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THE EFFECT OF ENVIRONMENTAL TEMPERATURE ON THE PERFORMANCE OF GROWING RABBITS(*)

G.M. Chiericato, L. Bailoni, C. Rizzi

Department of Animal Science, Via Gradenigo 6, 35131 Padova. Italy

ABSTRACT

64 male rabbits, aged 50 days and with a mean weight of 1163±105 g, were divided up into two groups and submitted to two different environmental treatments.

In the first group of 34 animals (HT), rearing temperature, in the first period of the trial (1-28 d), was kept between 26.3 and 28.4°C, and then increased in the second period (29-56 d) to 29.7 and 31.8°C. In the second group of 30 rabbits (LT), the temperature varied between 10.8 and 12.8°C throughout rearing. Relative humidity remained between 59.1 and 74.6% for both treatments, for the entire duration of the study.

In the first period, the rabbits in the HT group displayed lower ($P<0.01$) live weight gains (34.6 vs 39.6 g/d) and feed intakes (114.7 vs 152.6 g/d), but better feed efficiency (3.35 vs 3.89 g/g) than the animals in the LT group. Rectal temperature (38.7 vs 38.9°C, $P<0.05$) and respiratory rate (124 vs 227 mov./min., $P<0.01$) were lower ($P<0.01$) in the animals undergoing LT treatment.

In the second period there was an increase in the effect of temperature on live weight gain (34.1 vs 19.3 g/d) and feed intake (193.6 vs 113.5 g/d), which were significantly ($P<0.01$) higher in the rabbits in the LT group. Feed efficiency did not prove to be significantly different and is on average equal to 5.91 g/g. The animals in the HT group show higher rectal temperature (39.1 vs 38.6°C, $P<0.01$) and a higher respiratory rate (246 vs 118 mov./min., $P<0.01$) than rabbits undergoing the LT treatment.

The HT treatment animals provided higher dressing percentages (64.61 vs 63.0 g, $P<0.01$) due to a lower ($P<0.01$) percentage of pelt (13.99 vs 15.38%) and liver (2.05 vs 2.76%). On jointing the carcass rabbits kept at lower temperatures had a higher percentage of thorax region (27.91 vs 25.13%, $P<0.05$) and lower percentage of rump, nates and thighs, (32.37 vs 33.86%, $P<0.05$). The LT treatment animals showed greater ($P<0.01$) synthesis of adipose tissue in the carcass than the HT ones, especially as regards kidney (4.92 vs 2.31%) and perivisceral fat (4.16 vs 2.60%).

INTRODUCTION

Although the meat rabbit is susceptible to temperature stress, only a limited amount of research work has been conducted on these animals'

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reactions to temperature in terms of productive and physiological performance.

Work produced to date therefore provides an incomplete picture, based on experimental conditions which are often quite different from each other. On examination of the existing literature (1,10,12,13,15), it would in particular appear appropriate to look into to the effect of temperature in the various stages of the production cycle, considering also carcass traits. Research work has accordingly been undertaken on the basis of these objectives.

MATERIALS AND METHODS

64 rabbits were used, aged 50 days, with an initial mean live weight of 1163±105g. The animals were commercial crossbred male rabbits.

At the start of the experiment, the rabbits were put in two different places kept at low (LT = 12°C) or high (HT = 30°C) temperatures, controlled by a split system room air conditioner. The temperature and humidity of the environment were continuously monitored by a thermohygrograph. The photoperiod was approximately 8L:16D, and light intensity was checked every seven days. Environmental controls on the concentration of carbon dioxide and ammonia were also carried out on a weekly basis using a Drägher pump and kits.

The animals were reared in individual, industrial-type cages and fed with pellets administered ad libitum. Each day the rabbits' state of health and feed intake were controlled; live weight gain was checked every seven days. Rectal temperatures and respiratory rates were also measured in duplicate on a weekly basis in 24 animals per treatment.

At the end of the study, 10 rabbits per environment were slaughtered and jointed according to indications given in other studies (5, 6).

The feed was submitted to chemical analysis based on official methods (2, 3). All data were submitted to variance analysis (14) based on model 1 of the Harvey package (8).

RESULTS AND DISCUSSION

a) <u>Environmental temperature and humidity and diets employed</u>

As far as the first period and HT environment are concerned, table 1 indicates that ambient temperatures varied on average between 26.3 and 28.4°C. In view of the satisfactory performance of the rabbits observed in the first 28 days, the temperature was increased in the second part of the research to the highest possible values, reaching minimum and maximum temperatures of around 29.7 and 31.8°C.

It has been postulated that productive performance may begin to be impaired in some way at 25°C (11); therephore during the trial temperatures able to stress the animals were observed, due also to the small fluctuations between maximum and minimum values.

