Mechanico-Structural Analysis of Different Types of Meat during Storage and Heat Treatment

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SUMMARY: The aim of the present work was analysis of changes taking place in muscle tissue of beef, pork and mutton during cold storage adn heat treatment.

Changes of meat consistency in process of cold storage and heat treatment were evaluated by rheological characteristics determined by quasistatic method.

The character of change of rheological characteristics of beef, mutton and pork in process of chilling and subsequent heat treatment was established. Correlation and regression analysis of research data was performed which made possible to propose equation of regression, characterizing correlation between rheological characteristics and time of cold storage and heat treatment.

INTRODUCTION: Technological processing and storage inevitably lead to structural changes in meat influencing its quality. One of the main parameters of meat quality is consistency which is determined by structuro-mechanical characteristics (SMC) of meat. Analysis of the available scientific data showed, that the majority of researchers devoted their attention to comparison of SMC of a definite type of meat by certain parameters. We failed to find any data, in which results of complex SMC study of different types of meat were given, the study being conducted using one method with further correlation and regression analysis of results. This hampers comparison of results obtained by different authors and compilation of information necessary for meat properties prediction.

MATERIALS AND METHODS: The aim of the present study was mechanica-structural analysis of different types of meat during cold storage and subsequent heat treatment.

As object of research served samples of beef, mutton and pork, dissected from M.Semitendinosus along muscle fibers.

State of meat was evaluated by the following moduli: resiliency (E_r), elasticity (E_e), resiliency-elasticity(E_{re}), equilibric resiliency (E_{eq}), by coefficient of viscosity(η), relaxation time (τ_r), by coefficient of resiliency (C_r) and coefficient of elasticity(C_e).

SMC were determined by quasistatic method, described in earlier works (Yevlev S.A., 1985; Yevlev S.A. et al.,1985). Temperature of samples was controlled by eletronic thermometer. Chilling of meat was performed in refrigeration chamber of "Grünland" type, heat treatment in thermostate of HLT type.

Muscles were dissected from carcasses 1.5-2.0 hours post mortem, they were placed in refrigeration chamber and stored at 0 - +4°C. In process of storage samples were dissected using a cylinder sampler which were treated in boiling water during different periods of time. After storage and subsequent heat treatment, SMC of samples were determined.

RESULTS AND DISCUSSION: Results of research evidence that character of SMC change of beef, mutton and pork muscle tissue during cold storage and further heat treatment, bear phasal character: during first 24 hours of storage and heat treatment (for pork, mutton and beef during 1.8×10^3, 3×10^3, 3.4×10^3s, respectively), values of structuro-mechanical characteristics increase (first stage), and during further technological processing - decrease(second stage). The change of SMC of muscle tissue during storage is caused by mechanico-chemical processes taking place in meat - by formation of actomyosin protein complex at rigor mortis (first stage) and further dissociation of actomyosin, by increase of permeability of lysosomic membranes, exit of enzymes therethrough, this flavouring meat ageing (second stage). Change of SMC of meat during heat treatment is explained first of all by protein denaturation the first stage, and by protein hydrolysis on the second stage.

Analysing the obtained dependencies, we could notice that change of SMC of different kinds of meat during storage in the majority of cases does not exceed 200%. After heat treatment, SMC of meat additionally changed by 2-50 times. For meat, being in the state of rigor mortis at heat treatment, SMC-values changed in a greater extent than for meat being in hot or post rigor mortis condition, for the majority of indices their by-level ranging in the process of technological treatment is in general preserved. This is developed in the absence of dependencies cross of SMC= f(τ_{st}, τ_{ht}) and SMC= f(τ_{ht}, τ_{st}), where st - means storage and ht - heat treatment. The obtained data evidence about differential character of meat SMC change. In this respect it seems interesting to compare correlation between their change.

Table 1.

Characteristics	E_{eq}	E_y	E_e	E_{re}			C_r	C_e
			B E E F					
$E_{eq} \cdot 10$	1	0.628	0.680	0.603	0.786	0.909	0.965	0.965
E_r	0.628	1	0.941	0.895	0.690	0.721	0.700	0.670
E_e	0.680	0.941	1	0.904	0.753	0.766	0.739	0.706
E_{re}	0.603	0.895	0.904	1	0.557	0.663	0.653	0.634
η	0.786	0.690	0.753	0.557	1	0.934	0.887	0.844
τ_2	0.909	0.721	0.766	0.663	0.934	1	0.968	0.954
C_r	0.965	0.700	0.739	0.653	0.887	0.968	1	0.987
C_e	0.965	0.670	0.706	0.634	0.844	0.954	0.987	1
			L A M B					
E_{eq}	1	0.634	0.657	0.456	0.870	0.923	0.940	0.962
E_r	0.634	1	0.880	0.875	0.717	0.698	0.684	0.607
E_e	0.657	0.880	1	0.880	0.765	0.719	0.723	0.635
E_{re}	0.456	0.875	0.880	1	0.528	0.466	0.471	0.403
η	0.870	0.717	0.765	0.528	1	0.973	0.957	0.908
τ_2	0.923	0.698	0.719	0.466	0.973	1	0.982	0.953
C_r	0.940	0.684	0.723	0.471	0.957	0.982	1	0.974
C_e	0.962	0.607	0.635	0.403	0.908	0.953	0.974	1
			P O R K					
E_{eq}	1	0.771	0.630	0.561	0.899	0.904	0.972	0.974
E_r	0.771	1	0.900	0.878	0.878	0.884	0.815	0.776
E_e	0.630	0.900	1	0.946	0.709	0.701	0.675	0.629
E_{re}	0.561	0.878	0.946	1	0.655	0.647	0.625	0.559
η	0.899	0.878	0.709	0.655	1	0.986	0.947	0.911
τ_2	0.904	0.884	0.701	0.647	0.986	1	0.943	0.910
C_r	0.972	0.815	0.675	0.625	0.947	0.943	1	0.973
C_e	0.974	0.776	0.629	0.559	0.911	0.910	0.973	1

