

Meat characteristics as related to changes in body weight during lactation and post-weaning period of primiparous sows*

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Meat properties were compared in three groups of first-litter sows, differing in body weight loss during a 21-day lactation. The weight loss was 3.53% in group A (n=16), 6.95% in group B (n=42) and 12.53% in group C (n=12). No significant differences between sow groups were identified for the meat pH, electric conductivity, colour, water-holding capacity and basic chemical composition. The mean values obtained showed that the meat was of good quality. Meat tenderness and partly juiciness received lower scores in the group of sows with the highest body weight loss ($P<0.01$).

The effect was also studied of body weight gain from weaning to slaughter on meat traits considered. During this period, animals showed a small weight loss (-1.60 kg, n=15), a moderate weight gain (2.63 kg, n=37) or a high weight gain (9.44 kg, n=18). Drip loss was the only parametre to be unfavourably correlated with body weight gain after weaning ($P<0.01$).

The simple correlations calculated between meat properties and the productive characteristics of sows showed favourable relationship between body weight and meat colour ($P<0.05$), and between water holding capacity and greater intramuscular fat content ($P<0.01$). Considerable lactational loss (LL) was unfavourably related to meat colour, fat content of meat, and meat tenderness and juiciness. The high body weight gain from weaning to slaughter increased drip loss and made the cooked meat less desirable ($P<0.01$).

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The high growth rate of slaughter animals favours the rapid deposition of muscle proteins and body weight gain. The proteolytic potential of muscles that guarantees high live weight gain has been shown to be a major factor regulating meat tenderization *post mortem*, due to a relationship between protein metabolism and the calpain system degrading myofibrillar protein bonds [Goll *et al.* 1998, Koohmaraie *et al.* 2002]. The relationship between *in vivo* rate of protein degradation and meat tenderization *post mortem* finds practical application using proper animal feeding strategy that leads to compensatory growth [Andersen *et al.* 2005, Therkildsen *et al.* 2002].

Equally intensive degradation of muscle proteins, accompanied by protein catabolism rather than deposition, takes place in suckling sows. The effect of the rate of tissue metabolism and body weight loss during lactation on meat properties has never been studied. Earlier studies on the meat quality of primiparous sows show that their meat was of high and desirable quality [Kapelańska *et al.* 2002, Wajda *et al.* 2006].

The aim of the present study was to estimate the effect of changes in the body weight of sows from farrowing to litter weaning and between the litter weaning to slaughter of sows, as a factor modifying the physico-chemical and sensory properties of meat.

Material and methods

The study was carried out with 70 primiparous sows, which were described in detail by Kapelański *et al.* [2007].

Meat quality traits were determined in the *longissimus lumborum* (LL) muscle 48 hours after slaughter. The pH_i was measured with the R. MATTHÄUS pH-meter and ultimate pH_u was determined in minced and water-suspended meat, 48 h *post mortem*. Water holding capacity (WHC) was analysed using the filter paper method [Grau and Hamm 1952] as modified by Pohja and Niinivaara [1957] and was expressed as the percentage of loose water in the meat. Drip loss was determined using 150 g samples of meat [Honikel 1987]. Meat colour was measured twice, first using a Specol 11 spectrophotometer with a reflectance attachment and applying regression equations [Różycka *et al.* 1968] to estimate colour parameters (dominant wavelength, saturation and lightness), and again using a second photocolorimeter (MINOLTA CR 310) that gives L*, a*, b* values according to the CIE system [1976]. The sensory properties of cooked meat were determined using a 5-point scale (1 point – lowest score, 5 points – highest score) according to Polish Standard [1998].

Water, crude protein, intramuscular fat and ash content [AOAC 1990] and the soluble protein fraction [Kotik 1970] were also determined.

The results obtained were evaluated statistically using STATISTICA 7.1 PL software [2007]. One-way analysis of variance was performed. Significance of differences was estimated using Duncan's test. General correlations between the productive traits of sows and meat quality characteristics were computed.

Results and discussion

The meat properties were compared for three groups of primiparous sows used earlier by Kapelański *et al.* [2007], which showed different body weight losses during lactation (3.53%, 6.95% and 12.53% on average, respectively, $P<0.01$). Table 1 shows data of the basic physico-chemical properties of meat pH, electric conductance (EC_1), colour parameters, water holding capacity (WHC), drip loss and chemical composition (water, protein and fat of meat). These properties are mainly associated with the technological suitability of meat, and like in the studies of Kristensen *et al.* [2002] and Oksbjerg *et al.* [2003], they were not significantly differentiated by changes in body weight or growth rate. Colour lightness (L) determined using a Minolta device was an exception. The lightest meat colour was found in sows with the highest weight loss during lactation ($P<0.01$), which suggests that the value of the parameter decreased in these animals. Likewise, the intramuscular fat content was the lowest in sows with the highest percentage of body weight loss during lactation, although the inter-group difference was not found significant.

