DEVELOPMENT OF JACKFRUIT SEED COAT REMOVER AND PREPARATION OF JACKFRUIT SEED FLOUR

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PROJECT REPORT

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DECLARATION

We hereby declare that this project report entitled "JACKFRUIT SEED COAT REMOVER AND FLOUR PREPARATION" is a bona fide 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 of any degree, diploma, associate ship, fellowship or other similar title of any University or Society.

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CERTIFICATE

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Anila

Anjaly M.G

Hasnath K.T

DEDICATED TO NEW ERA OF FOOD REVOLUTION

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SYMBOLS AND ABBREVIATIONS

%	Percentage
/	Per
°C	Degree Celsius
APAARI	Asia-Pacific Association of Agricultural Research Institutions
cm	Centimetre
DPPH	2,2-diphenyl-1-picrylhydrazyl
et al.	and other people
etc.	etc etera
g	gram
h	hour
ha	hectre
hp	horse power
IBA	Indole-3-butyric acid
KCAET	Kelappaji College of Agricultural Engineering and Technology
kg	Kilogram
m	Metre
MJ	Mega Joule
ml	Milli litre
mm	Milli metre
NAA	1-Naphthalene acetic acid
No.	Number
rpm	Revolutions per minute
s	Seconds

INTRODUCTION

CHAPTER 1

INTRODUCTION

Jackfruit (*Artocarpus heterophillus*) belongs to the family *Moraceae* is a popular and important fruit, very under utilized. It is a native fruit of India, now widely cultivated throughout the tropical countries in both the hemispheres such as India, Bangladesh, Nepal, Sri Lanka, Vietnam, Thailand, Malaysia, Indonesia and Philippines. India is the largest producer of jackfruit followed by Bangladesh and Thailand (Kittur etal.,2015). The trees populate North-eastern states like Assam, Tripura, Bihar, Uttar Pradesh, the foothills of Himalayas and South Indian states like Kerala, Tami Nadu and Karnataka.

The edible bulbs of ripe jackfruit are usually consumed fresh or processed into canned products. 10-15% of a total fruit weight is considered as its seed weight. Though the seeds are rich in carbohydrate and protein, jackfruit seeds are used occasionally as a minor supplement in culinary recipes but are mostly wasted. Keeping the colossal waste of this nutritious seed in view, the present studies focuses on making seed flour which can be stored for longer period and find varied industrial applications. The jackfruit seed flour may also be blended with wheat flour to explore the potential of low cost flour from jackfruit seed as an alternative raw material for bakery and confectionery products. The jackfruit seed flour is not only a rich source of protein, starch and dietary fibers but also can be regarded as abundant yet cheap sources of said nutrients. Lection, a class of glycoproteins found in jackfruit seed has been reported to possess antibacterial, antifungal and anticarcinogenic properties.

In India, malnutrition is prevalent due to inadequate intake of protein. In view of this effort was made for identifying and evaluating underutilized non-conventional cheap protein sources like jackfruit seed as an alternative.

Jackfruit seed contain lignans, isoflavanones, saponin and all phytonutrients and their health benefits are wide ranging from anticancer to antihypertensive, antiaging, antiulcer and so on.(Omar and Friday,2010). The seed

contains two lectins, jacalin and artocarpin. Jacalin has been proven to be useful for the evaluation of immune status of patients infected with human immunodeficiency virus 1(Haq.,2006).

Jackfruit seed flour (JSF) is a cheap source of protein (13.49%), ash (2.47%) and carbohydrate (70.73%). The calorific value was 357.665 kcal/100g. It was also rich in potassium (6466 ppm), magnesium (4582 ppm) and sodium (8906 ppm). High water absorption capacity (2.91ml/g), oil absorption capacity (0.884ml/g) and bulk density (0.873g/ml) were recorded for JSF. It had a least gelation capacity of 17%.

The seed coat removal is the one of the most time consuming process in flour preparation. Generally seed coat is removed manually. The manual peeling is very time consuming and laborious. Only skilled person can do the work properly. The peeling machine even for small scale is not available commercially and the machine developed so far is not fully successful in meeting the requirements of peeling.

As an attempt to overcome the problems associated with seed coat removal of jackfruit seed a study was conducted at KCAET, Tavanur with the following objectives.

1. To fabricate electrically operated seed coat remover for jackfruit seed.

2. To study the performance of machine with samples subjected to different pre-treatment.

3. To produce optimum quality flour

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LIERATURE

2.1 Jackfruit *(Artocarpus heterophyllus)*

Artocarpus heterophllus belong to the Moraceae family, colloquially jack fruit in English is native to India and seen abundant in Western Ghats. Besides India, jackfruit is commonly grown in home gardens of tropical and sub-tropical countries especially Sri Lanka, Bangladesh, Burma, Philippines, Indonesia, Thailand, Malaysia and Brazil .In India, it widely distributed in the states of Assam, West Bengal, Uttar Pradesh, Maharashtra, Kerala, Tamil Nadu and Karnataka and considered to be the "Poor man's food" . In Malayalam (regional language in Kerala, India) jack fruit is called as “Chakka” while the ancient Indian language Sanskrit refers as Atibruhatphala. The morphology of the tree varies with 10-30 m tall; with long tap root and dense crown producing the largest tree born fruit in the world. The fruit weight up to 50 kg, but average weigh is considered to be 10 kg, while only 30-35% of the bulb is edible.

Jack fruit is considered as national fruit in Bangladesh and highly appreciated in India due to cheap and availability in summer seasons were food is scarce. The fruit provide 2 MJ per kg/wet weight of ripe perianth and contain high levels of carbohydrates, protein, starch, calcium and vitamins. Jackfruit is widely used in culinary preparation, baking, candid jackfruit, baby food, jams, jellies, juice, chips, deserts and the advances in food processing technologies further expanded the possibilities.

Jackfruit is an organic fruit cultivated as a homestead tree without any management practices. There are several varieties of jackfruit available which differ widely in shape, size and taste. The values of fruit weight, length and diameter in different accessions of Kerala ranging from 3.95-20.3kg, 28.66-52.66cm and 18.46-30.50cm respectively (Gomaz *et al*.,2015). Also it constitutes three main parts, namely bulb, seed and rind. There proportion is 30%, 12% and 50-55% respectively.

