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INFLUENCE OF CUT AND THERMAL TREATMENT ON CONSUMER PERCEPTION OF BEEF IN POLISH TRIALS

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Aim of study was to evaluate influence of cut and thermal treatment on consumer's perception of beef, measured according to MQ4 scheme, in Polish trials conducted for 13 cuts and 3 methods of thermal treatment. 30 carcasses, representing various genders and types of production, were chosen. 540 samples were cooked using three cooking methods (180 samples for grill, roast and slow cook). Consumers rated the tenderness, juiciness, flavor, overall acceptability (in 100-mm scale), and satisfaction (from 2 to 5), according to the MSA protocol. The MQ4 score was calculated using linear discriminant analysis. Quality of Polish beef meat from cross breeding depends on cut and thermal treatment, as well as both factors combined. Cut being perceived by Polish consumers as the best one is tenderloin, characterized by only juiciness comparable with other cuts (oyster blade, rump). Tenderness of Polish beef, being important for consumers is simultaneously not sufficient and lower than in other countries that results in low general quality of beef. General quality of beef meat may be improved by proper choice of thermal treatment – being especially important in the case of juiciness of striploin, outside flat and topside, as well as tenderness and flavor.
Keywords: Beef, quality score, meat standard, thermal treatment

INTRODUCTION

Nowadays, it is observed, that the consumption of raw beef in Poland for over 10 years has maintained at a constant low level, being lower than 5 kg per capita per year, although in 1990 it exceeded 15 kg per capita per year (GUS, 2012). Simultaneously, the total meat consumption in Poland is higher than 78 kg per capita per year, being similar as in the United Kingdom, Germany, Greece and Brasil (FAO, 2004). It may be concluded, that beef has been replaced by the meat of other slaughtered animals – pork and poultry meat. Similar situation is observed in other countries all over the world where beef production farms tend to be unprofitable – e.g. Czech Republic, Hungary, Australia or Namibia (Deblitz *et al.,* 2005).

Observed situation may result from various factors, among which are, *inter alia*, unsatisfactory quality of beef available on the market (Legrand *et al.,* 2012) accompanied by high prices (Gutkowska *et al.,* 2013). Moreover, consumers do not have the knowledge of the optimal method of thermal treatment for beef and how long should thermal treatment last, e.g. only 13% of respondents know the recommended internal temperature for ground beef (Phang and Bruhn, 2011). Chosen thermal treatment should be dependent on the type of cut that determines, *inter alia*, fat and connective tissue content and nutritional value of meat (Karolyi *et al.,* 2008). Knowledge about optimum methods of thermal treatment in relation to cut is very important – in the case of steaks preparation it is crucial in consumers' preferences (Behrends *et al.,* 2005), so higher consumer satisfaction may be achieved by choosing better method for specified cut.

In countries where the beef meat industry is well developed, a consumer purchasing a cut of beef can, simultaneously, obtain information about which thermal treatment is this cut dedicated for, and how it should be conducted, thanks to which customers get a higher satisfaction with the consumption of beef, which translates directly into an interest in this kind of meat (Polkinghorne *et al.,* 2013). An example of such a country may be Australia, where a meat grading system – Meat Standards Australia (MSA) was designed and developed, which provides complete information on beef quality (Polkinghorne *et al.,* 2008). Under the scheme, an indicator of the quality of beef – MQ4 (meat quality) score was developed, which provides the consumer with information on the quality characteristics of a

given cut, depending on the applied thermal treatment (Lyford *et al.,* 2010).

The aim of the present study was to evaluate the influence of cut and thermal treatment on the consumer perception of beef meat, measured according to MQ4 scheme, in Polish trials conducted for 13 cuts and 3 methods of thermal treatment.

MATERIAL AND METHODS

***Sample preparation*:** Thirty carcasses were selected on a cutting line, and 13 cuts were obtained from each carcass, one day after slaughter. Chosen cuts were: *Psoas major* from tenderloin (TDR062), *Longissimus dorsi* from striploin (STR045), *Infraspinatus* from oyster blade (OYS036), *Triceps brachii caput longum* from blade (BLD096), *Biceps femoris* from rump (RMP005), *Gluteus medius* from rump – two parts (RMP131, RMP231), *Rectus femoris* from knuckle (KNU066), *Vastus lateralis* from knuckle (KNU099), *Biceps femoris* from outside flat (OUT005), *Gracilis* from topside (TOP033), *Semimembranosus* from topside (TOP073), *Serratus ventralis cervicis* from chuck (CHK078) – the codes of the cuts are on the basis of the of MSA Standards (MSA, 2005).

