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Authors: Kuźnicka, Ewa, Gabryszuk, Mirosław, Kunowska-Slósarz, Małgorzata, Gołębiewski, Marcin, and Balcerak, Marek

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# Plasma leptin as a predictor for carcass composition in growing lambs

Ewa Kuźnicka, Mirosław Gabryszuk, Małgorzata Kunowska-Słószarz, Marcin Gołębiowski, and Marek Balcerak

**Abstract:** The experiment was conducted on 30 single born Polish Merino ram lambs. At the age of 112 d, 10 ram lambs were slaughtered at 20 kg (group 1), 25 kg (group 2), and 30 kg (group 3) live weight. Plasma leptin increased between 20 and 25 kg, as well as 25 and 30 kg live weight. The differences between group 1 vs. group 3 and group 2 vs. group 3 were statistically important ( $P < 0.001$ ). The lack of differences in meat content of the pelvic limb between the groups and, at the same time, the lower fat content ( $P < 0.001$ ) in group 1, plus the higher fat content of the two remaining groups, are evidence of the higher fatness of carcasses in groups 2 and 3. The fat tissues except the subcutaneous fat were significantly related with the leptin concentrations at slaughter. The leptin concentration of lambs slaughtered at 30 kg live weight surpassed significantly the values noted in groups 1 and 2 ( $P < 0.001$ ). The correlations between leptin and body composition indicate that plasma leptin concentration at 30 kg live weight can be a predictor of body fat. The correlation of meat weight with leptin concentration has shown no statistical differences.

**Key words:** lambs, growing, leptin, carcass.

**Résumé :** L'expérience a été effectuée auprès de 30 agneaux mâles (de portée unique) Polish Merino. À l'âge de 112 j, 10 agneaux ont été abattus à 20 kg (groupe 1), 25 kg (groupe 2) et 30 kg (groupe 3) de poids vif. Les taux de leptine plasmatique augmentaient entre les agneaux de 20 et 25 kg ainsi qu'entre les agneaux de 25 et 30 kg de poids vif. Les différences entre groupe 1 contre groupe 3 et groupe 2 contre groupe 3 étaient statistiquement importantes ( $P < 0,001$ ). L'absence de différence en teneur de viande des membres pelviens et, en même temps, la plus faible teneur en gras ( $P < 0,001$ ) dans le groupe 1, ainsi que la plus grande teneur en gras des deux autres groupes, sont des indications de la plus grande teneur en gras des carcasses des groupes 2 et 3. Les tissus gras, à l'exception du gras sous-cutané, étaient reliés significativement aux concentrations de leptine à l'abattage. La concentration de leptine chez les agneaux abattus au poids vif de 30 kg dépassait les valeurs obtenues dans les groupes 1 et 2 de façon significative ( $P < 0,001$ ). Les corrélations entre la leptine et la composition corporelle indiquent que la concentration plasmatique de leptine à 30 kg de poids vif peut servir d'élément prédictif du gras corporel. La corrélation du poids de la viande et de la concentration de leptine ne montre aucune différence statistique. [Traduit par la Rédaction]

**Mots-clés :** agneaux, croissance, leptine, carcasse.

## Introduction

The protein hormone leptin has been known as the main regulator of food intake and body composition in many species of mammals. Plasma leptin is released mainly from the adipose tissue and correlates with body fat (Altmann et al. 2006). As the adipocyte counts and mass increases, the peripheral concentration of

leptin increases as well (Considine 1997; Ahima and Flier 2000). Auwerx and Staels (1998) also stated that adipocyte size may influence leptin synthesis and secretion, because larger cells contain more leptin mRNA. Once the animal reaches its mature size, most subsequent growth occurs in the form of adipocytes; thus,

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E. Kuźnicka, M. Kunowska-Słószarz, M. Gołębiowski, and M. Balcerak. Animal Breeding Department, Warsaw University of Life Sciences — SGGW, Warsaw 02-786, Poland.

