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WOODEN STICKS AS ENVIRONMENTAL ENRICHMENT: EFFECT ON FATTENING AND CARCASS TRAITS OF INDIVIDUALLY HOUSED GROWING RABBITS

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Abstract: The aim of our study was to examine the influence of wooden sticks for gnawing as environmental enrichment on fattening, carcass and meat quality traits of growing rabbits. Forty-eight rabbits of SIKA sire line (Slovenian line for meat production) of both sexes were housed individually in wire-mesh cages equipped only with a feeder and a nipple drinker. Half of the cages were enriched with wooden sticks of Norway spruce (*Picea abies*). That was the experimental group whereas the other half was the control group. Animals had free access to feed and water, daily duration of lighting was 12 h. The experiment lasted from 44th to 103rd d of age. The consumption of wood was less than 0.5 % of the total feed intake. Results indicate that fattening and carcass traits, as well as meat quality were not influenced by environmental enrichment, although in the experimental group a smaller large intestine percentage (−0.21±0.13 %; [Pr(|difference|>0)=0.94]) was observed. Additionally rabbits in experimental group had redder meat values [Pr(|difference|>0)=0.92]. However, given that wooden sticks had no negative impact on rabbits' performance, sticks made of Norway spruce can still be treated as appropriate environmental enrichment for growing rabbits.

Key words: rabbits, gnawing sticks, environmental enrichment, fattening traits, carcass traits, meat quality.

INTRODUCTION

In intensive husbandry systems rabbits are conventionally reared in wire-mesh cages, which represent a barren, unstructured environment where rabbits are additionally confronted with very limited floor area (Verga, 2000). The problems the animals deal with in such systems negatively affect animal welfare and consequently also the production (Verga, 2000). A promising method for improving rabbits' living conditions and hence their welfare is to ameliorate husbandry conditions by enriching them (Morton *et al*., 1993; Trocino and Xiccato, 2006). There are numerous ways of enriching the rabbit environment (Young, 2003; EFSA, 2005; Jordan *et al*., 2006). Because rabbits have a huge need to gnaw wood, which in the semi-natural environment they satisfy through gnawing roots or branches (Stauffacher, 1992), sticks of soft wood (Baumans, 2005) could be one possible method of environmental enrichments for rabbits. Environmental enrichment has to be evaluated according to animals' benefit, that is, in terms of improving their welfare (Chave, 2003). For this purpose, the effect of environmental enrichment on one or more of the welfare indicators (mortality, morbidity, species-specific behaviour, physiological parameters, performance) has to be examined (Hoy, 2004).

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The aim of our study was therefore to examine the influence of gnawing sticks as environmental enrichment on the behaviour and performance of individually housed growing rabbits. Results related to the behavioural changes are reported elsewhere (Jordan *et al*., 2008), so therefore the subject of this paper is the influence of gnawing sticks on fattening traits, carcass traits, and also meat quality.

MATERIALS AND METHODS

Animals and Housing

The study included 48 rabbits of both sexes (50 % males and 50 % females) of Slovenian sire line SIKA for meat production. At the age of 44 d animals were housed in Californian battery with individual wire-mesh cages (37.5 cm width×40 cm depth×30 cm height), equipped with feeder and nipple drinker. Half of the cages were enriched with wooden sticks (experimental group) for gnawing (2.2×50×4.4 cm) from Norway spruce (*Picea abies*), fixed firmly under the ceiling of the rabbit's cage (alongside the longer partition, so that both ends of each stick stuck 5 cm out of the cage). This material has been recently proposed as suitable for gnawing sticks in rabbits by Princz *et al*. (2007). For reasons of hygiene, (prevention of mould) all wooden sticks were made from well dried wood without bark. The other half of the cages did not have wooden sticks (control group). Throughout the entire fattening period the wooden sticks did not need to be replaced, since the rabbits did not gnaw them to an extent that made this necessary.

Water and food were available *ad libitum*. Animals were fed with complete feed mixture for fattening rabbits, containing 10.4 MJ DE/kg, 17 % crude protein, 14 % crude fibre and 2 % ether extract. Artificial lighting in the experimental rabbit house was from 6:00 a.m. to 6:00 p.m. The ambient temperature varied from 11 to 18°C and relative humidity was between 25 and 50 %.

Measurements

Individual live weight of rabbits and feed intake were measured weekly. From these measurements average daily gain, daily feed intake and feed conversion ratio were calculated for the entire fattening period.

