DETERMINATION OF THE CHEMICAL COMPOSITION AND NUTRITIVE CONTENT OF *TAMARINDUS INDICA* FRUIT PULP FROM UKAMBANI DISTRICTS IN KENYA

BY

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ABSTRACT

The edible portion of T*amarindus indica* fruit ("Ukwaju" – Kiswahili) was analysed for its chemical and nutritional composition. The fruit was sampled from three Ukambani districts. The analysis carried out included moisture content, sulphated ash, Ascorbic acid content, crude protein and minerals namely, Na, K, Ca, Mg, Fe, Zn, Cu and Mn. The energy contents were determined and total carbohydrates calculated.

The results show that the lowest protein protein content was 0.008% for Kavisuni and Makindu) while Mwingi district plus Kambu gave the highest value of 0.02%. This gives a fairly low protein content compared to other indigenous fruits like *Adansonia digitata* (Baobab) with a value of 2.9%. The fat content was also low, especially for Makueni which has a value of 0.04 % while Mwingi gave 0.44%, which is expected for a fruit apart from avocado that has 22.2g/100g of sample.

The highest fibre content was given by a sample from Katse (6.75%) while ascorbic content was uniform for the 3 districts (8mg/100 sample). The fruit also has had an appreciable high internal energy with Mbitini recording 1463kcalg^{-1} as the highest. Levels of macro – elements such as K, Ca, Mg and Na are high while Fe, Zn, Cu and Mn are found in trace amounts.

This fruit, therefore, has the potential of providing all nutritive ingredients and can be used as a food supplement.

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LIST OF ABBREVIATIONS

KV1.....Kavisuni
MK1.....Makindu
MB2.....Mbitini
KT3.....Katse
KY.....Kyanundu
TR3.....TARDA

CHAPTER ONE

1.0 INTRODUCTION

1.1 General

Since time immemorial human beings have used natural vegetation as a source of food. Trees provide fruit which cuts across the whole spectrum of society with the degree of reliance being reflected more in the low income group and communities living in marginal areas. Traditionally people ate fruit from the wild trees between meals while herding or working in the fields. This is still the case today.

Kenya has a variety of indigenous food plants that are under exploited and are now also in danger of disappearing. Although indigenous fruits have always played an important role in the diet of many communities, most of them grow in the wilderness and now domestication is being done.

With increasing population in Kenya, and need for agricultural land many of these indigenous fruit trees are being cleared as land is opened for cultivation. There is pressure on land which has led to deforestation and environmental degradation.

Modern times have also brought new food habits and several new crops and the plants from which traditional foods were obtained are now facing double tragedy i.e. genetic erosion and loss of traditional knowledge on how to grow and use them. Little has been done to conserve the germplasm of these important species and also very little is known about their chemical composition.

Tamarindus indica found in the Caesalpiniadae family of the Fabaceae species, is an evergreen savannah tree indigenous to tropical Africa and is widely cultivated and used in the Sahel, South East Asia, the Carribean and Central America. It measures 4 – 15m with thick bole and spreading crown. The bark is rough grey – brown. It is semi – domesticated food resource picked from the wild but often planted on a small scale in crop land a near homesteads.

The fruit is a sausage shaped pod to 10cm or more. Young fruits are greenish brown turning rusty brown at maturity. Dry fruit coat is brittle while pulp is reddish brown. The seeds are dark red.

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The fruits appear as seen in the picture below;

In Kenya, the tree is found in lowlands, 0 – 1600m, usually 0 – 1300m. It is very common in the drier parts of the coast and along rivers and streams in the humid semi – arid areas. Rainfall ranges between 250 – 1200mm. The plant is not restricted to riverine environments.

In the past, there has been little emphasis on growing of indigenous tree in the farms. Efforts have been laid mainly on the cultivation of exotic fruit tree species, since the agronomic and market information is available on the exotic species. The only attempt that has been made is to leave out some important trees standing when clearing bushes for agricultural practices. Due to changing feeding habits, the indigenous fruit tree species have been largely ignored. The utilization of indigenous fruit tree species, therefore depend mainly on the supply from natural woodlands and forests. Considering the rate at which the natural woodlands are disappearing, there is no doubt that this utilization strategy is not sustainable and has very little provision for conservation of the resource base.

