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COMPARISON OF TEXTURE, COOKING LOSSES AND DEGREE OF SHRINKAGE OF GRILLED STEAKS FROM BOVINE *LONGISSIMUS DORSI* AND *SEMITENDINOSUS* MUSCLES*

PORÓWNANIE TEKSTURY, UBYTKÓW CIEPLNYCH I STOPNIA KURCZLIWOŚCI GRILLOWANYCH STEKÓW WOŁOWYCH Z MIĘŚNI *LONGISSIMUS DORSI* I *SEMITENDINOSUS*

Summary. The aim of the study was to compare the grilled steaks prepared from bovine *longissimus dorsi* (LD) and *semitendinosus* (ST) muscles in terms of texture, cooking losses and degree of shrinkage and to determine if there were any relationships between these attributes and moisture and fat content in raw muscles. Cooking losses and degree of shrinkage were determined 5, 10 and 20 min after the thermal treatment. There were no significant differences between raw steaks prepared from LD and ST muscles in terms of moisture and fat content. Higher cooking losses and degree of shrinkage were noted for ST muscle. The steaks from selected muscles did not differ in hardness, adhesiveness, gumminess, but higher values of springiness, cohesiveness and chewiness were noted for ST muscle steaks. The size of cooking losses was affected only by type of muscle, whereas shrinkage was affected by type of muscle and time after the thermal treatment. No relationships between moisture and fat content, texture parameters, cooking losses and shrinkage were noted, whereas a significant correlation between shrinkage and cooking losses determined 10 and 20 min after the thermal treatment was found.

Key words: bovine muscles, grilled steaks, degree of shrinkage, cooking losses, texture analysis

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Introduction

When purchasing meat, consumers decide about a portion size, which determines the cost. However, during thermal treatment of meat both shrinkage and cooking losses occur. Cooking losses range from 20 to 50% (BERTRAM et AL. 2004, MODZELEWSKA-KAPITUŁA et AL. 2012). In places such as restaurants when many consumers are placing orders at the same time, dishes, such as steaks, are often not served immediately after their thermal treatment. Thus, it is interesting to learn if the time that passes after the termination of thermal treatment affects shrinkage and cooking loss of beef steaks.

Beef carcass muscles differ in tenderness which is caused by differences in their location in carcass, activity during animal's life, muscle structure and composition, particularly concentration of connective tissue proteins (BELEW et AL. 2003). The most suitable cut for steaks is sirloin (*m. rectus femoris*), however because of its high price, cheaper cuts are also chosen e.g. ribeye (*m. longissimus dorsi*) or eye of round (*m. semitendinosus*). The *longissimus dorsi* and *semitendinosus* muscles differ in their location in beef carcass, the first being loin and the latter being round muscle, but also in fat content and texture (JEREMIAH et AL. 2003, RHEE et AL. 2004) and that is why they were chosen as material to study changes in shrinkage and cooking losses after the thermal treatment.

Cooking loss and shrinkage enable to determine production yield and its profitability and are correlated with some of sensorial traits of meat products, such as juiciness (BARBERA and TASSONE 2006). Until recently, to determine meat area shrinkage manual methods subjected to substantial measurement error were applied, however, currently there is a possibility to use Computer Vision System (CVS) to estimate shrinkage (ZHENG et AL. 2006, VELIOĞLU et AL. 2010). The method is objective, accurate and gives repeatable results (JACKMAN et AL. 2009). Nowadays also chemical composition of beef can be determined quickly, in less than 1 min using NIT (Near Infrared Transmittance) analysers (EFEKTYWNA KONTROLA... 2007) and it can be done by meat producers in meat processing plants. Having the knowledge about relationship between fat and moisture content and cooking losses, shrinkage and texture it will be possible for raw steaks producers to guarantee certain portion size or tenderness of grilled steaks. Although, there are many reports concerning beef quality, still the relationships between moisture and fat content and texture of bovine meat and cooking loss and shrinkage are not fully recognised.

