Carcass characteristics of farmed fallow deer bucks

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SUMMARY

The aim of the study was to determine the characteristics of farmed fallow deer carcasses and possible correlations between parameters. The research material consisted of carcasses from male deer slaughtered at the age of 20-21 months. Carcass weight, the weight and percentage share of cuts and internal organs, and correlations between selected parameters were determined. The rump was shown to have the largest percentage share of the carcass, followed by the shoulders and loins. Significant statistical correlations were noted between those cuts and the total carcass weight. Linear regression revealed significant relationships between the weights of individual cuts, which will make it possible to determine them without the need to dissect the carcass. The development of indirect methods of evaluating carcasses can also facilitate their classification, e.g. in meat processing plants.

KEY WORDS: deer, *Dama dama,* farm-raised, dressing percentage

INTRODUCTION

According to the act of March 11 2004, farm animals include the following deer species kept in farm conditions: red deer (*Cervus elaphus*), sika deer (*Cervus nippon*), and fallow deer (*Dama dama*) (Journal of Laws 2004 no. 69 item 625). It allows for farming of those animals for the production of high quality meat and hides. All animal husbandry activities are performed by qualified personnel in compliance with hygienic and veterinary standards, while continuous veterinary monitoring ensures food safety (Tuckwell, 2003; Janiszewski et al., 2020).

In order to produce meat of the highest quality, young bucks are usually slaughtered at 18-20 months of age. The carcasses are of high value, as the intensive growth of muscle tissue is complete. Fallow deer meat has high nutritional and dietary value. It has high content of minerals, vitamins, and protein, with low intramuscular fat content (Dzierżyńska-Cybulko and Fruziński, 1997; Daszkiewicz et al., 2013).

The productivity of farm-raised animals can be modified via zootechnical measures. The most common actions taken to increase daily gains in deer include the use of a correctly balanced diet, keeping calves indoors during the winter, and castration (Wiklund et al., 2001; Kudrnáčová et al., 2018; Kim et al. 2019; Serrano et al., 2019; Pérez-Serrano et al., 2020). Analysis of carcass parameters is the basis for calculating the profitability of the zootechnical procedures in the final sale of fallow and red deer meat (Tuckwell, 2003).

Evaluation of the quality of livestock carcasses includes the determination of parameters such as live or carcass weight, zoometrical measurements, and percentage shares of individual carcass cuts (Keçici et al., 2020; Barcelos et al., 2021). Separation into elements also enables assessment of the commercial and technological value of the carcass (Dzierżyńska-Cybulko and Fruziński, 1997). The content of meat tissue in the carcasses of various farm animals is one of the most important utility parameters, but its determination requires dissection into tissue components or dissection of the cuts (Wilkiewicz-Wawro et al., 2003). This reduces the technological quality of the cuts, which may lose their commercial value.

The use of indirect methods can significantly simplify the characterization of farm animal carcasses, including farm-raised red deer and fallow deer. Correlations between carcass measurements and weight and the weight of individual cuts is one indirect method that facilitates carcass evaluation. For example, Żurkowski et al. (2000) demonstrated a significant relationship between the carcass weight and dimensions of red deer. A similar relationship was noted by Janiszewski and Kolasa (2006). Furthermore, Jansen (2000) provided equations quantifying the weight of live deer of North American species based on their carcass weight. Given the above, it would be useful to perform in-depth research on the use of indirect methods of evaluating the carcass parameters of farm-raised deer.

The aim of this study was to characterize the carcasses of farm-raised fallow deer bucks based on their post-slaughter parameters. This was accomplished by determining the average weight and dimensions of carcasses and the percentage shares of its cuts. The data was used to investigate the correlations between parameters, and linear regression was performed to estimate the weights of the most important carcass cuts.

MATERIALS AND METHODS

The research material consisted of fallow deer carcasses from bucks at the age of 20-21 months, raised on the deer farm at the Research Station of the Institute of Parasitology of the Polish Academy of Sciences in Kosewo Górne. The animals were fed in the standard manner used on the farm. In summer, they used only pastures in grazing quarters. The winter diet was based on grass haylage (*ad libitum*), prepared on the farm, and crushed oats (about 0,7-1,0 kg per individual), supplemented with a mineral mixture (2,5%). After the animals were separated from the herd, they were tested by the district veterinarian and fasted for 12 h before slaughter.

