REFINEMENT AND PERFORMANCE EVALUATION OF EXISTING JACKFRUIT PEELER, CORER CUM CUTTING MACHINE

By

HISANA THASNIM M (2018-06-001)

ADEEBA MUHSINA LULU (2018-06-002)

BINCY T P (2018-06-007)

HIMA M M (2018-06-012)

DEEPTHI K V (2018-06-028)

DEPARTMENT OF PROCESSING AND FOOD ENGINEERING

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY, TAVANUR-679573

KERALA, INDIA

2022

REFINEMENT AND PERFORMANCE EVALUATION OF EXISTING JACKFRUIT PEELER, CORER CUM CUTTING MACHINE

HISANA THASNIM M (2018-06-001)

ADEEBA MUHSINA LULU (2018-06-002)

BINCY T P (2018-06-007)

HIMA M M (2018-06-012)

DEEPTHI K V (2018-06-028)

PROJECT REPORT

Submitted in partial fulfilment of the requirement for the degree of

Bachelor of Technology

In

Food Engineering and Technology

Faculty of Agricultural Engineering and Technology

KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF PROCESSING AND FOOD ENGINEERING

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY, TAVANUR-679573

KERALA, INDIA

2022

DECLARATION

We hereby declare that this thesis entitled **“REFINEMENT AND PERFORMANCE EVALUATION OF EXISTING JACKFRUIT PEELER, CORER CUM CUTTING MACHINE"** is a bonafide record of research work done by us during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Place: Tavanur **Hisana Thasnim M (2018-06-001)**

Date: **Adeeba Muhsina Lulu (2018-06-002)**

Bincy TP (2018-06-007)

Hima M M (2018-06-012)

Deepthi KV (2018-06-028)

CERTIFICATE

Certified that this project entitled **"REFINEMENT AND PERFORMANCE EVALUATION OF EXISTING JACKFRUIT PEELER, CORER CUM CUTTING MACHINE"** is a record of project work done jointly by Hisana Thasnim M (2018-06-001), Adeeba Muhsina Lulu (2018-06-002), Bincy T P (2018-06-007), Hima M M (2018-06-012), Deepthi K V (2018-06-028) under my guidance and supervision and that it has note previously formed the basis for the award of any degree, diploma, associateship or fellowship to them.

Tavanur

Date:

Dr. Rajesh G. K.

Guide &Assistant Professor

Dept. of Processing and Food Engineering

K.C.A.E.T.,
Tavanur

Er. Anjaly M.G.

Co Guide and Assistant Professor

Dept. of Processing and Food Engineering

K.C.A.E.T., Tavanur

ACKNOWLEDEMENT

Any accomplishment requires the efforts of many people, and this work is no different. We find great pleasure in expressing our deep sense of gratitude success.

First of all, with profound and reverence we would like to express our sincere gratitude to our project guide, **Dr Rajesh. G. K,** Assistant Professor, Dept. of Processing and Food Engineering, Kelappaji College of Agricultural Engineering and Technology, Tavanur, for his valuable guidance, profound suggestions, constant backing, encouragement and advice throughout the project work. This project has been a result of the combined efforts of our guide and us. We consider it as our greatest fortune to have him as the guide for our project work and our obligation to him lasts forever.

With great gratitude and due respect, we express our heartfelt thanks to **Dr Sathian K. K.,** Dean, K.C.A.E.T., Tavanur. We engrave our deep sense of gratitude to **Dr Prince M.V.,** HOD, Department of Processing and Food Engineering, **Mrs. Sreeja R.,** Assistant Professor, Department of Processing and Food Engineering, **Er. Anjaly M. G.,** Assistant Professor, AICRP PHET, and **Er. Shahama,** K.C.A.E.T., Tavanur for their support and encouragement.

We also express our profound sense of gratitude to **Mr. Lenin**, Technician, and **Mr. Vipin,** Technician, K.C.A.E.T., Tavanur for their immense help and continuous support throughout the project or completing it successfully. We also thankfully remember the help and support offered by **Mrs Geetha,** staff member of Department of Food and Agricultural Process Engineering, K.C.A.E.T., Tavanur and **Mr Radhakrishnan M.V.,** Lab Assistant, K.C.A.E.T., Tavanur. We express our thanks to all the library staff members, KCAET, Tavanur for their ever- willing help and cooperation.

We are greatly indebted to our parents or their love, blessings and support which gave strength to complete our study. We also acknowledge our friends or their support and care throughout the project duration. Last but not the least, we bow

our heads before **God Almighty** for the blessings bestowed upon us which made us materialize this endeavour.

DEDICATED TO OUR BELOVED PARENTS, TEACHERS & TO OUR PROFESSION

CONTENTS

Sl.No.	Title	Page No.
	LIST OF TABLES	i
	LIST OF FIGURES	ii
	LIST OF PLATES	iii
	SYMBOLS AND ABBREVIATIONS	iv
1	INTRODUCTION	1
2	REVIEW OF LITERATURE	5
3	MATERIALS AND METHODS	21
4	RESULTS AND DISCUSSIONS	37
5	SUMMARY AND CONCLUSION	43
6	REFERENCES	46
7	ABSTRACT	

LIST OF TABLES

Table no.	Title	Page No.
2.1	Nutritional composition of jackfruit (per 100g)	8
4.1	Specification of jackfruit	38
4.2	Cutting force of matured jackfruit	39
4.3	Peeling efficiency of jackfruit peeler, corer cum cutting machine	40
4.4	Coring efficiency of jackfruit peeler, corer cum cutting machine	40
4.5	Jackfruit bulb wastage during peeling operation	41
4.6	Jackfruit bulb wastage during coring operation	41

LIST OF FIGURES

Fig. No.	Title	Page No.
2.1	Production status of jackfruit during 2021-22	7
2.2	Measurement of diameter, length and placental diameter of cucumber and ash gourd	11

LIST OF PLATES

Table no.	Title	Page No.
3.1	Cutting probe	24
3.2	Fruit holder	27
3.3	Peeler assembly	27
3.4	Jackfruit corer	29
3.5	Jackfruit peeler, corer cum cutting machine	30
3.6	Trimmed jackfruit	32
3.7	Loading of jackfruit	32
3.8	Performance evaluation of jackfruit peeler	33
3.9	Peeled jackfruit	33
3.10	Cutting-coring operation of jackfruit	34

SYMBOLS AND ABBREVIATIONS

Abbreviations/ Notations	Description
=	Equal to
×	Multiplication
/	Per
%	Percentage
MT	Million tonne
m	Metre
ft	Feet
in	Inch
NHB	National Horticultural Board
g	Gram
mg	Milligram
mm	Millimetre
viz.	Namely
cm	Centimetre
kg	Kilogram
K.C.A.E.T	Kelappaji College of Agricultural Engineering and Technology
min	Minute
kJ	Kilojoule

m^2	metre square
s	Second
UTM	Universal Testing Machine
N	Newton
kN	Kilonewton
Fig.	Figure
etc.	Etcetera
rpm	Revolution per minute
Pa	Pascal
NaOH	Sodium hydroxide
hr	Hour
Sl.	Serial
No.	Number
SD	Standard deviation
W	Watts
kW	Kilowatts
-	Subtraction
+	Addition
±	Plus or Minus
hp	Horsepower
MS	Mild steel
SS	Stainless steel

°	Degree
&	And
ID	Inner diameter
OD	Outer diameter
US	United States
CAD	Computer Aided Design
ie.	That is
APEDA	Agricultural and Processed Food Products Export Development Authority
IPGRI	International Plant Genetic Resources Institute

Introduction

CHAPTER I

INTRODUCTION

India, known to be the fruit and vegetable basket of the world, has a diverse climate that ensures availability of fresh fruits and vegetables. India is the second largest producer of fruits and vegetables in the world after China. The production of fruits and vegetables in India during 2019-20 was 102.03MT and 188.91MT, respectively (Ministry of Agriculture and Farmers Welfare, 2020). Despite its strong agricultural production base, processing of fruits and vegetables is currently less than 3% as compared to countries like China (23%), US (65%) and Philippines (78%). India is far below to reduce the postharvest loss and enhance value addition and shelf life of farm products. The estimated postharvest loss in fruit and vegetable sector is higher and reached from 25% to 30%. These percentages are not acceptable and adversely affects Indian economy (Hegazy, 2016). To avoid these problems, we need technological intervention and diversification of these valuable fruits which is most important in filling the ever-increasing demand-supply gap.

