DEGRADATION OF ADENOSINE TRIPHOSPHATE OF SHEEP MUSCLE MEAT DURING HYDROSTATIC HIGH-PRESSURE TREATMENT

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Introduction

Hydrostatic high-pressure (HHP) treatments of foods were studied a century ago by Hite. Giddings and Weakley (1914). The results of those studies showed that high pressure caused coagulation of albumen. It is applied via a pressure-transferring medium is effective at ambient temperature which would reduce the amount of thermal energy needed for conventional food processing. The main effects of HHP include: (a) Modification of biopolymers characterized by protein denature, enzyme activation or inactivation，gel formation influence on degradation. (b) inactivation of microorganism and (c) quality retention (especially flavor and color). Subjecting fresh muscle tissues to pressure induces conformation changes and structural degradation leading to tenderization (Iwasaki & Yamamoto, 2002).

The degradation rate of ATP after slaughter have a strong influence on the muscle structure, water holding capacity, and the flavor of meat，especially，for the ruminant such as cattle and sheep . In the conventional slaughtering and fabricating process, the degradation of ATP in the muscle lasts for three to ten days before it reaches a level of being undetectable. However, there is a lack of research on the effect of HHP on degradation of ATP in muscle of sheep. The objective of this study was to investigate the effects of HHP treatment on the degradation of ATP in sheep muscle and on the constituents of meat flavor formation.

Materials and methods

Raw meat was obtained from thigh cuts (4 kg) of four carcasses of one- year old Mongolian sheep carcasses. *Semimenbranosus* (SM) and *Semitendinous* (ST) muscles were dissected from thighs and visible fat was removed. Each sample contained a mixture of SM and ST muscle and weighed 80 grams. The samples were packaged in bags made from PE/Nylon film and sealed with a heat sealer, then stored at a temperature between 0°C and 4°C.

The test samples were subjected to hydrostatic high pressure treatment at 100MPa-700MPa for five and twenty minutes at room temperature. After treatment the muscle samples were stored at a temperature of －80°C for future analysis. The treated samples were then divided into two groups for HPLC measurement. The first group was measured one day after the high pressure treatment and the second was measured 105 days later.

The levels of ATP and it's degradation products were measured by HPLC .Standards of ATP, ADP, AMP, IMP, GMP, INO, and HYP were purchased from Sigma company.

The high-pressure mashine set including high pressure vessel and high pressure generator with capacity of producing pressure value of 100MPa to700MPa were prepared locally.

Collected data was analyzed with Analysis of Variance (ANOVA) procedure in SAS (Version 6.12，1997). The significance between means was determined by Duncan's Multiple Range Test.

Results and discussion

Findings of this study are listed in Table ,2,and 3. Table 1 shows test codes for each treated sample. As the applied pressure increased the levels of ATP of treated meat samples decreased and the levels of AMP，IMP，and GMP of muscle samples increased. As the pressure increased from 100 to 300MPa the ATP level of the treated muscle samples dropped from 9.55mg/100g to 0.00mg/100g within 5min holding time and the AMP，GMP，and IMP level increased to14.49mg/100g，1.79 mg/100g, and 167.23 mg/100g respectively (Table 2). As the pressure value increased to 500MPa for 5min of holding time the maximum values of IMP and GMP degraded from ATP were 188.47mg/100g and 2.04mg/100g (Table 2) which were statistically significant ($P<0.05$) comparing with control group. With the pressure value increased upto 300Mpa for 20min holding time the maximum values of IMP and GMP degraded from ATP were 203.1mg/100g and 2.14mg/100g which were also statistically significant ($P<0.05$) comparing with control group (Table 3). All these indicate that high pressure and holding time had an effect on degradation of ATP. Low pressure combined with a long holding time had the same effect on the degradation of ATP as high pressure combined with a short holding time. The results of this research on degradation of ATP by high pressure treatment indicated that some enzymes catalyse degradation process were activated by high pressure treatment. As degraded products of ATP, those IMP and GMP are commonly recognized meat flavor substances (Pearson. Wolzak & Gray 1983). It was evidenced by this research study that

high pressure facilitated the conversion of muscle to meat within such a short time as five to twenty minutes. .

