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Physical and texture parameters used in the analysis of meat freshness

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Abstract

Finding physical and texture parameters that reflects the freshness of meat is aim of this study. Fresh meat of horse was used for the study. In a previous study it has been determined and studied all primary and secondary texture parameters resulting from the texture profile analysis (TPA) to this type of meat. Pronounced anisotropy due the fibering both meat and area of the sampling, led to inconclusive results. Based on these findings in the present work the study of meat freshness has approached using other physical and texture parameters namely: tension stress (σ_{max}), hardness under load (Hs), work of deformation (Lm), slope of the line F_{1N} -F_{max} and relaxation (R) of the meat sample. For this purpose the samples from the slaughtered animal of the croup area were loaded with a force increasing progressively to 10 mm compression then stopped the application of force and it was recorded the evolution of this force in time corresponding to the deformation. Measurements were made daily for 10 days, the samples of meat held in a refrigerated temperature of 5^0C, until the appearance of the biogenic amines of degradation , when testing was stopped

Keywords: horse meat, freshness, physical and texture parameters

1. Introduction

The horse meat is consumed for centuries, its consumption varying depending on the historical period and country. And nowadays horse meat consumption varies depending on the geographic area. The consumption of this food is admitted provided that the cutting to be made in specialized butchers and the product to be labeled "horse meat". Currently in Romania horse meat is produced in Timisoara, Ploiesti, Bucharest, Botosani and Suceava. Chemical composition of meat is determined by the ratio of the tissues that compose it. Therefore, it is found differences in the chemical composition of meat by a state of fattening of animals, age and sampling anatomical region. The horse meat is rich in protein (20g/100g) and a very low fat content (2-4%).

It is an important source of omega-3 and iron and compared with other meats have a low level of saturated fatty acids, but it is rich in polyunsaturated fatty acids easily and quickly assimilated by the body [1]. The iron is found in amounts of about 4mg/100g in the horse meat. The essential amino acids such as leucine, lysine and histidine are found in appreciable amounts. It also remarks a high content of B3, B6 and B12 vitamins. In terms of human sensory the horsemeat presents a red – brown color and gets bluish reflections in contact with air, has a slightly sweet taste and a specific smell. The smell can be changed due to nutrition and physical overstressing of animals [2].

Consistency of meat is influenced by fattening: a meat marbling and a finer texture compared to one that has more connective tissue between muscle fibers.

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In cross section, the muscle bundle is detected as granulations. Unlike other meats the horsemeat easily degrades under refrigerated conditions, which is why its use for testing meat freshness. In terms of instrumental sensory the horsemeat can be characterized by some specific parameters such as color, tenderness, consistency. Instead, using texture profile analysis (TPA) did not give results for this material food because it shows a high degree of anisotropy due to the alignment of muscle fibers, marbling and sampling area under test.

2. Materials and methods

Determinations were carried out for 10 days until they appeared biogenic amines most powerful manifesting smell of cadaverine.

Horse meat samples with dimensions of 30x30x30 mm [3] were cut daily from a massive piece of horse meat with about weight of 2 kg. Between the test days meat was kept under refrigerated conditions at 5^0C. In order to realize the study an electronic texturometer [4], [5], Figure 1, with a sensory system for measuring force, displacement and time was used. Samples of the meat were tested to compression between the discs of texturometer with a progressively increasing force with displacement of the disc at a speed higher than 10 mm / minute.

Figure 1. Texturometer Mark-10-ESM301 [4],[5]

Application of force *F* was made until the height of samples decreased by 10 mm , respectively from 30 mm to 20 mm, then the application of the force was stopped being recorded automatically, the evolution of its decreasing value as function of time, until the time is 450 seconds [6].

