POLISH JOURNAL OF FOOD AND NUTRITION SCIENCES

www.pan.olsztyn.pl/journal/
e-mail: joan@pan.olsztyn.pl

Pol. J. Food Nutr. Sci.
2008, Vol. 58, No. 4, pp. 451-455

COMPENSATORY GROWTH OF PIGS: QUANTITATIVE AND QUALITATIVE PARAMETERS OF PORK CARCASS OF FATTENERS ADMINISTERED A MIXTURE WITH LINSEED OIL IN THE RE-ALIMENTATION PERIOD

Justyna Więcek[1], *Jacek Skomiał*[2], *Anna Rekiel*[1], *Tomasz Florowski*[3], *Krzysztof Dasiewicz*[3], *Agnieszka Woźniak*[3]

[1]Department of Pig Breeding, Warsaw University of Life Sciences; [2]Department of Animal Nutrition and Feed Science, Warsaw University of Life Sciences; [3]Department of Food Technology, Warsaw University of Life Sciences

Key words: pigs, compensatory growth, carcass and meat quality, linseed oil

An experiment conducted on 56 fatteners was aimed at determining the effect of compensatory growth and addition of linseed oil in the II period of fattening on their slaughter value and meat quality. On termination of the I fattening period (23-60 kg b.w.) carcasses of animals fed in that period with a restrictive diet (-25% of diet), as compared to those of animals fed *semi ad libitum,* were characterised by greater meatiness ($p \leq 0.05$), lower fat content of *longissimus thoracis*, smaller free drip as well as higher values of chewiness and hardness. After the re-alimentation period, in which the animals were fed *semi ad libitum* with mixtures containing 0 or 4% of linseed oil, the greatest meatiness was observed in the pigs fed with a restrictive diet in the I fattening period and with a mixture containing 0% of linseed oil in the II fattening period. The restrictive-compensatory feeding strategy was found to exert a positive effect on contents of dry matter and total protein in *longissimus thoracis* and to have a negative impact on texture parameters of *longissimus lumborum*. The addition of linseed oil to feed mixtures caused a decrease in carcass meatiness ($p \leq 0.05$) and an increase in meat springiness ($p \leq 0.05$).

INTRODUCTION

An increase in meat consumption has affected a change in consumers' demands in terms of sensory traits of food products. Owing to this, consumers search for tender and juicy pork with appropriate aroma and taste [Aaslyng *et al*., 2007].

Compensatory growth is characterised by the prevalence of the synthesis of protein over its decomposition. Initially, that phenomenon is observed in the internal organs and then in muscles [Hornick *et al*., 2000; Heyer & Lebret, 2007]. It leads to a rapid increase in protein content and reduced excretion of nitrogen. The growth rate increases since the organism needs less energy for the gain of muscle tissue than for the gain of adipose tissue [Hornick *et al*., 2000]. After the period of compensatory growth, animals are often characterised by a higher adiposity [Daza *et al*., 2006; Skiba *et al*., 2006], though the growth of various tissues depends, most of all, on breed and age of an animal. At the initial stage of compensatory growth, deposition of mainly protein is observed and the composition of carcass is similar to that from the period of restrictive feeding. Afterwards, fat deposition enhances. The final body composition is determined by the length of the re-alimentation period [Hornick *et al*., 2000].

Growth rate of animals and concomitant rate of muscle tissue formation may affect meat tenderness [Łyczyński *et al*., 2006]. As reported by Therkildsen *et al*. [2004], the rate of the course of after-slaughter tenderization of meat is determined by the rate of muscle protein decomposition in live animals during slaughter. According to those authors, the reaction of compensatory growth enhances decomposition of muscle protein and may be a means of improving meat tenderness. Results of a study by Kristensen *et al*. [2004] demonstrate that the compensatory growth improves tenderness of meat, yet only in gilts. In turn, Heyer & Lebret [2007] claim that the restrictive-compensatory feeding strategy does not yield the improvement neither in tenderness nor in juiciness of meat. Results obtained by Wood *et al*. [1998] indicate that, as compared to restrictive feeding, the *ad libitum* feeding of pigs enhances both tenderness and juiciness of their meat. All those observations enable advancing a hypothesis that the compensatory growth, characterised by a rapid growth of muscle tissue, may be a practical method for improving meat tenderness. Nevertheless, results of investigations on the quality of meat obtained in the restrictive-compensatory feeding strategy are not explicit [Oksbjerg *et al*., 2002; Therkildsen *et al*., 2002; Więcek *et al*., 2005].