In both periods, relative humidity remained within fully acceptable levels for meat rabbit rearing, varying between 59.1 and 67.2% (11).

Moving on to the LT treatment, we see that in the first and second periods of the research, humidity levels were kept at between 67.0 and 74.6%, and temperatures between 10.8 and 12.8°C. The latter values, which are below optimum levels (11), are rather typical in unheated meat rabbit farms in the Northern Italian lowlands during the winter.

Light intensity was between 10 and 45 lux, on cloudy and fine days respectively, which were roughly equal during rearing.

Carbon dioxide (0.16%) and ammonia (5-10/ppm) remained within suitable levels for intensive rabbit rearing employing intensive feeding programs (11).

Before considering the chemical composition of the diet, it should be pointed out that a commercial diet was used, based on dehydrated alfalfa meal, wheat middlings and soybean meal.

The feed (Table 2) was composed of 17.8% crude protein, 11.80 MJ/kg digestible energy and 15.0, 38.35 and 18.70% crude fibre, NDF and ADF, respectively. These values appear to be suitable for meat rabbit production (9).

b) Fattening performance

Table 3 indicates that in the first 28 days of the trial, the animals undergoing LT treatment presented significantly higher ($P<0.01$) live weight gains than those in the HT group (39.6 vs 34.6 g/d).

Even though the differences observed are as high as 14.5%, they do not appear to be particularly important, bearing in mind the difference in temperature in the two environments in which the trials were performed.

The higher live weight gain at 12-13°C is the result of greater daily intake, since this value is 33% higher for the rabbits kept at the lower temperature (152.6 vs 114.7 g/d, $P<0.01$).

On the basis of the results taken from the above daily weight gain and intake trends, feed efficiency proves to be 14% better for the animals belonging to the HT group (3.35 vs 3.89 g/g). This poorer feed efficiency will be mainly attributable to heat production due to thermoregulation.

The respiratory rates observed in the first period of the trial appear to be greater in the rabbits kept at high temperatures (227 mov./min.), which is decidedly higher ($P<0.01$) than in the rabbits reared at approximately 13°C (124 mov./min.). Rectal temperature is also higher ($P<0.01$) in animals undergoing HT treatment (38.9 vs 38.7°C).

In the second period (table 4), the rabbits kept in the HT environment were notably affected by the environmental conditions, resulting in appreciably lower live weight gains than the ones observed for the LT treatment animals (19.3 vs 34.1 g/d, $P<0.01$).

The effect of temperature-related stress is shown if we consider daily feed intake. In the case of HT treatment, intake remains practically unchanged in absolute terms compared with the first period, while in relation to metabolic body size, it is reduced by 25.3%.

Rabbits kept at low temperatures showed appreciably higher values ($P<0.01$) than the ones undergoing HT treatment (193.6 g/d). If we compare these values with the ones observed in the first period of the trial, we see that there is an increase in absolute values. In relation to metabolic body size, however, we find a contained reduction in feed intake (11.3%).

There are no significant differences in feed efficiency values for the second period of the trial (5.74 and 6.07 g/g for the rabbits in the LT and HT groups, respectively). These high values are attributable, in the case of HT treatment rabbits, to the higher incidence of maintenance requirements in the quantity of daily energy intake. In the case of LT treatment rabbits, mention should be made of the higher synthesis of adipose tissue confirmed by the greater fat deposits on the carcass, as specified in more detail below.

The worsening in feed efficiency in both treatments is partly attributable to heat production due to thermoregulation.

In the second period, the animals kept at a high temperature proved to be under greater stress, marked by significantly (P<0.01) higher rectal temperature (39.1 vs 38.6°C) and respiratory rate (246 vs 118 mov./min.).

Table 5 summarizes the data obtained from the study as a whole. The rabbits reared in the LT environment showed 37.6% higher daily weight gain (36.6 vs 26.6 g/d, P<0.01) than those undergoing the HT treatment, although they reached an appreciably higher final live weight (3227 vs 2668 g, P<0.01). These final results agree with the findings of other Authors in different experimental conditions (10, 13, 15).

Temperature exerted a negative influence on daily feed intake, going from 173.4 to 114.0 g/d for rabbits belonging to the LT and HT treatment groups, respectively. Other studies (10,13,15) have pointed out the influence that high temperatures may have on the reduction of feed intake.

Rabbits reared at low temperatures showed 10.4% poorer feed efficiency (4.76 vs 4.31, P<0.01). The reduction in feed efficiency in cold climates is corroborated by the experimental findings of other researchers (15).

