DEVELOPMENT OF TECHNOLOGY FOR ALTERNATIVE MATERIAL TO ARECA LEAF PLATES

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PROJECT REPORT
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DECLARATION

We hereby declare that this project report entitled **"DEVELOPMENT OF TECHNOLOGY FOR ALTERNATIVE MATERIAL TO ARECA LEAF PLATES"** is a bonafide record of project work done by us during the course of study and that the report has not previously formed the basis for the award to us of any degree, diploma, associateship, fellowship or other similar title of another University or Society.

Place: Tavanur

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CERTIFICATE

Certified that this project report entitled **“DEVELOPMENT OF TECHNOLOGY FOR ALTERNATIVE MATERIAL TO ARECA LEAF PLATES”** is a record of project work done jointly by **Albert C.J, Anusha P and Shemeema U.S** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of another University or Society.

Place: Tavanur

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Albert C.J

Anusha P

Shemeema U.S

Dedicated to
Our Loving Parents

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SYMBOLS AND ABBREVIATION

%	percentage
/	per
^{0}C	degree Celsius
µl	micro litre
µm	micro meter
cm	centimeter
CFTRI	Central Food Technology Research Institute.
ECS	Evaporative Coolant System
et al.	and other people
etc.	Etcetera
g	gram
g/l	gram per litre
hr	hours
HP	Horse Power
i.e	that is
J.	journal
KAU	Kerala Agricultural University
Kg	kilogram
kg/m^3	kilogram per cubic meter
LDPE	Low Density Polyethylene
mg	milligram

min.	minutes
ml	millilitre
NIRD	National Institute for Rural Development
PHT & AP	Post Harvest Technology and Agricultural Processing
PP	Polypropylene
RH	Relative Humidity
s	second
SHGs	Self Help Groups
viz.	namely
wb	wet basis

CHAPTER I
INTRODUCTION

Disposable plastic wares are an essential part of any special occasions now a days such as wedding, social gathering, festival etc. It is suitable to the busy human life. The wide acceptance made this industry to develop faster and faster. Though, the use of disposable plastic wares gives a temporary relief and satisfaction its bad effects on environment and earth does not end.

Waste disposal treatments are some of the major issues we have to deal with. Disposable plastic wares are a major chunk to the waste accumulation. As a solution, we can introduce eco plates made of leaves.

The leaf plates are completely eco friendly, biodegradable and compostable, chemical free and non toxic, light weight, hygienic, natural and attractive, microwave safe and refrigerator safe, sturdy and light, ideal in buffet parties and hold liquid for three to four hours which can serve all kinds of food like hot, cold, oily, dry and greasy. It can be easily moulded into different size and shape like oval, round, rectangular etc.

The above qualities make the leaf plates much better than the existing disposable plates, made out of plastic, thermocol and paper. Thus it has a potential demand at places like marriage halls, hotels, food chains like haldirams, temples etc. If marketed properly; then the international environment friendly natural product based markets will be also accessible.

Now-a-days poverty rate is fast increasing in rural areas and the per capita income is getting declined. So we should lead the youth of our nation towards gainful and productive activity. To promote self employment among the youth, we have to encourage and support community level micro enterprises. Leaf plates based industries give much opportunity for self employment. The enterprises based on leaf plates affect employability in a positive light in rural areas. At the same time, it would lead to the production of an eco friendly product from a resource which is generally considered as a waste.

Eco friendly leaf plates are very common. In Kerala, the raw material used for the production of plates is the areca leaf sheath. Self Help Groups, Cottage industries, Individual farmers etc. are engaged in leaf plate making micro enterprises. The shed leaves are gathered from nearby areca plantations. The leaves are then made into the shape of plates with the help of machines. The leaf plates can eliminate unhygienic practices like serving food in reusable plastic, metal or ceramic plates. One machine can provide sufficient income for three to four people from the sale of plates. High quality plates made from areca leaf sheath can be exported. These leaf plates are used in weddings, parties, family get together, picnic, restaurant, coffee shop etc.

Kerala has an abundance of Areca Palm trees, which shed leaves every 21 days or so. When the leaves fall to the ground, the farmers collect them - some are composted or used for earthworm farming. Some of the leaves are used to make plates and bowls. Making palm plates is a good way for the rural people to earn a living and help support their families. As the process is very hands on, for the amount of leaves that fall to ground in India every year, up to 300,000 people could be employed making palm leaf plates to replace the paper and plastic ones.

But the availability of the raw materials is less compared to the production capacity. So alternative materials to areca leaf sheath is needed. Hence a study was conducted at Kelappaji College of Agricultural Engineering and Technology, Tavanur. This encompasses the following specific objectives.

- Identification of suitable alternative leaves to the areca leaf sheath
- Studies on effect of moisture content on quality of plates
- Standardization of die temperature and retention time.
- Development of eco plates from the alternative leaves

CHAPTER II
REVIEW OF LITERATUE

A brief review of the various materials used for the production of plate by various investigators is presented in this chapter. History, origin and physical properties of the materials have also been reviewed up and presented briefly.

2.1 Leaf plates

Making plates from leaves has been a part of Asian and African cultures for centuries. The plates which are made from fresh leaves or pretreated leaves with the help of leaf plate making machine are known as leaf plates. These plates are biodegradable, compostable, having a natural and attractive appearance, non toxic, light weight and can be easily moulded into different sizes and shapes like oval, round, rectangle etc.

2.1.1 Areca leaf sheath

Areca nut palm (*Areca catechu)* belongs to the family Arecaceae. As a part of Supari Leaf Sheath project a single unit is established in Maharashtra. This unit is established by CHAMPS Eco Friendly unit for self help groups, small entrepreneurs and farmers in Konkan region, Maharashtra. This project has been aimed as a community based development programme, income generating activity and poverty alleviation programme.

The beneficiaries of this project are Supari farmers, leaf collection labours, transporters, entrepreneurs and consumers. This “BEST OUT OF AGRO WASTE” concept is an on going process by CHAMPS Eco Friendly Unit. They promote Self Help Groups, Unemployed Youth and Entrepreneurs by training, supplying of machinery, technical know-how and buy back the finished products.

Nowadays areca leaf plates are very common in Kerala. There is an agro processing unit called ‘Friends Agro Processing Unit’, near the K.C.A.E.T, Tavanur campus, at Edappal manufacturing and distributing areca leaf plates. Locally available

leaves are collected and a pre-treatment is given by soaking it in fresh turmeric solution for half an hour. Then they are allowed to drain for about ten minutes. The leaves are then placed in leaf plate making machine for shaping. The SHGs engaged in this job earns monetary benefits through this. There are number of SHGs engaged in leaf plate making in Kerala.

2.1.2 Siali leaves

Siali (*Bauhinia vahili*) of the family Fabaceae is a woody climber, found deep inside the forest. After monsoon the newly flushed leaves are hand plucked, partially sun dried and stitched by the tribal women. These women were organized as SHGs and provided with sewing machine for stitching of leaves to reduce their drudgery and to improve productivity. The stitched leaf plates are cut in to uniform size and packed as per buyer's demand. The plates are made of 12" diameter. For buffet plates, they are machine pressed with cardboard at base.