The undertaken study was aimed, therefore, at evaluating the effect of compensatory growth on slaughter value and meat quality of fatteners administered feed mixtures with 0 or 4% addition of linseed oil in the re-alimentation period.

MATERIAL AND METHODS

The experiment was conducted on 56 fatteners (28 barrows and 28 gilts), hybrids of (wbp x pbz) x duroc (gilts:barrows, 1:1). It was began at body weight of animals reaching *ca.* 23 kg. Eight animals were slaughtered at the beginning of the ex-

Author's address for correspondence: Justyna Więcek, Department of Pig Breeding, Warsaw University of Life Sciences, ul. Ciszewskiego 8, 02-786 Warszawa, Poland; tel.: (48 22) 59 365 63; fax (48 22) 853 09 14; e-mail: justyna_wiecek@sggw.pl

periment (group 0). The remaining 48 fatteners were divided based on analogs into two groups: A and R. The animals were fed individually with feed mixtures for the I (23-60 kg b.w.) and II (60-102 kg b.w.) fattening period. In the I fattening period, animals from group A were fed *semi ad libitum*, and those from group R were fed a restrictive diet, *i.e.* 75% of that of group A. In the II fattening period, all animals were fed *semi ad libitum,* and each of the groups (A and R) was divided into 2 sub-groups. All animals in the I fattening period and animals from groups AC and RC in the II fattening period were administered feed mixtures without the addition of linseed oil. A 4% addition linseed oil was introduced in the II fattening periods to diets of animals from groups AO and RO. The composition of feed mixtures was provided in Table 1.

On termination of the first fattening period (at body weight of 60 kg), 8 animals selected at random from groups A and R (gilts: barrows, 1:1) were slaughtered (a total of 16 fatteners). All other animals (8 animals per each group: AC, AO, RC and RO) were slaughtered on termination of the second fattening period (at body weight of 102 kg).

Measurements of pH were performed on right half-carcasses according to Polish Standard [PN-77/A – 82058], using an HI-98240 pH-meter with a spike electrode, in the 45th min and 24th h after slaughter. After 24-h chilling of the half-carcasses, measurements and meatiness evaluation were conducted on the right half-carcasses and selected cuts with the total dissection method according to the SKURTCh methodology [Różycki, 1996]. A specimen of *longissimus thoracis* was collected from the area of the penultimate thoracic vertebra in the intracephalic direction. The material was comminuted and determined for the chemical composition [AOAC, 1994]. A specimen of *longissimus lumborum* was collected from the area after the last rib in the intracaudal direction from 6 animals of each group (0, A, R, AC, AO, RC, RO; a total of 42 animals) and assayed for the amount of free drip, amount of absorbed brine [Mroczek, 1997], and water holding capacity [Grau & Hamm, 1952 in modification of Pohja & Niinivaara, 1957]. Colour analysis was conducted with a Minolta CR-200 colorimeter, whereas texture measurements – with a ZWICKI testing machine type 1120.

Results obtained were elaborated statistically by means of one-way or two-way analysis of variance using the method of the least squares. The statistical model included the effect of a feeding level in the I fattening period and the effect of a feeding level and addition of linseed oil in the II fattening period [SPSS, 2000]. In analyzing values of quantitative slaughter traits, the body weight of an animal at slaughter was adopted as a co-variable. Values of traits of the animals slaughtered at body weight of *ca.* 23 kg were presented as arithmetic means.

TABLE 1. Composition (%) and nutritive value of feed mixtures in the experimental diets.