Half of the animals from both groups were slaughtered at the age of 89 d and the other half at the age of 103 d. Rabbits received feed for the last time the day before slaughter. Animals were individually weighed before the electric stunning. After slaughter the weight of hot carcasses was measured; excluding the head (removed at the atlas joint) and the lower parts of the legs (removed at carpametacarpal or tarsometatarsal joint, respectively), including kidneys and liver without gall bladder. The gastrointestinal tract was separated into individual parts (stomach, small and large intestine, caecum) which were weighed together with their content. Weight of liver without gall bladder, kidneys and visceral fat was also determined. Carcasses without liver and kidneys were weighed again after 24 h cooling at + 4°C. After that kidney fat was removed and weighed, and pH_{24} and meat colour were measured on the cross section of LM (m. *longissimus dorsi*) between the last thorax and first lumbar vertebra. The pH_{24} was measured by the pH meter MA130 (Mettler-Toledo International Inc.). Meat colour was evaluated with the CIE coordinates L* (lightness), a* (redness) and b* (yellowness) using a Minolta CR300 chromameter (Minolta Camera Co., Osaka, Japan).

The weight of the gastrointestinal tract and its individual parts, of the liver, kidneys, kidneys fat, and visceral fat was expressed as a percentage of slaughter weight. Additionally, dressing out percentage and drip loss percentage were calculated as described by Blasco and Ouhayoun (1993). However, it should be noted that: i) carcasses were prepared as described above, ii) hot carcass weight was used when calculating the dressing out percentage, and iii) when calculating the drip loss percentage the hot carcass was prepared in the same way as chilled carcass (without liver and kidneys).

Two wooden sticks were placed in the barn, where animals could not reach them. These two sticks had 14 % of moisture at the beginning of the experiment. Measurements of wood moisture were taken also at the end of experiment with the GANN Hydrometter HT 85T instrument (GANN Mess- und Regeltechnik GmbH, Stuttgart, Germany).

Statistical Analysis

Rabbits that died during the trial were not included in the statistical analysis. We assumed that all fattening, carcass, and meat quality traits were normally distributed and fitted a linear model (1) including the following factors (each with two levels): group (g_i), sex (s_j) and age at slaughter (a_k). Additionally, for the analysis of fattening traits the linear regression on animal weight at the beginning of the trial (x_{ijkl}) was included in the model. Possible interactions did not improve the fit of the model.

$$y_{ijkl} \sim \text{Normal}(\mu + g_i + s_j + a_k + bx_{ijkl}, \sigma_e^2) \quad (1)$$

A Bayesian approach, with "non-informative" prior distributions (2) for all parameters in the model (e.g. Gelman *et al*., 2004; Gelman and Hill, 2006) using Markov chain Monte Carlo (MCMC) methods, was used for estimation and inference.

$$\begin{aligned} &\mu, g_i, s_j, a_k, b \sim Normal(0, 10000^2) \\ &\sigma_e^2 \sim Uniform(0, 10000) \end{aligned} \quad (2)$$

Three chains with 10000 samples were run. Burn-in period was assessed graphically with trace plots and BGR statistics (Gelman *et al*., 2004) and finally conservatively set to 1.000 samples. After saving every 10th sample, chain auto-correlations were negligible and 2700 samples were kept for posterior analysis. Posterior distributions were symmetrical and were described with mean and standard deviation. The influence of environmental enrichment was evaluated with a posterior difference between experimental and control group and posterior probability that absolute difference between groups is larger than zero denoted as Pr(|difference| > 0). All calculations were performed with R (R development core team, 2005) and Bayesian inference using Gibbs sampling (BUGS; Spiegelhalter *et al*., 2003; Sturtz *et al*., 2005) software. In this study only the results for the group effect are presented because this effect is the main objective of our research. However, other effects were retained in the model to increase the explained variance of the data and to control any possible confounding effects.

RESULTS

During the trial 9 rabbits died (18.75 %), mainly because of digestive problems: 6 rabbits died from the experimental group (25.0 %) and 3 from the control group (12.5 %), but the difference between groups could not be deemed as different from zero [Pr(|difference|>0)=0.88]. Enrichment of wire-mesh cages with wooden gnawing sticks had no influence on average daily gain, feed intake or feed conversion ratio of individually housed growing rabbits (Table 1). In the case of carcass traits too, there was no difference between the experimental and the control group (Table 2). We only noticed a difference between groups close to the significance [Pr(|difference|>0)=0.94] in percentage of large intestine. Rabbits in enriched cages had smaller large intestine percentage (−0.21±0.13 %) than rabbits in unenriched cages. Meat colour and pH_{24} value measured on cross section of LM were also uninfluenced by environmental enrichment (Table 3), although the meat of rabbits from experimental group tended to be redder [Pr(|difference|>0)=0.92].

Table 1: Mean (with standard deviation) of the posterior distributions, of environmental enrichment influence on fattening traits of growing rabbits.

