Effect of carcass fat and conformation class on consumer perception of various grilled beef muscles

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Abstract The aim of the study was to analyse the attributes influencing consumer perception of grilled beef steaks. The objects were 30 carcasses out of which eight cuts were obtained (2100 single samples were prepared). A total of 350 consumers were asked to rate the meat samples (6 samples for each consumer) by assessing: tenderness, juiciness, flavour, overall acceptability and satisfaction. The MQ4, which is a combination of consumer rates for tenderness, juiciness, flavour and overall acceptability that is transformed into a single parameter with greater discriminatory ability, was calculated using linear discriminate analysis. The tenderloin was the cut that had the highest ratings for all attributes, however, tenderness, juiciness, MQ4 and consumer satisfaction evaluated for oyster blade were not significantly different from tenderloin. The results of this study indicated that consumer preferences regarding grilled steak were not influenced by fat class, conformation

rib fat thickness and ossification score of the carcasses but only by the type of meat cuts.

Keywords Beef · Consumer analysis · Cut · Grill · Quality score

Introduction

In the last two decades, the demand for beef in Poland has fallen significantly. Since the early 1990s, beef meat consumption declined from 15 kg to about 1.5 kg per capita per year (GUS 2014). European beef consumption has also gradually declined within the last few decades (Van Wezemael et al. 2010). It should be noted that especially the Polish beef sector is in a weak condition, as many farms are unprofitable, with their costs running higher than their incomes (Deblitz et al. 2005). In Poland, the above-mentioned trend is associated with an increase in beef export and a rise in beef prices, which may have contributed to the price's greater role as a determinant of attitude (McCarthy et al. 2003). Moreover, unpopular beef quality (Węglarz 2010) and lack of knowledge regarding the influence of the thermal treatment method on beef quality (Brooks et al. 2000) may be factors inducing the low demand for beef in Poland.

Regardless of the above-mentioned aspects, consumers would be willing to pay more for beef steaks characterised by higher, guaranteed tenderness and palatability (Miller et al. 2001). However, beef meat quality is a highly variable feature that depends on many factors, including pre-slaughter and post-slaughter treatment, both of which simultaneously influence a given consumer's willingness to pay (Feldkamp et al. 2005). In Europe, the (S)EUROP beef carcass classification is used to describe meat quality, but it is applied mainly for pricing purposes. The (S)EUROP grid

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system assesses scores for conformation and fat classes. The conformation score ranges from S (superior) to P (poor) and the fat score ranges from 1 (low) to 5 (high) (Craigie et al. 2012). However, such a classification describes only carcasses, not cuts or muscles. As a result, such a system is of limited value to consumers, as it describes only the quality related to the characteristics of the carcasses (Soji et al. 2015b). However, there have been studies indicating that criteria ranking carcasses may predict the eating quality of loin muscles which is not observed for cuts characterised by a higher level of connective tissue (Strydom 2011).

In other countries, in their classification systems of beef meat, more quality attributes are involved, such as marbling score, lean meat and fat colour, etc. In South Africa (Soji et al. 2015a) or Australia (MSA 2005), the classification system also has carcass maturity based, respectively, on dentition or ossification. Such quality features are indicated as a unique element of those classification systems because they are actually associated with the meat's quality (Strydom 2011). As has been indicated, classification systems currently provide limited possibilities for descriptions of the carcasses (Soji and Muchenje 2016).

The differences in the biological characteristics of specified cuts, e.g. chemical composition, cause that only appropriate thermal treatment methods can be applied for selected cuts. Consumers prefer dry-heat methods of thermal treatment, i.e. outdoor grilling, broiling and indoor grilling, but they have poor knowledge regarding which methods to apply for chosen beef cuts. Generally, as regards beef, it might be concluded that not only the selected cut but also the method of thermal treatment has an important influence on obtained palatability (Lorenzen et al. 2003; Guzek et al. 2015b).

