Carcass quality in restricted and *ad libitum* fed rabbits

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ABSTRACT: The effect of the length and intensity of feed restriction on carcass quality characteristics was studied in two experiments. In the first experiment rabbits were restricted 1 or 3 weeks. Group 1 was fed *ad libitum*, group 2 was restricted from 35 to 42 days of age (50 g per day/rabbit), group 3 was restricted from 42 to 49 days of age (65 g per day/rabbit), group 4 was restricted from 56 to 63 days of age (90 g per day/rabbit) and group 5 was restricted three weeks, from 35 to 42 days of age (50 g per day/rabbit), 42 to 49 days of age (65 g per day/rabbit) and from 56 to 63 days of age (90 g per day/rabbit). Rabbits were slaughtered at the age of 84 days. In the second experiment the rabbits were restricted between 42 and 56 days of age and the rabbits were divided into three groups. Group 1 was fed *ad libitum*, the rabbits in group 2 got 50 g of feed at the age of 42 to 49 days and 65 g of feed at the age of 49 to 56 days and in group 3, 50 g and 75 g of feed in the two periods, respectively. Carcass characteristics were evaluated at the age of 49, 56, 63 and 84 days. Restriction did not affect dressing percentage but reduced the weight of loin. Renal fat was detected in restricted rabbits at the age of 63 days whereas in the *ad libitum* fed ones at 56 days. Renal fat was significantly ($P \leq 0.05$) reduced in rabbits restricted from 56 days of age (experiment 1, 19.71 g, 19.28 g, 26 g vs. 14.33 g and 11.43 g). Kidney and liver weight was influenced by the restriction and realimentation period. The meat colour and pH (measured 24 h *post mortem*) were not affected by treatments.

Keywords: rabbit; restriction; carcass characteristics; colour; pH

Feed restriction has been studied in order to improve biological and economic performance. Restricted feeding induces compensatory growth and increases feed efficiency (Maertens and Peeters, 1988; Szendro et al., 1989; Schlolaut and Lange, 1990; Perrier and Ouhayoun, 1996; Tůmová et al., 2002, 2003; Dalle Zotte et al., 2005), improves digestibility of nutrients in a restricted feeding period (Ledin, 1984a,b; Gidenne, 1993; Tůmová et al., 2003, 2004) and restricted feeding can be a prevention against post-weaning digestive disorders (Gidenne et al., 2003; Boisot et al., 2004).

Carcass characteristics are important factors to consider when evaluating alternative feeding programs. Ledin et al. (1984a) concluded that carcass and dissection characteristics were not influenced by restriction. According to Perrier and Ouhayoun (1996) rabbits restricted from 56 days of age had lighter carcasses but carcass yield was the same as in the *ad libitum* fed rabbits. Rabbits restricted till 56 days had better carcass yield. In our previous experiments (Tůmová et al., 2003) time restriction did not affect carcass weight and dressing percentage. Quantitatively restricted rabbits with a restriction period of 3 weeks had significantly lower ($P \leq 0.05$) carcass weight than the groups restricted one or two weeks, but dressing percentage was not significantly ($P \leq 0.05$) influenced by the feeding regime.

As organs perform different metabolic functions and grow at a different rate, undernutrition may affect the growth and development of some organs and tissues. Ledin (1984b) revealed that internal organs were markedly affected by restriction and realimentation period whereas the stomach grew rapidly at the beginning of the realimentation period and the other organs except kidneys had the same growth rate as in *ad libitum* fed rabbits. Higher proportions of liver, heart and kidneys in carcass weight were reported by Ledin (1984a), Perrier and Ouhayoun (1996), Perrier (1998), Tůmová et

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al. (2003). In our following experiment (Tůmová et al., 2004) restriction treatments reduced the weight and length of intestines but in the first week after restriction the weight of small intestine was higher and at the end of the experiment there were no differences in weight between groups but the small intestine was longer than in *ad libitum* fed rabbits. The large intestine was heavier in restricted rabbits at the end of the experiment (Tůmová et al., 2006, in press).

The aim of the present study was to determine the effect of the length and intensity of quantitative feed restriction on development of carcass characteristics in broiler rabbits.