M. Gabryszuk. Institute of Technology and Life Sciences, Falenty, 05-090 Raszyn, Poland.

**Corresponding author:** Ewa Kuźnicka (email: ewa\_kuznicka@sggw.pl).

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it might be linked to the elevated concentration of plasma leptin. Adipocytes' diameter varies according to tissue location. The following regions have been classified as containing the largest to smallest adipocytes: mesenteric, subcutaneous, intermuscular, intramuscular, and brisket fat (Cianzio et al. 1985).

The utilization of hormones as predictors for production characteristics has been discussed over several years. An early assessment of the growth and carcass quality of lambs without involving carcass damage can help to increase market profitability. Leptin is one potential hormone to be used as the basis for a prediction of fattening ability and carcass composition. According to Altmann et al. (2005), the accuracy for the estimation of carcass fat in lambs by plasma leptin concentration at the time of slaughter was similar to ultrasound fat thickness measurements. The correlation between leptin and body composition indicates that the plasma leptin concentration at the end of the fattening period at 40 kg live weight is the most suitable predictor of body fat (Altmann et al. 2006). However, traditional lamb meat production in European countries is based on light lambs (Carrasco et al. 2009a), with maximum of 30 kg live weight.

In this context, the objective of this study was to investigate whether the plasma leptin concentration can be used as a predictor of light lamb's carcass fat content.

## Materials and Methods

### Animals

The experimental procedures were in accordance with the principles and guidelines established by the Canadian Council on Animal Care (2009), updated March 2011.

This study was approved by the III-rd Local Animal Ethics Committee in Warsaw Nr. 25/2016.

The experiment was conducted in a central part of Poland on 30 single born Polish Merino ram lambs of dual, wool and meat purpose. The parturition was held at a typical term for that breed (December/January).

### Maintenance and feeding

The lambs were reared by their dams until 56 d of age (on average). They were kept in the barn on deep litter. After weaning, the lambs were placed in individual straw-bedded pens and fattened individually until the 112th d of life with a concentrate offered ad libitum. The concentrate was composed of 40% oat meal, 29% wheat-rye meal, 19.5% soybean meal, 10% rapeseed cake, 1% limestone, and 0.5% NaCl. Each lamb was additionally offered about 0.1 kg of meadow hay daily. The proximate analysis of feeds (Table 1) was performed using the standard procedure.

### Growth rate of lambs

The lambs were weighed at birth and then every second week to estimate the body weight at birth and at 28, 56, and 112 d of age. Daily gains between 1 and 28, 1 and 56, 28 and 56, 28 and 112, and 56 and 112 d were evaluated as well.

**Table 1.** Chemical composition of feed (g kg<sup>-1</sup> DM).

Item	Concentrate <sup>a</sup>	Meadow hay
Organic matter	912	922
Crude protein	192	82
Crude fiber	106	303
Ether extract	36	20
Neutral detergent fiber	282	566
Acid detergent fiber	124	361

<sup>a</sup>The concentrate was composed of 40% oat meal, 29% wheat-rye meal, 19.5% soybean cake, 1% limestone, and 0.5% NaCl.

### Carcass quality estimation

At the age of 112 d, 10 ram lambs were slaughtered at each 20 kg (group 1), 25 kg (group 2), and 30 kg (group 3) live weight. After slaughter, the carcasses were chilled at 4 °C for 24 h. For carcass quality estimation, the methodology recommended by the National Research Institute of Animal Production was used (Krupiński 2009; Kuźnicka and Rant 2013). Kidney with pelvic fat from the left carcass side was removed and weighed to obtain the contents of kidney knob and channel fat (KKCF). The carcass was split longitudinally, and the two halves were weighed. The left side was divided into joints. The pelvic limbs were dissected into muscle, bone, and fat. The weight and percentage of each tissue in hind leg were calculated. The fat thickness over musculus *longissimus dorsi* (m.l.d) was measured as well.

### Blood sampling and hormone assay

Blood samples were withdrawn via jugular venipuncture from each lamb at 10 am, 2 h after feeding and stored at -20 °C.

Plasma leptin concentrations were analyzed with a specific enzyme immunoassay that has been validated for use in several ungulate species, including ovine samples (Sauerwein et al. 2004). The interassay coefficient of variation was 13.9%, and the limit of detection was 0.3 ng mL<sup>-1</sup>.