In total 20 deer carcasses were studied. Prior to weighing and slaughter, the animals were placed in a crush with a built-in electronic scale. All of these procedures were carried out in compliance with hygienic and veterinary standards (Journal of Laws 2021 item 36; Journal of Laws 2004 no. 33 item 287). Slaughter of farm-raised deer and fallow deer at the research farm is a routine technological procedure, so no special permits were required from the Local Ethics Committee for Animal Experimentation.

Following slaughter, the carcasses were transported to a specialized carcass processing room, where they were eviscerated. Selected internal organs (the heart, liver, spleen and kidneys) were collected in order to determine their weight.

The carcasses were cooled in specialized cold storage at 4°C for 12 h, after which the following measurements were taken, using a zoometric tape and cane, with precision within 1 cm:

1 – body length – from the atlas bone, along the spine, to the base of the tail
2 – height at withers – from the highest point of the withers, along the centre of the limb, to the tip of the hoof
3 – rump height – from the highest point of the back of the spine, along the hind leg, to the tip of the hoof
4 – chest girth – behind the withers and shoulders
5 – chest depth – at the point of greatest chest depth, behind the shoulders.

The following inedible parts were separated from the carcass:
– head – cut perpendicular to the axis of the spine, between the atlas bone and occipital condyles
– lower sections of the forelimbs and hind limbs – cut at the hock and carpal joint
– skin with subcutaneous fat tissue.

The chilled carcass, without these inedible parts, is hereafter referred to as the cold carcass.

The carcass obtained in this way was divided into the following cuts:
– neck – from the first cervical vertebra to the loin cut-off point
– shoulders – from the carpal joint, separated from the carcass by a cut through the muscles connecting them to the ribs. The shoulders were separated with a semi-circular cut in accordance with their shape, running through the muscles connecting the forelimbs with the chest.
– ribs with skirt – ribbed part of the carcass with abdominal muscles (skirt), hereafter referred to as the ribs
– rump – ilio-pelvic part of the carcass with the upper sections of the hind limbs, separated at the hock
– loin – dorsolumbar part of the carcass, cut between the last sacral vertebra and the first lumbar vertebra. The loin was separated at the front by a cut along the ribs perpendicular to the spine, and at the back by a cut along the line separating the loin.

The division of the carcass into edible and inedible parts was based on previous research (Janiszewski, 2009), with a modification accounting for the body characteristics of the species.

Weighing was performed using an electronic scale with precision within 0,01 kg. The cold dressing percentage was determined as the ratio of cold carcass weight to body weight.

The numerical data were presented in tabular form using Excel 365. The data were expressed as means and standard deviation of the mean (SD). The results were analysed statistically by one-way ANOVA, and the significance of differences between groups was determined with Duncan's multiple range test at significance levels of $P \leq 0,01$ and $P \leq 0,05$. Line regression equations for major cuts (rumps, shoulders, and loin), were used to predict the cold carcass composition. All calculations were made in STATISTICA 8.0 PL.

RESULTS AND DISCUSSION

The average body weight of the 20-21-month-old bucks was 48,00 kg, with an average cold carcass weight of 24,08 kg (Table 1). Research by Żmijewski et al. (2020) showed an average body weight of more than 48 kg in 18-month-old deer bucks, with an average cold carcass weight of 26 kg.

According to Volpelli et al. (2002), animals of the same age had an average body weight of 42 kg and a cold carcass weight of 24 kg. Those results are similar to the values presented in this study, which suggests that the body development of the animals studied was normal.

The average carcass weight of 24-month-old fallow deer acquired in natural hunting grounds has been found to be 36,2 kg (Dzierżyńska-Cybulko and Fruziński, 1997). It is worth noting that animals living in the wild are more physically active than farm-raised animals, which may be reflected in differences in their average body weight. The differences between values may be linked to many factors, e.g. health, activity, and/or the quality and amount of food in the diet. It should also be noted that deer body weight differs during the hunting season and off-season, while farmed animals can be slaughtered all year long.