Carcasses represented various genders and types of production, adequately to the variation in Polish beef production (beef bulls, dairy bulls, heifers and cows), as well as various breeds (crossbreeds of Holstein-Friesian, Limousine, Belgian Blue, Charolaise or Hereford sires with Holstein-Friesian dames or individuals with not specified breed) and age (12-156 months).

540 samples were cooked using three cooking methods (180 samples for each method – grill, roast and slow cook). The basic meat composition was determined in previous study (Guzek *et al.,* 2014).

Detailed protocols for the consumer tests have been described by Watson *et al.* (2008a). Polish consumers representing a wide demographic range were recruited by the Warsaw University of Life Sciences (WULS - SGGW) and attended sensory test sessions at the University. Consumers rated the tenderness, juiciness, flavor, overall acceptability (100 mm graphic unstructured line scale), and satisfaction (unsatisfactory/2-star, good everyday/3-star, better than everyday/4-star, and premium quality/5-star) for analyzed samples.

The MQ4 score was calculated using linear discriminant analysis as described by Watson *et al.,* (2008b), as in the MSA prediction model (Polkinghorne *et al.,* 2008; Watson *et al.,* 2008b). The MQ4 score was calculated by weighting tenderness, juiciness, flavor and overall acceptability by 0.3, 0.1, 0.3 and 0.3 respectively (Hocquette *et al.,* 2014).

***Statistical analysis*:** To verify the normality of distribution, the W Shapiro-Wilk test was conducted. To characterize the influence of the cut and thermal treatment on the tenderness, juiciness, flavor, overall acceptability, MQ4 and satisfaction, the one-way ANOVA/ Kruskal-Wallis ANOVA and two-way ANOVA/ Kruskal-Wallis ANOVA were used. Detailed comparisons between the groups were conducted using the post-hoc Fisher test and post-hoc Dunn test. Level of significance $p \leq 0.05$ was used and level of $p \leq 0.1$, as close to significance was also indicated. In the case of detailed comparisons, only level of significance $p \leq 0.05$ was taken into account. Statistical analysis was conducted using Statgraphics Plus for Windows 4.0 (Statistical Graphics Corporation, Rockville, MD, USA) and Statistica 8.0 (StatSoft, Tulsa, Oklahoma, USA).

RESULTS

The analysis of the influence of cut and thermal treatment on the tenderness, juiciness, flavor, overall acceptability, MQ4 and satisfaction is presented in Table 1. In the case of all analysed factors, influence of either cut or thermal treatment combined or cut alone and thermal treatment alone was proven. Only for overall acceptability, influence of cut and thermal treatment combined was close to significance and influence of thermal treatment was not significant, but according to applied methodology, close to significance relationship was also taken into account.

Table 1. Analysis of the influence of cut and thermal treatment on the tenderness, juiciness, flavor, overall acceptability, MQ4 and satisfaction – in the table p-Values are presented

	Cut	Thermal treatment	Cut × thermal treatment
Tenderness	0.0000[a]	0.0102 [a]	>0.1 [b]
Juiciness	0.0052[a]	0.0000 [a]	0.0002 [b]
Flavor	0.0011[a]	0.0057 [a]	>0.1 [b]
Overall acceptability	0.0001[a]	>0.1 [a]	0.0987 [b]
MQ4	0.0001[a]	0.0260 [a]	0.0492 [b]
Satisfaction	0.0004[a]	>0.1 [a]	0.0080 [b]

[a]Assessed on the basis of one-way ANOVA/ Kruskal-Wallis ANOVA; [b]Assessed on the basis of two-way ANOVA/ Kruskal-Wallis ANOVA

In the case of factors for which was proven the significance of influence of cut and thermal treatment combined, the further detailed comparisons were made between all groups characterized by specified cut and thermal treatment that is presented in Table 2. It was conducted for juiciness, MQ4, satisfaction, and overall acceptability, as for overall acceptability influence of cut and thermal treatment combined close to significance was observed.

