Effect of replacement of berseem (*Trifolium alexandrinum* L.) hay by berseem silage on performance of growing rabbits

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SUMMARY

Two experiments were done to study the effect of partial replacement of berseem hay by berseem silage on the performance of growing rabbits. In the first one, 8 mature eight-months-old male NZW rabbits with an average body weight of 2.5 kg were used to determine digestibility coefficients and nutritive values of berseem hay (BH) and berseem silage (BS). In the second one, 30 NZW growing rabbits of 60 days of age were used in a complete randomized design experiment with three treatments. The first group was fed commercial rabbit diet including 40% BH (control diet), while in the other two groups 50 or 100% of BH was replaced by BS throughout the 70 days of the experiment. Results of the first experiment indicated that the contents of crude protein (CP) and ash tended to be higher, but the contents of organic matter (OM), crude fiber (CF), ether extract (EE) and nitrogen free extract (NFE) tended to be lower in BS compared with BH. The digestibility coefficients of DM, OM, CP, CF and NFE and the contents of TDN, DCP and DE were significantly higher ($P<0.05$) for BS than BH. In the second experiment, the contents of CP and ash tended to increase, but the contents of OM, CF and NFE tended to be decreased with increasing the level of replacing BH by BS. The digestibilities of DM, OM CP, EE and NFE and TDN, DCP and DE values and caecal values (TVFA's and NH_3-N concentrations) increased significantly ($P<0.05$), however pH value decreased significantly ($P<0.05$) with increasing the level of replacing BH by BS. The final body weight, total and daily weight gain, the total and net revenue and net revenue improvement increased significantly ($P<0.05$), however, the average daily and total DM intake, the amount of DM required per kg weight gain and also the feed cost and feed cost/kg gain decreased significantly ($P<0.05$) with increasing the level of replacing BH by BS. The slaughter weight, carcass weight, dressing percentage, meat weight and percentage increased significantly ($P<0.05$), but the DM content of the meat decreased significantly

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(P<0.05) with increasing the level of replacing BH by BS. Protein content in meat of rabbits fed 50 and 100% BS diets was significantly higher (P<0.05) than that of those fed commercial diet, while the contents of ether extract and ash were nearly similar for different groups.

Keywords: NZW rabbits, berseem silage, digestibility, body weight gain, economic efficiency and carcass traits

INTRODUCTION

As herbivores, wild rabbits consume a high proportion of plants as an integral part of their diet (Abou-Ashour et al., 2003). Thus, rabbits can profit from forages and by-products which are also a major constituent of commercial feeds in industrial farms (Toson et al., 1999). Moreover, the use of locally produced forages can help to overcome the dietary protein gap in rabbit meat production (Lebas, 1983). In Egypt, there has been a great attempt successfully performed on ensiled locally produced forages such as berseem, which are cheaper, easily accessible and more sustainable and contribute to local development, help preserve local plant gene variability and their reflexes on rabbit growth performance (Abou-Ashour et al., 2003 and Omara et al., 2005a).

The effect of nutrition on carcass traits has been studied in previous works (Volek et al., 2002 and Omara et al., 2005b), but little information is available dealing with the effect of feeding rabbits on the carcass traits and meat quality.

The objective of this study was to investigate nutritive value of berseem silage and the effect of replacing berseem hay by berseem silage on the growth performance, feed conversion, economic efficiency and carcass traits of growing NZW rabbits.

MATERIAL AND METHODS

The current work was carried out at Sakha Animal Production Research Station, Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture (Dokki, Giza, Egypt) to investigate the effect of partial replacement of berseem hay by berseem silage on the performance of growing rabbits.

Berseem silage and hay

Berseem hay was made from the 4th cut which was spread on ground in rows and layers of range 10-25 cm high. Berseem was turned upside down every day at 9 a.m. after dew disappearance until being cured. After that hay was collected and stored as bales until used to feed rabbits. The 4th cut of

berseem (*Sakha 4*) (*Trifolium alexandrinum L.*) was chopped (1-1.5 cm long) and ensiled with 5% molasses additive in plastic bags (40-50 kg) for two months. Silage quality parameters determined were pH value using Bechman pH meter, NH_3-N concentration (AOAC, 1990), TVFA's concentration (Warner, 1964) and lactic acid concentration (Analytical Chemistry of Foods, 1995).

