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GNAWING BLOCKS AS CAGE ENRICHMENT AND DIETARY SUPPLEMENT FOR DOES AND FATTENERS: INTAKE, PERFORMANCE AND BEHAVIOUR

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Abstract: The aim of this study was to evaluate different experimental gnawing blocks as cage enrichment in rabbits. One hundred and five pregnant rabbit does housed in conventional wire cages were distributed according to their parity number in 4 homogenous treatment groups. Throughout one complete reproductive cycle (from day 18 of pregnancy till weaning of the litter), does either received no enrichment (controls) or a gnawing block hung from a wire on the cage wall. The 3 different blocks had the same basal components (wheat, molasses and oligoelements), but additionally wood mash (WM), wood mash+chicory pulp (ChP) or wood mash and inulin syrup (I) were respectively incorporated. After weaning, each litter continued to receive the same blocks as before and block consumption was measured as well as the performance of the fatteners. Weight development during the lactation was comparable except in does that received the wood powder blocks. These females had a significantly lower weight ($P<0.05$) at different time points compared to controls. Litter weight or kit weight was not significantly different at any of the time points measured, but again the treatment with wood powder blocks presented the lowest weight. The consumption of blocks during the whole reproduction cycle (42 d) was 11.0±1.1; 6.8±1.0 and 4.4±0.7 g/d per cage for wood mash, chicory pulp or inulin enriched blocks, respectively. A very high variability in consumption of blocks was observed between females. This varied between 1 and 5 (I or ChP group) or even 1 and 9 blocks (WM group) per reproductive cycle. In fatteners, daily block consumption was significantly different ($P<0.05$) and reached on average 7.0±0.5; 3.9±0.5 and 2.2±0.2 g/d per fattener, respectively for WM, ChP and I. Five females with a block and 5 females without a block were observed for 1 h 3 d before the expected parturition and at 2 time points during lactation. Distinction was made between 15 different behaviours. Although the presence of a block did not significantly increase the total number of behavioural transitions, locomotion and intake behaviour were significantly ($P<0.05$) increased when a gnawing block was available. The observation period influenced the frequency of many behavioural transitions and before parturition was significantly higher than post parturition, respectively 56.1±11.1 *vs*. 13.7±3.8 (Week 1, $P<0.01$) and 25.1±5.5 (Week 2, $P<0.01$). However, a very large variability was observed between does and, moreover, some does were mostly inactive after parturition during the observation period. Based on the consumption pattern and behaviour, these gnawing blocks could be considered as cage enrichment and those with the chicory pulp best fulfilled the objective of a suitable gnawing material.

Key Words: gnawing blocks, feed supplement, does, fatteners, intake, behaviour.

INTRODUCTION

In current rabbit farming systems, rabbits are housed in barren cages. The lack of cage enrichment is often mentioned as a welfare problem (EFSA, 2005; Baumans, 2005; Verga *et al*., 2007). Cage enrichment is defined as providing stimuli meeting the animals' species-specific needs. There are several possibilities to enrich the environment, although most efforts have focused on gnawing material (see review of Jordan *et al*., 2006) or with the use of an elevated platform (Lang and Hoy, 2011). The results of these studies have shown some beneficial trends in terms of

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welfare and even production. However, some experiments have pointed out the increased risk of infectious diseases due to hygiene problems (Dal Bosco *et al.*, 2002; Mirabito, 2003). Therefore, enrichment material should preferably be hung from the cage ceiling (Trocino and Xiccato, 2006).

Apart from providing stimuli, gnawing material could have a second function, namely as nutrient supply. As rabbits have special dietary fibre needs for optimal gut health (Gidenne, 2003) and in consequence to reduce the risk of enteric diseases, we were looking for gnawing materials with a supplementary feeding value. Wood or wood products with their very high ADL content could contribute to the dietary requirement of low digestible fibre fractions. Moreover, digestible fibres or soluble fibre also play a key role in digestive health (Gidenne, 2003; Goméz-Conde *et al.*, 2007). One such source of fermentable fibre is chicory pulp, which contains over 30% of pectins (Bailoni *et al.*, 2004) and a high inulin content (Socode, 2008). Inulins have been shown to have some potential to increase digestive health (Volek *et al.*, 2007; Volek and Marounek, 2011).

