DEVELOPMENT AND PERFORMANCE EVALUATION OF COCONUT SCRAPER

by,

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DECLARATION

We hereby declare that this project report entitled ”**DEVELOPMENT AND PERFORMANCE EVALUATION OF COCONUT SCRAPER**” is a bonafide record of project work done by us during the course of project and that the report has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title of any other University or Society.

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Date:

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Rasmi P.K. (2013-06-015)

CERTIFICATE

Certified that this project report entitled "**DEVELOPMENT AND PERFORMANCE EVALUATION OF COCONUT SCRAPER**" is a record of project work done jointly by **Nandhu Lal A.M. (2013-06-013)** and **Rasmi P.K. (2013-06-015)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship, fellowship to them.

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Nandhu Lal A.M. (2013-06-013)

Rasmi P.K. (2013-06-015)

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Dedicated to

FARMERS,

TEACHERS

and FAMILY

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SYMBOLS & ABBREVATIONS

&	:	and
°	:	degree
%	:	percentage
AC	:	alternating current
APCC	:	Asian Pacific Coconut Community
aw	:	water activity
C.B	:	Citric acid Blanched
cfu	:	Colony Forming Unit
C.U.B	:	Citric acid Unblanched
cm	:	centimetre
DF	:	dilution factor
e.g.	:	example
et al	:	and others
etc	:	etcetera
fig.	:	figure
FFA	:	Free Fatty Acid
ft	:	feet
g	:	gram
Ha	:	hectare
H.B	:	Hot water Blanched
hp	:	horse power
H.U.B	:	Hot water Unblanched
Hz	:	hertz

i.e.	:	that is
KAU	:	Kerala Agricultural University
KCAET	:	Kelappaji College of Agricultural Engineering and Technology
KMS	:	Potassium metabisulfate
KOH	:	Potassium Hydroxide
LDPE	:	Linear Density Poly Ethylene
m	:	Meter
MAP	:	Modified Atmospheric Packaging
min	:	minute
ml	:	milli litre
N	:	Normality
N.B	:	Normal Blanched
N.U.B	:	Normal Unblanched
rpm	:	revolutions per minute
s	:	second
S.B	:	Salt solution Blanched
soln	:	solution
S.U.B	:	Salt solution Unblanched
TPC	:	Total Plate Count
VP	:	Vacuum Packaging
w	:	watt

Introduction

CHAPTER 1

INTRODUCTION

The coconut (*Cocos nucifera*) is a member of the family Arecaceae (palm family). The coconut palm is grown throughout the tropic region for many culinary and non-culinary uses; virtually every part of the coconut palm can be used by humans in some manner and has significant economic value. According to the estimate given by the Asian Pacific Coconut Community (APCC), the global coconut area in 2005 was 12 million ha, with a total production of 62 million tonnes per year. Indonesia, Philippines and India are the major producers and account for about 73% of world production. As per 2014-15 statistics from Coconut Development Board of Government of India, four southern states combined account for almost 90% of the total production in the country: Tamil Nadu (33.84%), Karnataka (25.15%), Kerala (23.96%), and Andhra Pradesh (7.16%).

It is classified as a “functional food” because it provides many health benefits beyond its nutritional content. Coconuts' versatility is sometimes noted in its naming. In Sanskrit, it is kalpavriksha ("the tree which provides all the necessities of life").

The various parts of the coconut have a number of culinary uses. The seed provides oil for frying, cooking, and making margarine. The white, fleshy part of the seed, the coconut meat is used fresh or dried in cooking, especially in confections and desserts such as macaroons. Desiccated coconut or coconut milk made from it is frequently added to curries and other savoury dishes. Coconut flour has also been developed for use in baking, to combat malnutrition. Coconut chips have been sold in the tourist regions of Hawaii and the Caribbean. Coconut butter is often used to describe solidified coconut oil, but has also been adopted as a name by certain specialty products made of coconut milk solids or puréed coconut meat and oil. Dried coconut is also used as the filling for many chocolate bars. Some countries in Southeast Asia use special coconut mutant called Kopyor (in Indonesian) or macapuno (in Philippines) as dessert drinks.

Scraped coconut is the product obtained from the white fleshy edible portion, *i.e*. the coconut kernel of the coconut. Fresh coconut kernel contains: moisture (50%), oil (34%), ash (2.2%), fibre (3.0%), protein (3.5%) and carbohydrate (7.3%).

In southern India, the most common way of cooking vegetables is to add grated coconut and then steam them with spices which are fried in oil. People from southern India also make chutney, which involves grinding the coconut with salt, chillies, and whole spices. *Uruttu chammanthi* (granulated chutney) is eaten with rice or *kanji* (rice gruel). It is also invariably the main side dish served with *idli*, vadai, and *dosai*. Coconut ground with spices is also mixed in *sambar* and other various lunch dishes for extra taste. Dishes garnished with grated coconut are generally referred to as *poduthol* in North Malabar and *thoran* in rest of Kerala. *Puttu* is a culinary delicacy of Kerala and Tamil Nadu, in which layers of coconut alternate with layers of powdered rice. Coconut meat can be eaten as a snack sweetened with jaggery or molasses. In Karnataka, sweets are prepared using coconut and dry coconut copra, such as *kaieobattu, kobrimitai, etc*. Scraped coconuts are also used in the production of coconut milk, which is a commonly used ingredient in various food items and in the preparation of virgin coconut oil.

The drudgery in the production of scraped coconut warrants the need for development of mechanical devices. As the product once shredded is highly perishable, suitable methods for preservation of scraped coconut and increasing its shelf life need to be developed.

The current coconut scraping machines include traditional manual scrapers, mechanical scrapers, and electronic scrapers. But such methods are comparatively difficult to use, since they are tedious, time consuming, dangerous and have many limitations. Enhanced machinery for the process is to be designed, which can be easily used for large scale production, as well as for household purposes.

Scraped coconuts have a low shelf life and hence, suitable preservation and packaging methods for storage of scraped coconuts are to be developed.

In this context a project was taken up with the following objectives:

1. To develop a coconut scraper
2. To evaluate the performance of the developed machine
3. To study and evaluate the shelf life of scraped coconuts

Review of Literature

CHAPTER 2

REVIEW OF LITERATURE

This chapter gives general information on its origin, coconut kernel, its chemical composition, vacuum packaging and its effects on the quality of end products. Research done on these aspects were reviewed and discussed in detail under the following sessions.

2.1 Coconut

The coconut (*Cocos nucifera*) is one of the high value commercial crops which have an immense scope for product diversification either by technology transfer or development of indigenous technology so that various proposed coconut based products can tap both the export and domestic markets (Gilman *et al*., 1993). The coconut palm is one of man's most useful plants. It is the most extensively grown nut in the world. It is an important palm. It provides people basic needs such as food, drink, shelter, fuel, furniture, medicine, decorative materials and much more. They are a necessity and a luxury. It is the "heavenly tree", "tree of life", "tree of abundance" and "nature's supermarket (Banzon and Velasco., 1982).

Coconut palm may grow up to a height of 50 to 60 feet and is spread on 15 to 25 feet. The shape of fruit is oval or round. The fruit length may differ from 6 to 12 inches. The fruit covering is dry or hard. The colour of fruit varies from brown, green and yellow. The characteristics of the coconut is that it does not attract wildlife and is suited for human consumption (Gilman *et al*., 1993)

Each and every part of the coconut palm is useful to man in one way or another. The raw kernel is an important food for consumption. The oil from the nut is used in cooking and in the manufacture of soap and other toilet requisites. The coconut oil cake is a valuable cattle feed. Fibre from the husk is used in the manufacture of coir ropes, mats and matting. The trunk, otherwise called 'porcupine wood', is used in house construction and furniture making. The leaves after plaiting are used to thatch houses. The juice obtained on tapping the inflorescence is rich in sugar and is converted into jaggery, sugar, vinegar and sweet or fermented toddy. The products of commercial importance are copra, oil, cake, desiccated coconut and fibre.

On account of all these utilitarian and desirable features, it has been rightly called Kalpavriksha, the 'Tree of Heaven', the tree that provides all the necessities of life. The coconut is, therefore, a unique tree among the economic plants of the tropics.

In India, coconut is consumed in the form of tender nuts, raw kernel, copra, coconut oil and desiccated coconut. Since dish made from the coconut furnish fat, protein and some vitamins, they counterbalance some of the deficiencies inherent in the predominantly starchy foods consumed in the countries concerned. Some of countries derive substantial revenue from the coconut industry. In India, coir products exported abroad earn the much needed foreign exchange. (Navratnarajah Sathiparan *et al.* 2017)

2. Coconut Kernel

Dehusked coconut yields three distinct but valuable raw materials (50% kernel, 17% water and 33% shell) for further processing. The coconut kernel is the white and fleshy edible part of the seed. Kernel may be processed to obtain many value added products. Coconut kernel contains on average 40 % oil. Protein in fresh coconut kernel is the highest in the eighth month old nuts. Coconut kernel is consumed as a culinary ingredient throughout the country even though its regular use is restricted to the traditional growing tracts in the country.

The coconut meat in the fruit begins to form after about 160 days, when it is at its full size. The shell begins to harden after 220 days and the meat gets fully formed after 300 days. However, for full maturity 360 days are required (Anvi, 2014)

2.2.1 Chemical composition

The composition of fresh coconut kernel (in percentage) as reported by the Central Food Technological Research Institute (CFTRI), Mysore, India.

Table 2.1 Chemical composition of fresh coconut kernel

Sl. No.	Composition	percentage
1	Moisture	45
2	Protein	4.0

3	Fat	37.0
4	Minerals	4.0
5	Carbohydrates	10.0

Source: Food Science and Technology Information Services Central Food Technological Research Institute, 2014)

2.2.2 Coconut kernel based products

In the recent years, there have been attempts to develop value added products. As a result, products such as desiccated coconut, coconut cream, dehydrated coconut milk, Virgin oil etc. were developed to cater the export market.

2.2.2.1. Desiccated coconut

Desiccated coconut is the white kernel of the fruit comminuted and dessicated to a moisture content of less than 3%. It is white in colour. It is very important commercial product having demand all over the world in the confectionary and in other food industries, as one of the main subsidiary ingredients of fillings for chocolate, candies *etc*. (Sun *et al.* 2012).