First experiment

The digestibility trial was conducted to determine nutritive values of both berseem hay (BH) and berseem silage (BS) using 8 mature male NZW rabbits (4 per forage) with an average body weight of 2.5 kg and age of 8 month. Rabbits were housed individually in galvanized wire cages and fed *ad libitum* and refusals were recorded every day and daily fecal output was also weighed. Representative samples of feedstuffs and feces were dried at 60^{o}C for 48 hours, ground to 1 mm and chemically analyzed in duplicate to determine CP, CF, EE and ash according to AOAC (1990).

Second experiment

Experimental rabbits and diets

Thirty NZW growing rabbits of 60 days of age with an average body weight of 773 g were used in a complete randomized design with three treatments (10 per each treatment). The first group was fed a commercial rabbit diet including 60% concentrates and 40% BH (control diet), while in the other two groups 50 or 100% of BH was replaced by BS throughout the 70 days of the experiment. The composition of the commercial rabbit diet is shown in Table 1.

Table 1 Ingredient composition (%) of the commercial rabbit diet.

Berseem hay	40	Molasses	2
Wheat bran	8	Limestone	1
Soybean meal	18	Common salt	0.5
Yellow corn	15	Premix*	0.5
Barley grain	15	Total	100

* Each kg of premix (minerals and vitamins mixture) contained vit. A, 20000 IU; vit. D3, 15000 IU; vit. E, 8.33 g; vit. K, 0.33 g; vit. B1, 0.33 g; vit. B2, 1.0 g; vit. B6, 0.33 g; vit. B5, 8.33 g; vit. B12, 1.7 mg; pantothenic acid, 3.33 g; biotine, 33 mg; folic acid, 0.83 g; choline chloride, 200 g; Zn, 11.7 g; Fe, 12.5 g; Cu, 0.5 g; I, 33.33 g; Se, 16.6 mg and Mg, 66.7 mg.

Housing and management

Rabbits were housed in galvanized wire cages and fresh water was automatically *ad libitum* available at all time. All rabbits were kept under the same managerial, hygienic and environmental conditions. Live body weight and feed consumption (introduced – refuse) were recorded at weekly intervals throughout the experimental period. Daily weight gain, feed conversion and economic efficiency in terms of feed cost and revenue were calculated.

Digestibility trials

Digestibility trial was undertaken at 112 days of age using four animals from each group. Rabbits were housed individually in metabolic cages fed their experimental diets. The experimental diets were offered daily and fresh water was provided all the time. Feed intake was accurately determined. Feces were collected daily for 5 days as a collection period, then the feces was dried at 60^{o}C for 48 hours. All collected feces for each animal were pooled and then feces were ground to 1 mm for chemical analyses. Chemical analysis of different feedstuffs and feces was carried out in duplicate to determine CP, CF, EE and ash and according to AOAC (1990).

Carcass traits

At the end of the experiment (130 days of age), 9 rabbits (3 from each group) with average body weight of 2725 g were fasted for 18 hours before slaughtering, then weighed and slaughtered. Carcass weight (the main body, head, kidneys, liver, heart and other total edible parts) were determined according to Blasco *et al*. (1993). Dorsi muscle was dried at 60^{o}C for 48 hours, ground to 1 mm and analyzed in duplicate to determine CP, EE and ash according to AOAC (1990).

Cecal parameters

Cecum contents of slaughtered rabbits (9 rabbits aged 130 days, 3 from each treatment) were sampled for the determination of pH using Bechman pH meter, NH_3-N concentration using saturated solution of magnesium oxide according to the method of AOAC (1990) and TVFA's concentration according to Warner (1964).

Statistical analysis

The data of 1st experiment were statistically analyzed using T-test, while the data of 2nd experiment were statistically analyzed using general linear models procedure adapted by SPSS (2008) for user's guide with one-way ANOVA. Duncan test within program SPSS was done to determine the degree of significance between mean values.