The aim of the study was to compare two bovine muscles: *m. longissimus dorsi* and *m. semitendinosus* in terms of texture, cooking losses and shrinkage and to determine if there was any relationship between these attributes and moisture and fat content in raw muscles. Also changes of cooking losses and shrinkage in time that passed after termination of thermal treatment were analysed.

Material and methods

Longissimus dorsi (LD, n = 4) and *semitendinosus* (ST, n = 4) muscles were obtained from four carcasses of cattle (17- to 19-month old, carcass weight 250-300 kg) 96 h *post mortem*. The muscle used in the study came from the cross-breed animals (different proportions of dairy vs. beef breeds) that were slaughtered in a commercial plant located in northern Poland. The muscles were transported under refrigeration to the laboratory of Department of Meat Technology and Chemistry and processed within 24 h.

Moisture and fat content was determined in each raw muscle. Moisture was determined using the oven drying method (PN-ISO1442:2000), drying the samples at 103 ±2°C to obtain constant weight. Fat content was determined by extracting fat with petroleum ether according to Soxhlet method (PN-ISO 1444:2000). Analyses were conducted in triplicate for each muscle (n = 12).

From each muscle three 2-cm thick steaks (n = 12) were cut perpendicularly to the muscle long axis. The steaks were subjected to the thermal treatment on a table electric grill (TSK–2702, EUPA Tsann, Beijing Century Tian Jian Technology Co. Ltd., Pekin, China) to obtain 60°C. The temperature was monitored by a digital thermometer (DIGI--TERMO WT-2, Suzhou Jingle Electronics Technology Co. Suzhou, Jiangsu, China). The surface temperature of electric grill was about 185°C. After termination of cooking steaks were placed in plates and kept at a room temperature (about 21°C) and sampled after 5, 10 and 20 min.

Shrinkage was determined using CVS on images of steaks (n = 48), which were taken just before and 5, 10 and 20 min after thermal treatment. Steaks were placed on green background and photographed with a digital camera (FinePix M603, Fujifilm, Tokyo, Japan) located vertically on a photographic bench at a distance of 30 cm from the samples using standard light conditions (fluorescent light). The area of steaks (cross-section of a muscle) was determined in NIS Elements Br 2.20 (Nikon Corporation, Tokyo, Japan) and expressed in square centimeters. Shrinkage was calculated based on the difference between raw and cooked steaks area and expressed in percentage. To determine cooking loss steaks were weighted before and 5, 10 and 20 min after thermal treatment.

Texture profile analysis (TPA) was performed by the twofold compression method using TA-XT2i (Stable Micro System, Godalming, UK). Samples cut from cooled steaks (about 10°C) parallely to muscle fibers with square cross-section (10 × 10 × 10 mm) were subjected to double compression to 50% of their height, using a piston 75 mm in diameter, at a velocity of 5 mm/s. Such attributes as: hardness (N), adhesiveness (N·s), cohesiveness (dimensionless), springiness (cm), gumminess (N/cm^2), chewiness (N/cm) were measured. From steaks prepared from each muscle at least six samples were analysed.

Statistical analysis was performed using Statistica 8.0 (StatSoft Inc.). Prior to means comparing assumptions of normal distribution of data and homogeneity of variance were tested with Shapiro-Wilk's and Levene's tests, respectively. When both assumptions were met further analyses were made. To compare three groups of means variance analysis was applied. After obtaining significant values of F statistic, Duncan's test was conducted. To compare two groups of means t-Student's test for independent samples was used. When the assumption concerning normal distribution of data was not fulfilled, nonparametric Mann-Whitney's test was applied. Whereas, if there was normal distribution of data, there was no variance homogeneity, Welch's test was used. To evaluate the effect of time after the thermal treatment and muscle type on shrinkage and cooking loss multiple factors Anova was used. Correlation coefficients (r) between moisture, fat in raw meat and texture parameters, shrinkage and cooking loss, as well as between texture parameters and shrinkage and cooking loss were calculated using General Linear Models (GLM). Significance was set at α = 0.05.