MATERIAL AND METHODS

In two feeding experiments Hyplus rabbits (male to female ratio 1:1) of weaning stage (35 days of age) were used. The rabbits were from a commercial farm. The rabbits were placed into cages with separation of urine and faeces. The temperature of 16°C and relative humidity 55% were maintained for the whole period of fattening. A twelve-hour photoperiod was used. Water was available *ad libitum*. The rabbits were fattened until 84 days of age.

In the first experiment, 40 rabbits were used. Rabbits were housed in individual metabolic cages (0.15 m^2 per rabbit). The rabbits were split into 5 groups with 8 rabbits per group. In this experiment, group 1 was fed *ad libitum*, group 2 was restricted from 35 to 42 days of age (50 g per day/rabbit), group 3 was restricted from 42 to 49 days of age (65 g per day/rabbit), group 4 was restricted from 56 to 63 days of age (90 g per day/rabbit) and group 5 was restricted three weeks, from 35 to 42 days of age, 42 to 49 days of age and from 56 to 63 days of age. The rabbits in this group got 50 g, 65 g and 90 g feed per day/rabbit. After the restriction period rabbits were fed *ad libitum*.

Table 1. Chemical composition of experimental diets (g/kg)

Measurement	Experiment 1	Experiment 2
Dry matter	914.54	899.9
Crude protein	175.16	173.9
Fat	26.20	25.3
Crude fibre	193.96	199.3
Ash	80.16	75.7

In the second experiment, 108 rabbits were divided into 3 groups by 36 individuals. The rabbits were housed in commercial cages for two rabbits with the space floor 0.09 m^2 per rabbit. The rabbits in group 1 were fed *ad libitum*, in group 2 they were restricted from 42 to 56 days of age (50 g at the age 42 to 49 days, 65 g at the age 49 to 56 days) and in group 3 they were restricted in the same period (50 g at the age 42 to 49 days, 75 g at the age 49 to 56 days). Following the restriction period, the rabbits were fed *ad libitum*. The quantity of feed was given on the basis of results of our previous experiments Tůmová et al. (2002, 2003).

In both experiments, the rabbits received commercial pelleted feeds that were used in our previous experiments (Tůmová et al., 2003, 2004). The analyzed content of nutrients per 1 kg of feed mixture is given in Table 1.

Six rabbits per treatment of the average weight were slaughtered in both experiments. In the first experiment rabbits were slaughtered at the age of 84 days and in the second experiment at the age of 49, 56, 63 and 84 days (6 rabbits per treatment/age). The slaughter and carcass dissection were carried out in an experimental slaughterhouse. Rabbits were fasted overnight, and slaughtered the following morning by electric stunning and bleeding by a jugular cut. The method of carcass measurements was harmonised by Blasco and Ouhayoun (1996). Carcass measurements included the weight of kidney and liver.

In the first experiment, the meat colour was measured with tristimulus analyzer Minolta 2500c. For pH determination the device WTW InoLab 720 was used. The values of pH were determined 3 and 24 h *post mortem*. Both characteristics were measured in loin.

Data of the first experiment were processed by analysis of variance using the ANOVA procedure of SAS (SAS Institute Inc, Cary, NC). The significance of differences between groups was tested by Scheffe's test on the level of significance $P \leq 0.05$. Data of the second experiment were evaluated by two-way analysis of variance, treatment and age interactions using the GLM procedure of SAS.

RESULTS AND DISCUSSION

In experiment 1, the length of the restriction period did not influence the majority of carcass characteristics (Table 2). Dressing percentage was