	Group			
Fattening trait	Experimental	Control	Difference	Pr(|difference|>0)
Daily gain, g/d	36±1	34±1	2±2	0.84
Feed intake, g/d	156±4	152±4	4±5	0.79
Feed conversion ratio, g/g	4.36±0.11	4.47±0.10	−0.11±0.15	0.77

DISCUSSION

In view of the intention to determine the amount of wood gnawed, wooden sticks from the experimental cages were weighed once a week. However, during the experiment it was observed that the weight of sticks oscillated. Sometimes, the weight of sticks was even greater than one or two week before. It seems that accurate assessment of quantity of consumed wood was not possible, because of wood moisture changes. Plausible explanation is that the moisture in the wooden stick was affected by animals' saliva. We attempted to quantify the change in wood moisture via two control wooden sticks, which had 14 % of moisture at the beginning of the experiment. However, at the end of the experiment the first control stick had 16.4 % of moisture and the second only 9.0 % of moisture. We can not explain this difference. Due to different changes of wood moisture, it was impossible to determine the accurate amount of gnawed wood by means of weighing. Results of behavioural analysis (Jordan *et al*., 2008) showed that rabbits did gnaw the sticks as can be also seen in Figure 1. Without taking the wood moisture into account the minimum and maximum quantities of gnawed wood over the whole experiment were 8 g and 30 g, respectively. In each case the amount of gnawed wood was small (less than 0.7 g per d) therefore consumed wood was not important as a source of crude fibre but more as a medium for occupation. Such sticks could be made cheaply with a circular saw.

Mortality rate is the traditional indicator to evaluate the impact of the treatment. This trait shows a large variation according to many factors (Gidenne and Garcia, 2006) and it can be very high (as high as 40 % or more) in intensive breeding with pathological health conditions, such as the presence of epizootic rabbit enteropathy (e.g. Licois *et al*., 2006). In our trial, differences in mortality between enriched and control group could not be declared as different from zero, possibly also due to the small number of animals in the study. Gidenne and Garcia (2006) reported that more than 300 animals in each group are required to detect

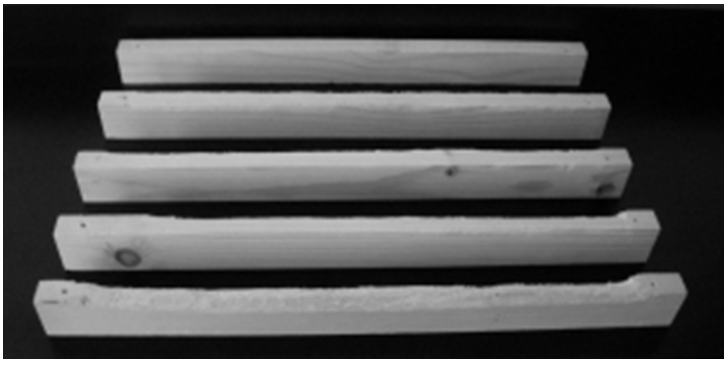

Figure 1: Examples of wooden sticks with different gnawing intensity – minimum (top) to maximum (bottom).

Table 2: Mean (with standard deviation) of the posterior distributions of environmental enrichment influence on carcass characteristics of growing rabbits.

	Group			
Carcass trait	Experimental	Control	Difference	Pr(|difference|>0)
Slaughter weight (SW), g	3247±62	3167±55	80±84	0.83
Hot carcass weight, g	1720±54	1747±52	−27±75	0.65
Dressing out percentage	54.19±0.36	54.37±0.32	−0.18±0.48	0.66
Chilled carcass weight, g	1586±53	1604±49	−18±73	0.60
Drip loss percentage	1.58±0.14	1.81±0.13	−0.23±0.19	0.89
Liver, % SW	2.99±0.09	3.04±0.08	−0.05±0.13	0.67
Kidneys, % SW	0.56±0.02	0.54±0.02	0.02±0.03	0.70
Kidneys fat, % SW	1.24±0.14	1.31±0.12	−0.07±0.19	0.65
Gastrointestinal tract, % SW	14.76±0.40	14.72±0.36	0.04±0.53	0.53
Stomach, % SW	4.28±0.16	4.01±0.15	0.26±0.23	0.88
Small intestine, % SW	2.96±0.10	2.99±0.09	−0.03±0.13	0.60
Large intestine, % SW	2.11±0.10	2.32±0.09	−0.21±0.13	0.94
Caecum, % SW	5.39±0.21	5.38±0.18	0.01±0.28	0.51
Visceral fat, % SW	0.84±0.06	0.90±0.05	−0.06±0.07	0.81

a 5 % deviation in mortality rates. Many authors found no influence of different enrichments on mortality rate (Maertens and Van Oeckel, 2001; Luzzi *et al*., 2003a; Maertens *et al*., 2004; Princz *et al*., 2005; for a review of these studies see Jordan *et al*., 2006). We did not observe any harmful effects of wooden sticks on rabbits during the whole experiment. Given that rabbits' daily intake of wood was not important in global feed intake (less than 0.5 %), we assumed that wooden sticks did not have any influence on health and consequently on the mortality rate.