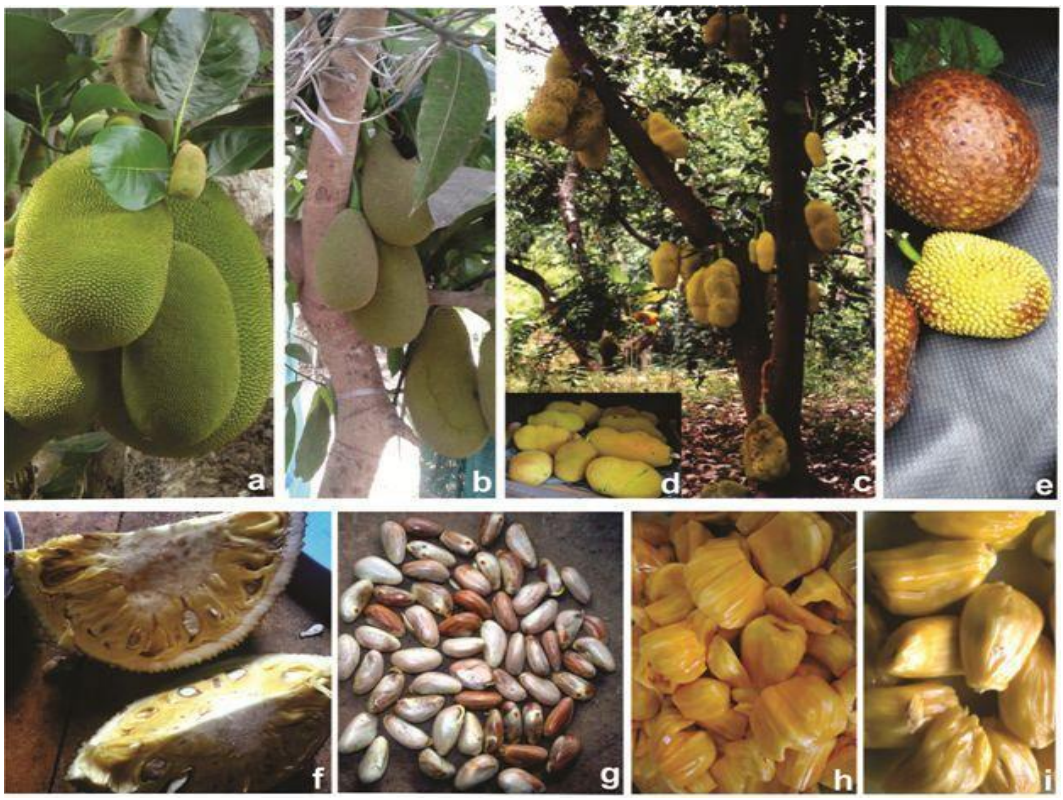

Fig 2.1: Jackfruit trees a) jackfruit with varying sizes; b) different stages of fruiting; c) tree bearing fruits; d) fruits plucked; e) small type of jackfruit; f) jackfruit cut opened; g) jackfruit seeds; h) opened jackfruit flakes; i) flakes unopened

2.1.1 Propagation

The most common method of propagation followed in jackfruit is through seeds. Seeds loose viability within a short time and hence they should be sown immediately after extraction from ripe fruits. Soaking seeds in NAA (25ppm) for 24 hours enhances percentage of germination and seedling growth. Since seeds will not be true to type and have a juvenile period, vegetative propagation is preferred. Cutting gave 90% success when shoots are etiolated and ringed for 30 days and then treated with IBA (3000 ppm) + ferulic acid (2000ppm) (Dhua et al.,1983). Air layering is reported as a better method which gave 100% rooting with the IBA treatment. Epicotyls grafting with 3-4 months old scion and 5-10

days old stocks results in 80-90% success under mist in Kerala (Jose and Valsalakumari,1991).

2.1.2 Production and cultivation in Kerala

The jackfruit is cultivated in an area of 1,02,552 ha, of which an estimated 1,00,000 trees are grown in backyards and as inter crop in other commercial crops. Kerala has the largest area jackfruit cultivation of about 97,540 ha and production around 348 million fruits (APAARI,2012).

Figure 2.2 and Figure 2.3 shows the district wise production and cultivation in Kerala. It shows that the cultivated area of jackfruit in Kerala during 2013-14 was 90,225 ha and jackfruit was widely cultivated in Idukki, Kozhikode and Kannur districts and stand first, second and third position with 16%, 11% and 9% of area respectively. The gross production of jackfruit in Kerala is 294 million fruits with Idukki district holding the top most position(60 million) followed by Kannur district(27 million).

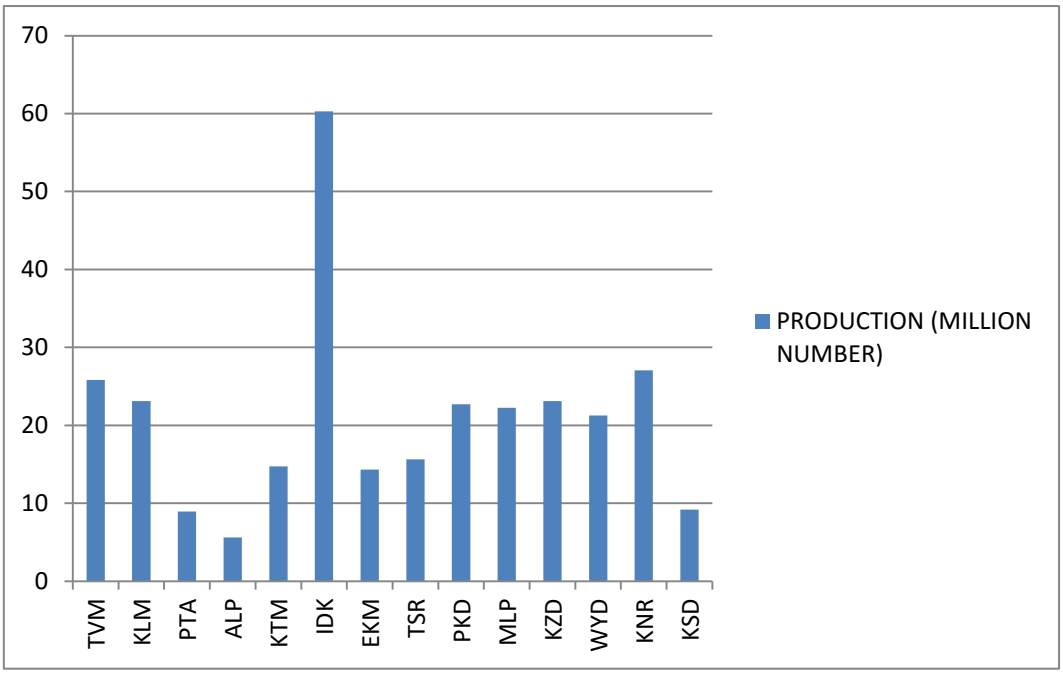

Fig 2.2: District wise production in Kerala (Agricultural Statistics, 2015)