In the case of factors for which was not found the significance of influence of cut and thermal treatment combined (tenderness and flavor), the further detailed comparisons were made for cut and thermal treatment

Table 2. Juiciness, overall acceptability, MQ4 and satisfaction of the analyzed samples in a groups characterized by various cuts and methods of thermal treatment (Median values are assessed on the basis of two-way Kruskal-Wallis ANOVA, post-hoc detailed comparisons conducted, p≤0.05)

Cut	Thermal treatment	Juiciness		Overall acceptability		MQ4		Satisfaction	
		Median	Detailed comparisons	Median	Detailed comparisons	Median	Detailed comparisons	Median	Detailed comparisons
TDR062[1]	Grill	70.8	ij	75.8	f	75.7	j	4.07	i
	Roast	74.5	j	72.9	f	74.7	j	3.94	i
STR045[2]	Grill	55.2	defg	52.0	abcde	50.4	bcefgh	3.03	bcdefgh
	Roast	46.2	bc	47.2	ab	45.8	abcde	2.76	abc
	Slow cook	44.0	abc	51.1	abcd	48.0	abcdefh	2.99	abcdefg
OYS036[3]	Grill	68.6	hij	60.2	e	61.0	i	3.39	h
BLD096[4]	Slow cook	46.1	abcd	54.4	bcde	50.8	bcefgh	3.07	cdefgh
RMP005[5]	Grill	63.9	ghi	52.8	bcde	51.6	cefgh	2.94	abcdef
RMP131[6]	Grill	51.7	cdef	52.5	abcde	51.0	abcdefghi	2.94	abcdefgh
	Roast	57.3	defgh	57.5	cde	56.5	fghi	3.21	dfgh
RMP231[7]	Grill	53.8	cdefg	55.9	bcde	54.0	efghi	3.20	defgh
	Roast	57.8	efgh	58.5	cde	58.2	ghi	3.26	dgh
KNU066[8]	Roast	52.1	cdef	53.7	abcde	51.8	bcdefghi	3.01	abcdefgh
	Slow cook	49.6	bcde	56.7	bcde	53.6	cefghi	3.14	bcdefgh
KNU099[9]	Roast	47.3	abcde	47.4	abc	45.2	abcdef	2.81	abcdef
	Slow cook	36.9	ab	44.9	ab	41.0	abd	2.71	abcef
OUT005[10]	Grill	49.0	cde	43.2	a	41.4	ad	2.70	ab
	Roast	50.6	cde	46.1	ab	45.4	abcde	2.80	abcef
	Slow cook	38.3	ab	43.7	a	40.7	a	2.66	a
TOP033[11]	Slow cook	56.0	efg	59.9	de	58.0	gi	3.18	dgh
TOP073[12]	Grill	45.5	abc	46.3	ab	43.3	abcd	2.70	ab
	Roast	48.8	cde	48.7	abc	46.4	abcdef	2.85	abcdef
	Slow cook	37.2	a	46.0	ab	42.3	abd	2.75	abce
CHK078[13]	Slow cook	61.0	fgh	60.7	e	58.5	gi	3.33	gh

*Statistics was conducted by using Kruskal-Wallis one-way ANOVA; [a, b, c] Values marked with different letters in columns differ significantly on the basic of post-hoc Dunn's test criteria for P < 0.05; [1]*Psoas major* from tenderloin; [2]*Longissimus dorsi* from striploin; [3]*Infraspinatus* from oyster blade; [4]*Triceps brachii caput longum* from blade; [5]*Biceps femoris* from rump; [6]*Gluteus medius* from rump (first part);[7]*Gluteus medius* from rump (second part); [8]*Rectus femoris* from knuckle; [9]*Vastus lateralis* from knuckle; [10]*Biceps femoris* from outside flat; [11]*Gracilis* from topside; [12]*Semimembranosus* from topside; [13]*Serratus ventralis cervicis* from chuck

separately. Tenderness and flavor of samples characterized by various cuts are presented on Table 3. The tenderness of the analyzed samples in a groups characterized by various methods of thermal treatment differed between roasting and slow cooking method – it was higher for roasting, on the basis of one-way Kruskal-Wallis ANOVA, while post-hoc detailed comparisons were conducted (p≤0.05). Simultaneously, the flavor of the analyzed grilled samples was higher than for roasting, on the basis of one-way Kruskal-Wallis ANOVA, while post-hoc detailed comparisons were conducted (p≤0.05).