Bearing the world's largest fruit also known as the Cinderella of fruits, jackfruit is native to India, originated in the western ghats of India. Jackfruit (*Artocarpus heterophyllus)* is one of the largest crops belonging to the family of Moracea. It is abundantly grown in India, Bangladesh, Malaysia, Indonesia, Thailand, Philippines, Sri Lanka (Baliga *et al.,* 2011), Brazil, Queensland, Africa and some part of Australia and America. In India major jackfruit growing states are Kerala, Tamil Nadu, Bihar, Assam. Jackfruit is the state fruit of Kerala. In India, annual production and total cultivation area of jackfruit during 2021-2022 was 18.76 lakh tonnes over 1.87 lakh hectares respectively. In Kerala the annual production of jackfruit was 2.63 lakh tonnes contributing to 14.01% of its share to India (APEDA, 2021-22)

Jackfruit is a very nutritious fruit which can be transformed into various value-added products. From the tender stage onwards, the fruit can be converted as value-added products like dehydrated jack fruit whereas the ripened fruit can be used for making a wide variety of jams, jellies, candy bars, beverages, wine, jack fruit chips and so on. Jackfruit is used as a traditional medicine for the treatment of asthma, ulcers, wound healing, hypertension, nervousness (Abdul and Martin 2015). It is well known for its anti-microbial, anti-fungal, antidiabetic, anti-inflammatory and anti-oxidant activities. Jackfruit can also provide carbohydrate, protein, phenolic compounds for the body, which will result in more strength for the individual. Jackfruit contains more protein, calcium, iron, vitamins, and other essential nutrients (Prem *et al*.,2015).

Nowadays, demand for jackfruit is increasing day by day owing to its availability, sweetness and nutritional composition. Sensitized growers and entrepreneurs focus more on development of value-added products. The increasing demand of jackfruit can be regulated by increasing production and also by varietal improvement in species and method of propagation. In spite of its huge production, the utilization as food material is quite negligible, less than 40% and the remaining is going as waste. The traditional method of peeling and coring is done by cutting the fruit into two halves lengthwise using a knife, which is a time-consuming process and causes drudgery. Moreover, the latex of this fruit is also hindering during the separation of the fruit bulb for consumption. The tedium in manual processing is a major reason for the underutilization of the fruit. Thus, effective mechanization in processing is a need of the hour.

The above scenario urgently demands for the development of a mechanical tool or machine for peeling, coring and cutting of whole jackfruit. This development will reduce the wastage of major quantity of jackfruit and also helps in preparation of primary processed products that can be used for production of other products. The developed tool can be easily operated by women and unskilled labour, so it also increases the commercial utilization of jackfruit

A similar jackfruit peeler cum corer was developed at K.C.A.E.T., Tavanur. However, it had only a single motor for the entire operation, due to which efficiency and capacity was found to be lower and was also time consuming. So, an attempt was carried out to improve the capacity and reduce the total processing time by making some modifications in the existing machine, with the following objectives.

1. To study the engineering properties of jackfruit.
2. To modify the existing mechanical tool for peeling, cutting and coring of jackfruit.
3. To evaluate the performance of the developed machine.

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

This chapter illustrates comprehensive review of the research work done by various research workers related to the general information of jackfruit, engineering properties of different agricultural produces, development and evaluation of peeler and slicer machines and the material selection for the equipment fabrication.

2.1. Jackfruit

Jack fruit is a monoecious evergreen tree possibly indigenous to the rain forests of the Western Ghats (Baliga *et al.*,2011). It is used as staple food in India and commonly known as kanthal, kathal, kathar, chakka, pala appears in market during spring to summer. Among the tropical fruits, Jackfruit is an important underutilised fruit and often called the poor man’s fruit commonly consumed foods in India from the ancient time by value addition of its fruits (Arora and Parley 2016).

2.1.1. Botanical aspects

Jacktree is a medium sized evergreen tree, typically reaches 8-25 m in height. The grows rapidly in early year, upto 1.5 m/year (5 ft /year) in height slowing to about 0.5 m /year (20 in/year) as the tree reaches maturity. It has a straight rough stem, the leaves are grown elliptic dark green in colour and alternate (R.A.S.N.Ranasingh, 2019).

Jackfruit has a green to yellow brown exterior rind that is composed of a hexagonal blundly conical carpel epic that cover a thick, rubbery, and whitish to yellowish wall. It is a multiple aggregate fruit which is formed by fusion of multiple flowers in an inflorescenes (D.G.Mushumbusi, 2015).

There are large number of bulbs which have high nutritional value. The colour changes from yellowish green to yellow due to conversion of chlorophylls and cyanins and carotenoids like pigments during ripening (A.K.Tiwari *et al.*, 2015)

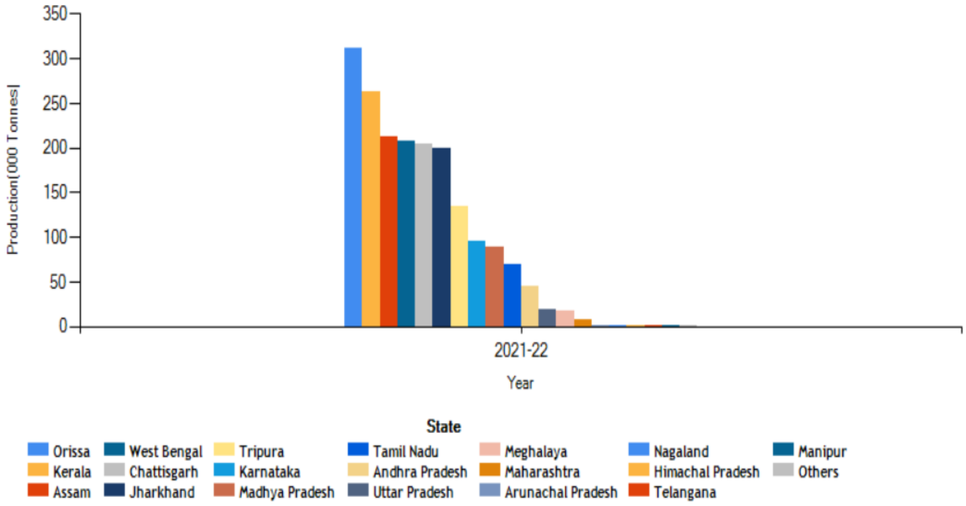

Fig. 2.1 Top 10 states in jackfruit production

Source : NHB, 2021-2022

2.1.2 Varieties of jackfruit

Koozha and Varikka are the two main varieties of jackfruits available in Kerala. Jackfruit having thin, fibrous and mushy edible pulp which is very strong, sweet and emitting odour is called Koozha. But Varikka is thick, firm, crisp and has less fragrant pulp. Thamara chakka, Nadavalam varikka, Vakathanam varikka, Muttom varikka, Aathimathuram 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).

2.1.3 Harvesting

In Asia, depending on the climatic region, fruits ripen mainly from March - June, April to September or June- August and for some off season crops from September to December (Morton,1987).

The harvest maturity of immature jackfruit for subsequent ripening is generally stated to be 90-120 days after appearance o spikes (Berry and Kalra, 1988)

Fruit should be harvested by cutting from the stalk using sharp bladed equipment. If the fruit is high up in the tree, a sack should be tied around the fruit with a rope, the stalk should be cut, and the fruit should be gently lowered to the ground (B K Palipane *et al*., 2008)

Accurate determination of maturity and best harvesting time and correct harvesting practices allows minimum loss of fruits (A K Tiwari *et al*., 2015).

Physiologically and commercially mature jackfruit can be harvested after hundred days of fruits set. Visible and sensible criteria like low spine density and moderate to high spreading of spine, presence of sensible hollow metallic sound, and moderately flattend fruit stalk attachment to the fruit can be used as the maturity indices of jackfruit for dessert purpose (M G Saha *et al.*,2021).

2.1.4 Nutritional composition

Jackfruit is rich in nutrients including carbohydrates, proteins, vitamins, minerals, and phytochemicals. The several parts of jack tree including fruits, leaves, and barks have been extensively used in traditional medicine due to its anticarcinogenic, antimicrobial, antifungal, anti-inflammatory, wound healing, and hypoglycaemic effects.

Table 2.1. Nutritional composition of jackfruit (per 100g)

Composition	Young Fruit	Ripe Fruit	Seed
Water (g)	76.20-85.20	72.0-94.0	51.0-64.5
Protein (g)	2.0-2.6	1.2-1.9	6.6-7.04
Fat (g)	0.1-0.6	0.1-0.4	0.40-0.43
Carbohydrate (g)	9.4-11.5	16.0-25.4	25.8-38.4
Fibre (g)	9.4-11.5	16.0-25.4	25.8-38.4
Total Sugars (g)	2.6-3.6	1.0-1.5	1.0-1.5

Total Minerals(g)	-	20.6	-
Calcium (mg)	30.0-73.2	20.0-37.0	50.0
Magnesium (mg)	-	27.0	54.0
Phosphorus (mg)	20.0-57.2	38.0-41.0	38.0-97.0
Potassium (mg)	287-323	191-407	246
Sodium (mg)	3.0-35.0	2.0-41.00.11-0.3	63.2
Iron (mg)	0.4-1.9	0.5-1.1	1.5
Vitamin A (IU)	30	175-540	10-17
Thiamine (mg)	0.05-0.15	0.03-0.09	0.25
Riboflavin (mg)	0.05-0.20	0.05-0.40	0.11-0.3
Vitamin C (mg)	12.0-14.0	7.0-10.0	11.0

Source: [Arkroyd *et al*. (1966), Narasimham, (1990), Gunasena *et al.* (1996), Azad, (2000) and Manjeshwar *et al.* (2011)]

2.1.5 Post harvest utility

Despite its nutritional and health benefits, the jackfruit is underutilized and not classified as a commercial crop due to its short shelf life and insufficient processing facilities in the regions where they are grown (B.M.C. Reddy et.al, 2004). About 60% of whole jackfruit consist of inedible parts such as outer prickly rind, inner perigones, and central core and only 35% of the whole fruit consist of edible flesh. In jackfruit processing industries, a huge amount of inedible parts such as peel are generated as waste. Therefore, advanced processing technologies and sustainable waste management strategies should be considered when processing jackfruit in commercial scale.