The aim was therefore to incorporate the 3 aforementioned products (wood, chicory pulp and inulin) in mineral blocks and to evaluate them as possible cage enrichment and additionally verify if such mineral blocks influence the production performances. Trials with the 3 experimental block compositions were carried out with both reproducing females and fatteners.

MATERIAL AND METHODS

Enrichment material and diets

The design of different blocks consisted of cones cut with a base diameter of 4 cm and height of 7 cm (Figure 1). The weight was between 200 and 250 g. A central hole in the block allowed us to hang the block up on the wall of the cage with a galvanised wire at a height of approximately 15 cm.

The 3 experimental blocks contained a base of wheat, molasses and oligoelements (Ca, Mg, Na, P, Zn, Mn, Cu, Fe, I, Co and Se). They contained the following amount of test material:

a) Wood mash blocks: 10% of wood mash (WM)
b) Chicory pulp blocks: 10% wood mash and 15% chicory pulp (ChP)
c) Inulin blocks: 10% of wood mash and 15% Inulin (I) syrup (Raftifeed, Orafti, Belgium)

During the experiments, each cage was always enriched with 1 block. Once the block was finished or the last part had fallen onto the bottom of the cage, a new block was immediately introduced. The remains of blocks were removed and weighed.

Figure 1: The different gnawing blocks: Inulin based (left), wood mash based (middle) and chicory pulp based (right).

During the experiments, females and fatteners always received a balanced pelleted diet *ad libitum*. Dietary composition was in line with the current nutrient recommendations and calculated to have a crude protein content of 18.0% and 16.5%, an ADF of 17.5% and 19.0% and a digestible energy content of 10.2 MJ/kg and 9.2 MJ/kg for does and fatteners, respectively (Maertens *et al.*, 2002).

Animals, husbandry and housing

Nulliparous and multiparous females (Institutes' strain, Maertens, 1992) used for the trial were inseminated on the same day. All females were housed individually in standard cages. The multiparous does were weaned when they were 18 d pregnant. Thereafter, all females were transferred to one compartment of the rabbit stable to start the trial. In total, 105 pregnant females were initially homogeneously assigned to one of the

4 experimental groups (no block and 3 different block types), taking into account their parity number (23 nulliparous and 82 multiparous does).

At parturition, litters were intra treatment standardised to 8 kits. Females were again inseminated 11 d post parturition while the weaning took place at the age of 35 d. After weaning, each litter was divided over 2 cages (sex was not considered) but remained on the same initial treatment. Their consumption of the blocks, mortality and final weight at 70 d of age was determined.

Females and weanlings were housed in dual purpose cages with the following dimensions: 0.78×0.50×0.50 m height and each cage was equipped with a feeder and a nipple drinker. Four days before parturition, females were allowed to enter their outside placed nest box filled with wood shavings.

Recordings

Females were individually weighed at the start of the experiment, day 1 (1 d post parturition), day 11, day 22, day 28 and day 35 (weaning). Feed intake and block consumption were measured during the 5 respective periods. Litter weight was measured on the same days and at the end of the fattening period (70 d of age).

Behaviour of the females was studied in 5 multiparous females from the control group (no block) and 5 multiparous females with a gnawing block. Observations were performed 3 times on the same females: 3 d before parturition and 1 and 2 wk after parturition, always between 9 a.m. and 12 a.m. The same person observed the females for 1 h (2 females simultaneously) in the stable after an initial 5 min adaptation period and distinguished 15 different behaviours. All behavioural transitions were noted.

Statistical analyses

The production data were statistically analysed using the ANOVA procedure of Statistica 10 (Statsoft, 2010). A linear model including the effects of treatment (1-4), parity (nulliparous, multiparous) and their interaction was used to carry out the analysis on lactating does' performances. Fattener data were submitted to a one way ANOVA. Differences between means were tested by the least significant difference test. Mortality rate was compared using Pearson's Chi-square test.

Data are presented as means and standard error (SE).

