# PROPERTIES OF *PROSOPIS JULIFLORA* AND ITS POTENTIAL USES IN ASAL AREAS OF KENYA

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**Abstract**

A study was done to determine the potential for processing and using prosopis juliflora for commercial purpose. The effects of the plant on the soil were evaluated as a measure of determining its influence on the environment. Preliminary analysis of three soils samples per site where showed that the highly infested areas had higher moisture content of 10.5+1.35% and was significantly different at 5% level. The pH value of 8.7+1.03 was slightly lower compared to the low infested areas and was not significantly different at 5% level. However, both soils had almost the same bulk density and ECE of 1.1 g/cm$^3$ and 0.03 dm/S respectively. The soil calcium content of 0.88+0.009 mg/l in the high density area was significant low at 5% level whereas the organic carbon content of 1.13+0.027% was significantly high. No significant difference was observed for the magnesium, sodium, potassium, organic matter and phosphorus content at 5% l. Plant samples of prosopis juliflora were also tested for their nutritive values, especially the leaves, pods, bark and roots. Preliminary results showed that the leaves contain the highest amount of calcium of 6.38+0.248%. However, the leaves are not consumed green by the animals indicating high toxicity. The pods, bark and roots were also found to contain significant proportions of calcium at 5% level. The different parts of the plant had relatively lower phosphorus content of less than 0.25%. Magnesium was higher in the bark at about 3.5% whereas potassium was higher in the pods at about 2%. Nitrogen was higher in the leaves at about 2.5% indicating the suitability of the plant leaves as a nitrogen fixer in the soil. The tissues also showed very high content of vitamin C especially in the green pods (46.3+5.18 m/100g). Thus the pods, leaves and bark can be used as natural sources of vitamin C. The high ash content of 8.9+1.19% in the bark was significantly different at 5% level when compared to the content of the leaves but not other plant parts. This showed high roughage in the plant parts. The nutritive value of the pods showed their high potential for development of nutritive products including juice, wine, gum, powder, essential oils and beverages. The yield for aloe roots as fermenting agent was about 7.1% on 9th day in Prosopis extract having sugar media, 6.3% for yeast, Prosopis extract and honey on the sixth day and 6.1% for extract, sugar and baobab on the sixth day.

**Key words:** *Prosopis juliflora*, properties, analysis, potential uses

## 1.0 Introduction

The genus *Prosopis* is highly adapted to drylands. There are about 44 species in the genus Prosopis that have been identified (Pasiecznick, *et al.,* 2001). *Prosopis juliflora* (Figure 1) is among species in *Prosopis* genus that has been widely introduced in various parts of the world including Kenya. In Kenya, *Prosopis juliflora* was first planted in beginning of 1970's to rehabilitate quarry in Bamburi near Mombasa, then 1980 was introduced in Baringo area (Kariuki, 1993). Currently Prosopis has been introduced in various drier parts of Kenya. The tree has extensively spread colonizing most of the grazing zones, forming impenetrable thickets that have prevented growth of other plants. There are reported claims of livestock dying, loosing teeth after feeding on Prosopis pods. The trees have closed most of the watersheds in affected areas. This has caused an outcry in Kenya and also in most countries where it has been introduced (Daily Nation, 2005; Choge *et al.,* 2004).

*Figure 1: Prosopis juliflora infestation in Baringo District*

There are serious problems associated with exotic invasive species for they spread so fast colonizing the native species where it becomes difficult to eradicate or manage them. This cost government lots of money. Like it was estimated in USA the negative economic impact from invasive species is about US$ 24 billions per year. Given the amount of money involved in eradication of the invasive species, now it is suggested that sustainable management may be best option since the species have other useful attributes (Geesing *et al.*, 2004).

Regardless of *Prosopis juliflora* being invasive with negative impact to biodiversity and inhabitants, it has useful attributes also. The species is good in rehabilitation of degraded places in drylands (Bryan and Sutherland, 1992). The species is good bee forage, leading to high honey production. The wood is highly appreciated for timber and fuelwood. Pods have been used as animal feeds by ranches in USA, Latin America and India. Leaves are organic fertilizers and pods have been also used for making various types of food and local Peru brew called Algarobina. Previous studies on *Prosopis* pods can be used for coffee substitute, instant soluble powder, syrup, alcohol by fermentation, protein enriched flour, forage, additives for dietic foods, while, endocarp for fuel and seed can produce protein concentrate and high value gum. Studies on endosperm, shows it has a galactomannan polysaccharide comparable to highly valued carob gum. The carob gum is used for as thickeners, stabilizers or gelifiers like ice cream, sauce, cheese, yoghurt, sausages and bakery products.

