Journal homepage: www.fia.usv.ro/fiajournal
Journal of Faculty of Food Engineering,
Ştefan cel Mare University of Suceava, Romania
Volume XIV, Issue 1- 2015, pag. ... - ...

THE USE OF TEXTURE DESTRUCTIVE METHODS TO ASSESS THE STATE OF PORK FRESHNESS

***Sergiu PADURET**[1]**, Gheorghe GUTT**[1]
[1]*Faculty Food Engineering, Stefan cel Mare University of Suceava, Romania*
sergiu_paduret@yahoo.com
*Corresponding author
Receive: May 25th 2015, accepted June 25th 2015

Abstract: *The aim of this study is to evaluate the freshness state of pork meat and for this we built an electronic device for creep test with a sensory system for measuring displacement and time. After each measurement a creep curve characterized by the penetration depth and mechanical work of compression was obtained. The color measurements was made with a USB 4000 Ocean Optics spectrophotometer, using the CIE L*a*b* uniform color space.After 10 days of measurements while the meat was kept refrigerated at 4 °C, a linear trend between the state of meat freshness (expressed as storage days), mechanical work (R^2=0.986) and penetration depth (R^2=0.987) was established. A Pearson correlation has also been established between meat freshness, penetration depth (r=0.994**) mechanical work, water activity and pH.*

Keywords: creep test, freshness, mechanical work, pork, color.

1. Introduction

The state of food freshness is very important for consumers, retailers and also for food processors; nowadays the consumers pay more attention to food safety than food price.
Among the quality attributes, freshness is of special significance and can equally well be seen as a sensory, nutritional or a food safety characteristic [1].
Pork represents more than 50% of the total amount of meat consumed in Romania, with an annual consumption of 30-35 kg/capita and half of this meat is sold as fresh meat for culinary purposes [2].
The meat freshness can be appreciated by: smell, color, appearance and texture (elasticity, hardness under load, relaxation tests). Textural characterization such as creep test can provide quick and valuable indications on the state of raw meat freshness.
Textural characteristics can be grouped into mechanical characteristics (hardness, cohesiveness, viscosity, elasticity, springiness, and adhesiveness); geometrical characteristics (particle size, shape, and orientation); andsurface characteristics (moisture content and fat content) [3,4].
Fresh meat quality is difficult to define because it is a complexconcept determined by consumer preferences. The quality characteristics of meatare influenced by various factors such as muscle structure, chemicalcomposition, chemical environment, interaction of chemicalconstituents, postmortem (p.m.) changes in muscle tissues, stressand pre-slaughter effects, product handling, processing and storage,microbiological numbers and populations, etc. In particular, freshmeat quality is directly related to muscle fiber characteristics [5].
The first impression consumers have of any meat product is its color and thus color is of utmost importance. The color of meat may vary from the deep purplish-red of

freshly cut beef to the light gray of faded cured pork [6].
Pork color can be influenced by thegenetics of the live animal, the nutritional programadministered, antemortem conditions and handling(those events and conditions prior to harvest), thevarious processes associated with harvesting the animal(stunning, dressing, and chilling), and by processing,packaging, distribution, and marketing conditions [3].
Meat texture is directly related to the size of muscle fiber and the amount of connective tissue, and is partially affected by the quantity of intramuscular fat; the amount of intramuscular fat affects the meat firmness [5].
Meat texture evaluation methods can be groupedinto sensory methods, instrumental methods, and indirectmethods. The most common instrumentalmethods are compression, penetration, shear, extension tests and texture profile analysis [3, 7].
The aim of this study is to assess the state of raw meat freshness by destructive methods of materials testing respectively by creep tests.
In the creep test the strain is measured under a constant stress and temperature as a function of time [8, 9].

2. Matherials and methods

An electronic device for creep test, Figure 1, with a sensory system for measuring displacement and time was built to make this study. Pork meat samples taken from pork leg with dimensions of 30x30x30 mm [10] and with a mass of about 55 g were obtained daily from bigger pieces of meat previously cut. Between the testing days the meat samples were kept under refrigerated conditions at 4 °C.The determinations were carried out for 10 days until the biogenic amines appeared.