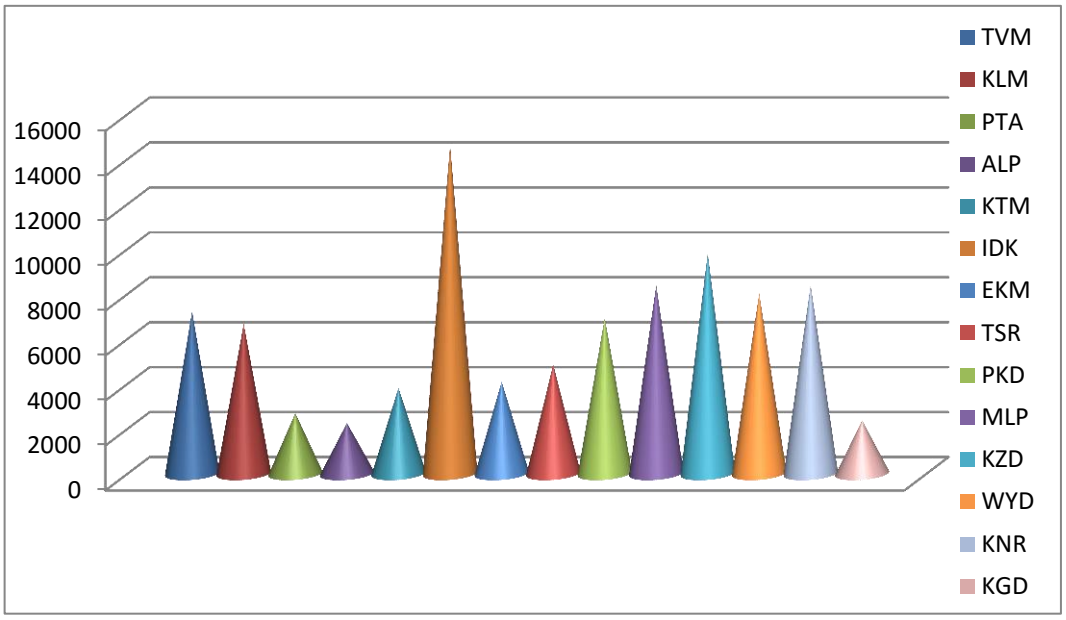

Fig 2.3: District wise cultivation area of Kerala (Agricultural Statistics, 2015)

2.1.3 Botanical aspects and variety

Jackfruit tree is an evergreen tree, around 10 to 15 m tall with oval shape dark green leaves. It is a long lived tree having a life span of 60-70 years and contains sticky white latex in all parts of the fruits. The flowery twigs are born primarily on the trunk and main branches. Jackfruit tree is monoecios, male and female flowers are born separately on same tree. The composite fruit may be large as 20 kg or more. Fruit is the primary economic part of tree and used in both stages both mature and immature (Nachegowda *et al*., 2014)

Koozha and Varikka are the main two varieties available in Kerala. Jackfruit having thin fibrous and mushy edible pulp which is very sweet and emitting strong odour is called Koozha. But Varikka is thick, firm, crisp and has less fragrant pulp. Thamarachakka, Nadavalam Varikka, Vakathanam Varikka, Mutton Varikka, Athimathuram Koozha, Ceylon Varikka and Thenga Varikka are the main jackfruit varieties in Kerala. Konkan prolific, Ceylon jack, Hybrid jack, Burliar-1, PLR-1, PPI-1 are few important varieties introduced from the various organizations (Priya *et al*., 2014).

Table 2.1: Nutritional aspects of jack fruit and seed

Composition	Young fruit	Ripe fruit	Seed
Water(g)	76.20 – 85.20	72.00 -94.00	51.00 – 64.50
Protein(g)	2.00 -2.60	1.20 – 1.90	6.60 – 7.04
Carbohydrates(g)	9.40-11.50	16.00 – 25.40	25.80 – 38.40
Fat(g)	0.10 -0.60	0.10 -0.40	0.40 – 0.43
Fiber(g)	2.60 -3.60	1.00 – 1.50	1.000 – 1.50
Total sugar(g)	-	20.60	-
Vitamin A(IU)	30.00	175 -540	10.00 -17.00
Thiamine(mg)	0.05 -0.15	0.03 -0 .09	0.25
Riboflavin(mg)	0.05 -0.20	0.05 – 0.40	0.11 – 0.30
Vitamin(mg)	12.00 -14.00	7.00 – 10.00	11.00
Energy(KJ)	50.00 -210.00	88.00 – 410 .00	133.00 – 139.00

2.2 Jackfruit seed

Jackfruit seed is a rich source of nutrients. The photochemical content of jackfruit seeds was analyzed and high quantity of saponin (0.098 g/100 g) was found. Saponins have been known for their medicinal uses, including antispasmodic activity, antitoxicity to cancer cells. Some alkaloids function as spasmolytic, anti-cholinergic and anesthetic agents. The alkaloid content in jackfruit seeds was found to be 1.16 • }0.09g/100g. Polyphenolics are known to function as antioxidants through a number of mechanisms including radical scavenging by H-donation, prevention of chain initiation by donating electrons or by binding of transition metal ion catalysts. Flavonoids prevent platelet stickiness and hence platelet aggregation. Colorimetric study of the two extracts of jackfruit seeds showed that dichloromethane: methanol (1:1) solvent system was able to extract more phytochemicals in comparison to acetone.

DPPH is a free-radical generating compound and has been widely used to evaluate the free-radical scavenging ability of various antioxidant compounds. Figure 2.4 shows the percentage inhibition of DPPH radicals by jackfruit seed extracts.

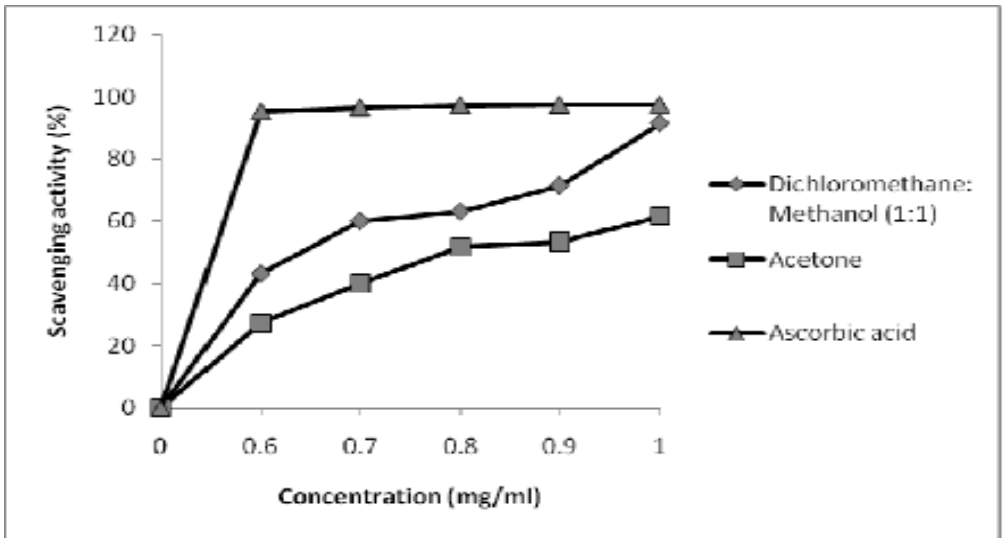

Fig 2.4: Scavenging activity of DPPH molecules

2.3 Jackfruit seed flour

Jackfruit seeds could be used in balanced diets and functional foods which can be consumed safely without any concern of health risk. In countries with high population where the food requirements are not being fulfilled by seasonal vegetables, jackfruit seeds can be used as a good substitute. As jackfruit seeds have shorter shelf life, they go waste during the seasonal glut. So, the seed flour can be an alternative product, which can be stored and utilized, for value addition. It used to produce a lot of products such as