The Prosopis seed gum has the following sugars, Rhamnose, fucose, arabinose, xylose, mannose, galactose and glucose that are of value in human health. Mannose is in higher concentration about 46% followed by galactose 33.97%. Fucose, xylose, mannose, galactose and glucose are currently major source of glyconutrients in human tissue health care (Pasiecznik, *et al.,* 2001). Food rich in mannose are being used in diabetic management. Already companies in South Africa utilized about 200 tones per year of *Prosopis* pods for production of food supplements with diabetic one being flagship product. Baringo district covers an area of about 8646 $km^2$ whereby 165 $km^2$ is occupied by a water surface of lakes Baringo, Bogoria and Kamnarock. The district is located 50 km north of the equator with an altitude that ranges between 900 and 1200 meters above seal level. The climate is semi-arid with mean annual rainfall of 635 mm (Ministry of Agriculture, 1991). Therefore the main objective of the study was to;

### 1.1 Objectives

i. To evaluate the effects of the plant on soil

ii. To characterize the various sections of the plant based on material properties and potential use

iii. To develop value added products from the plant leaves, flowers, seeds, bark, stem and roots through procesing and extraction

## 2.0 Methodology

### 2.1 Study Area

Prosopis juliflora was initially planted on selected areas of Baringo and Bogoria in 1983 by the Forest Department (Ministry of Agriculture, 2005). These areas include Kampi ya Samaki, Marigat, Ng'ambo, Eldume and Loruk among others. At least three of the above areas were visited and the pattern of spread and severity observed seemed to follow the initial pattern of introduction. Figure 2 shows the area map of Marigat Division where the survey was done.

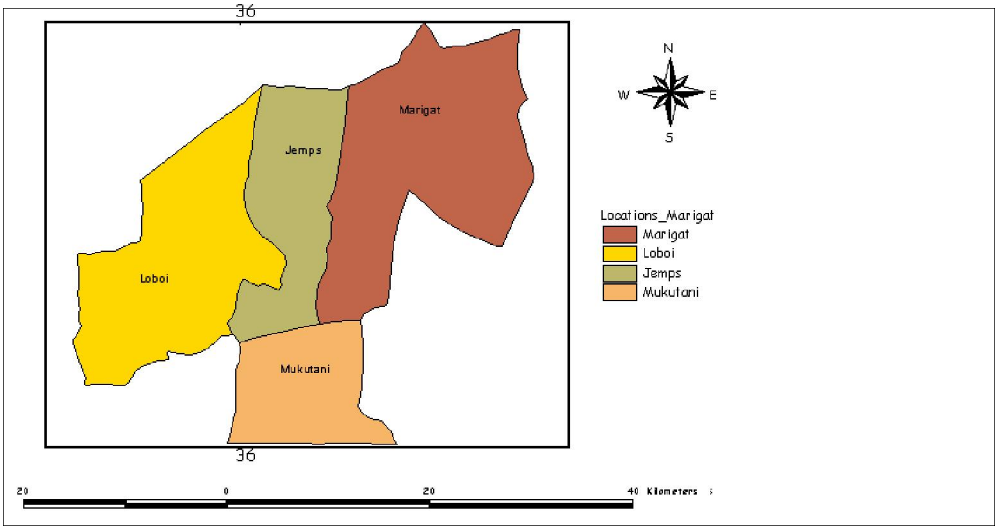



*Figure 2: Area map of Marigat division*

Observations made concurred with what has been reported in the literature, that *Prosopis* is quite adaptive and spreads rapidly, but contrary to popular opinion, it seems that *Prosopis juliflora* may turn out not to be as devastating as has been reported in the media. Ng'ambo is approximately 12 km from Marigat town and it lies within latitude $00^0$ 30' 25''N and $36^0$ 03' 43'' E and with an elevation of 982 m. Using questionnaires, information was gathered from the respondents who included officers from the Ministry of Agriculture, Forestry and Culture and local residence.

