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Original scientific paper

Cook Loss as a Function of Meat Heat Treatment and Regime

Dragan P. Vujadinović[1], Radoslav D. Grujić[1], Vladimir M. Tomović[2], Vukić S. Milan[1], Marija R. Jokanović[2]
[1]University of East Sarajevo, Faculty of Technology, 74000 Zvornik, Karakaj bb, Bosnia and Herzegovina,
E-mail: draganvjd@gmail.com
[2]University of Novi Sad, Faculty of Technology, 21000 Novi Sad, Bulevar Cara Lazara 1, Serbia

Abstract: Heat treatment of meat causes different changes in the structure of meat, for example, decimation of cell films, tearing of muscle strands, tearing and disintegration of the connective tissue proteins, coagulation and gel development of the myofibrillar and sarcoplasmic proteins.

The aim of the study presented in this paper was to investigate the effect of heat treatment by roasting and cooking at atmospheric pressure on cook loss of M. Longissimus dorsi of pork in the temperature range between 50**°C** and 100**°C**. Consequently were analyzed and the drip losses seen as a result of freezing and thawing of meat before heat treatment.

The observed parameters amid tests indicated steady measurably critical change ($P<0.001$) of observed qualities with temperature expanding amid the both hotness treatment forms in the given temperature range. The most ideal temperature in the core of the pork meat sample during heat treatment is in the temperature range somewhere around 70**°C** and 80**°C**. Heat treatment by cooking gave samples with less cook loss yield, compared to the heat treatment by roasting.

Key words: Cook loss, Pork meat, Heat processing of meat.

Introduction

Meat is a very important component in the diet of people, because it is a source of easily digestible, biological and energetic valuable ingredients. The term meat in the strictest sense refers to skeletal musculature associated with connective tissue and fat, nerve and blood vessels, which is removed from the bone, cartilage, connective tissue, as well as larger outer layers of fatty tissue. Fats are, in addition to protein, the most important component of meat. (Rede and Petrović, 1997; Toldrá, 2010; Benedini et al. 2012). For a more complete utilization of meat proteins, and to fully satisfy the body needs for all amino acids meal should be prepared from diverse sources of proteins. At least half of the protein in the daily ration should be of animal origin (Grujić, 2006). The temperature's height in the middle of the piece of meat during heat treatment, affects the change in proteins. As a result of changes in the structure of proteins there is a change of textural, sensory properties of meat and cook loss. The final effect is different acceptability of finished products by consumers (Thornberg, 2005).

Meat has property to hold water under exposure to force and it is referred as water holding capacity (WHC). This property of meat should be distinguished from swelling properties, which is spontaneous absorption of water from the surrounding fluid with the effect of increasing of mass and volume. The main carriers of water binding in muscle are myofibrillar proteins, certainly due to their specific chemical structure. About 50% of the water holding capacity is conditioned by this type of protein, while the remaining percentage of water holding capacity mostly refers to sarcoplasmic proteins (Radetić, 2000). About 90% of the total water is within the muscle proteins and the remaining 10% retained connective tissue (Hamm, 1978; Murphy and Marks, 2000; Caine et al. 2003).

Depending on the proximity of the water molecules to the muscle proteins and of the properties of the protein, the water is bound in the meat, as follows: tightly and loosely bound, immobilize fully and as free water. Tightly bound water in proteins, in mono and multimolecules layer is referred also as the hydration water. This water has a lower solubility, lower freezing point, it is much more difficult to translate into ice during freezing of meat and is released by cooking, thus significantly affects the properties of the meat. Loosely bound water in the muscle is about 10% all water. This water is retained with the muscle proteins in the form of a "lattice" which formation is induced by nonpolar groups of muscle proteins. Immobilized and completely free water makes the rest of around 80% water content in the meat. Immobilized water has a lower solubility, as well as partially restricted mobility of the water molecules. It is hard to withdrawn sharp distinction between the loosely bound water and immobilized water, under certain conditions transition from one state to another is possible (Rede and Petrović, 1997; Leo and Toldrá, 2009).

Very important parameter of the processed meat during heat treatment is a cook losses. During this process, moisture content of the thermally treated product is greatly reduced. Cook loss of heat treatment occurs due to loss of moisture in the form of liquid or in the form of steam. Above 70°C cook loss of heat treatment significantly increases. Cook losses of thermal evaporation process can be significantly reduced with increased relative humidity in the oven or if temperature is maintained below 65°C. Boles and Swan (2002b) found that if meat is maintained with slightly higher pH during storage in the refrigerator, cook loss during heat treatment decreases (Drummond and Sun, 2006; Toldrá, 2010).

