I INTRODUCTION

Tamarind (*Tamarindus indica* Linn.) is one of the most extensively planted and highly valued tree in India and it is intimately associated with the common man. It belongs to the family *Papaceae* (*Leguminosae*) and sub family *Caesalpiniaceae*.

The name tamarind is derived from the Arabic word “Tamr-ul-hind”, which means, “Date of India”. It is also known as Tamarin (Spanish and Portuguese) and tamarinier (French). Tamarind is indigenous to tropical Africa and to South Asia (Gamble, 1922). In Indian regional languages it is also called as Hunase (Kannada), Puli (Tamil and Malayalam), Imli (Hindi), Tintri (Bengal), Amla (Marathi), Chintu (Telugu), Koya (Oriya) and Amlika (Sanskrit).

1.1 Area and Production

Tamarind tree is grown widely in the tropical and sub tropical regions of the Indian sub continent along side of the roads, avenues, in and around villages as a multipurpose tree species and also in agro-forestry systems. But the commercial cultivation of the tree was initiated in the recent days only. The tree is commonly found in India in the states of Tamil Nadu, Karnataka, Bihar, Madya Pradesh, Andra Pradesh and Kerala. In Karnataka, tamarind is grown extensively both in cultivated and rainfed conditions. In Karnataka state, tamarind occupied an area of 26,177 ha, producing 23,559 tonnes of pulp (Anon, 1994).

India is the major producer of tamarind in the world with an estimated annual production of 4,00,000 MT of tamarind fruit and its products worth about Rs.50,00 crores are exported per annum (Babu, *et al*, 1999).

Among the different spices, tamarind occupies sixth position in terms of export earnings. It is exported as fresh, dry pulp and also as a
paste. During the year 1995-96, the pulp worth of Rs.2.44 crores was exported to 33 countries and including dry pulp and paste earned Rs.2G.86 crores for 16,587.66 tonnes (George and Rao, 1997).

1.2 Characters of Tamarind Tree

Tamarind is a large long living tree growing up to 80-120 years. It has spreading crown, slow in growth and usually an evergreen ornamental and shade tree, found throughout the rural areas. Tamarind tree thrives best, on deep alluvial soils. It prefers warm climates and can tolerate drought, but is sensitive to frost. It can tolerate a maximum temperature of 48°C and minimum of around 8°C and the rainfall range of 500-1500 mm. It is known as a hurricane - resistant tree (Lefevre, 1971).

Tamarind tree can grow up to 100 ft. height and girth of 30 ft. or more, with a spreading rounded crown. Leaves are paripinnate with 10-20 pairs of leaflets, which are about 0.5 inch long (Lewis and Neelakantan, 1964). Bark of the tree is dark brown, moderately thick and deeply cracked.

Tamarind’s heart wood, is strong and termite proof and takes a fine polish. It is excellent in turnery, toys, tool handles, decorative paneling and furniture and has been sold in North America as “Madeira Mahogany” (Lefevre, 1971). The tree also serves as excellent fuel and timber is invariably used for making agricultural implements. It is having a lot of scope in social forestry and agro-forestry. When burnt, it gives off intense heat. In India it is the preferred wood for firing brick kilns (Srinivasan and Agarwal, 1968).

Fruit set was only 36 per cent with open pollination and increased to 56 per cent with cross pollination. Bees are known to pollinate tamarind and bee farming could provide additional income to farmers. Fruit set is influenced by environmental factors, such as age and size of
shoots, C:N ratios. Due to the influence of these factors, high seasonal and annual yield variation can be expected (Usha and Singh, 1996).

The fruits are straight, semi curved and curved type, brown in colour, 5-18 cm long and 1.25-2.50 cm wide. They are flattened and constricted at intervals, with a thin brittle shell, containing a soft brownish or red pulp. The pods contain 3-16 seeds, which are ovate, oblong, smooth, flattened and brownish in colour. The seeds are contained in a locule enveloped by a tough, lea then membrane, so called endocarp. Outside the endocarp is the light brown, red, sweet, acidic edible pulp, traversed by a number of branched ligneous strands. The outermost covering of the shell is fragile and easily separable.

A full grown tree yields 150-500 kg fruits per season and the weight of each fruit varies from 15-30 g. There are only a few improved varieties of tamarind in India, which are grown in Tamil Nadu (Urigum), Karnataka (Chitradurga) and Rajasthan (Pratisthan). Some are less acidic and some are more acidic to taste and the colour of the pulp is usually brownish red. Although red variety is not so common but fetches better price and is preferred for making preservatives.

About half of the pod weight consists pulp, which has a sweet sour flavour, as it contains both sugars and organic acids such as citric, tartaric, acetic and ascorbic acid. The pulp is a rich source of vitamins and important minerals also contains calcium. Though reputed to be richer in sugar than any other fruit, the pulp usually has an acid taste.