2.2 Engineering Properties

In handling, processing, storage and distribution of foods at various stages, engineering properties play a key role in design of the equipment, processes and monitoring of the quality. Knowledge of these engineering properties may lead to greater efficiency in production and utilization of food materials, less waste, and foods of higher quality and lower cost to the consumer.

2.2.1 Physical properties

The study of the physical properties of products is very important in the design of particular equipment and analysis of the behaviour of the product during post-harvest operations (Sahay and Singh, 1994). It can increase the efficiency of processing equipment, especially for peeler and slicer. Knowledge of the physical properties like weight, length and diameter of the fruit, length and diameter of fruit core and fruit rind thickness are necessary for development of mechanical tool for jackfruit peeling, cutting and coring. The determination of physical properties of different fruits followed by various research workers were reviewed for the study.

2.2.1.1 Size

Size, generally refers to characteristics of an object which determines the space requirement within the limit and necessary for satisfactory description of the any solid object. The size of fruits is important in determining their suitability and understands the properties that may affect the design of machines. Researchers have used various techniques to investigate the dimensions of different produce and its experimental results are given below.

Chakespari *et al*. (2010) studied about mass modelling of two apple varieties by geometrical attributes. Digital calipers (0.01 mm accuracy) were used for determining the fruit size. In order to obtain average size, they considered three linear dimensions *viz*., length (equivalent distance of the stem from top to the bottom calyx), width (longest dimension perpendicular to length) and thickness (longest dimension perpendicular to length and width). Whereas, projected area of each fruit which are perpendicular to length, width and thickness were recorded with an accuracy of 0.05mm using a Win Area UT-06 system.

Haq (2011) investigated the variation in jackfruit characteristics. Wide variation was observed in fruits characteristics like fruit length values from 20.50 to 60.60 cm and diameter 16.40 to 29.5 cm with the majority of the selections.

Mohan (2012) determined some physical properties of ash gourd and cucumber to develop a seed extractor by image analysis. Experiments were carried out using a standard digital camera, camera stand, computer and the AutoCAD software. The photographs were taken by fixing the camera in stand and captured images of each fruits were processed in the computer using AutoCAD software. The outlines of the fruits were drawn and dimensions viz., diameter, length and placental diameter was measured by providing proper scale factor (Fig.2.1).

Shyamalamma *et al*. (2014) investigated the physical properties of elite jackfruit genotypes collected from the Bangalore rural and Tumkur district. Study revealed that wide variation was observed in fruits characteristics like fruit length of 20.50-43.00 cm, fruit diameter of 14.50-22.00 cm and rind thickness of 0.60 to 2.00 cm among the jackfruit genotypes.

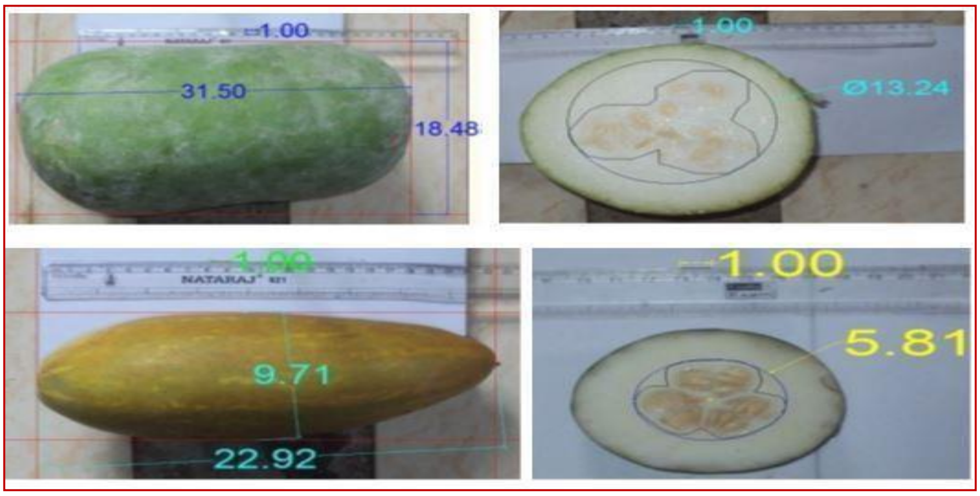

Fig 2.2. Measurement of diameter, length and placental diameter of cucumber and ash gourd

Kotoky *et al*, (2014) carried out the survey in different districts of Assam to study the qualitative traits of some jackfruit genotypes based on jackfruit descriptor described by International Plant Genetic Resource Institute (IPGRI).

The study revealed that, there was wide range of variability exists with regards to many desirable quantitative characters viz., fruit length (19.50-62.08cm), fruit diameter (7.00-24.00cm) and fruit rind thickness (0.30-2.00cm) among the different jackfruit genotypes.

Gomez *et al,* (2015) studied the physic-morphological characteristics of jackfruit accessions in Kerala. The dimension of the jackfruits among the jackfruit accessions varied from 28.66-52.66cm in length and 18.46-30.50cm in diameter.

Hareesha T Shidenur (2016) the mean, minimum and maximum values of fruit length, fruit diameter, core length, core diameter and rind thickness of the jackfruit were found out using image processing method. The mean, minimum and maximum values of length of jackfruit were found as 38±7.79, 26.52 and 55.81cm where the core length as 29.95±7.7, 20.23 and 48.06cm respectively.

Abdul Vahid P *et al,* (2017) study conducted on pineapple and the result shows that the diameter varies from 80mm to 95mm and the length of pineapple varies between 180mm to 200mm.

Manoj Kumar Mahawar *et al,* (2020) conducted the study on development and composite mechanical peeler cum juice extractor for kinnow and sweet orange. The fruit dimensions, thickness of peel were measured by a vernier caliper (M/s Mitutoyo, Japan, ±0.01mm)

2.2.1.2 Mass

Jagadeesh *et al*. (2007) studied the important physico-chemical characters of jackfruits to determine the degree of divergence present among the selections. Observed values of total fruit mass, seed mass, rind mass, flake mass and bulb mass of the jackfruits among the clusters varied from 4.68-14.86 kg, 0.71-3.67 kg, 2.06- 4.85 kg, 1.61-5.62 kg and 3.11-9.28 kg, respectively.

Haq (2011) investigated the variation in jackfruit characteristics. Wide variation was observed in fruit weight ranging from 1.2-22.0 kg with the majority of the selections.

Kotoky *et al*. (2014) carried out the survey in different districts of Assam to study the qualitative traits of some jackfruit genotypes based on jackfruit descriptor described by the International Plant Genetic Resource Institute (IPGRI). The observed values of fruit weight, fruit rind weight and weight of flakes per kg of fruit in the different jackfruit genotype were ranges from 0.5815.45 kg, 0.02-1.23 kg and 0.06-0.37 kg, respectively among the different jackfruit genotypes.

Shyamalamma *et al*. (2014) investigated the physical properties of elite jackfruit genotypes collected from the Bangalore rural and Tumkur district. Study revealed that wide variation was observed in fruits characteristics like fruit weight of 3.75-10.35 kg, fruit rind weight of 0.30-0.50 kg and weight of flakes per kg of fruit was 0.50-0.71 kg among the jackfruit genotypes.

Gomez *et al.* (2015) studied the physico-morphological characteristics of jackfruit accessions in Kerala. The observed value of fruit weight among the jackfruit accessions ranged from 3.95-20.13 kg.

Hareesha T Shidenur (2016) weight of fruit was important in determining the factor of safety distribution in designed fruit holder disc in order to withstand against maximum load during the cutting-coring operations. The weight of jackfruit varied from 5.35-16.65kg and mean weight found as 8.34±2.94kg.

Abdul Vahid P *et al,* (2017) Pineapples of different varieties and of different maturity were purchased from the market and the result shows the weight of the pineapple ranges from 1721 kg to 1627kg.

Manoj Kumar Mahawar *et al, (*2020) conducted the study on development and composite mechanical peeler cum juice extractor for kinnow and sweet orange. The weight of whole fruit, peeled fruit, flavedo, albedo, pomace and juice content were determined by means of a digital electronic balance (M/s Shimadzu Corporation, Japan, ± 0.007g).

2.3 Mechanical properties of jackfruit

2.3.1 Cutting force

The cutting strength is one of the most important tests in the mechanical properties. The test used to determine the materials strength and resistance of tissue to loading cutting force during cutting and coring operation. Some researches carried out work on requirement of cutting force to cut the fruits which helps in the particular equipment. The determination of cutting strength of different produce followed by various research workers were reviewed for the study.

Ohwovoriole *et al*. (1988) determine the cutting strength to identify the necessary cutting force of unpeeled and peeled cassava tuber. During this test, cutting tool (1.5 mm thick piece of sheet metal with sharpened edge at 30º angle) was placed between the plungers of the universal testing machine. The machine subjects the samples to compression at the speed of 20 mm/min and the resulting data were used to design a cassava peeler.

