HALOPHYTE S AS FEEDSTUFFS IN FEEDING FARM ANIMALS, A REVIEW

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ABSTRACT

The term halophytes are plants that can occur in a wide range of salinities. Halophytes can tolerate high levels of salinity in water and soil and some extent drought. It grows in water of high salinity, coming into contact with saline water through its roots or by salt spray such as in saline semi-deserts, mangrove swamps, marshes and sloughs and seashores. Halophytes are plants which tolerate even demand sodium chloride concentrations in the soil water they absorb. The plants, which grow in saline habitats, are called halophytes. There is high concentration of salts like sodium hydroxide, magnesium sulphate etc. in these habitats. There are 80 species of halophytes in Egypt, belonging to 32 genera and 17 families. The concentration of salts in halophyte feeds, especially halophyte forages, will restrict the amounts of forage used in livestock feeding systems. Salts are causing tow problems: 1- Dilution of organic constituents led to decrease energy density in the feeds; and 2 – A potential direct effect on feed intake or physiological status of animals. Most, Ash content of halophytes is high relative to that of non-halophytic species. Ash content can be as 200 g / kg for shrubs irrigated with sweet water and as high as 300 to 400 g / kg under saline conditions. The present article review summarizes the utilization of some halophyte forages such as Salicornia bigelovii Torr, Atriplex species, Acacia species and Kochia indica for feeding animals. Salicornia bigelovii Torr is a halophytic oilseed crop tolerant to seawater irrigation. It
yielded up to 18 tons per hectare of dry matter biomass under seawater irrigation. The seeds representing 10 – 15% of the harvest weight, contained 30-33% CP, 26-33% Oil, 5-7% CF and 5-7% ash. Straw contained 4-6% CP and 30-45% ash consisting mainly of NaCl. Also, this article explains the chemical composition, nutritive values and using these halophytes in the feeding systems of livestock.

Key wards: Halophytes, Salicornia, Atriplex, Kochia, Acacia

INTRODUCTION

The term halophyte refers to those plants, which tolerate high levels of salinity in the soil and to some extend drought. Growing agricultural crops with direct seawater irrigation has been accomplished by selecting halophytes with inherently high salinity tolerance for use as crop plants rather than by increasing the ability of traditional crop plants to tolerate seawater. Some of the halophytes being investigated for use as crops under seawater irrigation have high nutritional value as forage or fodder crops, and most also have high digestibility. The limiting factor in such use is their high salt content, but this can be moderated. The greatest promise for seawater irrigated halophytes will probably be as seed crops. The seeds of many halophytes have high protein and oil contents and compare favorably with traditional oilseed crops (O’Leary et al., 1985). The use of highly saline water to grow crops requires an adequate drainage system and availability of adequate quantities of water. The abilities of particular plant genotypes to grow and produce yield under high salinity, well drained environment is dependant up on restriction of salt from cytoplasm compartments and maintenance of positive water balance. Temperature, humidity and light intensity have profound interactive effects with salinity at the upper limits of ionic and osmotic stress (Shannon et al., 1993). Qureshi et al. (1993) reported that, in Pakistan, a number of suitable forages species including Leucaena leucocephela, Prosopis cineraria, Acacia nilotica, Sasbania, Atriplex and Maireana spp., Diplachne fusca, Echinochloa curs-gall and Cenchrus ciliaris. Among these species, the grasses tended to tolerate both salinity and water logging, while the shrubs and trees were less tolerant to water logging but needed little irrigation. El-shaer et al. (1994) reported that there are 80 species of halophyte in Egypt,
belonging to 32 genera and 17 families. The protein content of these halophytes average 10% CP with 21.7% crude fiber and 27% ash. Nutritive value is affected by species, stage of growth, stocking rate and other environmental factors. Increased stage of maturity is associated with a decline in digestibility and CP. The use of these halophytes as a feed for livestock is considered a solution to the problem of feed shortage in Egypt.

The present review will be summarized the effect of feeding livestock animals on some silty plants (halophytes) which contained high levels of salts on the nutritive values, growth performance, efficiency of feed utilization and discuss the utilization of the most commonly halophytic plants, widely distributed at the most arid and semiarid countries with high amount of biomass production, especially, *Salicornia*, *Atriplex* (Saltbush), *Kochia* (Bluebush) and *Acacia* shrubs.