Hardness value *Hs* under load was calculated from the ratio of F_{max}, read from the load-relaxation curve (Fig. 2) and the value of 10, the latter representing the deformation *h* in mm of meat sample caused by loading it to F_{max}.

$$H_S = \frac{F_{max}}{h_{10}} = \frac{F_{max}}{10} \qquad (1)$$

The relaxation *R* value was calculated from the ratio of the difference between forces F_{max} - F_{450} and the difference between t_{450} and t_2 times:

$$R = \frac{\Delta F}{\Delta t} = \frac{F_{max} - F_{450}}{t_{450} - t_2} = \qquad (2)$$

$$= \frac{F_{max} - F_{450}}{450 - t_2}$$

where: F_{450} corresponds to the force at the t_{450} time measured from the starting of loading (t = 0) to passing the time of 450 seconds and t_2 is the time of the beginning of meat sample relaxation**.**

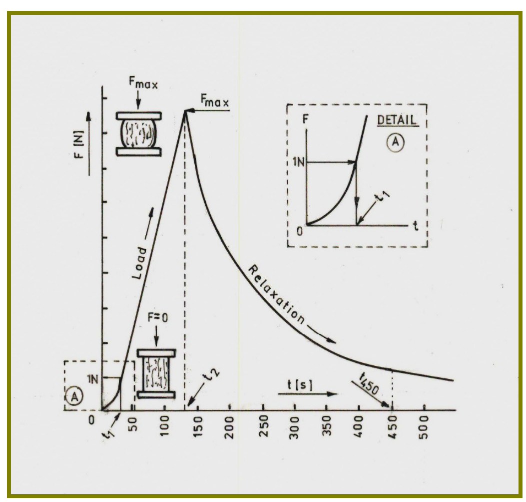

Figure 2. Cyclogram and stress characteristics of massive or prepared meat samples [4].

The work value L_m was calculated from the surface area under the curve of load from 1 N preload value force F (F_{max}), which corresponds to a sample deformation of 10 mm and the time interval t_2 - t_1:

$$L_m = \int_{t_1}^{t_2} F \cdot dt \qquad (3)$$

where : t_2 is the time corresponding to the maximum value of the force F at a meat sample deformation h of 10 mm, and the time t_1 corresponding to F_{1N} preloading force of the sample with 1N.

Modern texturometers software enables automatic calculation of areas under different curves. Given the almost linear increase of the load samples in time to achieve the deformation of 10 mm was taken into account the using of the slope of loading as a parameter that could reflect the freshness of meat. At the beginning it was started from the force of loading $F=0$. In these conditions the regression equation describing the evolution of the load presented low values of R^2 regression coefficients because the inflection point of the curve near the point of zero loading, Fig.2, Fig.3-Fig.7. In these conditions it was used the method of preloading to eliminate the variations and nonlinearities around the zero point [7], and for it was translated the conventional force axis from 0 N to 1 N.

Considering that meat samples had defined contact surfaces as some cubes with dimensions 30mm x30 mmx30mm, as sample deformation h of 10 mm was done with a force F gradually and linearly increasing with loading speed of 10 mm / minute, and that the tension loading of the sample is the ratio of the force F and the area over which the force acts (A=30x30 mm=900 mm^2), it can be written as:

$$\sigma_{max} = \frac{F}{A} = \frac{F_{max}}{900} \qquad (4)$$

Considering the definition of the modulus of elasticity for the linear behavior of Hooke's law [8] as:

$$E = \frac{\sigma}{\varepsilon} \qquad (5)$$

where ε represents the relative deformation of the sample:

$$\varepsilon = \frac{30mm - 20mm}{30mm} = 0{,}33 \qquad (6)$$

tangent of the angle α (Fig.2) can be expressed as:

$$tg\alpha = \frac{\Delta F}{\Delta t} = \frac{F_{max} - F_{1N}}{t_2 - t_1} = \frac{900 \cdot \sigma_{max} - \frac{1}{900} \cdot \sigma_{1N}}{t_2 - t_1} = \frac{9 \cdot 10^2 \cdot \sigma_{max} - 1{,}1 \cdot 10^{-3} \cdot \sigma_{1N}}{t_2 - t_1} \qquad (7)$$