2.2.2.2. Coconut cream

Coconut cream is a white, smooth, liquid cream with excellent coconut flavour and 20-30% fat, aseptically packed. The product is easily pourable and ready for direct serving or to be used in other food preparation (Sun *et al.* 2012)

2.2.2.3. Dehydrated coconut milk

This is produced on a commercial scale in the, Malaysia and India. In the Philippines, the fresh coconut milk is blended with small amounts of additives such as maltodextrin or casein and is spray dried. The powder is easily dissolved in water to form a milky white liquid with the flavour and texture of coconut milk (Jena, 2011)

2.2.2.4. Virgin coconut oil

Virgin coconut oil is a high quality product from coconut kernel with the added values *viz.,* coconut flavour, low free fatty acid and maximum natural vitamin E content. In this process, coconut milk is filtered, concentrated and then cream is separated by centrifugation.

The cream is stirred vigorously to get the virgin coconut oil. The oil thus obtained is very clear, nutritious and has got longer shelf life (Mannekote *et al* 2016).

2.2.2.5. Edible coconut flour

After expelling the milk, the protein rich residue is dried and powdered to obtain a product called coconut flour. The flour so obtained typically contains 7-8% protein, 3-5% moisture and 17% oil. It can be used as an ingredient in dietary foods because of its high fibre content (Sivakami *et al*. 2013).

Coconut has been a traditional food in almost all South Asian countries. In the aqueous processing of coconuts, extraction of coconut milk is a major step, which is used for many purposes *viz*., recovery of coconut oil, conversion to spray dried coconut milk powder and preparation of coconut skim milk and cream. One of the by-products after coconut milk extraction is the coconut solid residue known as press cake. Coconut press cake poses a tremendous disposal problem to processors of coconut milk owing to its high nutritional content. One of the novel uses of this by-product is drying of the press cake (vacuum drying, tray drying) and making it into flour, which can be used as ingredients in the preparation of curries, chutney etc. (Hagenmier 1983; Gonzalez 1986; Arumughan *et al*. 1993; Jena and Das 2007).

2.3 Coconut scrapers

Different types of coconut scrapers are available for use. They may be classified into traditional and mechanical. Traditional scrapers include those which are commonly used in household purposes. They are operated by hand. Mechanical scrapers include scrapers such as those attached to the grinder. Electrical scrapers available in market are difficult to use, unsafe, and incur high cost. Most of the scrapers are operated in such a way that the operator cannot see the kernel while scraping. This makes it difficult to judge the completion of operation. Also the operator needs to be careful about the occupational safety hazards, as the scrapers are attached to the grinder and electric motor.

Raj, *et al* (2016) stated the advantages of mechanical scrapers over the traditional methods. Mechanical coconut graters were time saving, less power consuming, safe and cost effective. It could grate coconuts within seconds. The mechanical scraper could scrap the coconut completely. The materials used for making their machine were safe and long lasting.

2.2.4 Shelf life of scraped coconuts

The coconut milk is primarily the extract obtained from the coconut endosperm. It is a rich medium which has the ability to support the growth of many spoilage microorganisms. In addition, it is highly susceptible to chemical deterioration by lipid auto oxidation and lipolysis which results in off odours and flavours, mainly contributed by the presence of peroxides and malondialdehyde end products of lipid oxidation. Many valiant attempts were being made commercially to extend the shelf life of coconut milk by canning, aseptic packaging and spray drying (Seow *et al.*, 1997).

Ghani *et al.* (2002) observed that the common causes of spoilage were pre-process spoilage, under-processing, inadequate cooling and contamination resulting from package leakage.

Gunathilakea (2005) stated that, application of hurdle technique on fresh coconut gratings extends the shelf life by one month at ambient conditions (30+2°C) and by three months at refrigerated conditions (5+2°C).

Jena (2007) stated that, moisture sorption characteristics of vacuum dried coconut press cake could be predicted agreeably with both GAB and Halsey model. However, Halsey model was found to be more suitable for accurate prediction of sorption isotherm at different temperatures with a relative deviation percent below 10%. The model developed was utilized for predicting the equilibrium moisture content of dehydrated coconut press cake at various temperatures and relative humidity. The predicted model could help in designing packaging systems of a nutritious product like coconut press cake. No significant effect of temperature on the equilibrium moisture content of coconut press cake was observed. Net isosteric heat of sorption for dried coconut press cake decreased with an increase in moisture content suggested endothermic reaction at low moisture contents.

2.5 Vacuum packaging

The role of food packaging is being increasingly recognized, as it has multiple functions such as product protection, identification, promotion and convenience, and is very important in increasing product shelf life by retarding quality degradation and ensuring safety (Gómez and Lorenzo, 2012).

Vacuum packaging (VP) may be regarded as a special type of MAP, since part of the normal headspace is withdrawn, leaving an altered initial atmosphere. VP of respiring produce was first successfully practiced with a system designed by S. Burg almost a quarter of a century ago (Burg, 1975; Burg and Burg, 1966). Although the system performed rather well, it was technically complex and never as widely adopted as CA or MA storage. A very simple VP system, designated as a moderate system, has recently been introduced in the Netherlands. In this system, perishable commodities are stored at >400 m Bar in a refrigerator. Vacuum packaging has been shown to extend the shelf life of food products (Jensen *et al*., 1980; Cann *et al*., 1983; Daniels *et al*., 1986; Jorgensen *et al*., 1988).

Rocha M. C. N *et al* (2003) stated that Vacuum packaging (VP) appeared to be an effective package for protection of the quality of MP 'Desirée' potatoes. The shelf life of MP potatoes may be extended to1 week under refrigerated storage by using vacuum packaging systems. The main quality parameters are constant during the storage. The 'fresh-like' quality of potatoes was effectively preserved by a 100-mm PE/PA bag, an outer PA layer and an inner PE layer. The PA is responsible for mechanical strength and impermeability to O_2 and other gases. PE is co-extruded for its water and vapour impermeability. PPO activity was greatly inhibited by vacuum packaging using 100 mm PE bags. Because the absence of air in vacuum packaging may favour the growth of anaerobic pathogens, such as Clostridium botulinum, it would be of extremely importance to develop the microbiological evaluation.

Denoya *et al* (2014) stated that, Colour and texture of fresh-cut peaches subjected to the combination of HPP +VP could be well preserved for at least 21 days under refrigerated storage (10 with only minor alterations such as translucency of tissues. Vacuum-packaging, a technology that guarantees the absence of oxygen inside the packaging, contributed to the preservation of colour by inhibiting the in-pack enzymatic browning. On the other hand, when the package was opened and the product re-exposed to the normal oxygen concentration, browning was prevented because of the partial inhibition of PPO brought about by the concomitant effect of HPP treatment organic acid dipping.

Chetti *et al* (2012) stated that VP has been found to be a superior technology in preserving the quality of whole chillies for up to 24 months when compared to jute bags where chilli can be stored for only a short period. Various quality parameters viz., total extractable colour, oleoresin extractable colour and capsaicin content were very high in vacuum packaging treatments compared to jute bags which are again due to the impermeability of packaging film to air and moisture. Among various treatments, vacuum packed chillies under cold storage were found to have the least per cent decline in various quality parameters.

Packaging may be termed active when it performs some role other than providing an inert barrier to the external environment (Rooney). Active packaging can be defined as a system in which the product, package and the environment interact in a positive way to extend the shelf life or to achieve some characteristics (Miltz *et al*. 1995). The goal of active packaging is to enhance the preservation of food in the package and prolonging shelf life involves application of various strategies like temperature control, oxygen removal, moisture control, addition of chemicals such as salt, sugar, carbon dioxide or natural acids or a combination of these with effective packaging (Robertson 2006 and Restuccia *et al*. 2010).

Colour, texture, and flavour of vegetables are critical factors in consumer acceptance and changes in these attributes can be controlled to some extent by maintaining optimal storage conditions. Control measures include temperature, and different forms of packaging (Bastrash *et al*, 1993). Packaging atmosphere can be modified using various barrier properties (gas and water vapour exchange) of different polymeric films that are specifically chosen based on the respiration rate of the vegetables (Jacobson *et al*., 2004). Controlled atmosphere (CA) or Modified atmosphere packaging (MAP) provides an atmosphere that is different from air and is sometimes monitored and maintained over time (Berrang *et al*., 1990).

The shelf life of packaged foods under chilled or ambient temperatures can be improved with the food product itself being processed, preservatives added or other auxiliary agents used to stabilize against biochemical, microbiological, and enzymatic activity. The protection against enzymes or microorganisms which could deteriorate or infect respectively, is usually achieved by hermetic sealing in a MAP, that usually consists of a high gas-barrier structure that is hermetically closed (i.e. low oxygen transmission rate – OTR); and thus low oxygen environment. However, residual oxygen is inherent in packed environment, i.e. void-space between food particles and headspace in packaging, and the dissolved and occluded air within food, which may hamper the use of gas flushing or vacuum sealing to create a low oxygen concentration after packaging. Removal of void-space (space not occupied by food particles) and the dissolved oxygen in food is crucial to provide extended shelf-life of various foods and beverages that may otherwise become deteriorated chiefly through enzymatic, microbiological and biochemical mechanisms (Mexis *et al*. 2012).

The MAP and VP slow down the metabolic activity of a product and of the microorganisms present, both spoilage and pathogenic by limiting the O_2 supply and applying an elevated level of CO_2. Because the same strategy underlies refrigerated storage, MAP and VP of respiring produce are usually combined with this technique (Zagory and Kader, 1988). Hence various MAP methods were adopted in the present study to extend the shelf life of scraped coconuts at refrigerated condition.

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

This chapter deals with the material used methodology opted for the development and evaluation of coconut scraper and the shelf life study of the scraped coconut, based on its type of packaging, preservation methods and various storage methods.

3. EXPERIMENTAL PROCEDURE

3.1 Raw Material

The raw material coconut used for the purpose of analysis of shelf life was procured from KCAET Tavanur farm.

3.2 Development of coconut scraper (Model 1)

A conceptual design of coconut scraper was conceived and the machine was fabricated in the workshop of KCAET, Tavanur.

The developed machine consists of the following parts:

- Frame
- Scraper head
- Flexible shaft
- Motor
- Pulley mechanism
- Coconut holder

3.2.1 Frame

A mild steel frame of 5 mm thickness was used to provide support to bear the load and minimise the vibration and to ensure stability of the machine. Frame of trapezoidal shape with 41 cm length at base, 22 cm at top side and a height of 43 cm and 75° angle on one side and on the rear side were square with a length of 35.5 cm x 43 cm. It was enclosed by stainless steel (grade 304) sheets at all sides. It encloses the motor and pulley mechanism. A coconut holder was welded to the rear side of the frame.

