II REVIEW OF LITERATURE

In this chapter, literature pertaining to studies on “Physical and Engineering properties of tamarind fruit, character, chemical composition of pulp, seed expulsion machine and economics involved in seed expulsion have been reviewed”. Since there is no much research has been carried out on the development of tamarind seed expeller, the related literature pertaining to the development of other seed and pulp expulsion machineries have also been reviewed.

2.1 Selection of tamarind fruit

Tamarind is mostly self sown or by sowing seeds of unknown parentage, which has resulted in wide variations among seedling progenies (Paulas, 1975).

Kakocinski (1979) reported that, selection of best individual from a native species is one of the most commonly used crop improvement programmes. This is the simple and promising method of crop improvement.

Usha (1.996) conducted field studies on to select high yielding tamarind trees based on their flowering pattern. Studies indicated that mid and late flowering types should be selected for higher yields.

Singh (1997) observed that native, species are well adopted to local conditions, it ensures successful establishment and gains selection of best, individuals from the native population.

Shivanandam (1980) reported that, there is a good scope for the selection of promising types of tamarind by studying the existing variation among seedling progenies with respect to quality and productive types.
2.2 Physical, Engineering and Chemical Properties of Tamarind Fruit

2.2.1 Physical properties

Mohsenin (1986) evolved a mathematical expression for measuring the size of fruit. The fruit size was recorded through three axial dimensions.

\[
\text{Size} = (\text{length} \times \text{breadth} \times \text{thickness})^{1/3}
\]

Bhattacharya et al. (1993) determined the chemical composition of tamarind seeds and some industrially important physical and engineering properties. The kernel powder is rich in potassium. The shape of the tamarind seed is not uniform to standard shapes of seeds. The length, breadth, thickness, sphericity, roundness, surface area, average weight and volume per seed have been determined. The static coefficient of friction of seed was determined on rough, smooth and very smooth surfaces. The angle of repose for roasted kernel is higher than that of the raw whole seeds.

Hiregoudar (2000) studied physical properties of fruits and reported that fruit length (13.35 cm), fruit breadth (1.29 cm), thickness (1.75 cm), volume (20.25 cm) and bulk density of 250 kg/m$^3$.

2.2.2 Shape of tamarind fruit

Paulas (1075) recognized a new tamarind type known “Valakatchi” winch bears long and rectangular pods as against some of the types which produce short and cylindrical pods.

It has been noted that tamarind pods are 7.5 to 20.0 cm long, 2.5 cm broad and 1.0 cm thick more or less constricted between the seeds, slightly curved, brownish, ash coloured, scurfy (Anon., 1972).

It has been reported that tamarind seeds are contained in locule enveloped by brownish and endocarp. Sweetish acidic edible pulp and
traversed by a number of ligneous strands (Anon, 1972). Hernandez - Unzon and Lakshminarayana (1982) described the ripe fruit of tamarind as fruit with curved pod of 12 to 15cm length, weighing 10 to 20g. It has a scurfy brown, weedy, fragile peel (Shell).

Shivanandam (1980) recognized four types of tamarind based on fruit shape, viz., (rails straight and bulged, fruits straight, and flattened, fruits curved and bulged, and fruits curved and flattened. Straight and bulged type fruits have shown more fruit length (16.35 cm) compared to other type of fruits. Most of the samples studied recorded pulp with light red colour. The tamarind (*Tamarindus indica* L.) fruit ranging from 7.5 to 17.5cm long and about 2.5 cm in breadth, is a straightly curved pulp, brownish pod, having brittle shell (Mowrv et al., 1967).

Bhattacharya et al. (1997) observed that, the tamarind is one of the important tree legumes in tropical and sub tropical countries. The fruit consists of seed (33.9%), pulp (55.0%) and shell and fibre (11.1%).

