The genus *Prosopis* and its potential to improve livestock production in arid and semi-arid regions

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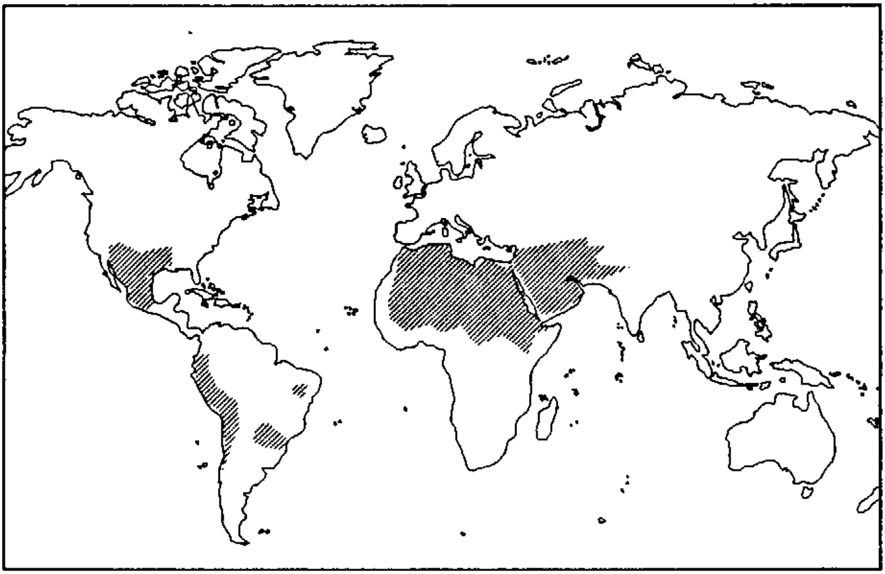
INTRODUCTION

The genus *Prosopis* has become one of the important plant genetic resources which may offer new alternatives and options for the development of arid and semi-arid regions. In the past, *Prosopis* spp. had an important role in the traditional agriculture practised by indigenous populations in Latin America, Africa and Asia. Now the Grassland Group of FAO has developed a programme to enhance the use of *Prosopis* spp. in those areas where it can be integrated into the current farming and livestock production systems.

The genus *Prosopis* comprises 44 species, of which 32 have been referred to by Burkart (1952) in Argentina. Although the genus *Prosopis* presents no difficulty of identification, individual species are difficult to determine in view of the large variability which is further complicated by the ease of hybridization among species. The genus is widely distributed in South, Central and North America, Africa and Asia. In the Chaco region of Argentina, many species are found and this area is recognized as a centre of biodiversity.

In spite of apparent optimism for its use, there are still a number of questions and doubts about the use of *Prosopis* species. It may become an invader when not managed adequately, resulting in widespread panic in some countries where it is considered a weed. Baumer (1990) suggests that "one should clearly distinguish between the rich pastures in temperate regions where the concept of 'invader' species is prevalent and the frequently very degraded drylands of the Third World, especially in Africa, where one would be happy to find an invading plant which has as many good properties as offered by the *Prosopis* genus".

FIGURE 1. **Dispersion of the genus *Prosopis* in the continents.**



The problems resulting from long drought periods in Africa, the interest in agro-forestry and the potential role of trees in the development of sustainable agriculture have resulted in an increased interest by international and national institutions which have organized workshops, conferences and seminars, and commissioned detailed studies on various aspects of fodder trees which have been published.

This paper will concentrate on the description of the use of three *Prosopis* species which are now well established and being utilized at a commercial level by local people. However, special attention and efforts in research, development and training are required to solve the many problems associated with the efficient utilization of these better known *Prosopis* spp.

PROSOPIS TAMARUGO IN CHILE

A comprehensive review on this subject was made in Chile at the First Round Table on *Prosopis tamarugo* held in Arica in 1984. The example of *Prosopis tamarugo* is important in the sense that it shows the possibilities that do exist for the rehabilitation of a degraded ecosystem where preference is given to a species adapted to that degraded environment, in contrast to the common practice of trying to adapt plants to difficult environments.

