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LEUCAENA LEUCOCEPHALA AS A FEED FOR RUMINANTS IN TROPICAL AND SUB-TROPICAL AREAS.

S.A.H. Abo El-Nor

Dairy Science Department, National Research Center Dokki , Egypt .

INTRODUCTION

Leucaena is the common name for leucaena leucocephala . Which is commonly known as acacia in Muritius ; Koahoole in Hawaii ; Ipil-Ipil in the Philippine; Lead tree in Carribean and Wild tamarind in the west Indies (NAP , 1984). Leucaena is considered a green legume used for animal feeding in tropical and sub-tropical areas. It has a high content of protein , gives a high yield of green plant and bears different environmental circumstances. Through its many varieties, leucaena can produce nutritions forage , fire wood , timber and rich organic fertilizer. Its diverse uses include revegetating tropical hillslopes and providing windbreaks, firebreaks, shade and ornamentation. Although individual leucaena trees have yielded extraordinary amounts of wood-indeed , among the highest annual total ever recorded and although the plant is responsible for some of the highest weight gains measured in cattle feeding on forage , it remains a neglected crop, its full potential largely unrealized. The plant's drought-tolerance and hardiness make it promising candidate for increasing meat and milk supplies throughout the dry tropics. Leucaena helps to enrich soil and aid neighboring plants because its foliage rivals manure in nitrogen content and natural leaf-drop returns this to the soil beneath the shrubs. Leucaena seedling grow slowly at first and this complicates plantation establishment: aggressive weeds or adverse climatic conditions can lead to total failure of the planting (NAP,1984).

Moerover, the development of animal production in many parts of the tropics and sub-tropics areas is limited to the availability of good quality forages. Forage deficiency is particularly marked in areas with a long dry season when green feed is limited or absent . The use of legumes to contribute nitrogen to the system and to provide high protein feed into the dry season has resulted in some dramatic increases in animal production in the tropics and sub-tropics areas (Stobbs, 1972 ; Upadhyaya, *et al.*, 1974; Jones ,1981; Jones and Megarrity, 1981 , Abo El-Nor , 1987 and 1991; Khattab *et al.*,1999 and McSweeney and Palmer , 1999), which have encouraged the more widespread adoption of this technology . A number of legumes are now available for use in tropical and sub-tropical areas (Hutton 1970 and 1974) among of them *Leucaena leucocephala* had been given prominence in National Acadmy Press publications (NAP,1984) . Moreover, it has the following advantages:

1- It is a highly palatable, succulent, protein rich green fodder.
2- Due to the presence of tannins, its proteins are degraded slowly in the rumen .
3- It fixes nitrogen in the soil and thus builds up soil fertility.
4- It can be planted on hill sides to provide wind breakers, shade to sensitive crops and to prevent soil erosion (Jones and Megarrity, 1981). The present review is concerning with the value of leucaena as an animal feed for ruminants to increase their productivity particularly in sub- tropical zones and newly reclaimed lands

Keywords: *leucaena leucocephala, ruminants, tropical and sub-tropical areas, forage, legumes*

Agronomic Characteristics

Leucaena leucocephala, formerly known as *L. glauca,* is a thornless long-lived shrub or tree which may grow to heights of 7 -18 m. The leaves are bipinnate with 6 -8 pairs of pinnae bearing 11 -23 pairs of leaflets 8 -16 mm long. The inflorescence is a cream coloured globular shape which produces a cluster of flat brown pods 13 -18 mm long containing 15 -30 seeds . Botanically, leucaena belongs to the family Mimosaceae; it is the best known species of the Leucaena genus and has a variety of common names. According to NAP (1984) there are, however, at least 14 other species recognised in the genus. These are *L. collinsii, L. cuspidata, L. diversifolia, L. esculenta, L. greggii, L. lanceolata, L. macrophylla, L. multicapitula, L. retusa, L. pallida, L. pulverulenta, L. salvadorensis, L. shannoni* and *L. trichodes. Leucaena leucocephala* and *L. pallida,* and one subspecies of *L. diversifolia,* are polyploids (104 chromosomes) while all other species are diploid (52 or 56 chromosomes). *Leucaena leucocephala* and the tetraploid varieties of *L. diversifolia* are self-pollinating while the others are outcrossing (NAP , 1984).

The species may be distinguished on the basis of their tree size, flower colour, leaflet size and pod size (Anonymous , 1990). These same authors consider the genus Leucaena to be an interbreeding complex capable of producing many interspecific hybrids. For instance, *L. leucocephala* crosses readily with *L. diversifolia* and *L. pallida* producing hybrids from which selection for improved growth form, psyllid resistance and cold tolerance is possible. *Leucaena pallida,* in particular, has excellent seedling vigour and hybridisation of this species with *L. leucocephala* has the potential to produce a new highly productive and psyllid resistant Leucaena (Sorensson *et al.*, 1998).

Leucaena grows well in a wide range of soils with the marked- exception of very acid soils (with low base status) and waterlogged soils and is particularly well adapted to calcareous clay soils. These characteristics have been well documented in the review of Gray (1968) ; Oakes (1968) ; Hill (1971) ; NAP (1984) ; Abo El-Nor (1987 and 1991) and Kadiata and Nokoe (2000). Leucaena helps to enrich soil and aid neighoring plants becuause its foliag rivals manure in nitrogen content . Leucaena seeding grow slowly at first and this complicates plantation establishment : aggressive weeds or adverse climatic conditions can lead to total failure of the planting (NAP, 1984) . Thus Cupta and Chopra (1985) reported that leucaena is one of the most useful perennial leguminous plant. It can be grown over a wide range of climates. This due to it has deep tap root system making it tolerant to drought and often provides green fodder in the dry season. pests and diseases do not appear to attact it. In its tender form, it can be used as a fodder, but the mature plant is used as fire wood and making paper pulp (Wong and Gibbs , 2000).