On an average tamarind fruit is composed of shell (15-25%), pulp (45-55% o.i. seeds (25-35%) and fiber (10-15%). The edible portion of dried tamarind contains moisture (15-30%), proteins (2.0-8.79 %), tartaric acid (8.0- 18.0%), carbohydrates (56.70 - 70.70%), fibre (2.20 - 18.30%), reducing, sugars (25.0 ~ 45.0%) and pectin (2.0-4.0 %), rest being insoluble cellulose material (Shankaracharya, 1998).
1.3 Utilization of Tamarind

The pulp is often eaten fresh, directly from the pod but it is also used in the preparation of many foods for e.g., chutney, curries, preservatives, confectioneries, ice cream, juice and syrups. When mixed with sugar and water it becomes a refreshing drink, which is carbonated and sold throughout Latin America, Guatemala and Mexico. In Europe and North American countries, it is used for preparation of Worcestershire and Barbecue sauce (Lefevre, 1971).

The tamarind pulp is rich in calcium, phosphorus, iron, thiamine and riboflavin. It is also good source of niacin. It is considered useful as a cooling agent during fevers and also used as a carminative and mild laxative. Many find it effective in treating digestive problems, bile disorders, bronchial problems and even as a gargle for sore throats. Tamarind pulp mixed with salt is used as a liniment for rheumatism and to alleviate sunstroke. The pulp is excellent for cleaning silver, copper and brass.

Young leaves, flowers and immature pods are edible, which are list’d 10 season rice, fish or meat in curries and soups. The flowers act as source of nectar for honeybees in South Asia (NAS, 1979 and Hasan, 1972). Leaves are also used for fodder and are relished by cattle and goats. Both leaves and flowers are used in making dyes.

Tamarind pulp powder is one of the convenience food products developed from tamarind pulp and is being produced on commercial scale by several manufacturers in the country (Anon, 1982a).

Tamarind seeds are the raw material used in the manufacture of kernel powder, polysaccharide adhesive and tannin. The seed is gaining importance as an alternative source of proteins, since rich in some essential amino acids. Hence, the chemists, food technologists and nutritionists show a lot of interest on the chemical aspects of tamarind
seed. Tamarind seeds are now largely wasted, can be ground to make a palatable livestock feed and can be processed to prepare a purified pectin like gum, used for jelling fruit juices and stabilizing other processed foods. This is also used for sizing textiles, paper and jute products. The amber coloured oil from seeds is suitable for food or industrial use, which are used to give a shiny finish to toys (Bhattacharya et al, 1994).

Tamarind seed testa is a byproduct obtained after the production of tamarind kernel powder, which has a good potential as a tanning material. It contains tannins to the extent of 20-24% with tannin to non tannin ratio of around 1:4 (Marangoni et al., 1988).

During the storage of pulp, the brownish red pulp becomes darker and after a year it becomes black. This is due to the onset of Maillard reaction, since free amino acids and reducing sugars are present. In humid climates the pulp becomes soft and sticky as pectolytic degradation takes place and moisture is absorbed. Insect infestation is serious problem, when the seeds are present in the pulp (Lewis, et al, 1970).

1.4 Post Harvest Operations

The tree begins to bear fruits at the age of 8-12 years and continues to yield for more than 70 years. But the trees from grafts and layering take only 5-6 years for bearing fruits. The flowering starts during June - July. The fruits are allowed to ripen on the tree, until the outer shell is dry and can be separated from the pulp without adherence. The fruits are harvested by hand picking, clipping with a hook mounted on a stick or merely shaking the branches and also by beating with sticks (Plate No 1.1 to 1.3). A sheet is usually placed beneath the tree to collect fallen fruits, this provides some protection against the hard earth and may prevent damage of the shell (Plate No 1.4). The sheet also allows
Plate No. 1.1  Plucking by using harvesting tools

Plate No. 1.2  Tree shaking

Plate No. 1.3  Harvesting tools
Plate No. 1.4  Collection of tamarind fruits
easy collection of the fruits. Fruit left on the tree will eventually fall off naturally (Chaturvedi, 1985).

In Karnataka, the harvesting of the tamarind will take place in the month of April - May and the practice is either by shaking the branches of the tree or by beating with long handle sticks. In post harvest operations dehulling, defibering and deseeding are the major processes before storage. The outer shell of the tamarind is removed manually by beating action.

The defibering and deseeding are normally carried out simultaneously by engaging the labourers. Simple tools like wooden mallet or hammer will be used to separate seed from pulp. Among the post harvest operations deseeding is considered to be important and it has to be done timely to prevent insect infestation. Almost all the post harvest operations are carried out manually which is found labourious and time consuming. There is no much study is undertaken in developing suitable post harvest machinery for tamarind.

1.5 Objectives

Keeping the above facts in view the present study entitled “Development and Performance Evaluation of a Tamarind Seed Expeller” was undertaken with the following objectives:

1) To study the existing practices and problems of seed expulsion from the fruit.
2) To study the physical, engineering and chemical properties of tamarind fruits.
3) To develop and standardize the operational parameters of tamarind seed expeller.
4) To evaluate the seed expeller in comparison with traditional practices.
5) To study the economics of tamarind seed expeller.