EFFECTS OF CURING AGENTS ON HEME PIGMENT CONTENT IN MEAT

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SUMMARY

The effects of curing agents on the content of heme pigments (HP) in meat were examined. Minced porcine skeletal muscle was treated with NaCl, $NaNO_2$ and sodium ascorbate (NaASC), separately or in combination, and stored at 2~3°C for 7 days. HP content decreased with increase in NaCl concentration and the decrease was 50% and 80% at NaCl concentrations of 2% and 10%, respectively. 2% NaCl prevented HP destruction, when previously mixed with 100 ppm $NaNo_2$ or 0.1% NaASC. Though some decrease in HP content was noted following application of a mixture of NaCl, $NaNO_2$ and NaASC, it was essentially the same as that of the control during 7 days of refrigerated storage. In a model solution containing the same curing agents as those applied to the meat, NaCl had no effect and myoglobin (Mb) content remained constant during storage. From the present results, endogenous muscle constitutes appear to act in concert with NaCl to bring about decrease in HP content.

INTRODUCTION

In a previous experiment, the extractability of introsomyoglobin (NOMb) from cured meat with water was investigated and NOMb formed in cured meat was found difficult to extract in spite of its high solubility in water (Nagata and Sakata, 1984; Sakata and Nagata, 1986). During the course of these experiments, minced porcine muscle following NaCl treatment appeared to undergo discoloration during storage, leading the authors to suspect a decrease in HP content in meat. The addition of NaCl has been reported to cause discoloration of meat during storage (Lamkey et al. 1986; Marriott et al. 1983). However, only little information is available on change in HP content in NaCl-treated meat. In the present study, an examination was made of the effects on HP content in meat of not only NaCl but also $NaNO_2$ and NaASC. The latter two are generally applied in combination with NaCl as curing agents.

EXPERIMENTAL METHODS

Normal porcine skeletal muscle (*M.longissimus thoracis*, 24 h postmortem) was minced twice through a perforated plate (hole diameter : 3.2 mm). pH of the meat was measured followed by treating it with either sodium chloride, sodium nitrite or sodium ascorbate or in combination to give levels of 2 or 10% NaCl, 100 ppm $NaNO_2$ and 0.1% NaASC. The minced muscle was then stored at 2 ~3°C for 7 days. HP content was then analysed by the 75% acetone - 0.7% HCl extraction method (Okayama and Nagata, 1979). Hunter a-values were determined by a colour difference meter (Nippon Denshoku Kogyo Co. Ltd., Model ND-1001 DP). Metmyoglobin (MetMb) content was determined from the K/S value of reflectance at 572 nm and 525 nm using a Beckman Model 25 spectrophotometer equipped with a reflectance accessory (Renerre and Labas, 1987).

A similar experiment was conducted using a model solution (medium: McIlvaine buffer, pH 5.5) containing the same curing agents as those applied to the meat, followed by storing the meat at 2 3°C for 7 days. The effects of the curing agents on Mb content were then investigated.

Myofibrils were prepared from minced porcine muscle by repeated washings with 0.85% NaCl solution (Nagata and Sakata, 1984). The crude myofibrils thus obtained were made up to the original weight of the muscle sample and adjusted to pH 5.5, followed by storing them in the presence of 0.1% Mb with and without 2% NaCl. After

Table 1. Effects of NaCl on Hunter a-values, MetMb and HP content in meat during storage

Meat sample	Hunter a-values 1 day[2]	Hunter a-values 7 days	MetMb% 7 days	HP content[1] 7 days
Control	21.7	10.7	43.6	67.7
2% NaCl	25.1	11.0	52.2	49.8
10% NaCl	18.2	5.0	68.2	19.2

[1] Relative content of HP in meat, calculated from initial content as 100;
[2] Period of storage at 2~3°C.

Table 2. pH_{24} values, HP content and extent of its decrease in meat during storage

Meat sample number	pH_{24}	Initial content of HP as Mb(%)	HP content decrease on storage day 7[1] Control	HP content decrease on storage day 7[1] +NaCl[2]
①	5.55	0.16	0.05 (31.2)[3]	0.08 (50.0)
②	5.54	0.10	0.04 (40.0)	0.08 (80.0)
③	5.57	0.11	0.04 (36.4)	0.07 (63.6)
④	5.75	0.14	0.02 (14.3)	0.08 (57.1)
⑤	5.57	0.11	0.02 (18.2)	0.08 (72.7)

[1] Expressed as Mb (%);
[2] 5% NaCl was added to sample ② and 2% NaCl to all other samples;
[3] Values in parenthesis determined from initial HP content as 100.