These are elegant and Eco Friendly gracefully stitched and pressed bio degradable plates. Siali leaf buffet plates are cheap, hygienic and ecological substitute for thermocol and plastic plates. The natural green colour with wild deciduous essence makes it ideal for parties and gatherings. The works carried out by Centre for People's Forestry in 2002 showed that the tribal communities (about 50,000) of coastal Andhra Pradesh are the poorest among the poor. These communities depend on the leaf plate making activity as sole means of income through out the year.

2.1.3 Sal leaves

The well-known timber-yielding tree Sal (*Shorea robusta*) belongs to the family Dipterocarpaceae has durable leaves and is a source of income to the tribal, which are hand plucked by tribal women. The leaves are stitched with Neem / Bamboo sticks (Khadika) and cured under sun with much care to avoid fungal attack. Then they are machine pressed to give desired size and shape by SHG members and are packed as per buyers / market demand.

Mature Sal leaves are intricately adjoined with traditional knowledge in to plates, trays and cups, which are widely preferred by eco-conscious world. Its glistening, dusky golden colour adds dignity to celebrations of any nature, especially in poojas, marriages and festivals.

In Orissa it is a village based industry. Main collectors of leaves are women. They sit together in the smoothed mud yard in their village and stitch the leaves into round with little sticks. They can be stitched further by machine. The stitched leaves are put out in the sun to dry. Each plate is made by pressing two such stitched leaves together in a machine.

2.1.4 Teak

Teak (*Tectona grandis*) is a genus of tropical hardwood trees in the mint family, Lamiaceae, native to the south and southeast of Asia, and is commonly found as a component of monsoon forest vegetation. The name teak comes from the Malayalam word Thekku. Teak is a deciduous tree and can grow up to 50 m high with a girth of well over one metre. Older trees leaves may be of 30 to 60 cm long and are broad; younger trees have still larger leaves. Teak trees typically thrive in deep soils that are well drained and rich in calcium. They will flourish where there is an average yearly temperature of 27 degrees Celsius (80 degrees Fahrenheit) and generous rainfall; although a 3 to 4 month dry season is necessary. The teak trees that are part of the live fence to the right are shedding their big leaves, as teak trees do in dry season. One of its advantages is that it grows quickly. Sometimes it is included in the subfamily Prostantheroideae. There are three species of *Tectona*:

- *Tectona grandis* (Common Teak) is the most important, with a wide distribution in India and Indo-China.
- *Tectona hamiltoniana* (Dahat Teak) is a local endemic species confined to Burma, where it is endangered.
- *Tectona philippinensis* (Philippine Teak) is endemic to the Philippines, and is also endangered.

2.1.5 Vattayila

Macaranga peltata is a large genus of Old World tropical trees of the family Euphorbiaceae. Native to Africa, Australasia, Asia and the South Pacific, the genus comprises over 300 different species

2.1.6 Fig leaves

The Common Fig (*Ficus auriculata*) in the family Moraceae is widely grown for its edible fruit throughout its natural range in the Mediterranean region, Iran and northern India. Figs can also be found in continental climate with hot summer, as far north as Hungary, and can be picked twice or thrice per year. Thousands of cultivars, most unnamed, have been developed or come into existence as human migration brought the fig to many places outside its natural range. It has been an important food crop for thousands of years, and was also thought to be highly beneficial in the diet. Fig tree has large leaves which can be used for leaf plate making.

2.1.7 Banana

Banana (*Musa paradisiacal)* is the common name for herbaceous plants of the family Musaceae and for the fruit they produce. They are native of the tropical region of Southeast Asia, and are likely to have been first domesticated in Papua New Guinea. Today, they are cultivated throughout the tropics. For some species, this pseudo stem can reach a height of up to 2–5 m, with leaves of up to 2.5 m in length.

2.1.8 Almond leaves

The Almond (*Prunus amygdalus*) is a species of tree native to the Middle East in the family Rosaceae. Almond is also the name of the edible and widely cultivated nut of this tree. Within the genus *Prunus*, it is classified in the subgenus *Amygdalus*, distinguished from the other subgenera by the corrugated shell (endocarp) surrounding the seed. It has leaves which can be used for leaf plate making.

2.2 Forms of Indian leaf plates

Mainly two forms; patrawallies and dona. These are being used in Wedding Poojas, Temples and Gurudwaras and in Hotel Parcel. These are environment friendly throw away items.

2.2.1 Leaf cup dona

Donas are machine pressed depending upon the size and contour desired. They are available in different diameters. Three and half inch donas are used in poojas as containers and also to serve small proportions of prasads in temples and Gurudwaras. Four and half inch round medium donas is used by the instant food stalls for serving pani puri, bhajias, and wadas. Four and half inch square medium donas are used for pani puri and ragda pattice. The same dishes are also served in Five inches, six corner donas. Super big six inch donas are used for parcels. Super jumbo seven and half inch donas are also used for the same purpose.

2.2.2 Leaf plate patrawallies

Patrawallies are made of leaves joined together by threads or dried grass leaves. Hands made patrawallies were used by Rushees and munees for serving food for 400 years ago. In rural areas of India, these plates are used in weddings and temples because it is considered pure as per Indian culture.

2.2.2.1 Plain patrawallies:-

Fourteen inch plain Patrawallies are now used by some restaurants as disposable dining mats under plates. Eleven inch leaf plate round plain are used to serve snacks which are of lower quantity and proportions. These are handmade but machine pressed to give the raised border. Thirteen inch plain round leaf plate is used to serve lunch and dinner in large quantities at a time. Thirteen inch plain round thread stitched leaf plate is also used for the same purpose.

2.2.2.2 Partition patrawallies:-

Partitions help in retaining liquids and to separate different food items. These are used in temples and Gurudwaras. These are handmade but machine pressed to give that contours. Thread stitched round partition leaf plates is available in 11 inch and 13 inch. Seven inch leaf plates are used for serving pani puri and ragda pattice. These are small

and sturdy plates. Five inch leaf plates are used for same purpose and also for making parcels.

2.3 Alternative material for leaf plate

Raj (1987) had conducted a series of experiments on alternative materials for leaf plates. As a result, he found that leaves should have specific characteristics such as optimum moisture content, fiber arrangement and the ability to withstand temperature. The alternative materials, selected are the leaves of *Beautia superba*, *Beautia monosperma* and *Bauhinia frondosa* (Sal leaves or Siali leaves). These leaves are available in Andhra Pradesh, Orissa, Madhya Pradesh, Chattisghad, Jharkund and Bihar in plenty. The specific characteristics of these leaves are

- The moisture content is about 15 %.
- It can withstand a temperature of 120^0 C to 150^0 C.
- The zigzag arrangement is preferred for leaf plate making.

The raw materials used are leaves, craft paper, adhering material etc. There are two alternatives for adhering the leaves with the craft paper. Chewing gum derivative or L.D.P.E. (Low Density Poly Ethylene) coating having a thickness of 6 to 8 micron can be used for adhering. The advantages of having L.D.P.E coating are better leak proof quality; good binding property and it provides desired shape.