**Effect of high concentration of salts in halophytic plants**

The high concentration of salts in halophyte feeds, especially halophyte forages, is the characteristic that ultimately will restrict the amount of forage which can be used in livestock feeding systems. Salts are causing tow problems: 1- Dilution of organic constituents decreases energy density in the feeds; and 2- A potential direct effect on feed intake or physiological status of animals. Productivity of livestock depends on animal’s ability to increase feed intake to compensate for the reduced dietary energy density. When feed intake is limited, either by gastrointestinal fill or by the direct effect of salt ingestion, energy intake, and efficiency of production will be lower than could be achieved using conventional feedstuffs (Swingle, 1994). Like most halophytes, the ash content of *Atriplex barclayang* is high relative to that of non- halophytic species. Depending on the growing conditions, the ash content can be as low as 200g/kg for shrubs irrigated with sweet water and as high as 300 to 400 g/kg under saline conditions (Pasternak et al., 1986). As a result of its high ash content, the growth energy content of its DM is low relative to that of herbaceous species. In general, the apparent digestibility of *Atriplex* species has been expressed in the literature on a DM basis, whether calculated by *in vivo* or *in vitro* methods. This can be misleading because the ash content may include a high proportion of soluble salts.
of no energy value to animals. Because of the high ash (salt) content of halophytes, animals eating it must have a relatively high water intake in order to excrete the ingested salt. Where drinking water is freely available this may be of no concern, but where the supply is limited, as is often the case in Africa, it may be a serious limitation to use of halophytes as an animal food. Most halophytes dry matter contains high concentration of mineral salts of which NaCl is the principal constituent (Mota, 1987). Glenn et al. (1992) reported that NaCl content in Salicornia biomass accounted for up to 30% of the dry matter. Gardeswartz and Schrir (1982) suggested that in humans, increased sodium intake and consequent water retention was a short-term phenomenon. The ability of sheep and goats have capability to ingest high levels of NaCl from saltbush (Atriplex spp.) and Salicornia biomass (Salicornia bigelovii Torr) without ill effects (Wilson, 1966a; Benjamin et al., 1992; Glenn et al., 1992). The inclusion of excess Na salts in the diet of the ruminant normally results in quantitative increases in the animal’s water requirement. Sodium chloride is an effective feed intake inhibitor for both cattle and sheep (Weir and Miller, 1953), and is commonly mixed with protein supplements to regulate (reduce) ad libitum intake in grazing systems. Additionally, many tropical grasses and semi-arid range plants contain elevated levels of Na. Grazing animals usually suffer no observable adverse physiological effects when subjected to feeding regimens, which include elevated amounts of Na if adequate water is provided. Toha et al. (1987) concluded that feeding high levels of Na might be reduce the utilization of feed nutrients, particularly when intake is restricted. Adaptive changes in kidney functions largely seem to account for the observed tolerance (Potter, 1961; Tomas et al., 1973), although changes in electrolyte movements across the rumen wall in response to osmotic stimuli may also be involved (Reffett and Boling, 1985; Toha et al., 1987). Harrison et al. (1975) and Kellaway et al. (1978) showed that sodium salts have an osmotic action in the rumen, which can increase rumen dilution rate. Accordingly, Kraidees et al. (1998) reported that the daily intake of 14.5 and 20.3 g Na and the concomitant increases in water intake of lambs fed on 100 g and 200 g / Kg Salicornia stem – diets, respectively, probably increased the ruminal dilution rate, and thereby the rate of microbial protein synthesis. In addition to that, the implied reduction of digesta-residue
time in the rumen might have increased the dietary escaping protein and soluble nutrient flow to the small intestine and resulted in increased absorption of nutrients % dietary origin. This is consistent with the findings of Hemsley (1975) who reported a 22 % improvement in wool growth rate when 130 g of NaCl per day was given in feed. In addition, Kellaway et al., (1977) found that inclusion of Na up to 20 g / Kg DM was well tolerated by calves; the growth rate was 44 % greater at 20 g Na / Kg DM in comparison to 2 g Na / Kg DM. Kraidiees et al., (1998) found that lambs tolerated a daily intake of up to 25 g Na without any observable adverse effect on daily gain, however, they reported that lambs ingesting about 35.9 g Na per day from complete diet contained 200 g Salicornia spikes per Kg DM, had negative effect on growth performance. Peirce (1957) suggested that the decline in food consumption in sheep ingesting large amounts of NaCl (100 g per day) may have been the result of general adverse effect on the rumen flora which could have led to retarded digestion of the food and consequently reduced food intake. Similar results were reported by Hemsley et al. (1975) who showed a 25% depression in ruminal digestion of organic matter on the diet containing 150 g NaCl per day. Kellaway et al. (1977) suggested that the renal capacity intake for concentrating sodium was a factor limiting food intake when dietary Na was greater than 20 g per Kg DM intake. They concluded that there were progressive changes towards metabolic acidosis at higher levels of NaCl inclusion. Another line of reasoning was reported by Wilson (1966b) who suggested that the decline in food intake was attributable to the acceptability or taste of high-salt diet (> 50 g NaCl per Kg DM) to the sheep. Wilson (1966) reported that when sheep were fed ad libitum on the fresh leaves of various species of Atriplex and Kochia the sodium intakes of the sheep varied from 25 to 97 g per day. Most of this sodium was excreted in the urine at concentrations up to 500 mEq /L. Feed intake of Atriplex nummularia decreased to less than half when the drinking water was replaced by water containing 0.9 to 1.2 % sodium chloride. Gihad et al. (1993) reported that when sheep drink water containing 1.0 % NaCl they suffered no ill effects, 1.5 % was detrimental to some and 2 % was detrimental to all sheep. Peirce (1957) conducted a long term experiments, sheep were offered over a 15- month period either rain water or synthetic drinking waters containing up to 2 % NaCl. It was
found that the performance of sheep receiving 1.0 % NaCl was similar in all respects to that of sheep receiving rain water. One animal of those, which have received 1.5 %, scoured and died, whereas all six animals that were on the 2.0 % NaCl went off feed after 9 months and died. It was assumed therefore that the maximum safe concentration of sodium chloride lay between 1.0 and 1.5 %. Several investigations reported that maximum safe concentration lies between 1.1 to 1.3 % NaCl in drinking water (Peirce, 1959; Wilson and Dudzinski, 1973. Nassar and Hammed, 1980). Increasing salt concentrations in drinking water, more than 2% (Peirce, 1957,1959; Ahmed, 1984) significantly increased water intake and feed intake. The general reaction of sheep to increasing salt concentration was to increase the volume of drinking water. At high intakes of salt, feed intake was erratic and decreased by about 20 to 30 %. There was an adverse effect on animal health and rumen microorganisms, leading to decreased digestion. Urinary nitrogen increased and nitrogen retention decreased with high salt intake. Adaptation may also be an important factor in relation to tolerance of sodium chloride loads. The earlier experiments by Peirce (1957; 1959) indicated some adaptation, as shown by increased feed intake. It was suggested that adaptation by microorganisms might be a factor. However, Wilson (1967) from both in vivo and in vitro digestion studies concluded that the adaptation was probably physiological.

Salicornia bigelovii Torr

Salicornia bigelovii is a species of flowering plant in the amaranth family known by the common names dwarf saltwort and dwarf glasswort. It is native to coastal areas of the eastern and southern United States, as well as southern California and coastal Mexico. It is a plant of saltmarshes, a halophyte which grows in saltwater. It is an annual herb producing an erect, branching stem which is jointed at many internodes. The fleshy green to red stem can reach about 60 centimeters in height. The leaves are usually small plates, pairs of which are fused into a band around the stem. The inflorescence is a dense sticklike spike of flowers. Each flower is made up of a fused pocket of sepals enclosing the stamens and stigmas; there are no petals. The fruit is a utricle containing tiny fuzzy seeds. The southern part of
the species range is represented by the Petenes mangroves of the Yucatán, where it is a subdominant plant associate in the mangroves (Mark McGinley, 2010).