Table 1. Means and their standard deviations (SD) for meat quality traits of primiparous sows as related to their body weight loss during lactation

Trait	Lactational loss of body weight (%)					
	Group A (n=16)		Group B (n=42)		Group C (n=12)	
	mean	SD	mean	SD	mean	SD
Lactational loss of body weight (%)	3.53 ^A	1.45	6.95 ^B	1.33	12.53 ^C	3.19
pH _i	6.45	0.19	6.36	0.29	6.38	0.29
pH _u	5.49	0.06	5.48	0.06	5.46	0.07
EC_1	3.43 ^a	0.70	2.85 ^b	0.73	3.15	0.95
Dominant wavelength (nm)	585.9	2.10	586.4	1.74	586.2	1.75
Colour saturation (%)	21.36	2.85	23.06	2.61	22.15	2.21
Colour lightness (%)	20.24	1.43	21.26	2.29	20.75	2.49
L*	48.84 ^A	1.65	50.03	2.42	51.07 ^B	1.75
a*	15.24	0.62	15.01	0.99	14.97	0.76
b*	2.26	0.47	2.50	0.81	2.39	0.38
WHC (% loose water)	21.40	2.14	21.40	2.46	22.15	2.32
Drip loss (%)	2.08	1.22	2.13	1.57	2.14	1.91
Water (%)	75.29	0.48	75.66	0.77	75.68	0.72
Protein (%)	21.55	0.73	21.02	0.94	21.43	0.80
Soluble protein (g/100 g)	6.22	0.41	5.89	0.57	5.96	0.54
Intramuscular fat (%)	1.65	0.56	1.63	0.47	1.38	0.40

^{aA} Within rows means bearing different superscripts differ significantly at: small letters – $P<0.05$; capitals – $P<0.01$.

In the present it was assumed study that animals with high body weight loss were characterized by more intense catabolism of body components (including muscle proteins), their degradation and increased proteolytic metabolism. It is known that there is a favourable relationship between the increased metabolism of muscle

proteins accompanying their deposition in carcass during compensatory growth, and the activity of the calpain enzymatic system and meat tenderness [Kristensen *et al.* 2002, Oksbjerg *et al.* 2002, Therkildsen *et al.* 2002].

The duration of underfeeding and realimentation also has some effect on meat properties, as indicated by Therkildsen *et al.* [2002], who reported that compensatory growth can have favourable results if abundant feeding prior to slaughter is at least 40 days long. In the muscle tissue of slaughtered pigs, they showed increased μ -calpain activity, higher rate of myofibrillar fragmentation and higher collagen solubility, the properties that can determine meat tenderness.

Mean values for meat sensory traits, including aroma, tenderness, juiciness and taste are shown in Table 2. Mean scores for aroma, aroma intensity and desirability ranged from 4.94 to 5.00 points. The scores for taste, its intensity and desirability were slightly lower and ranged from 4.63 to 4.37 points. They appeared close to maximum and must be considered as very good. The scores for meat tenderness and juiciness varied considerably according to the extent of lactational loss of sows' body weight. The lowest scores were given to the meat of sows characterized by the most advanced catabolic processes and the highest body weight loss. The differences in meat tenderness scores were highly significant and ranged from 4.26 to 3.54 points ($P < 0.01$). The differences in juiciness scores although clear were not found significant (from 4.26 to 3.92 points). These results lead us to conclude that the increased metabolism of muscle proteins, accompanied by body weight loss rather than body weight gain, had a negative effect on meat tenderness and the consumers' opinion of the meat.

Table 2. Sensory evaluation of cooked meat on a scale of 1 to 5 points as related to lactational loss of body weight in primiparous sows

Trait	Lactational loss of body weight					
	Group A		Group B		Group C	
	mean	SD	mean	SD	mean	SD
Aroma						
intensity (N)	4.94	0.24	4.94	0.20	4.92	0.29
desirability (P)	5.00	0.00	4.99	0.08	5.00	0.00
Tenderness	4.26 ^{Aa}	0.56	3.65 ^b	0.86	3.54 ^B	0.69
Juiciness	4.26	0.59	4.21	0.62	3.92	0.70
Taste						
intensity (N)	4.62	0.42	4.62	0.44	4.37	0.48
desirability (P)	4.62	0.42	4.63	0.42	4.37	0.48

^{aA...} Within rows means bearing different superscripts differ significantly at: small letters – $P < 0.05$; capitals – $P < 0.01$.