Table 2. Carcass analysis at 84 days of age, experiment 1

Characteristic	*Ad libitum*	Restriction (days of age)				SEM
		35–42	42–49	56–63	35–49, 56–63	
Live weight 84th day of age (g)	2653^{ab}	2721^{a}	2748^{a}	2610^{ab}	2373^{b}	40.53
Dressing percentage (%)	58.88	59.17	58.11	58.39	56.38	2.13
Hind part of the carcass (%)	49.24	48.60	48.20	47.63	47.54	2.80
Fore part of the carcass (%)	42.12	42.06	42.31	41.08	42.53	1.53
Loin (%)	14.72^{a}	13.58^{ab}	13.88^{ab}	13.12^{b}	12.74^{b}	1.10
Hind legs (%)	28.92	29.27	28.24	28.82	29.29	1.85
Thigh muscles (%)	21.43	21.50	21.54	21.64	20.46	1.54
Kidney (g)	19.14	21.29	19.60	18.67	18.29	0.56
Renal fat (g)	19.71^{a}	19.28^{a}	26.00^{a}	14.33^{b}	11.43^{b}	0.56
Liver (g)	77.83	79.71	72.40	75.00	65.86	2.11
Skin (%)	17.45^{a}	16.44^{ab}	16.59^{ab}	15.95^{ab}	14.61^{b}	1.43

$^{a,b}P \leq 0.05$

insignificantly lower in rabbits restricted 3 weeks in comparison with rabbits fed *ad libitum* or restricted 1 week. The highest dressing percentage was in the group which was restricted 1 week from 35 to 42 days of age. This result coincides with findings reported by Ledin (1984a), Perrier and Ouhayoun (1996), Tůmová et al. (2003), Boisot et al. (2004). Differences between groups were not significant either in dressing percentage or in the hind part of the carcass. Restriction had a significant ($P \leq 0.05$) effect on the proportion of loin. All restricted rabbits had a lower proportion of loin but in rabbits restricted from the age of 56 days and in those with the restriction period 3 weeks the loin proportion was significantly ($P \leq 0.05$) lower (11% and 14%, respectively). The same trends were found in renal fat. Significantly lower weight of renal fat was in the group restricted from 56 days of age and with restriction 3 weeks. The same results were reported by Perrier and Ouhayoun (1996), Perrier (1998) and Lazur et al. (2004).

The meat colour (Table 3) measured in loin was not affected by restriction and it agreed with findings of Combes et al. (2003) or Dalle Zotte et al. (2005). The pH value (Table 3) determined 3 hours *post mortem* was significantly higher in rabbits restricted till 63 days of age whereas its measurement 24 h *post mortem* did not indicate any differences between groups. Dalle Zotte and Ouhayoun (1995) stated that pH was not affected by restriction but Perrier and Ouhayoun (1996) found out significantly lower pH in rabbits restricted till 56 days of age. Different results could be explained either by different lengths of the restriction period or by the strictness of feed rationing (Dalle Zotte et al., 2005).

Development of carcass characteristics was examined in the second experiment (Table 4). Dressing percentage was significantly ($P \leq 0.05$) affected by age and feeding regime when it increased with age significantly. At variance with findings of Lebas and Laplace (1982), in the middle of the restriction period

Table 3. Physical characteristics of meat quality

Characteristic	*Ad libitum*	Restriction (days of age)				SEM
		35–42	42–49	56–63	35–49, 56–63	
pH24	5.87	5.75	5.87	5.85	9.92	0.02
Colour	17.33	15.83	17.60	17.33	15.83	3.18