Plate 3.1 Frame of the unit

3.2.2 Scraper head

Scraper head was used to penetrate the coconut kernel for scraping coconut. The scraper head was made of stainless steel (304 grade) of 40 cm length and 5 cm diameter, attached to a pipe of 16 cm diameter of 24 cm length. The scraper head consists of 8 blades, each having 10 tooth of 0.5 cm length at an angle of 60°. The tooth was tig welded to the pipe. The handle for holding the scraper head was of 35 cm diameter and 100 cm length. One end of scraper head was connected to a rotating shaft.

Plate 3.2 Scraper head of model 1

3.2.3 Flexible Shaft

A flexible shaft was used for transmitting the rotational motion from the motor to the scraper head. Here, a flexible shaft of length 2 m was used.

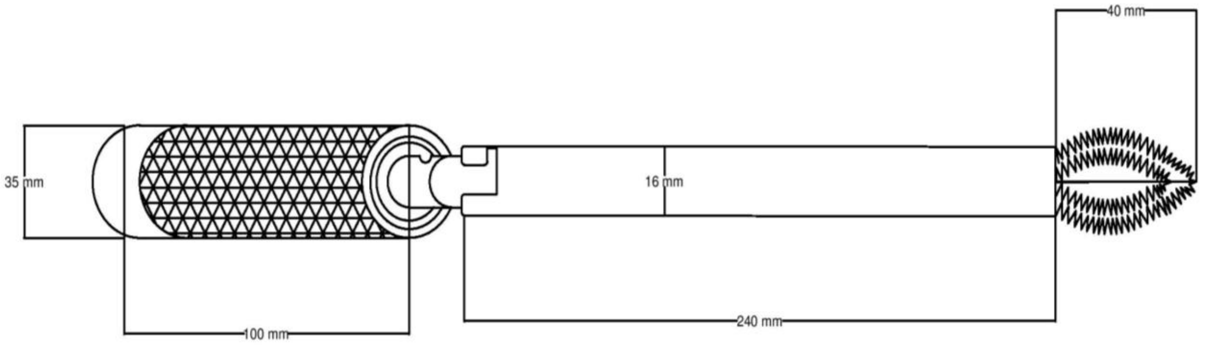

Fig 3.1 Side view of scraper head of model 1

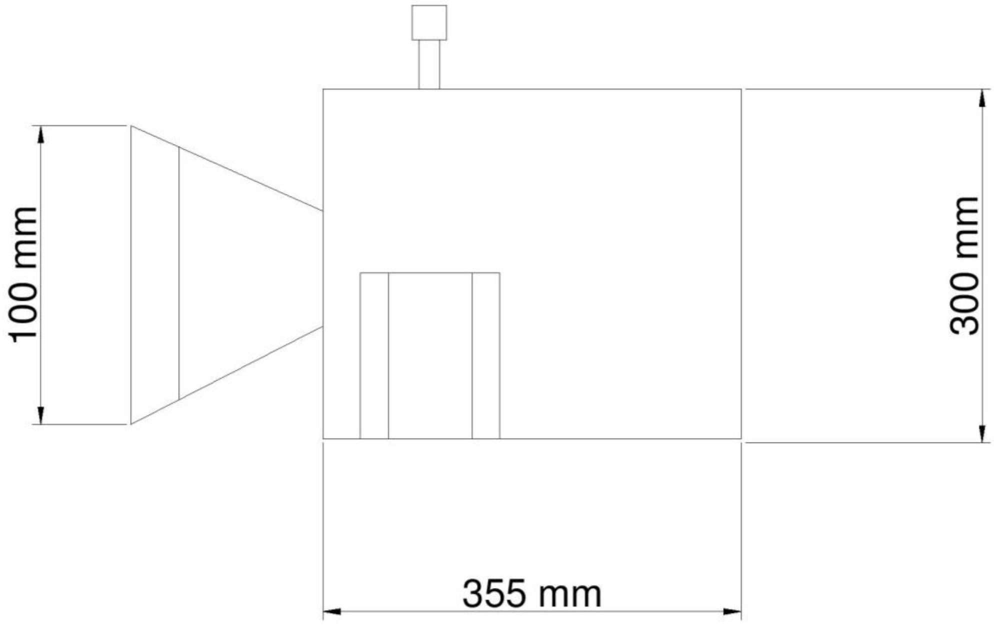

Fig 3.2 Side view of coconut scraper (model 1)

3.2.4 Motor

An electric motor is an electrical machine that converts electrical energy into mechanical energy. A single phase motor of power 0.25 hp with a speed of 1425 rpm and a frequency of 60 Hz was used as the prime mover for the operation. Single phase AC motor was used with a voltage range of 220-230 V. The motor was placed inside the frame at 25 mm from the surface.

3.2.5 Pulley mechanism

The motor was connected end to end to a pulley via a belt. The diameter of the pulley was 8 inch. The pulley was placed in a metal rod of 35.5 cm length placed horizontally at above 30 cm from the surface. The end of the rod was connected to the rotating shaft. The motor rotates the belt which in turn rotates the pulley, which transmits motion to the rotating shaft. The centre to centre distance between the pulley and motor was 9 inches.

Plate 3.3 Pulley mechanism

3.2.6 Coconut holder

A coconut holder of 100 mm diameter was used to hold the coconut in position for easier scraping. It was made of cast iron and was placed at a distance of 75 mm from sides and 18 mm from top of the frame. It consists of grooves cut on the top of the surface of the holder. The coconuts can be pushed inside and pressed in order to fix it inside. A ring was also provided above the grooves which can be pulled to hold the coconut tightly. It was fixed horizontally on the side of the enclosed frame. Around the coconut holder, an outer covering was provided to prevent spillage of scraped coconut while working.

Plate 3.4 Coconut holder

3.3 Operational procedure for coconut scraper (Model 1)

The machine works on single phase AC electricity, 220 - 230 V voltage. A single phase motor of power 0.25 hp at a speed of 1425 rpm and a frequency of 60 Hz was used as the prime mover for the operation. The motor was placed 25 mm above the ground on the frame. The speed was reduced by employing a pulley mechanism. The prime mover motor was connected to the input electricity so that electric current would be converted into mechanical energy. The motor connected to an 8 inch pulley, which was placed on a shaft at a height of 30 cm from ground. The shaft was then connected to the rotating shaft of 2 m length. The scraper head was attached at the end of the rotating shaft.

The coconut to be scraped was fitted in the holding mechanism provided at the side of the machine. The coconut was inserted and pressed inside to get fit in properly. A collecting plate may be provided below the holding mechanism, near to the machine.

The motor was connected to a power source for operation. From the motor the rotational motion was transmitted to a shaft, which reduced the speed from the motor and rotates the rotating shaft. The scraper head attached at the end of the rotating shaft rotates, which in turn can be pressed into the surface of the coconut.

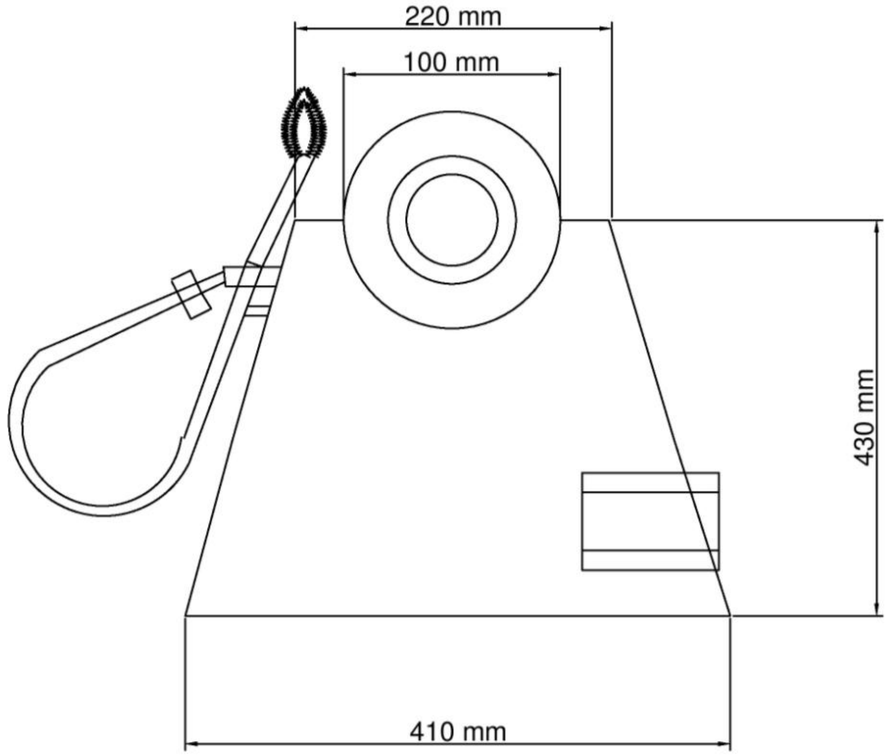

Fig. 3.3 Front view of coconut scraper (model 1)

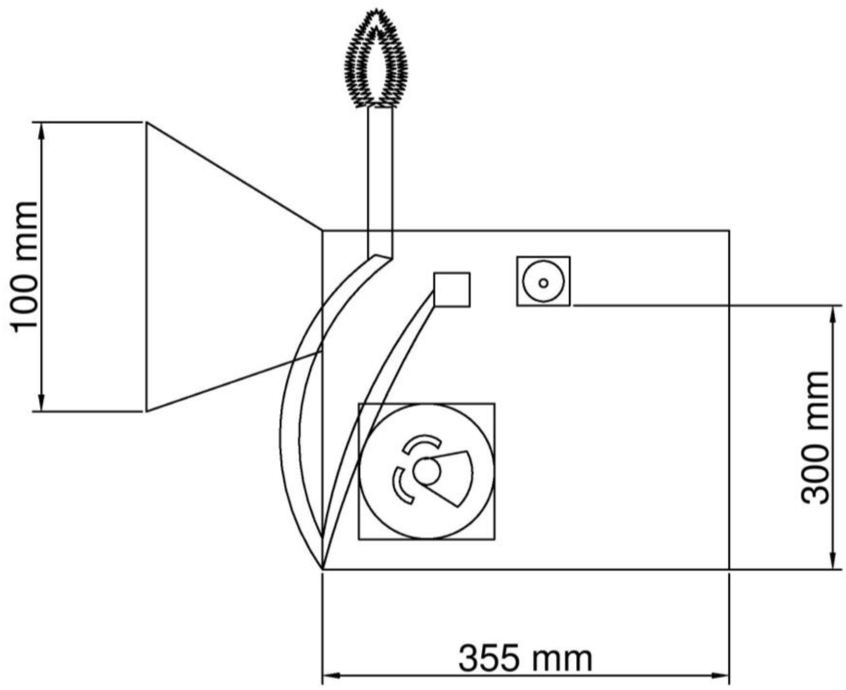

Fig 3.4 Side view of coconut scraper (model 1)

The power source was switched on and then scraper head was pressed against coconut. The scraper head was rotated inside the kernel so as to scrape the whole coconut. The scraped coconut was then collected on a tray.