Item	Growing period	Finishing period	
	Group A and R	Group AC and RC	Group AO and RO
Ground wheat	18.00	19.00	19.00
Ground barley	59.25	66.61	60.93
Wheat bran	3.00	-	-
Soybean meal	17.20	11.80	13.20
Linseed oil	-	-	4.00
Vitamin E	-	-	0.30
Mineral-vitamin mix	2.10	2.25	2.25
L-lysine	0.27	0.24	0.22
DL-methionine	0.09	0.04	0.04
L-threonine	0.09	0.06	0.06
Metabolizable energy (MJ/1 kg)	12.5	12.5	13.5
Crude protein (g/1 kg)	153.4	134.3	146.6

RESULTS

Restrictive period

The intensity of feeding in the I period of fattening was found to affect values of slaughter traits (Table 2). Carcasses

TABLE 2. Results of slaughter evaluation, chemical composition and meat quality at the beginning and at the end of the restrictive period.

Specification	Group 0	Group		Se	p*
		A	R		
Body weight at slaughter (kg)	20.0	59.9	58.4	0.65	NS
Mass of cold half-carcass (kg)	6.8	21.5	21.8	0.13	NS
Dressing percentage (%)	67.0	72.7	73.6	0.44	NS
Length of half-carcass (cm)	46.9	72.7	73.6	0.80	NS
Mean back fat thickness (mm)	6.1	13.0	9.9	0.42	0.004
Loin eye area (cm^2)	11.8	26.4	30.7	1.03	NS
Mass of loin meat (kg)	0.58	2.07	2.43	0.05	0.007
Mass of ham meat (kg)	1.06	3.63	3.92	0.06	0.034
Carcass meatiness (%)	52.6	55.9	59.3	0.58	0.015
Longissimus thoracis					
Dry matter (%)	23.03	24.83	25.08	0.18	NS
Total protein (%)	20.83	22.61	23.01	0.23	NS
Crude fat (%)	1.10	1.11	0.67	0.14	NS
pH 45’	6.27	6.28	6.22	0.08	NS
pH 24h	5.75	5.51	5.50	0.05	NS
Longissimus lumborum					
Free drip (%)	1.65	6.00	5.60	0.72	NS
Water holding capacity (cm^2/g)	28.4	35.1	31.7	1.25	NS
Absorbed brine (%)	2.07	3.72	1.47	0.42	0.022
Colour					
L	51.29	56.45	55.19	1.47	NS
a*	9.06	8.74	8.15	0.35	0.048
b*	0.29	3.03	3.10	0.68	NS
Shear force (N)	17.6	67.6	48.9	5.50	NS
Penetration force (N)	57.9	56.5	65.1	3.70	NS
Springiness	0.59	0.55	0.56	0.01	NS
Cohesiveness	0.51	0.42	0.48	0.01	NS
Chewiness (N)	21.7	14.9	19.6	1.19	NS
Hardness (N)	69.7	64.5	74.0	4.49	NS

*NS – $p>0.05$

of the fatteners feed a restrictive diet (group R), as compared to those obtained from pigs fed *semi ad libitum* (group A), were characterized by smaller by 4.1 mm back fat thickness ($p \leq 0.01$), greater by 16% loin eye area, a higher mass of meat of loin ($p \leq 0.01$) and ham ($p \leq 0.05$) as well as by lower meatiness ($p \leq 0.05$). The animals fed a restrictive diet, as compared to those fed *semi ad libitum*, displayed a higher content of dry matter and protein (by 0.25 and 0.4 percentage points, respectively) as well as lower by 0.44 percentage points content of crude fat (lack of significant differences). In turn, the fatteners fed *semi ad libitum* in respect of those receiving a restrictive diet were demonstrated to have higher values of: free drip, water holding capacity, and percentages of absorbed brine ($p \leq 0.05$) and colour component a* ($p \leq 0.05$).

Re-alimentation period

The thinnest back fat, the largest loin eye area and the highest meatiness were reported for carcasses of animals fed a restrictive diet in the I fattening period and receiving fat mixtures without oil addition for the whole fattening period – group RC (Table 3). The addition of oil to a feed mixture in the II fattening period was shown to have a statistically significant ($p \leq 0.05$) effect on meatiness of the carcasses.