Singh et al. (1907) made comprehensive survey of bearing cultivars and carried out physico chemical studies of the fruits. Out of the several cultivars, eight outstanding selections were described based on fruit and seed characters. Kokate (1988) reported that through survey, MPAU, Rahuri as located six promising tamarind types having large fruit size (22.5 cm long weighing 35 to 42 g) with extra while endocarp membrane colour.

Shanakaracharva (1998) studied and reported that, the pulpy portion of fruits from the tamarind of commerce, which finds extensive use in culinary preparations. The fruit pulp is the richest natural source of tartaric acid (8-18%), is composed of shell (15-25%), pulp (45-55%), seeds (25-35%) and fibre (10-15%). The pulp contains mainly tartaric acid, reducing sugars, tannin, fibre and cellulose material.
2.3 Engineering Properties

2.3.1 Angle of Repose

Dutta et al. (1988) indicated that, the angle of repose increased from 25.5 to .30.4° for grams as the moisture content, increased from 8.62 to 17.6 per cent d.b.

Igathinathane (1990) stated that, the angle of repose of tamarind fruit was 45.28°.

Kaleemullah (1992) reported that, the angle of repose increased from 19.79 to 25.13° for groundnut kernels as the moisture content increased from 9.05 to 30 per cent d.b. respectively.

Rai and Kumar (1995) stated that, the angle of repose increased, from 19.54 to 29.1.0° for kabuli chana as the moisture content increased from 7.6 to 2 1 per cent d.b. respectively.

Vishvanathan et al. (1996) indicated that, the angle of repose increased from 30.80 to 37.70° for neem nut as the moisture content increased from 5 to 22 percent d.b. respectively.

Avia.ra et al. (1999) reported that, the angle of repose increased from 28.07 to 43.58° for guna seeds as the moisture content increased from 7 to 30.60 per cent. d.b. respectively.

2.3.2 Co-efficient of friction

Igathinathane (1990) reported that, the co-efficient of static friction of tamarind fruit on MS surface was 0.68.

Carman (1996) stated that, the static and dynamic co-efficients of friction of lentil seeds against galvanized sheet metal, plywood and rubber surfaces increased with moisture content in the range from 6.5 to 32.6 per cent (d.b.).
Vishvanathan et al. (1996) stated that, the co-efficient of friction of neem nut increased linearly with moisture content for surfaces such as plywood, mild steel, galvanized iron and glass. The maximum friction was offered by plywood, followed by mild steel, galvanized iron and glass surface.

Suthar and Das (1996) reported that, the static coefficient of friction of karingda seeds varied from 0.34 to 0.91 with plywood, 0.29 to 0.80 with mild steel and 0.23 to 0.67 with galvanized iron in the moisture range of 4 to 5 per cent d.b. The corresponding values for karingda kernels were 0.33 to 0.79, 0.27 to 0.69 and 0.22 to 0.67.

Aviara et al (1999) reported that, the coefficient of friction of guna seeds increased linearly with increase in moisture content and varied from 0.4 1 to 0.98 according to the surface.

Chandrashekhar and Vishvanathan (2002) observed that, the coefficient of friction for coffee beans increased linearly with increase in moisture content, on various test surfaces, namely, aluminum, galvanized iron, mild steel and stainless steel. The maximum friction was offered by the mild steel surface, followed by galvanized iron, aluminum and stainless steel surfaces.

Kallemullah (2003) reported that, frictional properties are important factors for proper design of agricultural product: handling equipment.

2.3.3 Moisture content

Moisture content is the main criteria in tamarind fruit. Based upon the moisture content of the fruit all the processing aspects occurred.

Hall (1970) described a method to determine the moisture content of the fruit. The moisture content could be found out by placing 25-30 g of sample in hot oven at. 100° C for 2 h.
2.4 Chemical composition of fruit

Rao *et al.* (1954) after analysis of pulp found that, pulp contain crude protein (3.1%), carbohydrates (67.4%) and fibre (5-6%) and mineral (2.9%) and out of 55% of the total nitrogen was non protein of which 70% was free amino acids, The pulp of tender fruit contains less nitrogen than ripe.