The main objective of this work was to investigate the impact of temperature and which one of the two methods of thermal processing has a greater impact on cook loss of thermally processed M. Longissimus dorsi of pork. Consequently, in order to determine the optimal conditions of heat treatment, the meat is treated at different temperatures in a given temperature range from 50°C to 100°C by dry method (roasting) and by cooking in water (at atmospheric pressure). Obtained results are very useful for the prediction of sensory texture for both in cooked meat and in roasted meat products.

Materials and methods

Samples and sample preparation

The study was conducted on the pork meat, reared on a modern farm in Bosnia and Herzegovina. Animals were under one year of age and had an average gross weight of about 130-140 kg. The animals were slaughtered in the usual manner and under identical conditions. After that, the carcasses were subjected to an identical procedure of primary treatment. After cooling during 24 hours, from six pork carcasses back muscles are stripped (Longissimus Dorsi). These pieces of muscle were frozen and cut into slices thickness 1,5-2,0 cm. After labeling, the samples were packed in polyethylene bags and frozen at a temperature of -30°C and kept at that temperature until the moment of testing. Samples were packed in sealed boxes and transferred to the laboratory where they were analyzed. By analyzing time, samples are stored at freezing temperatures, and were thawed before testing; so they were kept overnight in a refrigerator at temperature 4-5 °C.

Heat treatment of samples

Thawed samples were subjected to wet and dry heat treatment. Dry heat treatment was carried out by roasting (slices thickness 1,5-2,0 cm) in oven type „Elit“ 3kW. The samples were heated to achieve desired temperature in the center of sample. The air temperature in the oven during all the experiment was

163±2°C. Temperature in the oven and the temperature in the center of the sample was continuously monitored using a dual-channel thermocouple „TESTO" and „HANNA" HI 98810, from -50 °C to +250 °C. Wet heat treatment is carried out in a water bath. Before putting in water, samples were wrapped in thermosetting plastic bags in absence of air, and then heated to achieve the desired temperature in the center of the sample. The temperature is continuously monitored using a dual-channel thermocouple „TESTO" and „HANNA" HI 98810, from -50 °C to +250°C. In the both tests, samples were treated at 50°C,60°C, 70°C, 80°C, 90°C and 100°C.

Determination of thawing drip loss

Samples of meat (sliced) from left and right side of carcass were weighted before and after thawing. Slices were placed on a plastic tray covered with clear plastic wrap and thawed during 24 hours in a refrigerator at 4-5°C. After thawing slices were transferred to the white paper foil in order to absorb surface bound water, retained in this film for another hour at 4-5°C and reweighted. Cook loss of thawing is calculated as the percentage mass loss after thawing.

$$L, D(\%) = \frac{m_1 - m_2}{m_1} 100$$

m_1 – Weight of frozen meat
m_2 – Weight of thawed meat

Determination of cook loss

After meat thawing and determining the mass of slices to determine cook loss of thawing, the samples were heat-treated in a given temperature range and by the wet and dry process. The input data for the determination of cook loss of heat treatment is mass slice after thawing. The obtained result is calculated and expressed as a percentage of mass loss after heat treatment.

$$L, D(\%) = \frac{m_2 - m_3}{m_2} 100$$

m_3 – Weight of heat treated meat at a given temperature.

Statisitcs and data analysis

The experiment was a completely randomized design with four replications. Data were subjected to PCA analysis, analysis of variance (ANOVA), and means were separated by Duncan's multiple range test at $p<0.05$; $p<0.01$; $p<0.001$ significance level.

Results and discussion

Results

Cook and thawing drip loss

In Figure1, Figure 2 and Figure 3 are presented results of PCA analysis for thawed samples, samples processed by cooking and by roasting in the observed temperature range in the center of the sample from 50 ˚C to 100 ˚C.