Anil (2006) conducted a study on different materials used for leaf plate and reported that leaf plates can be made from dried banana leaves, dried bauhinia vahili leaves, areca leaf sheath, and dried *Beautia frondoza* leaves. Stronger, elegant and uniform plates of different sizes were prepared at a rate much faster than the conventional method by using these leaves with the help of a of plate making machine. In the case of flimsy leaves, another layer of leaf, paper or polythene may be used for reinforcement. No adhesives are needed.

Chandrasiri (2008) makes disposable plates, dishes, lunch boxes and cups from teak, banana, palm leaf and areca nut leaf sheaths known locally as the Kolapatha, replacing environmentally harmful plastic, polythene and styrofoam containers.

The leaves are pressed into shape by an electrical machine, and once the shape is obtained the excess is removed and the rough edges are filed. There is a slight increase in the cost of production because areca leaves are being collected from far away areas like Kithulgala and Passara which adds on to the transport cost.

David Tanis (2008) said that banana leaves can be cut down to make plates or unfurled into wrappers which is perfect for steaming fish on a low-slung grill. Fig trees and grape vines yield leaves of sufficient sizes for enclosing, then grilling, a cube of feta, a recumbent sardine or a mint-studded lamb meatball.

Kev (2008) conducted study on wide range of 100% biodegradable plates and bowls made from potato starch. The products are non-toxic and of course, very environment friendly. The current available products range from ‘dinner-sized’ plates, to small bowls and even ‘take-away style’ punnets with secure lids. These products will quickly break down in compost heap or even a worm farm. The packaging that the products arrived in is known as pop starch, a starch based cushioning product which eliminates the need for polystyrene filling in the package. The product did, however, come with minimal plastic wrap and concluded that the plates and bowls are a bit thicker than polystyrene plates and bowls.

London Mum’s Blog (2008) had conducted studies on procedures for leaf plate making from palm leaves and concluded that the leaves which are destined to be beautiful compostable plates, serving dishes and bowls are collected and soaked in local spring water, before being shaped by stamping the leaves at high heat between two moulds. The process is totally natural and has no need for any nasty additives or chemicals. Durable and robust, they are suitable for hot, wet and oily foods and can even be used in the oven or microwave. After use they can become lovely enriched compost for garden or they can be donated to local farms to be fed to the animals.

Paul Smith (2008) researched about compostable ware extensively and this does indeed sound like a grand-slam solution. They spent two years working with many materials and developed this new one using only fallen leaves steam heat and pressure to prove that the nature can have a sustainably produced product that was beautiful, with no

chemicals glues or bonding agents, with better functionality (oven, fridge and microwave safe) . Regarding the concerns of safety, they have tested all the types of leaves individually as well as finished product for any and all likely health concerns. As well they have conducted all the tests on the product for compostability. He concluded that there are many organic and natural plant chemicals that are quite unhealthy for particular uses.

2.4 Moisture content determination of leaves

Moisture content of agricultural commodities plays an important role in maintaining the desirable quality of the product. The information of moisture content is necessary because it tells us whether the product is suitable for safe storage or any other processing steps.

Sasikala Yadav (2002) conducted research on spinach leaves. Fresh samples of spinach were obtained from the local market. The leaves were then washed in running tap water, followed by distilled water and spreaded on filter paper sheets to remove excess moisture, then dried in oven at 60-65^{0}C till dried completely. The result obtained was 91.05%

Sreenivasa Kumar (2003) conducted experiment in cabbage leaves. The moisture content was determined by drying the sample in an oven at 105^{0}C. He obtained the moisture content of leaves within a range of 85-90^{0}C.

2.5 Pre treatments

To retain the shelf life and to maintain the quality of leaves some pretreatments should be given. Drying is one of the common pretreatment techniques. By using chemicals also we can do the pretreatments.

2 .5.1 Drying

Drying of agricultural products is the most widely used method of preservation and pretreatment. It is a thermo-physical and physico-chemical operation by which the excess moisture is removed to a predetermined level. Micro organisms that cause spoilage and decay cannot grow and multiply in the absence of water. Different driers used for the purpose are hot air oven, RRLT-NC driers, solar driers etc.

Hot air oven is one of the convective types of driers mostly used for moisture determination. These are sufficiently heat resistant. These ovens maintain pre determined temperature. The oven should have arrangements for proper air circulation, transferable perforated trays and suitable thermometer sensitive enough to show 0.5^0C temperature difference. These ovens are equipped with proper temperature control system. The oven should be run for few hours prior to their use for moisture determination.

RRLT-NC driers (different models) are for the drying of different wet materials like tamarind, ginger pepper, etc. The existing natural convection (NC) driers that work on the principle of natural upward movement of hot air are perhaps the simplest form of driers and have been known for drying of agricultural products. In the new invention, hot air is generated in a separate duct and it is made to pass in a downward direction through the wet material spread over perforated trays without the need for blower/ fan. The moisture-rich exit air leaves the bottom tray into the atmosphere. The chambers are made of MS angles and flats with GI sheets and insulating sheet screws to make air-tight covers, Thermostat, electrical switches, etc. are also provided. The driers are ideally suited for drying of solid granular materials and can be conveniently used by small farmers/rural industry.

Solar drying of agricultural products can be advantageous alternative to sun drying for the farmers of developing nations. It can be a means of supplementing or replacing artificial dryers with consequential savings in fuels and costs. Solar drying provides higher air temperatures and lower relative humidities than simple sun drying. It enhances the drying rates and lower final moisture content of dried products. As a result the risk of spoilage is reduced, both during the actual drying process and in subsequent storage. In many cases, solar drying can be feasible alternative wholly or partially to artificial drying. In solar drying system, a source of motive power is required for some types but considerable saving in energy costs is possible. Two basic principles are inherent in the operation of solar dryers, firstly the solar heating of air, and secondly the removal of moisture from the wet material by the heated air.

Anon (1986) had studied on impact of drying on quality of Betel leaves (piper betle L.).Fresh Betel leaves of five kilogram were procured from local market. After

washing the leaves, surface water was drip dried. He conducted different drying methods like sun drying, shade drying, solar drying, mechanical drying and microwave drying.

Sun drying: - fresh leaves were spread uniformly and evenly in trays (81×40×2.5cm) and exposed to sunlight (34 ± 5^0 C) for a period of eight hours.

Shade drying: - fresh leaves were spread uniformly on a concrete floor area of $2m^2$ inside a room for 48 hours (25 ± 3^0 C) and dried.

Solar drying: - the leaves were loaded in trays (112×26×2 cm) and kept in place in the solar dryer and positioned under the sun so that the solar panels received maximum sunlight. The position of the dryer was also changed during the course of the day so that the panels were exposed to sunlight in the temperature range of (52 ± 5^0 C).The leaves were dried for a period of five hours.

Mechanical drying: -fresh leaves were spread uniformly and evenly in trays (81×40×2.5cm) dried in a cross flow dryer at two different temperatures such as 70^0 C and 55^0 C for periods of 2 and 3 hours respectively.

