EFFECT OF DIFFERENT STORAGE TEMPERATURES (INCLUDE CONTROL FREEZING POINT AND PARTIALLY FREEZING STORAGE) ON FLAVOR AND ATP-RELATED COMPOUNDS OF PORK LOIN CHOPS

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Summary

This study was designed to determine the changes of ATP-related compounds, especially the concentration of IMP, and compares the relationship between IMP and flavor of pork loin chops during storage as three different storage temperatures (include 4℃, CF and PF). Pork loin chops were kept under 4℃, -1.5 ± 0.5℃ (control freezing storage) and -3 ± 0.5℃ (partially freezing storage). The changes of TBA values, ATP-related compounds, pH value and sensory score of the pork loin chops were measured. The results were as follows: TBA values, in CF stored samples were higher than PF stored samples, but it had lower TBA values than 4℃ storage. The IMP concentration reached their peak after 2 days in 4℃, 5 days in CF and 7 days in PF storage, and the ATP, ADP, AMP contents of the loin chops showed minimum, respectively. Flavor of meat sensory score for 4℃ stored samples were more intense ($p < 0.05$) than CF and PF samples on day 2 of storage. However, after storage for 5 days, flavor scores for CF samples were more intense ($p < 0.05$) than 4℃ and PF samples. Flavor scores for PF samples were more intense ($p < 0.05$) than 4℃ and CF on day 7 of storage. As the meat with the peak of IMP contents was most preferred, it was considered that the content of IMP was related to the flavor of meat and that CF, PF had influence on the IMP content.

(**Key Words**: IMP, Flavor, Pork, ATP Related Compound, Temperature)

Introduction

The acceptability of fresh meat for consumption is usually assessed organoleptically and/or by the measurement of freshness. Saito et al. (1959) introduced the term "K value" as an indicator of the freshness of fish meat. The K value is ratio of inosine (HxR) + hypoxanthine (Hx) to the total amount of ATP-related compounds, expressed as a percentage. It has been suggested that the break down products of ATP contribute to the taste and aroma of ripened meat. Kazeniac (1961) observed that IMP, make a major contribution to mouth satisfaction, intensifying the flavor effects of other compounds, and that inosine and hypoxanthine are bitter. Jones (1961) also suggested that much of the loss of the sweet, meaty flavor during the early chill storage of cod muscle results from the loss of IMP, glucose, and the hexosephosphates, and that the degradation of IMP to hypoxanthine results in progressive development of bitterness. It was been suggested that IMP and its degradation products were important components of the flavor-precursor complex of beef, as well as for pork and chicken muscle. (Doty et al., 1961; Dannert and Pearson, 1967). Terasaki et al. (1965) reported that the more IMP the meats of pigs and chicken contain, the better they taste.

New practical methods for preserving freshness of meat and fish, controlled freezing point (CF, $-2 \sim 0$℃) and partially freezing storage (PF, $-2 \sim -8$℃) have been reported. It has been found that use of CF and PF are effective methods of improving the preserving quality of meat. (Yamane, 1982; Uchiyama and Iida, 1987; Uchiyama et al., 1988; Lin, 1991). Since it appears that IMP may play an important role in meat flavor, the present study was designed to determine the change of ATP-related compounds, especially the concentration of IMP, and compares the relationship between IMP and flavor of pork

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loin chops during storage at three different temperatures (4℃, CF and PF).

Materials and Methods

Sample preparation

Samples of fifteen market weight (about 100 kg) crossbred barrows loin (postmortem 3 hr) were purchased from a local meat market. The loin sections were sliced into 0.5 cm thickness, and the samples were held separately in a plastic foam trays and overwrapped with a polyvinylchloride firm (thickness 1.5 μm, H_2O transmission rate 1.98 × $10^9/m^2$/24 hrs, O_2 transmission rate 2.75 × 10 c.c/m^2/hr atn 23℃, Nan Ya Co.)

Loin sections were allocated to each of ten storage intervals (0, 2, 4, 5, 6, 7, 10, 14, 21 days) and storage at 4℃ (SANYO Co. 4 ± 2℃), controlled freezing point [−1.5 ± 0.5℃, SANYO INCUBACTOR (−10∼+50℃)] and partial freezing storage [−3 ± 0.5℃, SANYO INCUBACTOR (−10∼+50℃)].

Measurement of pH value:

The pH was measured after homogenization of 5 g of muscle in 20 ml of distilled water by means of a electric pH meter with glass electrode (Micro-computer; model 6200, Jenco Elect. LTD).