Jones (1981) reported that the leucaena will grow anywhere in the tropics and sub-tropics within an annual rainfall range of 500 to 3000 mm. Its Rhizobium requirements are highly specific and all seed must be inoculated. While also to grow in frosty conditions its yield is greatly reduced at low temperatures , at high altitudes and in dry conditions . In the wet tropics, yields of 20 t dry matter/ ha/ year have been obtained with crude protien yields in excss of 3 t / ha , similar results were obtained by Abo El-Nor (1987) , under Egyptian conditions . These are much higher than for most other tropical legumes are equivalent to nitrogen fixation rates of up to 500 Kg N /ha / year (Jones, 1981). Abo El-Nor (1987) reported that increasing plant distance and number of plants per hill to 4 plants caused an increase in plant height , number of leaves and branches at 4 and 5 months from planting .The rate of increase was higher at 5 months than that at 4 months . More production per unit area from leucaena plant parts, i.e. stems, branches, leaves and whole plant was obtained as the number of plants per hill was increased and as distance between hill was decreased. The cutting of the plant can be started after 15 to 18 weeks. The first cutting of the plant is done when it is 60 cm above the ground .Subsequent cutting can be taking at an interval of 6 to 8 weeks before the shoots become fibereous (Abo El-Nor,1987). Leucaena is not tolerant of poorly drained soils, especially during seedling growth and production can be substantially reduced during periods of waterlogging. However, once established it can survive short periods of excess moisture. Leucaena does best on deep, well drained, neutral to calcareous soils; it is often found naturalised on the rocky coralline terraces of Pacific island countries. However, it grows on a wide variety of soil types including mildly acid soils (pH > 5.2). It is well adapted to clay soils and requires good levels of phosphorus and calcium for best growth (Sivasupiramaniam *et al.* , 1986). Leucaena can be planted by seed or 'bare stem' seedlings. Large areas are best planted by seed in rows into fully prepared seed beds or into cultivated strips in existing grasslands. Seeding rates of 1-2 kg/ha at depths of 2-3 cm are usually recommended in rows 3-10 m apart. Sowings are best made early in the growing season but when rainfall is reliable using good weed control measures (cultivation and herbicides) to minimise competition; leucaena seedlings are very susceptible to competition in the root zone. Trifluralin (0.5 kg active ingredient /ha) for grass species and Dacthal (8-10 kg /ha) or 2,4-D amine (6 kg /ha) for broadleaf species are recommended for pre-emergence control of weeds (Brewbaker *et al.,* 1985). Fusilade (2 kg /ha) and Basagran (2 kg /ha) are recommended for post-emergence grass and broadleaf weed control respectively. Hand weeding or mechanical cultivation are also effective means of controlling weeds (Wilson , 1998). Fertilisation at planting will be necessary on most soils to achieve vigorous seedling growth as many tropical soils are infertile following years of intensive cropping, leaching and erosion from high intensity rains. leucaena is particularly susceptible to phosphorus deficiency and is dependent on Vesicular Arbuscular Mycorrhizae (VAM) to extend the capacity of its root system to access immobile nutrients such as phosphorus. In soils low in phosphorus, or low in natural VAM activity, quite high rates of phosphorus (100 kg P/ha) should be applied (Wilson, 1998). Leucaena is also sensitive to calcium deficiency as this will reduce nodulation. Other nutrients may be necessary if soil tests indicate a deficiency, to ensure vigorous early growth of seedlings. In very acid soils (pH < 5.0), liming is necessary. In the past, 'starter' nitrogen was often applied as *Rhizobium* strains were slow to nodulate and begin fixing atmospheric nitrogen. 'Starter' nitrogen promoted both early growth and nodulation although very high rates tended to suppress nodulation completely. However, with the more effective *Rhizobium* strains currently available, 'starter' nitrogen should not be necessary although the use of nitrogen in nursery plantings is advised (Wilson,1998) .

Leucaena may be planted as single plants, single hedgerows or multiple hedgerows depending on its use. In the latter case, hedgerows may be closely spaced (75-100 cm) to achieve maximum yield per hectare for cut-and-carry feeding or more widely spaced (3-10 m) for alley cropping or grazing. Intra-row plant spacings of 25-50 cm are adequate. In widely spaced rows for grazing, grasses may be planted between leucaena rows to increase total fodder supply to animals. In Australia, green panic (*Panicum maximum* var. *Trichoglume*), setaria (*Setaria sphacelata*), pangola (*Digitaria decumbens*) and buffer grass (*Cenchrus ciliaris*) have been successful companion grasses for leucaena (Akyeampong and Dzowela , 1996).

Productivity

Dry matter productivity of leucaena varies with soil fertility and rainfall (Brewbaker *et al.*, 1985) . Edible forage yields range from 3 to 30 tons dry matter / ha / year. Deep fertile soils receiving greater than 1,500 mm of well distributed rainfall produce the largest quantities of quality fodder. Yields in the subtropics, where temperature limitations reduce growth rates, may be only 1.5-10 tons of edible fodder / ha /year (Brewbaker *et al.*, 1985).

The most suitable cutting or grazing intervals to promote high yields vary with environmental factors. In general, longer intervals between defoliation have increased total yield ; however, the proportion of inedible wood may also increase leading to a decline in forage quality. At very productive sites, harvest intervals may be 6-8 weeks and up to 12 weeks at less productive locations. Harvest height has less influence on total yield than harvest frequency (Akyeampong and Dzowela , 1996).

In Australia, it is recommended that regular heavy grazing of leucaena does not commence until plants are mature and well established (NAP,1984). This may take 1-3 years depending on growing conditions. However, light grazing can occur in the first year when plants reach 1.5 m in height especially if frosts and wildlife may damage leucaena plants during winter. Grazing promotes branching, results in a protective thickening of main stems and can remove flowers and pods which reduce growth rates (NAP,1984).

