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Effects of dietary inclusion of dried *Kochia indica* Wight tree foliages on growth performance and nutrient digestibility of growing rabbits

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Abstract This study presents an experimental investigation of the dietary inclusion effect of dried *Kochia indica* Wight (K) tree foliages on growth performance and nutrient digestibility of growing rabbits. Four experimental diets were prepared in which 25, 50, 75 and 100% of the berseem hay (*Trifolium alexandrinum* L., Egyptian clover) in the control (K0) diet was replaced by dried *Kochia* foliages and designated as K25, K50, K75 and K100, respectively. Live weight at 6th, 7th and 8th weeks of age for K25, K50, K75 and K100 diet fed rabbits were similar to the K0 while other diets aside K25 reduced the live body weight and final live body weight. Total body weight gain

between week (6–13 weeks of age) was higher ($P < 0.05$) in K25 diet while other treatments were lower than K0. Total feed consumption of K0, K25 and K50 were similar. The overall feed conversion ratio of K0 and K25 were similar but higher ($P < 0.05$) in K50, K75 and K100. Performance index (PI) was the highest in groups fed the K0 and K25 diets and there were 36.4, 32.7 and 30.98% decrease in K50, K75 and K100 fed groups respectively. In conclusion, dried *Kochia* could be replaced up to 25% of the dietary berseem hay in growing rabbit diets without any obvious negative effects from the practical point of view on growth performance, nutrients evaluation, digestibility and productivity.

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Keywords *Kochia indica* Wight · Nutritive value · Growth performance · Nutrient digestibility · Rabbits

Introduction

Shortage of feed for livestock are common occurrence in the tropics, and sub-tropics during some part of the production cycle. For instance, in Egypt, availability of green fodder is limited only to 5 months during summer, due to the semi-arid environment (not more than 250 mm rainfall/year). This affect fodder in quality and quantity, and consequently, the productivity of livestock that depends on fodder. In practice,

Barseem (*Trifolium alexandrinum* L.) hay is an Egyptian clover which is useful, and considered as the principal forage for animal nutrition in Egypt. However, it is not available all year round, especially, in summer time when animals usually witness on and off growth pattern. Barseem is a leguminous forage that belongs to the family Fabaceae, and it is found in the Mediterranean region, and Middle-East. It is -grown where irrigation is practiced in the sub-tropics or cultivated as winter annual (Mohammed et al. 2014). Thus, there is need for alternative plants that are nutritious and could grow in summer time or all year round. Meanwhile, Kochia-a halophyte grows all year round irrespective of season, they are technically classed as a drought resistant and salt tolerant plant. This calls for the investigations in the possibility of using non-convectional feedstuffs such as multipurpose trees and halophytes plants.

Rabbit production avails an opportunity for diversification in animal agriculture. They empower women and the youth, reduce unemployment rate, in addition to providing animal protein. Still, before a wide spread use of halophytes plants as feed for rabbits is recommended, there is a need to test the nutritional characteristic, nutrient digestibility and growth responses for rabbit production. El Shereef (2006) noted that *Kochia indica* Wight has high crude protein (CP) ranging from 9.8 to 18.6% of hay and fresh fodder, respectively. The high CP (15.85%) of Kochia, was reported by Tagel-Din et al. (1991). Egypt Kochia plants grow in large numbers in the Nile Delta region, on roadsides and thrives during the period of March to December, under drought and saline conditions, which offers an opportunity for sustainable feeding of rabbits. Regardless of the notable quality of Kochia as indexed by crude protein, the plant also contains anti-nutritional compounds. These includes, tannins, alkaloids, saponins and oxalates (El Shereef 2012) in different forms of Kochia. The levels of tannins in fresh Kochia were observed to be 4.8% which is below 5.0%, the level which condensed tannins could negatively affect feed intake and digestibility. In addition, these fodder are not solely used as feed, but, in combination with other ingredients which could lower or limit the anti-nutritional compounds, thus, diluting the detrimental effects of anti-nutritional compounds. Presence of bacteria in the caecum of rabbits may also play a part in detoxifying anti-nutritional compounds. However, there is no

information on the digestibility and growth of rabbits given diets with varying proportion of Kochia. Therefore, the aim of this investigation was to study the effect of partial or total substitution of berseem hay (*T. alexandrinum* L.; Egyptian clover), by dried Kochia tree foliages in complete pelleted diets on nutritive value of diets, growth performance and nutrient digestibility of New Zealand White rabbits.

