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PERIRENAL FAT, CARCASS CONFORMATION, GAIN AND FEED EFFICIENCY OF GROWING RABBITS AS AFFECTED BY DIETARY PROTEIN AND ENERGY CONTENT

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ABSTRACT : In three experiments, a total of 617 rabbits from weaning at 37 days until a live weight of approx. 2.5 kg at an avg. of 85 days were fed one of six different compound feeds with increasing protein/energy ratios (P/E). Experiment 1: 1.79 and 1.96 % crude protein/MJDE per kg DM, experiment 2: 1.79, 2.28 and 2.46, and experiment 3: 1.79, 1.83 and 2.59. The rabbits were slaughtered at an average of 2.9 kg live weight at 99 days of age. An increase in P/E resulted in a significant decrease in the amount of perirenal fat, in experiment 2 from 49.4 g to 38.7 g and in experiment 3 from 39.4 g to 28.4 g. A significant reduction of dressing out percentage was seen in experiment 2 and the same non-significant reduction was seen in experiments 1 and 3. A significant increase of feed conversion was found in experiment 2. For hind part as well as back, a subjective score for fleshiness showed a tendency to fall at the highest P/E-values and for the combined evaluation the effect was significant. It is concluded that it is possible to affect the amount of perirenal fat by changing the P/E ratio of the feed. At high P/E-values, this may, however, be expected to result in reduced daily gain and feed conversion, increased mortality and poorer fleshiness. It should be considered to use other methods for adjusting the amount of perirenal fat at a given weight, for instance through breeding.

RESUME : Influence du contenu en protéine et en énergie de l'aliment sur le gras périrénal, la conformation de la carcasse, le gain de poids et l'efficacité alimentaire de lapins en croissance. *Au cours de trois expérimentations, un total de 617 lapins ont été nourris avec 6 régimes expérimentaux à taux de protéines/énergie croissants, du sevrage à 37 jours jusqu'au poids vif approximatif de 2,5 kg atteint en moyenne à 85 jours. Expérience n°1 : 1,79 et 1,96% de protéines brutes/MJED par kg ; expérience n°2 : 1,79 - 2,28 et 2,46 ; expérience n°3 : 1,79 - 1,83 et 2,59. Les lapins ont été abattus à un poids vif moyen de 2,9 kg à 99 jours d'âge. Une augmentation du rapport P/E provoque une diminution significative du gras périrénal, de 49,4 g à 38,7 g dans l'expérience n°2, et de 39,4 g à 28,4 g dans l'expérience n°3. On a observé une diminution significative du rendement à l'abattage dans l'expérience n°2 et une même diminution mais non significative dans les expériences n°1 et n°3. Une augmentation significative de l'efficacité alimentaire a été observée dans l'expérience n°2. Concernant les parties arrières et le râble, une évaluation subjective de la musculairité montre une tendance à la baisse avec les rapports P/E les plus hauts, et un effet significatif pour l'ensemble des évaluations. On peut conclure qu'il est possible de modifier la quantité de gras périrénal en changeant le rapport P/E de la ration. Toutefois, lorsque le rapport P/E est élevé, on peut s'attendre à une réduction de la vitesse de croissance et de l'efficacité alimentaire, une augmentation de la mortalité et un mauvais rapport muscle/os. On peut considérer qu'il existe d'autres méthodes d'élevage permettant d'ajuster la quantité de gras périrénal à un poids vif donné.*

INTRODUCTION

The content of perirenal carcass fat should be kept within specific limits given by the existing demand. The producers therefore wish - through feeding - to be able to adjust the average fat content in rabbit carcasses to the given requirements. During recent years, an undesirable tendency towards an increasing fat content in the carcass of rabbits from the herd at the Danish Institute of Animal Science (DIAS) has been experienced.

Experiments with poultry have shown that when the protein content of the feed is changed, the animals will try to compensate by eating the quantity of feed required to meet the need for essential amino acids (SUMMERS *et al.*, 1992). It is thus not possible to maintain a certain energy intake when giving compound feeds with different protein contents. The protein to energy ratio (P/E) is an essential parameter when comparing different compound feeds. Experiments with pigs (CAMPBELL *et al.*, 1984) have shown that it is possible to reduce the total fat content of the carcass by using feed with an increasing P/E ratio. Also in rabbits, a decreasing content of fat in the carcass totally (SPREADBURY, 1978; TAIE and ZANATY, 1993) and abdominally (AYYAT, 1991) has been observed at an increasing P/E ratio, but with a relatively limited number of animals. An investigation was therefore initiated, in which slaughter rabbits were given feed with increasing P/E. As dressing out percentage, fleshiness as well as daily gain and feed conversion are very important to the economic gain, these parameters as well as the carcass content of perirenal fat were recorded, and the results are given in the following.