In accordance with other works using gnawing sticks as environmental enrichment for rabbits, similar production performances were obtained with and without enrichment (Jordan and Štuhec, 2002; Luzi *et al*., 2003a,b; Jordan *et al*., 2004; Princz *et al*., 2005; Verga *et al*., 2005). In feed intake and feed conversion ratio no differences were established either in our study or in the studies of Jordan *et al*. (2004) and Princz *et al*. (2005). Besides fattening traits, gnawing sticks had no influence on slaughter weight and hot and chilled carcass weight (Table 2). Jordan and Štuhec (2002) also found no significant difference in hot carcass weight between individually housed rabbits with and without Norway spruce gnawing sticks, whereas Luzi *et al*. (2003a) reported significantly greater slaughter weight in group housed rabbits with wooden sticks. In contrast to our results they also found significantly greater hot and chilled carcass weight in rabbits from enriched cages. Kermauner *et al*. (2004) studied the influence of gnawing sticks of different types of wood on carcass traits of individually housed growing rabbits and reported no significant influence of wooden sticks on slaughter weight and hot and chilled carcass weight. They also reported no difference between the control and experimental groups in drip loss percentage, a similar finding to that of Luzi *et al*. (2003a). In the present study there was also no significant difference in drip loss percentage between groups. We found no influence of environmental enrichment on the dressing out percentage, which is in accordance with the results of Luzi *et al*. (2003a) and Kermauner *et al*. (2004). However, Princz *et al*. (2005) found a significantly greater dressing out percentage in rabbits with wooden sticks

Table 3: Mean (with standard deviation) of the posterior distributions of environmental enrichment influence on meat quality in LM of growing rabbits.

	Group			
Meat quality trait	Experimental	Control	Difference	Pr(|difference|>0)
pH_{24}	5.64±0.02	5.64±0.02	0.01±0.03	0.57
Meat colour (CIE Lab)[1]				
L* (lightness)	61.80±0.76	60.58±0.69	1.22±1.05	0.88
a* (redness)	3.18±0.30	2.60±0.27	0.58±0.40	0.92
b* (yellowness)	3.94±0.26	3.68±0.24	0.26±0.36	0.76

[1]CIE L* = a measure of lightness, with a larger number indicating a lighter colour; CIE a* = red (+) to green (−) colour scale; CIE b* = yellow (+) to blue (−) colour scale.

housed either in pairs or in groups than in rabbits without wooden sticks. Like Kermauner *et al*. (2004), we also did not find any difference in liver and kidneys percentage between the experimental and the control group, although Maertens and Van Oeckel (2001) established a greater percentage for the liver in rabbits housed in pens enriched with wooden sticks than in rabbits in unenriched pens. Kidneys fat was not influenced by environmental enrichment in our study, and this is in agreement with other studies (Luzi *et al*., 2003b; Kermauner *et al*., 2004; Princz *et al*., 2005). We also found no influence of environmental enrichment on percentage for the gastrointestinal tract and its individual parts, although a trend towards smaller percentage for large intestine was noticed in the experimental group.

Enrichment with wooden sticks for gnawing did not influence pH_{24} value, lightness (CIE L*) and yellowness (CIE b*) of LM (Table 3), but rabbits in the experimental group could have a redder (CIE a*) meat. By contrast, Luzi *et al*. (2003b) and Kermauner *et al*. (2004) registered redder meat in animals without wooden sticks. Meat colour, besides other factors, depends also upon an animal's activity during its lifetime. Greater activity is reflected in a darker colour of muscles (Lebas *et al*., 1997; Skvarča, 2001). Rabbits in the control group tended to jump around the cage for a greater percentage of time than in the experimental group (Jordan *et al*., 2008), and therefore a possible reason for darker colour of meat in control group could be the animal's greater activity. Kermauner *et al*. (2004) reported no significant difference in meat lightness between rabbits with and without wooden sticks, and likewise in pH_{24} value and meat yellowness, which is in accordance with our findings.

CONCLUSIONS

Gnawing sticks from Norway spruce as environmental enrichment had no influence on the fattening, carcass, and meat quality traits of growing rabbits housed individually in wire cages. However, it must be pointed out, that wooden sticks had no negative impact on rabbits' performance, which is very important from the breeders' point of view. The consumption of wood was very low, less than 0.5 % of total food intake. As such, wooden sticks were more important as a medium for occupation. Given this fact, wooden sticks made of Norway spruce can still be treated as appropriate environmental enrichment for growing rabbits.

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