MODEL 1

Plate 3.5 Coconut scraper (Model 1)

3.4 Development of Coconut scraper (Model 2)

The coconut scraper which was fabricated earlier (Model 1) was comparatively larger in size. In order to make it safer, easy and more human friendly, a machine was fabricated which is easier to operate for household purposes.

The second fabricated model consists of following parts:

- Scraper Head
- Rechargeable Handle
- Coconut Holder

3.4.1 Scraper head

A scraper head was used to penetrate the coconut kernel for scraping coconut. The scraper head was made of stainless steel 304 grade of 35 mm length and 6 mm diameter. The scraper head consists of six blades, each having teeth at angle of 60°.

Plate 3.6 Scraper head of model 2

3.4.2 Rechargeable Handle

This part was used for holding the equipment. It consists of a switch which needs to be pressed for working the scraper. The handle consists of a small motor of 4.8 V voltages and a speed of 150 rpm. The handle also consists of a recharging part, where the charger can be connected for charging the device. Once charged, the machine can work up to 30 min.

3.4.3 Coconut Holder

The same coconut holder which was fabricated for the first model was used.

3.5 Operational procedure for Model 2

The machine works on single rechargeable type of motor working on 4.8 V. A single phase motor of speed of 150 rpm and a frequency of 60 Hz was used as the prime mover for the operation.

The coconut to be scraped was fitted in the holding mechanism provided at the side of the machine. The coconut was inserted and pressed inside to get fit in properly. A collecting plate was provided below the holding mechanism, near to the machine.

For scraping coconut, the switch was pressed ON and then scraper head was pressed against the coconut. The scraper head was rotated inside the kernel so as to scrape whole coconut. The scraped coconut was then collected on a tray.

MODEL 2

Plate3.7 Coconut scraper (Model 2)

3.6 Performance evaluation of the developed machine

Performance of the machine was evaluated in terms of time of operation, capacity, power, and efficiency.

3.6.1 Power consumption

The power consumption of the developed machine was found out using a wattmeter. The wattmeter was connected to the coconut scraper and was operated. The reading obtained on the dial was noted. The reading gives the power consumed during the working of coconut scraper.

3.6.2 Time of operation

The average time required for operation for both male and female were calculated. Ten coconuts were broken into equal half and one of the sides were scraped by male, while the other side was scraped by female. This was done to ensure equality in size of coconuts being scraped. The average of time taken for scraping one half of 10 coconuts was taken as the time taken to scrap coconuts by the developed machine. The test was conducted for male and female of age group 20-25 years.

3.6.3 Capacity of machine

Capacity of Model 2 was measured by operating the machine continuously from complete charged state till the charge exhausted. It was measured by scraping the coconut continuously till the machine stopped working

3.6.4 Efficiency

The efficiency of device was calculated considering the amount of coconut kernel scraped off from the shell and the amount of wastage occurred during scraping process.

The efficiency of scraping coconut was found out using the following equation;

$$\text{efficiency} = \frac{\text{weight of kernel scraped}}{\text{total weight of coconut kernel}} \text{ x } 100 \quad \dots (3.1)$$

However loss occurred during the time of scraping as full amount of scraped coconut couldn’t be collected as some spilled off. So the overall efficiency considering this loss will be;

$$\text{efficiency} = \frac{\text{weight of kernel collected}}{\text{total weight of coconut kernel}} \text{ x } 100 \quad \dots (3.2)$$

3.6.5 Comparison of developed models with conventional models

The efficiency of the two developed models was compared between each other. Also the parameters of the machine was compared with existing models which are presently in use, like manual scrapers and mechanical scraper, *i.e.* the scraper attached to grinders. The test was done with same subjects of age group 20-25 years.

3.7 Shelf life study of fresh scraped coconut

3.7.1 Preliminary tests

Preliminary tests were conducted for the standardisation of the following parameters required for effective packaging. They are;

1. Suitable concentration of preservatives.
2. Suitable method for introducing preservatives to scraped coconut.
3. Suitable packaging method.
4. Suitable gauge thickness of packing material required.

3.7.2 Steam blanching

The samples were steam blanched for detecting the presence of enzymes in it. Three samples, each of 25 g were weighed and steam blanched for 30 s, 1 min and 2 min, respectively. The shelf life of samples was analysed separately for both blanched and unblanched samples.

3.7.3 Enzyme test

Guaiacol test was done for checking the presence of any enzymes. Twenty gram of crushed sample was taken in 20 ml distilled water. To this, 1 ml of guaiacol solution II (0.5 ml guaiacol and 49.5 ml ethyl alcohol) was added. Then 1.6 ml of H_2O_2 solution I was poured to the prepared mix. The change in colour was noted.

3.7.4 Preservation methods

Different preservation techniques were performed as cited below;

i. Hot water: 100 ml of water was taken and boiled for 5 min at 100°C.
ii. Salt solution: Different concentrations (0.5 g, 1 g, 1.5 g) of salt were taken and mixed with 100 ml water and solution was prepared.
iii. Citric acid solution: Different concentrations (0.3 g, 0.5 g, 1 g) of citric acid were taken and mixed with 100 ml water and solution was prepared.
iv. KMS solution: Different concentrations (0.5 g, 1 g, 1.5 g) of KMS were taken and mixed with 100 ml water and solution was prepared.

3.7.5 Experimental procedure

The procedure includes the following steps:

i. 25 g samples, both blanched and unblanched were weighed and taken.
ii. Control sample (25 g) was taken.
iii. Hot water, salt solution (0.5 %, 1 %, and 1.5 %), and citric acid solution (0.3 %, 0.5 %, 1 %) were prepared to test for best concentration to be used.
iv. The preservatives were spread, sprayed and poured to the scraped coconut samples to find the effective application.
v. The samples were then air dried for 20 min.
vi. Then the samples were packed in normal packs (MAP) and vacuum packs (VP).

vii. The samples were packed in 50, 100, 200 and 400 gauge LDPE packets and observed.

viii. The packed samples were kept in ambient, refrigerated and freezing temperature for shelf life study.

ix. Samples were observed at regular time intervals for the standardization of:

- Suitable concentration of preservatives.
- Suitable method for introducing preservatives to scraped coconut.
- Suitable packaging method.
- Suitable gauge thickness of packing material required.

Plate 3.8 Scraped coconut samples

3.8 Shelf life study

Investigations were performed to find out the maximum shelf life of the product using various preservatives at various storage temperatures.

i. 25 g samples, both blanched and unblanched were weighed and taken.

ii. Control sample (25 g) was taken.

iii. Hot water, salt solution (1 %), and citric acid solution (0.3 %) were sprayed to the samples.

iv. The samples were then air dried for 15 min.

v. Then the samples were packed in 400 gauge LDPE packs and vacuum packed.

vi. The samples are kept at room temperature, cold storage of 15°C temperature, at 3°C and at -20°C.

vii. The samples were analysed at regular intervals for the following parameters.

3.8.1 Colour

Colour of scraped coconut was assessed using Colorimeter. Hunter Lab colour flex meter was used for the measurement of colour of prepared samples.

It works on the principle of collecting the light and measures energy from the sample reflected across the entire visible spectrum. The meter uses filters and mathematical models which rely on "standard observer curves" that defines the amount of green, red and blue primary lights required to match a series of colour across the visible spectrum. It provides a reading in terms of 'L*', 'a*' and 'b*'. The 'L*' coordinate measures the value or luminance of a colour and ranges from black at 0 to white at 100. The 'a*'coordinate measures red when positive and green when negative and 'b' measures yellow when positive and blue when negative. All the three standard colour parameters 'L*', 'a*'and 'b*' were observed for day light colour. The colour meter was standardized using black and white ceramic calibration tiles.

Readings were observed by placing the samples on trays on colorimeter. Values of each sample is noted and the mean values of 'L*', 'a*' and 'b*'were reported (Shahir, 2014).

3.8.2 Water activity (aw)

Water activity of scraped coconut was measured using digital water activity meter. Water activity is important in determining product safety and quality maintenance in a particular storage environment. An automated instrument (M/s Aqua lab, USA) model XT-2i, was used to determine the water activity of samples.

Water activity was measured by equilibrating the liquid phase water in the sample with the vapour phase water in the headspace and measuring the relative humidity of the headspace. The water activity meter was provided with a sample cup which was sealed against a sensor block. Inside the sensor block there was a fan, a dew point sensor, a temperature sensor and an infrared thermometer. The dew point sensor measures the dew point temperature of the air and the infrared thermometer measures the sample temperature. From these measurements, the relative humidity of the headspace computed as the ratio of saturation vapour pressure of air to the saturation vapour pressure of the sample. The measurement of the headspace humidity gives the water activity of the sample. The purpose of the fan was to speed up the equilibrium process and to control the boundary layer conductance of the dew point sensor.

Water activity was measured by placing the sample in a container which was placed in a sealed chamber and then the knob was closed to read the water activity of the sample. The water activities of the samples were recorded with respect to atmospheric temperature.

3.8.3 pH

pH was measured using pH meter. pH is the logarithm of the reciprocal of hydrogen ion concentration or measure of active acidity. Change in pH will affect the flavour and overall acceptance of product. By using digital pH meter, pH of raw and processed samples was analysed. The pH meter was standardized with buffer solutions of different pH.

Each sample was mixed in water and the pH rod was kept in the samples and the values are noted. The values were taken as pH of the sample.

3.8.4 Free fatty acid content

Acid value test was performed to determine the free fatty acid content of the samples. Above 5 g of fat or oil was weighed accurately into a 250 ml conical flask to which 25 ml of mixture of equal volumes of alcohol and ether was added. Add 1ml of phenolphthalein solution. If necessary, the contents may be warmed in water bath until substance was completely dissolved. The solution was titrated with 0.1N KOH with constant shaking until pink colour persists for 15 s. The titre value in ml was noted.

3.8.5 Microbial analysis

Standard plate count method was performed to find the microbial content of the given samples.

This method allowed the growth of microorganism in nutrient culture Petri plate and the colonies developed were counted. One gram of sample was mixed in 100 ml of distilled water. From the prepared sample one ml (W_s) was then added to 90 ml of sterile water (10^{-1} dilution) and shaken well for 10 - 15 min to assure uniform distribution of microorganisms.1ml of this diluted sample was transferred to sterile petri plate with a sterile micro pipette. Molten and cooled nutrient medium (15 – 20 ml) at 45°C conducive for the growth of the specific organism were added to respective petri plates. The plates were rotated clockwise and anti-clock wise for the thorough mixing of dilutent and the medium. Then the petri plates were incubated at 37°C for one to two days, for the bacterial growth (Rao, 1986).