A number of physiological changes emerged in the temperature-related stress conditions to which the rabbits kept at a high temperature were subjected. The animals belonging to the HT group showed appreciably higher (P<0.01) rectal temperature (39.0 vs 38.6°C) and respiratory rate (236 vs 121 mov./min.). These findings are confirmed by the results of other trials (15).

c) Slaughtering and jointing performance

Observations made at the slaughter-house are indicated in table 6 and show that the animals in the LT group have a higher final empty body weight than the ones kept at high temperatures (2553 vs 2293, P<0.01).

The pelt is significantly (P<0.01) lower in animals in the HT group than in ones kept at LT (13.99 vs 15.38%). Other Authors have likewise observed a lower proportion of pelt in animals kept at high temperatures (10). The LT animals also present a lower (P<0.01) percentage of distal fore and hind legs (2.71 vs 3.10%), and a higher (P<0.01) proportion of liver (2.76 vs 2.05%) and kidneys (0.55 vs 0.45%).

The dressing percentage differs significantly between the two treatments, being higher (P<0.05) in the animals reared at a high temperature (64.61 vs 63.00).

Carcass jointing data (Table 7) show that there is similarity between the various joints examined, with the exception of the thorax region, which is higher in rabbits in the LT group, (27.91 vs 25.13%, P<0.05) and rump, nates and thighs, which are higher in proportion in animals undergoing HT treatment (33.86 vs 32.37%, P<0.05).

This result is probably attributable to the increase in fat deposits in the thorax region of animals kept at a low temperature, as a function of the resulting higher final live weight. In rabbits, this part of the carcass is in fact marked by greater synthesis of adipose tissue. Since the rump, nates and thighs have the opposite tendency and as the data are expressed as percentages, it is not difficult to deduce that the leanest part of the carcass has been penalized.

Table 7 shows data on fat deposits on the carcass, which clearly indicate that there is greater synthesis of adipose tissue in animals kept at a low temperature, in which the percentage of total fat is significantly (P<0.01) higher (10.37 vs 5.74%).

From analysis of the individual fat deposits (Table 7), it emerges that the effect (P<0.01) is exerted above all on kidney (4.92 vs 2.31) and perivisceral fat (4.16 vs 2.60%).

The reduction of fat deposits, particularly kidney fat, through the action exerted by high temperatures, has already emerged in other experimental studies (10).

In conclusion the experiment makes a contribution to the study of the effects of rearing temperature in the production of meat rabbits.

Homogeneous environmental conditions were studied. Humidity did not constitute a constraining factor since it was within fully acceptable limits. Experimental temperatures were kept relatively constant, with only limited variations during the course of the 24 hours.

The animals' physiological response to high temperatures was similar in the various stages of the trial, with a significant rise in rectal temperature and an increase in respiratory rate being observed.

In the first 28 days, productive parameters were affected by the increase in temperature from approximately 12 to 28°C, in particular with a reduction in daily feed intake and weight gain. This effect was much more marked in the second period of the trial, in which there was also an increase in temperature to around 30°C.

These results seem to indicate that high temperatures have a particularly marked effect in the final stage of the production cycle, when the reduction in feed intake is combined with greater nutritional requirements connected with the increase in the synthesis of adipose tissue.

Feed efficiency showed diffentiated behaviour. At the end of the trial it proved to be greater in rabbits kept at a high temperature. This final result is, however, derived from two different trends. During the first 28 days of the trial, the animals kept at a high temperature showed greater feed efficiency. In the second period, however, this trend was reversed, with the animals subjected to the cold climate treatment tending to show better feed efficiency. This occurred despite the fact that the carcasses of the rabbits belonging to the latter group showed notably higher fat deposits.

Results therefore show that the increase in temperature may, within certain limits, improve feed efficiency. This factor seems to be connected with the reduction in feed intake and heat production due to thermoregulation which is observed in a range around thermal neutrality. When, however, temperatures are further increased, there is a reversal in tendency owing to an excessive drop in feed intake and an increase in maintenance requirements due above all to thermoregulation.

As far as slaughtering data are concerned, rabbits kept at low temperatures provided a lower dressing percentage, due mainly to the higher proportion of pelt. In addition to the increase of pelt in size connected with the need for protection, mention should be made of the presence of subcutaneous fat deposits, which are undoubtedly higher in animals kept at lower temperatures.

Lastly, dissection data have confirmed that the effect observed at lower temperatures is attributable to the action exerted on feed intake and very similar to the one which follows if the nutritive value of the diet is increased. The animals reared in a cold climate do in fact present notably higher synthesis of adipose tissue in the form of kidney, perivisceral and peridorsal fat.

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Table 1: Environmental temperature and relative humidity during the trial

	HT		LT	
	1-28 d	28-56 d	1-28 d	28-56 d
Temperature:				
- maxima	28.4±1.1	31.8±1.1	12.8±1.5	12.1±1.5
- minima	26.3±1.5	29.7±1.5	11.5±1.3	10.8±1.3
Relative humidity:				
- maxima	67.2±3.1	63.5±1.8	73.9±5.5	74.6±7.3
- minima	59.5±3.2	59.1±2.1	67.0±5.9	68.8±7.4

Table 2: Chemical composition and nutritive value of feed (means ± S.D.)