Oakes and Skov (1962) obtained green forage yields of 25 tons per acre per annual from 4 cuttings from the crop grown 80 feet above sea level ; 18 tons from 2 cuttings at 700 feet and plants at 2000 feet elevation grew only 2 feet in years . The authors added that the growth rate and production of the plant depend largely upon natural soil fertility and rainfall, however, increased yields result from the use of fertilizers and irrigation . Thus , Ferraris (1979) concluded that the total dry matter production was 20 ton /ha/ year for whole plant and 10 ton / ha / year for leaf with nitrogen content of 20.9% and 3.9 %, respectively on fresh matter basis. However, yields and nitrogen content were unaffected by number of rows per hedges or by pruning height.

Regular grazing of well established rows of leucaena leads to the development of quite uniform hedgerows. Taller plants or branches are readily broken and reduced in size by hungry animals. In Vanuatu and Papua New Guinea, cattle graze in leucaena thickets which may be up to 10 m in height (NAP,1984). Cattle graze lower branches and newly emerging seedlings and the upper canopy is kept as a drought reserve. The amount of leucaena material available for grazing is reduced in this system of management. Leucaena paddocks are normally rotationally grazed with cattle moved to new areas when most leaf and edible stem have been removed and before serious damage to the wooden framework of the plants has occurred (NAP,1984).

Chemical composition

Leucaena leucocephala is a multipurpose leguminous plant . There are controversial reports in the literatuer regarding the suitability of feeding leucaena to the ruminants because it contains substances like mimosine and tannins (Felker and Sorensson, 1998, Karachi, 1998 ; Abo El-Nor , 1987 and 1991; Jones, 1979 ; Upadhaya *et al*., 1974 and Singh and Mudgal , 1967) . Certain reports indicate that it can be fed safety to cattle and buffaloes to the extent of 30- 50 % of the green (Jones *et al.* , 1978 ; Hiremath , 1981; Abo El-Nor , 1987 and 1991and Khattab *et al.* , 1998).

Although leucaena contains high dry matter (DM) organic matter (OM) and crude protein (CP) values (Table , 1) , which are like almost 2 and 4 folds that of fresh 2nd cut berseem (Abo El-nor,1987). Moreover , EE and NFE contents are higher than the corresponding values of the winter or summer Egyptian forage crops (Abo El-nor,1987 and 1991) .

Table (1) shows the chemical composition, mimosine and minerals content of leucaena leaves (on DM basis) at different stages from planting . Data of Table (2) showed that dry matter, crude fibre and nitrogen free extract percentages seemed to increase gradually by age.Crude protein and EE contents were shown to be more higher at the early stage of growth and gradually decreased with advancing stage of growth . Total ash conent is increasing as the age of the plant increased . Mimosine content was shown to get the same trend of protein content in relation to the stage of growth. The highest mimosine content was obtained at 4th month and decreased gradually to reach the lowest content at 12th month from planting . Minerals content of leucaena leaves at different stages of maturity showed that phosphorus percent was the highest at the easliest stage of growth and then decreased gradually with age . Soduim, potassium and magnesium content were shown to be low at the 4th month and then increased by age . Maximum micro elements were recorded at the early stage of growth and then decreased to the minimum percentage at 12th month from planting (Abo El-Nor ,1991) . Gupta and Raheja (1986) reported that CP content of leucaena seed was 36.5% and true protein accounted was 25.1% (Table, 2). This suggested that it is a good protein source. The NDF content was 25.6% and ADF content was 17.6 % as DM with high cell contents (74.7%) and low ash and tannin contents . The seeds could be considered as a good feed source . The macro-and micro-element analysis (Tables, 3) revealed that the seeds were moderate sources for Ca and P and had optimum Fe, Zn, Mn and Cu contents for use in feeding of ruminants. However , the minerals content of the seed is likely to be influenced by variety, climate and soil conditions (Smith *et al.*, 1992).

Leaf material of leucaena compares favourably with alfalfa leaf material in terms of protein and minerals.Data of Table (4) shows that amino acids composition of leucaena and alfalfa leaves are very similar except for the higher isoleucine content of leucaena . The presence of significant amounts of tannins in leucaena may also have an important role in the protection of protein from degardation in rumen and therefor in mak it more available in the small intestine (NAP ,1984).

Nutritive value

B-carotene content of leucaena would be a distinct advantage for such high energy ratios, which required high levels of vitamin A (Preston and Willis, 1970) . Leucaena had been as a protein supplement with other feeds there have not been toxic effects on the animals . The beneficial effects recorded had been comparable with those derived from concentrated protein sources such as

Table (1) : Effect of advance in maturity on chemical composition, mimosine and minerals of sun-dried leucaena leaves.

Items	Months					
	4	5	6	7	9	12
DM %	88.50	90.20	92.60	93.90	95.00	95.80
Ash %	6.90	6.40	8.50	9.10	9.90	10.10
OM %	93.10	93.60	91.50	90.90	90.10	89.90
CP %	39.00	37.60	33.00	31.00	29.60	27.00
EE %	7.20	4.50	5.60	5.20	5.00	5.80
CF %	13.00	14.50	15.70	16.20	17.00	17.80
NFE %	33.90	37.00	37.20	38.50	38.50	39.30
Mimosine %	3.40	3.22	2.95	1.93	0.79	0.69
P %	0.750	0.578	0.541	0.511	0.444	0.421
Ca %	0.202	0.232	0.270	0.307	0.423	0.663
Na %	1.264	1.442	1.766	2.676	2.693	3.064
K %	2.190	2.460	2.543	2.530	2.917	3.121
Mg %	0.186	0.217	0.239	0.292	0.321	0.353
Cu ppm	68.296	52.472	45.890	39.980	27.878	24.580
Fe ppm	55.710	53.149	49.75	48.99	39.560	35.648
Zn ppm	40.058	38.245	35.082	21.500	16.020	21.919
Mn ppm	55.830	52.820	51.018	43.440	40.600	28.734

(From , Abo El-Nor ,1991).
 # DM : Dry matter ; OM :Organic matter ; CP : crude protein ; EE : ether extract ; CF :crude fidre ; NFE : nitrogen free extract .