Materials and methods

Preparation of Kochia

Foliages of Kochia (K-leaves and shoot) were collected and were cut into small parts (5 cm) and dried at 80 °C for 48 h in an oven. The dried materials were milled, stored in cellophane bag and kept in a dry place pending use.

Proximate analysis

Sub-samples of the Kochia plants (dried and fresh foliages) were analysed for moisture, crude protein, crude fiber, ether extracts, Neutral detergent fiber, ash, calcium and phosphorus according to methods of AOAC (2000). Total tannins, condensed tannins and total phenols were determined according to Makkar (2003) and Porter et al. (1986).

Experimental diet

The control diet (K0) was formulated to meet or exceed nutrient requirements for growing rabbits according to NRC (1984) and it contained berseem hay (BH) as the main source of forage. Other four experimental diets were prepared in which, berseem hay in the control diet was replaced by 25, 50, 75 and 100% dried Kochia and designated as K25, K50, K75 and K100, respectively (Table 1). The berseem hay and Kochia were pellet together before offering it to rabbits. The chemical composition of the two forages is shown in Table 2. All diets were approximately iso-nitrogenous and iso-caloric containing similar levels of microelements.

Table 1 Composition of experimental diets¹ fed to rabbits

Ingredients	Control (K0)	K25	K50	K75	K100
Egyptian berseem hay	32.0	24.0	16.0	8.0	–
<i>Kochia indica</i>	–	8.0	16.0	24.0	32.0
Yellow corn	7.0	6.5	6.0	5.5	5.0
Barley grain	16.4	16.4	16.4	16.4	16.4
Wheat bran	22.5	22.5	21.5	21.0	20.5
Soybean meal (44% crude protein)	17.0	17.0	18.0	18.5	19.0
Rice straw	–	–	1.0	1.5	2.00
Common salt	0.5	0.5	0.5	0.5	0.5
Molasses	3.0	3.0	3.0	3.0	3.0
Limestone	0.8	0.8	0.8	0.8	0.8
Di-calcium	0.4	0.4	0.4	0.4	0.4
Vitamin and mineral premix ²	0.2	0.2	0.2	0.2	0.2
DL-methionine	0.2	0.2	0.2	0.2	0.2
Total	100	100	100	100	100

K = Dried Kochia

¹Dried Kochia added at 0% (K0), 25% (K25), 50% (K50) and 100% (K100), replacing 0%, 25, 50, 75 and 100% of the berseem hay, respectively

²Each 3 kg of premix contain: Vitamin A 12,000,000 IU, V.D3 2,200,000 IU, V.E 10,000 mg, V.K3 2000 mg, V.B1 1000 mg, V.B2 4000 mg, V.B6 1500 mg, V.B 12 10 mg, Pantothenic Acid 10,000 mg, Niacin 20,000 mg, Biotin 50 mg, Folic Acid 1000 mg, Coline chloride 500 gm, Selenium 100 mg, Copper 10,000 mg, Iron 30,000 mg, Manganese 55,000 mg, Zinc 50,000 mg, Iodine 1000 mg and carrier CaCoi to 3000 gm

Table 2 Chemical composition (% dry matter) and some secondary components of dried Kochia (K) and berseem hay (BH)

Parameter	Chemical composition (%) ¹	
	Berseem hay (BH)	Dried <i>Kochia indica</i> (K)
Dry matter	88.71	93.36
Organic matter	87.76	85.77
Crude protein	12.35	12.60
Crude fibre	21.78	23.52
Ether extract	2.09	1.34
Nitrogen free extract	51.54	48.31
Neutral detergent fibre	64.14 ¹	62.2
Acid detergent fibre	42.49 ¹	37.1
Acid deterget lignin	14.03 ¹	19.9
Total tannins	3.51	4.31
Condensed tannins	0.38	0.47
Total phenols	3.84	4.43
Calcium	1.25	0.413
Phosphorus	0.207	0.321

¹Source: Youssef et al. (2009)

Growth trial

Ninety New Zealand White rabbits (*Oryctolagus cuniculus* L.) approximately 6 weeks of age with average initial body weight of 857 g were used. Rabbits were blocked by weight into five groups and randomly allotted among five equal experimental groups (18 rabbits/treatment). The rabbits were housed in individual flat galvanized wire batteries (50 × 50 × 35 cm) with troughs for diets and automatic nipple drinkers. The experimental diets of Table 1 and 3 were offered to rabbits *ad libitum* in pelleted form. Drinking water was also offered free choice by automatic drinkers. All rabbits were subjected to the same managerial, hygienic and environmental conditions. Rabbits were routinely inspected for any sickness every 15 days and vaccinated against common diseases.