DISCUSSION

The consumer analysis of the beef meat attributes is the promising area of the meat research (Mennecke *et al.,* 2007). In the modern consumer-oriented market, producers must provide meat products meeting consumer demands, by offering product attributes relative to changing consumer preferences (Schroeder and Mark, 2000). For Polish beef consumers, nowadays decisive in the choice of a particular piece of beef are color, general appearance and fat content (Gutkowska *et al.,* 2013). Moreover, the previous analysis conducted in groups of Polish beef consumers, revealed the presence of strong correlations between beef texture attributes (tenderness, juiciness) in the consumer perception (Guzek *et al.,* 2012).

However, for all the countries, taking into account also export possibilities, essential is comparing the obtained results with results of other research conducted in other countries. The MQ4 scheme of consumer analysis was applied not only in Australia (Petherick *et al.,* 2002), but also in France (Legrand *et al.,* 2012), South Africa (Thompson *et al.,* 2010), Korea (Thompson *et al.,* 2008) or Japan (Polkinghorne *et al.,* 2013), so it is possible to compare consumer preferences in various countries.

Table 3. Tenderness and flavor of the analyzed samples in a groups characterized by various cut (Median values are assessed on the basis of one-way Kruskal-Wallis ANOVA, while post-hoc detailed comparisons were conducted, p≤0.05).

Cut	Tenderess		Flavor	
	Median	Detailed comparisons	Median	Detailed comparisons
TDR062[1]	80.0	f	73.9	f
STR045[2]	37.9	abc	52.8	ae
OYS036[3]	61.2	ef	61.9	e
BLD096[4]	44.4	abcd	55.8	ae
RMP005[5]	42.1	abcd	57.3	cde
RMP131[6]	49.0	cde	53.8	bcde
RMP231[7]	51.0	de	57.7	cde
KNU066[8]	48.3	bcd	58.1	bcde
KNU099[9]	33.6	ab	50.3	ac
OUT005[10]	31.4	a	50.0	ab
TOP033[11]	53.0	de	60.5	e
TOP073[12]	31.1	a	50.5	ad
CHK078[13]	54.1	de	61.1	e

*Statistics was conducted by using Kruskal-Wallis one-way ANOVA; [a, b, c] Values marked with different letters in columns differ significantly on the basic of post-hoc criteria for P < 0.05; [1]*Psoas major* from tenderloin; [2]*Longissimus dorsi* from striploin; [3]*Infraspinatus* from oyster blade; [4]*Triceps brachii caput longum* from blade; [5]*Biceps femoris* from rump; [6]*Gluteus medius* from rump (first part);[7]*Gluteus medius* from rump (second part); [8]*Rectus femoris* from knuckle; [9]*Vastus lateralis* from knuckle; [10]*Biceps femoris* from outside flat; [11]*Gracilis* from topside; [12]*Semimembranosus* from topside; [13]*Serratus ventralis cervicis* from chuck

MQ4 indicator is calculated for raw beef meat and is to determine its sensory characteristics after the appropriate thermal treatment. The indicator was developed on the basis of a predictive model which defines the overall quality, based on tenderness, juiciness, flavor and overall acceptability, assessed sensory. Its values range from 0 to 100 and it allows to define the quality of beef as unsatisfactory (not classified), good everyday quality (MSA 3), quality better than everyday (MSA 4) and Premium (MSA 5) (Watson *et al.,* 2008b).

In the Polish research, the MQ4 score was calculated by weighting tenderness, juiciness, flavor and overall acceptability by 0.3, 0.1, 0.3 and 0.3 respectively, as it was weighted in France (Legrand *et al.,* 2013). In the Japanese research it was concluded, that the coefficients may depend on the method of thermal treatment, and for grill the results indicated that consumers rated tenderness as most important (0.30), followed by overall acceptability (0.26), flavor (0.24) and juiciness (0.20) (Polkinghorne *et al.,* 2011). In the Japanese research general calculation was also elaborated – the coefficients for overall MQ4 score for tenderness, juiciness, flavor and overall acceptability were 0.24, 0.15, 0.35 and 0.26 respectively (Polkinghorne *et al.,* 2011).