Longissimus thoracis of the fatteners receiving in the I fattening period feed mixture doses reduced by 25%, as compared to that of the pigs fed *ad libitum*, was characterised by a higher content of dry matter ($p \leq 0.05$) and protein ($p \leq 0.05$) as well as by a lower content of fat (lack of statistical differences). Although analyses did not confirm any statistically significant effect of oil addition to a feed mixture on the examined traits, fat content of *longissimus thoracis* in pigs fed the oil-supplemented feed mixtures was higher than that in the fatteners receiving feed mixtures without the addition of oil.

The animals fed in the I fattening period a restrictive diet, as compared to those fed *semi ad libitum*, were characterized by higher values of shear force, penetration force, springiness ($p < 0.01$), chewiness and hardness, irrespective of the feed mix-

TABLE 3. Results of slaughter evaluation, chemical composition and meat quality after the re-alimentation period.

Specification	Group				Se	Effect of, p*	
	AC	AO	RC	RO		Feeding level	Oil addition
Body weight at slaughter (kg)	102.1	102.3	101.3	103.5	0.53	NS	NS
Mass of cold half-carcass (kg)	39.5	39.7	39.2	39.1	0.14	NS	NS
Dressing percentage (%)	77.3	77.5	76.6	76.4	0.28	NS	NS
Length of half-carcass (cm)	75.9	76.1	75.8	75.8	0.58	NS	NS
Mean back fat thickness (mm)	19.2	19.7	15.5	20.4	0.68	NS	NS
Loin eye area (cm^2)	40.1	40.2	47.9	40.4	1.12	NS	NS
Mass of loin meat (kg)	3.85	3.70	3.98	3.78	0.06	NS	NS
Mass of ham meat (kg)	6.41	6.38	6.77	6.37	0.09	NS	NS
Carcass meatiness (%)	54.3	52.4	56.9	53.2	0.61	NS	0.035
Longissimus thoracis							
Dry matter (%)	26.19	26.09	26.77	26.77	0.12	0.011	NS
Total protein (%)	23.49	23.37	24.04	24.08	0.13	0.019	NS
Crude fat (%)	1.29	1.42	1.02	1.19	0.11	NS	NS
pH 45’	6.04	6.13	6.06	6.18	0.06	NS	NS
pH 24h	5.81	5.78	5.85	5.77	0.03	NS	NS
Longissimus lumborum							
Free drip (%)	2.98	3.30	3.53	3.60	0.23	NS	NS
Water holding capacity (cm^2/g)	32.5	34.5	29.8	30.0	1.02	NS	NS
Absorbed brine (%)	2.42	1.90	1.68	2.65	0.30	NS	NS
Colour							
L	57.08	55.48	54.87	54.19	0.95	NS	NS
a*	10.53	9.03	9.76	9.60	0.34	NS	NS
b*	2.40	2.60	1.62	1.29	0.43	NS	NS
Shear force (N)	72. 9	69.0	76.2	77.7	4.44	NS	NS
Penetration force (N)	47.8	60.1	63.9	70.2	2.86	0.033	NS
Springiness	0.48	0.51	0.53	0.55	0.01	0.002	0.030
Cohesiveness	0.45	0.44	0.45	0.44	0.01	NS	NS
Chewiness (N)	13.4	17.9	24.9	24.3	1.86	0.026	NS
Hardness (N)	59.7	79.7	104.0	102.2	7.44	0.036	NS

* NS – $p > 0.05$

ture administered in the II fattening period. The addition of linseed oil was found to affect only values of springiness ($p \leq 0.05$).

DISCUSSION

Likewise in experiments by Daza *et al*. [2006], Bee *et al*. [2007], Heyer & Lebret [2007] and Więcek *et al*. [2008], the strategy of restrictive feeding of pigs applied in the I fattening period evoke an increase in meatiness of their carcasses. A higher level of growth hormone (GH) in the animals, observed after the period of restrictive feed supply, enhances mobilization of fatty acids from adipose tissue and their utilization as a source of energy [Hornick *et al*., 2000]. At a moderate restriction of diet in growing animals, investigations show deposition of protein, and not of fat. Feeding restrictions that consist in the reduction of protein content of a feed mixture lead to a great adiposity of carcasses, whereas restricted doses of a feed mixture cause smaller fat deposition [Skiba, 2005]. Nutrients absorbed with diet are first utilized by an animal organism for covering vital needs, deposition of protein and then for deposition of fat. Pigs fed in a less intensive system are observed to deposit less fat [Kristensen *et al*., 2002; Oksbjerg *et al*., 2002; Mason *et al*., 2005; Więcek *et al*., 2008].