- Noodles
- Pasta
- Snacks
- Cakes and bakery products
- Gluten free biscuits
- Nutrient mix
- Nutrient drink

2.3.1 Nutritional composition of jackfruit seed flour

2.3.1.1 Moisture

Moisture provides a measure of the water content of the seed flour and for that matter its total solid content. It is also an index of storage stability of the flour. The moisture content of the seed flour is 7.758%. The lower the moisture content of flour, the better its shelf stability and the quality. Moisture content of flour generally is depended upon the duration of the drying process. (Albel Abraham *et al*., 2015)

2.3.1.2 Crude Fat

The fat content of the jackfruit seed flour is 2.317% (Albel Abraham *et al*.,2015).

2.3.1.3 Crude Ash

The percent ash content of the flour is 2.472% .The ash content is the inorganic residue remaining after the organic matter has been burnt away. Ash content of 2.76 – 3.31% (dry matter basis) has been reported for jackfruit seeds. The disparity may be due to varietal differences and the locality.

2.3.1.4 Crude Protein

The percent crude protein of the flour is 13.49%. The difference observed may be contributed by varietal differences, maturation of the seeds and environmental conditions. Bobbio *et al*., (1978) reported value of 31.9%. Kumar *et al*., (1988) also reported a protein content of 17.8-18.3% for jackfruit seeds.

2.3.1.5 Crude Fiber

The percentage crude fibre of the flour is 3.25%. (Albel Abraham *et al.,* 2015).

2.3.1.6 Energy

The caloric value (energy) of the Jackfruit seed flour is 357.66 kcal/100g (Albel Abraham *et al.,* 2015).

2.3.2 Functional properties

2.3.2.1 Water Absorption Capacity

The water absorption capacity of the JSF is 2.916 ml/. F.C.K.Ocloo *et al*., (2010) reported the water absorption capacity for the Jackfruit seed flour was 25% (2.5 ml/g). The value is higher than 2.3 ml/g reported for raw jackfruit flour. Water ab-sorption capacity describes flour – water association ability under limited water supply. The disparities observed could be attributed to the method used as well as the varietal differences. The result obtained shows that the flour has a good ability to bind water. This result suggests that Jackfruit seed flour could be used in bakery industry.

2.3.2.2 Oil Absorption Capacity

The oil absorption capacity of JSF is 0.884 ml/g. Fat absorption is an important property in food formulations because fats improve the flavour and mouth feel of foods. The disparities observed could be attributed to the method used as well as the varietal differences. The result obtained shows that jackfruit seed flour is a high flavor retainer and may therefore find useful application in food systems such as ground meat formulations.

2.3.2.3 Bulk Density

Bulk density is depended upon the particle size of the samples. Its value is 0.873 g/ml. Bulk density is a measure of heaviness of a flour sample. It is important for determining packaging requirements, material handling and application in wet processing in the food industry. The value obtained is higher than that reported in literature. Since flours with high bulk densities are used as thickeners in food products, the Jackfruit seed flour studied could be used as a thickener.

2.3.2.4 Swelling Power

The JSF has a swelling power of 5.264. Swelling power is a measure of hydration capacity, because the determination is a weight measure of

swollen starch granules and their occluded water. Food eating quality is often connected with retention of water in the swollen starch granules.

2.3.2.5 Gelation

The least gelation capacity of the jackfruit seed flour is 17%. The value is comparable with the least gelation concentrations for the raw and heat processed jackfruit flour 16% and 18% (w/v), respectively. These variations may be due to variations in the different constituents of the flour such as carbohydrates, lipids and proteins, which have a significant role on functional properties of flour (Abbey and Ibeh.,1988). Swelling of starch granules occurs in gelation while heating. Hence jackfruit seed flour is a good gelling agent and thickener, useful in food systems such as puddings, sauces, soups etc.

Table 2.2: Comparison between wheat flour and jackfruit seed flour (Proximate Analysis)

Proximate analysis (%)	Wheat flour	Flour with brown seed coat(without lye peeling	Flour without brown seed coat(with lye peeling)
Moisture content	11.5	10.7	10.1
Crude protein	8.9	14.02	12.6
Ash	0.63	2.54	2.24
Crude Fat	1.4	4.08	3.37
Crude fibre	0.48	1.8	1.47
Total digestible carbohydrate	76.79	66.86	70.22

2.4 Peelers

There are innumerable numbers of peelers whose use depend upon the type of raw material being processed.

Agarwal *et al*., (1983) developed an abrasive brush type ginger peeling machine. The main parts of the machine are two continuous abrasive vertical brush belts which are driven in opposite direction with downward relative velocity with a variable-speed electric motor. When two belts are driven in opposite direction causes abrasive action on ginger passing in between while the downward relative velocities provide the downward movement of the ginger.

Radha Charan *et al.,* (1993) developed an abrasive ginger peeling machine for application at individual farmer level. It operates on the principle of abrasive peeling. The machine had the following components, moving abrasive surface, stationary abrasive surface, frame and hopper and a driving mechanism. The moving abrasive surface was made of coconut fibre brushes mounted on an endless canvas belt of 40 mm width and 5mm thick with the help of bolts and nuts. The flexibility of fibre helps in minimizing the loss of ginger meat along with the proper cleaning of grooves on irregular surface of ginger pawn. Wooden pulley was selected to provide movement of abrasion surface. Pulleys were mounted on 20mm diameter M.S shafts keeping 160mm apart. The stationary abrasion was also developed with the same brushes arranging them side by side on wooden plank .A uniform gap of 15mm was maintained between the moving and stationary surfaces so as to accommodate ginger pawns between them. This peeling machine had an efficiency of 71% with 1.38 material losses and capacity was about 24kg/hr. The main disadvantage of this machine was that the strength of coconut fibre was lost after a number of operations.

Nagarajan (2005) developed a garlic peeler. It consists of a hollow cylinder, a top cover with hopper and a concave with opening outlet. The cylinder is lined with lining material such as rubber, coir mat, emery etc. the top cover and concave also covered with lining material to impact abrasive action. The cylinder is placed on angle iron frame such that it makes an angle 8º from the horizontal. The peeling device works satisfactorily if the cloves are conditioned to 50 to 55% moisture. However it is found that the fine skin adheres to the lining material.

Jiji *et al*., (1994) developed a hand operated brush type ginger peeling machine. Two abrasive surfaces, one stationary and the other moving were made by means of canvass belts. The brush was made manually with nylon.