RESULTS AND DISCUSSION

First experiment

Composition of tested feedstuffs

Contents of CP and ash tended to be higher, whereas the contents of OM, CF, EE and nitrogen free extract (NFE) tended to be lower in berseem silage

(BS) compared with berseem hay (BH) as presented in Table (2). Similar results were obtained by Abd El-Lateif (2002) and Omara et al. (2005c).

Digestibility coefficients and nutritive values of tested feedstuffs

Results in Table 2 showed that the digestibility coefficients of DM, OM, CP, CF and NFE and the contents of TDN, DCP and DE were higher ($P<0.05$) for BS than BH. The obtained results are within the values obtained for NZW rabbits fed commercial rabbit diets or berseem silage, as reported by Abd El-Lateif (2002) and Omara et al. (2005c).

Table 2 Chemical composition, apparent fecal digestibility and nutritive values of berseem hay (BH) and berseem silage (BS).

Item	BH	BS*	SEM	P-value
Number	4	4		
Chemical composition:				
DM %	89.5	24.6		
Composition of DM %:				
OM	89.7	87.3		
CP	14.4	15.3		
CF	27.6	25.2		
EE	2.45	2.50		
NFE	45.2	44.3		
Ash	10.3	12.8		
Digestibility coefficients %:				
DM	66.2	69.1	0.68	0.020
OM	67.7	70.6	0.82	0.074
CP	67.6	69.4	0.42	0.022
CF	63.5	66.9	0.80	0.022
EE	70.4	71.6	0.36	0.099
NFE	66.4	70.3	0.89	0.018
Nutritive values (on DM basis):				
TDN %	61.1	62.6	0.34	0.018
DCP %	9.70	10.62	0.18	0.002
DE (kcal/kg)	2694	2760	15	0.018

* Silage quality was pH 4.12, lactic acid 4.72% of DM, TVFA's 2.30% of DM and NH_3-N 6.15% of total-N.
DE = TDN x 44.09

Second experiment

Composition of experimental diets

The composition of experimental diets showed that the contents of CP and ash tended to increase, but the contents of OM, CF and NFE tended to decrease with increasing the level of replacing BH by BS (Table 3). Close results were reported by Abd El-Lateif (2002) and Omara et al. (2005c).

Table 3 Chemical composition, apparent fecal digestibility and nutritive values of experimental diets.

Item	Replacing level %			SEM	P-value
	0	50	100		
Number	10	10	10		
Chemical composition:					
DM %	91.2	59.3	44.0		
Composition of DM %					
OM	90.3	89.8	89.3		
CP	16.8	17.0	17.2		
CF	17.8	17.3	16.8		
EE	2.69	2.70	2.71		
NFE	53.0	52.8	52.6		
Ash	9.7	10.2	10.7		
Digestibility coefficients %:					
DM	69.5^{b}	72.3^{ab}	73.4^{a}	0.75	0.080
OM	70.8^{b}	73.8^{ab}	74.5^{a}	0.68	0.056
CP	71.4^{b}	76.4^{a}	77.5^{a}	1.04	0.022
CF	64.6	64.1	63.9	0.25	0.477
EE	76.9^{b}	80.1^{a}	80.5^{a}	0.57	0.007
NFE	71.2^{b}	74.1^{a}	74.6^{a}	0.55	0.010
Nutritive values (on DM basis):					
TDN %	65.9^{b}	68.1^{a}	68.2^{a}	0.34	0.001
DCP %	12.0^{b}	13.0^{a}	13.3^{a}	0.24	0.052
DE (kcal/kg)	2904^{b}	3004^{a}	3006^{a}	15.1	0.001

a, b: Means in the same row with different superscripts differ significantly (P<0.05).