*Salicornia bigelovii* Torr is a halophytic oilseed crop tolerant of seawater irrigation. It is grown as an annual crop, requiring about 200 days from sowing to harvest under seawater irrigation. This plant is an annual leafless, salt-march plant with green, pointed, succulent shrub, 50 to 60 cm tall, with joint stem ultimately formed terminal fruiting spikes on the upper one-third of the plant. The plant was identified as having the greatest promise amongst many halophyte species for possible domestication as a potentially valuable high-yielding oilseed crop plant for subtropical coastal deserts (Munz, 1974; Wiggins; 1980; Glenn *et al*., 1991). Mota (1987) reported that *S. bigelovii* yielded up to 18 tons per ha of dry matter biomass under seawater irrigation in United Arab Emirates. The seeds representing approximately 10 – 15 % of the harvest weight, contained 30 – 33 % crude protein, 26 – 33 % oil, 5 – 7 % crude fiber and 5- 7 % ash. Oil fatty acids contained 6.9 – 8.7 % palmitic, 1.6- 2.8 % stearic, 12.0 – 14.1 % oleic, 73.0 – 75.2 % linoleic and 2.1 – 2.7 % lenolenic (Glenn *et al*., 1991; Riley, 1988).

*Salicornia* straw has lower lignin content per unit of crude fiber than *Atriplex* or conventional forages. It contained 4 – 6 % crude protein and 30 – 45 % ash consisting mainly of NaCl (Glenn *et al*., 1991; Kraidees *et al*., 1998). Despite a higher ash content and lower protein level than *Atriplex*, *Salicornia* straw has proven to be a valuable forage material in formulated ruminant diets. *Salicornia* straw was incorporated at 15 % instead of alfalfa hay in diets fed to goats for 93 days feeding trial. All diets were adjusted by adding cottonseed meal. Average daily gain (ADG) and feed conversion ratio (FCR) were 83.9, 69.9 g/day and 10.5, 13.5 Kg DMI / Kg gain for goat fed alfalfa hay or *Salicornia* straw, respectively. In another experiment, sheep were fed on diets contained 15 or 30 % *S. straw* comparing with 15 % alfalfa –diet for 92-day feeding trial. *Salicornia* diets contained 10 % extra cottonseed meal and 10 % rolled wheat straw to balance protein levels (ca. 10 %) across treatment, ADG and FCR were 87.0, 105.4, 157.6 g/day and 11.4, 12.6, 11.2 Kg DMI/Kg gain for diets contained 15 % alfalfa, 15 % *S. straw* and 30 % *S. straw*, respectively. These results appear that *Salicornia* plus cottonseed meal substituted
favorably for alfalfa; comparing the two S. treatments favorably for wheat straw as well. De La Liata (1991) measured acceptability and digestibility by lambs of Salicornia forage harvested at three different cutting dates during the growth cycle. Ash content was high at all cutting dates (35-46%) but protein levels were higher than in straw (7.5 – 8.5%). Salicornia was incorporated at 30 % of the diet; the control diet contained 30 % wheat straw, and all diets contained 35 % alfalfa hay, 33 % sorghum grain and 2% molasses. All three cuttings of Salicornia compared favorably to the control diet in acceptability and digestibility. It was concluded that unleached Salicornia hay (immature plants) could replace wheat straw in lamb diets. Glen et al. (1992) reported that dry biomass of the halophyte S. bigelovii substituted Rhodes grass (Chloris gayana) as the forage component (about 50 % as consumed) of diets fed to Damascus lamb goats in the United Arab Emirates. Because of the high NaCl content of the biomass, it was given a 1:1(w/w) mixture with Rhodesgrass to dilute the NaCl content, or was washed in seawater, pressed and redried to reduce the NaCl content, and given as the sole forage. Washing reduced the NaCl content of the biomass from 30% to 11%, but also removed all soluble nutrients. There were no significant differences among diet treatments in weight gain of goats (63 – 90 g/day for males and 50 – 57 g/day for females). Goats ate more washed biomass than Rhodes grasses or unwashed biomass / Rhodes grasses mixture. They also required more feed per unit of weight gain on the treatment, which was attributed to the lowered protein content, and partial loss of cell soluble of washed biomass. Differences in water intake among treatments were not significant. They concluded that S. bigelovii biomass is an acceptable substitute for Rhodes grass in coastal arid zones where fresh water for forage production is limited but where saline water resources can be exploited. Besides high ash content, the other apparent limitation to incorporating Salicornia straw into goat or sheep diets is low protein content, which can be adjusted by adding more protein concentration. However, Mota (1987) has demonstrated that, for local Awasi-type sheep in the United Arab Emirates, protein can also be supplemented by adding Salicornia seeds into the feed. He compared three tested diets containing three levels of Salicornia straw (50, 60 and 70%) and seed (25, 20 and 15%), with a control diet containing 25% wheat bran and 50% Rhodes as the forage component.
plus corn and dates. The control diet contained 9.3 % CP and was a typical diet for sheep in this area. The tested diet containing 50% untreated Salicornia straw and 20% seeds had the highest protein level (12.6%) and supported weight gain of the sheep at 80 g/day over 97 days. The other diets, containing 10.55 and 9.94% crude protein, supported growth at 60 and 65 g/day, compared to 74 g/day for the control. Riley et al. (1994) reported that the vegetative portion of the seawater-irrigated halophyte, Salicornia bigelovii, was fed, washed or unwashed, to sheep and goats in four trials in the United Arab Emirates and Kuwait during 1987 – 1990. They concluded that diets of 50 and 100 % Salicornia could be fed to sheep and goats, respectively, as long dietary crude protein content was adequate. Swingle (1994) studied two feeding trials 84-day with growing lambs. In the first trial, forage treatments were Bermudagrass hay, Atriplex forage and Salicornia straw with cottonseed meal as the source of supplemental protein. In trial (2), forage treatments were Salicornial forage, Suaeda forage and Bermudagrass hay plus NaCl to give the same total ash content (26.5%) as the halophyte forages. All diets contained 30 % forage and 70% concentrates. Dry matter intake and average daily weight gain were higher for lambs fed diets containing halophyte forages than for lambs fed Bermudagrass hay control diet in both trials. Furthermore, carcass merit of all lambs was excellent and carcass characteristics (trial 1) were not affected by inclusion of halophyte forages in the diet. Digestibility of DM and OM were slightly lower for halophyte forage diet than for control diet in both trials, but the lower digestible organic matter content of the halophyte diets (% organic matter x apparent digestion coefficient of organic matter) illustrates the diluting effect of the high mineral content in halophyte forages. Water intake was higher in trial (1) than in Trial (2) because ambient temperatures were higher during trial (1). It was higher for lambs fed halophyte forages than lambs fed control diet as L/day or L/Kg DMI in both trials. Lambs fed the Bermudagrass plus salt diet in Trial (2) did not compensate for the diluted organic matter by increasing dry matter intake as did lambs fed approximately the same amount of salt from halophyte forages. These lambs gained more slowly than lambs fed on the other treatments. Feed efficiencies of lambs fed the Bermuda grass plus salt diet or halophyte forage diet were similar, again illustrating the effect of dilution by salt on this
trait. Kraidees et al. (1998) studied the effect of dietary inclusion of *Salicornia* by-products on the performance, carcass characteristics, and mineral and water intakes of Najdi sheep lambs. Either the dry stems or spikes of this seawater-irrigated halophyte were incorporated into complete diets at four rates of 0, 10, 20 or 30%, replacing equal amounts of Rhodes grass hay. Feeding *Salicornia* stems up to 30% or spikes at 10% did not affect dry matter intake (DMI) compared to control diet, however, the inclusion of spikes at levels above 10% decreased DMI. Feeding stems at 10 and 20% improved ADG by 10.6 and 4.8%, respectively, whereas feeding 20 and 30% decreased ADG by 20.2 and 23.9% respectively, compared to the control diet. Daily Na intake increased with increasing levels of *Salicornia* in the diet. This in turn increased daily water consumption by 20.5, 31.3 and 34.6% in lamps fed *Salicornia* stems at 10, 20, or 30% levels, respectively. Corresponding increases in spike-fed lambs were 33.3, 39.6 and 47.5%, respectively, compared to control. Graded levels of either *Salicornia* stems or spikes had no effect on empty body weight and dressing percentages, but linearly increased the percentages of kidneys and heart weights. Hot carcass decreased linearly with increasing levels of spikes. Abouheif et al. (1998) estimated the digestibility coefficients, nutritive values, nitrogen balance and the rumen functions of the *Salicornia* by-products diets used by Kraidees et al. (1998). They found that the digestibility of DM, OM, EE and fecal and urinary nitrogen, expressed as percentage of nitrogen intake, were not affected by increased level of *Salicornia* stems in the diet. As level of *S.* stems increased from 0 to 20% in the diet, CP digestibility reached its minimum, however, increasing them to 30% no further effects were observed. On the other hand. Except for EE, digestion of all nutrients and nitrogen retention was linearly depressed as *S.* spikes increased from 0 to 30% level. Concentrations of ammonia-nitrogen and total VFA in the rumen were lower with *S.* by-products than the control. Ba-Smaiel et al. (1998) reported that *S.* forage hay can be fed to Majaheem camel lambs at the level of 25% in complete diet, instead of Rhodes grass hay, contained 13.5% CP.