Longissimus thoracis of pigs fed a restrictive diet, as compared to that of fatteners fed *semi ad libitum,* was demonstrated to display a higher content of dry matter and total protein, and a lower content of crude fat (a lack statistically significant differences). Investigations of numerous authors [Kristensen *et al*., 2002; Mason *et al*., 2005; Heyer & Lebret, 2007; Więcek *et al*., 2008] showed a lower content of fat in the chemical composition of selected muscles at a lower total adiposity of carcasses. Hover, worthy of notice is high differentiation in that respect which results, among other things, from the type of muscle. Bee *et al*. [2007] demonstrated a higher and lower content of fat in, respectively, *longissimus dorsi* and *semitendinosus* muscles obtained from pigs fed a restrictive diet *vs.* those fed *ad libitum*.

The thinnest back fat, the highest meatiness and the lowest content of fat in *longissimus thoracis* were reported for carcasses originating from fatteners receiving feed mixtures without oil addition for the entire fattening period and fed a restrictive diet in the I fattening period (group RC). Once in the re-alimentation period the animals were administered feed mixtures with the addition of linseed oil (groups AO and RO), they were characterised by increasing back fat thickness and diminishing meatiness of carcasses. According to Doyle & Leeson [2003], if feeding restrictions are rigorous enough to diminish bodily reserves of proteins, then deposition of protein occurs during the after-restriction feeding; whereas at a more moderate restriction of feeding the compensatory growth may lead to a greater adiposity. The compensatory growth occurring during re-alimentation is initially characterised by deposition of protein. It spans for a few days or weeks and is followed by reduced synthesis of protein, whereas a high intake of feed mixtures leads to enhanced fat deposition [Hornick *et al*., 2000; Daza *et al*., 2006]. An increase in insulin secretion observed at the initial phase of re-alimentation may, according to Blum *et al*. [1985], initiate metabolic processes. At the later stage of compensatory growth, the concentration of insulin in blood serum is high, which is likely to contribute to enhanced fat deposition in animals undergoing growth compensation.

Meat obtained from animals with body weight of 60 kg fed in the I fattening period with a restrictive diet was characterised by a greater free drip and, simultaneously, higher values of chewiness and hardness and worse absorption of brine as compared to meat of the fatteners fed *semi ad libitum*. Similar dependencies were observed between groups once the same feeding strategy was implemented in the I fattening period (-25% of feed mixture dose) yet with the application of feed mixtures supplemented with linseed oil [Więcek *et al*., 2008]. The reported study, likewise experiments by Riley *et al.* [2000] and Kouba *et al.* [2003], did not demonstrate any significant effect of the addition of linseed oil or linseeds on the quality of pork. In turn, it was shown that the quality of meat may be affected by the feeding level and that the extent of its effect is greater than that of oil addition to a feed mixture in the re-alimentation period. Feeding the pigs in the I fattening period with feed mixture doses reduced by 25% as compared to the control group caused a favourable increase in the contents of dry matter and protein in *longissimus thoracis*, yet it had a negative impact on meat quality. Feeding restriction evoked an increase in free drip and texture parameters. In animals fed from 30 to 70 kg of body weight with feed mixture doses reduced by 35% as compared to pigs fed *ad libitum*, Heyer & Lebret [2007] observed only small differences in quality parameters of pork after the re-alimentation period (110 kg b.w.). They assumed that the restrictive-compensatory feeding strategy, in contrast to the *ad libitum* one (from 30 to 110 kg b.w.), would improve the quality of meat, but results obtained in their study did not confirm that hypothesis. Also in a research by Więcek *et al*. [2005] the feeding restrictions implemented in the I fattening period and consisting in a reduction of feed mixture dose (with 4% addition of linseed oil) by 25% as compared to the control group were observed to increase hardness and chewiness of *m. longissimus*. Deterioration of texture parameters of meat might have resulted from a low content of intramuscular fat (IMF), since as shown by some studies [Bartkowiak, 2003; Daszkiewicz *et al*., 2005] an increase in IMF content is accompanied by increasing palatability, juiciness and tenderness of pork.