The frequency of the different behaviour types, as well as the total number of behavioural transitions (i.e., the sums of the frequencies of all types of behaviour), were analysed using a generalised linear mixed model (PROC GLIMMIX in SAS 9.3). A log link was used and an underlying Poisson distribution was assumed. Treatment (with or without feed block) and period (before, 1 wk after, or 2 wk after parturition) and their interaction were included as categorical fixed variables. Overdispersion was accounted for by adding a random residual component. Pairwise comparisons between periods were performed using a Bonferroni correction.

RESULTS

During the experimental period (between day 18 of pregnancy till weaning), the data of 4 does were excluded from the data set due to doe mortality (2 females) or doe sickness resulting in very high early mortality of kits in the lactation stage.

Performance results

In Table 1, the litter size at different time points is presented. Mortality before weaning in the standardised litters was quite low, except for does without a gnawing block. In this control group, mortality reached 12.5% but did not reach the significance level (P>0.05). After weaning, mortality was between 4.6 and 5.8% in all treatment groups.

Weight of the does at different time points is presented in Table 2. Females in the control group had a higher (NS) weight at the start of the trial compared to the other treatments. This difference of about 200 g remained till weaning, compared with females from the I and ChP group. However, this difference with the control does increased in WM does, being significant (P<0.05) at parturition and at day 22 and 28.

Table 1: Litter size and mortality before and after weaning in cages without or with a gnawing block (means±standard error).

	Controls	Enrichment blocks			*P*-value
		Wood mash	Chicory pulp	Inulin syrup	
No. litters	27	25	23	26	-
Litter size (alive)					
Day 1 (parturition)	8.0	8.0	8.0	8.0	-
Day 11	7.4±0.2	7.7±0.1	7.7±0.1	7.9±0.1	0.181
Day 22	7.4±0.2	7.5±0.2	7.7±0.2	7.7±0.1	0.585
Day 35 (weaning)	7.0±0.2	7.4±0.3	7.5±0.2	7.3±0.2	0.319
Day 70	6.6±0.4	6.9±0.2	7.1±0.2	7.0±0.2	0.440
Mortality of young (%)					
1-35 d	12.5±0.6	7.5±0.4	6.5±0.3	8.8±0.5	0.123
35-70 d	5.8±0.3	6.5±0.2	4.6±0.2	5.7±0.4	0.654

Feed consumption was not influenced in any of the periods considered before or during the lactation period (Table 2).

Litter and individual young weight at different time points is presented in Table 3. Weight of the litter around 3 wk is a good indicator for does' milk production (Maertens *et al.*, 2006). Litter weight in WM does was about 4-5% ($P>0.05$) lower than in the other groups. At fattening age, weight of the litter in the ChP group was about 1.5 kg higher than in the control group and 1.0-1.2 kg compared with I and WM. However, due to the quite low number of litters, this difference was not significant.

Block consumption

Before 22 d of lactation, block consumption can be exclusively considered as that of the does. During this period, does consumed around 3.0 g/d of the inulin enriched blocks but more than twice the amount of the wood mash blocks ($P<0.05$). During the reproduction cycle, females increased their intake of the blocks (WM and ChP) before the young began to consume significant amounts (day 22). The week before weaning, quite high amounts were consumed (9.0; 13.6 and 11.0 g/d in I, ChP and WM groups, respectively) and the difference between citrus pulp and inulin enriched blocks was significant. A notable difference was observed between cages (females), from a very small amount

Table 2: Weight and feed consumption of the does during the experimental period (means±standard error).