The Tamarugal Pampa is a plain stretching from latitude 19°33' to 21°50' south where the climate is classified as desert, characterized by almost total lack of rainfall and wide variations in day and night temperatures; mean maximum is 30.9°C, mean minimum is 16.7°C, relative humidity is 52% and average annual rainfall is 0.7mm. The groundwater table is located between 1 and 10m deep but, in certain sectors, it is found at 60m. *P. tamurugo* grows on soils with a thick salt layer.

Studies carried out in Israel (Gindel, 1966) have reported that the Negev soils in which *P. tamarugo* grows had a high moisture content. This is a result of the water intake by leaves which occurs with certain plants under arid and semi-arid conditions and which allows a discharge of small amounts of water into the soil through the roots, enabling the plant to stay alive (Slatyer, 1967). The possibility of inverted potentials during periods of high humidity has been carefully studied; this is a way to enable the plant to absorb atmospheric water, either as liquid or gas. Studies have shown that the *P. tamarugo* opens its stomata during the night and that the percentage of opened stomata is in direct relation to relative humidity (Sudzuki, 1985).

The development of commercial plantations in the Tamarugal Pampa was initiated in 1961 through the National Livestock Development Programme. Here, an area covering 1.5 million hectares was cut for timber and fuel at the turn of the century to supply fuel for local mining operations. Today, mining for nitrate of soda has almost ceased and, of several thousand former inhabitants in the Tamarugal Pampa, only a few hundred are left who are involved in agriculture (lucerne combined with

Prosopis), which is now the only source of wealth in this region. In the relic forest of the Tirana oasis, species have been found up to 400 years old.

The basic concept and idea of the development of the *Prosopis tamarugo* plantation was to rehabilitate and transform the desert into an ecosystem whereby agro-forestry would have a key role in the economic and social development. The tentative conclusions reached after five years of this work can be summarized as follows:

1. The *P. tamarugo* tree is easy to propagate and established well when adequately planted from seedlings.
2. It is advisable to plant where ground water level is found between 2-10m; this reduces costs as little initial watering is required.
3. *P. tamarugo* can be planted in ground covered by a salt crust that varies in thickness from 10-60cm, although it does not appear to be as salt tolerant as *Propsopis juliflora*. It can also grow in soils with no salt cover, clay or sandy soils. *P. tamarugo* presents no problem in the Tamarugal Pampa and its tap-root develops well.
4. *P. tamarugo* has a highly specific physiology. Under conditions of pronounced atmospheric humidity above 80%, the plant absorbs water through its foliar system, transports it along the root system and deposits it in the microrhizosphere where it is re-absorbed as water (Sudzuki, 1985). This explains its adaptation to where ground-water lies at 40m deep.
5. Carrying capacity of a fully productive hectare (8th year plantation) exceeds that of natural grassland in many arid and semi-arid ecosystems (Table 1). Best adaptation is seen with Angora goats.
6. The nutritive value of *P. tamarugo* is good; it contains approximately 5% digestible crude protein (DCP) and 55% total digestible nutrients (TDN) (Table 2).

TABLE 1. **Projected annual yield of *P. tamarugo* fruit by age and ground area covered; yield estimated per tree and per hectare.**

Age in years	Area covered (m^2)	Fruit and leaves (yield per tree) kg.	Fruit and leaves* (yield per ha) T.
5	12	-	-
10	33	79.2	4.4
15	50	120.0	6.6
20	67	160.8	8.8
25	84	201.6	11.1
30	100	240.0	13.2
35	113	271.2	14.9
40	125	300.0	16.5

* Based on 55 trees per hectare

TABLE 2. **Nutritive value of *P. tamarugo* dry leaves and fruit.**

Components	Leaves		Fruits	
	Composition %	Digestible nutrients %	Composition %	Digestible nutrients %
Dry matter	90.53		96.66	
Crude protein (N x 6.25)	9.98	1.27	11.14	6.07
Crude fibre	10.72	2.70	31.45	16.22
Ether extract	1.90	0.90	1.62	0.81
Nitrogen free extractives	45.91	17.45	48.18	35.72
Ash	22.02		4.27	
Calcium	2.82		0.28	
Phosphorus	0.91		1.44	

Source: Lanino (1966)

TABLE 3. Average composition of various *P. tamarugo* components for cattle feed.