Table (2) : Chemical composition of leucaena seeds (% DM basis). (From Gupta and Raheja , 1986)

Constituents	Concentration
CP	36.50
TP	25.10
NDF	25.60
ADF	17.60
CF	13.70
Cellulose	15.00
Lignin	2.64
Hemicellulose	7.94
Cell contents	74.40
Total ash	3.91
Mimosine	4.00
Tannins	4.86
Total Lipids	7.30
Polar Lipids	2.84
No Polar Lipids	4.46

(From Gupta and Raheja, 1986)

ground nut cake and meat meal (Karachi, 1998).

Leucaena leaf is also an excellent source of B-carotene, which could be a valuable characteristic, particularly during the dry season when leucaena is able to return green leaf better than many other pasture species (Karachi,1998). Morover, Jones, 1979, reported that Leucaena leucocephala is very palatable to livestock. Regrowing shoots , 0.5 to 1 m long , are usually composed 75 to 80 % of highly nutritious leaf . The young green steems up to 5-6 mm diameter are also eaten .Thickened stem is for less palatabie and nutritious then the leaf or young stems . The leaves , young , flowers and pods are all excellent sources of proteinand minerals . Leaf material of leucaena compares favourable with alfalfa or lucerne leaf material in terms of protein and minerals , the amino acid composition of these two species is very similar except for the higher isoleucine content of the leucaena . The presence of significant amounts of tannins in leucaena may also have an important untritional aspect (Jones , 1979) . These tannins may have an important role in the protection of protein from degradation in the rumen and therefore in making it more available in the small intestine . The calcium concentration in leucaena appears to vary considerably , depending on the location . Leucaena leaf material is also an excellent source of B – carotene , which could be a valuable characteristic , particularly during the dry season when leucaena is able to retain green leaf better then many other pasture species (Jones, 1979) . Moreover , Rosas *et al.*(1980) showed that leucaena leucocephala wold be an acceptable forage for ruminants and was similar income position to pilgeon pea and lucerne . Shukla , 1982 , noted also thet leucaena leucocephala has been popular as feed for cattle , goats , sheep etc. because of its high protein content and high palatability , but its value as an ideal fodder has been limited due to the presence of mimosine .

Lowry , 1983 , reported thet leucaena forage is highly palatable , digestible and nutritious , although it is in variable low in sodium and some times low in iodine . Animals fed a sole diet of leucaena require minerals supplementation for good live weight gains . The drough tolerance and persistence in grazed pastures of leucaena are other attributes which have contributed to its increasing popularity for fodder production on well drained non – acids soils in the tropics . Moreover, Von u. Ter Meulen and El – Harith , 1985 , reported thet leucaena's forage compromises a source of nutrients and roughage and make an almost complete ruminant feed . The crude protein content , which is normally over 25% of the dry matter , has a high nutritional quality and its amino acids are comparable to those contained in soyabean . Leucaena leaf meal is agood source of B-Carotene; the B-Carotene in malawi leucaena leaf meal amounted to 227-228 mg / Kg DM . Leucaena leaf meal could be a ritcher source of vitamin K than alfalfa leaf meal . Moreover , leucaena's forage can also be considered a good source of calcium , phosphorus and some trace elements.Thus, Devendra , 1987 , showed that leucaena leaves and forages (leaves + stems + pods) have been the most widely used of the green feeds in feeding systems for buffaloes . The consistent conclusion that emerges is the fact that leucaena supplementation was advantageous for meat and milk production.

Abo El-Nor , 1987 , found thet the In-Vitro dry matter and organic matter disappearance were 71.70 and 68.00% , 44.70 and 40.50% and 37.00 and 28.50% for concentrate feed mixture , leucaena and berseem hay , respectively . However, values of In-Vitro – dry matter disappearance (IVDMD) were similar for different mixtures of berseem hay and leucaena forage with ratios of 50 : 50%, 25 : 75% and 75 : 25% being 46.4 ,44.5 and 46.0%, respectively .The associative effects of the mixture of berseem hay and leucaena forage were positive for DM being + 5.55 , + 1.71 and +7.07 for berseem hay : leucaena forage ratios of 1 : 1 , 1 : 3 and 3: 1 , respectively . While the corresponding values for OM were + 4.2 , + 0.175 and + 6.5 . The combinations of concentrate feed mixture and leucaena forage ratios of 75 : 25%, 50 : 50% and 25 : 75% showed digestion coefficients for DM and OM of 66.0 and 41.9%, 57.0 and 41.8, 55.0 and 55.7%, respectively . The associative effects of there rations were positive for DM being + 1.05 and + 3.55 for 75 : 25% and 25 : 75% (concentrate : leucaena) ; while a negative effect was recorded with 50 : 50% (concentrate : leucaena) being – 1.2 . More pronounced negative associative effect was recorded for mixture of 75 : 25% (concentrate : leucaena) and 50 : 50% (concentrate : leucaena) , in IVOMD being – 19.23 and – 12.45 ; while a positive associative effects were recorded for 1:3 (concentrate : leucaena ratio) being + 8.33 unit percentages (Abo El-Nor , 1987) .

Hulman *et al.* , 1978 and Khattab *et al.* , 1998 , found lower level of rumen ammonia associated in – vitro fermentation of leucaena compared with ground nut cake or soybean meal , which means that the degradablility of ground nut cake or soybean meal were considerable greater than that of leucaena.

