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Effect of Restricted Access to Drinking Water on Growth, Feed Efficiency and Carcass Characteristics of Fattening Rabbits

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ABSTRACT

A single factor experimental design was used to evaluate the effect of indirect feed restriction generated by limiting the access to drinking water on postweaning performance of growing rabbits. Ninety six weanling rabbits were divided into three equal groups: A1 and A2 had access to drinking water for 1 and 2 h day^{-1}, respectively, while A24 (control) had free access throughout the day. Water Restriction (WR) was applied from weaning (35 day) to 63 days of age; thereafter, all groups were allowed a free access to water until slaughter (77 day). During the restriction period, there was significant feed intake reduction of 25.1% (A1) and 19.1% (A2) compared to A24; however, A1 and A2 rabbits demonstrated progressive adaptation to the restriction regimens. Growth rate was significantly lower (A1, -26.6%; A2, -21%) but feed conversion was similar to A24. On subsequent free access to drinking water, previously restricted rabbits compensated significantly for growth (A1, +31.2%; A2, +24.3%), had similar feed intake and better feed conversion (A1, -1.11 unit; A2, -0.88 unit) relative to the control. Allover the postweaning period, WR significantly reduced growth rate and feed intake, but improved feed conversion (A1, $p<0.05$; A2, $p>0.05$). A1 and A2 rabbits attained 94.1 and 95.5% of slaughter weight of A24. Mortality was significantly low in restricted groups (1.56%, A1+A2 vs. 12.5%, A24). WR had a slight impact on carcass characteristics. Results validate the concern that WR is an indirect feed restriction and has comparable effects in reducing postweaning mortality and eliciting compensatory growth on subsequent re-watering.

Key words: Growing rabbits, water restriction, performance, carcass traits

INTRODUCTION

Controlled Feed Intake (FI) has recently been addressed extensively in rabbit production. It has been successfully practiced to avoid overconditioning and to improve reproductive performance of young females and their first litter weight (Rommers *et al*., 2004; Matics *et al*., 2008b; Manal *et al*., 2010). In fattening rabbits, Feed Restriction (FR) was used as a strategy to reduce production costs and to control digestive troubles. Although, growth rate and eventually body weight are usually impaired during FR, compensatory growth has been observed on realimentation due better nutrient digestibility and feed conversion (Di-Meo *et al*., 2007; Foubert *et al*., 2007a; Tumova *et al*., 2007; Yakubu *et al.,* 2007). Studies have shown little effect of FR on relative organ weights, carcass portions, meat quality and dressing out percentage (Matics *et al*., 2008a; Metzger *et al*., 2008, 2009; Gidenne *et al*., 2009). More interesting, a potential of reducing carcass adiposity (perirenal, scapular and intramuscular fat deposition) by limited FI has been demonstrated in other studies (Gondret *et al.*, 2000; Bergaoui *et al.*, 2008; Metzger *et al.*, 2009). Other reports have demonstrated digestive health benefits of FR in terms of higher resistance of fattening rabbits to experimental challenge with epizootic rabbit enteropathy, ERE (Boisot *et al.*, 2003; Foubert *et al.*, 2008) and lower morbidity and mortality rates (Verdelhan *et al.*, 2004a; Gidenne *et al.*, 2003, 2009). Their results indicated that FI reduction of at least 20% of the *ad libitum* intake is necessary to reduce digestive pathologies and mortality in growing rabbits.

Practically, FR is achieved in terms of a time limited access to the feeders (h day^{-1}), or as a quantitative reduction (e.g., -20 or -30%) of *ad libitum* FI. However, differences between planned and realized FR have been observed upon application of restriction protocols on a large number of rabbits (Gidenne *et al.*, 2009). It is not trouble-free because of more work load and the need for automatic systems for feed distribution to accurately adjust FI. Limited access to Drinking Water (DW) as an indirect FR is an interesting alternative for its effectiveness and, in particular, ease of application (Boisot *et al.*, 2004; Verdelhan *et al.*, 2004a, b; Foubert *et al.*, 2007a, b; Ben-Rayana *et al.*, 2008a, b). Therefore, the current study was designed to investigate the effect of restricting the access of fattening rabbits to DW on their growth performance, survival and carcass characteristics.

MATERIALS AND METHODS

Animals, experimental design and management: This study was carried out from March through May, 2009 in the rabbit production unit of the department of Animal Husbandry and Animal Wealth Development, Faculty of Veterinary Medicine, Alexandria University, Egypt. Ninety-six immediately weaned (35 days of age) Line V rabbits were divided into three equal groups balanced by sex and litter. Rabbits were placed in wire net cages (0.09 m^2 per rabbit, 4 animals per cage) in a closed house. There was no control on environmental temperature and ventilation was brought about through wall windows without exhaust fans. Cleaning and washing of the floor was done manually once daily at 8.00 a.m.