It seems obvious that it is necessary to inform consumers as to how to prepare specified beef cuts in order to achieve consumers' highest satisfaction (McKenna et al. 2004). However, knowing the attributes influencing consumer perception is an essential factor that will enable the beef industry to deliver sufficient knowledge of how to prepare beef to consumers and to efficiently change their attitude regarding grilled beef steaks.

The aim of the study was to analyse the influence of fat and conformation class of the carcasses on the consumers' sensory perception while they assessed various grilled beef muscles.

Materials and methods

Samples preparation

A total of 30 carcasses were selected for the research—2 groups of 5 beef bulls (age: 16 and 28 months), 2 groups of

5 dairy bulls (age: 16 and 28 months), 5 heifers (age: 20–39 months) and 5 cows (age: 88–156 months), representing various genders, adequately to the variation in Polish beef production. One day after slaughter procedure, the following cuts were obtained: *Psoas major* from tenderloin (TDR062), *Longissimus dorsi* from striploin (STR045), *Infraspinatus* from oyster blade (OYS036), *Semimembranosus* from topside (TOP073), *Biceps femoris* from outside flat (OUT005), *Biceps femoris* from rump (RMP005) and two cuts—*Gluteus medius* from rump (two parts: RMP131, RMP231). Eight cuts were obtained from each carcass. In the case of *Gluteus medius* from rump, one of the two parts was obtained for each carcass, in order to have RMP131 and RMP231 equally represented in the pool and to analyse only one rump cut sample from each animal—either RMP131 or RMP231. The cuts were routinely obtained from federally inspected slaughter facilities, thus special approval from the Animal Care and Use Committee was not required.

Out of the thirty carcasses, seven cuts from each carcass were obtained and a total of 210 sample cuts were prepared. From each cut, single consumer samples were prepared, thus the total number of consumer samples was 2100. The samples were coded by using an animal code and the code of the cut on the basis of the MSA System (MSA 2005). From each cut, steaks ($2.5 \times 5 \times 10$ cm), weighing approximately 250 g, were prepared after removing any visible fat and connective tissue. The most anterior and posterior parts of the cuts were excluded from consumer analysis. The samples were vacuum packed and frozen (-18°C) until the consumer tests were conducted. The samples were thawed at $2-4^\circ\text{C}$ for 24 h before a consumer panel evaluation.

The samples were prepared by using the grill method with a Silex clamshell grill (Silex, Hamburg, Germany). The grill was set to 220°C for 4.75 min to obtain the “medium” degree of doneness (McKenna et al. 2004) corresponding to the internal temperature of the samples at about 71°C measured using a NiCr-NiAl thermocouple type TP-151 with an EMT-50-K recorder (Czaki Thermo-Product, Raszyn, Poland).

Subsequently, the steaks were allowed to stand for 3 min before being served. Each steak was cut into 4 equally sized pieces and served to preselected consumers. The grill was allowed to stand empty for 75 s between the preparing rounds for cleaning. Each sample was coded with a unique label generated before the session containing 2 letters and 2-digit numbers.

All samples were obtained and analysed within the project titled “Optimising beef production in Poland according to the *from-fork-to-farm strategy*”. For each cut, eight samples were analysed according to AOAC (1995) methodology for fat, protein, moisture and total mineral contents (Table 1).

Table 1 The characteristics of composition of meat cuts assessed for the experiment (Guzek et al. 2015a)

Parameter (g/100 g)	Minimum	Maximum
Protein	21.94 ± 0.24	22.96 ± 0.21
Fat	1.74 ± 0.54	3.81 ± 0.40
Moisture	70.87 ± 0.40	74.03 ± 0.42
Total mineral content	1.09 ± 0.01	1.17 ± 0.01

For each carcass, the fat and conformation class were specified using the European Union beef carcass classification system (EUROP) scale, and rib fat thickness was measured. Skeletal ossification scores were measured according to MSA standards.