## 2.2 Sample Analysis

Soil and plant tissues were collected at Kambi Ya Samaki in Marigat Division of Baringo District. The area lies at latitude $00^0$ 36' 30''N and at Latitude $36^0$ 81' 18'' E with an elevation of 975 m. This is one of the areas where *Prosopis juliflora* was initially planted according to the local residents. The site is next to the shores of LakeBaringo and the density of *Prosopis* decreases as one moves away from the shores of the lake. Two 50 x 20 meters plots were selected in a high-density area (2 or more plants/$m^2$) and one in a low-density area (1 or less plants/$m^2$). In order to determine soil chemical properties, 30 soil samples were taken from a depth of 15-20 cm using core samplers (Figure 3a). The following parameters were analyzed in the soils: Total organic carbon, nitrogen, pH, electrical conductivity, exchangeable sodium and potassium, phosphorus, calcium and magnesium. The chemical properties of soils were analyzed in relation to the density of the plant in the Baringo ecosystem.

Plant tissues were collected at random from various plants tissues, taken to the laboratory and ground. The content of calcium, magnesium, phosphorus, potassium and nitrogen were measured and compared between the plant organs. These samples were analyzed at the Departments of Horticulture (Figure 3b) and Biomechanical and Environmental Engineering laboratories at Jomo Kenyatta University of Agriculture and Technology.

*Figure 3 Soil sampling and analysis in the lab (a) Soil sampling near Lake Baringo (b) Sample analysis in the lab*

## 2.3 Prosopis Products Development

Prosopis pods were milled using a 0.25mm sieve and then used for making the juice, wine and the gum. The seeds were separated from the prosopis powder since they could not go through the sieve. Various fermentation agents, baobab powder, yeast and aloe roots were used in solutions of sugar or honey for determination of the best fermenting method for ethanol production. 300g of sugar and honey were used separately as media in 2 kg of *Prosopis juliflora* pod flour in 10 litres of water. The experiment was set for 9 days and yield calculated after the 1st, 3rd, 6th and 9th days respectively.

## 3.0 Results and Discussion

## 3.1 Soil Analysis

Preliminary analysis of the soils where prosopis grows showed that the highly infested areas had higher moisture content of about 10.5+1.35% and slightly lower pH value of about 8.7+1.03 compared to the low infested areas which showed a pH of 9.4. However, both soils had almost the same bulk density and ECE of 1.1 g/cm3 and 0.03 dm/s respectively. Prosopis was found to have effect on soils. In the areas underneath the canopies of prosopis there was an appreciable reduction in terms of salinity and alkalinity. The soil pH and sodium levels were lower as compared to the adjacent open areas. The ameliorating effects encouraged presence of macro and trace elements in the areas underneath the canopies of the plant. This was attested by the high quantities of elements as phosphorus and exchangeable magnesium and potassium and trace elements such as copper, manganese, and iron that are essential for plant growth (Table 1). High levels of organic matter were from the falling leaves while the tree being a nitrogen fixer contributed to high levels of total nitrogen.

High levels of macro and trace elements were also associated with an increase in leaf litter deposition, mycorrhizal associations and or nutrient pumping in to the soil. Large quantities of leaves shed each year are considered to have been the potential source of nutrients (Pasiecknic *et al*, 2001). The presence of these elements played an important role in the improvement of soil physical and chemical properties. An increase in organic carbon greatly influenced infiltration rates and subsequently controlled run-off and hence reduces soil erosion. Increased ground coverage and canopy increased relative humidity, reduced evapo-transpiration and wind erosion which led to alterations of micro-climate. The improved micro – climate was important for the activities of soil fauna and macro – organisms. However, in Ng'ambo area, there were no changes in all the parameters analyzed. This may have been attributed by change in land use in which prosopis was uprooted and the land was converted in to growing of crops. Grass cover played an important role in the recycling of nutrients in the soil.

*Table 1: Minerals analysis of soils in areas infested with prosopis*

| Prosopis density | Ca (mg/l) | Mg (mg/l) | Na (mg/l) | K (mg/l) | OC (%) | OM (%) | P (%) | pH (-) | ECE (Dm/s) |
|---|---|---|---|---|---|---|---|---|---|
| High | 0.88±0.009 | 0.37± 0.015 | 4.11± 0.094 | 1.86± 0.075 | 1.13± 0.027 | 1.94± 0.081 | 0.18± 0.011 | 8.7± 1.03 | 0.3± 0.055 |
| Low | 1.14±0.057 | 0.42± 0.039 | 5.06± 1.08 | 1.52± 0.04 | 0.80± 0.062 | 1.39± 0.097 | 0.14± 0.009 | 9.4± 1.05 | 0.3± 0.078 |

Ca- Calcium; Mg-Magnesium; Na-Sodium; K-Potassium; OC-Organic carbon; OM-Organic matter; P-Phosphorus
ECE-Exchange capacity