Table 1. The test codes for each treated sample

Pressure (MPa)	Holding time (minutes)	
	Five	Twenty
0	ck	ck
100	p_1t_1	p_1t_2
300	P_2t_1	P_2t_2
500	P_3t_1	P_3t_2
700	P_4t_1	P_4t_2

Table 2. Degraded products levels under different pressure for 5min (t_1) of holding time Unit: mg / 100 g

Treatment Code	ATP	ADP	AMP	GMP	IMP
ck	9.54	7.23	5.62	0.86	86.09
p_1t_1	9.55	6.68	4.94	1.31	113.87
p_2t_1	0.00	0.56	14.49	1.79	167.23
p_3t_1	0.00	1.13	17.69	2.04	188.47
p_4t_1	0.00	0.00	19.48	2.02	174.60
C.V.%	2.00	1.48	0.46	0.19	0.20
T-Test statistics	–2.99	-3.32^{a}	2.63	5.51^{b}	4.59^{c}

$^{a-c}$ Means with different superscript letters differ significantly *(P<0.05*)

Table 3. Degraded products levels under different pressure for 20min (t_2) of holding time Unit: mg / 100 g

Treatment Code	ATP	ADP	AMP	GMP	IMP
ck	9.54	7.23	5.62	0.86	86.09
p_1t_2	9.76	4.38	4.74	1.26	102.31
p_2t_2	0.00	0.60	17.13	2.14	203.17
p_3t_2	0.00	0.09	18.53	1.81	149.97
p_4t_2	0.00	4.73	15.03	1.52	153.73
. C.V.%	2.00	1.00	0.45	0.24	0.27
T-Test statistics	-4.87^{a}	-3.92^{b}	2.64	4.06^{c}	3.21^{d}

$^{a-d}$ Means with different superscript letters differ significantly (*P<0.05*)\

After the high pressure treatment at 100MPa ATP levels of treated groups (p_1t_1，p_1t_2) were slightly higher than those of control group. This could be due to the fact that supply of ATP inside muscle was kept at a high level by regeneration via creatine phosphate and by glycolysis during the early stage of postmortem metabolism. However， under normal conditions it takes 16 to 48 hours to reach this level (Bodwell et al. 1965) which undoubtedly prolongs the production cycle.

Conclusions

Hydrostatic high-pressure treatment had a significant effect on accelerating the degradation of adenosine triphosphate of the muscle samples of sheep and facilitating conversion procedure of muscle to meat .As the pressure increased from 100MPa to 700MPa. both levels of ATP and ADP in the muscle samples were reduced significantly (P<0.05) and IMP and GMP, as a degrated products of ATP ,increased significantly (P<0.05) with increasing pressure and holding time.

References

[1] Asaka , M. , Aoyama , Y. Ritsuko , and Hayashi , R. (1994). Purification of a latent Form of Polyphenoloxidasefrom La France Pear fruit and its Pressure- activation in *Biosci. Biotech. Biochem., 58*. 1486-1489

[2] Bodwell， C. E.，Pearson，A. M.，and Spooner， M.E. (1965a). Postmortem changes in muscle. I. Chemical changes in beef muscle. *Food Science, 30*，766 .

[3] Bridgman , P. W. (1914). *Bio. Chem.* , *19*（4） , 511-512

[4] Cano，M.P.，Hernandez. and DeAncos,B. (1997). High Pressure and Temperature Effects on Enzyme Inactivation in Strawberry and ORANGE products in *Food Science 62*， 85-88

[5] Cheftel , J.C. (1992). Effects of high hydrostatic pressure on food constituents: *an overview high pressure and biotechnology* .195-209

[6] Iwasaki , T.and Yamamoto , K. (2002). Effect of high hydrostatic pressure on chicken myosin subfragment-1. *Int. J. Biol. Macromol . 30* (5) ， 227-232

[7] Pearson，A.M.，Wolzak，A.M. and Gray，J. I. (1983). Possible role of muscle proteins in flavor and tenderness of meat . *Food Biochem. ,7*，189-210

[8] Suzuki , A. , Homma , Y. , Kim , K. , Ikeuchi , Y. , Sugiyama , T. , and Saito , M.. (2001). Pressure induced changes in the connection/titin localization in the myofibrils revealed by immunoelectron microscopy , *Meat Science. 59* , 193-!97.