Consumer tests

Detailed protocols for consumer tests have been described by Watson et al. (2008a). On the basis of gender, age, educational background, current occupation, number of family members and income per family member, Polish consumers representing a wide demographic range were recruited with the use of an online questionnaire by the Warsaw University of Life Sciences (WULS-SGGW) and attended consumer test sessions that were a part of the “Optimising beef production in Poland according to the *from-fork-to-farm strategy*” project (contract no. UDA-POIG.01.03.01-00-204/095).

Random, representative consumers were selected for the consumer analysis, while the inclusion criteria were: age—18 to 65 years old, being a beef meat consumer, eating beef meat at least twice a month and preferring the medium degree of doneness. A total of 350 consumers were divided into sessions and each of the sessions was conducted according to the sessions’ schedule. The consumer tests were conducted in standard conditions, i.e. avoiding any disturbances, in a peaceful and quiet atmosphere, with the participants separated from one another by plastic, non-transparent separation walls. The test was conducted in a special consumer test room where the room temperature was stable at about 20–24 °C, in accordance with Polish norms for comfortable conditions in the winter season. Each consumer received seven portions; the first portion which was a link sample was not taken into account in the statistical analysis. Each muscle from each carcass was assessed by 10 individual, untrained consumers. The first sample was a link sample and the order of samples’ evaluation was randomly set on the basis of a 6 × 6 Latin square to exclude any potential order, lag or halo effects. Between samples, consumers could cleanse the insides of their mouths by first taking a sip of 10 % apple juice, then biting a piece of bread and then taking another sip of 10 % apple juice.

For the analysed samples, the consumers rated the tenderness, juiciness, flavour and overall acceptability on a 100 mm, graphic, unstructured line scale and they rated satisfaction as either: unsatisfactory/2 stars, good every day/3 stars, better than every day/4 stars, and premium quality/5 stars.

A total of 2100 questionnaires (one for each sample) were completed. The MQ4 score was calculated using linear discriminant analysis, as described by Watson et al. (2008a) in accordance with the MSA prediction model of the MQ4 (Polkinghorne et al. 2008), which is a combination of consumer rates for tenderness, juiciness, flavour and overall acceptability transformed into a single parameter that has a greater discriminatory ability. The MQ4 score was calculated by summing up the four sensory scores after weighting per 0.3, 0.1, 0.3 and 0.3 for the tenderness, juiciness, flavour and overall acceptability scores, respectively, as was developed by Watson et al. (2008b).

Statistical analysis

Random order and consumer sessions, due to their lack of influence on the results of tenderness, juiciness, flavour, overall acceptability, MQ4 and satisfaction, were not taken into account during the analysis. The W Shapiro–Wilk test was conducted to verify the normality of distribution, which was observed as different than normal. Type of animal, cut, fat class, conformation class, rib fat thickness and ossification score were all indicated as the main independent variables characterising the analysed samples, since a lack of any connection between cut and animal was observed. The Kruskal–Wallis ANOVA was used to measure the influence of attributes on consumer perceptions of tenderness, juiciness, flavour, overall acceptability, MQ4 and satisfaction. Detailed comparisons between the groups were conducted by using the post hoc Dunn’s test. The level of significance was set at $P \leq 0.05$. Statistical analysis was conducted using Statistica 8.0 software (StatSoft, Tulsa, Oklahoma, USA).

Results

No influence of type of animal of consumer analysis was observed on the results (Table 2). On the other hand, the influence of the cut on consumer analysis was significant for all of the analysed attributes (Table 3). The highest values for all consumer attributes were observed for TDR062, however, for tenderness, MQ4 and satisfaction the obtained values were comparable with OYS036, while for juiciness they were comparable with OYS036 and RMP005. Simultaneously, the lowest values of consumer attributes were observed for TOP073 and OUT005,

Table 2 Median, minimum and maximum values and comparisons between samples for consumer analysis of beef samples by type of animal