The experiment lasted for 7 weeks (13th weeks of age as marketing weight). During the experimental period, individual live body weights and feed intake were recorded weekly. Weekly and total weight gain, actual feed intake were calculated. Relative growth rate, feed conversion ratio, performance index (%) and viability (%) were calculated for the experimental groups.

Relative growth rate was calculated according to North (1981) as given below

$$\text{Relative growth rate} = \frac{w_2 - w_1}{1/2(w_1 + w_2)} \times 100 \quad (1)$$

Where: w_1 = the initial weight, and w_2 = the final body weight.

Feed conversion ratio was calculated as:

Feed conversion ratio

$$= \frac{\text{Feed consumed (g) during a certain period}}{\text{Body weight gain (g) during the same period}} \quad (2)$$

Performance index% (PI%) was calculated according to North (1981) as given below:

$$\text{Performance index} = \left[\frac{\text{Live body weight (kg)}}{\text{Feed conversion}} \right] \times 100 \quad (3)$$

Viability % and the clinical health status of all rabbits were recorded daily and viability percentage was calculated as follows:

Viability

$$= \left[\frac{\text{Total number of live animals at the end}}{\text{Total number of animals at the start}} \right] \times 100 \quad (4)$$

Digestibility trial

Feed digestibility, and nitrogen balance trials were conducted using 20 rabbits. Four rabbits, with similar average live body weight, from each experimental

Table 3 Chemical composition (% dry matter) of the experimental diets¹

Parameters	Control (K0)	K25	K50	K75	K100
Dry matter	91.46	91.16	91.53	91.34	91.07
Organic matter	87.81	87.75	87.63	87.64	87.69
Crude protein	14.30	14.21	14.16	14.17	14.08
Ether extract	1.90	1.94	1.91	1.90	1.87
Crude fiber	11.78	11.81	11.79	11.71	11.62
Nitrogen free extract	59.83	59.79	59.77	59.96	59.12
DE, kcal/kg ²	2146.06	2053	2080	2099	2094

¹Dried Kochia (K) added at 0 (K0), 25 (K25), 50 (K50) and 100% (K100), replacing 0, 25, 50, 75 and 100% of the berseem hay, respectively

²Calculated according to Fekete and Gippert (1985): DE (kcal/kg) = 4253–32.8 (CF %)–144.4 (Ash %)

group were randomly chosen. The rabbits were kept individually in metabolic cages (50 × 50 × 40 cm), that allows separate collection of feces and urine. Rabbits of each group were offered one of the experimental diets used for the growth study. After 15 days of adaptation period, quantity of feed consumed, feces excreted and urine output were measured daily for seven consecutive days according to Perez-Alonso et al. (1995). Feed was offered once daily at 8 am and left overs were measured the following day to determine feed intake. Total feces of each rabbit was collected and measured daily, before the morning meal. A sample (20%) was then obtained, dried at 60–70 °C for 48 h, bulked, mixed, milled and kept for chemical analysis. The digestibility trials were carried out within 7 days after adaptation period.

Total urine was collected from each animal using plastic buckets plastic buckets. Ten percent of the total urine was sampled each day for 7 days, and 0.1 ml concentrated Hydrochloric acid was added and stored at – 10 °C pending chemical analysis.

Samples of feed offered and feces from each animal were analyzed for dry matter, crude protein, crude fiber, ether extract, and ash according to AOAC (2000) method. Total digestible nutrients (TDN) and the digestible crude protein (DCP) were calculated according to Cheeke et al. (1982) as follows:

$$\text{TDN (\%)} = \text{DCP} + \text{DCF} + \text{DNEF} + (\text{DEE} \times 2.25) \quad (5)$$

where DCP = Digestible crude protein. DCF = Digestible crude fiber. DNFE = Digestible nitrogen free extract. DEE = Digestible ether extract.