The continuous beetroot peeler developed by Gobashy *et al.,* (2003) consisted of 10 abrasive rollers coated with carborundum. The rollers are split into 2 pairs of 5 rollers. The 5 left hand rollers rotate anti-clockwise while the 5 right rollers rotate clockwise in order to scrape/peel the products uniformly. A conveyor screw (frequency controlled) transports the product through the machine. The peeling time in the machine is continuously adjustable.

Cambell(1982) described the construction of a peeler for potatoes. It tumbles the potatoes along a rasp like surface on the interior of rotating nearly horizontal cylinder.

Anie *et al.,*(1996) developed a mechanical abrasive roller type ginger peeling machine and studied the performance by varying pretreating conditions and speed of roller. The machine consists of an abrasive unit, driving unit, collector unit and frame. Abrasion unit does the work of peeling when ginger rhizomes are pressed manually on to the rotating rollers.

K.K Singh (1995) developed a batch type power operated abrasive peeling machine for potatoes. The main parts of the machine are a peeling drum and a spraying unit. The peeling drum with protrusions on the inside surface rotates and detach peel from the potatoes by abrasion. The water spraying unit washes the potatoes and simultaneously peel is removed from the drum through the perforation along with the flow of water.

Leslie Black (1984) developed a banana peeling machine in which the skin of a banana is engaged by impinging spikes on periphery of the three resiliently supported rotatable wheels with separating and cutting means to assist the skin being pulled away from the flesh to effect peeling of banana.

O.J Olukunle *et al*., (2012) developed a knife edged automated cassava peeling machine. This machine has its peeling chamber and peeling tool mounted upon a supporting frame. The peeling tool is a rotating cylindrical drum or barrel

upon which the peeling blades are permanently welded in an auger-like manner. Also a stripe of metal is attached between columns of blade so as to enhance the conveyance of the tuber in the machine while in operation. The barrel is driven by open shaft which is operated by electric motor and belt-pulley mechanism. The hopper is designed such that tubers put into it will automatically lie horizontally on blade. The peeling blades on the hollow cylinder roll against tuber and against an adjustable sharpened blade welded to the body with very little clearance that will not allow the cassava tuber go through but will be large enough to allow the tuber peel to fall off and find its way to the exit point.

Mandher and Senthil Kumaran (1995) developed a continuous motorized peeler for raw mangoes. The principle is to rotate the fruit in an enclosed cylinder against the sharp projections on the inner surface.

Ohwovoriole *et al.,* (1988) have reported the development of a rotary tuber peeling machine based on a new peeling concept. The machine essentially consisted of a fixed outer frustum of a cone and a rotating inner cylinder. The result showed that the machine could peel about 92% of the tuber slices fed into it with no loss of useful flesh.

Emmanuel *et al.,* (1994) developed a hand operated brush type ginger peeling machine and performance at different soaking times were evaluated. The machine essentially consists of a stationary abrasive unit, a moving abrasive unit, a driving mechanism, a feeding unit and a frame.

MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

An attempt was made to develop a jackfruit seed coat remover and to produce good quality flour. The fabrication procedure of jackfruit seed coat remover and test procedure adopted are described below.

3.1General layout of the machine

1. Frame assembly
2. Power transmission
3. Hollow cylinder
4. Circular disc

3.1.1 Frame assembly

The main frame was made to house and support the various components of the machine including motor, cylinder and rotating disc. The frame is made up of stainless steel bar of width 2.5 cm. The base of the frame is about 32×32 cm. It consists of a semicircular holding section.

Fig 3.1: Frame assembly

3.1.2 Power transmission

A single phase 0.5 hp, 1000 rpm induction motor was used as the prime over. The motor rotated in the clockwise direction. The drive from the motor was directly given to the peeling disc through a shaft of 20cm. An AC regulator was used to control the speed of rotation of the motor.

3.1.3 Circular disc

8mm thick circular disc was coated with emery stone and this was connected to the motor via the shaft.

3.1.3 Cylinder

1mm thick stainless steel cylinder of 30cm diameter and 40 cm height was used to hold the seed. The cylinder was coated with food grade emery stone at 1 mm thickness.