CONCLUSIONS

Restriction of the feeding level by 25% in the I fattening period (23-60 kg b.w.) caused an increase in the meatiness of carcasses, a decrease in the content of IMF and deterioration of texture parameters of meat. The administration of feed mixtures with 4% addition of linseed oil in the II fattening period contributed to diminished meatiness of carcasses, but did not affect negatively meat quality. The restrictive-compensatory feeding strategy resulted in an increase in the contents of dry matter and total protein in *longissimus thoracis* and deterioration of texture parameters of *longissimus lumborum*.

ACKNOWLEDGEMENTS

The study was conducted under a research project No. 3 P06Z 014 23.

REFERENCES

1. Aaslyng M.D., Oksama M., Olsen E.V., Bejerholm C., Baltzer M., Andersen G., Bredie W.L.P., Byrne D.V., Gabrielsen G., The impact of sensory quality of pork on consumer preference. Meat Sci., 2007, 76, 61–73.
2. AOAC, 1994. Official Methods of Analysis. Association of Official Analytical Chemists. 15th Edition. Washington, DC.
3. Bartkowiak Z., Feeding systems and fattening and slaughter traits of pigs. 2003, PhD Thesis. Agricultural University of Poznań, pp. 49–56 (in Polish).
4. Bee G., Calderini M., Biolley C., Guex G., Herzog W., Lindemann M.D., Changes in the histochemical properties and meat quality traits of porcine muscles during the growing-finishing period as affected by feed restriction, slaughter age, or slaughter weight. J. Anim. Sci., 2007, 85, 1030–1045.
5. Blum J.W., Schnyder W., Kunz P.L., Blom A.K., Bickel H., Schürch A., Reduced and compensatory growth: endocrine and metabolic changes during food restriction and refeeding in steers. J. Nutr., 1985, 115, 417–424.
6. Daszkiewicz T., Bąk T., Denaburski J., Quality of pork with a different intramuscular fat (IMF) content. Pol. J. Food Nutr. Sci., 2005, 14/55, 1, 31–36.
7. Daza A., Olivares A., López-Bote C., Effect of a moderate feed restriction on subsequent growth and body composition in pigs raised under high environmental temperatures. J. Anim. Feed Sci., 2006, 15, 417–426.
8. Doyle F., Leeson S., Compensatory growth in farm animals. Factors influencing Response. University of Guelph, Ontario, Canada, 2003, [http://www.novusint.com/Public/Library/DocViewer.asp?ID=1].
9. Grau R., Hamm R., Eine einfache Methode zur Bestimmung der Wasserbindung Fleisch. Fleischwirtschaft, 1952, 4, 195–297.
10. Heyer A., Lebret B., Compensatory growth response in pigs: Effects on growth performance, composition of weight gain at carcass and muscle levels, and meat quality. J. Anim. Sci., 2007, 85, 769–778.
11. Hornick J.L., van Eenaeme C., Gérard O., Dufrasne I., Istasse L., Mechanisms of reduced and compensatory growth. Domest. Anim. Endocrinol., 2000, 19, 121–132.
12. Kouba M., Enser M., Whittington F.M., Nute G.R., Wood J.D., Effect of a high-linolenic acid diet on lipogenic enzyme activities, fatty acid composition, and meat quality in the growing pig. J. Anim. Sci., 2003, 81, 1967–1979.
13. Kristensen L., Therkildsen M., Aaslyng M.D., Oksbjerg N., Ertbjerg P., Compensatory growth improves meat tenderness in gilts but not in barrows. J. Anim. Sci., 2004, 82, 3617–3624.
14. Kristensen L., Therkildsen M., Riis B., Sørensen M.T., Oksbjerg N., Purslow P.P., Ertbjerg P., Dietary-induced changes of muscle growth rate in pigs: Effects on *in vivo* and *post-mortem* muscle proteolysis and meat quality. J. Anim. Sci., 2002, 80, 2862–2871.