Visvanathan *et al*. (1996) studied the cutting strength of cassava tuber. The study revealed that, cutting force required to cut the cassava tuber depends on angle and velocity of the knife. The specific cutting energy for cassava tubers was observed to be a minimum (6.5 kJ/m^2) at a knife bevel angle of 30-45˚, knife velocity of about 2.5 m/s and shear angle of 63-75˚.

Emadi (2005) determined the mechanical properties of different varieties of pumpkin and melon fruit to develop a peeler machine. A cutting indentor, cutter device and holder for unpeeled and skin sample were designed and built for testing cutting force of a product in three stages *viz*., unpeeled, flesh and skin. Sharpened edge (30˚ included angle) of stainless steel with 1.5 mm thick was used for designing and constructing the cutting indentor. Samples were prepared from the different parts of the pumpkin and melon using a cutting device and kept in the holder. The cutting indentor was fixed on the universal testing machine (UTM) which subjects a load at a speed of 20 mm/min. The study reveals that, the cutting strength of unpeeled sample of Jarrahdale, Butternut, Jap, Rockmelon, Honeydew and Watermelon was 5.15, 20.48, 10.99, 12.19, 9.55 and 10.13 N respectively whereas in skin samples, it was found as 2.82, 17.31, 9.41, 12.65, 9.96 and 10.16 N respectively.

Ambrish (2005) determine the maximum required force to cut the anola fruits, which ranged from 15.25 kg for the NA-7 varieties along the stem end side and the least requirement of cutting force was 7.43 kg for Kanchan variety along the axis of fruit.

Shamsudin *et al.* (2009) conducted the experiments on firmness of pineapple fruit at three different locations. The fruit firmness was measured using a cylindrical die of 6 mm diameter with the Instron Universal Testing Machine (UTM). The result revealed that, force decreased with the stage of maturity from 74.79-42.93 N (top position), 62.56-37.20 N (middle position) and 57.14-36.04 N (bottom position) due to cause of ripening process and storage period.

Hareesha T Shidenur (2016) conducted study on jackfruit peeler. Five numbers of jackfruit were randomly selected and the cutting strength of peeled jackfruits was found using a universal testing machine (UTM). Cutting strength was important in simulation of core removing tool and fruit holder to stand with against maximum load while cutting-coring of large size of jackfruit.
Result shows that cutting strength of jackfruits was varying from 2.5-3.5 kN and average value was found to be 2.96±0.42 kN.

2.4 Peeler and corer machines for different agricultural produce

Peeling and coring operations are the important preliminary stage of fruits and vegetables processing. The price and quality of the processed product is highly dependent on these stages. Manual peeling and coring are possible for all products but high losses and consumption of time and labour, have motivated the peeling industry to use mechanical peeler. There is a number of mechanical peelers and slicer/cutting machines are developed to suit the peeling and slicing of either a particular product or a group of products. In general, mechanical peelers are classified into various groups on the basis of type of mechanism that can incorporate during peeling system. The mechanical peelers include abrasive devices, devices with blades, rollers and drums. There is a variety of peeler and slicer machines which are developed by various research scientists to peeling and slicing/cutting of different types of fruits and vegetables viz., pumpkin, apple, mango, pineapple, melon, papaya, cucumber etc. A review of peeler and slicers machines for different produces is presented below.

Harding (2001) patented a peeler for convex surface of a fruits and vegetables. The machine includes a U-shaped peeling blade and a feeder which grips and contacts the fruits/vegetables at a position opposite the apex of the peeling blade. This apparatus also includes at least one guide for guiding the fruits or vegetables to pass in front of peeling blade

Kim (2006) patented a fruits peeler with cutting part. The simple device consists of a single piece of metal piece with a round peeling part inside of metal and cutting part outside of the same metal to peel and cut fruits. Peeling part removes the peel from round and convex surfaces of fruits and cutting part is used to cut the fruit to eatable size.

Singh *et al*. (2013) developed a pineapple peeler cum slicer with a slicing plate of 7cm and a core diameter of 2.5cm, respectively with peeling efficiency as high as 97.2% and wastage as low as 5.3%. It was a hand operated peeler cum slicer which works satisfactorily with easy operation. Twenty numbers of pineapple fruits can easily be peeled and sliced by skilled worker in one hour with the designed device.

Hareesha T shidenur (2016) fabricated jackfruit peeler cum corer machine in which the major components are fruit holder, peeler assembly, corer assembly along with cutting mechanism, power transmission unit and frame assembly. Performance evaluation of the machine was conducted in the laboratory to optimize the speed of peeling and coring with minimum bulb damages.

Yen *et al,* (2020) done research on the design and analysis of a garlic peeling machine. The streamline of the air flow produced in the model was able to form in the spiral structural, due to which a vortex of air will be performed in the model. The air flows in from the inlet and then leaves the main body through outlet. The design was able to replace the traditional hand peeling method. The simulation of fluid flow proves that the air flow in from the bottom, inlet is able to produce a vortex in the peeling chamber and then the garlic skin goes out through the top, outlet. It was able to separate the peeled garlic and the garlic skin and hence the design was generated.

Gowda *et al* (2021) developed a pneumatic based jackfruit corer cum splitter that could be used for continuous processing of jackfruit of different size by overcoming sticky latex problem. The fruits were graded into small (15-30cm), medium (30-45cm), and large(45-60cm) size before processing. The graded fruits were cut and split by mounting an appropriate size coring spindle to the machine. The core cutting was also tested at different spindle speeds (700, 800, 900 rpm) and the optimum was found at 800 rpm. The highest coring efficiency recorded was 92.7%, 94.5% & 88.4% for small, medium and large fruits respectively.

Sandra *et al* (2021), studied the design and fabrication of small-scale potato peeling machine with lye method. The machine can be used for other thin skinned horticultural products. It was designed to peel ± 3kg of potato chips in one go. This machine works by spraying pressurized water on the fruit soaked in hot NaOH solution. Engine performance was determined by water pressure. The results showed that the best pressure was 5.6051 Pa with 11% NaOH.

2.5 Cutting/slicing tool for different agricultural produce

Many factors were considered in the design of the cutting machine which includes the physical and mechanical properties of the materials for construction. The blade of the cutting machine is usually expected to be sharp enough to cut easily. Further the materials needed for construction of the machine must neither contaminates the vegetables nor get corroded when in contact with water. Stainless steel materials were therefore used for fabricating components.

Olajide *et al,* (1997) evaluated an okra slicer and found out that there are higher losses in the manual knife slicing of okra than in the okra slicer. He reported that the machine gave 65% and 312kg/hr

Ajibola *et al*, (2016) et al designated a manual potato peeler cum slicer, material used was stainless steel and slicing efficiency was 88%.

P Embomwomyil *et al*, (2017) emphasizes the concept of design and development of semi-automated potato slicing machine, the electrically operated device is designated to cut the whole into slices of thickness of 2.5mm. The principal parts of this design works include hopper, electric motor, shafts, bearings, wire brushes, and a V-attached to the pulley that rotates the shaft embedded with wire brushes.

Thomas Alias *et al*, (2019) emphasizes fabricate the prototype of cutting and peeling machine. It is aimed at providing a base for commercial production of a peeling and cutting machine, using locally available raw materials at a relatively low cost.

M. H. Kabir *et al*, (2021) designed, constructed and evaluated motorized tomato slicing machine based on three different sample sizes of tomato. It was found that machine is capable of slicing tomatoes with slicing efficiency, output capacity and minimum damage. It consists of mild steel, stainless steel, cast iron, gear and electric motor, synthetic rubber and bearings.

E.G. Khater (2021) fabricated and evaluated a cutting machine for turnip fingers to be used in small and medium production like stainless steel and mild steel. The components of machine include the machine frame, feeding unit, cutting unit, and power transmission unit. The uniformity index and cutting efficiency increased with increasing size, cutting speed

2.6 Performance evaluation of peeler and slicer machines

Agrawal (1987) determined the performance of a ginger peeler machine. The peeling efficiency and the ginger meat loss were calculated by the following formula.

$$\text{Peeling efficiency} = \frac{(weight\ of\ total\ skin\ removed\ by\ machine)}{(weight\ of\ total\ skin\ on\ ginger)} \times 100 \qquad \ldots 2.1$$

$$\text{Meat mass} = \frac{(weight\ of\ ginger\ meat\ loss\ during\ mechanical\ peeling)}{(total\ weight\ of\ the\ sample)} \times 100$$

…2.2

The peeling efficiency and meat loss of the machine at full capacity (20 kg/h) were found as 71% and 1.6%, respectively.

Srivastava *et al.,* (1997) computed the peeling efficiency;

$$P_{e} = \frac{Mi - Mm}{Mi - Mf} \times 100 \qquad \ldots 2.3$$

$P_{e=}$ Machine peeling capacity (%), M_M: Sample mass after machine peeling, Final sample mass (kg)

Jain *et al*, (2007) evaluated the abrasive peeler cum polisher for ginger. Peeling efficiency and peel losses of peeler were calculated as follows:

$$\eta = \frac{(Y - X)}{Y} \times 100 \qquad \ldots 2.4$$

$$M = W - \frac{(Y - X)}{W} \times 100 \qquad \ldots 2.5$$

Where,

η = peeling efficiency (%), Y = weight of total skin on ginger (g) X = weight of skin removed by hand trimming after mechanical peeling (g), M = meat loss (%), w = total reduction in weight during mechanical peeling (g), W = total weight of the sample (g). The average peeling efficiency of the machine was found as 74, 81.2 and 81.7% at operation time of 8, 10 and 12 minutes with a meat loss of 1.54, 2.58 and 3.82% respectively. The data reveals that peeling efficiency and meat loss increased with the increasing holding time for ginger in the peeler drum.