Microwave drying: -Leaves were subjected to microwave drying at a frequency of 2450 MHz, at a power level of 455 W and 730 W. Fifty gram leaves were spread in Petri plates and exposed to the above condition and drying times were 20 and 10 minutes, respectively.

The result shown that among all the drying methods adopted, the leaves dried in solar cabinet dryer undergo lesser changes in the quality parameters as compared to fresh leaves. Thus, the method of indirect drying of betel leaves in solar cabinet dryer could be adopted in tropical regions for obtaining more acceptable product although it take longer time.

According to Raj (1987) the leaves are initially dried in sun or shade. Care should be taken to see that leaves are sufficiently dried to avoid fungus attack. They should not be over dried, as they become brittle. The dried leave are arranged in and bundled either in gunny bag or in bamboo baskets and stored for further use.

2.5.2 Application of disinfectants

Potassium permanganate is an inorganic but water soluble compound. It is also known as Candy's crystals and permanganate of potash. The solution is made by dissolving potassium permanganate crystals in water. This chemical has a strong oxidizing property that is why it is very useful in many applications. However, one of its more popular uses is in medicine, as an antiseptic and fungicide. It is a strong oxidizer therefore proper storage is necessary and must be kept away from other highly oxidizable substances. It should be separated well away from concentrated sulphuric acid because reaction with these two chemicals can be explosive. Always use gloves when handling this chemical since it quickly reacts with the skin leaving a dark brown stain.

Turmeric (*Curcuma longa*) has been used in Indian cooking, and in herbal remedies. Turmeric is a rhizomatous herbaceous perennial plant of the ginger family, Zingiberaceae. It is native to tropical South Asia . In Ayurvedic practices, turmeric is thought to have many medicinal properties and many in South Asia use it as a readily available antiseptic for cuts, burns and bruises. It is also used as an antibacterial agent.

Tilak (2001) had studied on antioxidant availability of turmeric in relation to its medicinal and culinary uses. Its possible mechanism of action was examined in terms of antioxidant availability during actual cooking conditions and in therapeutic applications using standardized extracts. It involve different levels of antioxidant action such as oxygen radical absorbance capacity (ORAC), radical scavenging abilities using 1, 1-diphenyl-2-picryl hydrazyl (DPPH), 2,2′-azobis-3-ethylbenzthiazoline-6-sulfonic acid (ABTS), ferric reducing antioxidant power (FRAP) and protection of membranes examined by inhibition of lipid peroxidation besides the content of phenols and total flavonoids. The aqueous and ethanol extracts of two major preparations of turmeric, corresponding to its use in cooking and medicine, showed significant antioxidant abilities. In conclusion, the studies reveal that the ability of turmeric to scavenge radicals, reduce iron complex and inhibit peroxidation may explain the possible mechanisms by which turmeric exhibits its beneficial effects in relation to its use in cooking and medicine.

Raj (1987) at the time of making the cup or plates the required quantity of leaves are taken out and a pretreatment is given by dipping it in water, treated with ammonium

bi fluoride or potassium permanganate for about 5 minutes and wiped out with clean cloth to remove dust and dirt. The dosage recommended is half tea spoon in a bucket of water. This pretreatment ensures disinfection of bacteria and other microbes. The leaves are then dried. The leaves in this condition are kept in a polythene bag to avoid drying before they are used.

2.6 Leaf plate making machine

With the availability of abundant raw material from forest and agricultural products and with continued consumption of leaf cups a need was felt to make some improvement in dimensional stability, shape, finishing and hygienic quality.

The salient features of the machine required are

1. It should manually operated with minimum power consumption
2. All the operations of folding, trimming, pressing and drying should do in single operation
3. The machine should consume only 300 watts to 1500 watts of electric power for heating the die. Heating the die for 30 minutes.
4. Single semi skilled operator and a helper could prepare 250 to 300 cups or 125 to 150 quality leaf plates per hour
5. The leaf cups or plates are subjected to heat upto 120^0 C to 150^0 C for about 6 to 10 seconds is sufficient to sterilize the product and does not need any fungicidal spray. About 60% free micro bacteria are assured and certified by C. F. T. R. I.

The machine can produce shallow plates / cups / donnas from various leaves. The leaf of sufficient size is placed on the lower die plate, the pedal pressed down and released after a few seconds. During this single operation machine press, folds and trims the two layers together.

The compactness of the unit and mode of operation should enable installation of number of units in rural areas, which could in turn generate employment and premiership among village craftsmen

Raj (1987) had designed and developed machines such as hydraulic, pneumatic and mechanical (pedal operated and hand operated) type for leaf plate manufacturing in large scale. The machines he developed were

2.6.1 Pedal operated leaf plate making machine

It is manually operated with minimum power consumption. All the operations of folding, trimming, pressing in to shape and drying are done in one single operation by pressing the pedal lever. The machine requires only 300 watts to 1500 watts of electric power for the heating die. For better quality of production lock the pedal and heat the dye for 30 minutes. Single semi skilled operator and a helper can prepare 400 to 500 cups or 300 to 400 quality leaf plates per hour. The leaf cups / plates is subject to heat up to 120° C to 150° C for about four to six seconds is sufficient to sterilize the product and does not need any fungicidal spray. About 60% free micro bacteria are assured.

2.6.2 Lamination machine

In particular season the leaf is not available for production of leaf plates, during this period Metalized Polyester laminated to craft paper can be replaced the market requirement. This laminated machine is operated on 2 HP DC motor with DC drive, a skilled operator is required to operate the machine. In 10 hours 750 kgs of production can be produced i.e. 16”/16” sized sheets 48, 750 numbers of rolled farm can be produced. Water mixed fevicol is required to joint both the Metalized Polyester and craft paper. Twenty units of power are consumed in 10 hours of run.

2.6.3 Cutting machine

The roll farm Metalized Polyester and craft paper is to be shared in desired sizes. This cutting machine will do the job of cutting in to pieces. Machine is operated on 1.5 HP AC motor. In 10 hours 50,000 to 100,000 pieces can be produced. Power consumption is 15 units per 10 hours.

2.6.4 Motor operated single die hydraulic machine

This machine is the advanced version of leaf plate making. Machine runs with one HP motor, a small liver is operated for the function of the machine die up and down movement with required pressure for molding, shaping and trimming. Twenty thousand

number of plates can be produced in 10 hours (Metalized Polyester and craft paper sheets four number of sheets at a time) i.e. 5000 strokes in 10 hours.

2.6.5 Motor operated double die hydraulic machine

Two dies and two persons can operated at a time for the production of 40,000 numbers of leaf plates (Metalized Polyester and craft paper 4 number of sheets at a time can feed in the die for higher production) i.e. 10,000 strokes in 10 hours. This machine runs on 2 HP motor and power consumption is 50 units per 10 hours of production work.

2.6.6 Motor operated four dies hydraulic machine

Four dies and four persons can operated at a time for the production of 80,000 numbers of leaf plates (Metalized Polyester and craft paper 4 number of sheets at a time can feed in the die for higher production) i.e. 20,000 strokes in 10 hours. This machine runs on 2 HP motor and power consumption is 80 units per 10 hours of production work. This machine runs on 3 HP three phase electric power.