Type of animal	n	Tenderness	Juiciness	Flavour	Overall acceptability	MQ4	Satisfaction
Beef bulls—16 months	35	42 (11–84)	54 (32–76)	56 (37–82)	52 (33–82)	51 (27–80)	3 (2.2–4.3)
Beef bulls—28 months	35	51 (21–85)	61 (41–78)	58 (41–79)	54 (35–81)	54 (35–81)	3 (2.2–4.4)
Dairy bulls—16 months	35	38 (14–88)	57 (34–84)	55 (43–77)	50 (34–84)	49 (32–83)	3 (2.3–4.4)
Dairy bulls—28 months	35	42 (10–84)	56 (27–77)	57 (42–79)	51 (30–83)	53 (31–81)	3 (2.3–4.5)
Heifers	35	51 (18–84)	65 (39–84)	62 (38–81)	60 (35–83)	59 (37–83)	3 (2.3–4.9)
Cows	35	43 (20–81)	54 (36–77)	57 (42–80)	54 (33–81)	51 (35–80)	3 (2.2–4.1)
<i>P</i> value ^a		0.150	0.060	0.119	0.215	0.140	0.184
H-statistic ^a		8.118	10.581	8.770	7.082	8.305	7.531

n number of animal cuts included in analysis

^a Statistics were conducted using Kruskal–Wallis one-way ANOVA

Table 3 Median, minimum and maximum values and comparisons between samples for consumer analysis of beef samples by cut

Cut ^a	n	Tenderness	Juiciness	Flavour	Overall acceptability	MQ4	Satisfaction
TOP073	30	29 (10–56) ^{ab}	45 (27–64) ^a	51 (37–69) ^a	44 (33–68) ^{ab}	41 (27–62) ^{ab}	3 (2.2–3.7) ^a
OUT005	30	27 (11–49) ^a	50 (35–65) ^a	50 (41–67) ^a	43 (30–60) ^a	40 (32–59) ^a	3 (2.2–4.9) ^a
STR045	30	41 (14–78) ^{abc}	54 (34–78) ^{ab}	58 (43–72) ^{ab}	53 (32–70) ^{abc}	52 (31–72) ^{bc}	3 (2.3–4.4) ^{abc}
RMP005	30	42 (23–54) ^{abc}	64 (47–76) ^{bc}	57 (38–72) ^{ab}	52 (35–68) ^{bc}	52 (37–64) ^{bcd}	3 (2.4–3.5) ^{ab}
RMP131	15	44 (29–67) ^{bcd}	51 (36–69) ^a	54 (45–74) ^{ab}	53 (40–69) ^{abc}	52 (40–68) ^{abcd}	3 (2.5–3.8) ^{abc}
RMP231	15	47 (30–77) ^{cd}	54 (37–72) ^{ab}	57 (45–69) ^{ab}	55 (43–71) ^{bc}	53 (45–72) ^{bcd}	3 (2.7–3.7) ^{bc}
OYS036	30	61 (38–77) ^{de}	67 (52–83) ^c	62 (48–77) ^b	60 (50–78) ^c	61 (50–77) ^{de}	3 (2.9–4.4) ^{cd}
TDR062	30	80 (65–88) ^e	71 (57–84) ^c	74 (65–82) ^c	75 (64–84) ^d	75 (66–83) ^e	4 (3.5–4.5) ^d
<i>P</i> value ^f		0.000	0.000	0.000	0.000	0.000	0.000
H-statistic ^f		138.444	118.275	98.805	115.486	130.231	117.465

n number of animal cuts included in analysis

Values marked with different letters in columns vary significantly on the basis of post hoc Dunn's test criteria for $P < 0.05$

^a TOP073 *Semimembranosus* from topside, OUT005 *Biceps femoris* from outside flat, STR045 *Longissimus dorsi* from striploin, RMP005 *Biceps femoris* from rump, RMP131 *Gluteus medius* from rump (first part), RMP231 *Gluteus medius* from rump (second part), OYS036 *Infrapinatus* from oyster blade, TDR062 *Psoas major* from tenderloin

^f Statistics were conducted using Kruskal–Wallis one-way ANOVA

Table 4 Median, minimum and maximum values and comparisons between samples for consumer analysis of beef samples by fat class