Yadav *et al.*, (2013) evaluated the performance of hand operated rind peeler for pomelo fruit and observed the peeling efficiency in the range of 80.72% (small fruits), 82,50% (medium fruits) and 84.09% (large fruits) respectively.

Abd El Hag *et al.*, (2016) found that cutting efficiency from the following equation:

$$\eta = 100 - P.L \qquad \ldots 2.6$$

Where η is the machine cutting efficiency (%), P.L is the percentage of loss (%).

Adibayo S Adekunle *et al.,* (2018) evaluated the performance of cassava peeling machine using the following equation:

Peeling efficiency, $\eta_p = \frac{weight\ of\ peel\ removed\ by\ machine}{total\ weiht\ of\ peel} \times 100$ …2.7

The average peeling efficiency of the machine was found as 76.92 %

Manoj K Mahawar *et al.,* (2020) calculated the peeling efficiency and peel remained on the kinnow and sweet orange.

Peeling efficiency = $\frac{(amount\ of\ peel\ on\ fruit - fraction\ of\ peel\ on\ peeled\ fruit)}{amount\ of\ peel\ on\ fruit} \times 100$

…2.8

Peel remained on fruit = $\frac{(weight\ of\ raw\ fruit - weight\ of\ peeled\ fruit)}{weight\ of\ raw\ fruit} \times 100$

…2.9

The peeling efficiency is 96.43-95.82% and it was inversely proportional to the rotational speed.

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

This chapter provides the detailed information regarding materials used and the methodologies adopted for the thesis work entitled "Refinement and Performance Evaluation of Existing Jackfruit Peeler, Corer cum Cutting Machine". Selected engineering properties related to the modification of tool and evaluation were undertaken and appended. The details regarding the modification of the machine and its performance evaluation are also included in this chapter.

3.1 Procurement of jackfruit

Fresh, matured and unripe jackfruit (*Artocarpus heterophyllus L, Moraceae* family) of Varikka variety were procured from Instructional Farm of KCAET, Tavanur and nearby localities. The fruit which bears oblong / round shape were harvested from the selected trees.

3.2 Determination of engineering properties of jackfruit

3.2.1 Physical properties of jackfruit

The major physical properties required for the development of the machine are fruit length, fruit diameter, core length, core diameter, rind thickness and fruit mass. Eight jackfruits were selected at random for the measurement of these physical parameters.

3.2.1.1 Fruit Length

The equivalent distance of the stem (top) to the calyx (bottom) was considered as fruit length. The length was obtained by placing the fruit lengthwise on a clean floor and the ends marked. The measurements were recorded in centimeter using a tape (Chandra et al, 2020)

3.2.1.2 Fruit diameter

Longest dimension perpendicular to fruit length is to be considered as fruit diameter and it was measured by using a tape in centimeter.

3.2.1.3 Fruit core length and core diameter

Distance from top (stem) to bottom of the core was considered core length and it was measured by using a measuring scale and longest dimension perpendicular to length of core is to be considered as core diameter and it was determined using a measuring scale.

3.2.1.4 Fruit rind thickness

The rind was removed manually from the jackfruit using a sharp knife. Its thickness was measured in centimeter using a digital calliper with accuracy of 0.01 mm and the mean values were calculated.

3.2.1.5 Fruit mass

Mass of individual fruit was determined with an electronic balance of 0.1 g sensitivity and the mean values were calculated. The values were recorded in kilogram.

3.2.2 Mechanical properties

3.2.2.1 Cutting strength of jackfruit

Study of cutting strength is essential to design and fabrication of core removing tool and fruit holder for machine development. The cutting strength of peeled jackfruit was determined using a universal testing machine (UTM) TUECN-600. Cutting probe (Plate. 3.1) used on UTM machine to find out cutting strength was fabricated with same dimension of core removing tool. Five jackfruits were selected at random to measure the cutting strength. The machine consists of hydraulic cylinder motor with chain and sprocket drive, load indicator system, fixed cross rail and movable cross rail. The peeled jackfruit was placed on movable cross rail and the rail was raised until it touches the cutting tool. The machine subjects the samples to compression at the speed of 20 mm/min. The machine was operated until sharpen edge of the probe, cut the sample to a depth up to 30 cm (average core length of jackfruit). The load indicator system records the amount of load (kN) applied during the test. Same procedure was repeated for remaining samples and mean values were calculated.

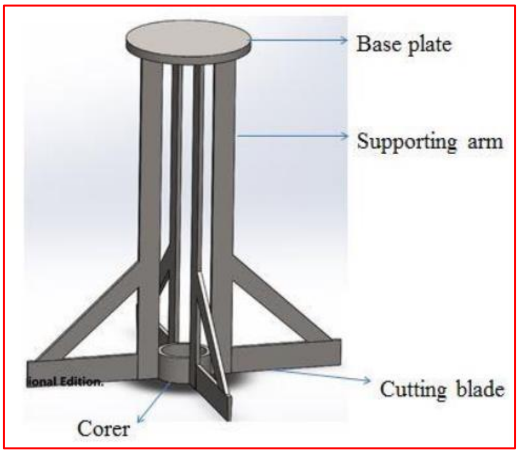

Plate 3.1 Cutting probe

3.3 Modification of the existing peeler cum corer for jackfruit

A jackfruit peeler cum corer machine was developed by Hareesha T Shidenur at K.C.A.E.T., Tavanur during the year 2016 as a part of his MTech research work. In the existing machine a single motor was provided to perform all activities viz. peeling, coring and cutting. The power transmission has to be changed after each unit operation to perform the whole action. Moreover, the size of the machine was too heavy and large. The modification of the existing machine is explained in the following sections.

3.4 Working principle of the machine

The working principle of peeling operation is, as the jackfruit rotates the peeling was done helically due to the linear motion of the blade from bottom to top. The clearance between the blade and peeler arm was fixed on the basis of thickness of the rind. Similarly cutting and coring operations was performed by converting the rotary motion of gear attached to shaft into linear motion with the help of screw mechanism. During these operations, the core removing tool which is attached to the screw shaft was pressed against the fruit. The thickness of corer and cutting blades of core removing tool was fixed based on cutting strength of jackfruit. The major fabricated components of the machine are

1) Fruit holder

2) Peeler assembly

3) Corer assembly along with cutting mechanism

4) Power transmission unit

5) Frame assembly

3.4.1 Fruit holder

Fruit holder consists of disc and blade, which are made up of food grade (SS 304) stainless steel. It was designed as a rotating disc that can carry the jackfruit on a horizontal plane. The dimensions of the disc were 1 cm thickness and 16 cm diameter and the trapezoidal sections cut out were made between the holding blades as shown in the Plate. 3.2. The jackfruit was fixed on the disc by four blades to avoid the slippage between fruit and circular disc; each projection was made with the dimensions (2 cm height, 2 cm width and 0.5 cm thickness) and welded circularly at 4 cm radius of disc with equal distance. The shaft was made using MS rod and it consisting of two pulleys (diameters of 15.24 and 17.78 cm) in order to connect with motor and peeler assembly for power transmission. The adjustment of angular velocity of the jackfruit holder was carried out by changing the pulley on holder shaft with the help of optical tachometer.

3.4.2 Peeler assembly

Peeler assembly consists of screw shaft, peeler arm, blade and spring as shown in the Plate. 3.3.

3.4.2.1 Screw shaft

The screw shaft was made using MS rod with square threads on the outer surface. The dimensions of the screw shaft were 67 cm length, 2.4 cm diameter and 2.3, 1.5 and 1.5 mm screw pitch, thread width and thread height, respectively.

It was passed through the internally threaded circular passage of rectangular housing, which in turn attached to the peeler arm. The 12.7 cm diameter pulley made up of cast iron was fixed on the bottom of the screw shaft to take the drive from fruit holder shaft. The main function of the screw shaft is to provide a linear motion to the peeler arm by rotating on its own axis.

3.4.2.2 Peeler arm

The peeler arm was made using food grade SS 304 stainless steel having 17.5 cm length, 3cm width and 0.5 cm thickness. One end of the peeler arm was connected to a rectangular housing, which in turn is attached to an internally threaded circular passage. For effective peeling another end of peeler arm was bent slightly at 35˚ angle which supports the peeling blade. The peeler was connected with screw shaft which enables the peeling blade to move parallel over the jackfruit profile, so that fruit was completely peeled from bottom to top.

