Contents of Heme and Nonheme Iron in Pig Muscle and Effects of Heating and Chemical Treatment on These Contents.

ZHANG HEPING, NA ERSONG and AN YIN

Department of Food Engineering, Inner Mongolia Collage of Agriculture and Animal Husbandry

SUMMARY

In fresh pig longissimus dorsi (LD),contents of total iron, heme iron and nonheme iron were 11.59 μg / g, 8.34 μg / g and 3.25 μg / g, respectively. After cooking meat at 85℃ for 30, 60 and 120 min, the contents of nonheme iron increased by 7.69%, 22.46% and 52.62%, respectively. Treatment of pig LD samples with sodium nitrite and sodium chloride had no significant effect on the level of nonheme iron ($P > 0.05$). Oxidative cleavage of the porphyrin ring followed by release of the iron is probably the mechanism for the observed increase in nonheme iron during the heat treatment.

INTRODUCTION

Investigations on the absorption of dietary iron indicated the heme iron and nonheme iron were absorbed by different mechanisms. Bothwell et al (1979) suggested that heme iron was absorbed as the intact iron porphyrin complex and the iron was released inside the intestinal mucosal cell, and for the most part, absorption of heme iron was not affected by the composition of the diet and it was highly available. In comparison with the heme iron, the absorption of nonheme iron was greatly influenced by a variety of enhancing and inhibiting substances existed in foodstuffs (Hussain et al 1965) and often the availability of nonheme iron was poor. Therefore,information on the heme and nonheme iron contents of foods and influence of processing upon heme and nonheme iron levels in these food is nessary for making estimates of the total available iron in the diet.

Recently, schriker et-al (1982) gave the details about differentiating quantitatively between heme and nonheme iron in meat. Schricker et al (1983) showed that treatment of ground beef samples with heat, ascorbic acid or H_2O_2increased the level of nonheme iron. With regard to the effects of addition of sodium-nitrite-and-sodium chloride on the changes of nonheme iron content during meat heating, there are few informations, these two kinds of chemicals often be used as additives in meat products processing.

The objectives of this study is mainly to determine the heme and nonheme iron in pig LD and evaluate the influence of heating and chemical treatment on these contents.

MATERIALS and METHODS

Preparation of samples

1.0kg of fresh pig LD was purchased from local market, then ground and mixed and meat samples were taken from the LD mixture.

5.0g of meat samples were weighted accurately into 50ml centrifuge tubes.The entire procedure of the heating and chemical treatment and nonheme iron determination was conducted in the same centrifuge tube. Through experiment 1 to 3, samples in each treatment were triplicate.

Experiment 1

The effect of heating on nonheme iron content of pig LD was determined. Samples with adding 5ml deionized water were heated in water bath at 85℃ for 30,60 and 120 min, respectively. Aften cooking, the water was evaporated fully. Subsequently, the effect of exposure to heat for various time periods on nonheme iron levels in meat was evaluated.

Experiment 2

The effect of addition of sodium nitrite during heating on the nonheme iron content of LD was determined, adding of sodium nitrite with 5ml deionized water to each meat samples thereby the concentration of

50ppm,100ppm and 200ppm of sodium nitrite were acheived respectively. All samples were heated in water bath at 85℃ for 60-min.

Experiment 3

The influence of sodium chloride treatment on the level of nonheme iron in meat was measured. Appropriate amount of sodium chloride and 5ml deionized water were added to each sample to reach following concentrations : 0.5%, 1.0% and 2.0%.After adding of sodium chloride, all samples were placed in water bath and cooked at 85℃ for 60 min.

The method provided by Schricker et al (1982) was used to determine nonheme iron concentration (DU-7 Spectrophotometer, Beckman). The contents of total iron in meat were determined on wet ashed samples using atomic absorption spectrophotometry (HITACHI.Polarized Zeeman Atomic Absorption Spectrophotometer, model 2-8000, Hitachi, Ltd.).The heme iron can be calculated as difference between total iron and nonheme iron. The results of all various kinds of iron were expressed as μg per g of raw meat. The date were evaluated statistically by T test.

