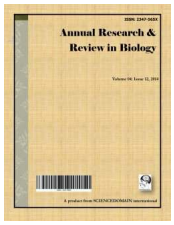

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Kochia Plant as Potential Forage for Ruminants under Desert Conditions

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Kochia plant adapting to extreme environmental factors provide an important part of forage requirements for livestock grazing in arid and semi-arid regions. Many wild Kochia species are undervalued mainly because of insufficient knowledge about their potential feeding value, yields and their effect on animal performance. Therefore this review paper gives knowledge on Kochia plant as salt tolerant forage for feeding small ruminants under desert conditions. Many studies show that this plant could be used successfully as alternative feed to replace partially common feedstuff. However, the presence plant secondary metabolites should be taken into consideration in rations containing Kochia forage for small ruminants feeding. Most of feeding studies reported in this review have been carried in Egypt, results indicate that Kochia spp. provide a high crop production under salinity condition, improve animal performance and decrease feed cost.

Keywords: Kochia plant; forage yield; salinity; nutritive value; animal performance.

1. INTRODUCTION

Ruminants feeding are mainly dependent on pasture grasses and crop production. The availability of these feeds may be more restricted in arid and semiarid zones. Forages from shrubs, trees and grasses play an important role in the nutrition of grazing animals in areas where few or no alternatives are available and are used to improve livestock performance [1]. Otherwise

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feeding of tropical trees and shrubs foliage could be an attractive strategy for reducing of ruminal methanogenesis for animals fed with low-quality forage diets [2].

Kochia plant is belongs to the family *Chenopodiaceae*, it has different species, perennial (*K. prostrata*) and annual (*K. scoparia* and *K. indica*). These plants can grow in saline habitats and have particular characteristics which enable them to tolerate salinity by various eco-physiological mechanisms. The vegetative yields would have greater potentiality particularly as source of livestock fodder [3]. In this review, we summarize the main information on *Kochia* spp. distribution, nutritive value and potential use of these plants as feed resource under desert condition, particularly in Egypt.

2. DISTRIBUTION

Forage kochia is a woody-based shrub or subshrub, it is native to arid and semiarid regions of central Eurasia, extending to the Mediterranean Basin and northeastern China and then it was introduced to North America in the early 1960s where it has proven to be well adapted to the temperate of semiarid rangelands of the western U.S. [4]. The plant has become a serious drought-resistant and salt tolerant, grows rapidly during cool season and widely adapted with many geographical zones as it serves under various temperatures as a grazing forage and hay processing [5].

3. AGRONOMY AND GROWTH HABITS

Kochia reproduces by seed, the bushy plants grow 1 to 7 ft tall and have tap roots. The leaves are alternate arrangement and linear to narrowly ovate 5 cm long, have hairs depending on growth stage. Stems and flowers are surrounded by tufts of hair. Small, green flowers and seeds are produced in narrow heads at the leaf. When mature, seeds are rough, flat, triangular and grayish-black in color. In the fall, the plants often break away from the roots and tumble over the ground, scattering the seeds, it typically produces from 13 - 15,000 seeds per plant. Kochia varies widely in morphological characters partially due the environment where it is found [6]. In Saudi Arabia, *K. indica* and *K. scoparia* germinated well on salt affected land using saline water (0.53 percent total dissolved solids) for irrigation. In Egypt, *K. indica* successfully grown as shown in Fig 1. using ground water for irrigation with total dissolved salt ranged from 5000 ppm to 8000 ppm.

4. FORAGE YIELD

Kochia hay produces of 1 to 4.5 ton/acre (dry matter) compared with clover hay 4.6 ton/acre [6]. In Egypt, the forage crop yield of some salt-tolerant plants such as Kochia, Sorghum grass, Pearl millet, and Sudan grass cultivated under moderate to high salinity condition were 12.5, 9.5, 8.0 and 7.3 ton /acre, respectively [7].

Fig. 1. *Kochia indica* cultivated in Egypt, the main source of irrigation was the ground water of which total dissolved salt ranged from 5000 ppm to 8000 ppm

5. PLANT SECONDARY METABOLITES

Plant secondary metabolites are those metabolites which are often produced in a phase of subsequent to growth, have no function in growth (although they may have survival function). They influence the feed palatability which reflects upon the intake, digestibility and nutritive values by many livestock species.