### 3.2 Plant Tissue Analysis

Preliminary results (Table 2) showed that the leaves contained the highest amount of calcium of about 6%. However, the leaves are not consumed green by the animals indicating high toxicity. The pods, bark and roots were also found to contain lower proportions of calcium. The presence of calcium is very useful in the development of bones and teeth. The different parts of the plant had relatively lower phosphorus content of less than 0.25%. Magnesium was higher in the bark at about 3.5% whereas potassium was higher in the pods at about 2%. Nitrogen was higher in the leaves at about 2.5% indicating the suitability of the plant leaves as a nitrogen fixer in the soil. The tissues also showed very high content of vitamin C especially in the green pods. Thus the pods, leaves and bark can be used as natural sources of vitamin C. The relatively high ash content shows that the plant tissues can all be used as sources of roughage for both human and animals (Table 3).

*Table 2: Percentage of trace elements in different parts of prosopis plant*

| Element (%) | Pods | Leaves | Bark | Roots |
|---|---|---|---|---|
| Calcium | 3.46±0.302 | 6.38±0.248 | 2.54±0.091 | 4.42±0.115 |
| Phosphorus | 0.23±0.066 | 0.21±0.018 | 0.21±0.011 | 0.15±0.009 |
| Magnesium | 1.52±0.065 | 2.83±0.024 | 3.46±0.082 | 3.25±0.053 |
| Potassium | 2.15±0.055 | 1.50±0.007 | 0.65±0.038 | 0.8±0.007 |
| Nitrogen | 1.57±0.041 | 1.57±0.033 | 2.43±0.061 | 1.17±0.077 |
| Zinc | 18.86±1.038 | 2.09±0.072 | 0.44±0.007 | 0.67±0.018 |
| Sodium | 0.02±0.002 | 0.04±0.003 | 0.04±0.002 | 0.04±0.006 |

*Table 3: Nutritive content of plant tissues*

| Content | Green pods | Dry pods | Leaves | Bark |
|---|---|---|---|---|
| Vitamin C (mg/100g) | 46.3±5.18 | 36.0±4.33 | 33.0±4.07 | 27.3±2.05 |
| Ash content (%) | 6.1±1.36 | 7.3±1.88 | 4.8±1.02 | 8.9±1.19 |
| Moisture content (%) | 61.3±5.44 | 26.3±4.09 | 56.0±6.38 | 35.0±4.99 |

The results obtained were comparable for some parameters with those obtained by other researchers in Kenya and other countries. The calcium, potassium zinc and zinc contents in the pods were very high compared to those reported by Cruz et al (1987). Most of the trace elements except for the calcium and magnesium in leaves, calcium and sodium in the bark and calcium in roots were within the ranges reported by Singh *et al*, 1988, Maghambe *et al*, 1983, and Sharma, 1968. Differences in the trace elements can be attributed to the species contamination, type of soil, climatic conditions, and methods of determination used. Although the ash content in the pods and leaves was within the range reported Talpada et al, 1987 and Gohl, 1981, vitamin C content in the pods was about half the reported value reported by Cruz *et al*, 1987.

### 3.3 Potential for Plant Use

The pant has great potential for various uses since it has been explored in many other countries like India, China, and South America among others. Some of the uses of the plant need enhancement. The pods could be processed by having reduction in sugar content and then be used to produce commercial human food and livestock feeds. This would provide income for the local residents. The leaves are said to be poisonous. They are however said to have antibiotic activity and have potential for use as herbal medicine. Although not eaten by animals when green due to the presents if tannin, the same seem to disintegrate when the leaves are dried. In these arid areas where land is left bare, the species should be planted to check desertification and control soil erosion. The amount of *Prosopis juliflora* resources in the northern parts of Baringo district can also support high wood fuel consuming industries such as tea and tobacco leaf – drying processes in the entire country. The government should also encourage the local communities to invest in honey production in large scales. The quality of honey produced from *Prosopis juliflora* is of high quality. Therefore, there is a need to encourage farmers through provision of technical skills and also sourcing markets for the honey. The tree has the ability to support timber industry and hence solutions to unemployment and the prevalent shortages of saw timbers not only in the district but also for the entire country.

