WHITE CRYSTALS FOUND IN THE MUSCLE OF JINHUA HAM

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***Abstract*—White crystals are common defects found on the cut surface of dry-cured ham muscle. In order to explore the mechanism of white crystal formation, the contents of the conventional components such as crude protein, crude fat and ash, and calcium, phosphorus and free amino acid of the white crystals were analyzed. The results showed that the contents of crude protein, crude fat and ash of white crystals were lower than those of ham muscle and most of the crude protein components in white crystals were composed of free amino acids in which tyrosine accounted for more than 80 percent. The results indicate that tyrosine crystallization is the main cause of white crystal formation.**

***Index Terms*—Dry-cured ham, Jinhua ham, Tyrosine, White crystal**

I. INTRODUCTION

White crystals in muscle or white film on cut surface are common defects found in dry-cured hams. It has been reported that the major components of the white crystals found in ham muscle or white film formed on cut surface are tyrosine (Butz, Blumer, Christian, & Swaisgood, 1974; Comi, Cantoni, Saronni, & Denozza, 1981; Silla, Innerarity, & Flores, 1985; Arnau, Hugas, Garcia-Regueiro, & Monfort, 1987; Toldra, Flores, & Voyle, 1990; Arnau, Guerrero, & Gou, 1994; Arnau, Guerrero, Hortos, & Antonio, 1996), followed by phenylalanine (Arnau, Hugas, Garcia-Regueiro, & Monfort, 1987; Arnau, Guerrero, Hortos, & Antonio, 1996). Dry-cured hams produced using frozen green hams incline to the defects (Arnau, Guerrero, & Gou, 1994). Also other study showed that the white spots found in ham muscle were formed by the deposits of myogen and fibrillin (Cantoni, Cattaneo, & Brenna, 1987). Jinhua ham is the most famous dry-cured ham produced in China. In traditional processing of Jinhua ham using fresh green hams, very few products are found white crystals in muscle. Recently, more and more Jinhua hams are produced using frozen green hams for the convenience of large scale production and safety control, while more and more consumers complain of white spots found in ham muscle and worry about their possible harms to human health. However, no report could be found to explain the composition of white crystals formed in the muscle of Jinhua ham. The purpose of this study is to make clear the components of the white crystals found in the muscle of Jinhua ham and their possible formation mechanism.

II. MATERIALS AND METHODS

Cut the sample Jinhua ham muscle to pieces, check the shape and texture of the white crystals or “white spots” on the cut surfaces, separate the white crystals or “white spots” manually with pins from muscle fibres and collect them in a glass bottle. The solubility of the crystals was tested by ethanol, acetone and 0.1M sodium phosphate solution (pH 7.0). Crude protein, crude fat, moisture, ash, chloride sodium, calcium and phosphorus contents in the white crystals or “white spots” as well as in the sample ham muscle were determined according to ISO 937-1978(E), ISO 1443-1973, ISO 1442:1997, ISO 1841-1:1996, GB/T 9695.18-88, GB/T 12398-1990 and ISO 2294-1974, respectively. Free amino acid analysis was also performed for both white crystals or “white spots” and sample ham muscle according to Zhao et al (2005a). For free amino acid analysis, white crystals or “white spots” were solved in 0.1M sodium phosphate buffer (pH 7.00) under stirring. Data were assessed by analysis of variance using one-way ANOVA procedure of SPSS 10.0 (SPSS Inc.).

III. RESULTS AND DISCUSSION

The crystals separated from ham muscle showed different size, shape and texture. The larger ones like irregular white sand grains about 1mm in diameter and the smaller ones are very tiny and yellowish. Some are hard and some soft. They can not be solved in ethanol or acetone, but can be solved in 0.1M sodium phosphate solution (pH 7.0) slowly. Components analysis showed that crude protein, crude fat and ash contents of the crystals were significantly lower than those of ham muscle (P<0.01) (see table 1). The white crystals contained a litter lower phosphors and higher calcium than ham muscle did. Calcium and phosphors accounted less than 1% of the white crystal composition. They should not be the major components of the white crystals.

Table 1 The general components of white crystals and ham muscle

	Protein (%)	Fat (%)	Ash (%)	Phosphors (%)	Calcium (mg/100g)
White crystal	33.15 ± 0.48^{B}	8.27 ± 0.15^{B}	11.43 ± 0.38^{B}	0.031±0.004	5.698 ± 0.080^{b}
Ham muscle	44.36 ± 0.42^{A}	11.88 ± 0.05^{A}	13.37 ± 0.12^{A}	0.029±0.003	7.592 ± 0.066^{a}

Note:

a. Data are present in means ± standard error.

b. Data in the same row without common superscript differ significantly, capital letters for P<0.01 and small letters for P<0.05.