### Statistical analysis

Data from lambs were analyzed using the GLM procedure of SPSS (IBM SPSS version 23, 2015), using body weights, daily gains, carcass traits, and dissection data as dependent variables and body weight groups as the independent variable. For relationships between serum concentrations of leptin and fat weight, fat content and fat thickness over the eye loin were quantified by the Pearson correlation coefficients.

## Results and Discussion

### Growth rate of lambs

The body weight growth and daily gain of lambs depending on the live weight are presented in Table 2.

**Table 2.** Body weight growth and daily gain of lambs depending on the live weight.

Item	Group <sup>a</sup>			P-value			
	1	2	3	SEM	1 vs. 2 <sup>b</sup>	1 vs. 3	2 vs. 3
Body weight at birth (kg)	3.9	4.3	5.4	0.26	0.344	0.000	0.003
Body weight at 112 d (kg)	20.9	25.7	30.7	0.28	0.000	0.000	0.000
<b>Daily gain (g) between</b>							
1 and 56 d	168	236	233	19.7	0.021	0.028	0.906
1 and 112 d	153	194	228	2.5	0.000	0.000	0.000
56 and 112 d	139	151	223	18.8	0.640	0.004	0.012

**Note:** SEM, standard error of mean.

<sup>a</sup>Group 1: 20 kg live weight at slaughter; group 2: 25 kg live weight at slaughter; group 3: 30 kg live weight at slaughter; *n* = 10 in each group.

<sup>b</sup>Slaughter body weight of lamb in groups 1 vs. 2, 1 vs. 3, and 2 vs. 3.

**Table 3.** Weight and content of fat in pelvic limb, fat thickness over the eye loin, kidney knob and channel fat (KKCF), and leptin concentration.

Item	Group <sup>a</sup>			P-value			
	1	2	3	SEM	1 vs. 2 <sup>b</sup>	1 vs. 3	2 vs. 3
Half carcass weight (kg)	4.7	6.0	6.8	0.136	0.344	0.000	0.003
Pelvic limb weight (kg)	1.2	1.4	1.9	0.090	0.013	0.000	0.000
Meat weight (kg)	0.9	1.1	1.4	0.074	0.012	0.000	0.000
Meat content (%)	73.7	73.9	73.2	1.05	0.949	0.972	0.921
Fat weight (kg)	0.251	0.417	0.482	0.038	0.000	0.000	0.094
Fat content (%)	9.3	10.7	12.4	1.16	0.230	0.013	0.161
KKCF (kg)	0.084	0.120	0.134	0.009	0.001	0.000	0.158
Fat thickness over the eye loin (mm)	1.20	1.10	1.50	0.023	0.664	0.199	0.090
Leptin concentration (ng mL <sup>-1</sup> )	3.01	3.06	3.67	0.147	0.812	0.004	0.007

**Note:** SEM, standard error of the mean.

<sup>a</sup>Group 1: 20 kg live weight at slaughter; group 2: 25 kg live weight at slaughter; group 3: 30 kg live weight at slaughter; *n* = 10 in each group.

<sup>b</sup>Slaughter body weight of lamb in groups 1 vs. 2, 1 vs. 3, and 2 vs. 3.

The mean birth body weight of lambs from group 1 was lower than for the other two groups, which caused slower growth rate during the rearing time. According to Yilmaz et al. (2007), the differences in lamb growth rate to weaning may partly be due to differences in birth body weight. Low birth weight lambs, being less energetic and having fewer tissue reserves, take much more time to reach the udder for suckling than heavier lambs, which results in their decreased growth (Dwyer and Morgan 2006). Moreover, the low birth weight lambs are less mature than the high birth weight ones in metabolic and endocrine development, which may enhance their capacity to utilize amino acids for energy production and to support gluconeogenesis (Greenwood et al. 2002).