Table 1. Correlations between variables and factors for thawed samples

	F1	F2
L (%)	0,8509	-0,5254
D (%)	0,7926	0,6098
Average L+D (%)	0,9995	0,0302
Eigenvalue	3,0407	0,9607
Variability (%)	75,9918	24,0082

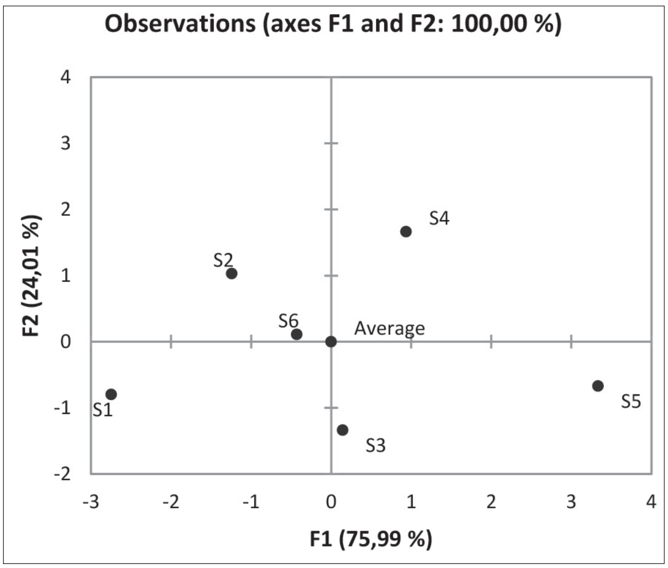

Figure 1. "Biplot" major components (F1-drip loss and F2-water binding) in the PCA analysis for thawing drip loss

Table 2. Correlations between variables and factors for roasted drip loss samples

	F1	F2
L (%)	0,9962	-0,0875
D (%)	0,9955	0,0948
Average L+D(%)	1,0000	0,0015
Eigenvalue	201,6254	1,1240
Variability (%)	99,4456	0,5544

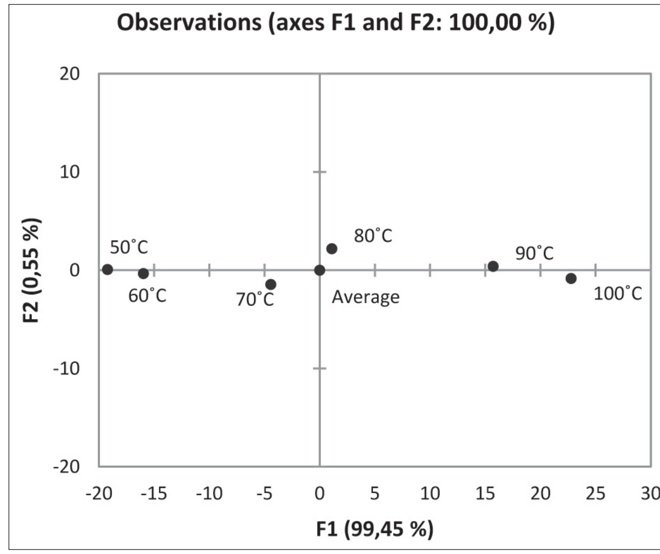

Figure 2. "Biplot" major components (F1-drip loss and F2-water binding) in the PCA analysis for roasted drip loss

Table 3. Correlations between variables and factors for cooked loss samples

	F1	F2
L (%)	0,9972	0,0742
D (%)	0,9983	-0,0580
Average L+D(%)	1,0000	0,0032
Eigenvalue	119,8486	0,3445
Variability (%)	99,7133	0,2867

L (%) - Average drip, cook loss for muscle from left side of carcass

D (%) - Average drip, cook loss for muscle from right side of carcass

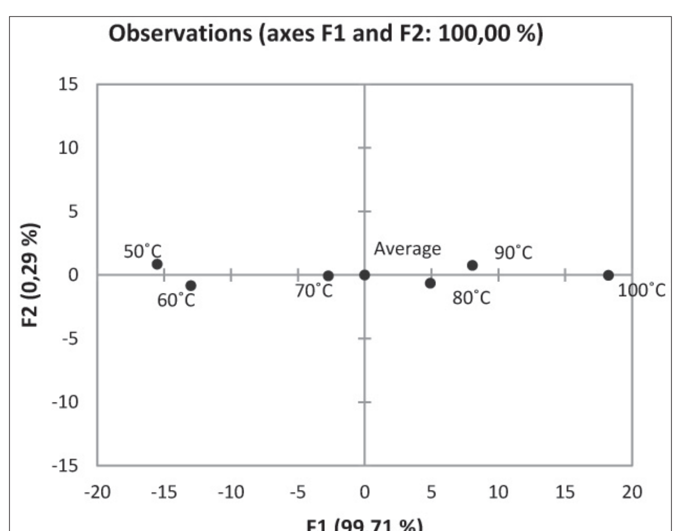

Figure 3. "Biplot" major components (F1-drip loss and F2-water binding) in the PCA analysis for cook loss