Replacing the value of tensions σ in the relationship (7) by its expression in equation (5), we obtain

$$tg\,\alpha = \frac{\Delta F}{\Delta t} = \frac{F_{max} - F_{1N}}{t_2 - t_1} = \frac{900\ \sigma_{max} - \frac{1}{900} \cdot \sigma_{1N}}{t_2 - t_1} = \frac{9 \cdot 10^2 \cdot \sigma_{max} - 1{,}1 \cdot 10^{-3} \cdot \sigma_{1N}}{t_2 - t_1}$$

$$= \frac{297 \cdot E - 0 \cdot E}{t_2} = \frac{297 \cdot E}{t_2} \qquad (8)$$

relation (8) which is actually the variation of modulus of elasticity E during meat sample loading.

3.Rezults

Cyclograms of loading-relaxation carried out according to the technique [3] described above, for horse meat samples studied are presented in Figures 3-7.

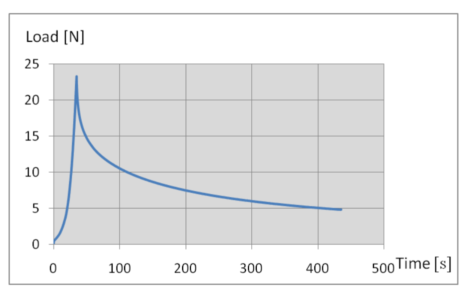

Figure 3. Cyclogram of loading-relaxation from the first day

Determinations were performed daily but for lack of space only cyclograms made every two days have been reproduced. Instead, values for all daily determinations of texture parameters studied are given in Table 1.

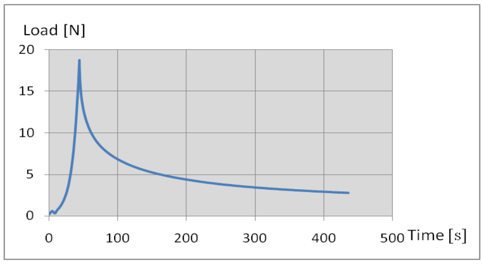

Figure 4. Cyclogram of loading-relaxation from the third day

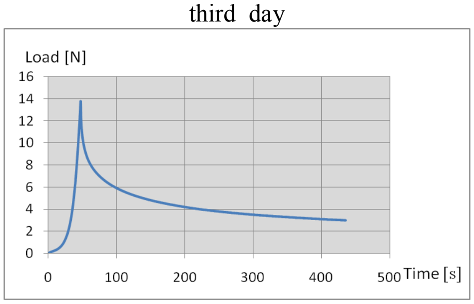

Figure 5. Cyclogram of loading-relaxation from the fifth day

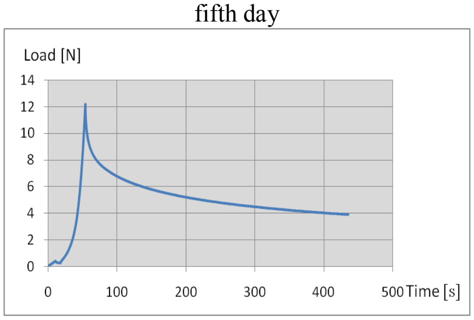

Figure 6. Cyclogram of loading-relaxation from the seventh day

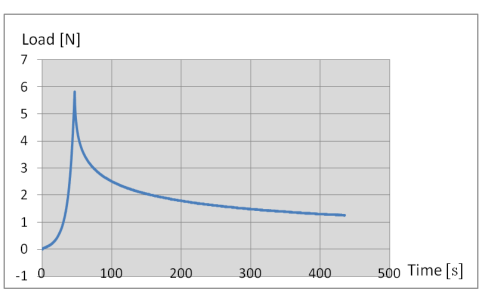

Figure.7. Cyclogram of loading-relaxation from the ninth day

4. Discutions

In order to establish a dependency between fresh horse meat and its texture evolution in time, texture parameters by analyzing the texture profile (TPA-Texture Profile Analysis) were studied in the first phase of research. The results were inconclusive because of anisotropy of meat. In the second phase the study of evolution of texture parameters, others [3] than those specified in TPA [9], [10], [11] was used. In this respect, the authors of the paper focused on the evolution in storage days of horse meat refrigerated at 5^0C of the following parameters: tension stress σ_{max}, hardness under load H_s, work L_m deformation of the sample, the slope evolution of F_{1N} and relaxation R line of the sample. All cyclogram were carried out over a period of time of 450 seconds. Dependences clear enough between several parameters and the freshness of meat were found, the latter being expressed by the number of days of storage it from the day of slaughter the animal.