The birth weight may also (directly or indirectly) impact the growth rate, as vigorous lambs (5.2 kg)

compared with weak lambs (4.1 kg) have a better suckling potential (Sušić et al. 2005; Dwyer and Morgan 2006). The comparison of daily gains among groups showed a slower growth rate of ram lambs from group 1 than those in groups 2 and 3 (*P* < 0.05). After weaning, the highest growth rate was noted in group 3. The statistical analysis confirmed the difference among all groups with respect to the daily gains between 1 and 112 d (*P* < 0.001), as well as 56 and 112 d between lambs of finishing weight 20 and 30 kg (*P* < 0.01), the same as 25 and 30 kg (*P* < 0.05). Plasma leptin increased significantly between 20 and 25 kg, as well as between 25 and 30 kg (Table 3). According to Altmann et al. (2005), this elevation was caused by a progressive increase of fat accretion. No correlations to average daily gain were found at each live weight indicating that leptin cannot be regarded as a reliable predictor for early growth rate selection (Altmann et al. 2006).

**Table 4.** Correlation of leptin concentration with group, kidney knob and channel fat (KKCF), fat weight, fat content, and fat thickness over the eye loin.

	Group	KKCF	Fat weight	Fat content	Fat thickness over the eye loin
Leptin	0.505**	0.410*	0.408*	0.335	0.052
Group	—	0.694**	0.735**	0.535**	0.250
KKCF	—	—	0.912**	0.626**	0.031
Fat weight	—	—	—	0.579**	0.088
Fat content	—	—	—	—	0.080

**Note:** Statistical significance at \*,  $P \leq 0.05$ ; \*\*,  $P \leq 0.01$ .

### Carcass quality estimation

The half carcass weights in group 3 were the heaviest, i.e., heavier than those in groups 1 ( $P < 0.001$ ) and 2 ( $P < 0.01$ ). Higher slaughter weight contributed to greater carcass weight (Mioč et al. 2013) and, according to many authors, a higher carcass weight positively impacts the weight of carcass sections (Priolo et al. 2002; Peña et al. 2005; Carrasco et al. 2009b; Önenç et al. 2012). The heavier pelvic limb of lambs slaughtered at 30 kg live weight compared with those of finishing weight at 20 and 25 kg confirm those observations. The differences between group 1 and group 3, as well as group 2 and group 3, were statistically important ( $P < 0.001$ ). Pelvic limb was the most accurate joint for the prediction of whole carcass muscle and fat tissue composition (Carrasco et al. 2009b). The highest values of meat weight were noted in carcasses of lambs slaughtered at 30 kg live weight, and the difference between group 1 and group 2 was statistically important ( $P < 0.001$ ). The results are consistent with the findings of Žgur et al. (2003) who reported that with an increase of live weight at slaughter, the percentage of muscle in hind leg increases as well. However, the analysis of meat content in the carcasses has shown no statistical differences with respect to the body weight at 112 d (Table 3). The dissection of pelvic limb in group 1 has shown about 166 and 231 g of less fat than those in groups 2 and 3, respectively ( $P < 0.001$ ). This is in agreement with the results observed by Cañeque et al. (2005) who reported that the fat thickness increases as the slaughter weight rises. Also the KKCF content in carcasses of lambs slaughtered at 20 kg live weight confirmed the claim of reduced fatness compared with lambs finishing at 25 and 30 kg ( $P < 0.001$ ). The lack of differences in meat content of the pelvic limb between the groups, and, at the same time, the reduced fat content ( $P < 0.001$ ) in group 1, plus the higher fat content of the two remaining groups, are evidence of the higher fatness of carcasses in groups 2 and 3. Other studies (Ehrhardt et al. 2000; Daniel et al. 2002; Geary et al. 2003) indicate that several body fat tissues are highly associated with blood leptin concentration measured at the same time as body fat. In the present experiment, the fat tissues, with exception of the subcutaneous fat,

were significantly related with leptin concentrations at slaughter. The analysis of fat thickness over the eye loin showed no statistical differences (Table 4).

### Leptin

The difference in the concentration of leptin between groups was observed. In the peripheral blood of lambs slaughtered at 30 kg live weight, the level of leptin surpassed significantly the values noted in the two remaining groups ( $P < 0.001$ ). With respect to the concentration of leptin between lambs of finishing weight at 20 and 25 kg, the analysis showed no statistical effect (Table 3).

Leptin is of prime importance in the regulation of metabolism. It inhibits food intake (Niswender et al. 2004; Broberger 2005; Moslemipur et al. 2009), reduces body weight, and increases energy expenditure (Houseknecht et al. 1998; Romsos 1998).