2.6.7 Paper plate making machines

Paper plates making machines and its dies will be supplied on specific order, hand operated, pedal operated and hydraulic operated systems can be supplied. Details of production, power consumption and man power will be discussed at the time of order. According to Raj, Baniyan tree leaves are suitable but due to its importance in Hindu faith, has some restriction also dealing with Banana leaves but due to its long fiber arrangement the proposal had rejected

Chattopadhyay (2003) invented a new modified sal leaf plate etc. moulding machine using biomass as fuel. The inventions relate to an apparatus for manufacturing of moulded sal leaf plates etc. by single operation to perform both moulding and trimming simultaneously. The system should ensure proper trimming of the plates attended in tandem with the moulding operation thereby maintaining uniformity in the manufacturing of sal plates and also avoid problems of groove clogging and would therefore necessarily provide for efficient functioning of the machine without requiring

regular maintenance. The system is developed such that it would not require replacement of the entire machine in case of worn out or damaged parts.

2.7 Storage

Leaves are highly perishable due to high moisture content. Therefore the plates made from leaves have to be stored if not marketed immediately.

Alam khan and Mebit Abrahem (2008) had studied on comparative efficiency of few storage techniques for preserving leaves. Freshly harvested leaves (Amaranthus hybridus, Celosia argentia and Corchorus olitorus) were collected from the six weeks old plants, washed and allowed to drain. They were bunched in 0.5 kg lots tagged and subjected to storage under seven different storage techniques viz. leaves placed on labotory desk, unwrapped leaves in dry basket, unwrapped leaves in wet lined basket, leaves wrapped with black polyethylene bag and placed in wet basket, leaves wrapped in transparent polyethylene bag in wet basket, vegetables in pot – in – pot (evaporative coolant system and leaves placed in refrigerator.

The selected storage baskets were constructed like a box and the entire box was covered with jute bag and then covered with a lid. The samples of Amaranthus, Celosia, and Corchorus were placed in the baskets. They were then watered once a day throughout the period of the experiment at the mean ambient temperature of 28^0 C – 29^0 C. The leaves wrapped with black polyethylene bag were placed in wet basket; the same method as described above was used except for the polyethylene bag covering each of the samples.

Leaves placed in pot-in pot under a temperature condition of 22^0 C. ECS potable which is a clay pot placed inside another and the space in between them filled with sand and kept constantly. Heat is transferred from the storage chamber to the wet sand which forms the cooling medium, from which the heat is also sent to the wall of the structure by evaporation. Leaves in refrigerator involved the placement of the sample each from the different categories of leaves into the refrigerator at a temperature of 10-12^0 C under constant electricity supply. The leaves wrapped and unwrapped were placed in the different storage techniques and were kept at the same ambient temperature.

The parameters measured included physical observation of change in colour, loss in weight and marketability, which were taken at three, six and nine days after storage. significant changes in colour were noted among the leaves stored under different storage methods. Generally, vegetables stored in evaporative coolant structure and refrigerator had the best colour retention throughout the period of storage, although colour retention decreased with time in all storage methods used. At three, six and nine days after storage vegetables stored in evaporative coolant structure had colour retention of very dark green, dark green and green with a score of four, three and two respectively on the rating scale. This was closely followed by vegetables kept in the refrigerator with colour retention of very green, green and pale green respectively. The least colour retention was observed in vegetables placed on laboratory desk and unwrapped vegetables in dry basket which together had colour retention of green, pale green and brown for the same period of storage. Like colour changes, freshness decreases with time for all the storage methods used. Significant differences were also noted among the vegetables in different storage methods with ECS maintaining the lead. At three, six and nine days, vegetables stored in ECS had the best freshness, this was again followed by leaves in refrigerator, which had very fresh, slightly fresh and not fresh scores for three, six and nine days. The least result in freshness was obtained in vegetables placed on laboratory desk and unwrapped vegetables in dry basket which had slightly fresh and not fresh respectively for the same period of storage.

Marketability of leaves in different storage methods decreased significantly with time in all storage methods. At six days after storage, only leaves kept in ECS and refrigerator were found marketable. The least marketable condition was observed in leaves placed on laboratory desk and the unwrapped leaves in dry basket which were very poor for the same storage periods. At nine days after storage, almost all the leaves in different storage methods were found no longer marketable except for leaves kept in refrigerator and ECS which were fair.

As a result he concluded that the evaporative coolant structure (ECS) gave best performance in terms of freshness of leaves, colour retention and marketability when compared with other storage structures used. This was because ECS was able to conserve moisture content of the leaves better than the others. Leaves stored in refrigerator

performed next best to ECS. Storage in ECS maintained freshness and green colour better than the other storage methods because of high relative humidity (87%) and moderate temperature (22-23^{0}C) of the storage atmosphere that suppressed metabolic activity and physiological reactions

CHAPTER III
MATERIALS AND METHODS

This chapter mainly deals with the identification of suitable alternative leaves to the areca leaf sheath, effect of moisture content on shelf life and development of leaf plates from the selected leaves.

3.1 Test sample

The study was undertaken using leaves collected from instructional farm of Kelappaji College of Agricultural Engineering and Technology, Tavanur. Teak leaves *(Tectona grandis)* belongs to Lamiaceae family, vattayila (*Macaranga peltata*) of the family Euphorbiaceae, banana leaves (*Musa paradisiaca*) in the family Musaceae, fig leaves (*Ficus auriculata*) of the family Moraceae and almond leaves (*Prunus amygdalus*) belongs to the family Rosaceae were the leaves used. The leaves should be large enough to match with the diameter of die of the leaf plate making machine. Otherwise two or more leaves should be fixed together either by stitching or pasting. The selected leaves should be free from any type of damages. In the case of banana leaf; fresh, partially dried as well as dried leaves were used.

3.2 Moisture content determination

Collected leaves were sorted and washed thoroughly in fresh water. Initial moisture content was estimated using oven drying method at 70+ 2^0C for five hours. The moisture content was calculated using the equation (Chakravarthy, 2000).

$$\text{Moisture (\%wb)} = \frac{Ww}{W} \times 100 \quad \text{..... 3.1}$$

Where, Ww = weight of water, g

W = total weight of sample, g

3.3 Effect of moisture content on quality of plates

Moisture content of leaves plays an important role in maintaining the desirable quality of the product. Drying will reduce the moisture content of leaves to a certain level. The leaves should be treated with turmeric solution at concentration of 1g/l to reduce the microbial load as a pre treatment .Solar drying, shade drying and mechanical drying are the methods adopted.

3.3.1 Sun drying

Sun drying is the most popular traditional method of drying. The samples were dried in the open air. The temperature was measured with a thermometer and intensity was measured using a Suryamapi. Temperature was recorded as 35- 45^0C and intensity was 56mW/cm^2.

3.3.2 Shade drying

Shade drying is the drying of materials at room temperature. Fresh leaves were spread uniformly on concrete floor inside room at a temperature of 29^0C and relative humidity of 60 %.