There are very few reports on the digestibility of leucaena when fed to ruminants. Values ranged from 50 to 71 percent for dry matter digestibility as reported in the literatures (Hutton and Bonner , 1960 ; Singh and Mudgal ,1967; Upadhyaya *et al.*, 1974; Joshi and Upadhyaya ,1976; Gupta *et al.* , 1979; Gupta *et al.*, 1980 ; Abo El-Nor , 1987 and 1991; Felker and Sorensson, 1998 ; Khattab *et al.* , 1998 ; Karachi, 1998; McSweeney and Palmer, 1999 and Nherera and Ndlovu ,1999 and).

A digestion trial with four adult Barbair bucks with an average body weight of 19Kg was conducted to determine the nutritive value of leucaena leaves (Upadhyaya *et al.*, 1974). The animals consumed an average 2.16 Kg dry matter per 100 Kg body weight . Digestibility co-efficient of DM, CP, EE, CF and NFE were found to be 71%, 78%, 47%, 57% and 81%, respectively. The DCP and TDN values were 16.73 and 70.22 percent, respectively . All the animals showed positive nitrogen and calcium balance and only one animal out of four showed negative phosphorus balance . Similar results were obtained by Abo El-Nor , 1987 and Karachi, 1998.

Rosas *et al.* (1980), showed that leucaena leucocephala would be an acceptable forage for ruminants and was similar income position to pilgeon pea and lucerne . Shukla (1982) and Abo El-Nor (1987 and 1991) noted also that leucaena leucocephala proved to be a good feed for cattle, buffaloes, goats and sheep because of its high protein content and high palatability.

Obst *et al .*, (1980) determined the respose of Indonesian sheep and goats offered a sole diet of leucaena and measured dry matter intake (DMI) , dry matter digestiblity (DMD) and live weight gains (LWG) for pelleted and fresh leucaena . They found that the intake of pelleted leucaena were greater than , or equal to those for fresh leucaena . However , live weight gains and digestibilies were significantly higher , within breeds , for fresh leucaena .

Carpenter and Niino – Duponte , (1981) found that the average DM digestibilities of live forage plants by goats were 56.79 , 51.24 and 56.76 % for alfalfa , leucaena , california grass, respectinely . While the corresponding values of CP digestibility were 72.86 , 68.65 and 64.18 %.

Jaikishan *et al.*, 1986, studied the nutrients utilization as influenced by incor- poration of subabul (leucaena leucocephala) to replace 25 and 50 % of DCP intake in goats . They found that average DMI ranged from 3.31 to 3.69 Kg / 100 Kg body weigh . TDN and DCP intake , the digestibility co- efficient of various nutrients (except CF and NFE), DE and ME values were lower in 50 % leucaena than those in zero and 25 % leucaena .

Kurar *et al.* , (1984) , selected twelve karan swiss (brown swiss x sahiwal) calves . Animals were distributed among 3 groups of 4 animals each in randomized block desing . Animals in group I were fed concentrate feed mixture to meet the DCP requirement . In group II , 25 % and in group III , 50% of the DCP requirements were met by feeding leucaena leucocephala leaves . Wheat straw was fed adlib . The DM intake / 100 kg weight was 2.840 , 2.746 and 2.79 kg for groups I ,II and III , respectively . The average apparent digestibility co-efficients of DM , OM , CP , EE , CF and NFE were almost similar in all groups . The TDN and DCP required / kg live weight gain was significantly higher for calves of group III .

Bhaskap *et al.* , (1987) , fed six crossbred steers for 28 days on 2 kg leucaena leave meal and 2 kg rice straw daily towards bulk requirement. Total daily DM intake was 4.77 , including 1.82 kg from leucaena and 2.89 kg from rice straw . leucaena was found to contain 48.6 TDN and 22.8 DCP . Dry matter digestibility was found to be 49.1 %.

Animal performance

Leucaena cut from natural stands growing in the Philippines and in Indonesia has been traditionally used for fattening cattle (NAP, 1984) . In the Philippines chopped leucaena shoots mixed with rice bran are used for finishing cattle. Similarly , in parts of Indonesia Timor, cattle are fattened for approximately six month on a diet essentially of leucaena and the pseudo-stems of bananas . The higher soil fertility around homesteads would enable vigorous growth of leucaena to take place while its value as a supplement during the dry season, in combination with rice straw and crop residues , would be an important adjust to the diet of both working animals and fattening animals under such conditions. Experimental results have confirmed the value of leucaena as a supplement to roughages low in protein to improve animal production. For example , Leng and Preston (1976) and Siebert *et al.* (1976)) reported that supplementing diet of chopped sugar cane with leucaena with an overall protein content of the diet was 9 % gave daily live weight gains of 0.6 Kg / head , identical to steers fed sugar cane and meat meal with an overall crude protein content in the diet of 10 % .

Steers given fresh leucaena in their daily ration at 20 % with sorghum hay had higher liveweight gains even when the total feed was restricted to 2.5 percent of the live body weight. After 112 days on leuceana supplemented rations, liveweight gain (LWG) of steers was 58 kg and for those on 80% leucaena was 11 Kg while it was 35 kg for control ration . Mean daily dry matter intakes for the three diets were 3.85, 3.91 and 1.99 Kg for animals recevied diets contained 0 , 20 and 80 % leucaena , respectively . The efficiency of the diet containing 20 % leucaena was higher (7.62 Kg feed / Kg gain) than that of the sorghum hay diet (12.3 Kg feed / Kg gain ; NAP, 1984).