Plant component	Dry matter %	Crude protein %	Ether extract %	Crude fibre %	NFE %	Ash %
Whole fruit*	94.4	13.3	1.4	34.2	44.8	6.4
Fruit without seed*	87.3	13.3	1.0	31.7	44.8	9.3
Seed*	90.8	27.3	5.3	10.8	50.5	6.1
Dry leaves without rachis*	91.7	13.6	1.7	9.9	52.6	22.2
Dry leaves*	91.4	9.0	1.8	22.3	55.4	11.5
Rachis of dry leaves*	88.2	11.3	1.8	16.0	50.7	20.3
Green leaves*	43.7	35.7	3.0	31.6	1.4	28.4
Dry leaves with rachis*	90.5	11.0	1.1	11.8	50.7	24.3
Fruit**	96.7	11.5	1.7	32.5	49.9	4.4

* Unpublished data from Gonzales and Haardt, Univ. of Chile, School of Veterin. Medicine (1966).
** Lanino (1966)
Source: Lamagdelaine (1972)

Tamarugo fruit is considered a good feed for sheep and cattle, as can be seen from Tables 2, 3 and 4. The FAO publication *Prosopis tamarugo: fodder tree for arid zones* (Habit *et al.*, 1981) is the only published information on animal production and can be summarized as follows:

1. The fruit of *P. tamarugo*, when not attacked by insects, has a low concentration of nutrients as compared to concentrates but it can be compared favourably to good quality hay.
2. *P. tamarugo* fruit intake seems to be high when consumed freely and compares favourably with that of other high-quality fodders.
3. In feeding trials with sheep which received 2kg (60% leaves, 40% fruit), it was found that production was significantly lower than that of grazing sheep; addition of lucerne made a significant difference. Supplementation with mineral salts has a marked effect and it appears that cobalt, iron and manganese are of major importance.
4. Table 5 provides an estimate of carrying capacity according to the age of the trees.

TABLE 4. **Comparison of results from early-maturing French Merino sheep in the Tamarugal Pampa, fed with leaves and fruit, lucerne hay and grazing freely in *P. tamarugo* forest (Lanino, 1966).**

Variables	Leaf hay & fruit (2kg/day)	Lucerne hay (1.5kg/day)	Free grazing in forest
Weight at weaning:			
Ewe lamb	15.0kg	21.5kg	26.7kg
Ram lamb	14.0kg	25.0kg	29.6kg
Fleece weight	2.8kg	3.2kg	3.77kg
Fibre length	5.9mm	6.4mm	-
Ratio lambing:symptoms of pregnancy	48%	63%	111%

TABLE 5. **Estimated carrying capacity (sheep/ha) by age of *P. tamarugo* forest (Cadahia, 1970).**

Age of forest (years)	Carrying capacity (sheep/ha)
1-6	Unused
7	0.5
8	0.75
9	1.5
10	2.0
11	3.0
12	4.0
13	5.0
14	6.0
15	8.0
16	10.0

Estimates of the potential of the Tamarugal Pampa have shown wide discrepancies. It is felt that 200,000 ha can be planted, with a potential carrying capacity of 800,000 sheep in the 12th year, increasing up to 2,000,000 sheep at the 18th year. At the present time, there are approximately 23,000 ha. No planting has been done during the last 8 years, other than the experimental area which the FAO Grassland Group is developing in order to test different management techniques.

The development should include those areas where the water table is not too deep (10-15m), followed by comprehensive feasibility studies in order to assess the economics of such a development programme. It is already felt that individual areas should not be smaller than 500 ha, otherwise the development costs are not justified.

PROSOPIS JULIFLORA IN BRAZIL

The north-east region of Brazil covers an area of over 1.5 million km² and extends over tropical and equatorial latitudes from 1° to 18°S. It represents 18% of the country and contains 125 million people, approximately 30% of the population.