Lewis and Johar (1956) revealed that, the red colour fruit is due to cyaniding to be sweet than very sour ones and 10-12% of tartaric acid present in combination with potassium bitartarate from common variety. The red pigment released was chromatographically identified as cyaniding. The pigment was isolated from the juice by extraction with n-butanol and precipitation with ether.

Shukla (1957) observed that, the acid originally present is free from potassium tartarate. The acid is regenerated by treatment with sulphuric acid in pulp, the use of ion exchange resins has been suggested for the isolation of the acid from aqueous extracts of the deshelled fruit.

Lewis *et al.* (1957) revealed that, the red tamarind berry contains a deep red pigment identified as crthrycyanin, chrysanthemin. Significant difference in the common composition of red fruit and common fruit as follows, moisture (20.1% and 18.2%), tartaric acid (6.6% and 9.8%), invert sugars (36.4% and 38.2%), pectin (4.4% and 2.4%), protein (3.0% and 2.8%), ash (4/2% and 2.8%), cellulose residue (13.0% and 19.4%) respectively.

Lewis and Neelakant.an (1964) revealed that, tamarind fruit, is the most acidic of all natural foods and contains tartaric acid (8-18/o), reducing sugars (25-41%), pectin (2-3.5%) and proteins (2-3%). The proteins of seed are reported to be of high biological value, comparing well with cereal proteins, but their utilizability is poor composition of
Tamarind leaves were as follows, moisture 60-80%, tartaric acid 12-27%, crude protein 10-14%, ash 4-12% and calcium 12-35%.

Cowen (1970) reported that, tamarind pulp is brown in colour and sour while on other it is sweet but the best considered to be one with reddish pulp. Because of its pleasant acid taste and rich aroma, tamarind pulp has been used in many commercial products (Lewis and Neelakantan, 1964; Benero et al, 1972; Bueso, 1980; Parameshwar and Sadashivaiah, 1985).

Shivanandam (1980) reported that, the highest per cent of tartaric acid was recorded in tamarind fruits which are curved and bulged types (3.16%) followed by straight and bulged type (2.99%).

Shivanandam (1980) observed a wide range of pulp weight in tamarind (8.80 to 17.03 g). The fruits of curved and bulged type (17.03 g) recorded highest value compared to other types of tamarind fruits studied. Four types of pulp colours viz., light red, rose red, brown and dark brown were recorded in tamarind fruits under study. As high as 72 per cent pulp content was recorded in tamarind fruits.

Hernandez - Unzon and Lakshminarayana (1982) reported that tamarind pulp has an acidic, sweet taste with a strong aroma, there are mainly two types one with brown pulp turning dark brown during storage and the other with red pulp. The former is extensively cultivated due to its enormous reduction.

Manjunath et al (1991) analysed for their physico-chemical constituents, viz., moisture (6.9%), acidity (9%), protein (2.1%), crude fibre (3.1%), total reducing sugars (20.1%), starch (33.8%), water soluble solids (14.7%), degree of browning (0.27%) and minerals like calcium (10.3%), phosphorous (25.5%), sodium (5.3%) and copper (1.4%). The data is used in proposing quality standards of tamarind powder, which is used in modern food processing. It is conveniently used as a souring
agent in the culinary preparation of rasam, sambar, puliyogare mix, sauce and chutney, etc.

Challapalli (1992) observed the range of variation in tartaric acid from 8.94 to 14.98 per cent.

2.5 Fruit characters

Lewis et al. (1954) analyzed that the tamarind fruit contains pulp (55%), seeds (33.9%), shell and fibre (11.1%). The pulp contains moisture content (20-30%), tartaric acid (10-12%), reducing sugars (25-30%) and other soluble solids (3-4%). The rest being insoluble cellulose materials, which examined by fermentation and found that it contains 2.31-3.70 per cent of pectin.