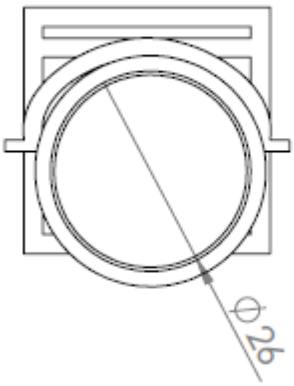

Fig 3.2: Top view of the machine

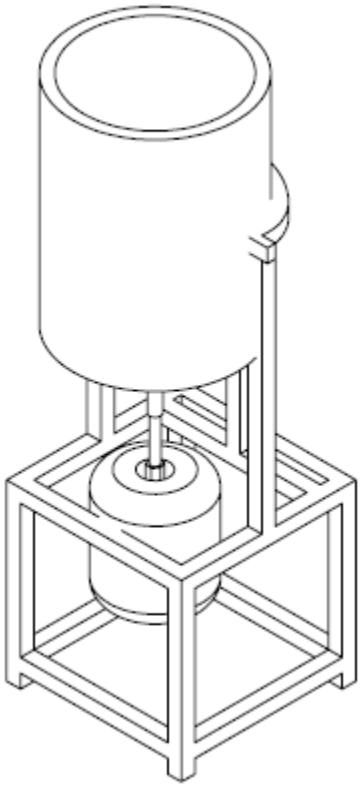

Fig 3.3: 3D diagram of the machine

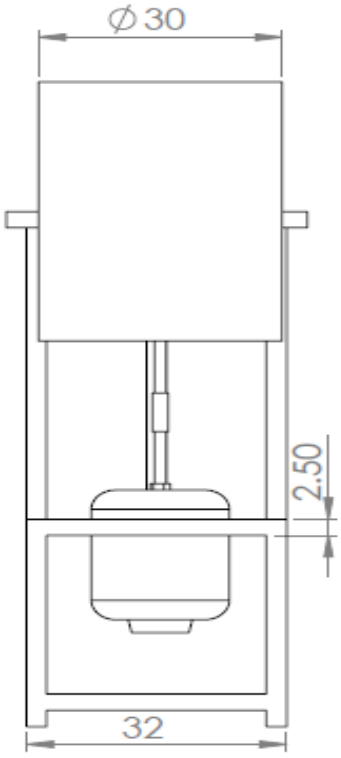

Fig 3.4: Front view

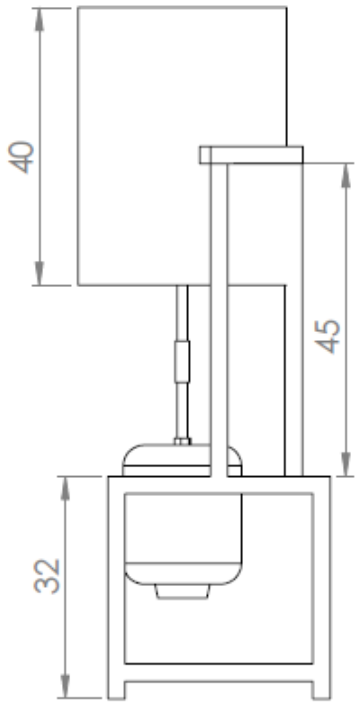

Fig 3.5: Side view

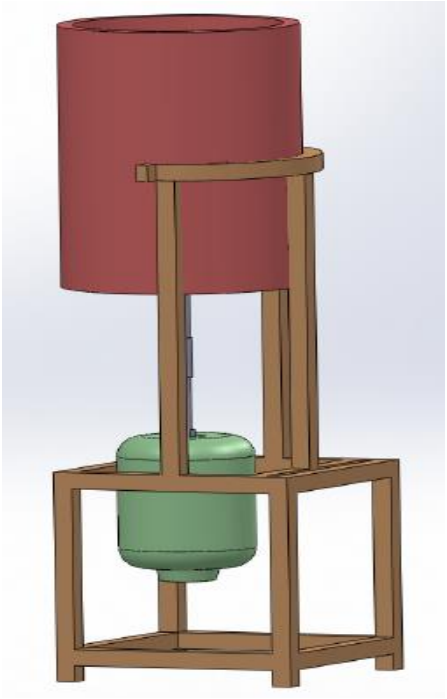

Fig 3.6: Diagrammatic view of jackfruit seed coat remover

3.2 Performance evaluation

Matured jackfruit seeds obtained from the local area were used for conducting the experiments. The samples were dried at different time temperature combinations. It was observed that 100°C for 1 hour gave the optimum results. This time temperature combination was used for performance evaluation. After cooling to room temperature the samples were fed into the jackfruit seed coat remover. The peeling was achieved by abrasion of the seeds against the emery coated disc and cylinder. The preliminary analysis was conducted at a constant motor speed of 1000 rpm which gave better results in terms of capacity and efficiency. Therefore, a motor speed of 1000 rpm in the clock wise direction was chosen as the optimum speed. The power was transmitted from the motor to the rotating disc by means of two shafts which are connected by a pair of nut and bolt as shown in Figure 3.7. The nut and bolt were provided in order to facilitate the sample removal after processing. The time required for operation was noted and the capacity, peeling efficiency and the energy required to operate the machine were then calculated. A comparison between Manual and mechanical method was also carried out.

Fig 3.7: Jackfruit seed coat remover

3.2.1 Capacity of the machine

The capacity of seed coat remover, which means the number of kilogram of jackfruit seed processed in an hour was calculated by noting the weight of decoated seeds produced and time taken for the same. It was then expressed in kg/hr.

3.2.2 Peeling efficiency

The initial weight of five different samples was taken. Each sample was decoated. Then the weight of peeled product and peel obtained were noted. The peel remaining in the seeds were removed manually for each sample and weights were noted. The peeling efficiency was calculated using the formula suggested by Singh and Shukla (1995).

$$\text{Peeling efficiency} = \frac{(X-Y)}{(X)} \times 100$$

Where,

X= total weight of seed coat (g)

Y= weight of seed coat removed manually (g)

3.2.3 Power requirement

Power required at no load and loaded conditions were determined by Watt meter. The Watt meter was connected in series with the motor while running the unit without load and with load and readings were recorded.

3.2.4 Comparison between manual and mechanical seed coat removal

The comparison was done by recording and comparing the total time required for manual and mechanical seed coat removal of a fixed quantity of sample.

3.3 Flour preparation

Generally there are two methods of flour preparation: dry milling and wet milling. We tried to produce flour by both the methods. In dry milling the samples were cleaned and the seed coats were removed manually, and then subjected to size reduction using knife. The samples were dried under sun for a day. Then it was made into flour using a grinder. The flour had been roasted to reduce moisture content.

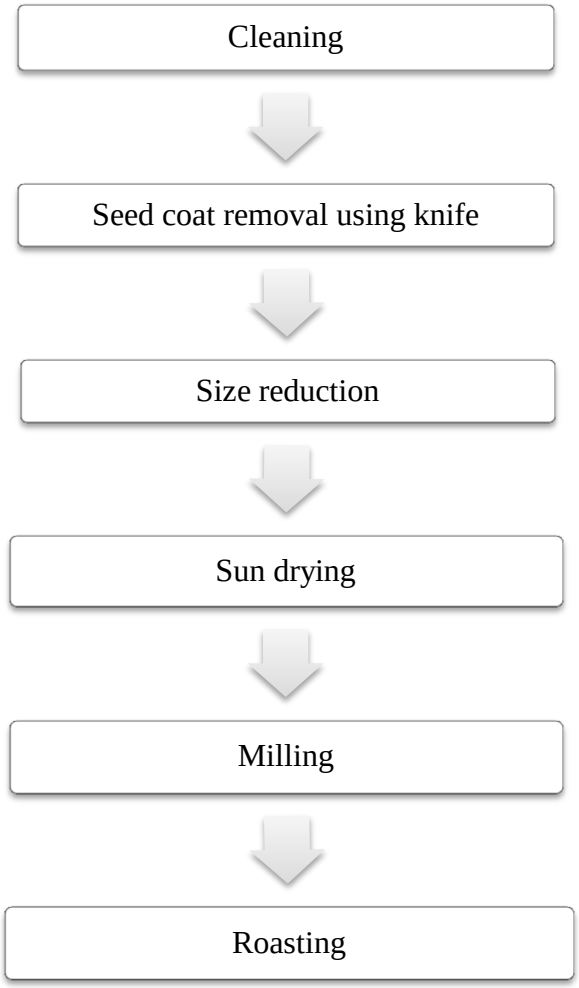

Fig 3.8: Dry milling of jackfruit seed

In wet milling the samples were cleaned, the seed coat was removed manually and subjected to size reduction using knife and is made in the form of

paste. The paste was taken in a muslin cloth and squeezed under for particle separation.

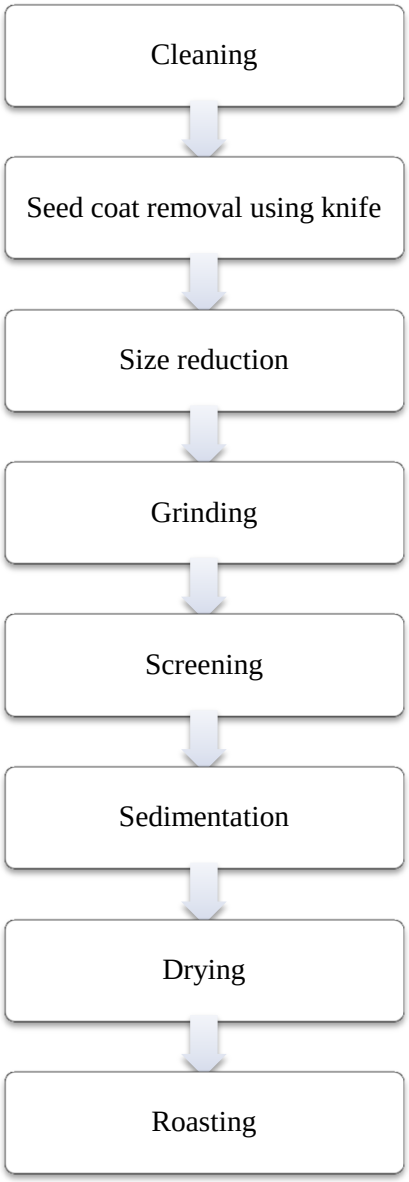

Fig 3.9: Wet milling of jackfruit seed

The appearance, consistency and smell of both samples had been analyzed following the experiment.