Prosopis juliflora (Swartz) is a thorny, large-crowned evergreen to semi-evergreen tree with a deep tap-root and a well developed lateral root system. It grows up to 10-15m high, depending on the type of soil, in arid and semi-arid conditions. It is adapted to a rainfall range from 250-800mm.

Prosopis juliflora was introduced into the north-east of Brazil from Piura, Peru in 1942. It is now found throughout the dry, semi-arid region, showing its economic potential as a multi-purpose tree. In recent years, due to recurrent drought periods affecting this vast region, it is becoming an important alternative to annual crops in marginal areas.

Planting *Prosopis juliflora* requires a source of high quality viable seed, which is the first problem to solve as seeds are difficult to extract from pods. Pods can be cut lengthwise with a knife or across between the seeds. Other systems consist of feeding the whole pod to animals; the digestion of the pod allows the seed to come free and can be easily separated from the faeces. The seed suffers no change through the digestion process, sugar being dissolved. Trees can vary their pod production from a few kilograms to over 400kg. Seeds are not true to their origin because of cross pollination.

It is now accepted that pruning is essential in the establishment phase of *Prosopis juliflora* in order to permit easy access for collecting pods from the ground and to allow grazing before the pods drop.

Vegetative reproduction by cuttings has not been common thus there is a need for further research on this subject, the main purpose being to to exploit the possibility to increase certain ecotypes which have a high pod production. At present, a comprehensive programme on the vegetative multiplication of *Prosopis juliflora* and on the possibility of grafting certain *Prosopis* spp. is underway in the University of Cordoba with funds from FAO. The grafting of *Prosopis* spp. would permit the use of fast growing tutors combined with heavy pod production. This work appears to be quite promising and, from preliminary results, there is a strong indication that certain species of *Prosopis* would develop a more efficient production system.

The development of a factory to process *Prosopis juliflora* pods in Iparaiba, with a capacity of 15 tonnes per day, has provided an incentive to local farmers to increase their interest in planting *P. juliflora*. Production of *P. juliflora* pods can be tripled or quadrupled if occasional or strategic irrigation can be provided during the 2 months period of flowering. Yields per hectare of over 15 tonnes have been obtained when trees were watered (600l per tree) every fortnight. Planting near a water course or dam should therefore be encouraged, considering that during 1991 the price of pods was equal to that of maize. Water available in the region is not sufficient to cover the overall requirement for maize.

Prosopis juliflora pod production varies according to the soil type and rainfall has an important effect, although production may continue even after 2-3 years of drought. In the north-east, yields of 2-3t/ha are obtained on shallow stony soils in gently rolling country. These soils have no agricultural value and the vegetation is typical of semi-arid regions, with little herbaceous production but nevertheless containing some browse species. *P. juliflora* is planted following strip clearing or total clearing, depending on the predominant vegetation.

On agricultural land with relatively high fertility, *Prosopis juliflora* planted at 10 x 10cm spacing can yield 6 tonnes of pods per ha after the 4th year, compared to an average of 400kg maize per ha. It is therefore easy to understand why farmers are encouraged to plant *P. juliflora*.

Processing and use

Pods of *Prosopis juliflora* are harvested from the ground as they fall freely when ripe and are taken to the factory. Pods contain approximately 17-19% moisture and are stocked in a well-ventilated building. Processing starts by passing them through a standard hammer-mill and then the broken pods are subjected to a process of drying for approximately 4 hours, lowering the moisture content to 6-8%. The drying has initially been done in converted coffee roasters and, more recently, a rotary oven has considerably simplified the operation. The following step consists of grinding the broken pods through a modified feed mill in which 16-18% of the product is considered to have long fibres and is utilized directly for feeding ruminants. The remainder goes into feed mixtures for both ruminants and monogastrics, mainly pigs and poultry.

In West Africa, it is claimed that pods can be dried in the sun, reducing the moisture from 9% to 5.5%, and down to 4.5% when passed through a hammer-mill. However, the problem of inhibitors remains when pods are not subjected to heat. Research is underway on this important subject.

Several trials to evaluate the potential of *Prosopis juliflora*-based supplements in livestock production have shown positive results. However long-term experiments with livestock under current local management conditions are necessary in order to be able to extrapolate results to the potential use by farmers.

