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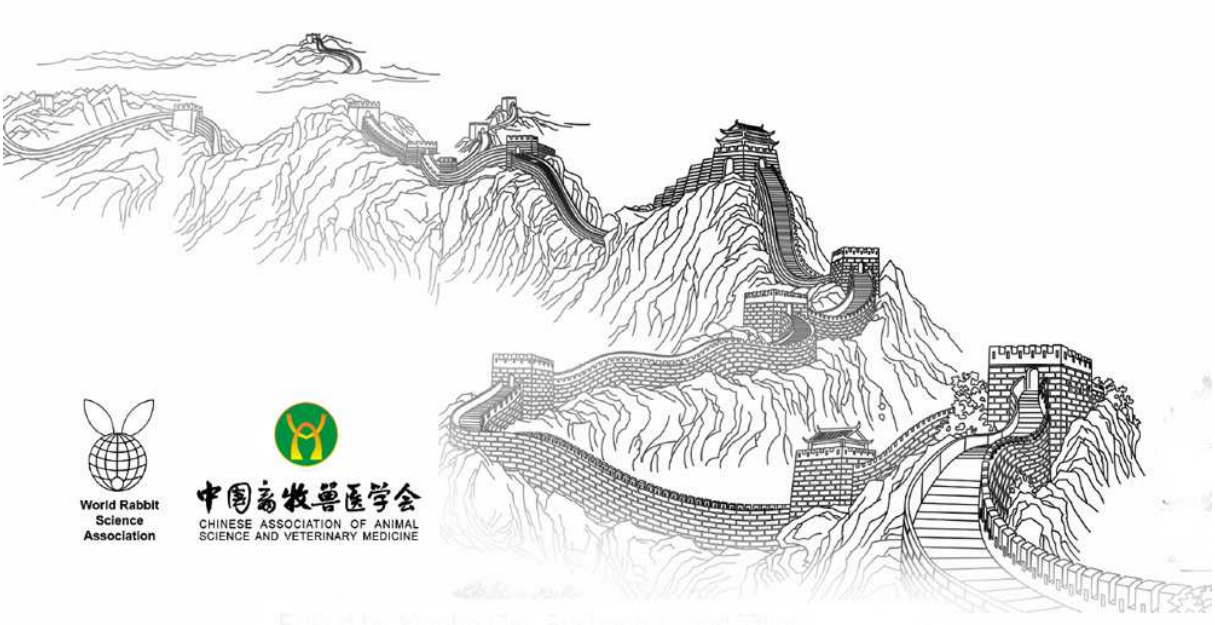

THE EFFECT OF DRIED CHICORY ROOT ADDED TO THE RESTRICTIVE FEED RATION OF RABBITS ON HEALTH STATUS, PERFORMANCE AND CAECAL AND CARCASS TRAITS

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ABSTRACT

Two experiments were carried out to analyse the effect of the addition of chicory roots to the restrictive feed ration on growth, caecal and carcass traits, and sanitary risk index (SRI). A total of 180 Hyplus rabbits (28 d of age; Experiment I) were randomly allocated to one of 3 groups (AL, R, and RC; 60 rabbits per group; 5 rabbits per cage) and fed a standard weaning diet. AL rabbits were fed *ad libitum* between 28 and 70 d of age; R rabbits were restrictively fed from 28 to 42 d of age (70% of the AL group), and then fed at a level of 80% of the AL group for 3 days before being fed *ad libitum* until 70 d of age; RC rabbits were offered the restrictive feed ration (70, 80 and 90% of the AL rabbits from 28 to 49, 49 to 56 and 56 to 63 d of age, respectively) with the addition of dried chicory root. Afterwards, RC rabbits were fed *ad libitum* without the addition of chicory root until 70 days of age. In addition, 30 additional Hyplus rabbits (28 d of age) were randomly allocated to one of 3 groups (AL, R, and RC; 10 rabbits per group; individually housed; sacrificed at 49 d of age) and used to assess the caecal traits. A total of 240 Hyplus rabbits (36 d of age; Experiment II) were randomly allocated to 2 groups (AL and RC; 120 rabbits per group; 5 rabbits per cage) and fed the above-mentioned diet. AL rabbits were fed *ad libitum* between 36 and 78 d of age; RC rabbits were offered the restrictive feed ration (70, 80 and 90% of the AL group from 36 to 57, 57 to 64 and 64 to 71 d of age, respectively) with the addition of dried chicory root. Afterwards, RC rabbits were fed *ad libitum* without the addition of chicory root until 78 days of age. In R rabbits, the caecal pH was higher (+0.3 unit) and total VFA concentration lower (-47 µmol/g, P<0.05) than in AL rabbits. In RC rabbits, we observed a significant decrease of the caecal dry matter (by 3.3 percentage points), caecal pH (-0.7 unit) and increase of the VFA concentration (+23 µmol/g) compared to R rabbits. RC rabbits also showed a higher caecum weight (by 26 g, P<0.05) and content (by 18 g, P<0.05) than AL and R rabbits. In experiment I, morbidity was significantly lower for RC rabbits compared to AL and R rabbits (4 *vs.* 13 and 18 rabbits, respectively). In experiment II, both mortality and SRI were significantly lower for RC rabbits than AL rabbits (1*vs.*11 rabbits and 17 *vs.* 32 rabbits, respectively). In experiment II, we also observed a better feed conversion ratio in RC rabbits than in AL rabbits (2.92 *vs.* 3.32. P<0.05). It can be concluded that the addition of chicory root to the restrictive feed ration affected the feed conversion ratio and digestive health of rabbits in a beneficial way, without an impairment of final live weight or dressing-out percentage.