That the total dry matter in ham muscle is higher than our previous report (Zhao, et al, 2005b) might be the result of moisture loss during separation of the white crystals in open air. Naturally, the white crystals should contain relatively litter moisture compared to the ham muscle. However, Wang et al (2007) also reported that the contents of protein, fat and ash in white crystals separated from Xuanwei ham were also lower than those of ham muscle, but they didn't give any explanation. We deduced that some combustible organic substances not included in protein or fat might be combusted during ash determination. However, our further analysis did not confirm the deduction. None organic substance not included in protein or fat found in white crystals was rich enough to be able to explain the results in table 1. The problem may most possibly be out of the coefficient used in crude protein calculation. If the amino acid composition in crystals differs obviously from that in muscle, the coefficient 6.25 used in protein content calculation may give a wrong result.

The contents of free amino acids in the white crystals and ham muscle were shown in table 2. The composition of free amino acids in the white crystals was quite different from that in ham muscle. Most of the free amino acids in the white crystals were higher than those in ham muscle (P<0.05), except methionine, cystine and phenylalanine that were higher in ham muscle (P<0.05). Tyrosine was the major component in the white crystals accounting about 81% of the total free amino acids, which accorded with the previous reports about the composition of white crystals found in dry-cured ham (Butz, Blumer, Christian, & Swaisgood, 1974; Comi, Cantoni, Saronni, & Denozza, 1981; Silla, Innerarity, & Flores, 1985; Arnau, Hugas, Garcia-Regueiro, & Monfort, 1987; Toldra, Flores, & Voyle, 1990; Arnau, Guerrero, & Gou, 1994; Arnau, Guerrero, Hortos, & Antonio, 1996). From table 1 and table 2 it could be found that the content of the total free amino acids in the white crystals was close to its crude protein content, which indicated that most of the nitrogen-compounds in the white crystals were free amino acids.

Table 2 Contents of free amino acids in ham muscle and white crystals

Amino acid	Ham muscle	White crystal
Asp (%)	0.06±0.03	$0.18\pm0.01^{**}$
Glu (%)	0.23±0.08	$0.95\pm0.27^{*}$
Ser (%)	0.19±0.03	0.20±0.02
Arg (%)	0.19±0.03	$0.39\pm0.01^{**}$
Gly (%)	0.18±0.03	0.20±0.01
Thr (%)	0.18±0.05	$0.26\pm0.01^{*}$
Pro (%)	0.12±0.04	$0.24\pm0.02^{*}$
Ala (%)	0.45±0.05	0.43±0.01
Val (%)	0.14±0.02	$0.28\pm0.01^{**}$
Met (%)	$0.11\pm0.01^{**}$	0.00±0.00
Cys-Cys(%)	$0.02\pm0.02^{**}$	0.00±0.00
Ile (%)	0.15±0.02	$0.28\pm0.01^{**}$
Leu (%)	0.35±0.03	$0.41\pm0.01^{*}$
Phe (%)	$2.98\pm0.39^{*}$	1.50±0.12
His (%)	0.00±0.00	0.78±0.07
Lys (%)	0.25±0.06	$0.59\pm0.01^{**}$
Tyr (%)	0.15±0.04	$28.26\pm1.90^{**}$
Total (%)	5.77±0.20	$34.93\pm2.14^{**}$
Tyr/Total (%)	2.64±0.57	$80.89\pm0.64^{**}$

Note:

a. Data are present in means ± standard error.

b. Data in the same row without common superscript differ significantly, capital letters for P<0.01 and small letters for P<0.05.

Tyrosine contains one nitrogen atom and the coefficient is 13.01 in calculating crude protein content according ISO 937-1978(E). This indicated that the crude protein of the white crystals in table 1 was mush underestimated, which well explained the abnormal results of table 1 showing lower total dry matter in the white crystals than that in ham muscle.

Table 2 showed that the white crystals contained 112 times of tyrosine as ham muscle did. It is still not clear why the crystals are able to pool so much tyrosine in ham muscle that contains very limit tyrosine. We know that the famous traditional Chinese sufu (soy cheese) also has similar white crystals in it and its major component is also tyrosine. It seems that tyrosine is inclined to collect and form crystal. Rlated documents show that dry-cured hams experiencing intense proteolytic process tend to form white crystal in the muscle tissues.

IV. CONCLUSION

The white crystals formed in Jinhua ham was polymorphous and differed in color, texture and solubility, but their major components were crude protein, fat and minerals. The crude protein was the major component and it mostly composed of free amino acids in which tyrosine accounted more than 80%.

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