Extraction and determination of ATP-related compounds:

Five gram of meat sample were extracted with 10% $HCLO_4$ according to the method described by Kita et al. (1983). The $HCLO_4$ extract was adjusted to pH 6.4 with 5N KOH, and filtered through a membrance filters (pore size 1.0 μm).

Procedures of high performance liquid chromatography (HPLC) analysis of ATP, ADP, AMP, IMP, inosine and hypoxanthine (ATP-related compounds) were as described by HITACHI Technical data LC-6. The HPLC analysis was performed on model L-6200. Intelligent pump equipped with a model L-400 UV detector for monitoring 260 μm and model D-2500 chromato-integrator (HITACHI Co. JAPAN), A HITACHI 3013-N (4 × 150 mm) column from HITACHI Co. (JAPAN) was used. All samples were analyzed in duplicate. Analysis were repeated when duplicate samples varied more than about 10%. The ATP-related compounds standards [(20 μl was injected (figure 1)] were obtained from Sigma chemical Co.

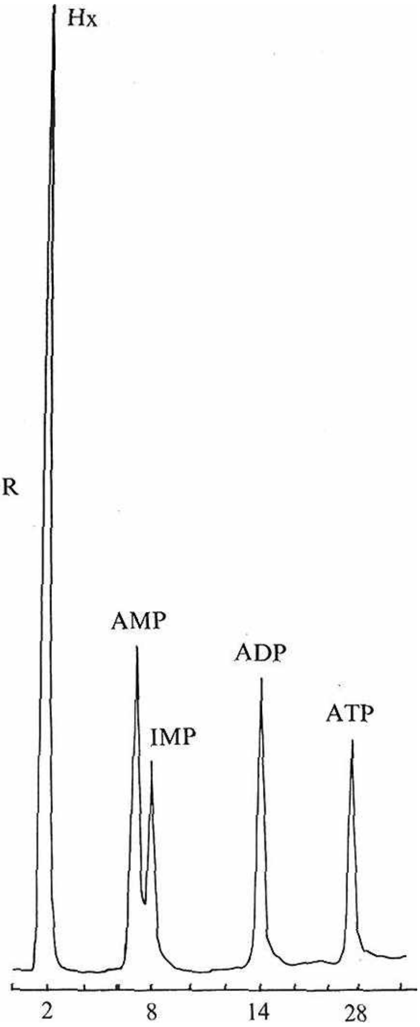

Figure 1. Typical HPLC of ATP-related substance standards.

ATP: adenosine triphosphate.
ADP: adenosine diphosphate.
AMP: adenosine monophosphate.
IMP: inosinic acid.
HxR: inosine.
Hx: hyphoxanthine.
Column type: HITACHI 3013-N.
Column size: 4 mm × 150 mm.
Column temperature: 70℃
Detector: UV monitor (260 nm)
Mobile phase:
A: 6% (v/v) CH_3CN in 0.06 M NH_4Cl, 0.01M KH_2PO_4 0.01 M K_2HPO_4
B: 6% (v/v) CH_3CN in 0.3 M NH_4Cl, 0.05 M KH_2PO_4 0.05 M K_2HPO_4

Measurement of 2-Thiobarbituric value:

2-Thiobarbituric acid measurement (TBA). Oxidative changes in the different storage methods were analyzed using the TBA test (Tarladgis et al., 1960). It were determined to measure ten amount of malonaldehyde.

Sensory Evaluation:

The experiment was made to find out the effect of IMP content on the flavor after different storage temperature treatments (include 4℃, CF and PF) on pork loin chops. A taste panel of 10 selected individuals using a pair test for preferences (Bernal et al., 1988) was carried out to compare the following samples.

Sensory evaluations in different storage methods were monitored using a five point scale.

Sample A: the meat having maximum IMP content, namely stored for 2 days at 4℃ storaged.

Sample B: the meat having maximum IMP content, namely stored for 5 days at CF storaged.

Sample C: the meat having maximum IMP content, namely stored for 7 days at PF storaged.

The sample were hold for 1 hr at 4℃ and boiling in water bath (90℃, 15 min) with plastic bag, and cooled to room temperature (25℃).

Statistical analysis:

Data were analysed by Statistical Analysis System (SAS) and Duncan's New Multiple Range Test (Duncan, 1955).