Key words: Rabbit, Restrictive feed ration, Chicory root, Growth performance, Health status.

INTRODUCTION

Evidence suggests that food restriction has a favourable impact on digestive disorders (Gidenne *et al*., 2012). This is best accomplished by employing a long restriction period (4 weeks after weaning), allowing animals of the restrictive groups to feed *ad libitum* at older ages, or via the adaptation of animals from restricted (3 weeks after weaning) to *ad libitum* intake (Gidenne *et al*., 2012). Indeed, Uhlířová *et al*. (2015) did not observe any favourable effect of shorter durations of feed restriction (2 weeks after weaning) on digestive health, when rabbits were fed *ad libitum* immediately after the restricted period. Regardless of the length and type of the feed restriction, there are several disadvantages of feed restriction, such as lower final live weight and dressing-out percentage in restricted rabbits (Gidenne *et al*., 2012; Uhlířová *et al*., 2015). Thus, the addition of some dietary

components, such as chicory root (Volek and Marounek, 2011), to the restrictive feed ration may be a way to solve this problem. Therefore, two experiments were carried out to analyse the effect of the addition of dried chicory roots to the restrictive feed ration on growth, sanitary risk index, and caecal and carcass traits of growing rabbits after weaning.

MATERIALS AND METHODS

Animals and experimental design

For experiment I, a total of 180 Hyplus rabbits (28 d of age) were randomly allocated to one of 3 groups (AL, R, and RC; 60 rabbits per group) and fed a standard weaning diet (CP 155, NDF 375, ADF 178, ADL 45, EE 40, starch 164 g/kg as-fed basis). Chicory root contained CP 68, NDF 85, ADF 81, ADL 39 g/kg as-fed basis. The rabbits were housed in wire net cages (80 x 60 x 45 cm) with 5 rabbits per cage. The feeding programme was applied as follows: AL rabbits were fed *ad libitum* between 28 and 70 d of age; R rabbits were restrictively fed from 28 to 42 d of age (70% of the AL group), and then fed at a level of 80% of the AL group for 3 days before being fed *ad libitum* until 70 d of age; RC rabbits were offered the restrictive feed ration (70, 80 and 90% of the AL rabbits from 28 to 49, 49 to 56 and 56 to 63 d of age, respectively) with the addition of dried chicory root (milled, sieve 8 mm in diameter). Afterwards, RC rabbits were fed *ad libitum* without the addition of chicory root until 70 days of age. Feed intake was recorded daily in the morning during the entire fattening period; thus, the restrictive feed ration was calculated every day for the restriction period, based on the previous average daily feed intake of the rabbits fed AL. The quantity of chicory root distributed daily to each feeder represented a difference between the restrictive feed ration and AL intake. The sanitary risk index of rabbits was calculated according to the definitions of EGRAN (Fernández-Carmona *et al*., 2005). At 70 d of age, 25 rabbits per group were randomly selected to assess the carcass traits according to the methodology of Blasco and Ouhayoun (1996). In addition, 30 additional Hyplus rabbits (765±27 g live weight; 28 d of age) were randomly allocated to one of 3 groups (AL, R, and RC; 10 rabbits per group) and individually housed in wire net cages (50 x 50 x 45 cm); these rabbits were sacrificed at 49 d of age and used to assess the caecal traits (digesta sampling between 9 to 10 h). For the experiment II, a total of 240 Hyplus rabbits (36 d of age) were randomly allocated to two groups (AL and RC; 120 rabbits per group) and fed the above-mentioned diet. The rabbits were housed in wire net cages (80 x 60 x 45 cm) with 5 animals per cage. The feeding programme was applied as follows: AL rabbits were fed *ad libitum* between 36 and 78 d of age; RC rabbits were offered the restrictive feed ration (70, 80 and 90% of the AL group from 36 to 57, 57 to 64 and 64 to 71 d of age, respectively) with the addition of dried chicory root. Afterwards, RC rabbits were fed *ad libitum* without the addition of chicory root until 78 days of age.