RESULTS and DISSCUSSIONS

The content of total iron in fresh pig LD is 11.59 μg / g, in which ,heme and nonheme iron account for 71.96% and 28.04%, respectively. Study of Schricker et al (1982) showed that contents of total, nonheme and heme iron in muscles from different species were significantly different ($P < 0.01$), and within a species, some differences between muscles were also different. The reason for different iron concentrations between different muscles of the same animal were not clear. A possible explantion has been given by Hunt and Hedrick (1977). They suggested these difference may relate to inherent differences in residual blood between white and red muscles in normal postmortem muscles.

Compared with unheated control, heating of samples at 85℃ increased the level of nonheme iron in meat (see table 1)and with the heating time of meat continuing,the content of nonheme iron in meat increased linearly.Schricker et al(1982) working with ground beef found that heat treatment in a boiling water bath increased nonheme iron concentration and a linear relationship between the nonheme iron level in meat and the time of exposure to the heat treatment was observed by Schricker et al(1983).Schricker et al(1982)suggested that these increases in nonheme iron may be due to the release of iron from the heme iron complex by oxidative cleavage of porphyrin ring .Convension of heme to nonhene iron caused by heat or other processing could reduce the availabilityof meat iron.

In experiment 2,increase of nonheme iron in the meat during heating after adding of sodium nitrite is less compared with unadded control,see table 2.It appears that adding of sodium nitrite can protest against the release of iron from heme complex induced by heating,but the effect was not significant ($P > 0.05$).This result is similar to that observed by Schricker et al (1983).Reaction of heme with nitrite does not alter its behavior in the nonheme iron assay (Schricker et al 1983).

Adding of sodium chloride during meat samples heat treatment nearly has no effect on the heat-induced change of nonheme iron concentration (table 3).In comparation with unadded control,the difference is not significant ($P > 0.05$).This result indicated that during the meat heating,the sodium chloride is not responsible for iron release fron heme complex.The convension of heme to nonheme iron is uneffected by sodium chloride.

Table 1–effect of heat treatment at 85℃ on the contents of heme and nonheme iron in pig LD.

Heat treatment	nonheme iron μg / g raw wt	heme iron μg / g raw wt
raw	3.25± 0.44a	8.34± 0.44
heated 30 min	3.50± 0.24a	8.09± 0.24
heated 60 min	3.98± 0.24b	7.61± 0.24
heated 120 min	4.96± 0.22c	6.63± 0.22

Values represent means ± S.D

Values followed by different letters are singificantly different ($P < 0.05$)

Table 2–Effect of adding of sodium nitrite during samples heating on the content of nonheme iron in meat (samples were heated at 85℃ for 60 min).

concentrations of sodium nitrite	nonheme iron μg / g raw wt	heme iron μg / g raw wt
0 ppm	3.98± 0.24	7.61± 0.24
50 ppm	3.82± 0.16	7.77± 0.16
100 ppm	3.66± 0.21	7.93± 0.21
200ppm	3.49± 0.48	8.10± 0.48

values represent means± S.D

Table 3–Effect of addition of sodium chloride during heat treatment of samples on nonheme iron level in meat (samples were heated at 85℃ for 60 min).

Concentration of sodium chloride	nonheme iron μg / g raw wt	heme iron μg / g raw wt
0	3.98± 0.24	7.61± 0.24
0.5%	3.98± 0.36	7.61± 0.36
1.0%	3.82± 0.24	7.77± 0.24
2.0%	4.04± 0.46	7.52± 0.46

Values represent means ± S.D

CONCLUSIONS

Heat treatment of meat can increase the level of nonheme iron in meat ,and at same temperature,this action had linear relationship with heating time.The heat–induced increase of nonheme iron is possibly due to the oxidative cleavage of the porphyrin ring thereby allowing release of iron from heme complex.In addition ,adding of soduim nitrite and sodium chloride during meat heating has no remarkable influence on the content of nonheme iron.For estimating the potential bioavailability of meat iron ,further detailted information about the contents of total ,heme and nonheme iron in different species muscles and different muscles fron same animal and effect of all variety of cooking methods or other processing on conversion of heme to nonheme iron is needed.

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