Swingle (1994) reported that, in trial (1), *Salicornia* meal (SM), 10% of dry matter, was compared with cottonseed meal in diets containing Bermudagrass hay as the source of forage, the results indicated that: feed intake, ADG, feed efficiencies, diet
digestibility and carcass characteristics did not differ between the control and SM diets, indicating that SM is at least equivalent to cottonseed meal as a source of supplemental protein for growing lambs. Tagel-Din et al. (1998) used SM at 0, 10 and 20 % instead of the equivalent amount of soybean meal nitrogen in four complete diets, contained 40 % roughage and 60 % concentrate, for growing Najdi male lambs. They observed that, increasing the level of SM slightly decreased digestibility coefficients of DM, OM, EE, and NFE, whereas these of CP and CF significantly decreased. The TDN and DCP were, also, decreased. Nitrogen balance was decreased when SM was increased to 20 %. Mineral balance of Na, K, Mg, and Ca was not affected, however, P balance was decreased by increasing the level of SM. Average daily gain was not affected, however, feed conversion ratio was decreased by increasing SM levels, the differences were not significant. Water drunk as L/Kg DMI was increased significantly by increased SM level to 20 %. Hot carcass and dressing percentage were not different among the three treatments. They concluded that SM could be incorporated into diets for growing lambs up to 20%.

*Salicornia* seed meal represents a potential primary protein source (42 % CP) in formulating diets. Experiments with sheep showed that ruminants readily accepted the milled whole seeds. However, the seeds contained 0.05 % of oleanolic acid, a saponin which acts as an antifeed compound in poultry (Glenn, 1994). In another study by Glenn et al. (1991), *S.* seed oil and meal was compared with soybean oil and meal in chicken diets. The control diet contained 2% soybean oil and 18% soybean meal. *S.* oil replaced soybean oil in one experiment. In another experiment, SM replaced soybean meal at 14% of the diet (plus 4% soybean meal to balance protein and essential amino acid requirements). SM was tested untreated or supplemented with 1% cholesterol to counteract saponins, or extracted from seeds washed in 1% NaOH to detective saponins. The results indicated that there were no significant differences between the tow sources of oil on the relative growth rate (RGR) or feed conversion ratio (FCR) of chicken diets. Using untreated SM instead of soybean meal significantly decreased (p<0.05) RGR an FCR, however, addition 1% cholesterol to SM or washing *S.* seed in NaOH diets obtained similar RGR and FCR to the control diet.
Salicornia bigelovii meal was replaced of fish meal at the levels of 0, 20, 40, 60, 80 and 100 % in Nili tilapia (Oreochromis niloticus) diets. Tilapia fed diets containing 0 or 20 or 40 % SM had similar growth parameters and was superior to those fed diets with higher levels. On the other hand, O. niloticus fed diets containing 60 and 80 % SM had similar growth parameter and were higher than these fed 100 % SM. It was concluded that SM could be used in O. niloticus feed up to 40 % of the feed without any effect on growth or body composition (Belal and Al- Dosari, 1998).