### 3.4 Proposed Management Strategies for Prosopis

In the areas infested with Prosopis, land is communally owned making the management of the plant difficult. The land should therefore be demarcated so as to allow individual responsibilities in the management of the plant. The rapid spread of the plant can be minimized through removal of the seedlings before they get established. However, due to the deep rooting system of the plant, it has been found to be very hard to pull the young plants out of the soil by hand. Thus specialized uprooting equipment is required. Young plants can also be minimized through continuous cultivation and deep ploughing. There is also need to explore biological control aimed at destroying the seeds or the plants. The hardy nature of the seeds enables them to withstand very severe conditions for a very long time. This makes complete eradication of the plant very difficulty. Promoting the use of the plant is expected to generate interest among the local community who seem to show no interest despite the dramatic environmental change causes by introducing the plant and the fact that is the main feed for animals especially during the dry season. The plant has great potential for use as outlined in section 3.1. Thus there is need to optimize the great potential the plant in enhancing the economic status and health of people in Baringo other than dueling on its negative effects.

### 3.5 Products Development

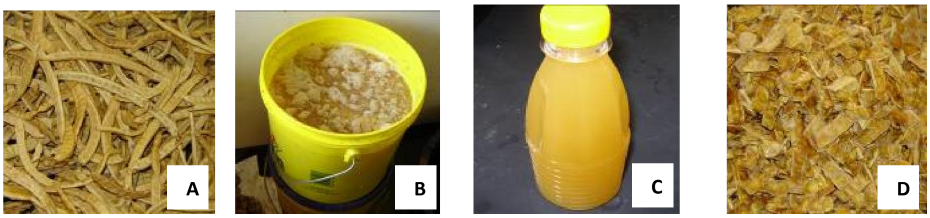
#### 3.5.1 Pods Milling

To facilitate the processing of prosopis in Marigat Division, an electric milling machine was installed at Salabani Secondary School in May 2006 for use by the local farmers. The machine was handed over to the school principal in the presence of local leaders and the manager of Kerio Valley Development Authority. The Authority was to coordinate the use of the machine. The machine was used to mill dry prosopis pods which were to be fed directly of as an additive to other animal feeds. The milling machine is equipped with a 0.25 mm sieve which can however be varied based on the need. Figure 4 shows the handling over of the machine to the school.

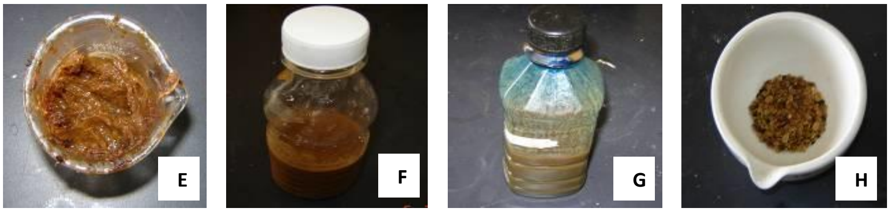
*Figure 4: Handing over of an electric mill to Salabani Secondary School*

### 3.5.2 Fortified Foods and Drinks

Nutritive content of Prosopis juliflora pods shows that it has very high potential for use directly or indirectly in the development of food product for humans and animals. Fermentation was noticeable in the third day and maximum ethanol yield was realized on the sixth day. However, the studies revealed that aloe roots fermentation picked up slowly whereas yeast fermentation was twice as fast. The yield for aloe roots as fermenting agent was about 7.1% on 9th day in Prosopis extract having sugar media, 6.3% for yeast, Prosopis extract and honey on the sixth day and 6.1% for extract, sugar and baobab on the sixth day. Simple milling of the pods and dissolving in water also gave a soft drink, which however requires further refining for taste improvement. Figure 5 shows some of the plant extracts which included the juice, gum, powder and seeds. There is also potential for steam distillation of the plant tissues for essential oil extraction mainly for beauty and medicinal products.




*(a)Dry Prosopis pods (b)Fermentation of dry powder (c)Fermented juice (d)Husked dry pods*




*(e) Prosopis gum (f) Prosopis gum juice (g) Prosopis powder juice (h) Prosopis seeds*

## 4.0 Conclusion and Recommendations

Prosopis plant affects the soil nutrients and structure thus improving the environment. It mainly influences the amounts of organic carbon, nitrogen, and calcium. Plant tissues showed high levels of different nutrients within the leaves, bark, roots and pods. Thus they have very high potential for development of plant extracts and products for economic gain of the poor in dry areas especially juices, wine and beverages. There was a very interesting trend in the distribution of nutrients both within the plant and in the soil. It is therefore important that further detailed investigation is carried out to backup commercial products developed.

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