Fig. 1. Device for determining the creep of food products

A creep method with preload and a creep method without preload was used for analysis. Stress time was 260 minutes and the weight stress was 1000 g. The preload consisted in sample stress with a mass of 300 g for 20 s.
The moisture content of meat samples was determined by oven drying –SR ISO 1442 – [11]. The fat content was determined by Soxhlet method –SR ISO 1444- [12], and the protein content was determined by Kjeldahl method – SR ISO 937- [13].
The color measurement of each samples was achieved with a USB 4000 Ocean Optics spectrophotometer, using the CIE L*a*b* uniform color space, the illuminant used was D65 in reflective mode and the color measurement was made at an angle of 45 degrees to the sample.
The a* axis extends from green (−a*) to red (+a*), the b* axis from blue (−b*) to yellow (+b*) and L* represents brightness (0 black and 100 white)[14].

Meat color difference (ΔE*) was calculated with the formula [15]:

$$\Delta E=\sqrt{\left(\left(L_1^*-L_2^*\right)^2+\left(a_1^*-a_2^*\right)^2+\left(b_1^*-b_2^*\right)^2\right)} \quad (1)$$

In addition, hue angle or tone (h^0) and chroma (color intensity) (C*) was calculated by the following formulas [16]:

$$h^0=tan^{-1}\,(b^*/\,a^*) \quad (2)$$

$$C^*=(a^{*2}+b^{*2})^{1/2} \quad (3)$$

Statistical analysis

The Pearson correlation has been made up using SPSS 13 (USA).

3. Results and discussion

Creep tests were also made by other scientists on dough, bread or butter to investigate the failure of soft viscoelastic solids [3].

The physico-chemical properties are presented in table 1; the pH value is in the acid region between 5.5 and 6.1, while the water activity ranged between 0.885 in the first day to 0.909 in the last day of testing.

Table1.

Meat properties

Meat samples	
Protein %	21.2±0.95
Fat%	6.9±0.87
Moisture %wb	71.6 ±0.9

Mean value ± standard deviation (n=3), wb-wet basis

Figure 2 shows the creep curve of meat samples stress with 1 Kg, 2 Kg and 3 Kg for 13 minutes, and as we can see the increasing of stress leads to high penetration depth. The depth range between 3.26 mm to 11.02 mm and the mechanical work calculated as the area under the curve range between 298 and 1279 mm·min^{-1}

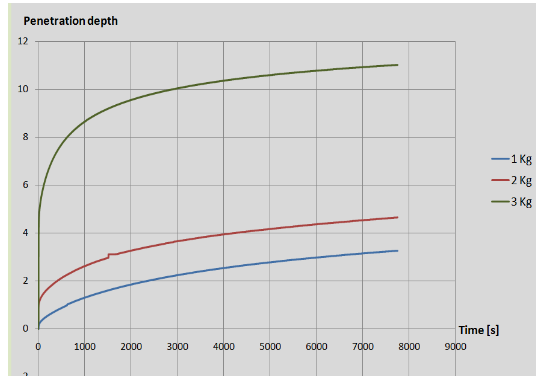

Fig.2. Creep curve of a meat samples stress with 1 Kg, 2 Kg and 3 Kg.

We chose for analysis weight stress of 1Kg because it produced a smaller lateral flow.

Table 2.

The characteristics of creep curves

Load [Kg]	Depth [mm]	Mechanical Work [mm·min^{-1}]
1	3.26	298.1
2	4.65	474.6
3	11.02	1279

Figure 3 shows the creep curves on days with preload (300g for 20 s) stress with 1 Kg and it can be seen a decrease of depth during the 10 days of testing, but the results of meat samples analyzed by preloading method were inconclusive, there was no correlation between the state of meat freshness and creep curves.