Table 1

Live and carcass weight, dimensions, weight of cuts, and their proportions

	Parameter	Unit	Statistic	
			Mean	SD[1]
Body measurements	Live weight	[kg]	48,00	5,64
Carcass measurements	Cold carcass weight	[kg]	24,08	3,60
	Cold dressing percentage	[%]	50,09	2,92
	Body length	[cm]	135,67	5,73
	Height:			
	rump	[cm]	92,83	3,76
	withers	[cm]	81,17	4,05
	Chest measurements:			
	girth	[cm]	85,33	3,73
	depth	[cm]	29,67	2,98
Carcass cuts	Neck	[kg]	2,71	0,10
		[%]	11,50	1,70
	Loin	[kg]	3,99	0,56
		[%]	16,60	0,73
	Ribs	[kg]	3,40	0,06
		[%]	14,41	1,93
	Shoulders	[kg]	4,70	0,77
		[%]	19,49	0,55
	Rump	[kg]	8,90	1,30
		[%]	36,97	0,80

[1] SD - standard deviation

The measurements presented in Table 1 are an important element of carcass assessment. Both the carcass proportions and the animal's individual development can be determined on the basis of these measurements. The average carcass length was 135,67 cm and was statistically significantly correlated ($P \leq 0,01$) with body weight (Tables 1 and 2). Żmijewski et al. (2020) reported an average

side length of 94 cm in fallow deer. This differs significantly from the data presented in our study, which can be explained by the use of different research methodologies.

A statistically significant relationship (P ≤ 0,01) was found between chest girth and body weight. Among height measurements, a significant relationship (P ≤ 0,05) was noted between height at the withers and body weight, and a highly statistically significant (P ≤ 0,01) relationship between rump height and body weight, as presented in Table 2.

Table 2

Phenotypic correlation coefficient (r) between carcass dimensions and body weight and between cut weights and cold carcass weight

Feature	Specification	Phenotypic correlation	
		Live weight	Cold carcass weight
Carcass measurements	Carcass length	0,85 [XX]	
	Height: rump wither	0,84 [XX] 0,55 [X]	
	Measurements of chest: girth depth	0,74 [XX] 0,13	
Carcass cuts	Neck		-0,67
	Loin		0,97 [XX]
	Ribs		-0,62
	Shoulders		0,99 [XX]
	Rumps		0,99 [XX]

[XX] - significant differences at P ≤ 0,01
[X] - significant differences at P ≤ 0,05

The cold dressing percentage was 50,09%, which is similar to the values obtained by Dzierżyńska-Cybulko and Fruziński (1997), ranging from 48,7% to 56,8%. According to Summer et al. (1997), 18-24-month-old fallow deer bucks can attain a dressing percentage of up to 56%, which is higher than the result presented here. Based on hot carcass weights, Stanisz et al. (2015) and Volpelli et al. (2002) estimated dressing percentages of 63,3% and 57,7%, respectively. The differences in the results may stem from differences in research methodologies, including the use of hot carcass weight rather than cold carcass weight to calculate dressing percentage.

The combined percentage share of inedible elements (skin, head, and lower limbs) in fallow deer from the research farm was calculated to be 15,42%. Żmijewski et al. (2020) reported a value of 12,48%, while Stanisz et al. (2015) estimated the weight of the head, skin, and lower limbs to be 2,41 kg, 4,31 kg, and 1,44 kg, respectively. In our study, the head and lower limb weights were higher (2,89 kg and 2,06 kg respectively), while the skin weight was lower (2,44 kg). The difference may be attributed to differences in the age of the animals.

The internal organs, i.e. the heart, liver, spleen, and kidneys, together constituted 2,86% of the animal's body weight (Table 3). A statistically significant positive relationship (P ≤ 0,01) was shown between the weight of the liver and body weight (Table 4). Stanisz et al. (2015) reported heart, kidney and liver weight of 0,41 kg, 0,12 kg, and 0,95 kg, respectively. The corresponding values in the

present study were 0,34 kg, 0,26 kg, and 0,62 kg. It is worth noting that the data used for comparison pertained to 32-month-old bucks, resulting in significantly different internal organ weights.

Table 3

Weights and percentage shares of inedible parts and internal organs of carcasses

Item		Unit	Statistic	
			Mean	SD[1]
Inedible parts	Skin	[kg]	2,44	0,21
		[%]	5,12	0,31
	Head	[kg]	2,89	0,36
		[%]	6,02	0,34
	Legs	[kg]	2,06	0,32
		[%]	4,28	0,40
	Total	[kg]	7,39	0,77
		[%]	15,42	0,43
Internal organs	Heart	[kg]	0,34	0,03
		[%]	0,71	0,10
	Liver	[kg]	0,62	0,04
		[%]	1,29	0,07
	Kidneys	[kg]	0,26	0,02
		[%]	0,56	0,10
	Spleen	[kg]	0,14	0,02
		[%]	0,30	0,03

[1] SD - standard deviation

Research by Czajkowska and Czaplejewicz (2020) showed that the average heart weight of 2-3-year-old fallow deer was 0,28 kg, while the heart weight in our research was 0,06 kg higher. The difference in heart weight can be attributed to different methods of extracting the organ, including different amounts of fat tissue left adhering to the heart.