Experimental groups A1 and A2 had free access to drinking water for one (9.00-10.00 a.m.) and 2 h (9.00-11.00 a.m.) per day, respectively from weaning to 63 days of age. Onwards to slaughter (77 days of age), they had free access to DW. Control rabbits (A24) had unrestricted access to DW the whole fattening period. DW was available from nipple drinkers.

The same pelleted diet (Table 1) was used throughout the fattening period. It was formulated as suggested by the Department of Nutrition, Faculty of Veterinary Medicine, Alexandria University. No antimicrobials were added to the diet. All groups were fed *ad libitum* from weaning to slaughter and fresh food was distributed daily.

Growth and feed efficiency measurements: At weaning, kits were individually identified by ear tags and weighed, then Body Weight (BW) was recorded weekly to slaughter. FI was measured weekly per cage giving eight FI records per group per week. When a kit was found dead, food in the feeder was weighed to exclude the amount consumed by the dead kit. At the end of the week, FI of the remaining kits in the cage was calculated. Food conversion was calculated weekly as FI to BW gain ratio.

Slaughter and carcass measurements: Twelve rabbits, six males and six females, were selected randomly from each group at 11 weeks of age, weighed (slaughter weight, SW) and then

Table 1: Ingredients and chemical composition of the fattening diet

Ingredients	Percentage	Chemical composition	Percentage
Berseem hay	36.65	Moisture (%)	11.13
Wheat bran	16.5	Crude protein (%)	17.27
Barley	16	Ether extract (%)	2.99
Yellow corn	9	Crude fiber (%)	13.12
Soybean meal (44%)	16	Total ash (%)	9.19
Vegetable oil	1	Nitrogen free extract (%)	46.30
Molasses	3	Calcium (%)	1.12
Limestone	0.5	Phosphorus (%)	0.43
Dicalcium phosphate	0.25	Digestible energy (kcal kg^{-1})	2566.50
Sodium bicarbonate	0.3		
Vitamin-Mineral mix	0.25		
Salt	0.5		
Dl-methionine	0.05		

slaughtered without previous fasting. Carcass trait definitions and dissection technique recommended by the World Rabbit Science Association (Blasco and Ouhayoun, 1993) was followed. Briefly, weight of the Hot Carcass (HC) was recorded about 30 min after slaughter and bleeding. HC did not include the skin, distal part of the tail, fore and hind legs, digestive tract and urogenital organs. Skin and full gastrointestinal tract weights were recorded and expressed as percentage of SW. Carcasses were then cooled at 4°C for 24 h and re-weighed to obtain chilled carcass weight (CC). The difference between HC and CC relative to HC was calculated as the drip loss. The proportion of CC to SW was determined to get the dressing out percentage (DoP). Edible organs were removed from the chilled carcass to get the reference carcass (RC) weight (meat, fat and bone). Edible organ weights and RC were presented as percentage of CC. Perirenal and scapular fat were dissected out and the RC was split between the 7th and 8th thoracic and between the 6th and 7th lumbar vertebrae to obtain the fore-, intermediate and hind parts. Carcass parts and depot fats were weighed and expressed as percentage of RC.

Statistical analysis: Effect of group on growth, feed efficiency and slaughter measurements was assessed by the analysis of variance using the general linear model procedure (PROC GLM) of SAS (SAS, 2002). Significance of differences among means was tested by the probability difference option (LSMEANS/PDIFF) of the same procedure. Another analysis was performed by including SW as a covariate to determine the effect of treatment on carcass weight if rabbits were slaughtered at a constant weight rather than a constant age. Weaning to slaughter mortality rate was compared using the chi-square test.

RESULTS AND DISCUSSION

Results of growth performance, feed efficiency and mortality rate are presented in Table 2. The three groups were homogenous at the start of the experiment given that they had similar mean BW (35 days) and BW variation (standard deviation of 138, 148 and 141 g for A1, A2 and A24, respectively). Except for differing FI during the first and third weeks and overall the restriction period, A1 and A2 rabbits did not differ significantly in growth and feed efficiency. Restricting the access of weaned rabbits to 1 and 2 h per day between weaning and 63 days could generate FI reduction of 25.1 and 19.1%, respectively compared to the intake of unrestricted animals. This

Table 2: Effect of limited access to drinking water on growth, feed intake and feed conversion of growing rabbits