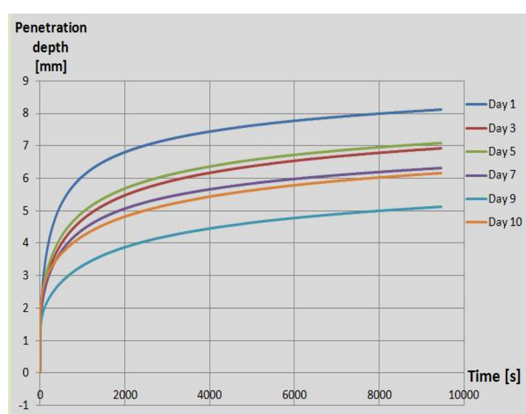

Fig. 3. Creep curves on days with preload stress with 1 Kg

Comparing thecreep methodwith preload with the creep method without preloadwe can observe that the penetration depth increases with storagein case of second method, and also shows an increasing evolution from day to day(figure 4).

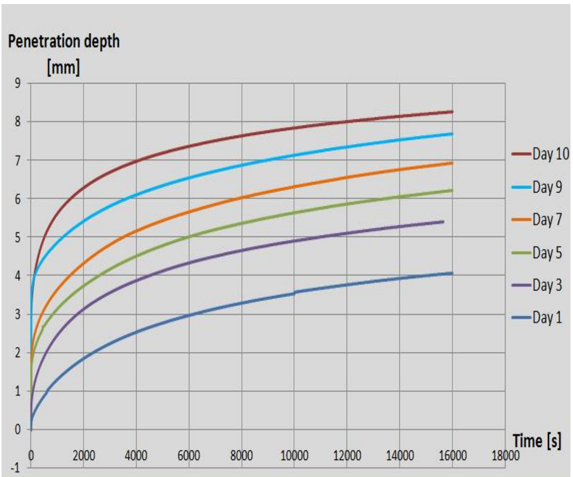

Fig.4. Creep curves on days without preload stress with 1 Kg

The depth for creep test without preload ranged between 4.06 mm on the first day of determination to 8.25 mm in the tenth day, and the mechanical work of compression varies between 787 mm·min^{-1} in first day to 1909mm·min^{-1} on the tenth day (table 3).

Figure 5 and 6 show the linear evolution of mechanical work (R^2=0.986) respectively the penetration depth (R^2=0.987) during storage and testing.

Color parameters have been also measured throughout the study; meat brightness, (L*) ranges between 59.1 and 89.65, in the seventh day meat samples presented the highest brightness and in the last day the lowest brightness. a* color parameter is situated in the positive region on red-green axis, more towards red only in the first day, instead the b* color parameter is situated in the negative region on yellow-blue axis, more towards yellow in the first seven day.

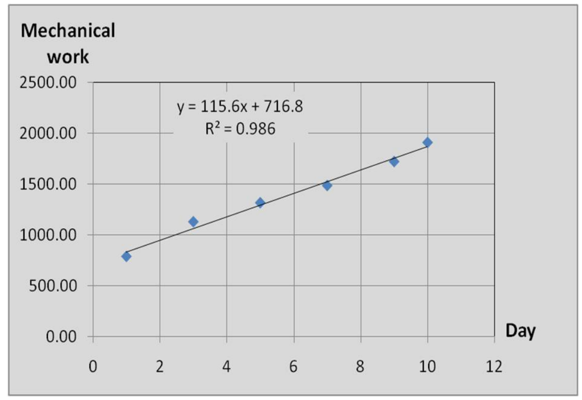

Fig. 5. The evolution of mechanical work

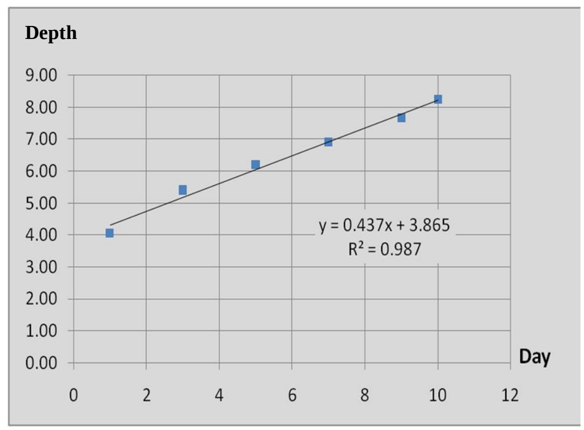

Fig. 6. The evolution of penetration depth

In the last days of determination the b* parameter was situated in the positive region on yellow-blue axis, more towards blue (Table 3).