The evolution of these parameters during the ten days taken into account is shown in Table 1 as a synthetic image. An edifying image offer also Figures 8, 9,10,11,12 that are the basis for calculating the parameters mentioned above.

In order to select correctly and for the prioritization of physical and texture parameters that express the freshness of horse meat their evolution depending on storage of meat refrigerated at 5^0C were represented in Figures 8-10.

For the election of the most representative parameter were taken into account the following criteria:

- correlation coefficient R^2 of the curve that represents the evolution of parameter values depending on testing day, Tab.2
- measuring sensitivity of parameter defined by the difference between the maximum and minimum value measured for the respective parameter on a ten-day period
- ensuring good reproducibility and traceability of determinations referring to the surface of the sample tested. This condition is ensured only if instead the force F the tension σ is used
- possibility of using a handheld device instead of an electronic texturometer laboratory for in situ testing of meat freshness

Table 1. Evolution of texture and physical parameters and horse meat by its freshness (number of days after the slaughter of the animal)

Day	Tension σ, [N/mm^2]	Hardness H_S, [N]	Mechanical work L_m, [N·s]	Slope of the line, F_{1N} -F_{max}, [N/s]	Relaxation [N/s]
1	0.0259	2.332	202	0.495	0.0440
2	0.0208	1.876	175	0.397	0.0390
3	0.0188	1.697	165	0.376	0.0321
4	0.0166	1.496	156	0.302	0.0271
5	0.0156	1.408	140	0.374	0.0269
6	0.0153	1.378	121	0.368	0.0268
7	0.0148	1.336	121	0.305	0.0259
8	0.0135	1.218	120	0.295	0.0208
9	0.0106	0.958	99	0.254	0.0196
10	0.00646	0.582	41	0.225	0.0113

Table 2. Correlation coefficient R^2 values, measurement sensitivity, nsurance of reproducibility and traceability i and the possibility of using a portable means of testing

	R^2	Sensitivity	Ensuring reproducibility and traceability	The possibility of using a portable device for testing
Hardness H_S, [N]	**0.913**	233	no	**yes**, portable electronic hardness tester
Mechanical work L_m, [N·s]	0.905	202	no	no, it involves texturometer and computer
Line slope F_{1N}-F_{max}	0.797	**495**	no	no, it involves texturometer and computers
Relaxation R, [N/s]	0.908	327	no	no, it involves texturometer and computers
Tension σ, [N/mm^2]	**0.913**	259	**yes**	**yes**, portable electronic dynamometer

Analyzing the results obtained for the four texture parameters analyzed in terms of the required criteria for choosing the most representative parameter it is clear that this is the loading tension of the sample to a set value of its deformation.

5. Conclusion

By achieving the cyclograms of loading – unloading for a predetermined time period a means of quantifying the freshness of meats is obtained .

Physical and texture parameters that can be determined from such a cyclogram are: tension stress (σ_{max}), hardness under load (H_s), mechanical work (L_m) of deformation, slope of line (F_{1N}-F_{max}) and relaxation (R) of the meat sample**.** In the concrete case of horse meat testing, the study showed that the parameter that best reflects its freshness is the tension stress(σ_{max}),to an imposed deformation followed by the hardness under load *(H_s)*. Tension stress can be an excellent instrumental indicator of laboratory and hardness under load an indicator for testing in situ characterization of this meat and other raw meats stored in some refrigerated conditions.

Compliance with Ethics Requirements: Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human and/or animal subjects (if exists) respect the specific regulations and standards.

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