	Controls	Wood mash	Chicory pulp	Inulin syrup	*P*-value
No. does	27	25	23	26	
Weight (g) at					
Start of trial	4654±96	4451±77	4498±104	4432±75	0.334
Day 1 (Parturition)	4301±73^{b}	4021±63^{a}	4152±92^{ab}	4055±72^{ab}	0.049
Day 11	4512±72	4263±75	4388±99	4283±69	0.107
Day 22	4556±83	4288±83	4506±94	4376±77	0.097
Day 28	4585±86^{b}	4272±72^{a}	4487±109^{ab}	4392±44^{ab}	0.046
Day 35 (weaning)	4500±87^{b}	4187±58^{a}	4366±103^{ab}	4308±76^{ab}	0.043
Weight loss between trial start and day 35	–153±64	–282±56	–132±53	–125±41	0.154
Feed consumption (kg)					
Start-Parturition	2.73±1.20	2.45±0.91	2.58±1.22	2.50±1.10	0.249
Parturition-Day 11	3.74±0.10	3.55±0.10	3.61±0.13	3.76±0.10	0.501
Day 11-Day 22	4.79±0.11	4.50±0.13	4.55±0.14	4.77±0.13	0.321
Day 22-Day 28	4.58±0.74	4.32±0.45	4.61±0.56	4.55±0.54	0.167
Day 28-Day 35	5.78±0.24	5.78±0.75	6.10±0.90	5.93±0.96	0.674
Total period	21.62±0.91	20.60±0.74	21.44±0.87	21.51±1.14	0.206

^{a,b} Means sharing a different letter in the same row are significantly different ($P<0.05$).

Table 3: Litter and young weight (means±standard error).

	Controls	Wood mash	Chicory pulp	Inulin syrup	*P*-value
No. litters	27	25	23	26	-
Weight of litter (g)					
Day 1 (Parturition)	571±11	578±12	609±14	582±11	0.147
Day 11	1807±63	1800±43	1835±56	1879±50	0.714
Day 22	3350±106	3190±70	3365±110	3378±96	0.489
Day 28	5744±174	5510±117	5835±176	5742±141	0.503
Day 35 (Weaning)	7828±332	8038±207	8442±279	8133±261	0.480
Day 70	17398±869	17766±544	18944±725	17940±634	0.481
Young weight (g)					
Day 1	71.3±1.4	72.3±1.5	76.1±1.7	72.7±1.4	0.147
Day 11	242.1±4.9	234.1±6.2	236.6±5.7	239.7±6.2	0.772
Day 22	453.4±9.4	426.9±9.1	438.0±10.0	439.6±11.4	0.310
Day 28	782.0±14.3	736.5±13.5	764.0±13.0	757.1±13.5	0.127
Day 35	1118±25	1089±21	1124±20	1097±22	0.645
Day 70	2626±37	2578±43	2642±37	2570±41	0.504

(<1 g/d) up to very high amounts (23.8 g/d in a WM cage). Expressed as blocks per reproduction cycle, this means from 1 to 5 (I and ChP does) or even 9 blocks (WM).

In the fatteners, the same effects on intake were observed (Table 5). However, the difference in intake was significant (P<0.01) between the 3 blocks studied. On average, during the 5 wk fattening period, daily consumption per rabbit reached 2.2; 5.8 and 12.8 g in I, ChP and WM groups, respectively. Again, a very high variability between litters (cages) was observed, being 5 to nearly 10 times higher in some cages than in others.

Behaviour

The presence of a gnawing block did not have a significant effect on the sum of the behavioural transitions, although on average 27.6±7.9 movements were observed in females without a block and 35.7±8.1 when a block was available (Table 6). However, an extremely high variability between females was observed, ranging from females being almost constantly inactive to females with over 100 behavioural transitions during the 1 h observation period. Nevertheless, the presence of a block induced significantly (P<0.05) higher locomotion and intake observations, while inspection of the nest box was significantly reduced.

Table 4: Block consumption in the female cages (means±standard error).

	Wood mash	Chicory pulp	Inulin syrup	*P*-value
No. cages	25	23	26	
Per doe (cage), g/d				
Start-parturition	5.5±0.5	3.4±0.5	3.0±1.3	0.102
Parturition-Day 11	7.0±1.0[a]	4.9±0.8[b]	3.0±0.5[b]	0.003
Day 11-Day 22	9.7±1.4[a]	5.5±1.1[b]	2.7±0.6[b]	<0.001
Day 22-Day 28	20.6±1.7[a]	13.1±1.8[b]	7.3±1.2[c]	<0.001
Day 28-Day 35	21.7±2.1[a]	13.6±2.3[b]	9.0±2.2[b]	<0.001
Total period	11.0±1.1[a]	6.8±1.0[b]	4.4±0.7[b]	<0.001
min-max	2.4-23.8	1.1-18.2	0.8-15.6	
Blocks per doe/cycle	4.4±0.4[a]	2.3±0.3[b]	1.8±0.2[b]	<0.001
min-max	1-9	1-5	1-5	

[a,b]Period means sharing a different superscript in the same row are significantly different (P<0.05).