After the incubation period, the colonies (cfu) were counted and the number of microbiological organisms per gram of sample (Ns) for dilution factor (DF) was calculated as given below

$$Ns = \frac{Ncfu \times DF}{Ws}$$

3.8.6 Sensory evaluation

Sensory characteristics like odour and taste of the scraped coconut were analysed. The packets were checked for odour and were tasted immediately after opening the packet.

The analysis was conducted at intervals of 1, 3, 5, 7, 10, 15, 30, 45, 90, 120, 150 and 180 until all the packets got spoiled. The samples once spoiled were discarded.

3.9 Cost economics

Based on the material cost and cost of fabrication, the total cost of developed coconut scraper (model 1 & model 2) was calculated. The operation cost of mechanical and manual operation was worked out, by including the fixed and variable costs as given in Appendix E.

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSIONS

This chapter deals with the results of the experiments conducted to evaluate the performance of the newly developed coconut scraper. The results of experiments based on the shelf life study of scraped coconut are also discussed.

4.1 Analysis of coconut scraper (Model 1)

4.1.1 Time of operation

The average time required for the scraping operation was estimated. The average time required for a male (age group 20-25 years old) to scrap one half piece of coconut was found to be 1.078 min and for female of the same age group, the average time required to scrap one half piece of coconut was found to be 1.381 min. The time for scraping coconut depends upon the size of coconut (Table 4.1).

Table 4.1 Time of operation for coconut scraper model 1

Sl. no.	Time(in min)	
	MEN	WOMEN
1	1.47	2.12
2	1.01	1.23
3	0.52	0.57
4	1.23	1.58
5	1.32	1.47
6	1.4	1.59
7	0.56	1.09
8	1.42	2.05
9	0.48	0.59
10	1.37	1.52
Average	**1.078**	**1.381**

4.1.2 Power requirement

The power was found out using a watt meter. It was connected to the machine as mentioned in the above section 3.6.1. It was found that the average power requirement for the operation of the coconut scraping machine was about 300 W.

4.1.3 Efficiency of operation

The efficiency of the machine was calculated using the formula (3.2) as discussed in the section 3.6.4. It could give maximum of 99.5 % of coconut kernel scraped off from the shell. But considering the wastage occurring due to spillage of coconut scraps, the efficiency reduced to 96.5 %.

4.2. Analysis of coconut scraper (Model 2)

4.2.1 Time of Operation

The average time required for operation was found out using model 2. The average time required for a male (age group 20-25 years old) to scrap one half piece of coconut was found to be 2.565 min and for female of the same age group, the average time required to scrap one half piece of coconut was found to be 3.196 min.(Table 4.2).

Table 4.2 Time of operation for coconut scraper model 2

Sl. no.	Time(in min)	
	MEN	WOMEN
1	2.42	2.59
2	2.5	3.01
3	1.58	2.46
4	3.2	3.34
5	3.15	3.57
6	4.09	4.54
7	2.25	3.34
8	1.42	2.4
9	2.55	3.5
10	2.49	3.21
Average	**2.565**	**3.196**

The time for scraping coconut depends upon the size of coconut. Small size coconuts took much lesser time to be scraped. The lower rpm (150 rpm) of the machine resulted in the increase in time of operation compared to model 1.

4.2.2 Efficiency of operation

The efficiency of the machine was calculated using the formula discussed under the section 3.6.4. A maximum efficiency of 99.5 % was noted for the second model. But considering the wastage occurred due to spillage of coconut scraps, the efficiency reduced to 97 %

4.2.3 Capacity

Capacity of machine was found out by working the machine from full charge until it gets exhausted. It was found that the machine could work up to 30 min once it gets fully charged.

4.3 Comparison of the two models

The Model 1 can be used for heavy duty purposes and also in household purposes. The Model 2 can only be used in household purposes, since it was rechargeable type and can be used for scraping less number of coconuts before it gets completely discharged.

The Model 2 was easier for handling compared to Model 1. The efficiency for both models were comparable since its method of operation was same. Due to low rpm of model 2, it took more time to scrap a coconut than Model 1.

4.3.2 Comparison of developed models with conventional models

The developed models were compared with existing conventional models used for household purposes. The test was performed by male and female, both of age group 20-25 years. The working of newly fabricated models was compared with manual scraper and mechanical scraper, *i.e.* scraper attached to grinder. (Table 4.3 and Table 4.4)

The results indicate that in manual scrapers, the time taken to scrap coconut was more compared to the newly fabricated models. Also the time taken was more for inexperienced, less skilled persons, whereas there was not much change in time of operation for both experienced as well as inexperienced persons. Also, the efficiency of operation decreased with time, which was not significant in the newly developed models.

Table 4.3 Time of operation for manual scrapers

Sl. no.	Time(in min)	
	MEN	**WOMEN**
1	3.15	3.58
2	3.5	4.29
3	5.4	5.15
4	3.56	4.24
5	4.19	6.39
6	3.51	5.25
7	4.26	6.48
8	4.48	5.59
9	4.39	5.17
10	5.03	5.24
Average	**4.147**	**5.138**

Table 4.4 Time of operation for mechanical scrapers (grinder attachment)

Sl. no.	Time(in min)	
	MEN	**WOMEN**
1	1.43	1.57
2	0.57	1.23
3	0.52	1.27
4	1.23	1.58
5	1.52	1.47
6	1.4	2.14
7	0.56	1.32
8	1.42	2.05
9	0.48	0.59
10	1.37	1.52
Average	**1.05**	**1.474**

In mechanical scrapers, *i.e.*, the scraper which has grinder attachments, the time of operation was similar (Table 4.4), but the power consumption was higher than the newly fabricated models. Further, scraper may cause danger to workers.

Though the efficiency of the machines was comparable, visibility of the scraping process was more effective in the newly fabricated models.

Overall, the newly fabricated models seemed to be time saving, safe, efficient and easier to operate than existing scrapers. The newly developed models were easier for operation, especially to inexperienced workers.

4.4 Analysis of shelf life of scraped coconut

4.4.1 Preliminary tests

Preliminary tests were carried out to find the suitable preservatives, concentration of selected preservatives, suitable packaging material and suitable type of packaging. The results obtained from preliminary tests are as follows:

4.4.1.1 Enzyme test

Guaiacol test was performed for both blanched and unblanched samples. No visible colour change was observed, indicating the absence of any enzymes that may cause rancidity.

4.4.1.2 Selection of preservatives and concentration

The concentration of citric acid solution was taken as (0.3%) and that of salt solution was taken as (1%), based on palatability. The results were in accordance with the experiment done by Gunathilake (2005). The preservatives thus finalised for secondary test were hot water, citric acid (0.3%) and salt solution (1%).

4.4.1.3 Selection of method to add preservatives

Out of the three methods evaluated (spreading, spraying and dipping), the following results were obtained.

In spreading method, the preservatives did not reach to all parts of test sample and was discarded. In spraying method, the preservatives which were sprayed in liquid form were able to cover all parts of test sample. In dipping method, the samples were dipped in preservatives. Loss of water soluble nutrients and oozing out of coconut milk was found out and the sample was discarded.

From the results, the spraying method was found to be effective and was used for further studies.

4.4.1.4 Suitable packaging method

Passive modified atmospheric packaging and vacuum packaging methods were tested to find suitable packaging material. Vacuum packaging restricted the entry of oxygen into the samples than passive modified atmospheric packaging. Thus vacuum packaging was selected for packaging of samples in further studies.

4.4.1.5 Selection of suitable packaging material

LDPE films of 50, 100, and 200 and 400 gauge thickness were analysed. Packages having 50, 100 and 200 gauge thickness, after vacuum packaging showed a pasty appearance and also caused oozing out of liquid inside package. Packages made of 400 gauge showed better appearance while packaging. Thus 400 gauge LDPE film packs were found to be suitable for vacuum packaging of scraped coconut.

Plate 4.1.Samples at various thicknesses of LDPE films

4.5 Storage study of vacuum packaged scraped coconut

Samples were analysed to find the shelf life of vacuum packaged scraped coconut and the results obtained were discussed below.

Plate 4.2 Storage study of vacuum packaged scraped coconut

4.5.1 Colour

Colour change was initially white. It turned to reddish brown and to yellow with respect to time. The results obtained are given in Appendix I.

Plate 4.3.Change in colour

The results indicated that preservatives have less effect on colour. The colour was better for samples kept at -20°C. The colour change was rapid in samples kept at room temperature. The colour change was low for samples kept at -20°C. Preservatives have less effect on change in colour, but colour change was comparatively slow in samples treated with citric acid solution. Blanching initially enhanced of the samples and colour was better in blanched samples than in unblanched samples.

4.5.2 Water activity

The results indicated that the water activity decreased rapidly during storage and increased further during storage time. The water activity was less on samples treated with Sodium chloride. The water activity was least on samples kept at -20°C. It was found that water activity decreased with decrease in temperature. It was determined as per the Association of Official Analytical Chemists (AOAC). It was found that the water activity of the samples increased rapidly during the time of thawing. The effect of blanching on water activity of the samples was not significant. The increase in water activity could be due to migration of moisture and condensation of water. The results obtained are given in Appendix II.

4.5.3 pH

It could be obtained from the values that pH decreased with decrease in temperature. The result indicates that pH decreased considerably and also was less in samples treated with citric acid. The change in pH was considerably less for samples stored at -20°C. The change in pH was rapid in samples stored at room temperature. The reduction in pH could be due to increase in FFA content of scraped coconut. The results obtained are given in Appendix III.

4.5.4 Fatty acid content (FFA)

Acid value test was performed in order to find the amount of free fatty acid present in the samples.

The results obtained are shown in graphs (fig 4.1, fig 4.2, fig 4.3 and fig 4.4) given below. The results showed that free fatty acid content formation was less in samples treated with citric acid. The fatty acid content was less in samples stored at -20°C. Fatty acid content was comparatively less in blanched samples than in unblanched samples.