After the weaning of piglets, milk production in the sow ceases and body weight is restored. In the present study, in a small number of sows catabolic processes continued to prevail after litter weaning manifesting themselves with no weight gains and even very small body weight losses (group A₁, Tab. 3). The largest group of sows showed very moderate weight gain, and a small group showed dynamic mean weight gain of over 1 kg/day.

Table 3. Means and their standard deviations (SD) for meat quality traits as related to post-weaning changes in body weight of primiparous sows

Trait	Body weight change in sows post-weaning					
	Body weight loss		Body weight gain			
	Group A ₁		Group B ₁		Group C ₁	
	0-5.0 kg (n=15)		0.5-5.0 kg (n=37)		6-17 kg (n=18)	
	mean	SD	mean	SD	mean	SD
Body weight gain post-weaning (kg)	-1.60 ^A	1.72	2.63 ^B	1.34	9.44 ^C	3.11
pH _i	6.35	0.34	6.40	0.26	6.39	0.22
pH _u	5.49	0.06	5.49	0.06	5.46	0.07
EC ₁	2.81	0.79	3.16	0.82	2.96	0.72
Dominant wavelength (nm)	586.8	1.73	586.0	1.97	586.4	1.54
Colour saturation (%)	23.67	3.24	22.10	2.65	22.41	2.06
Colour lightness (%)	20.46	2.21	21.19	2.20	20.72	2.10
L*	50.30	2.79	49.79	1.95	49.88	2.46
a*	15.19	0.90	14.97	0.80	15.13	0.60
b*	2.41	0.41	2.37	0.64	2.56	0.91
WHC (% loose water)	21.06	2.52	21.43	2.24	22.09	2.46
Drip loss (%)	1.38 ^A	0.94	1.96 ^a	1.39	3.03 ^{Bb}	1.82
Water (%)	75.63	0.74	75.55	0.70	75.58	0.73
Protein (%)	21.17	0.88	21.14	0.96	21.43	0.78
Soluble protein (g/100)	5.89	0.60	5.97	0.57	6.06	0.45
Intramuscular fat (%)	1.68	0.46	1.64	0.45	1.43	0.56

^{aA...} Within rows means bearing different superscripts differ significantly at: small letters – $P<0.05$; capitals – $P<0.01$.

However, such a wide variation in the rate of metabolic processes had no perceptible effect on meat properties. Only drip loss was differentiated by the rate of body weight gain in sows before slaughter ($P<0.01$). The highest drip loss was found in animals with the greatest body weight gain after weaning of piglets. In the sensory evaluation of cooked meat, the scores for aroma, tenderness, juiciness and taste were not found significantly differentiated between the groups of sows with different rates of body weight recovery after lactation (Tab. 4). Mean scores reached the satisfactorily high level, and meat tenderness was the only parametre with a score below 4 points.

Simple correlation coefficients were calculated (Tab. 5) for the whole group of sows between more important meat properties and post-farrowing weight of sows, their weight at weaning litters, lactational loss, post-weaning body weight gain, and age and body weight at slaughter, so as to identify factors affecting meat traits, with special reference to those that help to obtain its most desired quality.

The post-farrowing body weight of sows correlated significantly with the meat properties analysed. With the higher post-farrowing body weights of sows, their meat was characterized by greater EC in the first hour *post mortem* (EC₁; $P<0.01$), as well as darker colour ($P<0.05$), better WHC 48 h *post mortem* ($P<0.01$) and higher intramuscular fat content ($P<0.01$). Likewise, higher weaning weight of the sow's

Table 4. Sensory evaluation of meat quality in primiparous sows on a scale of 1 to 5 points as related to post-weaning body weight loss or gain

Trait	Body weight change in sows post-weaning					
	Body weight loss		Body weight gain			
	Group A ₁		Group B ₁		Group C ₁	
	0-5.0 kg		0.5-5.0 kg		6-17kg	
	mean	SD	mean	SD	mean	SD
Aroma						
intensity (N)	4.96	0.13	4.89	0.29	5.00	0.00
desirability (P)	5.00	0.00	5.00	0.00	4.97	0.12
Tenderness	3.79	0.99	3.75	0.75	3.83	0.82
Juiciness	4.32	0.70	4.16	0.59	4.08	0.67
Taste						
intensity (N)	4.61	0.53	4.54	0.43	4.64	0.45
desirability (P)	4.61	0.53	4.55	0.40	4.64	0.45