Prosopis juliflora has a high carbohydrate content and acceptable protein level, as shown in Tables 6 and 7.

In the north-east of Brazil, as in other tropical regions of the world, wheat bran constitutes an important component of rations not only for poultry but also for other animals. Wheat bran is generally imported and therefore its price fluctuates considerably according to the season and local availability. This has stimulated research on alternatives to the use of bran and other imported feedstuffs. It is fortunate that *P. juliflora* and other *Prosopis* spp. pods are available during the dry season which makes it possible to use these pods during critical times of the year.

TABLE 6. Analysis of seeds and flour of *P.juliflora* as % in DM (Baiao, 1987).

Component	Seeds	Pod flour
Moisture	11.6	10.8
Crude protein	35.8	59.0
Ether extract	4.5	8.9
Ash	3.7	4.9
Crude fibre	6.1	1.7
NFE	38.3	15.0
Reducing sugars	1.7	1.9
Non-reducing sugars	5.1	5.8
Starch	1.0	3.6

TABLE 7. Amino acid composition of *P. juliflora* pod flour (Baiao, 1987).

Amino acid	Amino acids in fresh material %	Amino acids g/16g N	Amino acids per 100g amino acids recovered
Lysine	1.71	3.96	4.43
Histidine	1.15	2.67	2.98
Arginine	5.72	13.27	14.83
Aspartic acid	3.24	7.54	8.43
Threonine	1.02	2.37	2.64
Serine	1.72	4.01	4.49
Glutamic acid	7.73	17.94	20.04
Proline	2.47	5.73	6.40
Glycine	1.91	4.43	4.95
Alanine	1.70	3.94	4.41
Cystine	0.51	1.18	1.32
Valine	1.50	3.48	3.98
Methionine	0.41	0.95	1.06
Isoleucine	1.17	2.71	3.03
Leucine	2.83	6.57	7.34
Tyrosine	0.99	2.30	2.57
Phenylalanine	1.51	3.50	3.91
Tryptophane*	0.46	1.07	1.19

* Determined separately by enzymatic hydrolysis.

In the Animal Husbandry Department of the Universidade Federale de Perambuco, experiments with chickens (Table 8) showed that wheat flour could be 100% replaced by *P. juliflora* bran (whole pod). The total ration contained ground maize, soyabean, bonemeal, calcium premix and methionine. Normally, the ration contained 7.5% wheat flour which was replaced with 7.5% *P. juliflora* bran. The replacement of up to 35% of maize in lactating sow rations in the north-east of Brazil also clearly demonstrated the value of *Prosopis* flour.

TABLE 8. **Replacement of wheat bran with *Prosopis juliflora* flour in rations for chickens (Universidade Federale de Pernambuco).**

Treatment	W* 100% Pj** 0%	W 67% Pj 33%	W 33% Pj 67%	W 0% Pj 100%
Mean daily ration intake g.	107.8	106.5	107.1	107.5
Mean egg weight g.	58.8	59.5	59.0	59.3
Feed conversion rate	1.58	1.62	1.57	1.55
Ration intake/kg egg weight	2.22	2.28	2.20	2.18

* Wheat bran ** *Prosopis juliflora* pod flour

The importance of *Prosopis juliflora* in silvo-pastoral systems is the subject of a research programme in the semi-arid NE of Brazil and in the Argentinean Chaco. It is known that the canopy of trees has a beneficial effect on the soil; it protects it from the direct effects of raindrops, reduces water run-off, etc. Of major importance is the recycling of nutrients which maintains or increases the fertility level, in particular through the accumulation of litter and through nitrogen fixation. It is also known that the canopy may reduce evapotranspiration, thus favouring overall moisture levels and increasing plant growth. It is important to highlight the fact that *P. juliflora* is sensitive to competition from grasses at the seedling stage.