Table 5: Block consumption of fatteners (mean±standard error).

	Wood mash	Chicory pulp	Inulin syrup	*P*-value
No. litters	25	23	26	
Per litter (cage), g	1664±117[a]	991±126[b]	532±61[c]	<0.001
Per rabbit, g	244±18[a]	137±16[b]	76±8[c]	<0.001
Per rabbit, g/d	7.0±0.5[a]	3.9±0.5[b]	2.2±0.2[c]	<0.001
min-max	2.2-12.7	1.1-10.3	0.5-4.8	
Blocks/litter (cage)	12.8±0.8[a]	5.8±0.7[b]	3.8±0.3[c]	<0.001
min-max	3-20	2-15	2-7	

[a,b,c] Means sharing a different letter in the same row are significantly different (*P*<0.05).

Before parturition, females were very active during the observation period, while 1 and 2 wk post parturition a significantly (*P*<0.01) lower number of behavioural transitions was observed (on average 56.1±11.1 *vs.* 13.7±3.8 and 25.1±5.5, respectively). The difference between before and after parturition was significant (*P*<0.05) for locomotion, grooming, cage manipulation and sniffing. Again, a very large difference was observed between females in behavioural patterns (Table 6). However, the overall ethogram was on average quite comparable between both groups.

Interactions between the presence of a block and the observation period were not significant.

DISCUSSION

Apart from the objective of cage enrichment, the tested blocks were supplied as dietary supplement. Both in does and fatteners, performance rates (kit mortality or weight development) were not influenced by the presence of gnawing

Table 6: Behavioural transitions observed in does (n=5) without or with a gnawing block (n=5) before and after parturition (mean±standard error).

Period	Block		Period			Significance[1]	
Block presence	No	Yes	3 d before parturition	1 wk after parturition	2 wk after parturition	Block	Period
Sum of movements	27.6±7.9	35.7±8.1	56.1±11.1[b]	13.7±3.8[a]	25.1±5.5[a]	0.297	<0.001
Posture/movement							
Locomotion	4.3±1.3	7.5±1.3	9.5±2.3[b]	3.6±0.7[a]	4.6±1.1[a]	0.043	0.011
Lying	0.6±0.2	1.3±0.3	0.5±0.2[a]	0.5±0.2[a]	1.8±0.4[b]	0.081	0.014
Sitting	0.6±0.5	1.7±0.9	3.5±1.3	0	0	0.032	0.999
Standing	3.0±0.9	2.5±0.5	2.0±1.2	2.3±0.4	3.9±0.9	0.630	0.339
Rearing up on hind legs	1.1±0.5	0.2±0.1	0.8±0.4	0.3±0.2	0.9±0.5	0.070	0.486
Look around	2.5±1.0	2.9±0.9	4.9±1.2[b]	1.0±0.5[a]	2.3±0.8[ab]	0.710	0.026
Grooming	5.5±2.0	8.1±2.6	13.2±3.4[b]	2.2±0.3[a]	5.0±1.0[a]	0.242	0.003
Activity							
Cage manipulation	2.6±1.3	2.8±1.6	6.8±2.1[b]	0.3±0.1[a]	1.0±0.3[a]	0.872	0.004
Inspection of the nest box	1.3±0.5	0.3±0.1	0.4±0.2	1.0±0.6	0.9±0.2	0.039	0.495
Visit of the nest box	2.7±0.7	2.9±2.0	6.6±1.9[b]	0.3±0.2[a]	1.4±0.9[a]	0.889	0.016
Sniffing	2.1±0.8	2.0±0.6	4.2±0.8[b]	0.8±0.3[a]	1.2±0.3[a]	0.852	0.002
Gnawing on the block	-	0.9±0.5	1.2±0.6	0	0.2±0.1	-	0.210
Drinking or eating	0.6±0.2	1.9±0.3	1.7±0.4	0.9±0.3	1.1±0.3	0.006	0.234
Urinating or defecating	0.3±0.1	0.4±0.1	0.3±0.1	0.4±0.1	0.3±0.1	0.478	0.878
Caecotrophy	0.5±0.2	0.3±0.1	0.5±0.3	0.1±0.1	0.5±0.1	0.387	0.334

[a,b] Period means sharing a different superscript in the same row are significantly different (P<0.05).