But time taken to decrease the moisture content to a certain level was more in sun drying and shade drying. So for the further studies these two methods of drying were not continued.

3.3.3 Mechanical drying

To study the effect of moisture content on quality of plates in terms of colour, overall appearance and stiffness a series of experiments were conducted in RRLT-NC drier at 40^0C. The pre treated samples were kept in the drier till the moisture content of leaves was in the range of below 30 %wb. Time taken for each sample to reach this range of moisture content was noted. In order to observe the effect of moisture content on shelf life of the plates made from the above dried leaves, it was packed in LDPE of 400 gauges and PP of 200 gauges.

3.4 Standardization of die temperature and retention time

The machine has two dies; an upper die and a lower die. The dried samples were pressed between the dies of the leaf plate making machine. The different die temperature combinations followed were

a) Upper die- 50 ^{0}C; lower die- 70 ^{0}C
b) Upper die- 76 ^{0}C; lower die- 90 ^{0}C
c) Upper die- 90 ^{0}C; lower die- 90 ^{0}C

To attain shape and to maintain colour leaves should be kept under die on definite period of time. The standardized retention time for each test sample were noted. Observations based on the colour, shape and overall appearance were made.

3.5 Flow chart for leaf plate making

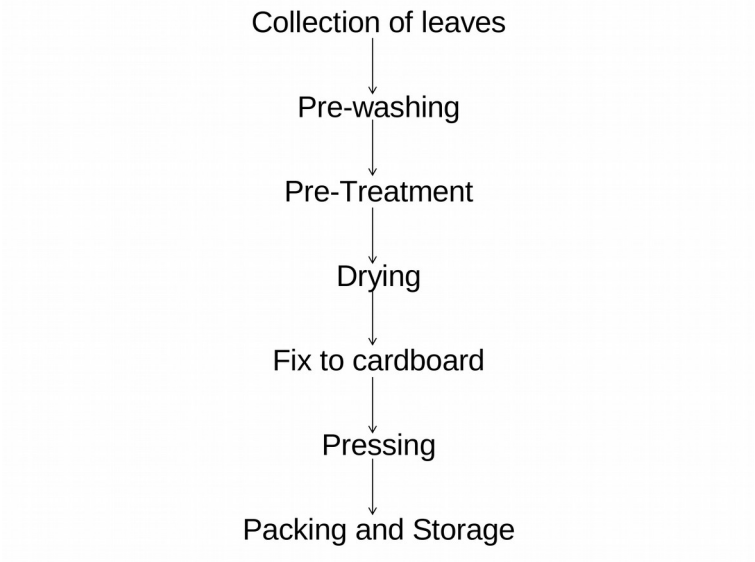


Fig 3.1 Flow chart for leaf plate making

3.6 The areca leaf plate making machine

Plate 3.1 Areca Leaf plate making machine

It is manually operated with minimum power consumption. It is a hand operated machine having two dies which is heated by electricity which is having a temperature regulator, regulates the temperature of upper die and lower die. For better quality of production heat the die for 30 minutes. All the operations of folding, trimming, pressing in to shape and drying are done in one single operation by turning the hand operated wheel. The machine requires 1000 watts of electric power for the heating dye. Single semi skilled operator and a helper can prepare 30 – 50 quality leaf plates per hour.

3.7 Experimental procedure for leaf plate

The collected leaves were pre washed with fresh and ordinary tap water. The leaves were then pre treated with turmeric solution, dried to standardized moisture content. Then sandwitch the dried leaves with the card board of 1mm thickness using natural and edible pasting material. Heat the upper and lower die of the leaf plate making machine to the standardized temperature. Prepared leaves were pressed in between the dies and kept for retention time. The leaf plates were packed in air tight LDPE or PP and kept for storage.

CHAPTER IV
RESULT AND DISCUSSION

The selected leaves harvested from the instructional farm of KCAET campus, were used for the study. The influence of moisture content, die temperature and retention time on quality of leaf plates were studied. This chapter highlights the results of various process parameters on shelf life of developed plates.

4.1 Test sample

The selected leaves after proper cleaning and grading were used for the study. The initial moisture content was estimated by standard method explained in chapter III and the results were tabulated.

Sl. no	Type of leaves	Moisture content(%)(wb)
1	Teak	42
2	Vattayila	65
3	Banana	
	Fresh	80
	Partially Dried	60
	Dried	10
4	Fig leaf	50
5	Almond leaf	60

Table 4.1 Moisture content of selected leaves

4.2 Effect moisture content on quality of plates

An investigation on effect of moisture content was studied. The samples except dried banana leaves and partially dried banana leaves were uniformly spread on perforated trays of RRLT-NC drier at 50^0C. Moisture content was estimated at 10, 20, 30 and 40 minutes interval using the equation 3.1.

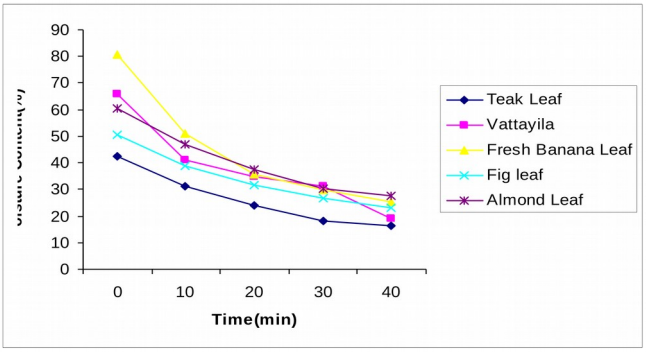


Fig.4.1 Drying curve for leaves

From the drying curve it is observed that as the time increases moisture content decreases. In the case of vattayila and for fresh banana leaf there is a sudden decline in moisture content in the first ten minutes and it may be because these leaves are thinner than other selected leaves. The plates made with these dried leaves were packed in either LDPE of 400 gauges or PP of 200 gauges and kept to study the effect of moisture content on shelf life. The tabulated values of shelf life for different moisture content were listed in table 4.2.

Teak	Moisture content(%wb)	42.43	30.9	23.8	18.1	16.4
	Shelf life (days)	5	25	30	8	4
Vattayila	Moisture content(%wb)	65.8	40.95	34.64	30.85	19.12
	Shelf life (days)	7	21	15	5	2
Fig	Moisture content(%wb)	50.35	38.74	31.47	26.68	23.1
	Shelf life (days)	3	5	10	8	2
Almond	Moisture content(%wb)	60.16	46.71	37.32	30.16	27.52
	Shelf life (days)	3	5	8	6	2
Fresh Banana	Moisture content(%wb)	80.5	50.8	35.35	29.72	25.34
	Shelf life (days)	1	3	2	1	1

Table 4.2 Effect of Moisture content on shelf life of selected leaves

Moisture content was standardized for each of the leaves based on shelf life in terms of colour, stiffness and overall appearance. From this study it is observed that the plates made of teak leaves dried at 50^0C for 20 minutes having moisture content of 23.8 % wb could store for 30 days without any change in quality followed by Vattayila for 21 days with a moisture content of 40.95%. Where as in the case of fresh banana leaves having a moisture content of 50.8% could store only for three days. This may be due to the fact that arrangements of veins of banana leaves are parallel compared to other selected leaves. From the above results, it is seen that moisture content has effect on shelf life. There should be optimum moisture content for each leaves to attain maximum shelf life.