As reported by [8], livestock should not graze on only *K. scoparia* for more than 90 to 120 days to prevent oxalate toxicity which ranged from 6% to 9% in fresh form. Moreover, rotational grazing of other crops will prevent oxalate poisoning. Also, feeding calcium phosphate and other kinds of feed (such as alfalfa) tends to reduce oxalates toxicity [9].

However, [10] reported that the initial hepatotoxicity in kochia followed by renal damage reflects changes more consistent with toxic alkaloids than with oxalate. The same authors found that alkaloids of unknown structure and toxicity have been reported for *K. scoparia* and its concentration which was differed with maturity of the plant.

Concerning *K. indica*, results of phytochemical screening indicated that this plant contain saponins, flavonoids, oxalates and sterols at low level that had no adverse effect on their nutritive value for sheep and goat feeding [11,12].

6. CHEMICAL COMPOSITION

Chemical composition of *K. indica* in different forms in Egypt was summarized in Table 1. The average dry matter (DM) content of fresh Kochia ranged from 30.6% to 45.4%. The level of crude protein (CP) decreased as result of drying process. In other studies crude protein and soluble carbohydrate contents of Kochia was higher than that of clover hay [13]. Based on data in Table 1 and many studies [15-18]. The average crude protein yield of Kochia and clover are 562 vs. 629 kg/feddan, respectively. In general, Kochia plants obtained reasonable crude protein and high ash contents as a character for salt tolerant plants. The fluctuation in chemical composition among studies is mainly due to some factors such as variable of soil, fertility, water supply, stage of growth, seasonal effect and management practices.

7. ANIMAL PERFORMANCE

7.1 Dry Matter Intake and Nutritive Value

Results of palatability trials for Kochia in different forms (fresh, hay and silage) by sheep showed that ensiling process significantly improved the palatability of Kochia by 61% compared to its hay [16]. Similar findings were observed by [12] who found that silage making increase voluntary feed intake for both sheep and goat by 20% and 54% for less palatable plants.

Dry matter intake by sheep from both of Kochia hay and clover hay was almost similar [19]. In other study [20], dry matter intake by goat from silage which consists of 75% Teosinte and 25% Kochia was higher than that of 100% Teosinte silage (50.1 vs. 46.9 g/kg $BW^{0.75}$/d).

Moreover, [12] studied the palatability of eight desert plants. They found that DM intake/kg $BW^{0.75}$ from fresh Kochia by both sheep and goat was higher than other tested plants. The corresponding values were 55.7 g/kg $BW^{0.75}$ for sheep and 57.8 g/kg $BW^{0.75}$ for goat. While, [17] studied the effect of feeding Kochia hay in comparison with clover hay and found that DM intake from Kochia hay ration was lower (P = .05) than that of clover hay ration (10.12 vs. 28.6 g/kg BW) for feeding lactating goat. The same result was obtained by [21] during a palatability trial when they tested pearl millet and Kochia hays for sheep feeding and found that sheep consumed greater amounts of pearl millet hay compared to

Table 1. Dry matter, chemical composition and fiber constituents of Kochia

Kochia indica	DM %	CP%	CF%	EE%	NFE%	Ash%	NDF%	ADF%	ADL%	Ref
Fresh	45.4	18.6	35.9	1.2	24.2	20.1	---	---	---	[14]
Fresh	30.6	14	30.2	2.8	37.9	15.1	62.1	39.45	12.03	[12]
Fresh	39.9	13.3	26.3	2.8	40.4	17.2	---	---	---	[15]
Hay	88.9	9.8	29.8	2.6	44.5	16.3	57.4	40.6	15.8	[16]
Hay	91.0	11.1	27.8	0.82	43.08	17.2	59.5	39.3	10.9	[17]
Silage	45	11.8	27	1.9	42.1	17.2	57.6	40.2	12.3	[16]
Silage	30.3	15.5	27.1	1.91	39.3	16.1	65.3	44.1	8.5	[5]

those fed Kochia hay (785 and 688 g DM/h/d). However, dry matter intake from fresh Kochia with traditional concentrate feed mixture (TCFM) at level 50 or 100% of maintenance requirements of lambs was significantly higher than those fed clover hay with TCFM at level 100% [22].