The metabolizable energy (ME) values were calculated according to the equation described by Kalogen (1985) as follow:

$$\text{ME (Kcal/kg DM)} = (0.588 + 0.164X)239 \quad (6)$$

where X is the dry matter digestion of the diet.

Statistical analysis

Data on chemical composition, digestibility coefficients, nitrogen balance and growth performance were analyzed according to SAS program (SAS, 2004). Data were subjected to analysis of variance (ANOVA) to test the effects of replacing berseem hay with Kochia. Separation of means between different treatments was done using Duncan's Multiple Range Test (1955), and the following model was used

$$Y_{ij} = \mu + T_i + e_{ijk} \quad (7)$$

where Y_{ij} = an observations, μ = Overall mean, T_i = Effect of using different levels of dried Kochia ($i = 0, 25, 50, 75$ and 100). e_{ijk} = Residual (Random error).

In addition, data of growth, feed intake, feed conversation and performance index were analyzed according to the following:

$$Y_{ijk} = \mu + T_i + W_j + T_i W_j + e_{ijk} \quad (8)$$

where Y_{ijk} = an observations, μ = Overall mean, T_i = Effect of using different levels of dried Kochia ($i = 0, 25, 50, 75$ and 100). W_j = Effect of jth week. $T_i W_j$ = The interaction effect between ith treatment and jth week, e_{ijk} = Residual (Random error).

Results and discussion

The digestibility of all nutrients were not significantly different between rabbits fed the control diet and those fed the diets K25 and K50, except for crude fiber digestibility which decreased ($P < 0.01$) in rabbits fed diet K25 and K50 by 7.3 and 12.0%, respectively, compared to those fed the control diet (K0)-(Tables 4, 5). However, Alsheikh (2012) showed that nutrients digestibility were higher ($P < 0.05$) in goats fed 40% Kochia and 60% concentrate mixture than those of goats fed 40% barseem hay and 60% concentrate mixture or 60% Kochia and 40% concentrate mixture, but no difference in crude fibre diigestibility among the three rations. The results showed that the replacement of 75 and 100% berseem hay by dried Kochia decreased ($P < 0.05$) all nutrients digestibility coefficients. The digestibility coefficients of organic matter, crude fibre, ether extract and nitrogen free extract decreased ($P < 0.01$) by 6.8, 6.4, 9.9 and 5.8% respectively in K75 rabbits than those fed the control diet (K0). The digestibility coefficients of dry matter, organic matter, crude protein, ether extract, crude fibre, and nitrogen free extract significantly ($P < 0.05$) decreased by 7.8, 10.0, 7.0, 7.4, 26.57 and 9.8%, respectively, in K100 rabbits *versus* control diet (K0). The lower digestibility coefficients obtained by increasing the level of Kochia instead of berseem hay, may be due to high lignin contents in Kochia which impeded the nutrient digestibility, and negatively

Table 4 Diets nutrient digestibility, total digestible nutrients (TDN) and digestible crude protein (DCP) of different levels of dried Kochia¹ in growing rabbit

Parameter	Control (K0)	K25	K50	K75	K100	SEM ¹	P value
No. of rabbits	4	4	4	4	4		
Dry matter	72.71 ^a	72.07 ^a	71.18 ^a	69.67 ^{ab}	67.06 ^b	1.003	0.0121
Organic matter	73.99 ^a	72.87 ^{ab}	70.35 ^{bc}	68.98 ^{cd}	66.56 ^d	1.044	0.0014
Crude protein	72.55 ^a	72.01 ^a	70.73 ^{ab}	69.68 ^{ab}	67.45 ^b	1.136	0.0499
Ether extract	75.56 ^a	75.33 ^a	72.31 ^{ab}	70.74 ^b	69.94 ^b	1.134	0.0082
Crude fiber	41.06 ^a	39.74 ^a	36.16 ^b	34.00 ^b	30.15 ^c	0.936	<.0001
Nitrogen free extract	80.05 ^a	79.67 ^a	77.23 ^{ab}	75.42 ^b	72.21 ^c	1.101	0.0010
Nutritive values							
TDN %	65.94 ^a	65.45 ^{ab}	63.14 ^b	61.72 ^b	58.94 ^c	0.163	0.0018
DCP %	10.38 ^a	10.23 ^a	10.01 ^{ab}	9.87 ^{ab}	9.50 ^b	1.031	0.0176