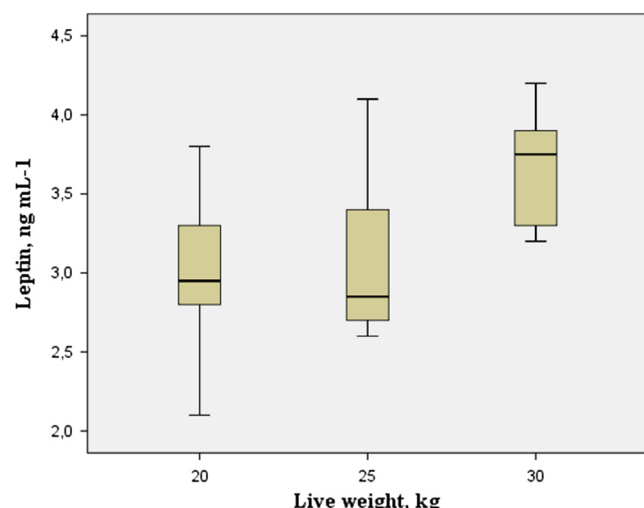
Several observations have led to the hypothesis that leptin is a signal arising from adipose tissue, linked to the level of fat reserves and (or) the nutritional status. This signal directly influences the central nervous system and peripheral organs, resulting in a better adaptation of body metabolism and physiological functions to the availability of metabolic energy (Chilliard et al. 1998; Hocquette et al. 2001).

The correlation of leptin concentration with group was statistically significant ( $P < 0.01$ ) as was the correlation of fat weight with KKCF ( $P < 0.05$ ). The obtained results are in agreement with those of other authors. According to Chilliard et al. (1998), the variation in plasma concentrations of leptin is related to the variation in body fatness. The relationship between body fat mass and circulating leptin levels is frequently reported to be strong (Delavaud et al. 2000) and well correlated with body fat mass (Ingvarsen and Boisclair 2001).

The correlation of fat thickness over the eye loin with leptin level on the blood was insignificant (Table 4). The concentration of leptin in peripheral blood of lambs at 20, 25, and 30 kg slaughter weight is illustrated in Fig. 1. The median of leptin level in groups 1 and 2 was almost on the same level, while the median in group 3 achieved a definitely higher value. This suggests that concentration of leptin in light lambs at the end of the fattening period at 20 and 25 kg live weight is too low for a fatness estimate.



**Fig. 1.** The concentration of leptin in peripheral blood of lambs at slaughter weight at 20, 25, and 30 kg. Figure appears in colour on the Web.



The level of leptin in peripheral blood of lambs slaughtered at 30 kg, compared with slaughter at 20 kg ( $P < 0.001$ ) and 25 kg ( $P < 0.01$ ), was higher. At the same time, the correlation of fat and leptin was significant and suggests that discus hormone may be used for predicting the fatness of lambs at 30 kg live weight. These results are similar to those obtained by [Altmann et al. \(2006\)](#) who found an accelerated deposition of carcass fat with advanced life weight; however, they concluded that the plasma leptin is the most suitable predictor of body fat at 40 kg slaughter weight. The difference of slaughter weight enabling the assessment of fat carcass probably depends on the growth rate of lambs. In our experiment, the highest daily growth rate of lambs merely surpassed 200 g, whereas [Altmann et al. \(2006\)](#) recorded the daily gains reaching almost 400 g. The slower growing rate could be caused by the higher fat tissue deposition and the greater concentration of leptin at lower (35 kg) slaughter weight. The slow growing rate can induce a higher fat tissue deposition and, consequently, a higher concentration of leptin at 35 kg slaughter weight.

The correlation of meat weight with leptin concentration has shown no statistical differences. It indicates that leptin cannot be a predictor of lean tissue.

## Conclusions

However, the level of leptin is related to fat deposition, and this concentration in light lambs (20 and 25 kg) is too low for a fatness estimate. The correlations between leptin and body composition indicate that plasma leptin concentration at 30 kg live weight can be a predictor of body fat. The lack of dependence between leptin level in the peripheral blood and meat weight suggests that leptin cannot be a predictor of lean tissue.

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