3.4.2.3 Spring

The spring was attached between peeler arm and rectangular housing. The specifications of the spring were 8 cm length and 1.5 cm diameter. It provides flexibility to the peeling operation, so that cutting blade easily passes over the surface of jackfruit. The main function is to press the peeler arm softly over the fruit profile and holds the peeling blade in position against the jackfruit. Apart from this, spring aids the blade against the irregular surface of jackfruit

3.4.2.4 Peeling blade

The blade was made using food grade SS 304 stainless steel having a thickness of 2 mm which is inwardly curved along its longitudinal length to provide a bow shaped construction. Clearance of 1.2 cm between peeler arm and blade was fixed based on the rind thickness of jackfruit by neglecting 0.5 cm of spikes length. Main functions of the blade is to peel the rind out of whole jackfruit and able to traverse an angular displacement of 40˚ angle during peeling operation, which depends on diameter of the jackfruit.

3.4.3 Corer assembly along with cutting mechanism

Corer assembly mainly consists of core removing tool and screw shaft mechanism and it was situated on the middle of the supporting frame assembly.

Plate 3.2 Fruit holder

Plate 3.3 Peeler Assembly

3.4.3.1 Core removing tool

It consists of fruit corer, cutting blades, supporting arms and base plate; which are made using food grade SS 304 stainless steel. The fruit core removing tool comprising a circular portion with 5.5 cm internal diameter, 2.5 cm height, 4mm thickness to which the bottom edges were sharpened at 30˚ angle. The diameter of corer was chosen based on the average core diameter of the jackfruit. Four number of steel flat, each having a 20 cm length, 2.5 cm width, 4 mm thickness to which the bottom edges are sharpened which results in 10 ˚ included angle were used for fabrication of the cutting blades. The cutting blades are welded to the side portion of supporting arms as shown in the Plate 3.4

The four supporting arms acts as a supporting medium to cut the large size of jackfruit and which are welded between blade and corer with equal spacing between them. The bottom side of each arm was ending with a sharp edge for 2 cm length whereas, top side was welded to a base plate having a diameter of 15 cm. The base plate was used to carry the load given for cutting and coring of large size of jackfruit without failure and its top surface was welded to a steel pipe having a 2.5 cm OD, 1.5 cm ID and 3.5 cm in length. This steel pipe was connected to the screw head with the help of bearings; therefore, core removing tool was able to rotate in clockwise or anticlockwise direction as per our requirement.

Main function of the core removing tool is to perform fruit cutting and core removal as a single operation. When the core remover tool moved down, jackfruit was subjected to cut with sharpened edge of the tool until it reaches calyx of jackfruit. Once the tool moved upside the core removed from the fruit has to be pushed down by hand.

3.4.3.2 Screw shaft mechanism

The screw shaft mechanism was made using MS shaft with square threads on the outer surface and cast iron pulley with threads on inside of the hole. The screw shaft with dimension of 3.8 cm diameter, 79 cm length, 0.58 cm screw pitch, 0.2 cm thread width and 0.18 cm thread depth were used. The main function of the screw mechanism is to convert rotary motion of pulley into linear motion of screw shaft which is connected to a core removing tool with the help of bearings. Two sliding arms were welded on screw head with equal distance between them, which acts as stopper for core removing tool when reaches the fruit holder disc.

3.4.4 Power transmission unit

Transmission system was developed for proper power transmission from electric motor to peeling and cutting-coring operations of the developed machine.

The power transmission system consisted of two electric motors attached with gears.

3.4.4.1 Electric motor

Two electric motors of 1.0 hp power having a speed of 1425 rpm were used as prime movers for the entire operations. The speed was reduced from 1425 to 40 rpm by means of gear mechanism.

3.4.4.2 Belt and pulley

The speed of the peeling and cutting-coring operations could be changed based on belt and pulley arrangement. Belt and pulley were used to transmit power from one shaft to another. Totally eight V-grooved pulleys made up of cast iron and five B type, V-belts made up of rubber material were used for power transmission. The diameter of the pulley used in this study includes three 15.24 cm diameter, one 17.78, 6.35, 12.7cm diameter and two 7.5cm diameter of pulleys and the size of the belt used were two 104.14 cm length and one 101.6 cm, 106.68 cm and 124.46 cm length, respectively.

Plate 3.4 Jackfruit corer

3.4.5 Frame assembly

Main frame was required to support other parts of the developed machine and to withstand against vibration during the operation. The main frame was fabricated from MS iron square channel having dimensions of 50×50×3 mm for mounting fruit holder, peeler assembly, corer assembly and power transmission system. The length, width and height of main frame were 66, 66 and 132 cm respectively. The peeler assembly, pillow block, gear box, core removing tool, fruit holder and electric motor were assembled on main frame using nuts and bolts.

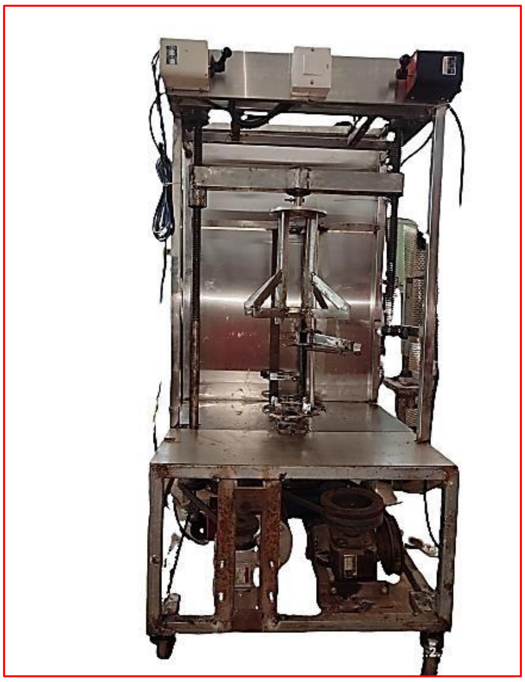

Plate 3.5 Jackfruit peeler, corer cum cutting machine

3.5 Operational procedure for jackfruit peeler, corer cum cutting machine

3.5.1 Pre-preparation

The stem (top) side portion of fruit was removed manually to find out the position of the central core and the calyx (bottom) portion of the fruit was also removed to make sure that the fruit stand properly over the fruit holder.

The fruit was placed on fruit holder which moves the jackfruit circularly on a horizontal plane. While loading, jackfruit was held vertically to stand on the fruit holder with correct fruit positioning to distribute the fruit load uniformly throughout surface of fruit holder at the time of peeling operation. Core removing tool was fixed properly on position of the central core by operating the motor. After loading the jackfruit between fruit holder and core remover tool, fruit was tightly holding in vertical direction.

3.5.2 Peeling operation

Motor (1425 rpm) connected to jackfruit holder and peeler assembly was switched on and speed was reduced to 40 rpm during the peeling operation. Fruit holder was driven in a clockwise direction on a horizontal plane. As the fruit holder rotates, it enables peeling blade to move parallel to profile of the jackfruit rotational axis. Spring pressed the peeling blade softly on the fruit profile, so that fruit was completely peeled. By changing the rotational direction of the motor shaft peeler blade was brought to its original position.

3.5.3 Cutting-coring operation

After the completion of peeling operation, the cutting-coring operation was started by switching on the second motor of 1425 rpm whose speed was reduced to 40 rpm by gear mechanism. Due to screw mechanism rotational motion of gear attached to shaft was converted into linear movement of screw shaft which is connected with corer tool. The downward motion of screw shaft pushes the core removing tool down. Motor was operated until the core removing tool reaches the calyx of jackfruit, ensuring that the blades and corer passed completely through the jackfruit. By changing the rotational direction of the motor core removing tool was moved upwards, cut core from the corer was pushed down manually by hand. The cutting-coring operation and the core removed from the whole jackfruit.

3.5.4 Bulb separation

The bulb separation of four cut portion jackfruit was done manually after the completion of above operations

Plate 3.6 Trimmed Jackfruit

Plate 3.7 Loading of Jackfruit

Plate 3.8 Performance evaluation of jackfruit peeler

Plate 3.9 Peeled Jackfruit

Plate 3.10 Cutting- Coring operation of jackfruit

3.6 Performance evaluation of a jackfruit peeler, corer cum cutter machine

3.6.1 Peeling efficiency

After the mechanical peeling was completed, the peels remaining on the jackfruit were removed manually for each of the samples and their weights were noted. Peeling efficiency was then calculated by using the formula suggested by Singh and Shukla (1995)

$$\text{Peeling efficiency (\%)} = \frac{(Y-Z)}{Y} \times 100 \qquad \ldots 3.1$$

Where, Y = Weight of total peel on jackfruit (g)

Z = Weight of peel removed by hand trimming after mechanical peeling (g)

3.6.2 Coring efficiency

Coring efficiency was determined as the ratio of weight of core removed to total weight of core. This formula suggested by Singh and Shukla (1995) was used for calculating coring efficiency.

$$\text{Coring efficiency (\%)} = \frac{(A-B)}{A} \times 100 \qquad \ldots 3.2$$

Where, A = Weight of total core in jackfruit (g)

B = Weight of core removed by hand trimming after mechanical coring (g)

3.6.3. Bulb wastage

3.6.3.1 Bulb wastage during the peeling operation

The suggested formula by Jimoh and Olukunle (2012) was used and modified for the calculation of the bulb wastage (%) during the peeling operation as given below.

$$\text{Bulb wastage, \% (peeling operation)} = \frac{W}{(W+X)} \times 100 \qquad ...3.3$$

Where, W= Weight of bulb portion obtained from the peeled produce (g)

X= Weight of separated bulb after mechanical peeling by hand trimming (g)

3.6.3.2 Bulb wastage during the coring operation

The suggested formula by Jimoh and Olukunle (2012) was used and modified for the calculation of the bulb wastage. The bulbs wastage (%) was calculated using the formula

$$\text{Bulb wastage, \% (coring operation)} = \frac{C}{(C+D)} \times 100 \qquad …3.4$$

Where, C= Weight of bulb portion obtained from the cored produce (g)

D= Weight of separated bulb after mechanical coring (g)

3.6.4 Time of operation

3.6.4.1 Time of peeling operation

The time taken for peeling operation of developed machine during each combination of jackfruit size and speed was determined using a stop watch.