Table 1 shows values of correlation coefficients characterizing connection between SMC of beef, mutton and pork muscle tissue in process of cold storage ta t=0...+4°C and further heat treatment in boiling water.

It is necessary to note significant difference between values of coefficients. This evidence about the fact, that different rheological parameters characterize properties of different groups of muscle tissue fragments and their behaviour at external effect. Howeve in general, analysis of table 1 shows that strong correlation is characteristic of the majority of indices. This could be explained by the fact that from different positions they characterize definite phenomena taking place in meat during storage and treatment. Mathematic analysis of research data enabled us to propose the following equation of regression characterizing correlation between rheological characteristics of muscle tissue and duration of chilling and heat treatment:

$$px = a_o + a_1x + a_2 \cdot y + a_3x^2 + a_4xy + a_4xy + a_5y^2,$$

where x - is time of storage, days,

y - time of treatment in boiling water, s;

$a_o \ldots a_n$ - regression coefficients (Table 2).

The obtained dependence create possibility to predict change of rheological characteristics of beef, mutton and pork muscle tissue depending on time of storage at 0 - +4°C and on further treatment in boiled water.

CONCLUSION: Dependencies between 8 rheological characteristics of beef, mutton and pork during cold storage and heat treatment, were established. Correlation and regression analysis of research data was performed, equation of regression was proposed, characteri

Table 2.

Characteristics	Regression coefficients					
	a_o	a_1	a_2	a_3	a_4	a_5
BEEF						
$E_{eq} \cdot 10^3$ Pa	12.518	1.772	35.931	-0.152	0.121	-5.618
$E_r \cdot 10^4$ Pa	13.911	1.682	7.096	-0.137	-0.076	-1.199
$E_e \cdot 10^4$ Pa	16.723	1.839	12.299	-0.157	-0.135	-2.061
$E_{re} \cdot 10^4$ Pa	9.436	0.838	3.170	-0.077	-0.026	-0.535
$\eta \cdot 10^6$ Pas	1.885	0.849	15.435	-0.077	-0.141	-2.241
τ_r	16.895	3.998	140.77	-0.384	-1.646	-19.751
C_r	6.976	0.714	20.738	-0.059	-0.079	-3.011
C_e	4.354	0.869	14.957	-0.074	-0.050	-2.205
LAMB						
$E_{eq} \cdot 10^3$ Pa	18.287	2.552	28.742	-0243	0.220	-4.087
$E_r \cdot 10^4$ Pa	17.573	3.184	11.629	-0.246	-0.150	-1.900
$E_e \cdot 10^4$ Pa	26.311	0.580	15.371	-0.113	-0.048	-2.569
$E_{re} \cdot 10^4$ Pa	14.030	0.490	3.743	-0.052	-0.023	-0.724
$\eta \cdot 10^6$ Pas	3.584	0.756	35.243	-0.093	-0.251	-5.492
τ_r	14.846	13.156	220.49	-1.210	-0.856	-32.641
C_r	8.128	1.050	23.851	-0.105	-0.026	-3.601
C_e	6.293	0.951	28.943	-0.079	-0.095	-2.821
PORK						
$E_{eq} \cdot 10^3$ Pa	13.426	1.122	30.526	-0.097	-0.132	-4.573
$E_r \cdot 10^4$ Pa	11.594	1.284	6.284	-0.107	-0.082	-1.033
$E_e \cdot 10^4$ Pa	12.449	1.867	5.140	-0.220	0.021	-0.995
$E_{re} \cdot 10^4$ Pa	7.810	0.893	3.412	-0.075	-0.029	-0.616
$\eta \cdot 10^6$ Pas	2.105	0.244	10.332	-0.030	-0.012	-1.657
τ_r	15.236	4.874	111.28	-0.468	-0.115	-18.159
C_r	5.611	0.904	17.811	-0.083	-0.023	-2.805
C_e	3.624	0.493	12.077	-0.043	0.012	-1.821

ing correlation between rheological characteristics, time of storage and heat treatment, ensuring prediction of values of muscle tissue rheological characteristics during cold storage and heat treatment of meat.

REFERENCES:

Yevlev S.A.(1985):"Instruments for study of structuro-mechanical properties of meat and fish". Izvestija vuzov SSSR. Food technology.1985,N°2,p.111.

Yevlev S.A., GOLOVKIN N.A.(1985):Rheological instruments and their application in studying of meat changes during refrigeration and storage. Proceedings of the 31st European Meeting of Meat Research Workers. Sophia, Bulgaria.1985,677-680.