1.2 Uses

It is one of the most commonly sold indigenous fruits in Baringo, Siaya, Lodwar, West Pokot and Coastal towns. It is used as food, medicinal, fuel wood, charcoal, fodder for camels in northern Kenya, branches used for water purification

1.3 Domestication problems of indigenous fruit trees

Even though indigenous fruit trees are cheap sources of food, medicine, fodder and cash, their domestication is still hampered by number of factors:

a) They are perceived as growing slower and taking longer to produce fruits as compared to exotic species

f) Lack of tree planting culture, especially of indigenous trees, among majority of farmers in Kenya

g) Seasonal availability discourages would – be investors, although this factor is important for domestication.

1.4 Analytical methods

Several analytical methods were used to determine the chemical composition and nutritive content of the fruit pulp and these include both physical and chemical methods.
The physical methods include oven drying, sulphated ash
This involves moistening the ash with concentrated sulphuric acid and igniting gently to constant weight. The chemical methods included analysis of potassium, calcium, sodium. magnesium as major elements and Iron, manganese, copper and zinc as trace elements. The fruit pulp is analysed using a CTA 2000 Atomic Absorption Spectrophotometer.
The ascorbic acid content of the fruits is determined by macerating the sample with a stabilizing agent, i.e., metaphosphoric acid, and titrating the decanted extract with 2, 6-dichlorophenolindophenol.
Nitrogen content is estimated by kjedahl method, for most routine purposes the "crude protein" in the sample is then calculated by multiplying the total nitrogen by an empirical factor.
Crude fibre is the organic residue which remains after food has been treated under standardized conditions with petroleum spirit, boiling sulphuric acid, boiling dilute sodium hydroxide solution, dilute hydrochloric acid, alcohol and ether.
The fatty constituents of foods consist of a number of lipid substances. The 'fat' content (sometimes called the ether extract, neutral fat or crude fat), is also analysed.
Energy values are determined by use of a bomb calorimeter. Yoshida seisakusho model 1013 – B

2.1 OBJECTIVES

2.1.1 Broad objective

To verify whether *Tamarindus indica* fruit pulp from three districts in Ukambani vary in both chemical and nutritive composition.

2.1.2 Specific objectives

- To determine the physical properties such as moisture content, ash content, cations and energy values of the *Tamarindus indica* fruit pulp from Mwingi, Kitui and Makueni districts.
- To determine the chemical properties that is proteins, carbohydrates, fats, fibre and vitamins in the fruit pulp.

CHAPTER 3.0

LITERATURE REVIEW

Table 1: Composition of commonly known/domesticated fruits/100g of sample. [Source: Kirk, R and Sawyer, R. (1991) Pearson's composition and analysis of Foods. 9th edition]

Fruit	Inedible Matter %	Ener. KJ	Prot. G	Fat g	CHO g	Water g	Ca mg	Iron mg	Vit. C mg
Apple	20	196	0.3	0	11.9	84	4	0.3	5
Avocado	29	922	4.2	22.2	1.8	69	15	1.5	15
Mango	34	253	0.5	0	15.3	83	10	0.5	30
Orange	25	150	0.8	0	8.5	86	41	0.3	57
Pears	28	175	0.3	0	10.6	83	8	0.2	3
Pineapple (canned in juice)	0	194	0.5	0	11.6	77	12	0.4	20-40
Strawberries	0	109	0.6	0	6.2	89	22	0.7	59
Plums	8	137	0.6	0	7.9	85	12	0.3	3
Beans	1	83	1.9	0.2	-	-	22	0.7	-
Eggs–boiled	12	612	12.3	10.9	0	-	52	2.0	-
Eggs -fried	0	961	14.1	19.5	0	-	64	2.5	-

3.1 Distribution of Tamarindus indica in Kenya

The full distribution picture for *Tamarindus indica* illustrates well the four basic geographical regions of Kenya as Nyanza region around lake Victoria, Rift valley, Eastern and coastal regions. See Appendix 1.

CHAPTER 4.0
MATERIALS AND METHODS

4.1 MATERIALS

- *Tamarindus indica* ripe fruits from the 3 districts in Ukambani
- Atomic Absorption Spectrophotometer, AAS (Shimadzu, AA – 630 – R)
- Kjedahl auto analyzer (Hitechhood, Fs – 182)
- steam bath, bomb calorimeter, oven, muffle furnace, hot plate, dessicator, crucibles with lids, beakers, labels, khaki paper bags, ignition wire, tissue paper, digestion tubes, thimbles, burette, cotton wool volumetric flask , sox let apparatus, pipette, ashles filter paper, buchner funnel, suction pump and weighing balance.