Fat class	n	Tenderness	Juiciness	Flavour	Overall acceptability	MQ4	Satisfaction
1	15	50 (19–80)	56 (37–76)	59 (42–74)	57 (36–82)	57 (33–78)	3 (2.4–4.3)
2	41	45 (11–88)	57 (32–78)	55 (37–82)	54 (32–82)	51 (27–81)	3.3 (2.2–4.4)
3	127	43 (10–88)	59 (36–84)	58 (41–81)	54 (30–84)	52 (32–83)	3 (2.2–4.9)
4	20	41 (14–83)	59 (27–77)	58 (44–79)	52 (34–83)	51 (31–81)	3 (2.3–4.5)
5	7	60 (32–80)	66 (53–82)	62 (38–76)	54 (35–82)	61 (37–80)	3 (2.4–4.2)
<i>P</i> value ^a		0.932	0.257	0.515	0.606	0.706	0.741
H-statistic ^a		2.509	3.055	1.702	0.653	1.364	0.629

n number of animal cuts including in analysis

^a Statistics were conducted using Kruskal–Wallis one-way ANOVA

however, for most features TOP073 and OUT005 were comparable with STR045 and RMP131.

For fat class (Table 4), conformation class (Table 5), rib fat thickness (Table 6) and ossification score (Table 7), no

equal number of cases was observed in the groups. The various numbers of results in the groups characterised by various fat class, conformation class, rib fat thickness and ossification score values were expected because in

Table 5 Median, minimum and maximum values and comparisons between samples for consumer analysis of beef samples by conformation class

Conformation class	n	Tenderness	Juiciness	Flavour	Overall acceptability	MQ4	Satisfaction
R+	7	38 (24–77)	51 (38–61)	47 (45–65)	48 (33–70)	46 (35–70)	3 (2.2–4.1)
R	99	43 (11–88)	59 (27–84)	57 (37–82)	53 (33–84)	52 (27–83)	3 (2.2–4.9)
R–	21	45 (14–76)	57 (34–76)	57 (44–76)	52 (32–76)	51 (32–72)	3 (2.3–4.2)
O+	19	38 (20–78)	60 (36–75)	60 (49–74)	54 (43–75)	51 (40–75)	3 (2.4–3.9)
O	57	45 (10–88)	60 (37–78)	57 (42–80)	54 (30–82)	53 (32–81)	3 (2.3–4.4)
O–	7	53 (19–77)	56 (39–65)	60 (42–73)	59 (36–74)	58 (33–74)	3 (2.4–4.2)
<i>P</i> value ^a		0.643	0.549	0.790	0.957	0.850	0.960
H-statistic ^a		1.330	6.544	4.242	3.618	2.964	2.730

n number of animal cuts included in analysis

^a Statistics were conducted using Kruskal–Wallis one-way ANOVA

Table 6 Median, minimum and maximum values and comparisons between samples for consumer analysis of beef samples by rib fat thickness

Rib fat thickness (mm)	n	Tenderness	Juiciness	Flavour	Overall acceptability	MQ4	Satisfaction
1	30	43 (10–84)	56 (36–77)	56 (45–77)	55 (30–82)	53 (32–78)	3 (2.2–4.3)
2	34	44 (17–85)	60 (34–78)	57 (42–79)	52 (35–81)	52 (33–81)	3 (2.2–4.4)
3	35	38 (14–88)	57 (38–84)	56 (43–77)	51 (32–84)	50 (32–83)	3 (2.3–4.4)
4	7	30 (11–80)	48 (32–69)	52 (37–82)	47 (33–82)	45 (27–80)	3 (2.3–4.3)
5	14	39 (24–77)	51 (38–74)	54 (44–73)	50 (33–70)	48 (35–70)	3 (2.2–4.1)
6	6	44 (22–70)	60 (45–75)	59 (47–76)	61 (45–75)	54 (39–72)	3 (2.7–4.0)
7	27	50 (18–84)	63 (39–78)	62 (41–78)	56 (35–83)	57 (35–81)	3 (2.2–4.9)
8	7	46 (19–76)	60 (41–70)	59 (50–69)	54 (41–68)	54 (37–70)	3 (2.3–3.7)
9	7	36 (14–83)	39 (27–77)	51 (44–79)	48 (34–83)	44 (31–81)	3 (2.3–4.5)
11	14	47 (20–81)	59 (40–77)	62 (42–80)	58 (39–81)	56 (35–80)	3 (2.3–4.1)
13	8	60 (41–84)	66 (47–84)	66 (55–81)	66 (46–83)	65 (48–83)	3 (2.7–4.5)
15	7	53 (32–77)	59 (46–77)	55 (43–78)	54 (35–79)	53 (38–78)	3 (2.3–4.0)
16	14	38 (25–80)	58 (36–82)	58 (38–76)	51 (35–82)	51 (37–80)	3 (2.4–4.2)
<i>P</i> value ^a		0.409	0.350	0.106	0.221	0.250	0.335
H-statistic ^a		12.469	13.270	18.344	15.393	14.839	13.476