Chemical analyses

The diet and chicory root were analysed by AOAC (1984) methods. The total volatile fatty acid concentration (VFA) was estimated by titration after steam distillation. The molar profile of VFA was estimated by gas chromatography at 140°C using a Chromosorb WAW glass column (2 m x 3 mm i.d.) with 15% SP 1220 and 1% H_3PO_4 (Supelco, Bellefonte, PA, USA).

Statistical Analysis

Data on growth performance and caecal and carcass traits were analysed by the GLM using one-way ANOVA (SAS, 2003). Means were compared by Scheffe's test. Health status was evaluated using Fisher's Exact Test. All differences were considered significant at $P<0.05$.

RESULTS AND DISCUSSION

In R rabbits, the caecal pH was higher (+0.3 unit) and could be related to their lower VFA concentration (-47 µmol/g compared to AL rabbits, $P<0.05$; Table 1). Gidenne and Feugier (2009) observed a lower caecal pH and a higher VFA concentration in restricted rabbits than in AL rabbits. These contradictory results might be partially explained by the time of digesta sampling, which is

related to the peak of digestion in the caecum (Gidenne *et al*., 2012). In RC rabbits, we observed a significant decrease in the caecal dry matter (by 3.3 percentage points) and caecal pH (-0.7 unit) and an increase of the VFA concentration (+23 µmol/g) compared to R rabbits. Rabbits with the addition of chicory root also showed a higher caecum weight (by 26 g, P<0.05) and content (by 18 g, P<0.05) than AL and R rabbits, which is consistent with other findings (Volek and Marounek, 2011). There was no significant effect of the feeding regime on the molar proportion of VFA.

Table 1: Experiment I. Caecal parameters and caecal fermentative activity at 49 d of age in rabbits with different feeding programmes

	AL	R	RC	RMSE[1]	*P*-value
Live weight (LW, g)[2]	1775	1597	1647	169	0.118
Feed intake (g/d)[3]	142.5[a]	130.7[a]	98.8[b]	14.5	0.001
Chicory root intake (g/d)[3]	-	-	23.1	-	-
Full organ (g/kg LW)	60.6[b]	72.2[b]	92.6[a]	14.9	0.001
Fresh content (g/kg LW)	35.6[b]	48.4[ab]	60.4[a]	11.8	0.002
Dry matter (%)	23.5[a]	23.2[a]	19.9[b]	1.9	0.001
pH	5.52[ab]	5.86[a]	5.16[b]	0.28	0.002
Total VFA (µmol/g)	103.6[a]	56.6[c]	79.8[b]	16.4	0.001
Acetate (mol.%)	77.58	81.30	77.95	6.24	0.502
Propionate (mol.%)	3.95	5.77	8.10	3.44	0.075
Butyrate (mol.%)	16.38	10.40	12.19	5.77	0.129
Valerate (mol.%)	0.45[b]	0.78[a]	0.49[ab]	0.25	0.034
Caproate (mol.%)	0.78	0.68	0.49	0.66	0.682
Heptanoate (mol.%)	0.86	1.07	0.78	0.40	0.344

Means with different letters in the same row differ significantly (P<0.05; Sheffe's test). [1]RMSE=root mean square error (n=10 rabbits per group). [2]at 49 d of age. [3]between 42 and 49 d of age.