Total digestible nutrients (TDN %) value of Kochia ranged from 42.7 as silage [16] to 73.2% [13] as fresh. It was found that *K. scoparia* hay had a higher percentage of TDN compared to alfalfa hay [23]. Besides, [18] reported that *K. indica* hay contained nearly similar TDN values to clover hay (46.8 vs. 45.2%).

Depending on the literature data**,** the average TDN and DCP yields of Kochia compared to clover hay are 2340 vs. 2420 kg TDN/feddan and 468 vs. 484 kg DCP/feddan, respectively. Concerning animal requirements, Kochia plants could cover the essential nutrients for maintenance requirements of 39 sheep and 46 goats compared to 42 sheep and 49 goats by clover hay (for 120 days) according to the recommended nutritional requirements of livestock in the Near East region as indicated by [24].

7.2 Nitrogen Balance

Nitrogen utilization data for Kochia species compared with different forages are briefed in the article, particularly in the Near East region. Both sheep and goat retained 2.4 g N/h/d and 2 g N/h/d when they fed fresh Kochia with CFM [13]. Moreover, sheep and goat were better in their utilization of nitrogen when they were fed *K. indica* hay than those fed clover hay [19]. While, it was found that nitrogen balance was slightly negative for goat fed Kochia hay ration compared to those fed clover hay ration [17].

Nitrogen balance for goat fed 100% Kochia silage ad lib or those fed 100% Teosinte silage was nearly similar and positive. Feeding on Kochia silage or Teosinte silage alone gained the lowest nitrogen balance compared to those feeding on its mixture, 75% Teosinte + 25% Kochia, 50% Teosinte + 50% Kochia or 25% Teosinte + 75% Kochia [20].

When nitrogen balance expressed as percent of intake, the higher value was recorded for sheep fed Kochia pearl millet haylage than those fed Kochia pearl millet hay or clover hay [21]. Recently, [16] reported that nitrogen intake, total nitrogen excretion and nitrogen balance did not significantly vary and recorded comparable values for lambs fed fresh Kochia with TCFM or those fed clover hay with TCFM.

7.3 Animal Production and Feed Conversion

The effect of feeding Kochia plant incorporated with traditional feed ingredients on small ruminant performance and feed conversion was investigated in many studies. Feed conversion expressed as kg DM/kg milk of Zaraibi goat fed four experimental rations was estimated by [20]. Feed conversion was 1.04, 1.00, 0.94 and 0.97 kg DM /kg milk for goat fed R1 (75% kochia silage + 25% Teosinte silage), R2 (50% kochia silage + 50% Teosinte silage), R3 (25% kochia silage + 75% Teosinte silage) and R4 (100% Teosinte silage), respectively. The effect of feeding *K. indica* with two levels of concentrate on growth performance of lambs was studied [22]. Three experimental rations were used in this experiment. The control ration (R1) was consisted of 60% concentrate mixture + clover hay ad lib whereas the second (R2) contained 40% concentrate mixture + fresh Kochia ad lib. The third ration (R3) was comprised of 60% concentrate mixture + fresh Kochia ad lib. 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 ration plus concentrate mixture. Average daily gain values were 174, 198 and 181 g/h/d for lambs fed R1, R2 and R3, respectively. Feed conversion as kg DM/kg gain detected the best value (6.8 kg DM/kg gain) for lambs fed ration R3 when compared to those fed ration R2 (7.00 kg/kg gain) or with R1 (7.26 kg DM/kg gain). Moreover, [25] found that the average daily gain for lambs fed *K. indica* compared to those fed clover hay was 86.7 vs. 172 g. The corresponding values for goats were 57.8 vs. 70.0 g, respectively. Barely was added to cover 50% of the maintenance energy of growing sheep and goat.