Table 3. Effect of NaCl on HP content in meat and on Mb added to myofibrils (MF)[1]

Porcine muscle Control	Porcine muscle +2%NaCl	MF+Mb[2] Control	MF+Mb[2] +2%NaCl	MF+Mb+NaASC[3] Control	MF+Mb+NaASC[3] +2%NaCl
95.0	63.2	52.6	23.5	95.7	95.8

[1] Relative content on day 7 of storage at 2~3°C, as determined from initial HP and Mb content as 100;
[2] 0.5mM equine Mb was added to MF at a rate of 10% by weight of MF;
[3] A solution containing 0.5 mM Mb and 50 mM NaASC was incubated anaerobically for 3 days and then added to MF at a rate of 10% by weight of MF.

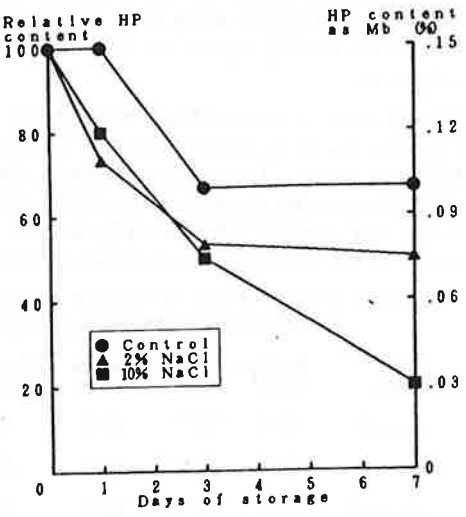

Fig. 1. Effects of NaCl on HP in meat during storage

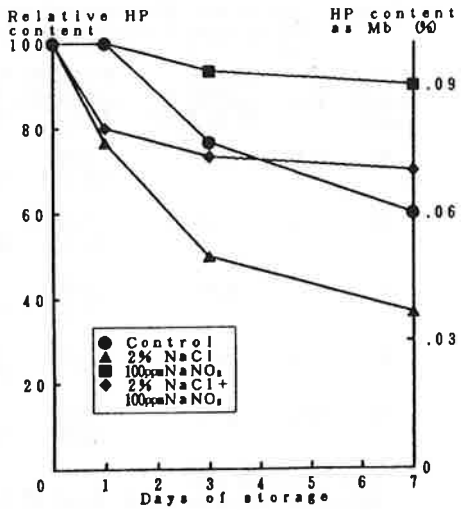

Fig. 2. Effects of NaCl and $NaNO_2$ on HP in meat during storage

storage for 7 days, HP content was analysed and compared with that of whole porcine muscle.

RESULTS AND DISCUSSIONS

Fig.1 shows the effects of NaCl on HP content in meat. Relative HP content was calculated from HP content at 0-day storage as 100, and HP content was expressed as Mb. HP content rapidly decreased with increase in NaCl concentration during the 7 days of refrigerated storage. At 2% and 10% NaCl, the decrease was 50% and 80%, respectively. The control sample also showed a 30% decrease in HP content during storage.

Hunter a-values significantly decreased and MetMb content increased in the meat sample treated with 10% NaCl (Table 1). The meat was visually noted to have a poor red colour.