Studies of the value of *Prosopis juliflora* and other *Prosopis* spp. in the dry Chaco in Argentina suggest that stability of this degraded ecosystem may be achieved by the intelligent use of indigenous *Prosopis* spp. The dry Chaco has high temperatures in the summer and moderate temperatures in the winter, with occasional frosts 5-10 times per year. 70% of the rainfall is concentrated in the summer, during the 4 warmest months, and there is hardly any rain at all during winter. Annual rainfall ranges from 300mm in the west to 500mm in the east. Productivity is very low at 4-10 kg beef per ha and 15-20 ha per head (Diaz and Karlin, 1984). As much as 300kg/ha has been obtained under intensive experimental conditions. A comprehensive study of the effects of *Prosopis nigra* on the vegetation under the canopy shows that higher production results from improved nutrient supply, higher organic matter and favourable water balance (Table 9). Further research is required in this area.

TABLE 9. Production and soil characteristics under canopy of *Prosopis nigra* and in the open.

		Under canopy of *P.nigra*	In the open
Acc. production of *C. ciliaris* (Buffel grass Texas 4464) planted 1976			
Output	14.4.83	4300	2000
(kg/DM/ha/year)	10.4.84	3900	2600
kg DM/ha/year	control (no fertilizer)	2500	
	50 kg N	2900	
	100 kg N	3700	
(Cleared Feb 1983, collected April 1983)		3900	2000
Crude protein % in *C. ciliaris* (1976)			
	9.4.84	8.6	4.8
	5.7.84	6.9	3.9
	18.9.84	6.7	3.7
Crude protein % in native grasses			
Setaria spp.		13.7	8.8
Trich. pluriflora		10.9	9.3
Dig. californica		10.0	8.3
Soil OM%	superficial	1.83	0.90
	2-10cm	1.57	0.94
	20-40cm	0.70	0.70
Soil Nitrogen %	superficial	0.26	0.13
	2-10cm	0.23	0.08
	20-40cm	0.05	0.06
Saline soil values			
Sample depth (cm)		0-10	0-10
Organic matter (%)		1.00	0.55
$CaCO_3$ (%)		0.12	0.37
pH hydrolitic		7.60	9.00
CE sat. extr. (mmho/cm)		1.80	0.40

PROSOPIS CINERARIA **(KHEJRI)**

Prosopis cineraria, locally known as Khejri, has an important place in the economy of the Indian desert. In the arid zone of Rajasthan, camels, goats, donkeys and mules, which make up about 40% of the 19 million head of livestock in the region, depend on browsing to meet their nutrient requirements.

Khejri is well adapted to the very dry conditions in India and is found in zones with annual rainfall ranging from 150-500mm; the optimum density is seen between 350-400mm range. This plant produces its leaves, flowers and fruit during the extreme dry months (March-June) when all other species adapted to arid zones are leafless and dormant. It is this characteristic which deserves greatest attention as the tree offers a new forage resource for extreme arid zones.

Khejri is a slow growing tree in its early stages, requiring 10-15 years to develop to a height of 6m, compared 12-15m in 4-5 years for *Prosopis juliflora*. Recent work at the Central Arid Zone Research Institute (CAZRI) in Jodhpur is showing the potential that exists for the selection of fast-growing lines. This research should benefit greatly from the use of micropropagation of tissue culture in order to obtain large populations of uniform, high-yielding and fast-growing trees.

Growth of natural pastures under *Prosopis cineraria* is significantly higher (1.1-1.5 t/ha) than under *Acacia senegal* (0.6-0.7 t/ha). Maximum production of 2.6 t/ha has been obtained during 1973 with 27 rainy days and 641mm of rainfall, clearly showing the advantage of a tree canopy in the semi arid conditions found in Rajasthan (Ahuja, 1980).

Prosopis cineraria is lopped for firewood and its productivity is greatly reduced when lopping is carried out every year; ideally, a rest of four years will result in 200% more leaf production (Saxena, 1980).

Khejri trees are ready to provide animal feed from the 10th year onwards and, if properly managed, may be kept in production for 2 centuries. An average tree yields 25-30kg of dry leaf forage per year. Tables 10 and 11 provide data of interest on the nutritional value of *Prosopis cineraria* leaves (Bohra and Ghosh, 1980). Dry matter intakes of 685 and 1306g/day are quoted for sheep and goats respectively.