3.3.1 Estimation of Carbohydrate

The carbohydrate present in the flour was determined using anthrone method. Aliquotes of 0.5, 0.5 and 1 ml sample solution was taken in a test tube and made up to 1 ml using distilled water. The test tube with 1ml distilled water served as the blank. 1 ml of H_2SO_4 and 4 ml of anthrone reagent was added to each test tube. The absorbance was measured at 578 nm in spectrometer.

3.3.2 Estimation of fat

The fat present in the flour was extracted using soxhlet apparatus using n-hexane as the solvent. The amount of fat present in the sample was expressed in percentage.

$$\% \text{ Fat} = \frac{w_2 - w_1}{p} \times 100$$

Where w_1 = weight of empty thimble

w_2 = weight of thimble after extraction (g)

p = weight of sample (g)

3.3.3 Physical and functional properties

3.3.3.1 Water absorption capacity

One gram sample was weighed into centrifugal tubes and about 10 ml of water added. The suspensions were allowed to stand at room temperature for 1 hour. The suspension was centrifuged at 2000 rpm for 30 minutes. The volume of water on the sediment was measured and the water absorbed expressed as percentage of water absorption based on original sample weight.

3.3.3.2 Oil absorption capacity

One gram sample was weighed into centrifuge tubes and about 10 ml of refined vegetable oil added. The suspension was centrifuged at 2000 rpm for 30 minutes. The volume of oil on the sediment was measured and the oil absorbed expressed as percentage of oil absorption based on original sample weight.

3.3.3.3 Flour dispersibility

Dispersibility was measured by placing 10 grams of seed flour sample in 100 ml stoppered measuring cylinder. Distilled water added to the volume of 100ml, stirred vigorously and allowed to settle for 3 hours. The volume of settled particle was subtracted from 100 and the difference was reported as percentage dispersability.

3.4 Product Development

3.4.1 Jackfruit seed flour cake

Jackfruit seed flour is a good alternative for Maida in cake preparation. It is gluten free and is a rich source of proteins and other nutrients. The cake was prepared as per the procedure given below:

- 60 g jackfruit seed flour, 40 g maida and 0.5 teaspoon baking soda was sifted and blended together.
- 100g butter, 100g sugar and 2 eggs were whipped using the electrical beater.
- The blended flour was added to the above mixture and was beaten.
- The cake mix was transferred to the mould and was baked in a preheated electric oven at 180°C for 25 minutes.

3.4.2 Jackfruit seed flour cookies

- 60 g jackfruit seed flour, 40 maida and a pinch of baking soda was sifted and blended together.
- The sifted flour was mixed with 100 g butter and 70 g granulated sugar and made into dough.
- It was sheeted using a roller
- The mix was cut in to desired shapes and sizes and was baked at 100°C for 30 minutes in a preheated electric oven.

RESULTS AND DISCUSSIONS

CHAPTER 4

RESULTS AND DISCUSSIONS

This chapter deals with the results of experiments conducted to evaluate the performance of the jackfruit seed coat remover and its comparative performance with manual method.

4.1 Performance evaluation

The experimental model was evaluated for its overall capacity, peeling efficiency and power requirement.

4.1.1Capacity of machine

The average capacity of machine was found to be 53.309 kg/hr. The results are shown in Table 4.1. It was observed that the capacity of machine varies with variety, drying temperature and time and moisture content and speed of rotation. The optimum capacity of machine was attained when the seeds were subjected to 100^0C for1 hour and speed of rotation was about 1000 rpm. Further increase in rpm resulted in material loss and breakage of seeds.

Table 4.1.Capacity of the machine

Sl.No	Weight of peeled jackfruit seeds (g)	Time taken for peeling (s)	Capacity (kg/hr)
1	500	38	47.368
2	100	70	51.428
3	1500	95	56.842
4	2000	125	57.6
		Average	53.309

4.1.2 Peeling efficiency

The peeling machine was calculated and the average peeling efficiency was found to 81.07%. The results were as shown in Table 4.2.

Fig 4.1: Jackfruit seeds after peeling

Table 4.2.Peeling efficiency

Sl.No	Weight of the peel(g)	Weight of the peel removed manually(g)	Peeling efficiency (%)
1	25	5	80
2	30	5	83.333
3	50	10	80
4	105	20	80.952
		Average	81.071

4.1.3 Power requirement

Energy required for operating the machine under no load condition and loaded condition at an optimum motor speed of 1000 rpm was determined. The average energy requirement under no load and loaded condition are found to be 300W and 500W respectively.

4.1.4 Comparison between manual and mechanical peeling

The results were as shown in Table 4.4

Table 4.5: Comparison between manual and mechanical peeling

Sl.No	Total time required for peeling one sample of 500gm(s)	
	Manual	Mechanical
1 2	794.44 803.32	38 38

From the study it was found that peeling using the fabricated machine was found to be 20 times more effective than manual peeling. Besides the efficiency of peeling is high and material loss is negligible in the case of fabricated jackfruit seed coat remover.

4.2 Flour preparation

From the experiment it was found that dry milling gave better product quality compared to wet milling. The seeds were blanched at 100°C for 10

minutes to remove the Lectin present in them.