3.6.4.2 Time of cutting-coring operation

The time taken for cutting, coring operation of developed machine during each combination of jackfruit size and speed was determined using a stop watch.

3.7 Comparison of developed jackfruit peeler, corer cum cutting machine with manual cutting

The experiments were conducted for optimized condition with peeler speed of 1425 rpm and corer speed of 40 rpm in newly developed machine with 56 jackfruits (total weight of 50 kg) and the throughput, processing time were also recorded. Similarly, manual cutting and separation of bulbs was also carried out for 1 jackfruit (total weight of 10 kg) by employing one skilled labour and the results were compared with mechanical operation to assess the throughput capacity. The throughput capacity was calculated by using the formula (Jimoh and Olukunle, 2012).

$$\text{Throughput capacity (kg/h)} = \frac{total\ weight\ of\ jackfruit\ processed, kg}{processing\ time, h} \quad \ldots 3.5$$

The total processing time for mechanical operation of peeling, cuttingcoring and bulb separation for each sample was recorded using stop watch. Similarly, time of manual operation was calculated by considering the cutting, coring and bulb separation time. The processing time per fruit was calculated by following formula

$$\text{Processing time (min/fruit)} = \frac{Total\ time\ of\ processing}{Number\ of\ jackkfruit} \quad \ldots 3.6$$

Results and Discussion

Chapter IV

RESULTS AND DISCUSSION

This chapter deals with the results of the experiments carried out for the evaluation of the modified peeler, corer cum cutting machine for jackfruit.

4.1 Physical properties of jackfruit

Jackfruit of uniform maturity indices were procured from the Instructional Farm of K.C.A.E.T., Tavanur and nearby farmer's field. The weight, diameter and length of each jackfruit were measured. The weight, diameter and length of jackfruit varied from 3.100 kg to 7.50 kg, 18.7 cm to 22.5 cm and 25 cm to 30 cm, respectively.

Table 4.1 Specifications of Jackfruit

Physical Properties	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight (kg)	6.200	7.50	3.57	4.300	3.100
Fruit Diameter (cm)	22.5	19	19	21	18.7
Fruit Length (cm)	30	25	26.6	29	26
Core Diameter(cm)	6.7	6.5	7	6.8	6.4
Core Length(cm)	24.7	22.5	25.5	27.5	24.4
Rind Thickness (mm)	5.56	5.22	5.23	5.52	5.1

4.2 Cutting strength of jackfruit

Five numbers of jackfruit were randomly selected and the theoretical values of cutting strength of peeled jackfruits was found using a universal testing machine (UTM).

Cutting strength was important in simulation of core removing tool and fruit holder to stand with against maximum load while cutting-coring of large size of jackfruit. The average cutting force of jackfruit was found to be 2.96 kN.

Table 4.2 Cutting force of matured jackfruit

Trial	**Cutting Strength, kN (average core length of fruit)**
Fruit 1	2.8
Fruit 2	3.5
Fruit 3	3.3
Fruit 4	2.5
Fruit 5	2.7
Mean±SD	**2.96±0.42**

4.3 Performance Evaluation of Jackfruit peeler, corer cum cutting machine

Performance evaluation of developed machine was carried out for its peeling efficiency, coring efficiency, bulb wastage and overall capacity.

4.3.1 Peeling Efficiency

Peeling efficiency was calculated using the formula described in 3.6.1. The average peeling efficiency of the machine was found to be 84.36%. The results are shown in Table 4.3.

Table 4.3 Peeling efficiency of jackfruit

Sl. No	Weight of the peel on jackfruit, Y(g)	Weight of the peel remained on jackfruit, Z(g)	Peeling efficiency (%)
1	1176.3	246.7	79.02
2	752.7	109.5	85.45
3	895.8	102	88.61
Average			84.36

4.3.2 Coring Efficiency

Coring efficiency was calculated using the formula described in 3.6.2. The average coring efficiency was found to be 81.27%. The results are shown in Table 4.4.

Table 4.4 Coring efficiency of jackfruit

Sl. No	Weight of total core in jackfruit, A (g)	Weight of core removed by hand trimming, B (g)	Coring efficiency (%)
1	416	103.5	80.64
2	351.7	70.2	80.04
3	403.2	67.9	83.15
Average			81.27

4.3.3 Bulb wastage

4.3.3.1 Bulb wastage during peeling operation

The bulb wastage (%) during the peeling operation of developed machine was calculated by using the equation 3.3.

Table 4.5 Bulb wastage during peeling operation

Sl. No.	Weight of bulb portion obtained from the peeled produce, W (g)	Weight of separated bulb after mechanical peeling by hand trimming, X (g)	Bulb wastage (%)
1	5	3482.7	0.14
2	8	1819.2	0.43
3	10	2203	0.45

From the table, it is observed that the bulb wastage ranged between 0.14 to 0.45%.

4.3.3.2 Bulb wastage during coring operation

The bulb wastage during the coring operation of developed machine was calculated by using the equation 3.4.

Table 4.6 Bulb wastage during coring operation

Sl. No.	Weight of bulb portion obtained from the cored produce, C (g)	Weight of separated bulb after mechanical coring, D (g)	Bulb wastage (%)
1	129.7	3482.7	3.59
2	121.2	1819.2	6.24
3	190.2	2203	7.95

From the table, it was observed that bulb wastage ranged between 3.59 to 7.94%.

4.4 Throughput capacity of the machine

Throughput capacity of machine with time lag was found to be 105.17 kg/hr and in case of without time lag was 218.39 kg/hr. Processing time with time lag was measured as 2.69 min per fruit and in case of without time lag the value was 1.3 min per fruit. Hence, the number of processed fruits in one hour was found to be 23 no. and 46 no. for time lag and without time lag, respectively.

4.5 Power consumption

Power consumption for the modified jackfruit peeler, corer cum cutting machine was measured as 1.5 kW.

4.6 Comparison of jackfruit peeler, corer cum cutting machine with the traditional manual cutting

The traditional method of peeling, coring and cutting is a time-consuming process and causes drudgery. Moreover, the latex of this fruits also hinders during the separation of fruit bulb for consumption. The innovation of the machine for these operations can reduce the wastage and increase the commercial utilization of fruit.

The experiments were conducted for comparing jackfruit peeler, corer cum cutting machine with the traditional method of manual cutting of jackfruit and the throughput, processing time were also recorded. The average time taken for peeling, cutting-coring and bulb separation was maximum (28.80 min/fruit) during manual operation and in case of mechanical operation, it was only 2.69 min/fruit, which is lesser than manual operation. The maximum throughput of machine with time lag was 105.17 kg/h, whereas in manual operation, it was 17.36 kg/h.

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

India is second largest producer of fruits and vegetables next to China. Jackfruit (*Artocarpus heterophyllus*), a tropical fruit which belongs to the family Moraceae is grown widely and consumed in India. Jackfruit is popular among growers but underutilised fruit which can be used at any stage from blooming to ripening. The total production and area of cultivation of jackfruit in India during 2021-22 was 18.76 lakh tonnes and 1.77 lakh hectares of land, respectively. Similarly, in Kerala the annual production of jackfruit during 2021-22 was 2.63 lakh tonnes.

At present, demand for jackfruit is increasing day by day owing to its availability, sweetness and nutritional composition. Diversified value-added products for consumption among all age group of consumers is needed. Sensitized growers, entrepreneurs and volunteers may focus more on jackfruit value added products. But traditional manual peeling, coring and cutting of jackfruit is time consuming and labour-intensive process. Moreover, the latex of this fruit also causes hindrance during separation of fruit bulb for consumption. The tedium in manual processing is the major reason for the underutilization of this fruit. Thus, effective mechanization for this process is a need of the hour.

Matured, unripe jackfruits (Varikka) harvested from the Instructional Farm of K.C.A.E.T and nearby localities, Tavanur were used for the study. Before the modification of the machine, the selected physical and mechanical properties were studied.

The machine consists of mainly fruit holder, peeler assembly, corer assembly along with cutting mechanism, power transmission unit, frame assembly. The working principle of peeling operation is, as the jackfruit rotates the peeling was done helically due to the linear motion of the blade from bottom to top. Similarly cutting and coring operations was performed by converting the rotary motion of shaft into linear motion of screw shaft with the help of gear mechanism. Two motor is connected, one with jackfruit holder and peeler and other with cutting-coring operation.

The overall capacity of the modified machine was 218.39 kg/hr (without time lag) and 105.17 kg/hr (with time lag). While comparing with the existing jackfruit peeler cum corer machine, it was found that the process is semi-automatic, there is no need of skilled labourers, capacity increased and processing time was reduced.