MATERIALS AND METHODS

The rabbits for these experiments were produced at the rabbitry at DIAS and were progeny of two pure lines of the Danish/New Zealand White lines and their crosses. See JENSEN *et al.* (1996b) for details on the origin of these lines, breeding plan and housing.

Three experiments were conducted. In each experiment, a control diet (diet 1 on tables) holding 19% crude protein in DM and 10.7 MJ DE per kg DM was compared to one or two diets higher in crude protein to digestible energy ratio (P/E). The dietary content of DE was calculated according the method described by BØRSTING *et al.* (1995) which is based on in vitro digestible organic matter as described by BOISEN (1991). Each litter was at random split in two,

67 dias s/carta de los autores

Table 1 : Ingredients of the experimental diets (%)

Diet	1	2	3	4	5	6
Grass meal	30.0	40.0	24.2	40.0	40.0	43.0
Oat	30.0	30.0	20.0	-	30.0	-
Barley	15.0	-	-	-	5.0	-
Straw pellets	-	-	10.0	10.0	-	10.0
Wheat bran	10.0	10.0	12.0	10.2	12.0	-
Sun seed cake	8.0	12.0	25.0	21.0	6.0	25.0
Ground nut cake	4.0	5.0	5.0	15.0	4.0	18.0
Molasses	1.5	1.5	2.0	2.0	1.5	2.0
$CaCO_3$	0.7	0.7	1.0	1.0	0.7	1.0
NaCl	0.2	0.2	0.2	0.2	0.2	0.2
$Ca_3(PO_4)_2$	0.1	0.1	0.1	0.1	0.1	0.1
Vitamin mixture	0.5	0.5	0.5	0.5	0.5	0.5

one half fed a control diet, the other half fed an experimental diet. Compound feed, as shown in table 1, was produced at the feed mill at DIAS and pelleted in 3 mm pellets.

A total of 617 rabbits were fed *ad lib.* from weaning at 37 days of age to an average of 86 days of age and live weight of 2.5 kg. At this age daily gain was determined as well as measures of feed intake and mortality, see later. The rabbits were slaughtered in batches at an average of 99 days of age and 13 days after termination of the feeding test. Therefore the weight at slaughter on average are higher than weight at the finish of the feeding trial (2.9 versus 2.5 kg).

The experimental set up and number of animals included can be seen in table 4.

Terminology and criteria for slaughtering and evaluation of carcass etc. follow (if nothing else is indicated) international standards as given by BLASCO and OUHAYOUN (1993). Prior to slaughter, the rabbits were fasted for 12 hours with access to water only and before being transported to the abattoir at DIAS they were weighed (LW99). After slaughter, the carcass was chilled in water for one hour and the dorsal length from atlas vertebra to the 7th lumbar vertebra was measured, in experiment 1 on the hanging carcass, in experiments 2 and 3 on the lying carcass. The chilled carcass weight (CCW) - including head and perirenal fat, but excluding liver, kidneys, lungs, oesophagus, trachea, thymus and heart - was recorded. The dressing out percentage was calculated as CCWx100/LW99. Perirenal fat was removed and weighed. In a subjective classification system, points from 1 to 5 were given for fleshiness of the back part (dorsal view of the body part between cut points 1 and 3 (BLASCO and OUHAYOUN, 1993)) and the hind part (dorsal view of the distal body part after cut point 4. The scores of back and hind part were summed in the variable 'fleshiness combined'. The amount of perirenal fat (degree of fatness) was scored 1 for too little fat, 2 for suitable amount and 3 for too much fat. Fleshiness and degree of fatness were evaluated on the uncut carcass. The feed intake was recorded per cage and mortality was recorded in each experimental treatment group.

Statistical analyses of experimental data concerning anatomical measurements and feed efficiency were performed by using the GLM procedure of SAS (SAS Inst. Inc., 1987). Data were analysed by analysis of covariance with combined effect experiment*feed, sex and genetic stock (see table 3) as fixed effects and weight at weaning as covariate. Three factor interactions were assumed to be non-significant. Effects tested non-significant were removed from the model. LSMEANS were calculated. Subjective measurements of fleshiness and fatness were analysed by χ^2-test. Mortalities are reported as means and as per cent of cages without any dead or with one or more dead. These last counts were subjected to χ^2-tests overall and by experiment respectively.

RESULTS

For all variables except feed conversion and mortality a significant effect of experiment*diet as well as genetic stock was found (Table 3). Average daily gain and feed conversion were independent of experiment*diet. For LW99, slaughter weight and for the amount of perirenal fat there was a significant effect of weight at weaning.