High ash content of kochia hay affect in milk ash content of Baladi goat and was reflected upon their kids. When Baladi goat fed Kochia hay ration, the lowest values in birth and weaning weights of their kids was recorded compared to those fed clover hay ration (1.57 and 6.73 kg vs. 2.37 and 10.3 kg). The authors noticed that the reduction of weaning weights was due to high milk ash content for goats fed Kochia hay that reflected upon their kid's growth [17].

Besides, [21] found that the average weight gain for growing lambs fed clover hay ration recorded the highest values (179 g/h/d) followed by those fed mixture of Kochia and pearl millet hay (150.5 g/h/d) then those fed mixture of Kochia and pearl millet haylage (125 g/h/d). Feed conversion for lambs fed clover hay compared to those fed Kochia pearl millet hay or Kochia pearl millet haylage were 5.1, 7.5 and 8.1 g feed/g gain. Authors recorded that feeding growing sheep on Kochia pearl millet hay or Kochia pearl millet haylage decrease the daily feed cost (EP/head) by approximately 31 and 34% compared to the traditional feed material (clover hay). The same results was observed by [22] who reported that average daily gain of lambs was significantly improved when they consumed fresh Kochia with TCFM at level 100% of their maintenance requirements compared to those fed clover hay with TCFM at the same level (106 vs. 99 g/h/d). These results show the potential use of such plants for improve animal growth as well as increase farmer's income.

It was noticed that daily milk yield was significantly highest (1.39 kg) when goat fed mixture of 75% Teosinte + 25% Kochia silage followed by 100% Teosinte silage (1.25 kg) then mixture of 50% Teosinte + 50% Kochia silage (1.18 kg) and lastly mixture of 25% Teosinte + 75% Kochia silage. However, milk fat, protein, total solids, nonfat solids (NFS), lactose and ash contents were not *(P* = .05) affected by using Teosinte silage alone or with Kochia silage [20].

Several studies indicate that total milk yield for baladi goats and Barki sheep were not significantly affected by feeding kochia plant compared to clover hay [11,17,26].

8. CONCLUSION

It could be concluded that Kochia plants could be considered as promising forage by smallholder crop livestock farmers and agro pastoralists in arid and semi-arid areas. Moreover, these plants can provide relatively high forage yield under salinity conditions, improve animal performance as well as increase farmer's income.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Ben Salem H, Nefzaoui A, Ben Salem L. Supplementation of *Acacia cyanophylla* Lindi. Foliage- based diets with barely or shrubs from arid areas (*Opuntiaficus–indica F. inermis* and *Atriplex nummularia* L.) on growth and digestibility in lambs. Animal Feed Sci. and Tech. 2002;96:15-30.
2. Delgado DC, Galindo J, Gonzalez R, Gonzalez N, Scull I, Dihigo L, Cairo J, Aldama AI, Moreira O. Feeding of tropical trees and shrub foliages as a strategy to reduce *Ruminal methanogenesis*: Studies conducted in Cuba. Trop. Anim. Health Prod. 2012;44(5):1097-1104.
3. Anon, Introduction of salt-tolerant forage production systems to salt-affected lands in Sinai Peninsula in Egypt: A pilot demonstration project. 2009. Final Report, DRC, Egypt-ICBA, UAE.
4. Harrison RD, Waldron BL, Jensen KB, Page RJ, Monaco TA, Horton WH, Palazzo AJ. Forage Kochia helps fight range fires. Rangelands. 2002;24(5):3-7.
5. Shehata EI, Ahmed ME, Abdel Hamid AM, Abou-Amou F, El Haggag M. Comparative nutritive values of silage rations containing different levels of Teosinte and Kochia. Egypt. J. Nutr. and Feeds. 2001;4:129-140.
6. Undersander DJ, Durgan BR, Kaminski AR, Doll JD, Worf GL, Schulte EE. Kochia. Extension service, University of Wisconsin-Madison, WI 53706.1990. Available:http://corn.agronomy.wisc.edu/Crops/Kochia.aspx
7. Fahmy AA, Youssef KM, El Shaer HM. Intake and nutritive value of some salt – tolerant fodder grasses for sheep under saline conditions of South Sinai, Egypt. Small Rumin. Res. 2010;91:110-115.
8. Rankins DL, Smith GS, Hallford DM. Some constituents and metabolic hormones in sheep and cattle fed *Kochia scoparia* hay. J. Anim. Sci. 1991;69:2932-2940.
9. Dickie CW and James LF. *Kochia scoparia* poisoning in cattle. J. Am. Vet. Med. Assoc. 1983;183:765-768.
10. Thilsted J, Hibbs C, Kiesling H, Hallford D, Kirksey R, Meininger A, Tompkins J.