Results and discussion

Bovine LD and ST muscles contained about 75.0 and 76.1% of moisture and 2.3 and 0.8% of fat, respectively. Moisture and fat content in the muscles was in agreement with previous reports (ŚMIECIŃSKA and WAJDA 2008, DASZKIEWICZ et AL. 2009, BRUGIAPAGLIA and DESTEFANIS 2012). Similar moisture and fat content in LD and ST muscles was noted by NOWAK et AL. (2005), whereas ZAJĄC et AL. (2011) found lower moisture and higher fat content in LD than in ST muscle.

The thermal treatment of beef steaks from LD and ST muscles caused shrinkage of their area and cooking losses (Table 1). The size of cooking losses was affected by type of muscle (P < 0.05), whereas time that passed after termination of the thermal treatment did not affect cooking losses. The average cooking losses of the steaks prepared from ST and LD muscles were 22.3% and 28.5%, respectively. In each sampling time (5, 10, 20 min after the thermal treatment) the size of cooking losses of the steaks prepared from ST muscle was higher (P < 0.05) as compared to LD muscle (Table 1). Similar findings were noted for LD muscle in earlier studies (MODZELEWSKA-KAPITUŁA and CIERACH 2009).

Table 1. Degree of shrinkage and cooking losses of grilled steaks from selected bovine muscles analysed 5, 10 and 20 min after the thermal treatment (%)
Tabela 1. Stopień kurczliwości i wielkość ubytków cieplnych grillowanych steków z wybranych mięśni bydlęcych analizowanych po 5, 10 i 20 min od zakończenia obróbki cieplnej (%)

Attribute Wyróżnik	Time after thermal treatment Czas od zakończenia obróbki cieplnej		
	5 min	10 min	20 min
Shrinkage Stopień kurczliwości			
M. longissimus dorsi	10.0 ±5.6^{bA}	13.0 ±5.8^{bA}	15.3 ±5.3^{bA}
M. semitendinosus	16.7 ±3.8^{aA}	20.4 ±4.1^{aB}	22.9 ±3.6^{aB}
Cooking losses Ubytki cieplne			
M. longissimus dorsi	21.5 ±5.0^{bA}	22.4 ±4.9^{bA}	22.9 ±4.8^{bA}
M. semitendinosus	27.6 ±3.7^{aA}	28.7 ±3.0^{aA}	29.2 ±2.9^{aA}

Means in rows designated with different big letters differ at P < 0.05.
Means in columns designated with different small letters differ within each attribute at P < 0.05.
Średnie w rzędach oznaczone różnymi dużymi literami różnią się przy P < 0,05.
Średnie w kolumnach oznaczone różnymi małymi literami różnią się w obrębie danego wyróżnika przy P < 0,05.

Both, the type of muscle and time after thermal treatment significantly ($P < 0.05$) affected shrinkage of steaks (Table 1). Shrinkage of the steaks prepared from LD muscle was significantly lower as compared to the steaks from ST muscle. The area of grilled ST muscle steaks decreased by about 16.7 to 22.9% (5 and 20 min after the thermal treatment, respectively), and LD muscle steaks by about 10.0 to 15.3% (Table 1) as compared to the raw steaks. BARBERA and TASSONE (2006) noted that shrinkage increased in the time of cooling meat after the thermal treatment (10 to 90 min) and is caused by moisture evaporation, which is affected by temperature and humidity.

The beef steaks from LD and ST muscles did not differ in hardness, adhesiveness, gumminess, but higher ($P < 0.05$) values of springiness, cohesiveness and chewiness were noted for steaks obtained from ST muscle (Table 2). Results obtained are partly in agreement with findings of ZAJĄC et AL. (2011) who noted that grilled steaks from ST muscle had higher values of all texture parameters as compared to steaks from LD muscle. The differences between results of the present study and reported by ZAJĄC et AL. (2011) may be caused by a higher homogeneity of raw material tested by ZAJĄC et AL. (2011) originating from lowland back-white heifers than used in the present study.