Results and Discussion

TBA values of loin sections exposed to different storage methods showed significant difference (figure 2). Concentrations of TBA values increase during storage. However, CF storage had TBA values higher than PF storage, but had lower TBA values than the 4℃ storage. No significant ($p > 0.05$) differences were found in CF and PF storage. It is important to note that TBA values were generally very low in CF and PF storage. It is common practice to consider a TBA value of 1.0 to be near the threshold where rancidity can be sensorally detected (Mattison et al., 1986). Loin chops in CF and PF storage were well below that level. However, at day 21, the 4℃ storage sample contained 1.15 mg malonaldehyde per 1,000 g muscle, above the level where rancidity can be sensorally detected.

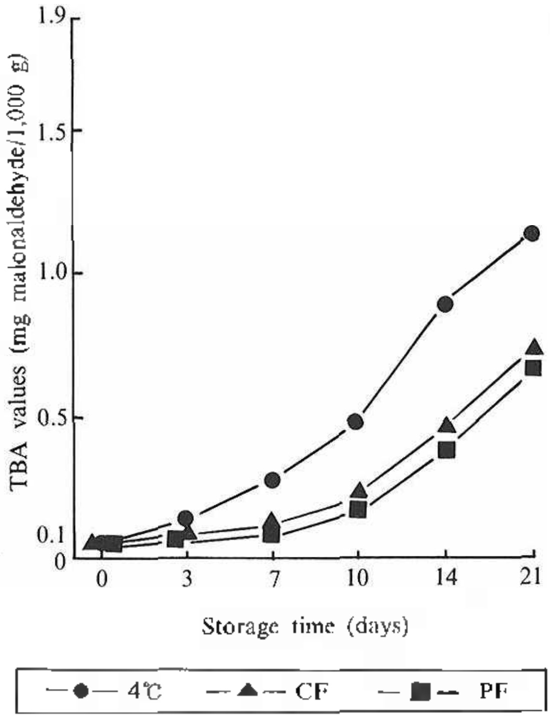

Figure 2. Changes of TBA values in pork loin chops with different storage temperature (4℃, CF and PF) during storage time.

The changes in the ATP-related compounds during storaged at 4℃ of pork loin chops is shown in figure 3. The contents of IMP reached the peak after 2 days, when the ATP, ADP and AMP contents of the loin chops reached it minimum, at 4℃ storaged. It was considered that maximum content of IMP was directly related to the disappearance of ATP, ADP and AMP in rigor mortis.

The changes of the ATP-related compounds during storaged at CF of pork loin chops is shown in figure 4. The IMP concentration reached its peak after 5 days, and the ATP, ADP and AMP contents of the loin chops showed minimum at this time.

The changes of the ATP-related compounds during storaged at PF of pork loin chops is shown in figure 5. The IMP concentration reached the peak after 7 days, and the ATP, ADP and AMP contents of the loin chops showed its minimum at this time.

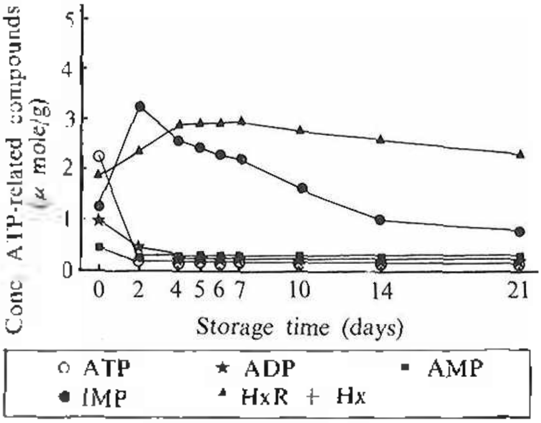

Figure 3. Changes in the concentration of ATP-related compounds during 4℃ storage.

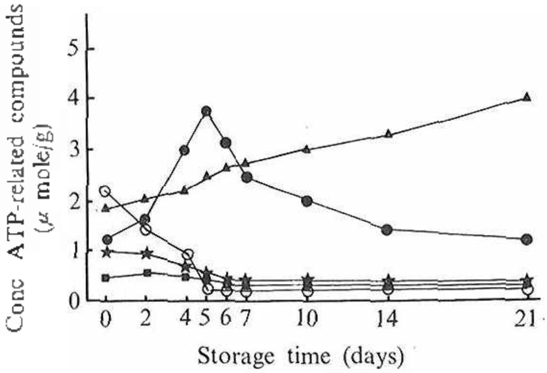

Figure 4. Changes in the concentration of ATP-related compounds during CF storage. Symbols are used the same as those in figure 3.