Table 2: Experiment I. Growth performance, sanitary risk index (28-70 d of age), and carcass traits in rabbits with different feeding programmes

	AL	R	RC	RMSE[1]	*P*-value
Growth performance and health					
Live weight (g)					
At 28 d (weaning)	742	755	744	67	0.883
At 70 d	2631	2595	2572	199	0.763
Daily weight gain (g/d)	45.0	43.8	43.5	4.2	0.671
Daily feed intake (g/d)	138.2[a]	127.7[b]	110.2[c]	10.6	0.001
Daily chicory root intake (g/d)[2]	-	-	22.1	-	-
Feed conversion ratio[3]	3.08	2.92	2.98	0.22	0.214
Morbidity (n)	13	18	4	-	0.005
Mortality (n)	6	5	7	-	0.831
Sanitary risk index (n)[4]	19	23	11	-	0.050
Carcass traits[5]					
Slaughter weight (SW, g)	2828	2809	2907	216	0.238
Full digestive tract (g/kg SW)	159[b]	168[a]	165[ab]	13	0.028
Skin (g/kg SW)	144	144	145	9	0.717
Hot carcass weight (g)	1658	1612	1688	140	0.160
Chilled carcass weight (CCW, g)	1630	1580	1653	138	0.167
Perirenal fat (g/kg CCW)	20	21	20	4	0.997
Dressing out percentage (%)[6]	57.4[a]	56.2[b]	56.8[ab]	1.4	0.022

Means with different letters in the same row differ significantly (P<0.05; Sheffe's test). [1]RMSE=root mean square error (n=12 cages per group for the growth performance). [2]between 28 and 63 d of age. [3]pellets intake + chicory intake in the RC rabbits. [4]Sanitary risk index=number of dead + number of morbid; (morbid animals that died were counted as dead). [5]at 70 d of age (25 randomly selected rabbits per group).[6]Dressing out percentage=(chilled carcass weight/slaughter weight)x100.

Feed restriction had a negative effect on the dressing-out percentage (Table 2), which generally concurred with the review describing a relationship between feed restriction and carcass quality (Gidenne *et al*., 2012). In RC rabbits, however, we did not observe this negative effect; this was most likely associated with a lower full digestive tract weight (-3 g compared to R rabbits). Over the entire fattening period, in R and RC rabbits, we observed a non-significantly better feed conversion ratio than in AL rabbits (on average 2.95 *vs.* 3.08) in experiment I (Table 2) and a better feed conversion ratio in RC rabbits than in AL rabbits (2.92 *vs.* 3.32. P<0.05) in experiment II (Table 3). This was

consistent with other findings (Gidenne *et al*., 2012). In experiment I, morbidity was significantly lower for RC rabbits compared to AL and R rabbits (4 *vs.* 13 and 18 rabbits, respectively; Table 2). In experiment II, both mortality and the sanitary risk index were significantly lower for RC rabbits than AL rabbits (1 *vs.* 11 rabbits and 17 *vs.* 32 rabbits, respectively; Table 3). The better health status of RC rabbits observed in our study may be partially explained by the beneficial effect of chicory fructans on the caecal microbial activity (Volek and Marounek, 2011). Furthermore, Gidenne and Feugier (2009) observed an increase of stomach pH in restricted rabbits relative to AL rabbits. It is well known that low stomach pH (1-2) provides an effective barrier against the microbial colonization of the stomach and small intestine in the period following weaning. In theory, an increase of stomach pH might negatively affect digestive health of short-term restricted rabbits. However, further studies should be conducted to elucidate the causes of the better digestive health of RC rabbits observed in our study.

Table 3: Experiment II. Growth performance and sanitary risk index (36 - 78 d of age) in rabbits with different feeding programmes

	AL	RC	RMSE[1]	*P*-value
Live weight (g)				
At 36 d (weaning)	1040	981	121	0.102
At 78 d	2995	2951	205	0.461
Daily weight gain (g/d)	46.6	46.9	4.4	0.791
Daily feed intake (g/d)	153.4	117.2	13.6	0.001
Daily chicory root intake (g/d)[2]	-	23.7	-	-
Feed conversion ratio[3]	3.32	2.92	0.29	0.001
Morbidity (n)	21	16	-	0.475
Mortality (n)	11	1	-	0.005
Sanitary risk index (n)[4]	32	17	-	0.024

All differences were considered significant at P<0.05. [1]RMSE=root mean square error (n=24 cages per group). [2]between 36 and 71 d of age. [3]pellets intake + chicory intake in the RC rabbits. [4]Sanitary risk index=number of dead + number of morbid; (morbid animals that died were counted as dead).

CONCLUSIONS

The addition of chicory root to the restrictive feed ration affected the feed conversion ratio and health of rabbits in a beneficial way, without an impairment of the final live weight or dressing-out percentage.

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