As a supplement to rice straw , leucaena fed to bulls has enable reasonable gains to be achieved . Daily gain of 0.53, 0.38 and 0.36 Kg / day resulted from feeding 60 % rice straw + 40 % concentrates ; 60% rice straw + 40% dry leucaena leaves and 10% rice straw + 90 % leucaena leaf , respectively (Perez, 1976) . For fattening animals, on ration containing of 50 % rice straw + 50% concentrates supportted daily liveweight gains was 0.54 Kg compared with 0.71 Kg when the ration was composed of 35 % rice straw + 35 % leucaena leafs + 30 % concentrates (Perez , 1976) .

Sun dried leucaena leafs has been used as a supplement for grazing animals during the dry season in Malawi. Supplemented steers gained more than the control, but gains were not statisticaly different from those obtained for animals recived a supplement of groundnut cake fed to provide the same level of crude protein in leucaena (Thomas and Addy , 1977).

Leucaena has also been used in intensive fattening rations in combination with forage and energy supplements. In Malawi Zebu and Zebu- Gross Friesian steers fed ration of maize stover, maize bran and leucaena in the ratio of one part of leucaena to four parts of maize stover and maize bran, gained 1.17 Kg per head per day. Leuceana in this study was used as protein supplement and the results of feed efficiency were comparable to ration supplemented with groundnut cake (Thomas and Addy, 1977) .

Intensive use of molasses and urea for fattening cattle requires some form of true protein, preferably by- pass protein for good liveweight gains (Preston and Willis ,1970). Leucaena, which has fairly low protein solubility in the rumen has proved to be an effective supplement for use with urea- molasses for intensive beef production (Alvarez *et al.*, 1977). In addition, the B- carotene content of leucaena would be a distinct advantage for such high energy rations, which require high levels of vitamin A for satisfactory animal performance (Preston and Willis , 1970).

Improvements in milk production, have been reported for animals fed leucaena in the tropics and sub-tropics (Henke *et al.* , 1950 ; Plucknett, 1970 ; Flores *et al.* ,1979 ; Abo El-Nor , 1987 and 1991and Khattab *et al.* , 1998) .

Improvements in milk production when dairy cows were given small supplements of leucaena in addition to the well fertilized rhodes grass pasture have been reported by Flores *et al.*, 1979 . The increase due to leucaena supplement occurred in spite of the fact that the fertilized pastures of rhodes grass contained over 20 percent crude protein . The effect of feeding 2 Kg leucaena leaves per cow per day was equivalent to feeding 250 gm of protected protein (Formal casein) .Thus feeding lactating cows on 2 Kg of fresh leucaena leaves each morning after milking raised milk yield from 9.6 to 10.3 Kg (Hutton and Beattie, 1976). Stobbs, *et al.*(1979) showed also that, the supplements of fresh leucaena resulted an increase of mean daily milk yields, solids-not-fat, protein, casein, fat and C4 to C16 fatty acids in fat but had no effect on feed intake of pasture .

Abo El-Nor (1991) studied the effect of replacing concentrates with leucaena hay on milk yield and composition of lactating buffaloes in Egypt . The data are shown in Table(5). The results clearly indicated that milk yield and FCM were increased as the level of leuceana in the ration was increased This improvement in production could be illustrated on the basis of the concepts of Thornton and Minson (1973) who reported that the response to leucaena feeding is probably due to its ability to overcome a protein deficency. Similar results with L. Imon and Baula (1978) who found that milk yield was increased from 4.6 to 7.3 Kg/head /day when Murrah buffaloes fed on leucaena dried leaves in replacement 50% of the conentrate protein of the ration . Abo El-Nor (1978) reported that replacing berseem hay with leucaena hay improved average milk yield and milk contents of fat , TP, TS , SNF , ash and minerals of lactating goats . Moreover , El-Bedawy *et al.* (1999), found that daily milk yield increased significantly by feeding leucaena to goats .

Toxicity of leucaena for ruminants:

The foliage and pods of leucaena contain the toxic amino acid mimosine which may reach 12% of the dry matter in growing tips but is less in young leaves (3-5% of dry matter) (Jones, 1979). Although quite toxic to non-ruminant animals, mimosine is broken down by microbes in the rumen to DHP (3 hydroxy-4-(1H)-pyridine , see Figure (1), a goitrogen, which is normally broken down further by rumen microorganisms to non-toxic compounds. The microbes are naturally present in ruminants in Indonesia and Hawaii and probably other countries of southeast Asia and the Pacific where there has been a long history of ruminant animals grazing naturalised leucaena.

However, in some countries, notably Australia, Papua New Guinea and perhaps African countries, the appropriate rumen microorganisms are not naturally present leading to an accumulation of DHP which causes goitre (enlargement of the thyroid gland) which results in listlessness, loss of appetite, excess saliva production, hair loss and loss of weight. However, this effect only occurs if leucaena introduced in animal's diet at high levels (>30%) for an extended period. Details of the discovery of the microorganisms which break down DHP by Dr RJ. Jones of the CSIRO Division of Tropical Crops and Pastures are described by Lowry (1987). Procedures for the transfer of the appropriate rumen microbes among ruminants have been developed in Australia.

Shiroma and Akashi (1976) found that rumen fluid from goats degradable the mimosine in leucaena tips from 0.3 to 60 mg/ g after 25 hours and ,with pure mimosine, 98 percent was degraded by the ruminant is alopecia 9 hair loss, which occurs sporadically when cattle are introduced to leucaena for the first time or when they receive rations containing high amounts of leucaena . However, experiments with goats in Queensland have showed that goats were affected by leucaena and their hair loss was similar to that encountered with cattle (NAP, 1984) .In addition to the alopecia noted when animals first have access to leucaena , there are other reports in the literature of toxicity in animals that have grazed leucaena for long periods. Clinical signs include alopecia , loss of appetite, excessive salivation, incoordination of gait , enlarged thyroid glands , poor breeding performance and the production of goiterous calves thet die at birth (Compere, 1959 ;Letts, 1963 ; Hamilton *et al* .,1968 ; Vohradsky, 1972; Jones *et al* ., 1976; Holmes, 1976 and Jons *et al*.,1978). Today , much of this fear is being dispelled . Ruminant animals in Indonesia . India , Hawaii , and several other countries have been shown to thrive without ill effect on diets of 100 % leucaena plus a salt supplement . It is now known that in most parts of the world , ruminants rarely have problems with mimosine because microbes in the first stomach alter mimosine to another compound , 3 , 4 – dihydroxy pyridine

Table (3) : Chemical composition of leucaena seeds (% DM basis).