n number of animal cuts included in analysis

^a Statistics were conducted using Kruskal–Wallis one-way ANOVA

biological conditions, normal distribution rather than rectangular distribution of the feature (fat class, conformation class, rib fat thickness, ossification) is typical. For the above-mentioned features, no influence on the results of consumer analysis was observed.

Discussion

The research of various authors indicated that the tenderness of beef, which is one of the most important quality attributes, may differ among various breeds, types of animals (Muchenje et al. 2009; Hanzelková et al. 2011), muscles (Calkins and Sullivan 2007), quality classes (Riley et al. 2009), conformation classes (Moloney et al. 2004)

and fat thicknesses (Shackelford et al. 1994) when measured instrumentally. In the case of sensory analysis of the texture features, similar observations were made only for muscles (Calkins and Sullivan 2007) and fat classes (Wajda et al. 2004). It may be suggested that differences detected during instrumental measurements were not always identified by consumers. In the present research, the complex analysis of beef aimed not only to indicate the attributes influencing beef sensory features but also to specify their influence on consumer rating of the beef's general quality and consumer satisfaction.

The most important result indicated that there was no feature other than the cut, associated with the animal or carcass, that influenced the consumers' perception of grilled beef. Similar observations were presented by other

Table 7 Median, minimum and maximum values and comparisons between samples for consumer analysis of beef samples by ossification score

Ossification score	n	Tenderness	Juiciness	Flavour	Overall acceptability	MQ4	Satisfaction
130	7	46 (19–84)	56 (36–64)	58 (45–72)	57 (45–74)	52 (38–75)	3 (2.2–4.0)
150	7	30 (11–80)	48 (32–69)	52 (37–82)	47 (33–82)	45 (27–80)	3 (2.3–4.3)
160	8	46 (27–80)	58 (37–76)	56 (47–74)	53 (41–82)	51 (39–78)	3 (2.4–4.3)
170	7	53 (19–77)	56 (39–65)	60 (42–73)	59 (36–74)	58 (33–74)	3 (2.4–4.2)
180	21	42 (25–88)	64 (39–84)	57 (45–79)	52 (40–84)	49 (40–83)	3 (2.6–4.4)
190	13	47 (23–84)	61 (39–75)	58 (49–77)	52 (38–79)	51 (40–79)	3 (2.4–4.4)
200	55	47 (14–88)	59 (34–84)	59 (41–81)	55 (32–83)	53 (32–83)	3 (2.2–4.5)
230	43	44 (10–84)	57 (39–82)	56 (38–78)	54 (30–83)	53 (32–81)	3 (2.2–4.9)
250	14	41 (14–83)	59 (27–77)	57 (44–79)	52 (34–83)	51 (31–81)	3 (2.3–4.5)
500	13	51 (20–77)	59 (41–77)	61 (43–78)	54 (35–79)	53 (38–78)	3 (2.3–4.0)
590	22	40 (21–81)	52 (36–77)	57 (42–80)	52 (33–81)	51 (35–80)	3 (2.2–4.1)
P value ^a		0.927	0.301	0.863	0.915	0.900	0.911
H-statistic ^a		4.416	11.771	5.397	4.625	4.871	4.707