An important attribute of carcass quality is the percentage share of the various cuts. In the present study, the rump had the largest percentage share, amounting to about 37% of the total carcass weight, followed by the shoulders (19,49%) and the loin (16,60%). The combined weight of all cuts was 24 kg (98,97%). Stanisz et al. (2015), in 32-month-old fallow deer, found that the loin and the shoulders constituted 17,7% and 16,7%, respectively, of the carcass weight. Żmijewski et al. (2020) reported the rump, loin and shoulder cuts to be 38,42%, 14,42%, and 15,50% of the carcass weight. Those numbers confirm that the rump accounts for the highest percentage share of the carcass, amounting to more than 37% of the overall carcass weight. It should be noted that detailed comparison of the data obtained in the present study with the results of other research may be problematic due to differing dissection methods.

Table 4

Phenotypic correlation coefficient (r) between the weight of inedible parts and internal organs and body weight

	Item	Correlation coefficient
		Live weight
Inedible parts	Skin	0,83 [XX]
	Head	0,90 [XX]
	Legs	0,80 [XX]
Internal organs	Heart	0,24
	Liver	0,95 [XX]
	Kidneys	-0,76
	Spleen	0,81 [XX]

[XX] - significant differences at P ≤ 0,01

The present study showed a highly significant (P ≤ 0,01) relationship between the shoulder, loin, and rump weights and carcass weight. The correlation coefficients ranged from 0,97 to 0,99. Łebacka and Gardzielewska (1975) noted similar relationships for loin and shoulder weights in red deer (r = 0,83 and r = 0,98, respectively). Similarly, Janiszewski (2009) found a highly statistically significant relationship between the weights of the cuts and carcass weight in red deer. For example, the correlation coefficients for the rump and shoulders were r = 0,82 and r = 0,84, respectively. A pronounced relationship between rump weight and carcass weight was also noted by Trziszka (1975), with a correlation coefficient (r = 0,95) very similar to that obtained in the present study. This confirms that calculating correlations between the weights of cuts can enable carcass assessment without the need for dissection.

To conclude, the research results confirmed that there are clear relationships between the carcass parameters determined in the study (Table 5), which can serve as a basis for developing indirect methods of assessing the carcasses of farm-raised fallow deer.

Table 5

Linear regression equations for major cuts (rump, shoulders, and loin)

Linear regression equation	Linear regression coefficient R	Standard deviation Sy
$\hat{Y}_1 = 0{,}541 + 0{,}347x_1$	0,99	0,22
$\hat{Y}_2 = -0{,}421 + 0{,}213x_1$	0,99	0,14
$\hat{Y}_3 = 0{,}354 + 0{,}151x_1$	0,97	0,17

$\hat{Y}_1$- estimated weight of rump [kg]
$\hat{Y}_2$- estimated weight of shoulders [kg]
$\hat{Y}_3$- estimated weight of loin [kg]
x_1- weight of cold carcass [kg]

Calculating linear regression equations made it possible to approximate the weight of the rump, shoulders, and loin based on the cold carcass weight. The results, presented in Table 6, indicate that

the equations are useful and quite accurate, as the estimated and actual weights of the cuts differ by less than 0,13%. The equation used to estimate the weight of the shoulders had the smallest standard error and a high correlation coefficient.

Table 6

Results of estimating the weight of basic cuts (rump, shoulders, and loin) using the linear regression equations from Table 5

Value [kg]		Difference	
Actual	Estimated	±kg	±%
8,897	8,898	0,001	0,011%
4,703	4,709	0,006	0,128%
3,988	3,991	0,003	0,075%

CONCLUSION

The following generalizations and conclusions were formulated based on the analysis of the carcasses of farmed fallow deer bucks:

1) The average body weight of the farmed fallow deer bucks was 48,00 kg, while their dressing percentage was calculated at 50%.
2) The rump made up the highest percentage share of the carcass weight (more than 37%), which can be considered a high value for meat producers, processors, and distributors calculating the market value of carcasses.
3) The cold carcass weight can be used to estimate the weights or percentage share of the rump, shoulders, and loin. This means that the weights of individual cuts can be obtained without need to divide the carcass of fallow deer.
4) The development of indirect methods of assessment of farmed fallow deer carcasses can facilitate their classification in practice.

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