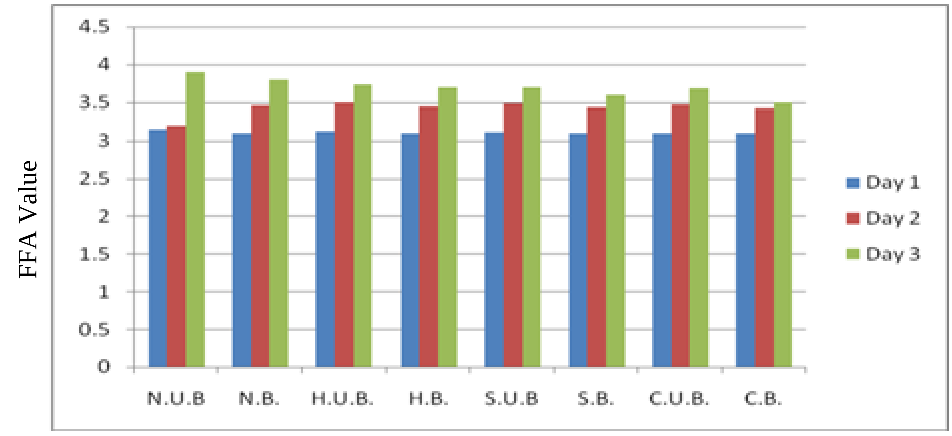

Fig 4.1 Effect of room temperature on FFA content

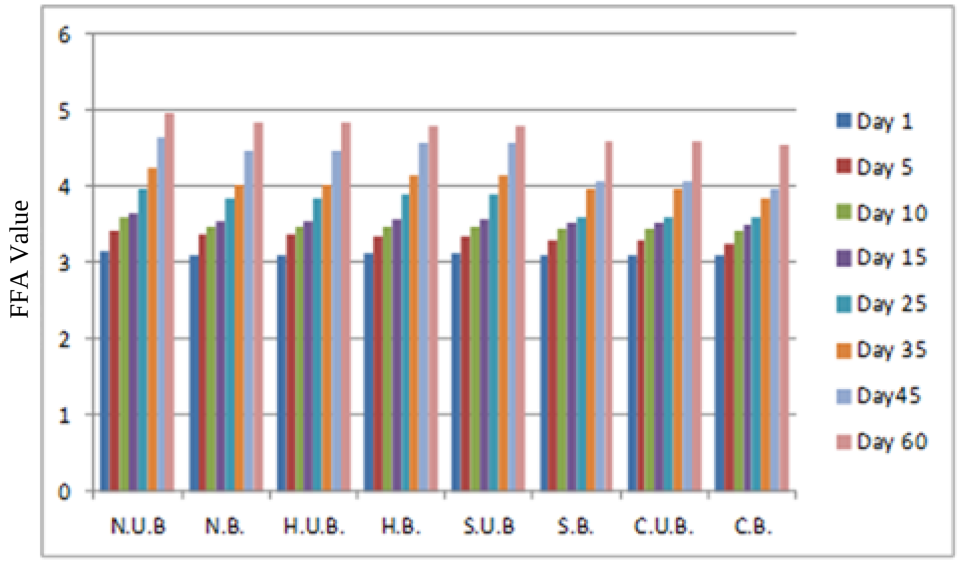

Fig 4.2 Effect of cold storage on FFA content

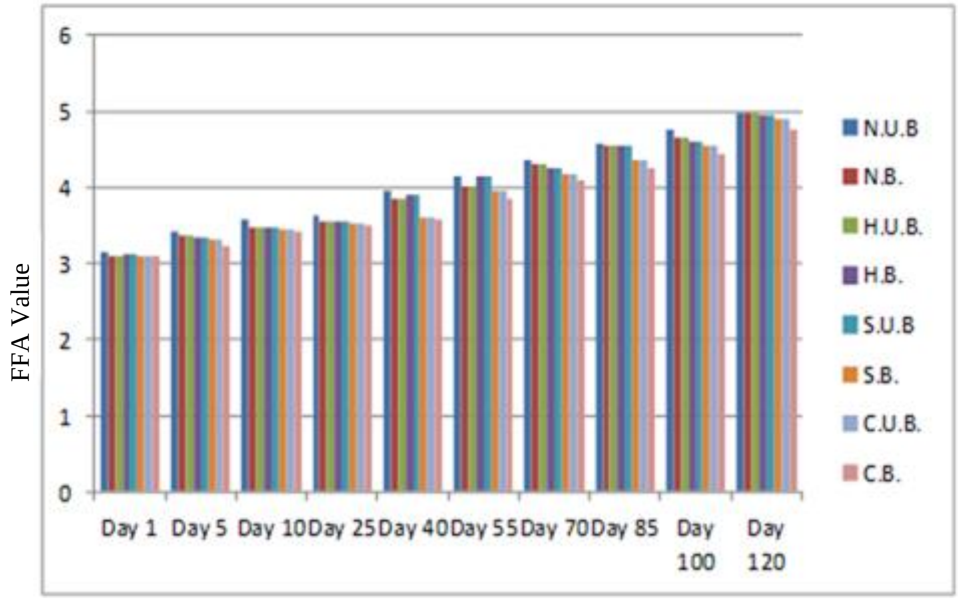

Fig 4.3 Effect of storage at 3°C on FFA content

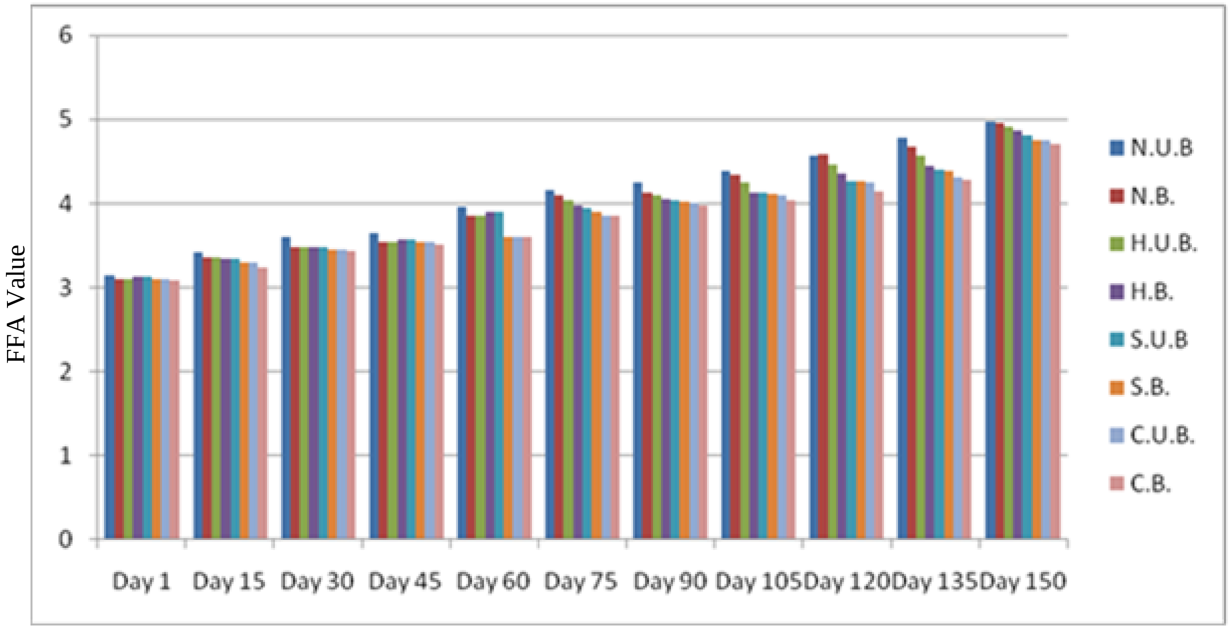

Fig 4.4 Effect of storage at -20°C on FFA content

Where, NUB = Normal unblanched NB = Normal Blanched

HUB = Hot water unblanched HB = Hot water Blanched

SUB = Salt solution unblanched SB = Salt solution Blanched

CUB = Citric acid unblanched CB = Citric acid Blanched

4.5.5 Microbial analysis

Standard plate count method was performed to find the microbial content of the given samples. The results obtained are shown in Appendix IV (Table A, Table B, Table C and Table D).

The results indicated that microbial growth was comparatively faster at samples kept on room temperature followed by samples at cold storage, samples at 3°C and then at samples stored at -20°C. This indicates that microbial activity decreases with decrease in temperature.

4.5.6 Sensory characteristics:

Observable sensory characters such as odour and taste of samples were tested.

4.5.6.1 Odour

The odour of the samples changed from normal kernel odour to rancid odour. The change in odour decreased the acceptability of the product at the same time indicated the degradation in quality of the product due to rancidity.

The change in odour was rapid for samples kept at room temperature, followed by those kept at cold storage (15°C) and then samples stored at -3°C and finally for samples stored at -20°C. The results indicate that change in odour could be decreased by decreasing temperature of storage.

Table 4.5 Change in odour during storage

Storage temperature	Odour	Time period
Room temperature	Rancid odour	3-5 days
Cold storage (15°C)	“	45-60 days
3°C	“	90-120 days
-20°C	“	180 days

4.5.6.2 Taste

The taste of the samples changed from normal taste to oily taste. The change in taste decreased the acceptability of the product as it changes the taste of products in which it was used. It indicated the degradation in quality of product due to rancidity.

Table 4.6 Change in taste during storage

Storage temperature	Taste	Time period
Room temperature	Rancid taste	3-5 days
Cold storage (15°C)	“	45-60 days
3°C	“	90-120 days
-20°C	“	180 days

The change in taste was rapid for samples kept at room temperature, followed by those kept at cold storage (15°C) and then samples stored at -3°C and finally for samples stored at -20°C. The results indicated that change in taste could be decreased by decreasing temperature of storage.

4.6 Cost economics

The cost of the developed machine was calculated by assessing the fixed cost and variable cost. The cost of coconut scraper model 1 was Rs. 8000/- (which included the material cost and fabrication cost) and that of model 2 was Rs. 23500/-. The operational cost of coconut scraping was Rs. 71.725/- and that for model 2 was Rs. 71.66/-.

Summary and Conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

Scraped coconut is the product obtained from the white fleshy edible portion, *i.e*. the coconut kernel of the coconut. Fresh coconut kernel contains: moisture (50%), oil (34%), ash (2.2%), fibre (3.0%), protein (3.5%) and carbohydrate (7.3%). Scraped coconut is used for various purposes like cooking, i.e. for cooking of food items like Chutneys, for making *puttu*, confectionaries, sweet items, and other products. Scraped coconuts are also used in the production of coconut milk, which is a commonly used ingredient in various food items and used for the preparation of virgin coconut oil

Due to the high perishability of these products, usually these are prepared instantly. Scraping with mechanical scrapers/ traditional method is tedious and less comfortable. The drudgery in the production of scraped coconut necessitated to explore the alternate possibilities for the development of mechanical devices for the same. Keeping this in mind, two models of coconut scrapers were developed and their performance evaluation was conducted based on time of scraping, efficiency and cost analysis. The coconut scraper was developed for eliminating the limitations of the existing coconut scrapers. Two models were developed; one working as motor driven and another one was comparatively of small size and is rechargeable. The study also investigated the suitable packaging method and storage temperature to enhance the shelf life of the highly perishable scraped coconut. Thus suitable preservation and packaging methods for storage of scraped coconuts are to be found out.