The color difference ranges between 1.5 in the first day to 20.58 in the seventh day of determination, if the color difference is greater than three; it means that the color difference of meat samples analyzed can be appreciated by the human eye.

Table 3.
Texture,color and physico-chemical evolution of raw pork meat during 10 days of storage (without preload).

Sto-rage Day	Depth [mm]	Work [mm·min^{-1}]	L*	a*	b*	C*	h^0	ΔE	pH	a_w	Moisture [%]
1	4.06 ±0.3	787.8 ±2.1	68.7 ±0.7	0.25 ±0.1	-2.3 ±0.1	2.31 ±0.2	-83.79 ±0.5	1.523 ±0.2	5.53 ±0.06	0.885 ±0.01	70.709 ±0.23
3	5.41 ±0.2	1129 ±1.9	81.98 ±3.1	-0.51 ±0.04	-1.665 ± 0.1	1.74 ±0.09	72.76 ±1.8	11.821 ±0.0.9	5.83 ±0.13	0.875 ±0.021	70.578 ±0.53
5	6.2 ±0.1	1316 ±1.5	67.95 ±2.1	-1.27 ±0.1	-2.4 ±0.2	2.71 ±0.2	62.02 ±1.4	17.168 ±0.5	5.52 ±0.01	0.895 ±0.01	68.492 ±0.85
7	6.91 ±0.2	1485 ±2.2	89.65 ±2.2	-4.9 ±0.21	-6.15 ±0.88	7.86±0.6	51.45 ±1.5	20.580 ±0.7	5.74 ±0.03	0.899 ±0.02	67.36 ±0.71
9	7.67 ±0.4	1721 ±2.3	60.15 ±1.3	-1.58 ±0.1	3.66 ±0.9	3.99±0.4	-66.56 ±0.9	11.703 ±0.5	6.1 ±0.02	0.903 ±0.02	70.013 ±0.11
10	8.25 ±0.1	1909 ±1.7	59.1 ±1	-2 ±0.06	5.2 ±0.7	5.57 ±0.3	-68.96 ±1.1	13.445 ±0.4	6.05± 0.03	0.909± 0.01	71.128± 0.32

Mean value ± standard deviation (n=3). L*- brightness, a*- red-green axis, b*- yellow-blue axis, C*- color intensity, ΔE- color difference, h°-tone,

Table 4 presents the Pearson correlation of the meat physico-chemical properties. In the case of creep tests without preload, a correlation between the mechanical work of compression, penetration depth and the state of raw meat freshness expressed as storage days was established.

Table 4.
Pearson Correlation of meat physico-chemical properties and creep texture parameters (without preload).

	Storage	Depth	Work	Moisture	pH	a_w	L	a	b	C	h	ΔE
Storage	1	0.994**	0.993**	-0.084	0.780*	0.891**	-0.375	-0.574	0.594	0.658	-0.224	0.548
Depth		1	0.998**	-0.101	0.772*	0.852*	-0.333	-0.578	0.575	0.634	-0.129	0.609
Work			1	-0.042	0.791	0.853*	-0.374	-0.538	0.619	0.611	-0.172	0.566
Moisture				1	0.374	-0.158	-0.591	0.734*	0.708	-0.522	-0.609	-0.737*
Ph					1	0.501	-0.366	-0.208	0.759*	0.314	-0.357	0.143
aw						1	-0.494	-0.536	0.498	0.689	-0.416	0.405
L							1	-0.464	-0.856*	0.257	0.729*	0.384
a*								1	0.297	-0.939**	-0.305	-0.810*
b*									1	-0.097	-0.643	-0.231
C										1	-0.012	0.621
h											1	0.650
ΔE												1

L*- brightness, a*- red-green axis, b*- yellow-blue axis, C*- color intensity, ΔE- color difference, h°-tone, a_w- water activity**. Correlation is significant at the 0.01 level (1-tailed).*. Correlation is significant at the 0.05 level (2-tailed).