¹Dried Kochia. (K) added at 0 (K0), 25 (K25), 50 (K50) and 100% (K100), replacing 0, 25, 50, 75 and 100% of berseem hay, respectively

^{a–d}Means with the different letters in the same row differ significantly ($P \leq 0.05$)

²SEM = Standard error of the mean

Table 5 Nitrogen utilization of different levels of dried Kochia¹ in growing rabbit diets

Parameter	Control (K0)	K25	K50	K75	K100	SEM ²	P value
No. of rabbits	4	4	4	4	4		
Feed intake (FI) (g/d)	136.69 ^a	138.18 ^a	136.46 ^a	128.74 ^b	125.45 ^b	1.529	0.0089
N-intake (NI) (g/d)	3.127 ^a	3.142 ^a	3.092 ^a	2.919 ^b	2.826 ^b	0.036	0.0041
Urinary N. (UN) ((g/d)	1.042	1.065	1.107	1.121	1.112	0.019	0.7003
Fecal N. (FN) (g/d)	0.858	0.879	0.905	0.885	0.919	0.008	0.1249
Digested N. (DN) (g/d)	2.269 ^a	2.263 ^a	2.187 ^a	2.034 ^b	1.906 ^c	0.036	<.0001
N-balance (NB) (g/d)	1.227 ^a	1.198 ^{ab}	1.080 ^b	0.913 ^c	0.794 ^c	0.036	<.0001
NB/NI %	39.189 ^a	38.129 ^{ab}	34.929 ^{bc}	31.128 ^{cd}	28.100 ^d	1.069	<.0001
NB/ND %	54.00 ^a	52.89 ^a	49.40 ^{ab}	44.90 ^b	41.69 ^c	1.282	0.0007

^{a–d}Means with the different letters in the same row are differ significant ($P \leq 0.05$), ¹Dried Kochia (K) added at 0 (K0), 25 (K25), 50 (K50) and 100% (K100), replacing 0, 25, 50, 75 and 100% of berseem hay, respectively

²SEM = Standard error of the mean

affected the microbial activity in the cecum fermentation.

There was a significant ($P < 0.05$) decrease in total digestible nutrients (TDN) and digestible crude protein (DCP) in K75 rabbits by 6.4 and 4.9%, respectively, and in K100 group by 10.61 and 8.15%, respectively, than those fed the control diet (K0). The depression of TDN and DCP values in K75 and K100 diets may be due to the lower values of

digestibility coefficients obtained in these groups. The lower nutritive values may be attributed to the high concentration of the secondary components. This exist with the diets containing high levels of dried Kochia which affected animal performance, metabolism negatively, impeded the digestibility and cecum fermentation. Zahran (1986) reported that increasing dried Kochia in diets decreased the nutrients digestibility in sheep. El-Shereef (2012) reported that

Table 6 Average live body weight (g) of different levels of dried Kochia¹ in growing rabbit from 6 to 13 weeks of age

Items	Control (K0)	K25	K50	75	K100	SEM ²
No. of rabbits	18	18	18	18	18	
Initial 6 weeks	838	844	832	836	847	3.517
7 weeks	926	934	917	905	938	4.048
8 weeks	1097	1113	1125	1093	1124	7.521
9 weeks	1264 ^b	1212 ^c	1304 ^a	1268 ^{ab}	1295 ^a	7.189
10 weeks	1455 ^{ab}	1471 ^a	1419 ^b	1422 ^b	1419 ^b	6.960
11 weeks	1671 ^{ab}	1682 ^a	1642 ^b	1605 ^c	1523 ^d	10.09
12 weeks	1885 ^a	1899 ^a	1839 ^b	1744 ^c	1698 ^d	12.936
Final body weight (13 weeks)	2042 ^a	2064 ^a	1947 ^b	1832 ^c	1774 ^d	17.924

^{a–d}Means with different letters in the same row differ significantly ($P < 0.05$)