Kochia (*Kochia scoparia*) toxicosis in cattle: results of four experimental grazing trials. Vet. Hum. Toxicol. 1989;31:34-41.
11. Friesen LF, Beckie HJ, Warwick SI and Van Acker. The biology of Canadian weeds. 138. *Kochia scoparia* L. Scrad. Can. J. Plant Sci. 2009;89:141-167.
12. Gihad EA, Shoukry MM, Hanafy MA, Mansour AF, Abd El-Rahman HH. Secondary compounds affect intake by range sheep and goats. Egypt. J. Nutr. and Feeds. 2003;6:1301-1310.
13. Nour A.A. Nutritional evaluation of Kochia indica. Alex. J. Agric. Res. 1995;40:61-70.
14. Zahran MA, Mohamed BK, Mashaly IA. Introduction of non-conventional livestock fodders under drought and salinity stress on arid lands. Proceeding of Workshop on Livestock and Drought Policies for Coping with Changes, FAO and DRC. Cairo, Egypt; 1999.
15. Fahmy AA. Productive performance of lambs fed *Kochia indica* shrubs under desert conditions of Sinai. J. Appl. Sci. 2010;25:17-28.
16. Hanafy MA, Fahmy AA, Farghaly MS, El-Sheref AA. Effect of different treatments on digestibility coefficients and nutritive values of Kochia plant by sheep. Egypt. J. Nutr. and Feeds. 2013;16(2)Special Issue:257-265.
17. Hanafy MA, Fahmy AA, Farghaly MS, El-Sheref AA. Effect of using some fodder plants in diets on goats performance under desert conditions of Sinai. Egypt. J. Nutr. and Feeds. 2007;10(1):151-163.
18. Kheraishi, AH. Performance of Kochia as halophytic fodder shrub under different levels of salinity at Wadi Sudr. M.Sc.Thesis, Fac. Agric., Ain Shams Univ., Egypt; 2005.
19. Fahmy AA, Fayed AM. Nutritional evaluation of *Kochia indica* hay as animal feed in Sinai. Egypt. J. Nutr and Feeds. 2000;3:97-106.
20. Ahmed ME, Abd El-Hamid AM, Abou Ammou FF, Soliman ES, El-Kholy NM, Shehata EI. Response of milk production of Zaraibi goat to feeding silage containing different levels of Teosinte and kochia. Egypt. J. Nutr. and Feeds. 2001;4:141-153.
21. Youssef KM, Fahmy AA, EL-Essawy AM. and El-Shaer HM. Nutritional studies on *Pennisetum americanum* and *Kochia indica* fed to sheep under saline conditions of Sinai, Egypt. American-Eurasian J. Agric. and Environ. Sci. 2009;5:63-68.
22. Abd El-Hamid AA. Effect of feeding different levels of green forages and complete rations on productive performance of ruminant animals. Ph.D. Thesis, Fac. Agric., Zagazig Univ., Egypt; 2003.
23. Sherrod LB. Nutritive value of *Kochia scoparia*. III. Digestibility of Kochia hay compared with Alfalfa hay. J. Dairy Sci. 1973;56:923-926.
24. Kearl LC. Nutrient requirements of ruminants in developing countries. Utah Agric. Exp. Sta., Utah State Univ., Logan, U.S.A; 1982.
25. Abd El-Rahman HH. Constrains and possibilities for their alleviation to improve utilization of desert natural range plants for grazing ruminants. Ph.D. Thesis, Fac. Agric., Cairo Univ., Egypt; 2003.
26. Hanafy MA, Fahmy AA, Farghaly MS, El-Sheref AA. Using alternative sources of roughages or concentrates for Barki ewes feeding. Egypt. J. Nutr and Feeds. 2011; 14(2):217-229.

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