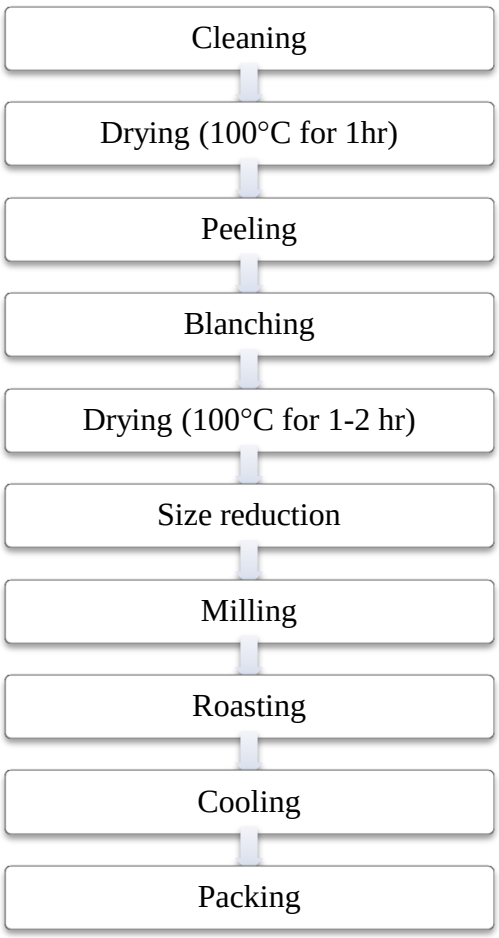

Fig 4.2: Preparation of jackfruit seed flour

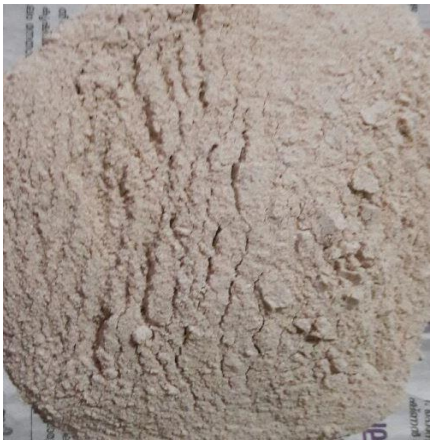

Fig 4.3: Jackfruit seed flour

4.2.1 Estimation of carbohydrate

4.2.2 Estimation of fat

The fat content in the flour was determined using the soxhlet apparatus. The fat content in the jackfruit seed flour was 1.62%. The results of the experiment were as given in Table 4.1.

Fig 4.2: Soxhlet apparatus for extraction of fat

Table 4.1: Estimation of fat content

Sl.No	Weight of sample (g)	Weight of empty thimble (g)	Weight of thimble after extraction (g)	% fat
1	2	77.1	77.13	1.5
2	2	77.1	77.135	1.75
			Average	1.625

4.2.3 Functional properties

4.2.3.1 Water absorption capacity

The water absorption capacity of jackfruit seed flour was found to be 3.4 ml/g. the water absorption capacity describes flour-water association ability under limited water supply. The result obtained showed that the flour has a good ability to bind water. This result suggests that jackfruit seed flour could be used in bakery industry.

4.2.3.2 Oil absorption capacity

The oil absorption capacity of jackfruit seed flour was found to be 2.8g/ml. Fat absorption is an important property in food formulation because fat improve flavour and mouth feel of food. The result obtained showed that the jackfruit seed flour is a high flavour retainer.

4.2.3.4 Flour Dispersibility

The flour dispersibility of jackfruit seed flour was 60.33%. The property of dispersibility determines the tendency of flour to move apart from water molecules and reveals its hydrophobic action.

4.3 Product development

Cake and cookies were prepared from the jackfruit seed flour. The panel evaluated our product characteristics on the basis of different properties.

Fig 4.3: Jackfruit seed flour cookies

Fig4.4: Jackfruit seed flour cake

Table 4.1: Sensory evaluation chart of cake

	Colour	**Texture**	**Taste**	**Overall**
1	4	3	4	11
2	3.5	3	4	10.5
3	4.5	3	3.5	11
4	4	3.5	4	11.5

Table 4.2: Sensory evaluation chart of cookies

	Colour	**Texture**	**Taste**	**Overall**
1	3.5	3	3.5	10
2	3.5	2.5	3.5	9.5
3	3	3	3	9
4	4	3	4	11

4.4 Cost analysis

The cost analysis was performed to determine the fabrication cost of the machine. The overall cost of fabrication of the machine was approximately Rs 10,288. The machine has a capacity to process 53.309 kg/hr and a peeling efficiency of 81.071%. This machine is economically feasible. The details of the cost are given in Appendix II.

SUMMARY AND CONCLUSION

CHAPTER 5

SUMMARY AND CONCLUSION

Jackfruit is widely cultivated in India. After consumption of the edible portion of the ripe fruit, the seeds, rich in carbohydrate are usually discarded as a waste. It can be converted into jackfruit seed flour and it has a great potential for new food formation along with other flours.

The removal of the outer coat is one of the time consuming process in the production of jackfruit seed flour. To overcome this difficulty a model was developed for removing the seed coat of jackfruit seeds in KCAET, Tavanur. This was tested for capacity and peeling efficiency. A comparison between manual and mechanical peeling was also carried out to find out the increased efficiency.

The machine consisted of a frame assembly which held the entire system. A cylinder coated with emery stone was used for the effective removal of the peel in short time. This was operated by an AC motor connected to the cylinder by means of shaft.

The machine had a capacity of 53.309 kg/hr and a peeling efficiency of 51.071%. The machine had simple operation and easy to handle. It is very compact. Skilled labour not required to run the machine. The time required for peeling is 20 times less than the manual peeling. Material loss is negligible. It is easy to clean and unload.

Jackfruit seed flour is rich in carbohydrates, protein and minerals. It has anti carcinogenic, antispasmodic, antiulcer and antihypertensive properties. It can be used as a gluten free substitute for maida for the preparation of cake, biscuits, energy drinks and other bakery products.

From our analysis we could find that dry milling gave better flour than dry milling. The flour has a shelf life of 6 to 12 months at room temperature. The

flour produced had comparable nutritional qualities with the flour produced for marketing.

Jackfruit seed flour has high market potential. It is a remedy for the nutrition deficiency problems in today's world.

APPENDICES

DEVELOPMENT OF JACKFRUIT SEED COAT REMOVER AND PREPARATION OF JACKFRUIT SEED FLOUR

APPENDIX I

Sensory evaluation card

	Colour	Texture	Flavour	Overall

1= poor; 2=fair; 3= good; 4=very good; 5= excellent

APPENDIX II

CALCULATION OF OPERATING COST

Initial cost (C)

Fabrication cost of pineapple peeler

Including cost of material, C = Rs. 10288

Average life of machine, L =10 years

Working hours per year, H =2920

Salvage value, S =10% of initial cost

A) Fixed cost

1. Depreciation $= \frac{C - S}{LH}$

$= \frac{10288 - 1028.8}{10 \times 2920}$

$=0.317$

2. Interest on investment@ 12% $= \frac{(C + S) \times 12}{2 \times H \times 100}$

$= \frac{(10288 + 1028.8) \times 12}{2 \times 2920 \times 100}$

$=0.232$

Total fixed cost =0.549

B) Variable cost

1. Labour wages

Wages of labour = Rs. 400/day 0f 8 h

2. Cost of electrical energy

Unit cost of electricity = Rs. 7/kwh

Energy consumption of machine =0.402

Cost of electricity =2.814/h

3. Repair and maintenance cost

@ 10% of initial cost p.a. $= \frac{10288 \times 10}{2920 \times 100}$

=0.352/h

Total variable cost =53.166/h

Total operating cost =53.715/h

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ABSTRACT

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