When comparing the results within the individual experiments it appears from table 4 that the amount of perirenal fat significantly decreased with increasing P/E, in experiment 2 from 49.4 to 38.7 (P<0.05) and in experiment 3 from 39.4 to 28.4 (P<0.05). Dressing out percentage was significantly reduced with increasing P/E in experiment 2, but also in the other two experiments this tendency could be seen. LW99 and slaughter weight significantly decreased at the highest P/E in experiments 2 and 3. The effect of P/E on average daily gain was not clear. In experiment 2 a P/E of

Table 2 : Chemical composition and digestible energy of diets (in relation to dry matter)

Diet	1 (control)	2	3	4	5	6
Crude protein, %	19.18	21.04	24.25	25.95	19.16	26.99
Crude fat, %	4.43	4.37	4.06	3.61	5.08	4.40
N-free extracts, %	69.34	66.22	62.84	59.88	65.81	55.73
Crude fibre, %	15.37	19.01	17.71	18.60	16.66	19.38
Gross energy (BE), MJ/kg	16.48	16.50	16.35	16.23	16.08	16.06
Digestible energy (DE), MJ/kg	10.71	10.73	10.63	10.55	10.45	10.44
Protein/energy (P/E) ratio, % CP per MJDE	1.79	1.96	2.28	2.46	1.83	2.59

Table 3 : Variance analysis for composition of chilled carcasses, growth rate and feed efficiency of the effects tested significant (feed conversion tested non significant)

	Exp. * diet (E)	Genetic stock (G)	Weaning weight	E*G	Residual
Degrees of freedom	7	2	1	14	580 to 606[3]
Live weight (LW99), g	418750***[1]	1081962***	1855826***	---	48175
Chilled carcass weight, g	208262***	138689**	272210***	---	21929
Dressing out percentage	22***	51***	---	---	5
Dorsal length, cm	120***	14***	---	---	2
Perirenal fat, g	3463***	5877***	1399*	--	261
Average daily gain [2], g	164***	1471***	---	92**	40
Degrees of freedom	7	---	---	---	69
Feed conversion[2]	5ns	---	---	---	3

[1] *** : P <= 0.001, ** : P <= 0.01, * : P <= 0.05, ns: non significant
[2] Avg. daily gain and feed conversion from 37 days to 87 days (approx. 2.5 kg)
[3] Residual degrees of freedom varies according to model used (non sign. effects removed)

2.28 resulted in the highest daily gain (43.0 g/d). Feed conversion showed a non-significant tendency to be the lowest at the highest P/E levels. The total fleshiness score significantly decreased at the highest P/E values. In experiment 3 significantly more animals were scored "lack of fat" at the highest P/E level. No effect of treatment on mortality rate was seen.

DISCUSSION

Experiment 1 was affected by an outbreak of enteritis which is supposed to have influenced the results, especially with regard to mortality and gain.

A distinct effect of increasing P/E was a reduction in the amount of perirenal fat. This result therefore supports other investigations with rabbits by LEDIN (1982), OUHAYOUN and CHERIET (1983) and AYYAT (1991). SPREADBURY (1978) and TAIE and ZANATY (1993) found a reduction in the total fat content of the carcass at increased P/E. In broilers (JACKSON *et al.* (1982), SUMMERS and LEESON (1984), KASSIM and SUWANPRADIT (1996)) both the total fat content and the amount of abdominal fat in the carcass can be reduced with the use of a high P/E feed. The subjective grading of the degree of fattening corresponded well with the objective classifications. JENSEN *et al.* (1996a) found a correlation of 0.54*** between subjectively graded and objectively measured fat content in the carcass of does, whereas the correlation could not be found in bucks (r=0.12). This suggests that a subjective grading of perirenal fat is valuable.

A high dietary protein level does not seem to have a negative effect on growth rate (experiment 2), but when P/E is increased to 2.3 the daily gain is reduced. De BLAS *et al.* (1981) found the optimum growth rate at 23.5 kcal DE per g digestible protein, corresponding to P/E = 1.78, very similar to the control feed in the present experiment (P/E = 1.79). PRASAD *et al.* (1996)

Table 4 : Least-squares means[1] and standard errors for composition of chilled carcasses, daily gain[2] and feed conversion[2]. Mortality[2] [3] means and percent cages with/without mortality