n number of animal cuts included in analysis

^a Statistics were conducted using Kruskal–Wallis one-way ANOVA

researchers after analysing the role of the cut, USDA quality grade and city on in-home consumer ratings (Neely et al. 1998). In that research study it was concluded that the cut and the city affected customer satisfaction more than USDA quality grade. In another research, McKenna et al. (2004) stated similarly that consumer ratings for top loin steaks were not affected by USDA quality grade. Similarly, Bonny et al. (2016) proved that there was almost no relationship between the European conformation score and untrained consumer sensory scores of quality for samples from France (45 cattle), Ireland (531 cattle) and Poland (54 cattle). This correlation could have resulted from the fact that the European conformation score (EUROP) assesses the whole carcass but not individual muscles. In the same study the authors found that a positive relationship between the European fat score and tenderness was stated only for three out of 17 analysed muscles and that it was explained by the marbling score. However, it should be mentioned that the European fat class is determined by visual assessment of the external fat cover, not marbling, and some authors stated that the fat cover does not have a high predictive value for marbling (Fukumoto and Kim 2007). Moreover, our previous study (Guzek et al. 2014) on beef blade muscle samples (*Infraspinatus*, *Supraspinatus*, *Triceps brachii caput laterale*, *Triceps brachii caput longum*, and *Triceps brachii caput mediale*) suggested that the overall impact of European fat class on marbling may be related to the muscles' in vivo function. Additionally, Gregory et al. (1995) confirmed a high genetic correlation between the marbling score and other measures of fat in the carcass.

Simultaneously, Yancey et al. (2010), reported that consumer tenderness of beef ribeye rolls did not differ

between quality grades. It may be concluded that the type of animal, fat class, conformation class, fat thickness and ossification score did not generally influence the quality of grilled meat to the extent to be perceived by consumers. A similar observation was made in the study of Bonny et al. (2016), in which the juiciness prediction model was analysed. Neither of the analysed features (ossification score, animal age, marbling score, carcass weight, ultimate pH) was a good predictive variable. In contrast, incorporating the USDA marbling score into the prediction model of juiciness or tenderness was more appropriate than incorporating the European conformation score and the European fat score. Also in our previous study, it was observed that the quality of beef meat from crossbreeding depended on the cut and thermal treatment (Guzek et al. 2015b).

For Polish producers, the lack of influence of the type of animal on consumer preferences is particularly important—as Poland is one of the “milk”, not “beef”, consuming country, which is defined as a country with the share of suckler cows at <25 % of the total number of cows (Deblitz et al. 2005). The result reflected, that Polish consumers perceived no difference between grilled meat from various types of animals but were only able to perceive differences between cuts, thus producers may try to use this fact in their marketing strategy, e.g. if doubting acceptability in the case of other methods of thermal treatment they may try to sell the steaks as dedicated for grilling, especially since in Poland the share of meat being sold as dedicated for a specified cooking method is still limited. It should also be noted that the MSA System (MSA 2005) assigned each cut to a number of suitable methods of thermal treatment, thus allowing consumers to conduct easy identification of the best method of thermal treatment

for the chosen cut or the best cut for the chosen method of thermal treatment, in order to maximise consumer satisfaction. It might be concluded on the basis of the economic performance indicators of Polish beef production that a higher income for producers, obtained due to selling beef cuts dedicated to specified methods of thermal treatment, could be a good trigger for satisfaction on the part of the producer, distributor and consumer.