Atriplex species

Atriplex (saltbush) is probably one of the most economically important genus of rangeland halophytes. It represented approximately 2300 species belong to the family Chenopodiaceae. Atriplex species are grown in saline soils in the arid and semi - arid lands under different environmental conditions in several countries in the world, out of these , there are almost 80 halophytic belonging to 32 genera and 17 families (Batanouny Absitta, 1977). Several species included in the genus Atriplex tolerate very high salinity level such as seawater (Mozafar and Goodin, 1970 and Sankry, 1978).Saltbush are able to grow at a moderate rate and to produce a reasonable amount of biomass under condition of high soil salinity(Arieli et al., 1989). The species are botanically interesting, particularly so because of the adaptation to many diverse, and generally harsh environments (Kelly et al., 1981). It is becoming apparent that many of the habitats of the species (rangeland, desert, salt marsh, etc.) are becoming increasingly important as valuable natural resources (Goodin, 1985), Rintoul et al.(2004). Atriplex halimus (desert saltbush) is an ever green shrub, widely distributed in Egypt along the Mediterranean sea coastal zone and the Sues Gulf and its chemical composition is generally characterized by its high content of ash and fiber, moderate protein and deficient in energy content (El- Shaer, 1981). It may represent an important contribution, for feeding sheep, goats and camels, when herbaceous forages are scarce or diminished. Hassan et al. (1979) showed that Atriplex nummularia contains 15 % CP, 24.8 % ash, 31.5% CF, 7.7 % EE and 20.9% NFE, however, Shawket et al. (1998) reported that Atriplex halimus contains 18.6 % CP, 19.5 % ash, 18.8 % CF, 2.5 % EE and 40.6 % NFE. Welch (1978) found that Atriplex


canescens contained 11.9 to 18.7% ash and averaged 14.8%, 8.9 to 22.4 % CP and the mean was 14.9%. He noted that some of the populations contained significantly higher levels of crude protein than others. Hyder (1981) found that ash content ranged from 17 % in A. polycarpa to 27% in A. nummularia. Protein percentage ranged from 11.1 % in A. inflata to 18.8% in A. polycarpa. Khalil et al. (1986) studied the nutritive characteristics of six Atriplex species grown in Saudi Arabia. They reported that crude protein, crude fat, crude fiber and ash contents varied between 16.7 and 25.2%, 1.0 and 1.6%, 7.8 and 10.4% and 18.5 and 27.2% on dry weight basis. Hyder et al. (1987) in Saudi Arabia reported that crude protein and soluble carbohydrates in Atriplex species ranged from 12 to 13 % and from 8.3 to 11 %, respectively. The differences in chemical composition may be due to different species, stage of growth, season, soil composition and other environmental factors. Reis and Williams (1965) found that crude digestible protein of Atriplex was high relative to the other pasture grasses and legumes and was maintained throughout the year. Atriplex shrubs remain green during the drought conditions and it had been suggested that Atriplex could serve as a valuable forage resource either when no other feed is available or in the seasonal drought in pasture production. Unpalatability of Atriplex might be explained on the basis of the digestion of protein, breaking down to ammonia and being lost before they can be absorbed and causing digestive discomfort to the animals. Davis (1981) reported that tannins were below the level at which animal acceptance is impaired. It averaged about 5.3 to 5.5 % tannin level required for rejection by grazing animals was about 20 mg / gm dry matter.

Wilson (1966a, 1977) and Hassan et al. (1979) previously investigated the nutritive value of saltbush, who found that High digestible crude protein and mineral contents characterize it. Its digestible ether extract and soluble carbohydrate contents were low. Such low level of readily available carbohydrates together with the rapid fermentation of its crude protein in the rumen (Weston et al., 1970; Hassan et al., 1979) may be responsible for the poor utilization of saltbush proteins as judged by the large losses of nitrogen in urine. Hassan et al. (1979) found that sheep consumed 30.6, 23.4 and 22.1 g/Kg\( ^{0.75} \) from saltbush, Rhodes grass and Napier grass, respectively. The digestibility coefficients of saltbush were 61.7, 61.1, 78.8, 78.2,
25.5 an 38.1 % for DM, OM, CP, CF, EE and NFE, respectively. Its nutritive values were 51.4 %TDN and 11.8 % DCP. These results were significantly lower than the results of Rhodes grass or Napier grass. The three forages obtained negative nitrogen balance, while, saltbush was the lowest balance (P<0.01). Hassan and Abdel - Aziz (1979) reported that the nutritive value of saltbush could be improved by barley supplementation and 150 g/head/day seemed to be sufficient. Increasing barley supplementation from 0 to 50 to 100 g/head/day, significantly increased organic matter intake from saltbush and body weight changes were increased. Also, digestibility coefficients of OM, CP and CF were increased. Since organic matter intake was not significantly increased when barley was raised from 100 to 150 g/head/day, it is expected that no substantial increase in salt bush intake will occur when the level of barley is raised above 150g. Before feeding, the concentration of rumen ammonia nitrogen in sheep fed 150 g barley as an addition to saltbush was doubled those unsupplemented ones. This may reflect the active urea recycling in the former. Ammonia concentration increased progressively after feeding. At the peak (at four hours after feeding), supplementing saltbush with 150 g barley decreased ruminal ammonia concentration by 57.3% compared to unsupplemented control. From 4 to 8 hours after feeding the changes in the ammonia nitrogen concentration were relatively more steady for the highest level of barley, may reflect better utilization by rumen microorganisms and the opposite was true for unsupplemented animals. Nitrogen balance was significantly higher for animals fed 150 g barley (+ 6.2 g N/day), however, it was negative in sheep fed 0 or 50 g barley (- 4.1 and - 2.8 g N/day) and positive for those fed 100 g barley (+ 0.7 g N/day), the differences were significant (P<0.01). These results were in agreement with the findings conducted by El- Shaer (1990) who reported that it must supplemented barley As a source of energy up 150 g /head/day to sheep and goats fed on Atriplex halimus. Shehata et al. (1988) reported that leaves represent 50 % of the shrub weight with a decline by increasing the shrub size for Atriplex nummular. Sheep exhibits a better digestion (55.7, 50.6, and 58.7%) than goats (40.7, 45.6 and 55.8 %) for OM, DM and CP, respectively. Low digestibility coefficients were recorded for CF when Atriplex was offered alone, but still sheep were better than goats (30 and 23%, respectively). The
addition of 250 g barley grains per head per day increased CF digestion in sheep to 72% while, decreased it in goats to 18% and enhance the rate of digestion of both DM and OM in sheep and goats. Adding barley increased nitrogen balance from 6.0 to 13.8 g/head/day in sheep.