Element	Concentration
Macro element (%)	
Calcium	0.50
Phosphorus	0.10
Magnesium	0.18
Sodium	0.51
Potassium	1.85
Micro element (ppm)	
Iron	50
Copper	16
Zinc	34
Manganese	35

(From Gupta and Raheja, 1986)

Table (4) : Comparative compositions of alfalfa (*Medicago saliva*) and Malawi-grown leucaena (NAP, 1984).

(a) General composition	Leucaena leaf	Alfalfa leaf
Total ash (%)	11.0	16.6
Total N (%)	4.2	4.3
Crude protein (%)	25.9	26.9
Modified-acid-detergent fibre (%)	20.4	21.7
Calcium (%)	2.36	3.15
Phosphorus (%)	0.23	0.36
□ -carotene (mg/kg)	536.0	253.0
Gross energy (kJ/g)	20.1	18.5
Tannin (mg/g)	10.15	0.13
(b) Amino acids	**Leucaena**	**Alfalfa**
Arginine (mg/gN)	294	357
Cysteine (mg/gN)	88	77
Histidine (mg/gN)	125	139
Isoleucine (mg/gN)	563	290
Leucine (mg/gN)	469	494
Lysine (mg/gN)	313	368
Methionine (mg/gN)	100	96
Methionine + cysteine (mg/gN)	188	173
Phenylalanine (mg/gN)	294	307
Threonine (mg/gN)	231	290
Tyrosine (mg/gN)	263	232
Valine (mg/gN)	338	356

(DHP) , which is then broken down further into nontoxic compounds . However , in Australia and a few other countries , DHP is not degraded because the requisite microbes are absent . Even where this is true , diets containing 30% or less of fresh leucaena appear to be safe for cattle . but feeding leucaena more extensively leads to goiter (enlargement of the thyroid gland); the animals become listless , their appetites and weight gains are depressed , they produce excessive saliva and some hair falls out (NAP, 1984) . Pregnant animals may also produce weak offsprings with enlarged thyroid glands .In studies where the level of leucaena in the diet of steers was varied from zero to 100 percent , rations containing up to 40 percent of leucaena resulted in good liveweight gain over a period of 112 days although the T4 levels in the serum of cattle on the 40 percent leucaena diet decreased to less then 20 n mol / litre by the end of the feeding period . Steers on the zero , 10 and 20 percent leucaene diets maintained normal T4 levels of 60 – 100 n mol / litre throughout (Jones, 1977) . It is therefore . suggested that diets containing less than 30 percent of leucaena would not be expected to cause toxicity problems in growing stock .

Detoxification

Most leucaena strains have about equal mimosine levels , but some from Colomdia and other species such as leucaena pulverulenta , from Northerr Mexico and Southern United States have much less (NAP, 1984) . Pioneering researchers in Hawaii and Australia have crossbred leucaena with leucaena Pulverulenta (i.e.Leucaena leucocephala) to obtain hybrids with less then half leucaena's mimosine content . The research in Australia has research an advanced stage , and low mimosine leucaena lines should be available for grazing trials in years (NAP , 1984) . Goat feeding trials have shown that , compared with strains available today , the new hybrids markedly reduced adverse effects caused by mimosine . Also , when fresh leucaena leaves are heated , their mimosine content decreases , cause their feed value to increase . (Abo El – Nor , 1991) . The reduction is greatest at temperatures above 70 C (158 f) . Also washing or soaking in water of the leucaena leaves considerably reduces their mimosine content without substancially influencing their raw protein content (Schulke *et al* ., 1982) .

Abo El – Nor (1991) studied the effect of different methods of detoxification and advance in maturith on mimosine content of leucaena (Table 6) he found that mimosine content was being high at the earlier ages and decreased gradually with advancing of age.

Mimosine content of leucaena leaf was reduced with increasing temperature of drying (Abo El –Nor, 1991) . Similar results were reported by Wong Choi Chee and Devendra (1982) who indicated that mimosine content of leucaena leaves was lowest with sudden heating or temperatures higher that 70 C and contact with acid (the enzyme is virtually inactive below pH 4) . They assumed these results indicate that drying leucaena under vacuum or oven heating caused decreasing of mimosine in leucaena leaves and there is almost no activity on rehydration .

Generally, many reports were dealing with methods of mimosine detoxification such as addition of ferrous sulfate (NAP, 1984), molasses supplement (Elliot *et al.* ,1985) , heating at 60 C(Kumar *et al.* ,1986) , ensiling (Khattab *et al.* ,1987) , soaking in water , treatment of 0.05 n NaOH (Murthy *et al.*, 1994) treatment of 0.05 % sodium acetate (El- Bedawy *et al.* ,1999).

Table (5): Overall means of milk yield and its contituent of buffaloes (for the different treatments) during the first 90 days of lactation period.