It can be observed that there is a strong positive correlation between penetration depth and day of storage (r=0.994**) and also between work and storage (r=0.993**), aw is correlated positively too with days of storage (r=0.891**), depth (r= 0.852*) and work (r=0.853*).

The color difference of meat is negatively corelated with moisture content (r=-0.737*) and a* -red-green axis (r=-0.810*). Another positive correlation can be observed between moisture content and a* (r =0.734*). The pH value is correlated positively with storage (r=0.780*), depth (r =0.772*) and b*-yellow-blue axis (r=0.759*).

4. Conclusion

Determining the state of meat freshness requires laborious operations related to spectrometric and chromatographic analytics, but given that the freshness of meat is reflected in its behavior to mechanical stress, creep methods without preload can be useful means for a rapid testing of meat freshness.

Another consideration is that the state of meat freshness expressed as storage days, penetration depth respectively the mechanical work of creep test without preload shows a linear trend R^2 =0.987 and R^2=0.986.

As a general conclusion creep tests without preload can be used to assess the state of food freshness.

5. References

[1]. HUI Y. H., Handbook of meat and meat processing, Second Edition, CRC PressTaylor & Francis Group, New York, (2012)

[2]. POPESCU A., Study concerning the trends in pork market in Romania, *Lucrări Ştiinţifice - Seria Zootehnie,* vol. 57, *University of Agricultural Sciences and Veterinary Medicine, Iasi*, (2012)

[3]. LEO M. L., TERRI B., FENG C., COGGINS P., GLORIA M., HUI H. Y., Handbook of meat, poultry and seafood quality, *Blackwell Publishing*, USA, (2007)

[4]. XXX- SR ISO 11036/2007- Senzory analysis - Methods- Texture profile (2007)

[5]. JOO S.T., KIM G.D., HWANG Y.H., RYU Y.C., Control of fresh meat quality through manipulation of muscle fiber characteristics, *Meat Science,* 95, 828–836, (2013)

[6]. BOLES J.A., PEGG R., Meat Color, *Food Product Innovation Program University of Saskatchewan,* Montana State University and Saskatchewan, (2010)

[7]. BOURNE C.M., Food Texture and Viscosity: Concept and Measurement, *An Elsevier Science Imprint*, London, (2002)

[8]. VITHANAGE C. R., GRIMSON M. J., SMITH B. G., WILLS P. R., Creep test observation of viscoelastic failure of edible fats, *Condensed Matter and Materials Physics Conference (CMMP10), Journal of Physics: Conference Series* 286 , 012008, (2011)

[9]. BETTEN, J., Creep Mechanics, 2nd Ed., *Springer, Aachen,* (2005)

[10]. GUTT, G., PĂDUREŢ, S., AMARIEI, S., PLESCA, M., Physical and texture parameters used in the analysis of meat freshness, *Journal of Agroalimentary Prosesses and Technologies,* 20(3), 257-262 (2014)

[11]. XXX-ISO 1442 –Carne şi produse din carne. Determinarea umidităţii (2010)

[12]. XXX- SR ISO 1444 Carne şi produse din carne. Determinarea conţinutului de grăsime liberă

[13]. XXX-ISO 937 –Carne şi produse din carne. Determinarea conţinutului de azot (2007)

[14]. AMSA, Meat Color Measurement Guidelines, *American Meat Science Association,* Illinois, USA, 61820 800-517-2672 (2012)

[15]. OLIVEIRA A. C. M., BALABAN M. O., Vision system in measuring color of gulf of Mexico sturgeon fillets,*Applied Engineering in Agriculture* Vol. 22(4): 583-587 American Society of Agricultural and Biological Engineers ISSN 0883–8542, (2006).

[16]. ALVES DE OLIVEIRA, E.N., COSTA SANTOS, D., GOMES, J. P., TRINDA DE ROCHA, A. P., DA SILVA, W. P., Physicochemical stability of diet umbu-caja jams stored under ambient conditions, Journal of Food Processing and Preservation 39, 70–79 (2015)