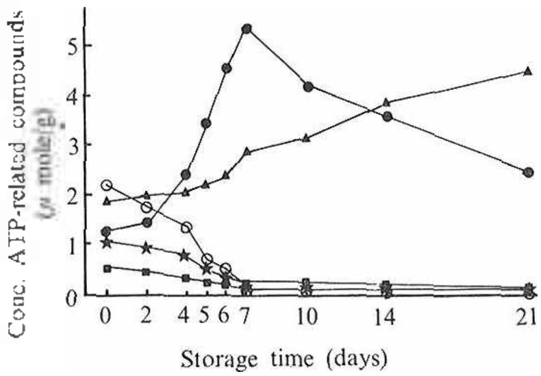

Figure 5. Changes in the concentration of ATP related compounds during PF storage. Symbols are used the same as those in figure 3.

Peak IMP concertration revealed after 2 days in 4℃ storage, was 3.3 μmoles/g muscle, and in CF storage was 3.8 μmoles/g muscle, and in PF storage was 5.4 μmoles/g muscle, respectively.

ATP content in CF and PF storage was generally low in comparison with that of 4℃ storage, and on further storage IMP decomposed slowly and after 21 days it remained 33% of maximum content in CF and 45% PF. On the other hand, ATP content in 4℃ stored samples fell quickly in comparison with that of CF and PF storage, and on further storage IMP decomposed quickly and after 21 days it remained 28 % of maximum content.

Comparing figure 3, 4 and 5, it concluded that storage at higher temperature (4℃) shortens the period required for IMP to reach its maximum. In pH values, it was found that the 4℃ stored samples was increased faster than that of the CF and PF samples (figure 6). It was considered that higher temperature had influence on the activity of creatine phosphokinase, ATPase, myokinase and 5'-AMP deaminase an that this phenomena related closely to the formation of

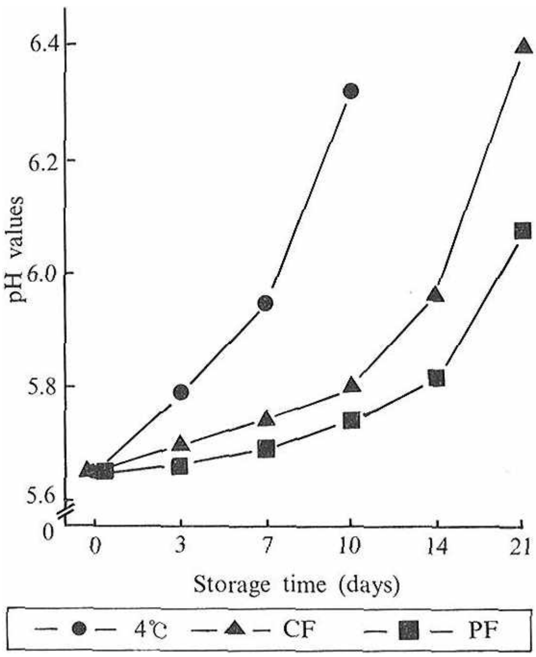

Figure 6. Changes of pH values in pork loin chops with different storage temperature (4℃, CF and PF) during storage times.

IMP. The mechanism of meat flavor during storage time is still poorly understood, but it is generally agreed the temperature has a great effect of muscle properties and final meat flavor.

Sensory score were consistently altered by different storage temperatures (table 1). Flavor of meat score for samples held at 4℃ were more intense ($p < 0.05$) than CF and PF stored samples on day 2 of storage. However, after storage for 5 days, flavor of meat score for CF sampes were more intense ($p < 0.05$) than 4℃ and PF samples. Flavor of score for PF samples were more intense ($p < 0.05$) than 4℃ and CF samples on day 7 of storage.

TABLE 1. SENSORY SCORE OF STORED PORK LOIN DURING DIFFERENT STORAGE TEMPERATURES

Storage temperatures	Time (days) 2	5	7	Difference
4℃	4.1^a	3.3^a	2.7^a	*
CF	3.1^b	4.5^b	3.5^b	*
PF	3.0^b	4.3^b	4.9^c	*

a,b,c Means of the same column without the same superscript are significantly difference ($p < 0.05$)

* Means among treatments of storage time are significantly difference ($p < 0.05$).

A descripative sensory panel using 5 points attribute scale;

1: very poor, 2: poor, 3: common, 4: good, 5: very good.

As the meat with the peak of IMP contents was most perferred, it was considered that the content of IMP was related to the flavor of meat and CF, PF had influence on the activity of IMP contents. This results suggest that the IMP content of meat is variable being dependent upon the storage temperatures and the length of storage.

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