TABLE 10. **Percentage (DM basis) proximate components of *P. cineraria* leaves (Bohra and Ghosh, 1980).**

Component/Source*	Patel (1961)	Sen & Ray (1964)	Ganguli *et al.* (1964)	Gupta (1967)	Mathur (1976)
Crude protein	15.4	15.3	13.9	14.1	11.9
Ether extract	4.5	3.1	-	3.9	2.9
Crude fibre	13.4	17.5	20.3	15.6	17.5
NFE	56.8	54.1	59.2	54.8	43.5
Ash	-	9.9	6.5	11.5	8.1
Phosphorus	0.18	0.24	0.20	0.93	0.38
Calcium	1.92	2.65	1.50	2.50	2.10

* References quoted by Bohra and Ghosh (1980)

TABLE 11. **Digestibility and balances of different nutrients of winter-lopped *P. cineraria* leaves in sheep and camels.**

Trait/type of animal	Sheep	Camel
A. Digestibility (%)		
Dry matter	38.9 ± 0.55	44.7 ± 1.62
Crude protein	7.2 ± 1.75	74.8 ± 1.93
Ether extract	31.5 ± 2.14	72.5 ± 0.69
Crude fibre	25.9 ± 1.19	49.3 ± 1.46
NFE	57.9 ± 1.38	60.6 ± 1.00
B. Nutrient balance (g/day)		
Nitrogen balance	-0.57 ± 0.22	8.33 ± 0.06
Calcium balance	-0.27 ± 0.03	17.66 ± 1.01
Phosphorus balance	-0.22 ± 0.04	6.96 ± 0.67
C. Nutritive value (%)		
Digestible crude protein	1.01	8.93
Total digestible nutrients	39.83	48.66

The importance of *Prosopis cineraria* is well recognized by farmers as it provides an extra source of revenue, acts as an insurance against drought and increases the sustainability of production systems in this drought-prone fragile ecosystem. An average, fully-developed tree provides green fodder worth Rs 20, twigs Rs 16 in the form of fencing and fuel material and Rs 6 as a vegetable, giving a total revenue per tree of Rs 42. According to CAZRI, in dry regions an average of 40 trees per ha is common, resulting in Rs 16,800 additional income per ha (1 US$ = 25 Rs). This income may be at least doubled if trees are planted 12m apart and the soil below the canopy is managed to favour water collection.

Prosopis cineraria is an important feed resource in the Sultanate of Oman, where large forests can still be found. In view of its important role in the environment and as a source of feed to livestock, a comprehensive study is underway.

RECOMMENDATIONS FOR FUTURE PROGRAMMES

It is felt that, although the value of this genus is recognized, there is a great number of questions that arise as to their real potential in terms of incorporation into production systems.

1. With respect to *Prosopis tamarugo*:
   a) It is important to review the economic factors that could lead to an extension of the present area planted, in particular considering the new approaches to the management of trees.
   b) It would be advisable to look at the possibilities that exist to test *Prosopis tamarugo* in those environments that appear similar to the conditions found in the Pampa del Tamarugal, e.g. coastal areas of Oman, Somalia and Sudan.
   c) Selection of fast-growing and high pod production trees should be studied.

2. Concerning *Prosopis juliflora*, there is a need to investigate the following aspects:
   a) The problems caused by enzyme inhibitors and the practical solutions, e.g. use of heat treatment of feedstuffs.
   b) research into micropropagation/tissue culture of high yielding lines.
   c) The advantage of grafting different species to combine favourable production attributes.
   d) The importance of nitrogen fixation and means to increase its efficiency.
   e) Nutritional aspects and feeding systems based on *Prosopis juliflora*.
   f) Management of plantations.
   g) Processing systems for feed and food production.
   h) Economic aspects, including irrigation practice.

3. Regarding *Prosopis cineraria*:
   a) Selection of fast growing types must take priority.
   b) Nutritional aspects.
   c) Selection of ecotypes for different ecological zones, particularly for very low rainfall conditions.
   d) Economics of the incorporation of *P. cineraria* into arid regions.

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