	Access to drinking water[1]				
Trait and age (day)	A1	A2	A24	SEM[2]	Sig[3]
Body weight (g)					
35	897	902	899	25.2	ns
42	1060[b]	1078[b]	1166[a]	27.9	*
49	1249[b]	1286[b]	1429[a]	31.1	***
56	1448[b]	1496[b]	1684[a]	30.8	***
63	1621[b]	1682[b]	1889[a]	31	***
77	2174[b]	2207[b]	2310[a]	29.7	**
Weight gain (g day^{-1})					
35-42	23.3[b]	25.1[b]	36.9[a]	1.2	***
42-49	27.0[b]	29.7[b]	38.6[a]	1.34	***
49-56	28.5[b]	30.0[b]	36.5[a]	1.25	***
56-63	24.7[c]	26.6[bc]	29.1[a]	1.26	*
Overall restriction period, 35-63	25.9[b]	27.9[b]	35.3[a]	0.81	***
64-77	39.5[a]	37.4[a]	30.1[b]	1.07	***
Overall postweaning period, 35-77	30.4[b]	31.0[b]	33.6[a]	0.68	**
Feed intake (g day^{-1})					
35-42	55.9[c]	64.6[b]	93.6[a]	1.31	***
42-49	85.3[b]	92.7[b]	119.6[a]	1.56	***
49-56	105.6[c]	111.8[b]	132.7[a]	1.08	***
56-63	110.3[b]	117.2[b]	131.8[a]	1.26	***
Overall restriction period, 35-63	89.3[c]	96.5[b]	119.3[a]	1.14	***
64-77	123	124.5	128.1	1.15	ns
Overall postweaning period, 35-77	100.5[b]	105.9[b]	122.2[a]	1.05	***
Feed conversion (g g^{-1})					
35-42	2.42	2.57	2.56	0.12	ns
42-49	3.17	3.13	3.11	0.19	ns
49-56	3.73	3.74	3.65	0.16	ns
56-63	4.48	4.42	4.53	0.29	ns
Overall restriction period, 35-63	3.47	3.49	3.4	0.12	ns
64-77	3.12[b]	3.35[b]	4.23[a]	0.1	***
Overall postweaning period, 35-77	3.31[b]	3.43[ab]	3.65[a]	0.09	*
Mortality (%)	3.13	0	12.5		P[4,5]

[1]Water restriction was applied from weaning to 63 days of age and all groups had free access to drinking water from 64 to 77 days of age. A1, A2 and A24 = access to drinking water of 1, 2 and 24 h per day, respectively. [2]Standard error of the least squares means. [3]Significance levels: ns: Not significant, $p>0.05$; *$p<0.05$; **$p<0.01$; ***$p<0.001$. [4]p-value = 0.06 for A1 vs A2 vs A24. [5]p-value = 0.02 for (A1+A2) vs A24. [a,b,c] Within a row, least squares means without a common superscript letter differ, $p<0.05$

verifies the first assumption of this study that WR can be an indirect FR. Practically, WR has the advantage of being easier in application and less labor-demanding than direct FR. Gidenne *et al.* (2009) planned to reduce FI to a level between 60 and 80% of the *ad libitum* intake of growing rabbits after weaning in a large scale trial (n = 1984) covering six sites of France. Their data indicated that the measured FR was less than the scheduled value in 59% of applications demonstrating practical difficulties in precisely adjusting FI for large numbers of animals. Previous studies on growing rabbits have demonstrated comparable impact of WR on FI. Boisot *et al.* (2004) reported 18.1% FI reduction after a 28 days period of restricted access to DW of 2 h per day. FI decreased to 78 and 83% of the *ad libitum* level in response to 1 h 30 and 2 h 30 access to DW per day from 32 to 62 d of age (Verdelhan *et al.*, 2004b). Also, Ben-Rayana *et al.* (2008a) obtained FI reduction of 25 and 20% due to WR of 2 or 4 h day^{-1} continuously from weaning (28 days) to slaughter (77 days).

During the period of WR (35 to 63 days), restricted groups had significantly slower growth rate than the control rabbits. Overall, A1 and A2 achieved 73.4 and 79%, respectively of daily BW gain of A24. The maximum growth retardation was observed during the first week where A1 and A2 attained only 63.1 and 68% of daily BW gain of the unlimited animals. After that, growth rate of restricted animals improved steadily. In consequence, BW of A1 and A2 was continually lower during the four weeks of restriction averaging 268 and 207 g significantly less than A24 rabbits at the end (63 days) of the restriction phase. Weekly and total FCR did not differ among the three groups throughout this period. So, the trend of FI paralleled the growth pattern. A1 rabbits consumed 40.3, 28.7, 20.4 and 16.3% and A2 animals consumed 31, 22.5, 15.7 and 11.1% significantly less feed than A24 rabbits the first through the fourth week of the restriction period, respectively. This pattern entails additional advantage for WR, since the greatest reduction in FI intake occurred during the first week known to be associated with the highest rate of digestive troubles and rabbit losses, as evidenced in the current and earlier experiments (will be discussed below). Reduced growth rate and FI without improvement of FCR during restriction was similarly reported by Bovera *et al.* (2008) and Gidenne *et al.* (2009). The observed growth and FI trends in the current study indicate that rabbits adapt progressively to WR. Likewise, Foubert *et al.* (2007b) reported a similar tendency during a three-week time limited access to the feeders.