¹Dried Kochia (K) added at 0 (K0), 25 (K25), 50 (K50) and 100% (K100), replacing 0, 25, 50, 75 and 100% of the berseem hay, respectively

²SEM = Standard error of the mean

nutritive TDN and DCP were significantly different in groups fed diets containing Kochia in different forms and recorded the highest values for those fed Kochia silage plus total concentrate (62.5 and 9.5%) while the lowest values were recorded for those fed Kochia hay plus total concentrate (52.8 and 6.9%). In contrast, Alsheikh (2012) reported that the nutritive values of TDN and DCP were higher ($P < 0.05$) in Shami kids fed 40% Kochia and 60% concentrate mixture, than those fed 40% berseem hay and 60% concentrate mixture, (64.3 and 9.9%, respectively).

Feed intake (FI), nitrogen intake (NI) digested nitrogen (DN) and nitrogen balance (NB) decreased ($P < 0.01$) in rabbits fed K75 diet by 5.8, 6.7, 10.4 and 13.8%, respectively, and the K100 diet by 8.2, 9.6, 16.0 and 35.3%, respectively than those fed the control diet (K0). The lower nitrogen utilization in groups with more than 50% Kochia may be due to lower feed intake and low digestibility of crude protein obtained in these groups. The nitrogen utilization expressed as nitrogen balance/nitrogen intake (NB/NI) and nitrogen balance/nitrogen digested (NB/ND %) were significantly ($P < 0.01$) low with increasing K in the rabbit diet. Furthermore, increasing the replacement of Kochia more than 25% of the dietary berseem hay negatively affected NB/NI and NB/DN. The results of NB/NI and NB/DN of K50, K75 and K100 diets were lower ($P < 0.01$), than those fed the control diet (K0). In contrast, Youssef et al. (2009) found that nitrogen balance was significantly higher for sheep fed Kochia

plus pearl millet haylage than those fed Kochia plus pearl millet hay or clover hay.

Live body weight of growing rabbits from the 8th to 13th weeks of age in diets with more than 25% of dietary berseem hay (i.e., K50, K75 and K100), were negatively affected and present significantly lower values (Table 6).

In contrast, feeding growing rabbits with diets K50, K75 and K100 decreased ($P < 0.05$) the final live body weight at 13 weeks of age by 4.5, 10.3 and 13.1%, respectively, than those fed the control diet (K0). The decrease in live body weight of rabbits fed diets K50, K75 and K100 compared with those fed K0 and K25 diets, may be due to the lower feeding values and digestibility of nutrients. This result is similar to the result of Hanafy et al. (2007) when Kochia fed to goat, had low birth and weaning weight.

Increasing the replacement levels of dried Kochia beyond 25% of dietary berseem hay in growing rabbit diets (K50, K75 and K100) decreased ($P < 0.05$) the weekly average weight gain (g/day) from the 9th to 13th weeks of age. Depression in daily weight gain in groups fed diets with more than 25% of dietary berseem hay (K50, K75 and K100) may be due to the increase in the percentage of lignin and anti-nutritional factors (tannins, saponins, alkaloids and oxalate) which negatively affected the palatability and decreased the voluntary intake (Tagel-Din et al. 1991; El-Shereef 2012).

Table 7 Average daily weight gain (g/day) of different levels of dried Kochia¹ in growing rabbit from 6 to 13 weeks of age

	Control (K0)	K25	K50	K75	K100	SEM ²
No. of rabbits	18	18	18	18	18	
6–7 weeks	12.56	12.85	12.1	9.85	12.99	0.346
7–8 weeks	24.39	25.56	29.71	26.85	26.57	1.092
8–9 weeks	23.83 ^a	14.13 ^b	25.57 ^a	24.99 ^a	24.42 ^a	1.188
9–10 weeks	27.28 ^b	36.99 ^a	16.42 ^c	21.99 ^c	17.71 ^c	1.261
10–11 weeks	30.85 ^a	30.13 ^a	31.85 ^a	25.99 ^b	14.56 ^c	1.166
11–12 weeks	30.56 ^a	30.99 ^a	28.13 ^a	19.99 ^c	25.28 ^b	0.882
12–13 weeks	22.43 ^a	23.56 ^a	15.42 ^b	12.56 ^c	10.85 ^c	1.173
Overall means	24.55 ^a	24.88 ^a	22.74 ^b	20.31 ^c	18.91 ^c	0.486