Srinivasan and Agarwal (1968) calculated the economics, statistics and commerce of this useful species in India, and found that 11.1 per ccml of dry pulp of fruit yield, about: 1C per cent of free tartaric acid pulp (red and brown colour). Pulp contains protein (3.1%), carbohydrate (67.4%), fibre (5.6%) and minerals (2.9%).

Lewis et al. (1970) revealed that, tamarind fruit contains pulp (55%), seeds (33%), fibre and shell (12%). He also reported that pulp contains moisture (18.2%), free tartaric acid (9.8%), combined acid (6.7%), pectin (2.4%), ash (2.8%)

2.6 Development of seed expulsion machine for different fruits

Nicholar (1971) developed a mechanical vegetable seed extracting machine. In this machine, a beater assembly arranged spirally on the rotary shaft was used to extract the seeds. There was no mechanical damage to the seeds. The capacity of the machine for brinjal was 10 kg/h of seed and the seed extraction efficiency was 75%. For tomato having a seed pulp ratio of 1:65 the machine could handle fruits at the rate of 2 tons/h and the seed extraction efficiency was 70 per cent.
Kalra et al (1983) developed a manually operated tomato seed extracting machine. The tomatoes were crushed due to shear between the rough surface of the concave and the rotary cylinder. The throughput capacity was 60 kg/h and there was no mechanical damage to the seeds.

Kachru and Sheriff (1992) evaluated the performance of an axial flow vegetable seed extractor, viz., tomato, brinjal, watermelon and pumpkin. The capacity of the machine ranged between 220 kg/h and 960 kg/h for different, vegetable fruits. The seed extraction efficiency for brinjal and tomato was 2.81 per cent and 0.17 per cent respectively. For brinjal and tomato the seed loss was 0.82 per cent to 5.02 per cent and the mechanical damage was ranged between 0.97 to 5.79.

Verma et al. (1992) developed an axial flow vegetable seed extracting machine operated by 2 kw electric motor. The fruits were crushed into small pieces using blades mounted on a rotor shaft inside a cylindrical casing. Feed rate varied from 3.10 to 1930 kg/h and the seed extraction rate was 0.47 to 3.14 kg/man - h of different vegetable fruits. The seed loss for all the vegetables except squash melon was below 5.86 per cent. The cost of seed extraction was below Rs.2.86/kg seed except for cucumber, for which it was Rs.7.26/kg.

Devadas et al (1993) developed a horizontal type tomato seed extractor. Ir this machine, a beater assembly arranged on a rotor shaft was used to extract the seeds. The machine was operated by 1.5 hp motor. The capacity, seed extraction efficiency and cost of extraction of the machine were 60 kg/h, 85 per cent and Rs.7/kg of seed respectively.

Deeptni et al (1993) fabricated and evaluated a power operated axial flow vegetable seed extractor. The machine was tested for tomato and cucumber. For tomato, the seed extraction rate was 40.97 kg/h with 4.3 per cent seed loss. For cucumber, the seed extraction rate was 6.56 kg/h with 4.91 per cent seed loss.
Gabani and Siripurapu (1993) fabricated a chilli seed extractor. A hopper fitted on the top of the crushing assembly encompassed a concave and star roller fitted on a shaft. A drum separator assembly, consists of a screen and flight fitted on a shaft. Here the chillies were crushed and the screen separates the seed from the crushed material. The mixture of seed and small particles was fed to cleaning unit and cleaned seeds were collected at the seed outlet.

More and Kanawade (1994) fabricated a power operated pomegranate seed extractor. The machine consisted of a hoper, shaft with knives, concave, outlet chute and a power transmission system. The capacity of the machine was 150 kg/h and the seed extraction efficiency was 86 per cent.

Mohanly et al. (1997) designed and developed a vegetable seed extracting machine, cutting, crushing and conveying blades mounted on rotor shaft separated the seeds from the vegetable fruits. The machine with a 0.5 hp electric motor had a capacity of 211 kg/h for tomato (at 370 rpm). The average seed out put, seed loss and seed extraction efficiency of the machine was 2.95 g/kg fruit, 0.527 g/kg fruit and 84.7 per cent respectively.