When all rabbits were allowed a free access to DW (64 to 77 days), previously restricted groups compensated significantly for growth. Since, FI did not differ among groups during this period, it was the improved FC (-1.11 units for A1 and -0.88 units for A2, $p<0.001$) that caused the significantly ($p<0.001$) faster BW gain of A1 (+31.2%) and A2 (+24.3%) than A24. During the whole postweaning period (35 to 77 days), A1 and A2 rabbits consumed less feed (-17.8 and -13.3%, $p<0.001$), grew at slower rate (-9.5 and -7.7%, $p<0.01$) and demonstrated better FCR (9.3%, $p<0.05$ and 6.0%, $p>0.05$) compared to unrestricted rabbits. Thus, at slaughter age, A1 and A2 rabbits weighed 136 and 103 g ($p<0.01$) less than A24, which are approximately half the differences observed at 63 days of age. Despite the clear compensatory growth, the short re-watering period (2 weeks) was, perhaps, not sufficient for A1 and A2 rabbits to completely attain the final BW of A24 animals. Several earlier studies have demonstrated the behavior of compensatory growth in young rabbits when returned to free access after various restriction periods (Verdelhan *et al.*, 2004b; Foubert *et al.*, 2007a, 2008; Gidenne and Feugier, 2009; Gidenne *et al.*, 2009). All the previous workers and Bovera *et al.* (2008) reported better FCR in restricted rabbits over the whole fattening period. In contrast, Boisot *et al.* (2004) did not observe compensatory growth in rabbits subjected to restricted access to DW of 2 and 3 h between 35 and 63 days of age. Their incomparable finding is probably due to the very short period (63 to 67 days) of subsequent unlimited access.

Collectively, restricted rabbit groups suffered significantly less postweaning mortality than unrestricted rabbits [1.56% (A1+A2) vs 12.5% (A24)]. All mortalities (5 of 96 kits) occurred during the first two weeks postweaning, with four of them were associated with digestive disturbances, i.e., diarrhea and abdominal distention. One kit in group A1 and three from group A24 died between 35 and 42 days of age and the fifth kit from A24 died at 46 days of age. In rabbits, the sensitivity to gut problems is high shortly after weaning causing a relatively high mortality rate (Boucher and Nouaille, 2002; Gidenne *et al.*, 2005). Gidenne *et al.* (2009) reported a health risk index (mortality+morbidity rates) of 9.5 to 16.7% from a FI reduction of 20 to 40% compared to 22.6% in unrestricted rabbits from weaning to 54 day. The results also agree with the preventive effect of FR demonstrated by young rabbits experimentally challenged with ERE (Boisot *et al.*, 2003; Foubert *et al.*, 2008). Moreover, under ERE conditions, WR (1 h day^{-1} between 32 to 53 days) has been shown to be as efficient as FR (65% of the *ad libitum* level) in controlling mortality and morbidity (Boisot *et al.*, 2005). High cecal acidity resulting from a change in FI pattern of FR rabbits has been reported by Gidenne and Feugier (2009). This may be less favorable for the growth of pathogens, hence the less gut disorders in restricted animals.

On a group basis, joining together total mortality and average slaughter weight, the calculated total production at marketing was 67.4, 70.6 and 64.7 kg of live rabbits in A1, A2 and A24 groups, respectively. As well, the total ration consumed in the three groups, respectively were 131.1, 142.3 and 145.7 kg, taking into account the amount consumed by dead kits. These figures indicate the cost-effectiveness of the suggested restriction regimens, as found by Gidenne *et al.* (2009) after FR in rabbits reared under good sanitary conditions and Foubert *et al.* (2008) in ERE conditions with high morality.