^{a–c}Means with the different letters in the same row differ significantly ($P < 0.05$)

¹Dried Kochia (K) added at 0 (K0), 25 (K25), 50 (K50) and 100% (K100), replacing 0, 25, 50, 75 and 100% of the berseem hay, respectively

²SEM = Standard error of the mean

Table 8 Average daily feed consumption (g dry matter/day) of different levels of dried Kochia¹ in growing rabbit from 6 to 13 weeks of age

	Control (K0)	K25	K50	K75	K100	SEM ¹
No. of rabbits	18	18	18	18	18	
6–7 weeks	42.36	43.58	43.26	36.75	49.24	1.225
7–8 weeks	83.80 ^c	88.91 ^b	106.63 ^a	103.58 ^a	111.32 ^a	4.499
8–9 weeks	82.64 ^a	49.33 ^b	93.28 ^a	97.66 ^a	106.51 ^a	4.733
9–10 weeks	97.29 ^b	130.92 ^a	63.41 ^c	92.62 ^b	78.72 ^b	4.225
10–11 weeks	115.65 ^a	113.70 ^a	130.96 ^a	116.76 ^a	68.18 ^b	4.390
11–12 weeks	115.36 ^a	121.83 ^a	122.93 ^a	93.37 ^b	121.48 ^a	3.440
12–13 weeks	85.01 ^a	93.00 ^a	71.34 ^b	62.91 ^c	54.74 ^c	4.495
Overall means	88.87	91.72	90.70	86.34	84.31	1.929

^{a–c}Means with the different letters in the same row differ significantly ($P < 0.05$)

¹Dried Kochia (K) added at 0 (K0), 25 (K25), 50 (K50) and 100% (K100), replacing 0, 25, 50, 75 and 100% of the berseem hay, respectively

¹SEM = Standard error of the mean

Rabbits fed on K50, K75 and K100 diets showed decrease ($P < 0.05$) in daily weight gain versus control (Table 7). In contrast, Abd El-Hamid (2003) studied that the effect of feeding Kochia with two levels of concentrate on growth performance of lambs. The author found that the average daily gain of lambs fed Kochia ration either with 40 or 60% concentrate mixture was higher by 4.02 and 13.8% than those fed clover hay with concentrate mixture.

Daily feed consumption was numerically lower by 2.9 and 5.1% in K75 and K100 respectively, when compared to the control diet (Table 8). This result is similar to the study of (Hanafy et al. 2007; Youssef et al. 2009) where goat and sheep consuming diet that contained Kochia had lower DM intake. Feed conversion ratio of dried Kochia inclusion diets increased ($P < 0.05$) in groups fed diets K25, K50, K75 and K100 compared to the control which had the lowest (Table 9).

Table 9 Average feed conversion ratio (FCR, g feed/g gain) of different levels of dried Kochia¹ in growing rabbit from 6 to 13 weeks of age

	Control (K0)	K25	K50	K75	K100	SEM ²
No. of rabbits	18	18	18	18	18	
6–7 weeks	3.37 ^c	3.39 ^c	3.52 ^b	3.71 ^a	3.81 ^a	0.040
7–8 weeks	3.42 ^c	3.48 ^c	3.59 ^c	3.82 ^b	4.14 ^a	0.047
8–9 weeks	3.47 ^c	3.51 ^c	3.64 ^c	3.97 ^b	4.36 ^a	0.054
9–10 weeks	3.56 ^d	3.56 ^d	3.85 ^c	4.21 ^b	4.46 ^a	0.056
10–11 weeks	3.74 ^d	3.77 ^c	4.11 ^b	4.49 ^a	4.66 ^a	0.059
11–12 weeks	3.77 ^d	3.93 ^c	4.35 ^b	4.68 ^a	4.82 ^a	0.066
12–13 weeks	3.79 ^d	3.95 ^c	4.65 ^b	4.99 ^a	4.98 ^a	0.077
Overall means	3.58 ^d	3.65 ^d	3.97 ^c	4.27 ^b	4.45 ^a	0.027

^{a–d}Means with the different letters in the same row differ significantly ($P < 0.05$)