Shawket et al. (1998), Pearce and Jacob (2004) studied the effect of barley grains supplementation on the performance of growing Barki lambs fed fresh saltbush (Atriplex halimus). Four feeding treatments were used, 1- free berseem hay plus barley, 100% of animal maintenance energy (MRBG), 2,3 and 4 offered free fresh saltbush plus barley covered 100, 75 and 50% of the maintenance energy requirement. Daily intakes of dry matter and organic matter were significantly decreased in groups fed on fresh saltbush compared with the control group. Decreasing barley grains were decreased saltbush dry matter intake. Animals fed on saltbush had lower growth performance than that fed berseem hay. Digestibility coefficient of crude protein was higher in group fed saltbush plus 100 % MRBG than other groups, however there were no differences in digestibility of DM, OM, CF, EE and NFE between the first two groups. Decreasing barley supplementation significantly decreased digestibility coefficients and the TDN values of the whole diets, while the DCP values increased in saltbush treatment groups. Also, saltbush and decreasing barley levels were decreased nitrogen balance than berseem group. They concluded that fresh saltbush is beneficial supplemental nitrogen source (18.6 % CP) for lambs as compared with berseem (Trifolium alexandrinum) hay (12.2 % CP), and supplementation with about 500 g/head/day barley grains was sufficient to reach the higher growth performance, digestibility coefficients and nutritive value. Pasternak et al. (1985) showed that the annual yields of dry matter of Atriplex nummularia, irrigated with 100 %, 75 % or 15 % seawater, were 1.53, 2.12 and 2.89 kg / m², respectively. Ash content was very high, from 25 to 40 % of the dry matter, depending on the treatment and season. The crude protein content was 15 - 21 %. Daily dry matter intake was 400 g per head of sheep, which was effective only with the daily addition of 400 g corn meal per head. Wilson (1966a) reported that Atriplex leaves contained up to 200 g CP /Kg DM, approximately, proportionately up to 60% of this chemical fraction may be non-protein nitrogen which is not
necessarily utilized by ruminants as a nitrogen source unless readily available energy material is present in the rumen during fermentation and digestion (Yaron et al., 1985). Low feed intake is the main limiting factor in the development of the seawater-irrigated fodder. Taha et al. (1990) concluded that brackish water, sewage and seawater dilutions of 1: 15, 1: 7, 1: 3 and 1: 1 (seawater: fresh water) could be used for seedling establishment of the Atriplex species. The Atriplex species responded better than the jojoba plant (Simmondsia chinensis) to dry farming experiments, under Kuwait’s natural conditions without the application of irrigation water. Abo Hassan (1985) reported that seed germination of Atriplex species decreased significantly as the salinity level increased. The highest concentration (5000 ppm or more) inhibited completely seed germination. The effect of salinity on the growth of seedlings followed the same trend as in seed germination. Also, chemical analysis of seedlings revealed a high percentage of crude protein, which decreased with the increase of salinity levels. The yield and crude protein content of Atriplex plants were higher than those of other pasture grasses and legumes grown under the same conditions were. El-Hyatem et al. (1993) reported that Atriplex nummularia (leaves and stems) grown in Nubaria in a calcareous soil contained 12.9 - 24.5 % CP, 8.56 - 13.11 % CF, 1.01 - 2.88 % EE, 19.2 - 30.7 % ash, 3.8 - 4.9 % saponins, 4.2 - 8.3 % Na, 0.9 - 5.0 % K, 1.4 - 2.0 % Ca and 0.2 - 0.6 % P. Wilson (1966) found that the digestible dry matter intake of Atriplex nummularia and A. vesicaria was sufficient for maintenance of the sheep, provided the fresh water was available. The intake of protein deficient roughage was not altered by the addition of 150 g dry matter of Atriplex or Kochia as a supplement. Body weight less was decreased or gains increased by addition of these supplements, which were high in nitrogen. Forti (1986) reported that Atriplex barclayana can grow well when irrigated with seawater, which could give this plant an advantage as a fodder source where fresh water is scarce. Arieli et al. (1989) reported that saltbush (Atriplex barclayana) was fed to sheep, it contained 31.2% ash and 1.5% nitrogen, after mixing them (477g sundried) with 270 g barley grains and 22g soybean meal compared to 392 g pea hay plus 347 g pellets containing barley grains plus NaCl (3:1) or control diet containing 377g pea hay and 271g barley grains. They found that water intake of animals fed a high salt intake was 2.9
times higher and urine excretion was 3.7 times higher than in the control. They suggested that the low energetic utilization of saltbush be related to its low digestibility and the associated increase in energy expenditure, which are apparently related to mineral metabolism in the rumen. To maintain sheep on saltbush diets efforts should be made to lower the mineral content of this shrub. Weston et al. (1970) and NRC (1985) concluded that saltbush may meet the nitrogen requirements for maintenance of ruminants.