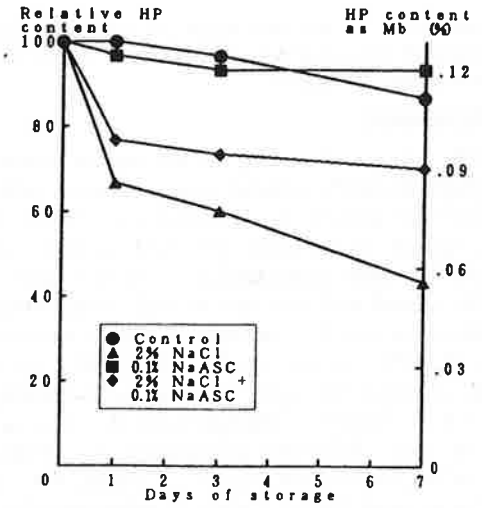

Fig. 3. Effects of NaCl and NaASC on HP in meat during storage

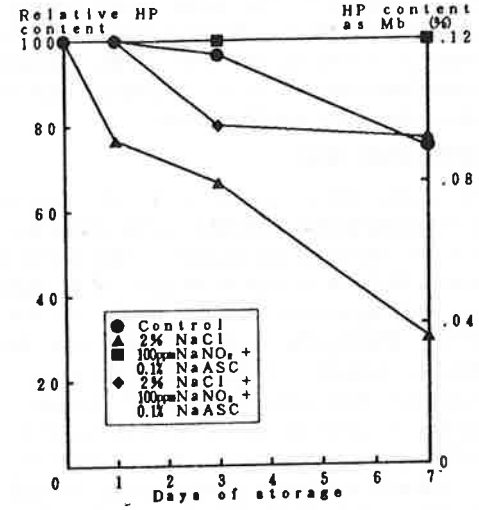

Fig. 4. Effects of NaCl, $NaNO_2$ and NaASC on HP in meat during storage

Since HP content was clearly observed to decrease with the addition of 2% NaCl, the same as that generally used in meat products, all subsequent experiments were conducted using NaCl at this concentration.

The effects of NaCl and $NaNO_2$ on HP content in meat are shown in Fig.2. This content significantly decreased in NaCl-added meat, and the addition of $NaNO_2$ alone was found to cause a small decrease during the 7-day storage period. With the addition of both NaCl and $NaNO_2$, HP content exceeded that of control sample after the 7 days, indicating nitrite to prevent HP destruction by NaCl.

Fig.3 shows changes in HP content on adding NaCl and NaASC as a combination, followed by storage. A significant decrease in HP was noted in meat to which only NaCl had been added, as evident from Figs. 1 and 2, while NaASC treatment alone caused no loss. HP content following application of this combination changed in the same manner as that noted for NaCl and $NaNO_2$ applied together. NaCl and NaASC virtually

prevented the effect of NaCl alone and HP content in the case of this combination exceeded that of NaCl alone but was less than that of the control.

The results obtained for the addition of NaCl, $NaNO_2$ and NaASC are shown in Fig.4. The initial HP content prior to storage was maintained in meat treated with $NaNO_2$ and NaASC. Though some decrease in HP content was noted following application of a mixture of all these agents, it was essentially the same as that of the control at the end of the 7-day storage, and the meat sample showed the characteristic red colour of cured meat.

The pH_{24} (pH of 24 h postmortem) values of porcine muscle, HP content and HP decrease observed in the present study are listed in Table 2. The addition of 2% NaCl apparently caused HP content to decrease in all cases, the extent of which showing considerable variation, with no definite indication of its being correlated to the initial pH value or HP level of the muscle examined.

In a similar experiment with a model solution containing Mb, NaCl had no effect and Mb content remained constant during storage (data not shown). Thus, from the findings presented above, an endogenous muscle constituent appears to act in concert with NaCl to affect decrease in HP content in meat.

Table 3 shows the effects of NaCl on HP content in porcine muscle and myofibrils treated with Mb derivatives on day 7 of storage at 2 3°C. When Mb (MetMb) was added to the myofibrils, its content decreased remarkably, especially in the presence of NaCl. A lesser decrease was noted in myofibrils mixed with Mb previously incubated with NaASC. The pigment added to myofibrils was spectrophotometrically confirmed to MbO_2. Whether prevention on the decrease in Mb content is due to the action of NaASC itself or the stability of MbO_2 formed is a point remaining to be clarified. NaCl has been shown to enhance the potential for Mb oxidation, and to promote lower oxygen tension in meat, leading to the oxidative discoloration of fresh meat (Hunt and Kropf, 1987). The decrease in Hp content due to NaCl may thus possibly be a phenomenon induced specifically by MetMb.

As an endogenous factor, myofibrils may be related in some way to the decrease in HP content, based on the present data. We have already reported a decline in the colour formation of pale, soft and exudative (PSE) porcine muscle to possibly result from interactions between HP and myofibrils in muscle postmortem at low pH and relatively high temperature (Sakata et al. 1981; 1983). The decrease noted in our previous study in extractability of native nitroso HP (NOHP) from cured meat with water was considered due to interactions between native NOHP and myofibrils in cured meat. The physicochemical characteristics of muscle proteins under PSE or cured meat conditions may not necessarily be directly related to the phenomena observed in NaCl-treated meat in this study. However, myofibrils may possibly react with HP under certain conditions, as reported by Bendall and Wisemer-Pedersen (1962) and Scopes (1964). Myofibrillar proteins affecting HP content and the degradation products of HP induced by NaCl treatment should be investigated.

CONCLUSIONS

NaCl itself causes decrease in HP content in meat, while $NaNO_2$ and NaASC are essential for its retention in cured meat. There appears to be the possibility that myofibrils act in concert with NaCl to bring about decrease in HP content.

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