Digestibility coefficients and nutritive values of experimental diets

Digestibility coefficients of DM and OM tended to be higher with increasing replacement of BH by BS. Coefficients of CP, EE and NFE as well as values of TDN, DCP and DE significantly increased with increasing the level of replacing BH by BS from a 0% replacement to a 100% (Table 3). On the contrary, CF digestibility was nearly similar between dies. The differences in nutrients digestibility and nutritive values among the different diets might be attributed to the differences in the chemical composition of different diets. The results obtained here were higher than those obtained by Abd El-Lateif (2002) and Omara et al. (2005a) with using berseem silage in rabbit feeding.

Cecal parameters

Results in Table 4 reveal that increasing replacing level of BH by BS led to a significant (P<0.05) reduction in cecal pH value and an increase in TVFA and NH_3-N cecal concentrations. Cecal fermentation parameters are affected by several factors such as: diet composition, feeding type, feeding level, ratio of

roughage to concentrate and post feeding period of sample. These results are in accordance with those obtained by Abd El-Lateif (2002) who found that the depression of cecal pH values with berseem silage is associated with the increase of VFA's production. Fluctuations in pH value reflect changes in organic acids concentrations accumulated in the ingesta. The concentration of NH_3-N in the cecal reflects the dietary protein content.

Table 4 Cecum activity of growing rabbits fed experimental diets.

Item	Replacing level %			SEM	P-value
	0	50	100		
Number	3	3	3		
pH value	6.12[a]	5.95[ab]	5.87[b]	0.05	0.015
TVFA's (mmol/dl)	8.74[b]	9.15[ab]	9.60[a]	0.13	0.024
NH_3-N (mg/dl)	21.9[b]	22.6[ab]	23.4[a]	0.25	0.035

a, b: Means in the same row with different superscripts differ significantly (P<0.05).

Body weight gain

The final body weight, total and daily weight gain increased (P<0.05) with increasing the level of replacing BH by BS (Table 5). The daily weight gain of rabbits fed diets containing 50 and 100% BS increased by 6.0 and 12.0% compared with those fed the commercial diet, respectively. Such variations were mainly a reflection of the quality of experimental diets as detected from the increase of TDN value by 2.2 and 2.3%, DCP value by 1.0 and 1.3% and DE value by 100 and 102 kcal/kg DM for 50 and 100% replacing level. Average daily weight gain reported herein was higher than those obtained by Abd El-Lateif (2002) that ranged from 18 to 24 g/day and than those of Omara et al. (2005a) which ranged from 15 to 23 g/day for NZW fed diets containing berseem silage. Nevertheless, values of the present work are in keeping with those obtained by Eweedah et al. (2007) being 26 or 27-30 g/day for NZW rabbits fed diets containing peanut vines.

Feed intake

Results in Table 5 showed that average daily and total DM intake decreased (P<0.05) with increasing the level of replacing BH by BS. Decreasing DM intake with diets contained BS might be due to the bulk of silage and increasing moisture content of silage. Feed consumption of rabbits depends basically on nutrient contents in accordance with the actual energy need of the animal (Dehalle, 1981) or/and protein and fiber level of its ration (Fekete and Bokori, 1985). These results agreed with those obtained by Abd El-Lateif (2002) and Omara et al. (2005a) for NZW fed rations containing berseem silage.

Table 5: Body weight gain, feed intake and conversion and economic efficiency of growing rabbits fed experimental diets.

Item	Replacing level %			SEM	P-value
	0	50	100		
Number	10	10	10		
Initial weight (g)	772	774	773	3.78	0.980
Final weight (g)	2613^{b}	2725^{ab}	2835^{a}	35.83	0.026
Total weight gain (g)	1841^{b}	1951^{ab}	2062^{a}	33.14	0.011
Average daily gain (g/day)	26.3^{b}	27.9^{ab}	29.5^{a}	0.47	0.011
Feed intake (g DM/head/day)	105^{a}	99.8^{ab}	96.8^{b}	1.36	0.020
Feed consumption (kg DM)	7.37^{a}	6.98^{ab}	6.78^{b}	0.10	0.020
Feed conversion (kg DM/kg gain)	4.01^{a}	3.58^{ab}	3.29^{b}	0.11	0.012
Total revenue (L.E.)	29.5^{b}	31.2^{ab}	33.0^{a}	0.54	0.014
Feed cost (L.E./head)	14.6^{a}	13.4^{b}	12.7^{b}	0.29	0.007
Feed cost (L.E.)/kg gain	7.93^{a}	6.88^{b}	6.14^{b}	0.25	0.003
Net revenue (L.E./head)	14.9^{c}	17.8^{b}	20.3^{a}	0.67	0.002
Net revenue improvement %	100^{c}	120^{b}	137^{a}	4.46	0.005