4.2 REAGENTS

- Concentrated sulphuric acid
- Petroleum ether
- Sodium sulphate, copper suphate, selenium catalyst
- Industrial methylated spirit, alcohol
- Hydrochloric acid, light petroleum ether, boiling point (40 – 60° C)
- 0.313M sodium hydroxide, pure ascorbic, 40% w/v sodium hydroxide
- 2% boric acid, bromophenol indicator, metaphosphoric acid
- 2,6 dichlorophenolindophenol
- Benzoic acid
- Salicyclic acid, 30% hydrogen peroxide
- Sulphuric acid and selenium powder mixture
- Digestive mixture

4.3 METHODOLOGY

Ripe fruits were collected from around Mwingi, Makueni and Kitui districts in Ukambani. Choice of fruits was based on the ripe ones during the period of July – September. The fruits were peeled and the edible part removed. Analyses of triplicate samples of the edible portion was carried out as follows:

4.3.1 Physical methods

Moisture content was determined using an oven, Sulphated ash using a muffle furnace.

4.3.2 Chemical methods

This included crude Protein using the kjedahl method, elemental analysis by AAS, Vitamin C content using metaphosphoric acid, Crude fibre, crude fat, carbohydrates were also determined whereas energy were determined by Bomb calorimeter.

CHAPTER 5.0
RESULTS AND DISCUSSION

Table 2: Results

DISTRICT	DIVISION	Codes	% MC	Av dry matter	% av ash	Vit. C	% protein	% crude fibre	CV Kcal	Crude fat
KITUI	KAVISUNI	KV1	18.35	81.65	4.53	7.994	0.008	5.30	2.85	0.17
	MBITINI	MB2	26.10	73.90	5.41	7.999	ND	5.23	2.94	0.11
MWINGI	MUI (KATSE)	KT3	18.30	81.80	5.15	7.997	0.02	6.75	2.90	0.44
	KYANUNDU	KY	28.30	71.70	4.59	7.995	0.02	3.30	2.86	0.42
MAKUENI	KAMBU (TARDA)	TR3	24.00	77.50	7.91	-	0.02	5.06	2.82	0.04
	MAKINDU	MK1	32.60	67.40	6.31	7.999	0.008	5.50	2.85	0.042

Samples obtained near the town centers had a lot of moisture and most were not yet ripe. This is due to the cold climate that was observed around the town centers leading to late ripening; as opposed to the outskirts which had their fruits ripe at the same period. This explains the difference in Mbitini and Kavisuni samples from Kitui districts; 26% and 18% respectively. This gave dry matter content of 73.9% and 81.7% respectively.

Samples from Tana and Athi river Development Authority (TARDA) area in Kambu Division of Makueni district had a lower moisture content of 24% as opposed to that from Makindu town center which had unripe fruits, with the highest moisture content of 32%. Thus the dry matter was 67.4% and 77.7% respectively.

From Mwingi division of Mwingi district a planted sample at Kyanundu shopping center gave a high moisture content of 28%, since it's near the town center, followed by 24% from Mui division which is further away from Mwingi town.
Katse in Mumoni division which is about 59km from Mwingi town gave the lowest moisture content of 18%.

From the above table, sulphated ash for Kitui and Mwingi districts ranged between 4% – 5% while the difference Makueni, TARDA had 7.91% which is the highest could be as a result of high composition of organic residue since the fruits were for the previous season and most were decomposing.
Makindu with 6.31% on the other hand showed second highest from TARDA since the fruits were still ripening and probably contained more cations like magnesium
and Iron; and anions such as chlorides and phosphates as inorganic residue. This was an indication that the fruit had not reached maturity.

Samples from all districts had same ascorbic acid content hence topography had no effect on its content in this case. This is higher than some domesticated fruits like apples which have 5mg, pears 3mg and plums having 3mg. Table 1.
This value also compares with that obtained in Traditional Food Plants of Kenya by National Museums of Kenya. (8.13%) Deficiency in Vitamin C results in scurvy.

MK1 and KV1 have the lowest protein values of 0.008% they were unripe. The fruits that gave the highest protein values of 0.02% were mature. It appears that protein content has something to do with maturity period. Percent protein is the same for all the 3 districts.

The fibre content ranges around 5% apart from KT3 which had 6.75%. This is because it's a riverine sample causing it to have less minerals as most are soluble in the large volume of water taken up by the plant. The less the mineral quantity, the larger the fibre content and vice versa. KY has the lowest crude fibre content of 3.30. It's a planted sample with less minerals and more fibre content.