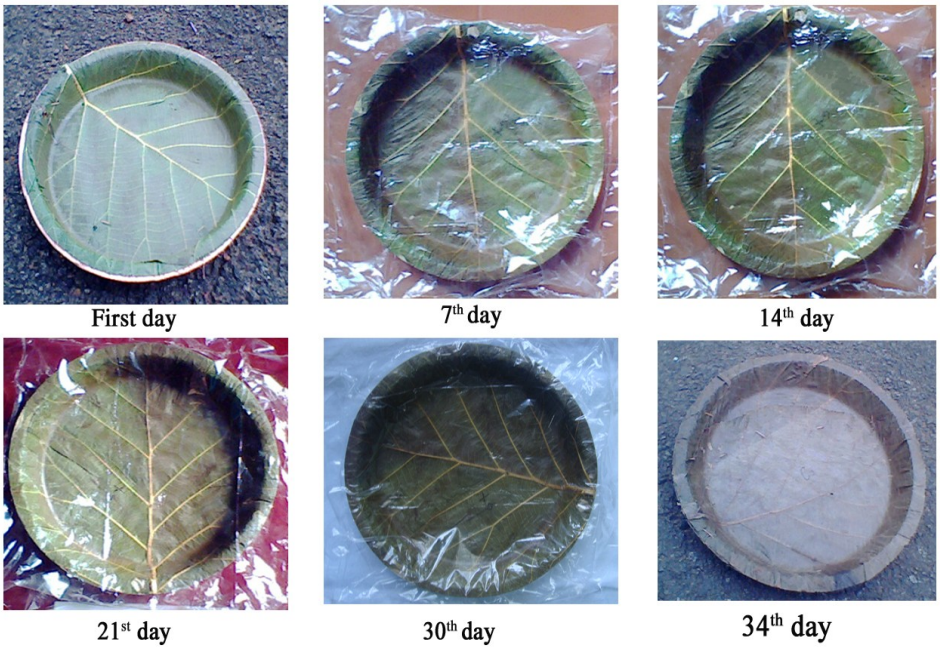


Plate 4.1. Effect of moisture content on shelf life of teak leaves

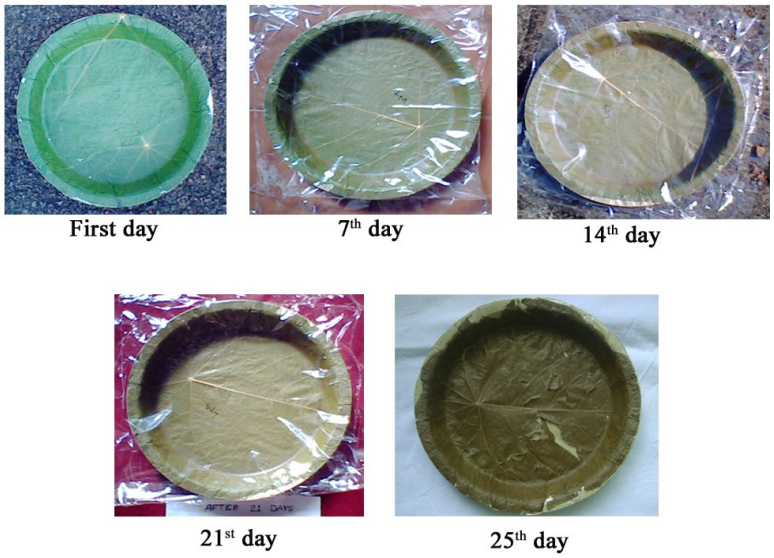


Plate 4.2. Effect of moisture content on shelf life of vattayila

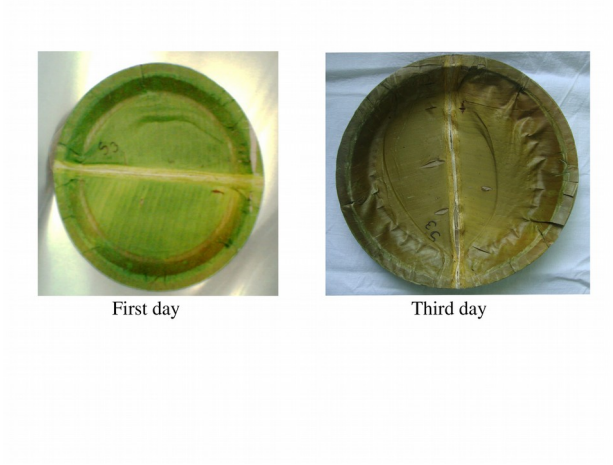


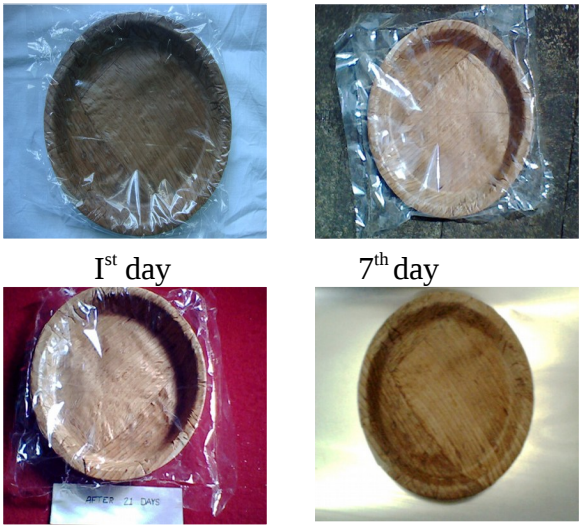
Plate 4.3. Effect of moisture content on shelf life of fresh banana leaf

4.2.1 Trials with banana leaves

Besides fresh leaves, partially dried and dried banana leaves can be used. In case of partially dried banana leaves, the fresh leaf was dried under flame and pressed in between the dies of the leaf plate making machine. Dried banana leaves after disinfecting directly made into plates.

First day

Plate 4.4 Partially dried banana leaf plate



Ist day

7th day

21st day

28th day

Plate 4.5 Dried banana leaf plate

Since fresh and partially dried banana leaf shows less shelf life, these two were discarded. In the other way dried banana leaf plate shows higher shelf life of 28 days.

4.3 Standardization of die temperature and retention time

The machine has two dies; an upper die and a lower die. Samples were pressed between the dies at different die temperature combinations as discussed in chapter III. Retention time is the time for which the leaves are kept under the die. The effects of die

temperature and retention time on quality of plates were evaluated based on colour, shape and overall appearance.

It shows that an upper die temperature of 75^0C and lower die temperature of 90^0C gave better result from visual observations. Colour, shape and overall appearance were superior at this temperature. If temperature is low it is very difficult to maintain the shape of plates, but colour will be maintained. Higher temperature will result in crumbling and loss of colour.