Table 5. Simple correlation coefficients between meat quality indicators and selected reproduction and production traits in primiparous sows

Correlated trait	Post-farrowing body weight	Post-weaning body weight	Lactational loss of body weight (%)	Post-weaning body weight gain	Age at slaughter	Body weight at slaughter
EC ₁	0.316 ^{xx}	0.312 ^{xx}	-0.048	0.004	0.574 ^{xx}	0.308 ^{xx}
L*	-0.296 ^x	-0.394 ^{xx}	0.276 ^x	0.074	-0.248 ^x	-0.367 ^{xx}
WHC	-0.317 ^{xx}	-0.356 ^{xx}	0.102	0.196	-0.288 ^x	-0.297 ^x
Drip loss	-0.043	-0.007	-0.086	0.370 ^{xx}	-0.499 ^{xx}	0.092
Fat content	0.366 ^{xx}	-0.203	-0.267 ^x	-0.203	-0.088	0.394 ^{xx}
Tenderness	0.142	-0.051	-0.285 ^x	-0.051	0.191	0.226
Juiciness	0.090	-0.151	-0.254 ^x	-0.151	-0.250 ^x	0.135
Taste (P)	0.029	0.035	-0.194	0.035	-0.380 ^{xx}	0.104
Aroma (P)	-0.019	-0.381 ^{xx}	-0.011	-0.381 ^{xx}	0.194	-0.116

^xP<0.05; ^{xx}P<0.01.

litter was favourably correlated with the same traits ($P<0.01$) except fat content. A high lactational loss of body weight in sows was unfavourably correlated with meat colour ($P<0.05$), intramuscular fat content, tenderness and juiciness of meat ($P<0.05$). The high body weight gain from weaning to slaughter led to increased drip loss during storage ($P<0.01$) and made the aroma of cooked meat less desirable ($P<0.01$). The meat of sows with greater slaughter weight was characterized by more favourable properties than the meat of lighter sows. It had darker colour, higher WHC and greater fat content ($P<0.01$).

The results presented here show that if moderate, changes in the body weight of primiparous sows during lactation and after weaning their litter do not affect

negatively the technological and eating properties of meat. However, radical changes involving lactational loss and/or high post-weaning weight gain can negatively affect the fat content of meat as well as meat tenderness and juiciness.

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Charakterystyka mięsa loszek jednorazówek na tle zmian masy ich ciała zachodzących podczas laktacji i po odsadzeniu miotu

Streszczenie

Porównano właściwości mięsa trzech grup loszek pierwiastek (A, B i C), różniących się ubytkiem masy ciała podczas 21-dniowej laktacji i ubitych po odchowaniu pierwszego miotu. W grupie A ubytek ten wynosił 3,53% (n=16), w grupie B – 6,95% (n=42), a w grupie C – 12,53% (n=12) w stosunku do masy ciała. Nie udowodniono istotnych różnic między grupami w zakresie cech mięsa obejmujących jego przydatność technologiczną (pH, przewodność elektryczna, barwa, wodochłonność) i podstawowy skład chemiczny. Wartości średnie świadczyły o wysokiej jakości mięsa. W grupie loch o największym ubytku masy ciała, wyróżniki sensoryczne mięsa – kruchość i częściowo soczystość – uzyskały noty niższe ($P<0,01$) niż w pozostałych dwóch grupach.

Dalsze badania poświęcono analizie wpływu na badane cechy mięsa loszek przyrostu masy ciała uzyskanego przez nie między odsadzeniem miotu a ich ubojem. W przypadku części zwierząt nie tylko nie stwierdzono w tym czasie przyrostu, ale nawet niewielki ubytek masy ciała (średnio -1,60 kg, n=15). Inne charakteryzował przyrost umiarkowany (średnio 2,63 kg, n=37), a pozostałe przyrost wysoki (średnio 9,44 kg, n=18). Ze wszystkich badanych cech jedynie wielkość swobodnego wycieku soku z mięsa była niekorzystnie związana z przyrostem masy ciała loch po odsadzeniu prosiąt ($P<0,01$). Współczynniki korelacji prostych ujawniły korzystne zależności między masą ciała a barwą ($P<0,05$), wodochłonnością i większą zawartością tłuszczu śródmięśniowego ($P<0,01$). Natomiast znaczny ubytek laktacyjny był niekorzystnie związany z barwą, zawartością tłuszczu, kruchością i soczystością mięsa. Z kolei znaczny przyrost masy ciała loch w okresie między odsadzeniem miotu a ich ubojem wiązał się ze wzrostem wycieku soku i spadkiem pożądalności zapachu mięsa gotowanego.