Exp. number	1	1	2	2	2	3	3	3
Diet	1	2	1	3	4	1	5	6
Number of animals	114	110	81	77	89	80	86	72
P/E	1.79	1.96	1.79	2.28	2.46	1.79	1.83	2.59
Live weight, g	2922 ± 24	2904 ± 25	3053 ± 26^a	2972 ± 28^b	3005 ± 25^a	2942 ± 26^a	2892 ± 24^a	2802 ± 27^b
Ch. carcass weight, g	1663 ± 18	1641 ± 19	1816 ± 20^a	1724 ± 20^b	1721 ± 17^b	1715 ± 19^a	1672 ± 18^a	1623 ± 23^b
Dressing out, %	57.4 ± 0.36	56.7 ± 0.37	58.6 ± 0.3^a	57.9 ± 0.3^a	57.2 ± 0.3^b	58.1 ± 0.3	58.2 ± 0.3	57.5 ± 0.3
Dorsal length, cm	33.9 ± 0.2	33.7 ± 0.2	37.0 ± 0.2	36.6 ± 0.2	37.1 ± 0.2	36.5 ± 0.2	36.4 ± 0.2	36.7 ± 0.2
Perirenal fat, g	29.8 ± 1.9	29.0 ± 2.0	49.4 ± 2.2^a	45.3 ± 2.1^b	38.7 ± 1.9^c	39.4 ± 2.1^a	36.7 ± 2.0^b	28.4 ± 2.5^c
Avg. daily gain,g/d[2]	38.3 ± 0.7	38.4 ± 0.8	40.6 ± 0.8^b	43.0 ± 0.9^a	40.7 ± 0.8^b	41.4 ± 0.8	39.3 ± 0.8	41.7 ± 1.0
Feed conversion[2]	3.58 ± 0.4	3.57 ± 0.5	3.29 ± 0.5^b	4.08 ± 0.5^a	5.11 ± 0.5^a	3.90 ± 0.5	4.28 ± 0.5	4.94 ± 0.5
Mortality, mean[3], %	12.7	12.0	6.3	7.5	8.0	7.3	3.5	9.3
Cages 0 dead[3], %	50	50	76	82	71	71	82	60
Cages >=1 dead[3], %	50	50	24	18	29	29	18	40

[1] Values bearing unlike superscripts in a row differ significantly (P<0.05) from each other within experiments
[2] Avg. daily gain, feed conversion and mortality from 37 days to 87 days (approx. 2.5 kg)
[3] Tested by χ^2-test

Table 5 : Subjective judgement of fleshiness and fatness of cold carcasses

Experiment number	1	1	2	2	2	3	3	3
Diet	1	2	1	3	4	1	5	6
P/E	1.79	1.96	1.79	2.28	2.46	1.79	1.83	2.59
Fleshiness, hind part	3.45 + 0.71	3.35 + 0.78	3.50 + 0.79	3.38 + 0.77	3.34 + 0.73	3.46 + 0.74	3.18 + 0.69	2.94 + 0.76
Fleshiness, back part	3.21 + 0.68	3.09 + 0.70	3.41 + 0.78	3.26 + 0.75	3.25 + 0.75	3.32 + 0.66	3.19 + 0.76	2.90 + 0.75
Fleshiness, comb.	6.66 + 1.27*	6.45 + 1.35	6.91 + 1.48	6.64 + 1.44	6.59 + 1.39	6.79 + 1.31*	6.37 + 1.39	5.84 + 1.46
Perirenal fat score:								
Too little fat, %	15	20	7	9	15	14***	8	32
Suitable, %	62	55	52	58	60	57	67	59
Too much fat, %	23	25	41	33	25	29	24	9

* = significant (χ^2-test; P<0.05) difference of scores between diets within experiments

*** = significant (χ^2-test; P<0.001) difference of scores between diets within experiments

could not find any significant correlation between growth rate and P/E (from 15 to 23% CP and 8.7 to 13.0 MJDE per kg DM).

The content of crude fibre ranged from 15 to 19 % of DM. At high levels of protein, De BLAS *et al.* (1981) found a considerable reduction in digestibility of protein and energy in compounds with 15% fibre compared to 11 or 7%. It is therefore important to evaluate the level of protein in relation to energy as well as to fibre content.

A distinct tendency towards a higher feed consumption per kg of weight gain with rising P/E was seen in all three experiments. This is in accordance with TAIE and ZANATY (1993) who found an increasing feed consumption per kg of weight gain when increasing P/E from 1.8 to 3.4.

The treatments used in this experiment had no significant effect on mortality, even though a tendency was seen to a positive correlation between mortality and P/E. De BLAS *et al.* (1981) found the lowest mortality rate at a P/E of 1.8 with a strongly increasing mortality rate at a higher as well as a lower P/E ratio.

In conclusion, it has been possible to manipulate the average amount of perirenal fat by changing the P/E ratio of the feed. This can, however, at high P/E values be expected to have certain negative effects such as reduced growth and feed conversion, increased mortality and poorer fleshiness. In the long period a different approach for changing the amount of perirenal fat ought to be examined, i.e. through breeding. Results from the experiments reported here gave evidence of an effect of genetic stock on amount of perirenal fat. AYYAT *et al.* (1994) found a high heritability for the amount of perirenal fat in New Zealand White rabbits indicating that a differentiation in the tendency to deposit perirenal fat is possible through selection. It is suggested, that different genetic stocks can be crossed and the result as regards the final body weight and thus the shape of the growth curve and deposition of perirenal fat at a given age be evaluated.

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