Kochia species

Kochia plant is drought-resistant and requires little water. It is suitable for soils with salinity problems. The plant is invasive due to high production of seeds and needs to be controlled (Garduno et al., 1993). Kochia indica and Kochia scoparis are annual bushy herbs, which belong to the family Chenopodiaceae, that may be considered as non-conventional forage-producing plants with nutritive values comparable to those of clover (Trifolium alexandrinum) and higher than those of many palatable xerophytes and halophytes, e.g. Diplachine fusca (L.), P. Beauv, Chloris gayana Kunth, Panicum repens L., Traganum nudatum Del., ...etc. but less than those of alfalfa, Medicago sativa L. (Draz, 1954 and Whyte et al., 1966).

Two Kochia species can be cultivated in arid lands using artesian saline water for irrigation. *K. indica* seeds showed that germination was highest when the seeds were watered with distilled water or with dilute solutions of NaCl. Increased NaCl concentration caused lengthening of the periods of 100% germination from 8 days in the dishes treated with fresh water to 13, 18 and 18 days in the dishes treated with 0.1, 0.2 and 0.3% NaCl solutions, respectively. *K. indica* seeds can germinate, though at a low rate, under salinity as high as 3% NaCl, however, its seedlings succeeded to grow normally after being irrigated with saline solution as high as 3% NaCl. The highest fresh and dry weights were recorded in pots filled with silty soil and watered with 3% NaCl solution (Means = 3.67 Kg/pot and 0.99 Kg/pot respectively. Under the same treatment in pots filled with sand, the means of fresh and dry weights were 1.14 Kg/pot and 0.24 Kg/pot respectively. *K. indica* plants gave higher vegetative yields in silty soil than sandy soil (Zahran, 1986). Kochia plants contain alkaloids yet the amounts present are not harmful to animals. However, cattle fed on *K.*
Scoparis in Texas, USA, gained about 0.4 Kg per day without showing symptoms of toxicity (Durham and Durham, 1979). Kochia cultivation can be carried out two times per year, i.e., green and/or dry fodder can be secured all year around. Its hay, with its great amounts of seeds, is a very rich dry fodder (Zahran, 1986). K. indica and K. scoparis have roots extend downwards in the soil for more than 3 meters carrying many secondary roots. They have long stems (more than 3.5 meters under favorable condition) which are cylindrical and richly branched. The stems and branches are softer in K. scoparis than in k. indica (Zahran, 1986). K. indica is a salt tolerant bush that grows in the salt affected and calcareous soils in Egypt (Sadic, 1974; Zahran, 1986; Abu Ziada, 1988). This can allow growing it as fodder crop for ruminants in these areas and can partially cover a part of the gap between the available and required amounts of animal feeds in Egypt. The chemical composition of K. indica grown in Egypt differ between green branches and hay, which contained, 84.2 - 7.7 % moisture, 3.4 - 17.0 % CP, 0.4 - 1.6 % EE, 4.1 - 22.0 % CF and 2.7 - 14.3 % ash (Draz, 1954). However, the chemical analysis of whole plant (stems plus branches) of K. indica was 15 - 15.8 % CP, 24 - 26 % CF, 2 - 3 % EE and 14 - 16 % ash (Tagel - Din et al, 1991; Nour, 1995). Tagel - Din et al. (1991) reported that K. indica contained CP (15.8%) similar to berseem hay (15.2%), however, digestibility coefficients of K. indica (72.5 % DM, 70.8 % OM, 71.0 % CP, 54.8 % EE, 58.6 % CF and 78.3 % NFE), and the TDN (60.4 %) and DCP (11.2 %) were higher than those of berseem hay. Cattle can feed on K. scoparis safely up to 40 % in the diet (Garduno et al., 1993). Tagel Din et al. (1991) studied the effect of inclusion of K. indica hay in complete diets, containing 45 % roughage and 55 % concentrates, at the level of 0, 15, 30, and 45 % instead of berseem hay on dry matter intake, digestibility coefficients, nutritive value and nitrogen balance by sheep. They reported that there were no significant differences in all parameters amongst the four diets. Nour (1995) fed fresh or dried Kochia indica alone and dried Kochia indica plus restricted amounts of rice bran or wheat bran or corn ear to sheep and goats. He found higher intake of sundried Kochia and rice bran or wheat bran, which were higher than fresh Kochia alone, without significant differences. Digestibility coefficients in sheep fed fresh Kochia were higher than sundried Kochia without or with concentrates, respectively.
nutritive values (TDN and DCP) of fresh Kochia were higher than those of sundried Kochia either alone or supplemented with concentrates. Nitrogen utilization was similar in fresh and dried Kochia. Tagel- Din et al. (1991); Nour (1995) concluded that Kochia indica could be used as a good green fodder or hay for ruminants, specially in newly reclaimed land of relatively high salinity, for its higher content of crude protein and higher palatability compared with berseem hay which is becoming scarce and expensive.

**Acacia species**

The number of feed materials from shrub and tree forages in developing countries is enormous. However, only few sources have been incorporated into ruminant feeding systems. The value of these forages in animal feeding is associated with features such as abundance, accessibility, protein content and quality, energy, minerals and vitamins (Ramirez, 1996). The value of shrub forages for ruminants are greatest in the more extensive system in the arid and semi-arid regions, in which browse in the diet of goats is very important (Kibria et al., 1994).