15. Łyczyński A., Wajda S., Czyżak-Runowska G., Rzosińska E., Grześ B., Effect of environmental conditions on pork meat quality – a review. Pol. J. Food Nutr. Sci., 2006, 15/56, 2, 109–116.
16. Mason L.M., Hogan S.A., Lynch A., O'Sullivan K., Lawlor P.G., Kerry J.P., Effects of restricted feeding and antioxidant supplementation on pig performance and quality characteristics of *longissimus dorsi* muscle from Landrace and Duroc pigs. Meat Sci., 2005, 70, 307–317.
17. Mroczek J., Ćwiczenia z kierunkowej technologii żywności. Technologia mięsa i jaj. 1997, Wyd. SGGW, Warszawa (in Polish).
18. Oksbjerg N., Sørensen M.T., Vestergaard M., Compensatory growth and its effect on muscularity and technological meat quality in growing pigs. Acta Agric. Scand., Sect. A, Anim. Sci., 2002, 52, 85–90.
19. PN – 77/A-82058. 1977. Meat and meat products. Determination of meat pH (in Polish).
20. Pohja N.S., Niinivaara F.P., Die Bestimmung des Wasserbindung des Fleisches mittels der Konstantdrück methode. Fleischwirtschaft, 1957, 9, 193–195.
21. Riley P.A., Enser M., Nute G.R., Wood J.D., Effects of dietary linseed on nutritional value and other quality aspects of pig muscle and adipose tissue. Anim. Sci., 2000, 71, 483–500.
22. Różycki M., Zasady postępowania przy ocenie świń w Stacjach Kontroli Użytkowości Rzeźnej Trzody Chlewnej. Stan hodowli i wyniki oceny świń. Wyd. Wł. IZ XIV, 1996, 69–82 (in Polish).
23. Skiba G., Physiological aspects of compensatory growth in pigs. J. Anim. Feed Sci., 2005, 14, Suppl. 1, 191–203.
24. Skiba G., Raj St., Weremko D., Fandrejewski H., The compensatory response of pigs previously fed a diet with an increased fibre content. 2. Chemical body components and composition of daily gain. J. Anim. Feed Sci., 2006, 15, 403–415.
25. SPSS, 2000: SPSS 10.0 for Windows user's Guide, by SPSS Ins. (USA).
26. Therkildsen M., Riis B., Karlsson A., Kristensen L., Ertbjerg P., Purslow P.P., Aaslyng D.M., Oksbjerg N., Compensatory growth response in pigs, muscle protein turn-over and meat texture: effects of restriction/realimentation period. Anim. Sci., 2002, 75, 367–377.
27. Therkildsen M., Vestergaard M., Busk H., Jensen M.T., Riis B., Karlsson A.H., Kristensen L., Ertbjerg P., Oksbjerg N., Compensatory growth in slaughter pigs – *in vitro* muscle protein turnover at slaughter, circulating IGF-I, performance and carcass quality. Lives. Prod. Sci., 2004, 88, 63–75.
28. Więcek J., Florowski T., Dasiewicz K., Kosińska M., Skomiał J., Initial studies on the effect of pig feeding system and linseed oil supplementation on technological properties and texture of meat. Ann. Anim. Sci., Suppl., 2005, 2, 215–218.
29. Więcek J., Skomiał J., Rekiel A., Florowski T., Dasiewicz K., Kosińska M., Fattening and slaughter parameters in the first period of fattening of pigs fed restrictive or *semi ad libitum* diets. Pol. J. Food Nutr. Sci., 2008, 58, 3, 325–329.
30. Wood J.D., Enser M., Fischer A.F., Nute G.R., Richardson R.I., Sheard P.R., Meat quality: an integrated approach for the future. 1998, *in*: Proc. the 15th IPVS Congress, Birmingham, England, 5–9 July 1998, v.1, pp. 103–113.

Received December 2007. Revision received April and accepted September 2008.