	Na-ascorbate	Food preservative		Before cooking	After cooking[b])
	%	%		%		
	0.01	—	—	—	100.0	100.0
	0.01	—	Sorbic acid	0.1	100.0	72.4
	0.01	—	K-sorbate	0.1	100.0	82.0
	0.01	—	Na-sorbate	0.1	100.0	83.3
	0.01	—	AF 2	0.025[c])	100.0	100.0
5.0	0.01	0.1	—	—	99.8	70.0
	0.01	0.1	Sorbic acid	0.1	99.8	56.5
	0.01	0.1	K-sorbate	0.1	99.8	75.9
	0.01	0.1	Na-sorbate	0.1	99.8	76.6
	0.01	0.1	AF 2	0.025[c])	99.8	70.0
	0.01	—	—	—	100.0	100.0
	0.01	—	Sorbic acid	0.1	100.0	96.4
	0.01	—	K-sorbate	0.1	100.0	96.8
	0.01	—	Na-sorbate	0.1	100.0	96.9
	0.01	—	AF 2	0.025[c])	100.0	100.0
6.0	0.01	0.1	—	—	100.0	94.2
	0.01	0.1	Sorbic acid	0.1	100.0	92.8
	0.01	0.1	K-sorbate	0.1	100.0	93.7
	0.01	0.1	Na-sorbate	0.1	100.0	94.3
	0.01	0.1	AF 2	0.025[c])	100.0	94.2

a) Adjusted with veronal buffer.

b) Cooked at 75 °C for one hour.

c) A mixture of 1 part of AF 2 and 49 parts of soluble starch. Accordingly, the AF 2 solution contains 5 ppm of AF 2.

of nitrite, whereas its salts, NaS and KS, tended to inhibit. These observations seem of great importance when they are put to practical use.

As for AF 2, it exhibited no effect at all on the behavior of nitrite in all cases tested.

2. Effects of sorbic acid (SA) and potassium sorbate (KS) on the pH and water-holding capacity (WHC) of cooked sausage

The results in Table 3 indicated that SA always depress the pH value of cooked sausage remarkably and gave evidently an unfavorable effect on WHC of cooked sausage, whereas KS had a tendency to increase slightly

Table 3. *Effects of sorbic acid (SA) and potassium sorbate (KS) on the pH and water-holding capacity (WHC) of cooked sausage*

Experiment	Sample number		pH		WHC	
			Before cooking	After cooking [a]	Mean	Statistical significance [c]
I	control		5.56	5.90	63.6	**
	1	© + SA	5.31	5.67	56.7	×
	2	© + KS	5.59	5.90	63.4	×
	3	© + NaA [b]	5.58	5.90	63.8	**
	4	© + NaA + SA	5.34	5.69	59.4	**
	5	© + NaA + KS	5.59	5.90	67.4	
II	control	©	5.59	5.96	67.5	**
	1	© + SA	5.34	5.72	62.7	**
	2	© + KS	5.62	5.95	71.5	*
	3	© + NaA [b]	5.63	5.94	69.5	**
	4	© + NaA + SA	5.38	5.71	63.7	**
	5	© + NaA + KS	5.63	5.96	72.9	

a) Cooked for one hour at 75° C.
b) Sodium ascorbate.
c) ** Jighly significant at $P<0.01$.
* Significant at $P<0.05$.
× Not significant.

the pH value of cooked sausage before cooking but after cooking any difference in the pH value could hardly be observed between the control and KS-treated sausages. In the present work, the addition of KS resulted in an appreciable increase in WHC on most occasions, but on some occasion any change in WHC could hardly be brought about by the addition of KS.

3. *Effects of sorbic acid (SA) and potassium sorbate (KS) on the content of nitrite and color formation value (CFV) of cooked sausage*

As shown in Table 4, in every case in which SA was added the decomposition of nitrite in cooked sausage was remarkably promoted and the color formation of cooked sausage seemed to be improved to a certain extent. As to KS, differing from the case in aqueous model system, the addition of KS consistently inhibited the decomposition of nitrite in cooked sausage and seemed to inhibit more or less the color formation of cooked sausage in both cases in the absence and presence of ascorbate. One of the reasons why in case of cooked sausage, differing from in case of aqueous model sys-

Table 4. *Effects of sorbic acid (SA) and potassium sorbate (KS) on the content of nitrite and color formation value (CFV) of cooked sausage*

Experiment	*Sample number*		$NaNO_2$ *found* *ppm*	*Index* [b] *number*	*CFV*	*(Absorbance at 395 mμ)*
I	control	©	115.2	100	100	(0.551)
	1	© + SA	95.0	82	102	(0.564)
	2	© + KS	116.1	101	97	(0.532)
	3	© + NaA[a]	84.1	73	103	(0.570)
	4	© + NaA+SA	54.2	47	105	(0.577)
	5	© + NaA+KS	85.9	75	101	(0.558)
II	control	©	106.7	100	100	(0.563)
	1	© + SA	92.2	86	102	(0.574)
	2	© + KS	112.4	105	96	(0.539)
	3	© + NaA[a]	71.9	67	103	(0.578)
	4	© + NaA+SA	46.1	43	104	(0.584)
	5	© + NaA+KS	74.7	70	102	(0.574)

a) Sodium ascorbate.

b) Figures for index number were calculated on the basis of the content of nitrite in control cooked sausage after cooking as 100.

tem, KS inhibited the decomposition of nitrite in the absence of ascorbate is presumably due to the fact that the reducing substances naturally existing in meat may have played a similar role to that played by the ascorbate in case of aqueous model system.

Detailed comparative studies of the effects of these food preservatives on the preservation and quality of meat products are now in progress and the results will be reported elsewhere.

REFERENCES

1. N. Ando, Y. Kako and Y. Nagata: Bulletin of Meat and Meat products, 1, 1 (1961).
2. N. Ando, Y. Kako, Y. Nagata, T. Ohashi, Y. Hirakata, N. Suematsu and E. Katamoto: Bulletin of Meat and Meat Products, 2, 1 (1963).
3. H. Saikachi: Japanese Patents 306438 (1962).
4. K. Aiiso, N. Kanizawa, H. Yamaoka, K. Tatsumi and N. Aikawa: Shokuhin Eiseigaku Zasshi, 3, 365 (1962).
5. K. Aiiso, N. Kanizawa, T. Okamoto and N. Aikawa: Shokuhin Eiseigaku Zasshi, 5, 120 (1964).

6. I. Shibazaki, T. Kasahara and G. Terui: Hakko Kogaku Zasshi, 40, 36 (1962).
7. I. Shibazaki and G. Terui: Hakko Kogaku Zasshi, 41, 31 (1963).
8. S. Sasayama: Tokaiku Suisan Kenkyusho Kenkyu Hokoku, No. 36, 11 (1963).
9. A. Obatake and T. Matsuda: Nippon Suisan Gakukaishi, 31, 138 (1965).
10. N. Ando, Y. Nagata, Y. Hirakata, T. Ohashi, and Y. Kako: Nippon Chikusan Gakukaiho, 37, 82 (1966).
11. Y. Nagata and N. Ando: Shokuhin Eiseigaku Zasshi, 8, 532 (1967).
12. Presented to the 14th European Meating of Meat Research Workers, Brno (1968).