Table 2. Texture parameters (TPA test) of grilled steaks from selected bovine muscles
Tabela 2. Parametry tekstury (test TPA) grillowanych steków z wybranych mięśni bydlęcych

Attribute Wyróżnik	Muscle – Mięsień	
	M. longissimus dorsi	*M. semitendinosus*
Hardness (N) Twardość (N)	28.38 ±9.29^{A}	29.01 ±5.40^{A}
Adhesiveness (N·s) Adhezyjność (N·s)	–3.86 ±3.44^{A}	–3.78 ±3.65^{A}
Springiness (cm) Sprężystość (cm)	0.58 ±0.06^{B}	0.64 ±0.06^{A}
Cohesiveness Kohezyjność	0.58 ±0.04^{B}	0.61 ±0.04^{A}
Gumminess (N/cm^2) Gumiastość (N/cm^2)	16.52 ±5.47^{A}	17.67 ±3.53^{A}
Chewiness (N/cm) Żujność (N/cm)	9.73 ±3.67^{B}	11.43 ±2.87^{A}

Means in rows designated with different letters differ at $P < 0.05$.
Średnie w rzędach oznaczone różnymi literami różnią się przy $P < 0,05$.

Correlation coefficients between moisture and fat content and size of cooking losses, degree of shrinkage and texture parameters are shown in Table 3. Moisture content in raw meat was strongly ($r > 0.5$) positively correlated with hardness, gumminess and chewiness, whereas fat content negatively with hardness, springiness, gumminess and chewiness. Statistically significant ($P < 0.05$) correlations were noted only between fat content and hardness ($r = –0.71$), gumminess ($r = –0.75$) and chewiness ($r = –0.71$).

Table 3. Correlation coefficients (r) between moisture and fat content in raw meat and degree of shrinkage, cooking losses and texture parameters (TPA test) of grilled steaks from selected bovine muscles
Tabela 3. Współczynniki korelacji (r) pomiędzy zawartością wody i tłuszczu w mięsie surowym a stopniem kurczliwości, wielkością ubytków cieplnych i parametrami tekstury (test TPA) grillowanych steków z wybranych mięśni bydlęcych

Attribute Wyróżnik	Moisture Woda	Fat Tłuszcz
Degree of shrinkage 5 min after thermal treatment Stopień kurczliwości po 5 min od zakończenia obróbki cieplnej	0.12	0.09
Degree of shrinkage 10 min after thermal treatment Stopień kurczliwości po 10 min od zakończenia obróbki cieplnej	0.09	0.09
Degree of shrinkage 20 min after thermal treatment Stopień kurczliwości po 20 min od zakończenia obróbki cieplnej	0.10	0.08
Cooking losses 5 min after thermal treatment Ubytki cieplne po 5 min od zakończenia obróbki cieplnej	0.50	–0.38
Cooking losses 10 min after thermal treatment Ubytki cieplne po 10 min od zakończenia obróbki cieplnej	0.38	–0.30
Cooking losses 20 min after thermal treatment Ubytki cieplne po 20 min od zakończenia obróbki cieplnej	0.38	–0.38
Hardness Twardość	0.58	–0.71*
Adhesiveness Adhezyjność	–0.28	0.37
Springiness Sprężystość	0.44	–0.54
Cohesiveness Kohezyjność	0.25	–0.13
Gumminess Gumiastość	0.67	–0.75*
Chewiness Żujność	0.60	–0.71*

*Correlation significant at $P < 0.05$.
*Korelacja istotna przy $P < 0,05$.