Results of slaughter traits are presented in Table 3. In general, watering regimens induced little effects on carcass traits. A1 and A2 rabbits had significantly smaller HC (-6.5 and -5.4%), CC (-7.1 and -6.1%) and RC (-7.6 and -6.2%) than those of unrestricted control rabbits. However,

Table 3: Effect of limited access to drinking water on carcass traits of growing rabbits

	Access to drinking water[1]				
Trait	A1	A2	A24	SEM[2]	Sig[3]
Weights (g)					
Slaughter weight	2182^{b}	2210^{b}	2307^{a}	29.7	*
Hot carcass	1257^{b}	1271^{b}	1344^{a}	19.2	**
Chilled carcass	1209^{b}	1222^{b}	1301^{a}	17.7	**
Reference carcass	981^{b}	996^{b}	1062^{a}	16.3	**
Percentage of slaughter weight (%)					
Chilled carcass (DoP[4])	55.4	55.3	56.4	0.44	ns
Skin	14.7	14.6	14.8	0.25	ns
Full gastrointestinal tract	18.3	18.1	17.7	0.5	ns
Percentage of chilled carcass (%)					
Reference carcass	81.2	81.5	81.6	0.33	ns
Head	9.12	9.21	8.91	0.22	ns
Liver	5.74	5.58	5.64	0.16	ns
Kidney	1.1	1.09	1.06	0.06	ns
LH[5]	2.29	2.19	2.28	0.33	ns
Percentage of reference carcass (%)					
Fore part	29.8	29.6	29.1	0.24	ns
Intermediate part	28.9	29	28.7	0.4	ns
Hind part	39.1	39.2	39.8	0.34	ns
Perirenal fat	1.52	1.54	1.72	0.15	ns
Scapular fat	0.52	0.49	0.61	0.05	ns
Drip loss (%)	3.8	3.84	3.15	0.32	ns

[1]Water restriction was applied from weaning to 63 days of age and all groups had free access to drinking water from 64 to 77 days of age. A1, A2 and A24 = access to drinking water of 1, 2 and 24 h per day, respectively. [2]Standard error of the least squares means. [3]Significance levels, ns: Not significant, $p>0.05$; *$p<0.05$; **$p<0.01$. [4] DoP: Dressing out percentage. [5]LH: Set of organs consisting of thymus, trachea, esophagus, lung and heart. [a,b,c] Within a row, least squares means without a common superscript letter differ, $p<0.05$

Table 4: Effect of limited access to drinking water on carcass yield traits of growing rabbits adjusted to a constant slaughter weight (2233 g)

	Access to drinking water[1]				
Trait	A1	A2	A24	SEM[2]	Sig[3]
Hot carcass (g)	1286	1284	1301	9.69	ns
Chilled carcass (g)	1234	1233	1264	10.83	ns
Reference carcass (g)	1004	1006	1029	10.46	ns

[1]Water restriction was applied from weaning to 63 days of age and all groups had free access to drinking water from 64 to 77 days of age. A1, A2 and A24: Access to drinking water of 1, 2 and 24 h per day, respectively. [2]Standard error of the least squares means. [3]Significance levels: ns: Not significant, p>0.05

if rabbits were slaughtered at a constant BW rather than at a fixed age, differences in HC, CC and RC weight disappeared (Table 4). So that, the variations observed in carcass yield traits are a consequence of differing SW, but not a result of the restriction regimens. On the other hand, DoP, relative organ weights, carcass portions, carcass adiposity and other relative carcass traits did not differ among the three groups. Similarly, other reports have indicated little impact of a variety of restriction protocols on carcass traits (Tumova *et al*., 2003, 2006; Boisot *et al*., 2004; Dalle Zotte *et al*., 2005; Yakubu *et al*., 2007). The decrease in DoP (-1 unit in A1; -1.1 units in A2, p>0.05) is within the range of reduction (-1.2 to -0.8%) recorded by Matics *et al*. (2008a), Metzger *et al*. (2008) and Gidenne *et al*. (2009) with quantitative and time FR. The higher proportion of the gastrointestinal tract in A1 and A2 rabbits, although was not statistically significant, is corresponding to the findings of Ben-Rayana *et al*. (2008b) with WR (access of 2 h day^{-1}) and Bergaoui *et al*. (2008) with 70-85% FR. This may partly explain the decrease in the DoP of restricted animals. In their experiments, unlike the current study, carcass adiposity (perirenal and scapular fat) was reduced in restricted rabbits. This contradiction may be due to different experimental designs since they practiced continuous restriction throughout the whole fattening period without the free access phase (2 weeks) prior to slaughter applied in the present study.

In conclusion, results of this study verified the interest that WR can be a practically easier alternative to FR. It is useful in controlling postweaning mortality and eliciting compensatory growth on subsequent free access with limited effect on carcass traits. Besides, WR is more cost-effective than the traditional systems of fattening rabbits based on free access.

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