The average time taken for peeling, coring and cutting was maximum (28.8 min/fruit) in manual operation and in case of mechanical operation (2.69 min/fruit) which is lesser than manual operation. This indicated that the developed machine aids in faster peeling and cutting of jackfruits with least drudgery and also could be used in small and medium scale jackfruit processing industries.

References

CHAPTER VI

REFERENCES

Abdul,M., Martin,K.A., 2015. Poor man's fruits: Now a miracle food. *Food chem.*5($):123-134.

Adeshina, F. and A. F.Olusola., 2020. Design and performance evaluation of multituber peeling machine, *Agri-engineering.*

Arora,T., parle,A., 2016. Jack fruit:A health boon. *Int. J. Res. Ayurveda Pharm.* 7 (3:59-64).

Agrawal, Y.C., Hiran, A., and Galundia, A.S. 1987. Ginger peeling machine parameters. Agric. Mechanization Asia Africa Latin Am. 18(2): 59-62. Agrawal, Y.C., Singhvi, A., and Sodhi, R.S. 1983. Development of an abrasive brush-type ginger peeling machine. *J. Agric. Eng.* 384(11): 179182

Akhila, B.G. and Shareena, K.P., 2009. Product diversification of jackfruit (Artocarpus heterophyllus Lam.). B.Tech (Ag) project, Kerala Agricultural University, Thrissur, 50p.

Baliga, M.S., Sivashankara, A.R., Haniadka, R., 2011. Phytochemistry, nutritional and pharmacological properties of *Artocarpus heterophyllus* Lam(jackfruit): A review, *Food research international 44 (7), 1800-1811.*

Coady, J., Eng, P., McKenna, M., and Eng, P., 2000. Good manufacturing and material selection in the design and fabrication of food processing equipment. By Engineers Egde.

Chakespari, A.G., Rajabipour,A.,and Mobil, H., 2010. Mass modelling of two apple varieties by geometrical *attributes. Australian j. Africa. Eng.1(3): 112- 118.*

Mushumbusi, D.G., 2015. *Production and Characterization of jackfruit jam, Master of science in food science thesis,* Sokoine University of Agriculture, Morogoro, Tanzania.

Gomez, S., Joseph, P.M., Sheela, K.B., Sruthi, C.V., and Lal, L., 2015. Variability in fruiting season and quality attributes of jackfruit (Artocarpus heterophyllus Lam.) accessions in Kerala. Int. *J. Trop. Agric.* 33(2): 12491255.

Gowda,N.A., Subramanya,S.,Ranganna,B., 2021. Development of a pneumatic based Jack fruit corer cum splitter for bulbs seperation. *An International Refereed,Peer Reviewed and Indexed Quarterly Journal for applied science* Volume 8.

Gunasena, H.P.M., Ariyadasa, K.P., Wikramasinghe, A., Herath, H.M.W., Wikramasinghe, P., and Rajakaruna, S.B., 1996. *Manual of jack cultivation in Sri Lanka.* Forest Information Service, Forest Department. 48.

Haq, N., 2011. Genetic resources and crop improvement in the jackfruit. Thottappilly G, Peter KV and Valavi SG, ed., Studium Press India Pvt. Ltd, New Delhi.

Jagadeesh, S.L., Reddy, B.S., Basavaraj, N., Swamy, G.S.K., Gorbal, K., Hegde, L., Raghavan, G.S.V., and Kajjidoni, S.T., 2007. Inter tree variability for fruit quality in jackfruit selections of Western Ghats of India. *Scientia Horticulturae*. 112: 382-387.

Jain, N.K., Doharey, D.S., and Sharma, K.C., 2007. Development of abrasive peeler cum polisher for ginger. *J. Agric. Engg*. 44 (3): 84-86.

Jannatizadeh, A., Naderi Boldaji, M., Fatahi, R., Ghasemi Varnamkhasti, M., and Tabatabaeefar, A. 2008. Some postharvest physical properties of Iranian apricot (Prunus armeniaca L). *Int. Agrophy*. 22: 125-131.

Jha, S.N., Kingsly, A.R.P., and Chopra, S., 2006. Physical and mechanical properties of mango during growth and storage for determination of maturity. *J. Fd. Engg*. 72: 73-76.

Mitra, S.K. and Mani, D., 2000. Conservation and utilization of genetic resources in jackfruit (Artocarpus heterophyllus L) - a potential underutilized fruit. *Acta Horticulturae*. 523: 229-232.

Mohan, A., 2012. Development and evaluation of a seed extractor for ash gourd and cucumber. Un published M.Tech.(Ag. Engg) thesis, Kerala Agricultural University, Thrissur,39P.

Nanje, N.A., Subramanya, S., and Rangana, B. 2021.development of a pneumatic based jackfruit corer cum splitter for bulbs separation, *an international refered, peer reviewed and indexed to quarterly journal for applied science*.

Ohwovoriole, E.N., Oboli, S., and Mgbeke, A.C.C.1988. Studies on preliminary design for a cassava tuber peeling machine. *Trand. Am.Soc.Agric. Engg.380-385.*

Priya, S.D., Devisunetra, T., Mathala, J.G., Thangam, M., and Singh, P.N. 2014. A guide on jackfruit cultivation and value addition. Technical Bulletin No. 41, ICAR (RC), Goa.

Rahman, A.K.M.M., Huq, E., Mian, A.J., and Chesson, A. 1995. Microscopic and chemical changes occurring during the ripening of two forms of jackfruit (Artocarpus heterophyllus L.*). Fd. Chem*.
52: 405-410.

Rais, M. and Sheoran, A. 2015. Scope of supply chain management in fruits and vegetables in India. J. Fd. Process Technol. 6 (3): 105-112. Ranganna, B., 2014, Research and development on jackfruit value addition at UAS, Bangalore. *I. Symp. Jackfruit Breadfruit Tropics.* 108-110.

Reddy, B.M.C., Patil, P., Kumar, S.S., and Govindaraju, L.R. 2004. Studies on physico-chemical characteristics of jackfruit clones of south Karnataka. Karnataka *J. Agri. Sci*. 17 (2): 279-282

Shidenur,H.T. 2016. Development of jackfruit peeler cum corer, http://14.139.181.140>jspui

Srivastava,R., Singh,A. 2020. Jack fruit (Artocarphus heterophyllus Lam) Biggest fruit with high nutritional and pharmacological values: A Review, *International Journal of Current Microbiology and Applied Science* ISSN:2319-7706 Volume 9 Number 8

Tiwari,A. K., Vidyarthi,A.S. Nutritional Evaluation of Various Edible Fruit Parts of Jackfruit (Artocarpus heterophyllus) at Different Maturity Stages. *International Journal of Chemical and Pharmaceutical Review and Research.* 2015; 1:21–26.

Vahid, P.A., Anjaly, A.V., Anjitha, P.K., Arun Krishnan, A., Neethu, K.P. 2017. Development and Performance Evaluation of a Semi-Automatic Pineapple Peeling Machine. B.Tech (Food Engg) thesis, Kerala Agricultural University, Thrissur.

REFINEMENT AND PERFORMANCE EVALUATION OF EXISTING JACKFRUIT PEELER, CORER CUM CUTTING MACHINE

HISANA THASNIM M (2018-06-001)

ADEEBA MUHSINA LULU (2018-06-002)

BINCY T P (2018-06-007)

HIMA M M (2018-06-012)

DEEPTHI K V (2018-06-028)

ABSTRACT

Submitted in partial fulfilment of the requirement for the degree of

Bachelor of Technology

In

Food Engineering and Technology

Faculty of Agricultural Engineering and Technology

KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF PROCESSING AND FOOD ENGINEERING

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY, TAVANUR-679573

KERALA, INDIA

2022

ABSTRACT

Jackfruit is one of the major fruits produced in India. The jackfruit is the national fruit of Bangladesh and Sri Lanka, and the state fruit of the Indian states, Tamil Nadu and Kerala. The Government of Kerala declared jackfruit as official state fruit. The traditional method of peeling and coring of jackfruit is done by cutting manually, which is a time-consuming, labour-intensive process and causes drudgery. Therefore, development of a mechanical tool or machine for peeling, coring and cutting of whole jackfruit will reduce the wastage of major quantity of jackfruit and maximum utilization of the fruit.

A similar jackfruit peeler cum corer was developed at K.C.A.E.T., Tavanur. However, it has less efficiency and capacity because of the single motor and was also time consuming. So, to improve the capacity and reduce the total processing time, some modifications are done to the existing machine. The main parts of the machine are fruit holder, peeler assembly, corer assembly along with cutting mechanism, power transmission unit and frame assembly.

The modified equipment was found to be semi-automatic, consisting of mainly two motors in which one is connected to fruit holder and peeler and the other with cutting-coring operation. The modified machine has an overall capacity of 218.39 kg/hr (without time lag) and 105.17 kg/hr (with time lag). The average time taken for peeling, coring and cutting was 28.8 min/fruit in manual operation and in case of mechanical operation, it was 2.69 min/fruit which is lesser than manual operation. This indicated that the developed machine aids in faster peeling and cutting of jackfruits with least drudgery and also could be used in small and medium scale jackfruit processing industries.