Also ZAJĄC et AL. (2011) reported negative correlation between fat content and hardness ($r = –0.63$), springiness ($r = –0.41$) and chewiness ($r = –0.61$) of grilled beef. Correlation coefficients between the size of cooking loss, degree of shrinkage and texture parameters ranged from 0.0 to 0.67. Strong correlation ($r > 0.5$) was noted between springiness and cooking loss evaluated 10 and 20 min after the thermal treatment ($r = 0.57$ and $r = 0.65$, respectively), cohesiveness and shrinkage evaluated 5, 10 and 20 min after the thermal treatment ($r = 0.62$, $r = 0.65$, $r = 0.65$, respectively) and between cooking loss 20 min after the thermal treatment and chewiness ($r = 0.67$). However, the correlations were not of statistical significance. No significant correlations were noted between cooking loss and shrinkage 5 min after the thermal treatment. However, there were significant correlations between cooking loss and shrinkage 10 and 20 min after the thermal treatment ($r = 0.48$, $P < 0.05$ and $r = 0.46$, $P < 0.05$, respectively). WYRWISZ et AL. (2012) noted a weak correlation ($r = 0.28$) between cooking loss of grilled steaks and shrinkage of their area. In the case of steaks subjected to frying and roasting the correlation was stronger ($r = 0.88$ and $r = 0.80$, respectively). The differences between the results obtained in the present study and reported by WYRWISZ et AL. (2012) might be caused by different supplies used for the thermal treatment (table grill vs. contact grill with top and bottom heating areas). Shrinkage is also affected by final temperature of meat. Myosin starts to denature at 40°C, which demonstrates in transversal shrinkage of meat, in the range of 55 to 60°C collagen fibers shrinkage occurs. During heating of meat at the range of 60 to 70°C collagen fibers shrink to 25% of their initial length (TORNBERG 2005). At about 60°C longitudinal shrinkage of muscles starts (BERTRAM et AL. 2004). In the present study steaks were heated to 60°C, whereas WYRWISZ et AL. (2012) heated steaks to 70°C, which caused differences in noted relationships.

Conclusions

1. The muscle from which steaks were prepared influenced the size of cooking losses, shrinkage and texture. Steaks from *longissimus dorsi* muscle showed lower shrinkage, cooking losses, springiness, cohesiveness and chewiness, as compared to steaks from *semitendinosus* muscle. Thus *longissimus dorsi* muscle is a better choice as a material for steaks.

2. Fat content in beef was significantly negatively correlated with hardness, gumminess and chewiness, and that is why meat with higher content of fat should be chosen for steaks to satisfy sensorial requirements of consumers.

3. The time that passed after termination of the thermal treatment had a significant ($P < 0.05$) influence on *semitendinosus* muscle shrinkage, thus steaks prepared from this muscle should be served immediately after the treatment.

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PORÓWNANIE TEKSTURY, UBYTKÓW CIEPLNYCH I STOPNIA KURCZLIWOŚCI GRILLOWANYCH STEKÓW WOŁOWYCH Z MIĘŚNI *LONGISSIMUS DORSI* I *SEMITENDINOSUS*

Streszczenie. Celem pracy było porównanie grillowanych steków przygotowanych z bydlęcych mięśni *longissimus dorsi* (LD) i *semitendinosus* (ST) pod względem parametrów tekstury, ubytków cieplnych oraz stopnia kurczliwości, jak również stwierdzenie, czy występują korelacje pomiędzy tymi wyróżnikami a zawartością wody i tłuszczu w mięsie surowym. Ubytki cieplne i stopień kurczliwości określano po 5, 10 i 20 min od zakończenia obróbki cieplnej. Surowe mięśnie LD i ST nie różniły się pod względem zawartości wody i tłuszczu. Większe ubytki cieplne i wyższy stopień kurczliwości odnotowano w przypadku mięśnia ST. Steki z badanych mięśni nie różniły się pod względem twardości ani gumiastości czy adhezyjności. Większe wartości sprężystości, kohezyjności i żujności odnotowano w przypadku steków z mięśnia ST niż z LD. Wielkość ubytków cieplnych była uzależniona od rodzaju mięśnia, a stopień kurczliwości – od rodzaju mięśnia i czasu, jaki upłynął od zakończenia obróbki cieplnej. Nie stwierdzono istotnych zależności pomiędzy zawartością wody, tłuszczu, parametrami tekstury a wielkością ubytków cieplnych i stopniem kurczliwości, odnotowano natomiast, że stopień kurczliwości oznaczony po 10 i 20 min od zakończenia obróbki cieplnej był skorelowany z wielkością ubytków cieplnych.

Słowa kluczowe: mięśnie bydlęce, grillowane steki, stopień kurczliwości, ubytki cieplne, analiza tekstury

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