Madaswamy et al (1999) designed and developed a brush type washer mechanism to remove the mucilage of both Arabica and Robusta coffee during pulping. The mucilage of the coffee beans was removed by nylon bristles of different thickness (0.3 mm and 0.5 mm) mounted on wooden rollers. The washing efficiencies for Arabica and Robusta parchment was 100 and 85.7 per cent respectively. The capacity of the machine using a 3 phase, 1 hp electric motor was 25 kg of parchment per hour and the cost of operation was Rs.0.24 /kg for arabaica coffee parchment. The cost of the machine was Rs.10,655.
Chandrashekar and Viswanathan (2002) developed and evaluated a low cost coffee pulper. Three pulper viz., i) pulper with screw conveyor, ii) pulper and iii) pulper with cylinder and concave were designed, fabricated and evaluated for pulping performance. Among the three, the pulper with cylinder and concave mechanism was best maximum effectiveness and minimum breakage of beans. The capacity, pulping efficiency and separation efficiency of the above pulper were 80 kg/h, 98 and 80.9 per cent.

2.7 Post harvest equipments of tamarind

Igathinathane (1990) developed a seed expeller unit itself consisted dehulled pod shearing machine. The performance of huller was 71 to 79 per cent and with a capacity of 130 kg/h and seed expeller unit having a capacity of 2.9 kg/h at 3.00 mm clearance.

Ramakumar et al. (1996) observed that, a comparison of hand and mechanical seed removal of tamarind seed expeller was 11 times faster than manual separation and had a capacity of 35 kg/h for 22% pulp moisture content on wet basis.

Ramakuar et al. (1997) developed a hulling machine with efficiency of 80 per cent and 58 per cent: for large fruit and small fruit, respectively. Also reported that, the tamarind dehuller developed was very efficient in saving time as compared to traditional methods, besides overcoming drudgery involved in manual dehulling.

Ramakumar et al (1997) developed an improved pulp squeezing machine by increasing the length of raspbar roller combine to 450 mm to obtain a capacity of 45 kg/h at moisture content of 22 per cent (w.b.). The sheared/smashed pulp needed for hand separation was 30 kg/women/day and packing to enhance the trade value.

Ramakumar et. al. (1997) revealed that, during the seed explosion process tamarind fibre get loosened followed by manual separation along
with any sticky seeds. The trials showed that the time taken for separation of fibre manually was 11.3 min from 4.14 kg of pulp.

Prakash and Sharadagopal (1998) reported that, Abdul Khadar Nadakattin from Annigeri near Gadag District developed seed and fibre, separation machine having a capacity of 800 kg/day. This unit is still in final stages.

Hiregoudar (2000) studied performance evaluation of traditional and mechanical methods of deseeding and reported that, maximum output was observed in the mechanical deseeding (16.07 kg/h) as compared to traditional method (2.31 kg/h) with higher mechanical damages to pulp and seed.

Hiregoudar (2000) developed and evaluated tamarind defibring machine. The study was carried out: at different age groups and both genders. The traditional method of separation gives less output compared to mechanical. The mechanical (29.1 ± 5.00 kg/h) defibring gives seven times faster than traditional (4.48 ± 1.0 kg/h) separation in straight, fruits after sun drying. The processing is efficient in saving lime, labour charges besides overcoming drudgery involved in manual processing.

Sharanakumar (2001) reported that traditional method of seed expulsion was found better among middle-aged labourers and more damages recorded in case of young-aged labourers.

2.8 Economics of tamarind seed expeller

The economics of the seed expeller was worked out by Babu et al. (1999). The cost of operation was Rs.0.65/kg of seed expulsion. The cost benefit of seed expulsion is 12.30 times beneficial as compared to manual method.