Dry matter	%	89.30±4.38
Crude protein (Nx6.25)	% d.m.	17.80±0.41
Ether extract	"	5.90±0.32
Crude fiber	"	15.00±0.65
Ash	"	9.35±0.51
N-free extract	"	51.95±0.58
NDF	"	38.35±1.19
ADF	"	18.70±0.79
ADL	"	4.15±0.63
Calcium	"	1.51±0.05
Phosphorus	"	0.51±0.02
Gross energy	Kcal/kg as fed	4460
	MJ/kg " "	18.66
Digestible energy	kcal/kg as fed	2820
	MJ/kg " "	11.80
Metabolizable energy	kcal/kg as fed	2710
	MJ/kg " "	11.33

Table 3: Performances observed during the first period (1-28d)

		HT	LT	Error mean square	d.f.
Animals	n	34	30	--	--
Initial live weight	g	1171	1154	12319	62
Final live weight	"	2129[A]	2278[B]	37603	62
Daily live weight gain	"	34.6[A]	39.6[B]	34.70	62
Daily intake	"	114.7[A]	152.6[B]	304.21	62
Feed efficiency	g/g	3.35[A]	3.89[B]	0.1443	62
Rectal temperature	°C	38.9[b]	38.7[a]	0.46	190
Respiratory rate	mov/min	227[B]	124[A]	980	190

A,B: P<0,01; a,b: P<0,05

Table 4: Performances observed during the second period (29-56 d)

		HT	LT	Error mean square	d.f.
Animals	n	34	30	--	--
Initial live weight	g	2129^A	2278^B	37603	62
Final live weight	"	2668^A	3227^B	65957	62
Daily live weight gain	"	19.3^A	34.1^B	22.17	62
Daily intake	"	113.5^A	193.6^B	427.91	62
Feed efficiency	g/g	6.07	5.74	0.8921	62
Rectal temperature	°C	39.1^B	38.6^A	0.21	190
Respiratory rate	mov/min	246^B	118^A	1014	190

A,B: P<0,01

Table 5: Performances observed during the trial (1-56 d)

		HT	LT	Error mean square	d.f.
Animals	n	34	30	--	--
Initial live weight	g	1171	1154	12319	62
Final live weight	"	2668^A	3227^B	65957	62
Daily live weight gain	"	26.6^A	36.6^B	19.56	62
Daily intake	"	114.0^A	173.4^B	311.65	62
Feed efficiency	g/g	4.31^A	4.76^B	0.1713	62
Rectal temperature	°C	39.0^B	38.6^A	0.34	382
Respiratory rate	mov/min	236^B	121^A	1050	382

A,B: P<0,01

Table 6: Slaughtering data

		HT	LT	Error mean square	d.f.
Animals	n	10	10	--	--
Empty body weight	g	2553^A	2993^B	11486	18
% of empty body weight:					
- pelt	%	13.99^A	15.38^B	1.1193	18
- head	"	10.60	10.37	0.4299	18
- distal fore legs	"	0.81^b	0.74^a	0.0056	18
- distal hind legs	"	2.29^B	1.97^A	0.0284	18
- heart	"	0.33	0.39	0.0058	18
- liver	"	2.05^A	2.76^B	0.2739	18
- kidneys	"	0.45^A	0.55^B	0.0051	18
- empty stomach and guts	"	4.61	4.96	0.1778	18
- warm carcass$^{(1)}$	"	64.61^b	63.00^a	3.2022	18
- warm carcass$^{(2)}$	"	56.03	54.92	3.8844	18

(1) with head and tail
(2) without head and tail
A,B: P<0.01; a,b: P<0,05

Table 7: Carcass jointing data

		HT	LT	Error mean square	d.f.
Animals	n	10	10	--	--
% warm carcass weight:					
- head	%	13.05	12.75	0.9435	18
- shoulder and fore legs	"	12.21	11.94	0.2998	18
- thoracic cage	"	25.13[a]	27.91[b]	1.8714	18
- loins and flanks	"	15.74	15.04	1.9050	18
- rump, nates and thighs	"	33.86[b]	32.37[a]	1.1398	18
- kidney fat	"	2.31[A]	4.92[B]	2.0588	18
- perivisceral fat	"	2.60[A]	4.16[B]	0.6359	18
- peridorsal fat	"	0.83[A]	1.29[B]	0.1246	18
- total fat	"	5.74[A]	10.37[B]	5.0521	18

A,B: P<0,01; a,b: P<0,05