Acacia and Atriplex species represent groups of plants well adapted to salt and drought stress. Several studies recommended the magnitude of cultivating such forages in saline soils as good feed resources (Draz, 1983; Anon, 1992). However, proper conservation of these shrubs could improve their palatability and nutritive values since feeding fresh materials hardly sustain the maintenance requirements of animals (El-Shaer et al., 1990). Abou El-Nasr et al. (1996) collected the succulent parts of the fresh acacia and saltbush (leaves and lush stems) from the Ras Sudr Research station, separately, air-dried for 30 days to produce saltbush (Atriplex nummularia) hay and acacia (Acacia saligna) hay. Similar fresh materials were allowed to wilt to an average 40 % DM, then chopped (3-5 cm) and each material was mixed with 10% molasses on DM basis, and ensiled in cemented pits for 45 days. Six digestion trials were conducted to determine the digestibility coefficients and the nutritive values of saltbush (fresh, hay and silage) and acacia (fresh, hay and silage). The results indicated that fresh acacia contained lower CP (10.5%), CF (26.4%) and ash (13.9%) and higher EE and NFE (44.1%) than fresh saltbush. Acacia hay contained higher CP (10.1%), EE (4.4%), NFE (44.1%)
and lower ash (13.3%) than saltbush hay. Acacia silage contained lower CP (10.2%), CF (25.3%), ash (13.1%) and higher EE (4.9%), NFE (46.5%) than saltbush silage. ADF, NDF and ADL of acacia were higher than that of saltbush. Both silage appeared to have optimum level of pH (4.1 and 4.5). Lactic acid and total VFA, s were higher in acacia silage than saltbush silage, the opposite was observed for concentration of NH$_3$-N % (0.26 vs 0.48). Dry matter intake (g/Kg$^{0.75}$) from acacia was lower (47.6-55.0) than that from saltbush (50.2-69.7). Digestibility coefficients of DM, CP, CF, NDF and ADF of acacia were lower than those of saltbush. They concluded that ensiled shrubs appeared to be the most nutritious diets. They can successfully provide sufficient digested nutrients (TDN and DCP) and characterized by reasonable DM intake. The fresh, air-dried or silage materials could enhance their palatability, consumption and nutrients utilization. Leaves of these shrubs, Acacia rigidula (blackbrush) and Acacia farnesiana (huisache), are consumed by livestock and deer. Leaves of balackbrush acacia contained higher levels of condensed tannins. Condensed tannins can form a complex with protein and can adversely affect N and cell digestion by ruminants (Robbins et al., 1987; Reed et al., 1990; Ramirez et al., 1993,1995). Ramirez and Ledezma-Torres (1997); Ramirez and Lara (1998) reported that the huisache contained more N than alfalfa hay and the black brush acacia. Inclusion of black brush and huisache in mixed diets increased dry matter intake and crude protein intake comparing with the diets contained alfalfa hay. However, the digestibility of CP, NDF, ADF were lower for acacia diets than those of alfalfa diets. Nitrogen retention of goats fed acacia diets were higher than that of goats fed on alfalfa diet. Condensed tannins in acacia shrubs had negative effects on CP, NDF and ADF digestibility. Woodward and Reed (1996) reported that Acacia brevispica and Sesbania sesban were beneficial supplemental nitrogen sources for sheep and goats. Sesbania sesban had low fiber and negligible tannin contents, enabling rapid fermentation that is characteristic of other quality leguminous feeds (e.g. alfalfa). However, Sesbania sesban could cause a high level of plasma nitrogen that would be excreted before it could be incorporated into tissue. Acacia brevispica contained tannins, which reduce the availability of feed nitrogen by forming indigestible tannin-protein complexes. It could be concluded that acacia species
leaves and pods could be used as feed for sheep and goats after mixing with readily available energy in arid lands in Northern East of Egypt.

**General recommendation**

The strategy for using halophyte plants, as feed for livestock production has the highest probability of success, is inclusion of moderate levels of halophyte ingredients into mixed diets. Halophytes can be used at moderate levels, if sufficient fresh drinking water is provided to animals to allow efficient excretion of the excessive minerals. Halophyte plants contained higher levels of crude protein and ash, and lower readily available carbohydrates than most of conventional feeds It must be supplemented or mixed with another ingredient feed that a good source of readily available energy, e.g. barley, corn, molasses and concentrate mixture to dilute the high minerals content, especially sodium chloride and adjust the N: C ratio. The level of halophyte inclusion in mixed diets could adjust to minimize any direct adverse effects on animal productivity, and to support a level of productivity necessary to justify the expense of growing halophytes under irrigated conditions. Where conventional feedstuffs are available, halophyte plant ingredients will apply only if cost per unit energy or per unit of production is comparable with those of competing feeds.

*Salicornia bigelovii* could be planted at the Mediterranean Sea and Red Sea coastal, which are silty lands, and irrigated with seawater. Three different products are obtained: 1- good quantity and quality oil, contained high percentage of essential fatty acids, can be used in human, birds and livestock animal feeding; 2- meal, a source of crude protein similar to cottonseed meal, can be used in ruminant nutrition and 3- straw, similar to wheat straw or Rhodes grass, can be used in mixed complete diets up to 30 % as dry matter basis for ruminants.

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النباتات الملحية هي مجموعة من النباتات التي تتحمل المستويات العالية من الملوحة في الماء والترغيم وتتحمل درجة من الجفاف. بعض النباتات الملحية يمكنها النمو والتطور واستخدامها كنباتات محصولية تحت ظروف الري بماء البحر وذلك بفضل قيمتها الغذائية عالية كمواد علف ومعظمها عيالياً. يوجد في مصر 48 نوع من النباتات الملحية ويذهن من 32 جنس و 7 عائلات. وتعتبر النباتات الملحية يعتبر من العوامل المحددة لاستخدامها كمواد علف للحيوانات المزرعة. يمكن استغلال نسبة الملح في النباتات الملحية التأثير على نسب المادة العضوية والتربة بكميات كبيرة من الفيتامينات والمغذيات. النباتات الملحية مثل نبات الساليكورنيا والكوكيا والأكاسيا والقطف الملحى، وهي أيضاً محاصيل زيتية مثل الساليكورنيا أو مواد علف مثل باقي النباتات. يحترم نبات السالمونية أحد النباتات الزراعة المغذية للطعام والجفاف وتزرع في الأراضي الملحية وتزرع بحوض البحر وينتج الهدايا حوالي 18 طن مادة عضوية وتمت النهوض من إليها إلى 15% من كمية المحصول التي تحتوي على 30% -33% بروتين حمض ويحتوي نبات السالمونية على 5% - 7% رماد و 4% إلى تت كود غير السالمونية 6% - 8% بروتين حمض. وتنطلق من استخدام هذه المنتجات في تغذية الحيوانات المزرعة، أولاً في نزاع الناس، وذلك ثم منافسة استخدام الطف والكوكيا والأكاسيا كمواد علف في تغذية الحيوانات المزرعة.