Fibre contributes to food bulkiness, thus contributing to low calorie intakes. It also plays an important role in digestion, hence preventing constipation and possibly colon cancer. It is also documented to have an effect on blood cholesterol, although the mechanism involved is not clearly understood. However fibre has been observed to result in lower levels of low – density lipoprotein in the blood, and the latter has been associated with coronary heart disease (Latham, 1979).

Makueni has low crude fat content probably due to the fact that the fruits were slightly green. Mwingi on the other hand had very ripe fruits and hence the high fat content since most were over ripe.

All samples have same internal energy hence difference in localities does not affect internal energy or the amount of calories in the fruits

TABLE 3: Concentration of mineral elements

			Mg/100g sample							
DISTRICT	**DIVISION**	**SAMPLE**	**Na**	**K**	**Mg**	**Ca**	**Fe**	**Mn**	**Zn**	**Cu**
KITUI	**KAVISUNI**	**KV1**	0.38	243	45.2	21.7	1.84	0.08	0.01	0.09
	MBITINI	**MB2**	0.64	ND	ND	ND	ND	ND	ND	ND
MWINGI	**MUI(KATSE)**	**KT3**	0.52	717	29.1	26.1	1.17	0.07	0	0.08
	KYANUNDU	**KY**	0.48	581	10.5	25.1	1.09	0.08	0.27	0.13
MAKUENI	**KAMBU (TARDA)**	**TR3**	0.80	1050	43.1	25.8	0.89	0.09	0.07	0.07
	MAKINDU	**MK1**	0.42	634	75.2	29.1	2.21	0.07	0.12	0.07

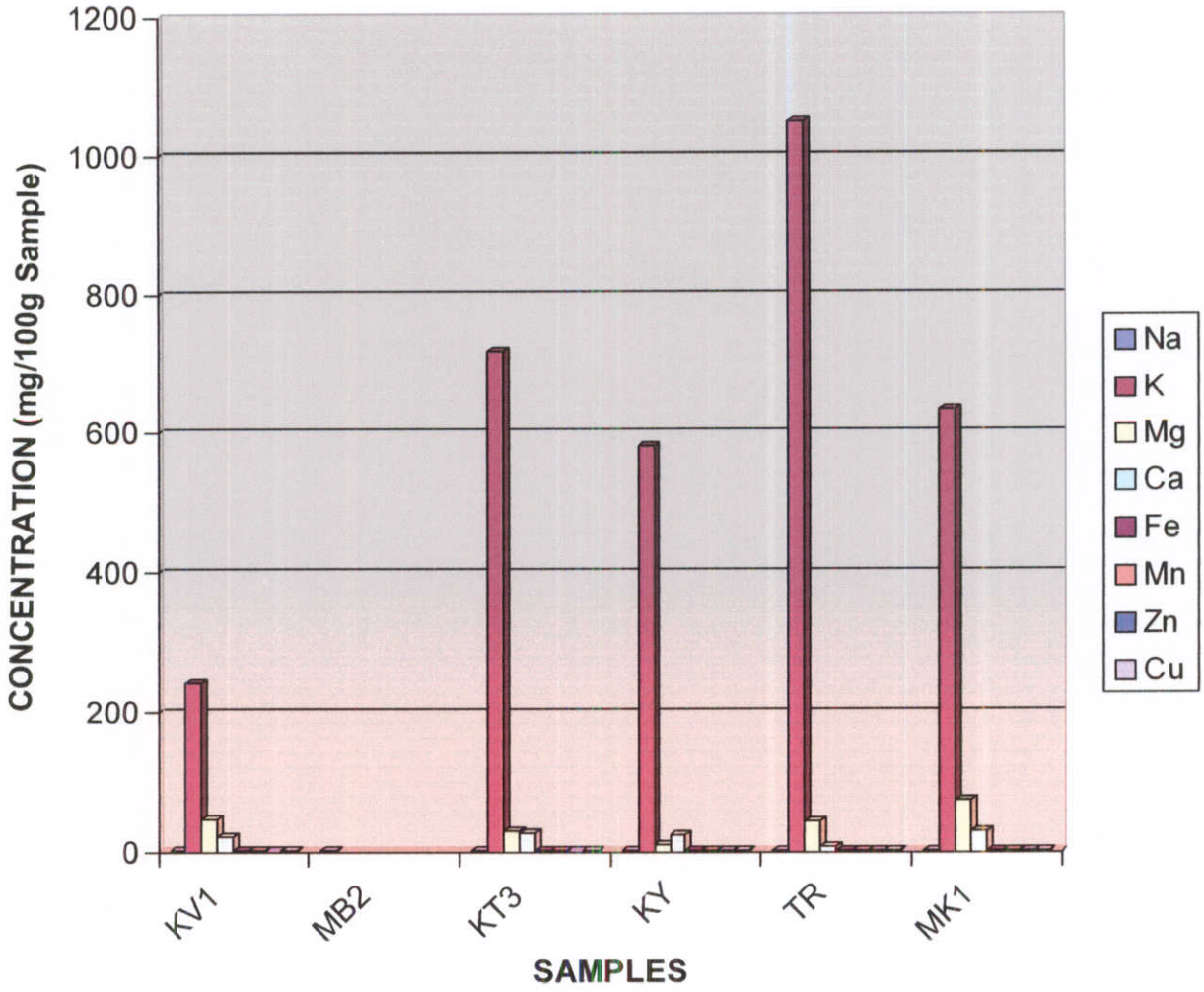
The Mn concentration is almost the same in all districts.
KY had the highest value for Zn and, Cu ,i.e., 0.27 & 0.13 respectively. This is a planted species. Zinc deficiency may contribute to a rare form of dwarfing found in the near east. Zinc is also essential in pregnant women as it is necessary for foetal development (Keen and Zindenberg – Cherr 1994)
Makueni district had the lowest values in Cu while it had the highest Na values with TR3 having 0.80 mg/100g sample. Copper in plants functions as electron transfer agents.