Discussion

As it can be seen from the results of PCA analysis in the previous three diagrams vector F1 strongly correlated results pertaining to the cook loss with increasing temperature during heat treatment, observed for both applied procedures. Vector F2 correlate the results pertaining to the water binding of heat-treated meat samples. From Figure 1 it is clear that vectors F1 and F2 are almost equally correlated, as can be seen from Table 1. Since, there was no heat treatment, the greater loss of liquid phase is a consequence of thawing before heat treatment and protein stability in frozen meat samples, therefore correlation is almost the same for all the observed samples. Compared to Figure 1, the value of cook loss during heat treatment (Figure 2 and Figure 3) is strongly correlated with the vector F1 with increasing temperature for both heat treatment (cooking and roasting). With increasing temperature of heat treatment the intensity of correlation increases. Mean values of observed parameters are generally significantly higher ($p<0.001$) for samples processed by dry heat treatment (roasting), compared to those treated with wet heat treatment by cooking in the observed temperature range.

Grujić (1989); Murphy et al. (2001); Boles et al. (2002b) reported that the decreasing of temperature during storage of meat, corresponds to a reduction in the total cook loss during heat treatment. Thus, according to Grujić (1989) on the sample of meat stored at -30 °C, then thawed and heat treated to the temperature at the center of the sample around 95 °C, the total cook losses were around 40% to 42% (Grujić 1989); Murphy et al. 2001); Boles et al. 2002b). From the above, it is clear that the increasing of heat treatment temperature in the center of the samples, leads to a statistically significant increasing ($p<0.001$) of mean values for observed parameters. The intensity of the increase for samples processed by roasting heat treatment was significantly higher ($p<0.01$) than for samples processed by cooking heat treatment. In the temperature range from 60˚C to 80˚**C** there are clearly distinguishable trends of increasing in intensity of observed parameters, compared to before and after this interval. As described by Barbieri and Rivaldi (2008), Bouton et al. (1981), this is caused by changes in the proteins structure, because in this interval denaturation on myofibrillar proteins is the most intense, caused by the decomposition of myofibrillar structure. This decomposition causes an increase in the secretion of liquid phase and samples mass loss during heat treatment (Thornberg, 2005; Supaluk et al. 2013).

According to the Bouton et al. (1981), changes in rheological properties and cook loss with temperature increasing are directly related to changes in the proteins (myofibrillar and connective tissue proteins). Heating leads to softening of connective tissue caused by gelling of collagen and increasing the toughness of muscle fibers, caused by thermal coagulation of myofibrillar proteins. Barbieri and Rivaldi (2008) indicate that water holding capacity of the meat is directly dependent on changes in the proteins during heat treatment. Between 60 °C and 80 °C decomposition of myofibrillar structure and increased secretion of the liquid phase happens. According Thornberg (2005) and Toldrá (2010) increase in temperature during the heat treatment leads to increased secretion of fluids in order to form a liquid phase for evaporation. This process for the end result has decrease in moisture content in the sample with increasing temperature of a heat treatment. Reducing moisture in the sample has for direct consequence the reduction of water activity as temperature increased in meat samples. (Thornberg, 2005; Toldrá, 2010).

Conclusions

Presented results of cook loss in this paper, showed a constant increase with increasing temperature during the heat treatment. Increasing of observed parameters is statistically significantly higher ($P<0.05$) in samples processed by roasting than in samples processed by cooking heat treatment. In the temperature range between 60˚C and 80˚C there is a significant ($p<0.01$) increase in the values of observed parameters. The optimal temperature in the center of the sample, during the heat treatment of this type of meat is in the temperature range between 70˚C and 80˚C. Below 70˚C, according to the instructions from the American Meat Science Association (1995), thermal treatment is not suitable because of insufficient microbiological safety of thermally processed meat products. Above 80˚C, samples do not satisfy in terms of cook loss, due to the lost significant amounts of liquids, treated samples above this temperature do not meet the terms of sensory and textural properties. In the temperature range between 60˚C to 80˚C, heat treatment by cooking gave products more balanced and favorable cook loss, considered in relation to the thermal treatment by roasting.

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