[1] Interactions between block presence and period were not significant.

blocks. However, in females with a WM block, a negative tendency on the weight development during lactation was observed, as well as a 4-5% lower litter weight. Although this difference was not significant, a possible explanation could be the rather high intake of WM without nutritional value at the expense of pelleted food. Indeed, in WM does the feed intake was somewhat lower (Table 2) than in the other groups. As a result, weight loss during the lactation period of the females in this group was greater, indicating a lower body condition.

The absence of a clear positive effect of the presence of a gnawing block on the performances has to be linked to the equilibrated diet fed. Zerrouki *et al.* (2008) obtained significant increased weight gain in fatteners fed an additional mineral block. However, in their trial a calcium deficient diet was used, while the mineral block contained 12% calcium. In our trial, diets were not deficient in minerals or fibre constituents.

The second objective of the gnawing blocks was cage enrichment. The preliminary behavioural observation study did not reveal an overall effect on the activity of females. However, the significantly increased locomotion and intake behaviour and the decreased number of inspections of the nest box, together with the trend towards reduced rearing up behaviour, indicate that females are more active and less nervous when they have a gnawing block. This is in line with the observations in fatteners when a gnawing stick is available (Jordan *et al.*, 2006; Princz *et al.*, 2007).

However, the main purpose of cage enrichment (e.g. gnawing block) is to reduce cage manipulation, considered a frequent abnormal behaviour in caged rabbits (Lidfors, 1997). The provision of a gnawing stick (Verga *et al.,* 2004; Prinz *et al.*, 2007) or a wooden structure (Buijs *et al.*, 2011) decreased cage manipulation in fatteners, but was not clear in our trial. Before parturition, cage manipulation was even more frequently observed in cages with a block. During the lactation stage, cage manipulation was so rare that a block effect could not be determined.

Therefore, a more detailed observation study is necessary, with video recordings at different times to judge effects on the behaviour.

Nevertheless, the quantity of blocks consumed (both in g/d and number of blocks) and the increased intake during the lactation stage or fattening stage indicate that the rabbits' interest in gnawing structure did not decline. The high consumption and continuous interest is evidence that gnawing material is a real environmental enrichment and increases rabbit welfare (Jordan *et al.*, 2006; Verga *et al.*, 2007; Prinz *et al.* 2007; Buijs *et al.,* 2011).

A very high variability in block consumption was observed between females or between fattener cages. This indicates that rabbits considered the blocks as enrichment rather than food. When judging the 3 block types as most appropriate for the initial objectives, wood mash enriched mineral blocks, apart from the tendency to deteriorate pre-weaning performance, also had the disadvantage of being too soft. In several cages with WM blocks, quite high losses of WM were observed, and a distribution of more than one block weekly per doe compromises their practical use. Inulin enriched blocks had the disadvantage that once the block was partly consumed a rigid sphere was left, which was difficult for the rabbits to use any further as gnawing material. On the other hand, the chicory pulp enriched blocks were quite well balanced in rigidity and allowed the rabbits to consume the blocks permanently and completely.

CONCLUSIONS

The tested gnawing blocks were intensively used and high amounts of intake were observed, especially with the soft wood mash enriched blocks. Although the preliminary behaviour observations did not allow us to detect differences in cage manipulation between does with and without a block, the high intake confirmed that the presence of gnawing material is helpful to increase rabbits' welfare.

Performance rates in does and fatteners were not improved with the presence of a gnawing block. On the contrary, females with a wood mash block had the highest weight loss during lactation and the lowest litter weight.

Based on the consumption pattern of the blocks and the hardness, blocks enriched with chicory pulp fit best with the objectives. Inulin enriched blocs on the other hand were transformed after some days into a rigid sphere, hindering further gnawing.

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