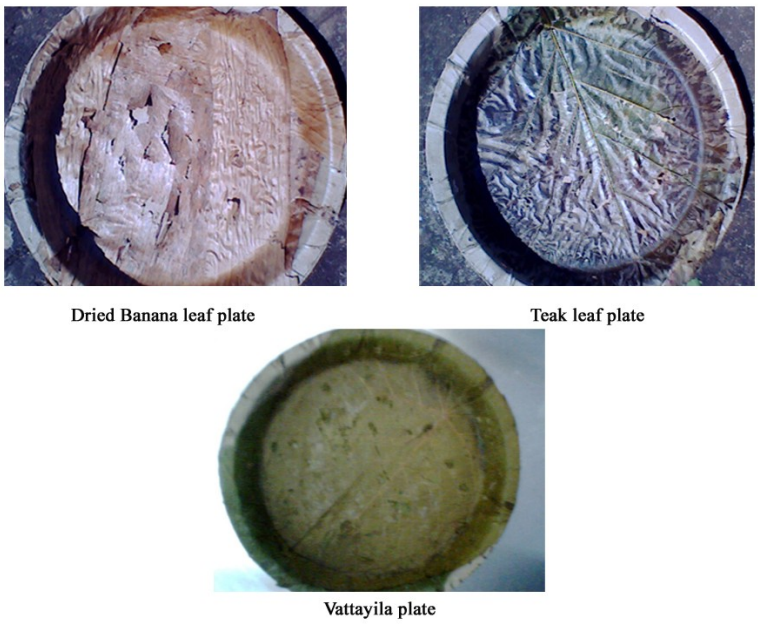


Plate 4.6 Effect of die temperature

Standardized retention time for teak, vattayila and dried banana leaves were listed below in the table 4.3

Sl no:	Samples	Retention time(seconds)
1	Teak	30
2	Vattayila	15
3	Dried banana leaves	25

Table 4.3 standardized retention time

CHAPTER V
SUMMARY AND CONCLUSION

The plates, which are made from fresh leaves or pretreated leaves with the help of leaf plate making machine are known as leaf plates. These biodegradable plates are having a natural and attractive appearance. The raw material used for the production of plates especially in Kerala is the areca leaf sheath. But the availability of the raw material is less compared to the production potential. In order to boost up the micro level enterprises engaged in leaf plate production, various alternative materials to areca leaf sheath were to be identified.

With this in view, an attempt was made in KCAET, Tavanur to identify suitable alternative leaves for the areca leaf sheath, to study about effect of moisture content on quality of plates and standardization of die temperature. The qualities of the leaf plates made were expressed in terms of shelf life evaluation results.

In the light of available literature the results obtained in present study are summarized below.

- Selected alternative leaves to areca leaf sheath such as teak leaves (*Tectona grandis*), vattayila (*Macaranga peltata*) and dried banana leaves ((*Musa paradisiaca*).
- Selected leaves were subjected to pre treatment in view of reducing microbial load and it was noted that pre treatment with turmeric solution for 10 minutes is suitable.
- Effect of Moisture content on shelf life of selected leaves were studied and Standardized the moisture content for selected leaves as

  Teak leaves - 23.8 % wb
  Vattayila - 40.95% wb
  Banana - 10% wb

- Standardized the die temperature as

Upper die	- 75 ^{0}C
Lower die	- 90 ^{0}C

- Standardized retention time

Teak	- 30 seconds
Vattayila	- 15 seconds
Dried banana	- 25 seconds

- Storage on LDPE and PP shows same effect on qualitiy parameters of leaf plates.

CHAPTER VI

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APPENDIX I

Moisture content of teak leaves

Time (min.)	m.c (% wb)
0	42.43
10	30.9
20	23.8
30	18.1
40	16.4

Moisture content of vattayila

Time (min.)	m.c (% wb)
0	65.8
10	40.95
20	34.64
30	30.85
40	19.12

Moisture content of fresh banana leaves

Time (min.)	m.c (% wb)
0	80.5
10	50.82
20	35.35
30	29.72
40	25.34

Moisture content of fig leaves

Time (min.)	m.c (% wb)
0	50.35
10	38.74
20	31.47
30	26.68
40	23.1

Moisture content of almond leaves

Time (min.)	m.c (% wb)
0	60.16
10	46.71
20	37.32
30	30.16
40	27.52

APPENDIX II

COST ANALYSIS

Fixed cost

Sl No:	Item	Cost/ Unit	Cost
1	Cost of Machine	20000	20000
	Total		**20000**

Variable cost

Sl.No:	Item	Cost/unit	Cost/day	Cost/year
1	Cost of Paper	0.5	150	54000
2	Pasting Material	20	30	10800
3	Cost of Turmeric	120	36	12960
4	Cost of Electricity	2.5	17.5	6300
5	Labour Cost	140	280	100800
	Total			**184860**

Cash flow statement

Year	CI	O & M	COF	CIF	CIF - COF
1	20000	184860	204860	216000	11140
2	0	184960	184960	216000	31040
3	0	185160	185160	216000	30840
4	0	185350	185350	216000	30650
5	0	185725	185725	216000	30275
	Total				133945

Payback Period: 341.4333333days

Benefit Cost Ratio

Year	CI	O & M	COF	CIF	DF	DCOF	DCIF
1	20000	184860	204860	216000	0.8929	182919.494	192866.4
2	0	184960	184960	216000	0.7972	147450.112	172195.2
3	0	185160	185160	216000	0.7118	131796.888	153748.8
4	0	185350	185350	216000	0.6355	117789.925	137268
5	0	185725	185725	216000	0.5674	105380.365	122558.4
	Total					685336.784	778636.8

BCR 1.13613747

DEVELOPMENT OF TECHNOLOGY FOR ALTERNATIVE MATERIAL TO ARECA LEAF PLATES

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ABSTRACT OF THE PROJECT REPORT
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Kerala Agricultural University

Department of Post Harvest Technology & Agricultural Processing
KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
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2009

ABSTRACT

The plates which are made from fresh leaves or pretreated leaves, with the help of leaf plate making machine are known as leaf plates. These plates are biodegradable and are having a natural and attractive appearance. Due to the unavailability of areca leaf sheath for the production of plates, alternative leaves such as teak leaves, vattayila, fig leaves, almond leaves, fresh banana leaves, partially dried banana leaves and dried banana leaves can be used. The leaves of standardized moisture content after pre treated with turmeric solution are pressed between the dies of leaf plate making machine. For supporting the food material in the plates; pre treated leaves should be pasted to a card board of 1mm thickness. The standardized die temperature and retention time should be followed. For enhancing the shelf life of the leaf plates; should be packed in air tight LDPE (400 gauges) or PP (200 gauges). Quality parameters in terms of shelf life and overall acceptability were done in every 7 days interval. The study concluded that the procedures should follow the standardized moisture content, die temperature and retention time depending upon the type of leaves and the LDPE or PP bags were more suitable for the packaging of leaf plates. The response shown by LDPE and PP were same. The study also revealed that leaf plates made of teak leaves, dried banana leaves and vattayila are the suitable alternatives for areca leaf sheath.