a-c: Means in the same row with different superscripts differ significantly (P<0.05).
The prices of year 2009 for commercial rabbit diet 1800 L.E./ ton, berseem hay 800 L.E./ ton, berseem silage 150 L.E./ ton, body weight gain 16 L.E./ kg. (LE, Egyptian pound = €).
Total revenue = total weight gain x 16
Net revenue = total revenue – feed cost

Feed conversion

As shown in Table 5, inclusion of BS in the diets of growing rabbits improved feed conversion, which the amount of DM required per kg weight gain decreased (P<0.05) with increasing the level of replacing BH by BS. The lower feed conversion for diet containing BH is due to reduced DM intake. Similar results were observed with NZW growing rabbits fed diets containing silage (Abou Ashour *et al*., 2003 and Omara *et al.*, 2005a).

Economic efficiency

The total and net revenue and net revenue improvement increased significantly (P<0.05), as feed cost and feed cost/kg gain decreased (P<0.05) with increasing the level of replacing BH by BS (Table 5). Net revenue for rabbits fed 50 and 100% BS diets increased by 19.8 and 37.0% compared with those fed berseem hay, respectively. These results may be due to the lower prices of berseem silage compared with berseem hay as well as improved body weight gain. Similar results were obtained by Abd El-Lateif (2002) and Omara *et al*. (2005a) who found that economical efficiency values for diets containing berseem silage were better than that of the commercial diets.

Carcass traits

Data in Table 6 showed that the slaughter weight, carcass weight, dressing percentage, meat weight and percentage increased (P<0.05) with increasing the level of replacing BH by BS. The differences in carcass traits may be attributed to the differences in growth rate and slaughter weight. It was obvious that dressing percentage increased with increasing body weight, which was in accordance with those obtained by Szendro *et al*. (1998). The results are in agreement with those obtained by Abd El-Lateif (2002) and Omara *et al*. (2005b).

Table 6: Carcass traits and chemical composition of meat of growing rabbits fed experimental diets.

Item	Replacing level %			SEM	P-value
	0	50	100		
Number	3	3	3		
Carcass traits:					
Slaughter weight (g)	2508^{b}	2617^{a}	2721^{a}	30	0.004
Carcass weight (g)	1512^{b}	1617^{b}	1726^{a}	30	0.004
Dressing %	60.3^{b}	61.8^{ab}	63.4^{a}	0.51	0.027
Meat weight (g)	1058^{b}	1132^{ab}	1208^{a}	25	0.035
Meat %	42.2^{b}	43.3^{ab}	44.4^{a}	0.39	0.054
Chemical composition of meat %:					
DM	29.1^{a}	28.3^{ab}	26.9^{b}	0.35	0.022
CP	77.2^{b}	80.7^{a}	80.7^{a}	0.70	0.042
EE	10.3	10.5	10.6	0.35	0.958
Ash	8.95	8.60	8.85	0.16	0.679

a-d: Means in the same row with different superscripts differ significantly (P<0.05).

Meat composition

The DM content of meat decreased significantly (P<0.05) with increasing the level of replacing BH by BS. Protein content in meat of rabbits fed 50 and 100% BS diets was higher (P<0.05) than that of those fed commercial diet. While, ether extract and ash contents were nearly similar for different groups. The chemical composition of the meat results from the protein and energy intake. Similar results were obtained by Abd El-Lateif (2002) and Omara et al. (2005b).

CONCLUSIONS

In conclusion, replacing all berseem hay in growing rabbit diets by berseem silage led to the best results concerning body weight gain, feed conversion, economic efficiency and carcass dressing percentage.

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