In the presented research the influence of cut and method of thermal treatment on the consumer perceiving of beef meat was observed, taking into account the fact, that the thermal treatment was conducted to the same temperature in the geometric centre of the samples. Influence of thermal treatment was also concluded by other authors (Behrends *et al.,* 2005). In the Japanese research also influence of thermal treatment was denoted – the overall weightings suggested that flavor was the most important attribute for rating beef by Japanese consumers, being simultaneously dominant attribute for *yakiniku* and *shabu shabu* method, but not for grill method, for which tenderness was more important than for other methods (Polkinghorne *et al.,* 2011). In the MSA prediction model, tenderness is generally taken into account as the most important meat attribute (Watson *et al.,* 2008b), that may be associated with the methods of thermal treatment applied in countries other than Japan (also in Poland) – other than traditional Japanese techniques.

Taking into account the detailed comparisons between samples, it may be observed that for specified cut, the choice of thermal treatment may cause higher juiciness, overall acceptability, MQ4 or satisfaction, however for almost no cut significant differences for various methods of thermal treatment were observed. Such significant differences were observed only in the cause of juiciness – choosing grilling for STR045 may cause higher juiciness; slow cook for OUT005 may cause lower juiciness, and roast for TOP073 may case higher juiciness in comparison with slow cook. Also the comparison of juiciness of tenderloin (the higher than in the case of other cuts) let to conclude, that grilled TDR062 may be characterized by the same juiciness as OYS036 and RMP005. Such knowledge may be of a great value especially in the catering.

In the presented research, only in the case of the overall acceptability and satisfaction, thermal treatment was not important factor influencing, that may result from the surpassing influence of cut and the fact that influence of cut * thermal treatment combined is in majority dominated by the influence of cut. The cut is one of the most important factors influencing consumer satisfaction – in the United States research the cut and city affected satisfaction more than USDA quality grade (Neely *et al.,* 1998). In the mentioned article, tenderness and flavor were both equal contributors of satisfaction.

The detailed comparisons conducted in the presented research let to conclude that for Polish consumers, the tenderness of roast samples is rated with the highest notes, while the flavor of grilled samples is rated with the highest notes. Taking into account all the analyzed features, the tenderloin is perceived as a most attractive cut, similarly as

in the case of United States research (Morgan *et al.,* 1991). Also in the instrumental measurement conducted using Warner-Bratzler shear test, tenderness of *Psoas major* from tenderloin is higher than for other muscles (Calkins and Sullivan, 2007). In the mentioned research of Morgan *et al.* (1991), was concluded that continued work is needed on improving meat tenderness, primarily for retail cuts, however comparing tenderness of tenderloin in the presented research and research of Morgan *et al.* (1991), allows concluding that in the Polish research tenderness is even lower.

The significant role of tenderness in creating general beef quality, may explain relatively low overall acceptability, MQ4 and satisfaction for analyzed samples as a result of low tenderness. Taking into account the boundaries (the points of intersection between the distribution curves, which are the optimal points at which the consumer distinguish between the grades of MSA 3, MSA 4 and MSA 5), also the general rating of Polish beef is not high. The boundaries between MSA 3/ MSA 4 are about 61-67, while between MSA 4/ MSA 5 are about 80-83 (Legrand *et al.,* 2013; Polkinghorne *et al.,* 2011), so for obtained median of MQ4, no cut may be rated as Premium quality (MSA 5), while only tenderloin may be rated as quality better than everyday (MSA 4). Of course, the mentioned rating is a simplification, as it should be rated for each sample separately, not for median of all samples, but it allows concluding that quality of Polish beef is still not very high. Moreover, the observations are confirmed by the satisfaction ratings – being not higher than 4.07 for grilled tenderloin, as satisfaction may be perceived as individual rating of quality class.

Consumer preferences for beef are dependent on the country and, as shown in the recent comparative studies conducted for the analysis of the MSA system in Australia and Japan (Polkinghorne *et al.,* 2013), it is not possible to transfer the system to another country directly, as various cuts prepared using different methods of thermal treatment have a different acceptability depending on the country. Therefore, the implementation of the MSA system, although it would improve consumer perception of beef, it must be preceded by an analysis of the general perception of beef by consumers.

***Conclusions*:** The quality of Polish beef meat from crossbreeding depends on the cut and thermal treatment, as well as both factors may have cumulative influence. The cut being perceived by Polish consumers as the best one is tenderloin characterized by only juiciness comparable with other cuts (oyster blade, rump). The tenderness of Polish beef, being important for consumers is simultaneously not sufficient and lower than in other countries that results in low general quality of beef. The general quality of beef meat may be improved by proper choice of thermal treatment – being especially important in the case of juiciness of striploin, outside flat and topside, as well as tenderness and flavor.

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