$^{a,b}P \leq 0.05$

Table 4. Carcass characteristics in experiment 2

Characteristic	Treatment	Age (days)				Significance		
		49	56	63	84	Age	Treatment	Age × treatment
Live weight (g)	ADL	1 417	1 748	1 918	3 111	***	***	NS
	R 50 + 65 g	1 108	1 261	1 671	2 650			
	R 50 + 75 g	1 191	1 222	1 606	2 762			
Dressing percentage (%)	ADL	46.89	48.41	55.5	63.8	***	NS	**
	R 50 + 65 g	48.37	47.85	51.8	62.5			
	R 50 + 75 g	47.52	49.48	51.1	62.8			
Hind part (g)	ADL	339.0	440.5	520.0	894.8	***	***	NS
	R 50 + 65 g	291.8	300.5	386.5	761.4			
	R 50 + 75 g	290.5	302.7	380.5	802.2			
Fore part (g)	ADL	318.3	398.3	435.8	752.8	***	***	NS
	R 50 + 65 g	276.2	294.0	366.8	626.0			
	R 50 + 75 g	271.3	294.0	341.7	644.3			
Loin (g)	ADL	123.0	150.7	205.8	307.3	***	***	NS
	R 50 + 65 g	102.0	99.2	136.8	243.0			
	R 50 + 75 g	104.2	95.3	141.8	261.3			
Hind legs (g)	ADL	201.0	274.3	294.0	492.7	***	***	NS
	R 50 + 65 g	162.7	188.0	230.3	432.8			
	R 50 + 75 g	159.7	195.7	221.7	458.0			
Thigh muscles (g)	ADL	–	–	211.0	385.3	***	***	**
	R 50 + 65 g	–	–	154.3	316.0			
	R 50 + 75 g	–	–	142.8	338.7			
Kidney (g)	ADL	10.8	11.8	14.3	21.0	***	***	NS
	R 50 + 65 g	8.7	8.8	13.3	17.2			
	R 50 + 75 g	10.0	8.8	13.5	16.7			
Renal fat (g)	ADL	0	2.2	3.8	26.7	***	NS	NS
	R 50 + 65 g	0	0	1.7	18.6			
	R 50 + 75 g	0	0	1.4	17.7			
Liver (g)	ADL	46.7	54.5	78.3	92.5	***	**	NS
	R 50 + 65 g	30.3	32.0	78.0	83.4			
	R 50 + 75 g	34.2	33.2	76.5	90.2			
Skin in live weight (%)	ADL	29.51	27.5	26.8	18.5	***	NS	NS
	R 50 + 65 g	29.27	28.3	26.6	17.7			
	R 50 + 75 g	29.37	26.6	27.3	18.5			

***$P \leq 0.001$; **$P \leq 0.05$

NS = non-significant

dressing percentage was higher in restricted rabbits in comparison with the *ad libitum* fed ones. However, dressing percentage was higher from 63 days of age in *ad libitum* fed rabbits, which is in accordance with Combes et al. (2003) but in contrast with the results of Ferreira and Carregal (1996), Tůmová et al. (2003) or Boisot et al. (2004), who reported that restriction did not affect dressing percentage.

The weight of the hind part and hind legs was insignificantly higher in *ad libitum* fed rabbits than

in restricted groups, which is in agreement with Perrier and Ouhayoun (1996), but Combes et al. (2003) reported a significantly higher proportion of hind part and hind legs in *ad libitum* fed rabbits. There was a significant ($P \leq 0.004$) interaction in thigh muscle weight which was evaluated from 63 days of age while the effect of restriction and restriction intensity on this characteristic was negative.

Renal fat was detected in *ad libitum* fed rabbits at the age of 56 days whereas in the restricted ones at 63 days of age. At the end of the experiment the restricted rabbits had a lower renal fat content than *ad libitum* fed ones. Consequently, this result agrees with our previous findings (Tůmová et al., 2003). Moreover, the effect of restriction intensity was not observed because the renal fat content in rabbits with stricter restriction was insignificantly higher. The effect of restriction on renal fat seems not to be clear and this result coincides with Combes et al. (2003).

The internal organs, kidney and liver, were affected by the restriction and realimentation period. During the restriction period kidney weight was lower in restricted rabbits but in the first week of the realimentation period there were no differences between restricted and *ad libitum* fed rabbits whereas at the end of the experiment kidney weight of restricted rabbits decreased in comparison with the *ad libitum* fed ones. Similar trends were observed in liver. Liver weight of restricted rabbits rapidly increased in the realimentation period and there were no differences in liver weight at the end of the experiment. Presumably in the realimentation period a priority is given to the development of internal organs which grow faster than the other parts of the body. Similar results were reported by Ledin (1984a,b), Perrier and Ouhayoun (1996) or in our previous experiment conducted by Tůmová et al. (2003).

It may be concluded that restriction slightly reduced dressing percentage but the length or the intensity of restriction did not have significant effects on this parameter. Therefore there could be some differences in the development of carcass parts. One of the most influenced parts of carcass was loin which was reduced in restricted rabbits according to the length and intensity of restriction. The effect of restriction on fat deposition seems not to be clear. On the one hand, fat deposition started later in restricted rabbits than in the *ad libitum* fed ones, and on the other hand, different results were found in connection with the length and intensity of restriction. Development of internal organs was influenced by the restriction and realimentation period. Presumably in the realimentation period a priority is given to the development of internal organs which grow faster than the other parts of the body.

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