MK1 had 2.21 value for Iron which was the highest while KY registered 1.09 as the lowest. This lower value may be as a result of the fact that KY is a planted species which may be classified as domesticated. Table 1 shows lower values of Iron content for domesticated fruits. Iron is the metallic center of activity in hemoglobin which carries oxygen from lungs to the rest of the body parts and carbon dioxide from the body parts to Iron deficiency in the human body causes anemia, a problem most common with women than men. *Tamarindus indica* fruits could come in handy to alleviate this problem.

Calcium levels in *Tamarindus* fruits are highest for MK1 having a value of 29.1 mg/100g of sample, and lowest for KV1 with 21.7 mg/100g of sample. These values are very much higher than those of domesticated fruits in Table1. This element is found entirely in the bones(98%) but also plays the roles of muscle contraction etc.

Presence of magnesium as a cation in the fruits indicates it was unripe. That is why MK1 gave 75.2 which was highest and TR3 gave 43.1mg/100g of sample which was the lowest since the latter was an old sample from the previous season. Magnesium in plants is important for photosynthetic activity because it makes up part of the chlorophyll structure.
MK1 had the highest value of 75.2 mg/100g of sample, Potassium (1050mg/100g sample) while KV1 had the lowest value of 243. Potassium is useful in Glucose metabolism, protein synthesis and activation of some enzymes.
As problematic as it may have been, Sodium content was determined in the fruit samples and TR3 recorded the highest value of 0.80mg/100g sample whereas KV1 gave 0.38mg/100g sample. Sodium together with potassium are used to maintain osmotic pressure within cells and as a sodium pump.

Chart 1: COMPARISON OF CONCENTRATIONS OF MINERAL ELEMENTS FOR VARIOUS SAMPLES



CONCLUSION

From this study, it was found that *Tamarindus indica* fruit ('Ukwaju" – Kiswahili) which is an indigenous fruit is chemically and nutritionally, fairly rich, hence important in contributing to the diets of the communities. The fruit has appreciable levels of macro and micro – elements which are essential in the human diets "Ukwaju" can be taken as a supplement for Vitamin C, Iron, Calcium, Na , K, Mg and crude fibre. It also has minimal levels of proteins, fats, Cu, Zn and Mn.