Tenderloin, ranked with the highest notes in the presented research, was generally perceived by consumers as the most attractive cut, which confirmed earlier classifications of *Psoas major* as a tender cut (Sullivan and Calkins 2011). Such an observation was noted in various countries for various ageing times and various doneness (Legrand et al. 2013). However, the research presented here allowed us to conclude that for Polish consumers oyster blade (m. *Infraspinatus*) did not differ significantly in comparison with tenderloin (m. *Psoas major*). In the previously mentioned study of Legrand et al. (2013), oyster blade was also perceived as a rather good cut by French and Australian consumers, but it was not concluded that both it and tenderloin did not differ. Similar results of comparison of consumer analyses were obtained earlier (Kukowski et al. 2004). It was indicated that *Infraspinatus* from oyster blade was rated the highest for overall liking, tenderness, juiciness and flavour in juxtaposition with the other cuts, while the *Psoas major* from tenderloin was not an object of analysis. It may be suggested that tenderloin was generally perceived by consumers as the best cut, however, the above-mentioned studies indicated the important potential of *Infraspinatus* from oyster blade. It should be taken into account that since it was possible to replace more valuable cuts with less expensive ones, and if their sensory attributes do not differ (Lepper-Blilie et al. 2014), *Infraspinatus* from oyster blade could be used instead of tenderloin, as Polish consumers perceived both cuts to be similar. Such a replacement would be desirable, particularly on foodservice menus (King et al. 2009).

The results presented here could be of great value to the beef production market, as they may lead to increased income in the beef sector through the sale of less valuable cuts (cheaper products) but ones that are good enough after appropriate thermal treatment. Such products may be purchased as a labelled product with information about the recommended cooking method and, as a consequence, may be associated with increased consumer satisfaction (Bernués et al. 2003). Especially in the case of countries where beef production farms tend to be unprofitable, which apart from Poland are also the Czech Republic, Hungary, Australia or Namibia (Deblitz et al. 2005), such labelled information (about the proper method of cooking) would be a good solution for consumers. It has already been

introduced in Australia, where as a part of the MSA System beef is identified on the basis of carton labels with described eating quality grades, recommended methods of thermal treatment and ageing requirements (MSA 2005). Such labelled information is a part of the larger actions of the MSA System in order to improve beef meat quality, i.e. not the only or main part but also one of the most important parts for consumers. As a result of these larger efforts of many various stakeholders, in the half-year 2013 Australia's beef production was 2.2 million tonnes, while export recorded nearly 1.5 million tonnes, thus making Australia the 5th most important producer and the 3rd most important exporter of beef in the world (USDA 2013). Since the MSA System turned out to be so profitable to Australian beef production, the system's elements may be instituted in other countries, such as the MQ4 score which was tested in Poland in the research presented previously (Guzek et al. 2015a, 2015b). However, it must be emphasised that consumers from various countries may have different beef perception (Polkinghorne et al. 2013), thus the applied criteria cannot be transferred directly to another country.

Conclusion

The results of this study indicate that the cut influenced consumer preferences regarding grilled beef meat, while such an influence was not observed in the case of fat class, conformation class, rib fat thickness and ossification score. Having knowledge about the importance of the cut's role in how beef meat is perceived by consumers is of great value—since other factors are not so important, the proper beef meat marketing strategy might be to purchase specified cuts or steaks dedicated for grilling originating from various animals. Differences in consumer acceptance levels regarding meat quality, which depend on the cuts, may result in grilling less valuable muscles (*Infraspinatus* from oyster blade) with a similar eating quality to those that are more valuable (*Psoas major* from tenderloin). Our research indicates that tenderness, juiciness, MQ4 and consumer satisfaction in the case of grilled *Infraspinatus* did not differ from consumer perception of *Psoas major*. In order to increase consumer satisfaction regarding grilled beef meat and to improve the image of this type of meat, labelled information about recommended methods of thermal treatment could be implemented.

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Author contributions DG, DGL realized this article on the basis of the scientific studies carried by them in this Project and jointly analyzed these data. KG supervised the consumer analysis. AW accepted the final version as a leader of the Project. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that there are no conflicts of interest.

Ethics standard All cattle were slaughtered in the main commercial slaughterhouse in Poland according European law.

Informed consent All participants provide their written informed consent to participate in this study.

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