The performance evaluation of the developed models was carried out on the basis of time of operation, *i.e.* the time taken to scrap one half of the coconut by both male and female of same age group (20-25 years old) were found out. For Model 1, the average time required for a male was found to be 1.078 min whereas for female of the same age group, it was found to be 1.381 min. For Model 2, the average time required for a male was found to be 2.565 min whereas for female of the same age group, it was found to be 3.196 min. The power consumption of the fabricated machines was found out using watt meter. The average power requirement for the operation of the coconut scraping machine was about 300 W. The capacity of model 2 was also found out. It was found that the machine could work up to 30 min once it gets charged. The efficiency of the models based on the amount of the coconut scraped from the coconut and also with respect to the amount of coconut obtained considering the spillage were found out. Efficiency of Model 1 was 99.5 %, but considering the spillage occurred during scraping, efficiency reduced to 96.5 %. Efficiency of Model 2 was 99.5 %, but considering the spillage occurred during scraping, the efficiency reduced to 97 %.

The shelf life of the product based on preservation, packaging and storage temperatures were found out. Preliminary tests were conducted for the standardisation of preservatives, selection of packaging material and its suitable gauge thickness, selection of packaging method and optimum storage conditions with respect to temperature. Here different concentrations of preservatives such as hot water, KMS solution, citric acid solution and salt solutions were taken and analysed. Based on the findings, preservatives finalised for secondary test were hot water, citric acid (0.3 %) and salt solution (1 %) were selected for further studies. The preservatives were incorporated by methods like spreading, spraying and dipping; out of which spraying method was found to be more effective and was chosen for further trials. Various gauges (50, 100, 200 and 400 gauge) of LDPE packages were analysed for suitable packaging method and LDPE packages of 400 gauge thicknesses was chosen for further investigations due to better appearance of the product. The samples were compared by vacuum packaging and passive modified atmospheric packaging for the purpose of selection of suitable packaging method. Vacuum packaging was chosen for packaging as it restricted the entry of oxygen and prevented rancidity of product. The samples were then kept in room temperature, cold storage (15°C), refrigeration temperature (3°C) and freezing temperatures (-20°C) and analysed at regular intervals.

Storage study were conducted in samples to find out the shelf life of scraped coconut at various storage temperature and to evaluate the best preservative method and the best storage conditions. The quality parameters such as colour, pH, water activity, fatty acid content, microbial analysis and sensory analysis such as taste and odour were evaluated. Twenty gram samples, both blanched and unblanched were taken separately and which are treated with different preservatives were weighed and then kept in 400 gauge LDPE plastic films and then vacuum packed. These samples were kept in various temperature conditions viz., room temperature, cold storage, 3°C and -20°C. Samples were analysed at intervals of 1, 3, 5, 7, 10, 15, 30, 45, 60, 90, 120, 150 and 180 days.

Colour was analysed using Colorimeter. Colour changed from white to reddish brown and to yellow with respect to time. Water activity was found out by using water activity meter. Water activity decreased during initial storage, but increased gradually with respect to time. It was in comparatively less for samples treated with citric acid. pH of the samples were analysed using pH meter. It was found that pH decreased with decrease in temperature and has range between 5.5 and 8.5. Acid value test was performed to find the free fatty acid content of the samples. FFA was less in samples treated with citric acid. Total plate count method was performed for finding the microbial load of the samples. It was found that microbial activity decreased with decrease in temperature. Sensory evaluation was carried out by analysing taste and odour. The odour of the samples changed from normal kernel odour to rancid odour, with respect to time. The taste of the samples changed from normal taste to oily taste, due to rancid formation.

From the results it could be concluded that the two models developed were better than the existing mechanical scrapers. The developed models were safe, easier to use and compatible than other machines and also more efficient than the existing scrapers.

The storage life of fresh scraped coconut could be increased using suitable preservatives, temperature and packaging methods. The shelf life of the product increases with decrease in storage temperature. Citric acid was found to be the best preservative among the tested preservatives. The product could be stored for one to three days at room temperature. The samples could be stored for 30 days in cold storage. The shelf life was increased to 90 days when stored at 3°C whereas at -20°C, the shelf life was increased up to 180 days. However, thawing decreased the quality of the product.

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CHAPTER 6

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Appendices

CHAPTER 7

APPENDIX

APPENDIX I

A. Colour of samples at room temperature

A.1 Colour of control samples at room temperature

no. of days	Unblanched			Blanched		
	L*	a*	b*	L*	a*	b*
1	72.94	2.41	8.59	72.94	2.41	8.59
3	70.18	2.53	9.06	70.29	2.51	8.93

A.2 Colour of samples treated with hot water at room temperature

no. of days	Unblanched			Blanched		
	L*	a*	b*	L*	a*	b*
1	72.94	2.41	8.59	72.94	2.41	8.59
3	70.36	2.49	8.59	70.79	2.49	8.81

A.3 Colour of samples treated with salt water at room temperature

no. of days	Unblanched			Blanched		
	L*	a*	b*	L*	a*	b*
1	72.94	2.41	8.59	72.94	2.41	8.59
3	71.06	2.51	8.81	71.24	2.94	8.79

A.4 Colour of samples treated with citric acid at room temperature

no. of days	Unblanched			Blanched		
	L*	**a***	**b***	**L***	**a***	**b***
1	72.94	2.41	8.59	72.94	2.41	8.59
3	71.56	2.47	8.72	72.67	2.48	8.69

B. Colour of samples in cold storage (15°C)

B.1 Colour of control samples in cold storage (15°C)

no. of days	Unblanched			Blanched		
	L*	**a***	**b***	**L***	**a***	**b***
1	72.94	2.41	8.59	72.94	2.41	8.59
3	72.83	2.43	8.59	72.82	2.42	8.59
5	72.4	2.44	8.61	72.14	2.44	8.62
7	71.98	2.47	8.63	71.99	2.45	8.63
10	71.19	2.52	8.66	71.2	2.53	8.67
15	70.54	2.55	8.7	71.55	2.57	8.71

B.2 Colour of samples treated with hot water in cold storage (15°C)

no. of days	Unblanched			Blanched		
	L*	a*	b*	L*	a*	b*
1	72.94	2.41	8.59	72.94	2.41	8.59
3	72.82	2.43	8.6	72.83	2.42	8.57
5	72.51	2.44	8.62	72.53	2.54	8.55
7	72.06	2.46	8.62	72.46	2.58	8.62
10	71.98	2.47	8.65	72.32	2.58	8.65
15	71.89	2.52	8.69	71.14	2.76	8.7

B.3 Colour of samples treated with salt solution in cold storage (15°C)

no. of days	Unblanched			Blanched		
	L*	a*	b*	L*	a*	b*
1	72.94	2.41	8.59	72.94	2.41	8.59
3	72.89	2.42	8.57	72.91	2.93	8.56
5	72.49	2.42	8.58	72.53	2.43	8.56
7	71.94	2.43	8.6	72.01	2.42	8.54
10	71.74	2.46	8.62	71.89	2.39	8.54
15	71.08	2.48	8.64	71.64	2.31	8.49

B.4 Colour of samples treated with citric acid in cold storage (15°C)

no. of days	Unblanched			Blanched		
	L*	**a***	**b***	**L***	**a***	**b***
1	72.94	2.41	8.59	72.94	2.41	8.59
3	72.91	2.43	8.56	72.93	2.43	8.58
5	72.87	2.43	8.54	72.92	2.43	8.56
7	72.91	2.44	8.54	72.91	2.43	8.54
10	72.71	2.49	8.54	72.71	2.43	8.54
15	72.7	2.51	8.62	72.7	2.44	8.58

C. Colour of samples at 3°C

C.1 Colour of control samples at 3°C

no. of days	Unblanched			blanched		
	L*	**a***	**b***	**L***	**a***	**b***
1	72.94	2.41	8.59	72.94	2.41	8.59
3	72.83	2.43	8.59	72.82	2.42	8.59
5	72.67	2.44	8.61	72.24	2.44	8.61
7	72.37	2.46	8.63	71.97	2.45	8.63
10	71.88	2.51	8.66	71.56	2.52	8.65
15	71.46	2.54	8.67	71.45	2.56	8.7
30	70.44	2.61	8.68	71.12	2.66	8.88

C.2 Colour of samples treated with hot water at 3°C

no. of days	Unblanched			blanched		
	L*	a*	b*	L*	a*	b*
1	72.94	2.41	8.59	72.94	2.41	8.59
3	72.9	2.43	8.59	72.82	2.42	8.59
5	72.77	2.43	8.6	72.14	2.43	8.6
7	72.37	2.45	8.61	71.87	2.44	8.62
10	71.98	2.49	8.64	71.66	2.51	8.64
15	71.56	2.51	8.65	71.35	2.54	8.68
30	71.34	2.59	8.67	71.22	2.65	8.78

C.3 Colour of samples treated with salt solution at 3°C

no. of days	Unblanched			blanched		
	L*	a*	b*	L*	a*	b*
1	72.94	2.41	8.59	72.94	2.41	8.59
3	72.9	2.42	8.58	72.8	2.42	8.49
5	72.86	2.42	8.58	72.23	2.42	8.59
7	72.46	2.43	8.61	71.76	2.43	8.61
10	71.87	2.47	8.63	71.51	2.52	8.64
15	71.57	2.5	8.64	71.35	2.54	8.67
30	71.33	2.56	8.65	71.12	2.55	8.77

C.4 Colour of samples treated with citric acid at 3°C

no. of days	Unblanched			blanched		
	L*	**a***	**b***	**L***	**a***	**b***
1	72.94	2.41	8.59	72.94	2.41	8.59
3	72.9	2.42	8.6	72.79	2.42	8.48
5	72.85	2.43	8.61	72.33	2.43	8.57
7	72.35	2.43	8.63	71.66	2.44	8.61
10	71.57	2.46	8.63	71.52	2.51	8.63
15	71.47	2.49	8.64	71.45	2.53	8.64
30	71.32	2.54	8.67	71.22	2.54	8.67