Items		Control	30% Leucaena T2	50% Leucaena T3
FCM 4%	(Kg/day)	8.27	9.68	11.53
Fat content	(%)	6.00	6.70	6.80
TS content	(%)	16.03	16.68	17.09
SNF content	(%)	9.67	9.98	10.36
TP content	(%)	3.49	3.83	4.71
NPN content	(%)	0.037	0.022	0.021
Lactose content	(%)	5.11	5.32	5.02
Minerals :				
P	(%)	75.30	92.60	91.10
Ca	(%)	151.19	154.90	152.36
Na	(%)	43.65	73.63	37.70
K	(%)	9.25	12.64	12.13
Mg	(%)	3.22	3.54	3.12
Cu	ppm	1.80	1.84	1.70
Zn	ppm	2.92	2.59	3.14
Fe	ppm	2.21	2.3	2.08
Mn	ppm	0.280	0.250	0.250

(From Abo El-Nor ,1991).

Table (6): Effect of different methods of detoxification and advantce in maturity on mimosin content of leucaena .

Treatments	Mimosine (%) Months					Overall means
	5	6	7	9	12	
Fresh	3.22	2.95	1.93	0.79	0.69	**1.92**
Sun dried	2.78	2.49	1.73	0.58	0.48	**1.61**
Dried under Vacum						
at 50 C	2.33	2.05	1.38	0.53	0.44	**1.35**
at 80 C	1.91	1.31	0.99	0.48	0.31	**1.00**
Oven dried 80C	1.04	0.91	0.84	0.32	0.10	**0.64**
Overall means	**2.26**	**1.94**	**1.37**	**0.54**	**0.40**	

(From Abo EL-Nor, 1991).

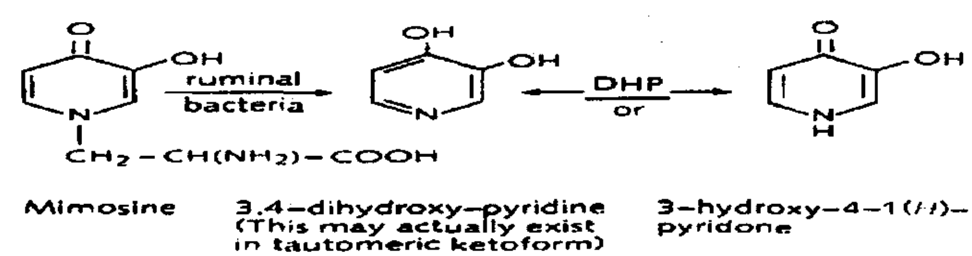

Figure (1): The structure components of mimosene and DHP (Jones and Megarrity , 1981)

Conclusions

Based on current evidence and the extent of utilization of leucaena forage by the various ruminants in Egypt , there is no doubt that the forage is one of increasing economic importance in my country and elsewhere . While several studies have reported beneticial effects when fed to buffaloes , cattle , goats and sheep , there is room for a lot more precision in the use of the forage in respect of leafiness , proportion of stems , level of feeding , and qulity with reference to crude protein , mimosine and tannin contents . These issues need to be defined in relation to specific species use in view of different thresholds of tolerance . Buffaloes and goats for example , appear to have greater tolerance and possibly also increased ability to degrade mimosine than do cattle and sheep . Inadequate attention has been given to dehydrated leucaena leave meal production and this is a potential that remains to be explored . Economic production of the meal can reduce the dependence on the need for imported preformed proteins at high cost . Accelerating the use of leucaena forage and improving the efficiency of feeding systems , thus represents an important development strategy .

There is a real need for further studies to assess the potentiality of leucaena as animal feed relative to other altenative forages . Most studies document the production of leucaena without reference to vialble alternatives . In any situation there needs to be clear advantage for leucaena if the extra effort of establishing and maintaining the plant is to be made . The advantages claimed for leucaena may be real , but unless they are documented in terms of increased animal productivity and economic gain there will be very little incentive for a wider utilization of the plant for ruminants .

In Egypt, where leucaena has been fed as a protein supplement with other feeds there have been no toxic effects on the animals and the beneficial effects recorded have been comparable with those derived from concentrated protein sources such as groundnut cake and meat meal.

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الليوكينا كغذاء للمجترات فى المناطق الاستوائية وشبة الاستوائية (دراسة تجميعية)

صلاح الدين عبد المنعم حسن ابو النور

المركز القومى للبحوث – قسم علوم الالبان

يعتبر نبات الليوكينا من نباتات العلف البقولية المعمرة والتى توجد فى المناطق الاستوائية وشبة الاستوائية وتجود زراعتة فى معظم الاراضى ولة قدرة كبيرة على تحمل الظروف البيئية الصعبة ويمكن الحصول علية على مدار العام فى صور مختلفة ، (طازج- جاف – سيلاج) .

يعطى نبات اليوكينا محصول كبير من العلف الاخضر يتراوح بين ٢٠ – ٤٠ طن / سنة / فدان كما يتميز بانة يقوم بتثبيت الزوت التربة مما يحسن من خصائصها ويزيد من انتاجية الفدان للمحاصيل المحملة علية مثل الذرة والخضروات كما يتميز بارتفاع محتواة من البروتين والعناصر المعدنية والكاروتين وتقدر القيمة الغذائية بة فى صورة طاقة (TDN) حوالى ٧١% ، ٢٠% بروتين مهضوم بالمقارنة بالبرسيم الحجازى كل هذة المميزات جعلت من نبات الليوكينا واحد من افضل الاعلاف الخضراء فى المناطق الاستوائية وشبة الاستوائية ز

وفى هذة الدراسة المرجعية تم التركيز على اهمية نبات الليوكينا وطرق زراعتة والتركيب الكيماوى والقيمة الغذائية لة كمحاولة لنشر واستخدام هذا النبات لرفع القيمة الغذائية لمواد العلف الفقيرة وزيادة الانتاج الحيوانى مع خفض تكاليف التغذية بتوفير مصدر جيد من الاعلاف على مدار العام يسد العجز الموجود فى غذاء الحيوان(خاصة فى موسم الصيف والذى يقل فية الاعلاف الخضراء) مما يزيد من الكفاءة الانتاجية للحيوانات المصرية وخاصة حيوانات اللبن .