¹Dried Kochia (K) added at 0 (K0), 25 (K25), 50 (K50) and 100% (K100), replacing 0, 25, 50, 75 and 100% of the berseem hay, respectively

²SEM = Standard error of the mean

Table 10 Total average performance index of different levels of dried Kochia¹ in growing rabbit from 6 to 13 weeks of age

	Control (K0)	K25	K50	K75	K100	SEM ²
No. of rabbits	18	18	18	18	18	
6–7 weeks	27.51 ^a	27.55 ^a	26.05 ^a	24.26 ^c	24.56 ^b	0.305
7–8 weeks	32.07 ^a	32.04 ^a	31.33 ^a	28.61 ^b	27.08 ^c	0.382
8–9 weeks	36.42 ^a	34.52 ^b	35.82 ^a	32.03 ^c	29.64 ^d	0.432
9–10 weeks	40.87 ^a	41.55 ^a	36.85 ^b	33.77 ^c	31.81 ^d	0.599
10–11 weeks	44.67 ^a	44.61 ^a	40.08 ^b	35.72 ^c	32.5 ^d	0.743
11–12 weeks	50.00 ^a	48.32 ^a	42.17 ^b	37.26 ^c	35.22 ^d	0.903
12–13 weeks	53.87 ^a	52.13 ^a	41.87 ^b	36.71 ^c	35.55 ^d	1.134
Overall means	40.82 ^a	40.18 ^a	36.38 ^b	32.65 ^c	30.98 ^d	0.419

^{a–d}Means with the different letters in the same row differ significantly ($P < 0.05$)

¹Dried Kochia (K) added at 0 (K0), 25 (K25), 50 (K50) and 100% (K100), replacing 0, 25, 50, 75 and 100% of the berseem hay, respectively

²SEM = Standard error of the mean

Groups fed the control (K0) and K25 diets had the highest performance index and relative growth. Increasing the replacement of dietary berseem hay by more than 25% dried Kochia (diets K50, K75 and K100) decreased ($P < 0.05$) the performance index and relative growth rate than K0 fed rabbits (Table 10). There were no cases of death in rabbit fed K0, K25, K50 diet up to 13 weeks which resulted in 100% viability. The lowered values of the viability recorded in K75 and K100 rabbits, may be due to excesses of the anti-nutritional factors

such as tannins, alkaloids, saponins and oxalates in the diets of K75 and K100 rabbits. However, the lower values of performance index recorded in rabbits fed the diets containing high levels of Kochia, may be due to the high values of the feed conversion ratio and the lower live body weights obtained in these groups (Table 11).

Table 11 Growth performance, relative growth rate and viability percentage of different levels of dried Kochia¹ in growing rabbit from 6 to 13 weeks of age

	Control (K0)	K25	K50	K75	K100	SEM ²
No. of rabbits	18	18	18	18	18	
Initial body weight (6 weeks)	838.0	844.0	832.0	836.0	847.0	3.517
Initial body weight (13 weeks)	2042.0 ^a	2064.0 ^a	1947.0 ^b	1832.0 ^c	1774.0 ^d	17.924
Daily weight gain (g/day)	24.55 ^a	24.88 ^a	22.74 ^b	20.31 ^c	18.91 ^c	0.486
Daily feed consumption (g/day)	88.87	91.72	90.70	86.34	84.31	1.929
Feed conversion ratio (g feed/g gain)	3.58 ^d	3.65 ^d	3.97 ^c	4.27 ^b	4.45 ^a	0.027
Relative growth rate (%)	83.61 ^a	83.91 ^a	80.25 ^b	74.66 ^c	70.74 ^d	0.903
Performance Index (%)	40.82 ^a	40.18 ^a	36.38 ^b	32.65 ^c	30.98 ^d	0.419
Viability %	100	100	100	83.33	77.78	–

^{a–d}Means with the different letters in the same row differ significantly ($P < 0.05$)

¹Dried Kochia (K) added at 0 (K0), 25 (K25), 50 (K50) and 100% (K100), replacing 0, 25, 50, 75 and 100% of the berseem hay, respectively

²SEM = standard error of the mean

Conclusion

Dried Kochia could replace up to 25% of the dietary berseem hay in growing rabbit diets, without any obvious negative effects on growth performance, nutrient digestibility and nitrogen utilization.

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