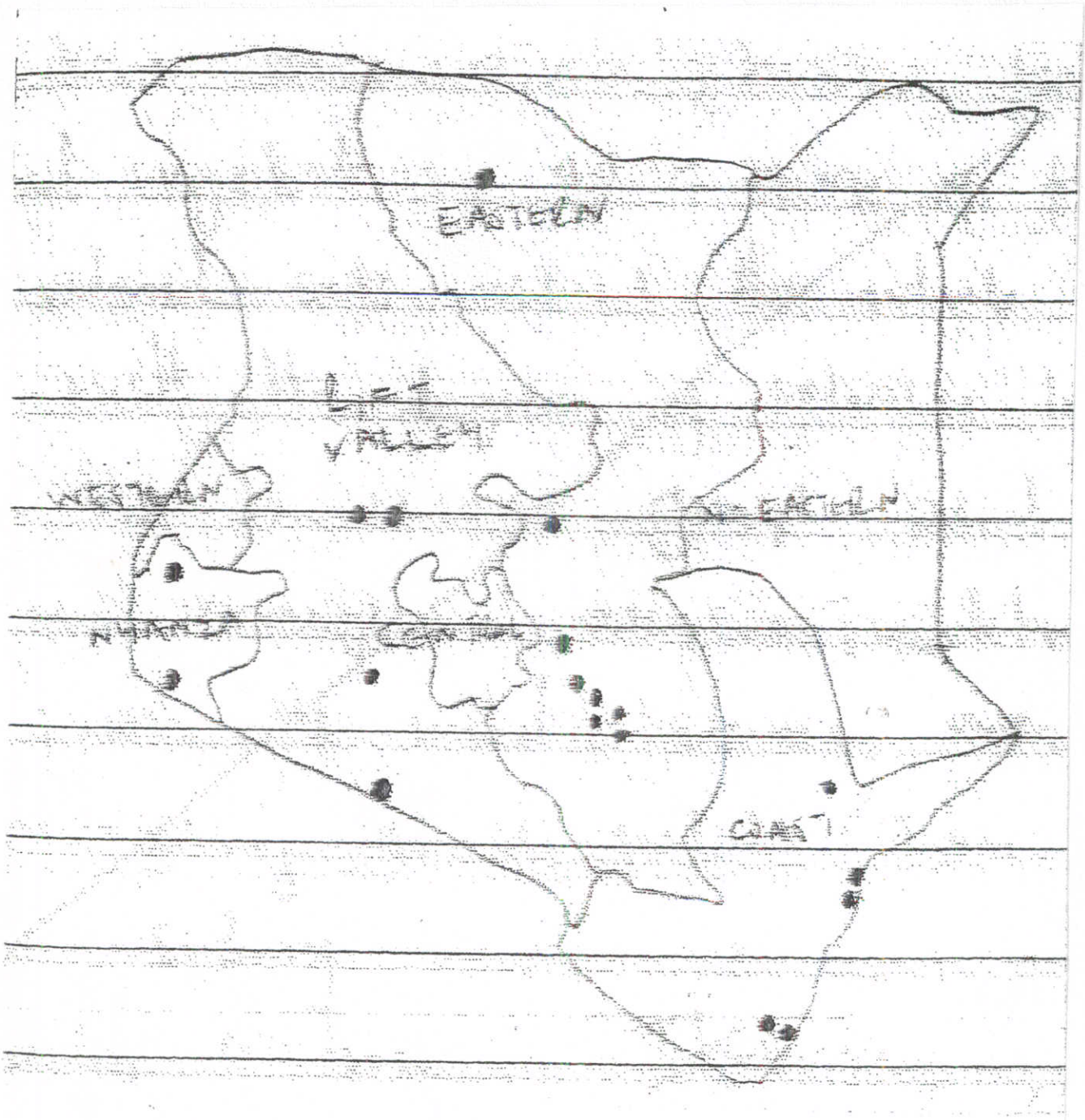
The fruit has high energy values making it an important energy source in the communities where it is found.

RECOMMENDATIONS

- Potential markets should be developed to enable indigenous fruits compete with commercial fruits in the market
- The industrial sector should develop appropriate processing techniques and develop the market infrastructure
- The communities should be educated on harvesting techniques to avoid destruction of the rest of the plant
- Further study using molecular techniques may give insight on the fact that morphological characteristics cannot be associated with species region (provenance)
- Chemical analysis of the seeds from the same region could be determined in order to advice the community on which part of the fruit is more nutritious.
- This fruits are found in dry areas and are a major supplement to the nutrition of these communities. While a lot has been done in west, Central and South Africa little has been done in east Africa. These is therefore need for research in this area that would lead to domestication and hence conservation.
- There is also need to compare effects of locality, time of harvesting storage, type of soil, climatic conditions, on nutritional composition of the fruit.

APPENDICES

APPENDIX 1: Distribution of Tamarindus indica in Kenya



APPENDIX 2 Tamarindus indica tree.