D. Colour of control samples at -20°C

D.1 Colour of control samples at -20°C

no. of days	Unblanched			blanched		
	L*	a*	b*	L*	a*	b*
1	72.94	2.41	8.59	72.94	2.41	8.59
3	72.9	2.42	8.6	72.69	2.42	8.47
5	72.84	2.42	8.61	72.43	2.42	8.47
7	72.44	2.44	8.62	71.56	2.43	8.52
10	71.47	2.45	8.62	71.52	2.5	8.62
15	71.36	2.47	8.63	71.44	2.52	8.63
30	71.34	2.53	8.68	71.23	2.53	8.66
45	70.98	2.56	8.69	71.11	2.54	8.67

60	70.77	2.61	8.71	70.87	2.54	8.67
90	70.56	2.66	8.88	70.67	2.55	8.77
120	70.12	2.75	8.89	70.35	2.57	8.86
150	69.65	2.89	8.97	69.57	2.68	8.98
180	68.01	3.18	9.01	69.97	2.99	9.11

D.2 Colour of samples treated with hot water at -20°C

no. of days	**Unblanched**			**blanched**		
	L*	a*	b*	L*	a*	b*
1	72.94	2.41	8.59	72.94	2.41	8.59
3	72.87	2.43	8.68	72.69	2.42	8.58
5	72.85	2.43	8.61	72.43	2.42	8.58
7	72.38	2.45	8.62	71.77	2.43	8.51
10	71.47	2.46	8.62	71.53	2.47	8.56
15	71.33	2.47	8.63	71.47	2.56	8.62
30	71.29	2.51	8.65	71.37	2.55	8.65
45	70.97	2.54	8.68	71.22	2.54	8.66
60	70.87	2.61	8.71	70.87	2.56	8.67
90	70.44	2.64	8.87	70.76	2.62	8.74
120	70.14	2.73	8.88	69.97	2.68	8.76
150	69.44	2.68	8.97	69.13	2.78	8.88
180	68.99	3.08	9.1	68.11	3.02	8.99

D.3 Colour of samples treated with salt solution at -20°C

no. of days	Unblanched			Blanched		
	L*	a*	b*	L*	a*	b*
1	72.94	2.42	8.59	72.93	2.41	8.59
3	72.77	2.42	8.67	72.78	2.42	8.58
5	72.83	2.44	8.62	72.33	2.43	8.57
7	72.48	2.45	8.63	71.67	2.44	8.65
10	71.57	2.46	8.64	71.43	2.46	8.64
15	71.43	2.47	8.64	71.46	2.46	8.61
30	71.39	2.56	8.66	71.47	2.48	8.64
45	70.98	2.58	8.67	71.32	2.49	8.65
60	70.87	2.69	8.7	70.97	2.55	8.66
90	70.34	2.72	8.76	70.78	2.65	8.73
120	70.23	2.75	8.87	69.34	2.67	8.75
150	69.34	2.89	8.96	69.67	2.76	8.87
180	68.87	3.15	9.13	69.98	2.98	8.97

D.4 Colour of samples treated with citric acid at -20°C

no. of days	Unblanched			Blanched		
	L*	a*	b*	L*	a*	b*
1	72.94	2.42	8.59	72.93	2.41	8.59
3	72.75	2.43	8.67	72.88	2.42	8.58
5	72.65	2.43	8.62	72.34	2.43	8.57

7	72.48	2.45	8.64	71.77	2.44	8.65
10	71.67	2.46	8.64	71.34	2.46	8.64
15	71.53	2.48	8.65	71.45	2.47	8.61
30	71.29	2.56	8.66	71.47	2.48	8.63
45	70.88	2.57	8.67	71.34	2.53	8.64
60	70.87	2.69	8.68	70.98	2.55	8.66
90	70.24	2.71	8.75	70.87	2.65	8.7
120	70.23	2.74	8.87	69.75	2.67	8.76
150	69.23	2.89	8.95	69.45	2.81	8.87
180	69.97	3.26	9.01	68.97	2.94	8.98

APPENDIX II

A. Water activity of scraped coconut at room temperature

no. of days	Control		Hot water		Salt soln		Citric acid soln	
	UB	B	UB	B	UB	B	UB	B
1	0.956	0.955	0.955	0.955	0.954	0.953	0.955	0.954
3	0.954	0.955	0.953	0.954	0.951	0.95	0.953	0.952
5	0.954	0.953	0.953	0.953	0.895	0.89	0.952	0.951

B. Water activity of scraped coconut at cold storage (15°C)

no. of days	Control		Hot water		Salt soln		Citric acid soln	
	UB	**B**	**UB**	**B**	**UB**	**B**	**UB**	**B**
1	0.954	0.955	0.955	0.955	0.956	0.956	0.955	0.954
3	0.91	0.953	0.913	0.913	0.912	0.912	0.91	0.91
5	0.899	0.95	0.901	0.9	0.9	0.9	0.901	0.9
7	0.895	0.896	0.899	0.897	0.885	0.885	0.88	0.88
10	0.89	0.884	0.896	0.896	0.873	0.873	0.88	0.88
15	0.886	0.884	0.884	0.884	0.866	0.866	0.875	0.874

C. Water activity of scraped coconut at 3°C

no. of days	Control		Hot water		Salt soln		Citric acid soln	
	UB	**B**	**UB**	**B**	**UB**	**B**	**UB**	**B**
1	0.951	0.95	0.955	0.954	0.944	0.943	0.95	0.95
3	0.932	0.931	0.924	0.921	0.933	0.934	0.948	0.949
5	0.918	0.913	0.913	0.91	0.932	0.929	0.941	0.94
7	0.905	0.9	0.903	0.901	0.924	0.91	0.935	0.937
10	0.897	0.896	0.891	0.891	0.905	0.901	0.924	0.926
15	0.893	0.894	0.885	0.885	0.901	0.897	0.906	0.91
30	0.891	0.894	0.884	0.88	0.867	0.854	0.901	0.906

D. Water activity of scraped coconut at -20°C

no. of days	Control		Hot water		Salt soln		Citric acid soln	
	UB	B	UB	B	UB	B	UB	B
1	0.953	0.952	0.954	954	0.959	95	0.955	0.954
3	0.924	0.923	0.926	0.927	0.903	0.901	0.901	0.9
5	0.901	0.901	0.913	0.915	0.857	0.851	0.875	0.875
7	0.895	0.899	0.905	0.91	0.836	0.833	0.845	0.843
10	0.876	0.881	0.898	0.899	0.824	0.813	0.808	0.801
15	0.832	0.835	0.871	0.875	0.791	0.79	0.774	0.772
30	0.807	0.81	0.834	0.837	0.778	0.761	0.732	0.73
45	0.789	0.79	0.791	0.798	0.75	0.742	0.701	0.695
60	0.754	0.759	0.754	0.76	0.714	0.71	0.68	0.681
90	0.732	0.735	0.707	0.709	0.694	0.685	0.676	0.674
120	0.701	0.705	0.698	0.699	0.674	0.676	0.674	0.674
150	0.7	0.702	0.695	0.697	0.673	0.675	0.671	0.671

APPENDIX III

A. pH of scraped coconut at room temperature

no. of days	Control		Hot water		Salt soln		Citric acid soln	
	UB	B	UB	B	UB	B	UB	B
1	7.64	7.64	7.64	7.64	7.64	7.64	5.84	5.84
3	7.72	7.75	7.79	7.76	7.73	7.69	5.96	5.92
5	7.9	7.89	7.86	7.83	7.88	7.82	6.21	6.16

B. pH of scraped coconut at cold storage (15°C)

no. of days	Control		Hot water		Salt soln		Citric acid soln	
	UB	B	UB	B	UB	B	UB	B
1	7.64	7.64	7.64	7.64	7.64	7.64	5.84	5.84
3	7.64	7.64	7.64	7.64	7.64	7.64	5.84	5.84
5	7.64	7.65	7.66	7.65	7.63	7.7	5.9	5.85
7	7.65	7.68	7.82	7.67	7.74	7.76	5.91	5.96
10	7.79	7.71	7.84	7.74	7.75	7.82	6.05	5.99
15	7.93	7.89	7.86	7.95	7.89	7.83	6.2	6.01

C. pH of scraped coconut at 3°C

no. of days	Control		Hot water		Salt soln		Citric acid soln	
	UB	B	UB	B	UB	B	UB	B
1	7.64	7.64	7.64	7.64	7.64	7.64	5.84	5.84
3	7.64	7.64	7.64	7.64	7.64	7.64	5.84	5.84
5	7.64	7.64	7.64	7.65	7.65	7.66	5.85	5.85

7	7.65	7.65	7.66	7.67	7.67	7.66	5.91	5.86
10	7.76	7.79	7.74	7.7	7.73	7.72	6.05	5.9
15	7.89	7.84	7.87	7.85	7.81	7.8	6.1	6.07
30	8.21	8.11	8.17	8.14	8.16	8.15	6.25	6.13

D. pH of scraped coconut at -20°C

no. of days	**Control**		**Hot water**		**Salt soln**		**Citric acid soln**	
	UB	B	UB	B	UB	B	UB	B
1	7.64	7.64	7.64	7.64	7.64	7.64	5.84	5.84
3	7.64	7.64	7.64	7.64	7.64	7.64	5.84	5.84
5	7.64	7.64	7.64	7.64	7.64	7.64	5.84	5.84
7	7.67	7.66	7.66	7.65	7.65	7.64	5.85	5.84
10	7.7	7.67	7.67	7.67	7.65	7.64	5.88	5.85
15	7.71	7.69	7.68	7.69	7.68	7.66	5.91	5.89
30	7.74	7.75	7.76	7.72	7.68	7.66	5.94	5.92
45	7.78	7.8	7.78	7.77	7.74	7.7	5.95	5.94
60	7.86	7.82	7.79	7.8	7.82	7.72	5.98	5.96
90	7.88	7.85	7.84	7.82	7.83	7.79	5.99	5.98
120	7.9	7.86	7.88	7.84	7.85	7.82	6.06	6.01
150	8.12	8.02	7.98	7.91	7.89	7.85	6.12	6.09
180	8.35	8.3	8.24	8.17	8.01	7.92	6.24	6.18

APPENDIX IV

A. TPC of scraped coconut at room temperature

No. of days	Total Plate Count (cfu/g)							
	Control		Hot water		Salt soln		Citric acid soln	
	UB	B	UB	B	UB	B	UB	B
1	$.24*10^{1}$	$.15*10^{1}$	$.20*10^{1}$	$.13*10^{1}$	$.19*10^{1}$	$.12*10^{1}$	$.18*10^{1}$	$.1*10^{1}$
3	$1.5*10^{1}$	$1.4*10^{1}$	$1.3*10^{1}$	$1.1*10^{1}$	$1.1*10^{1}$	$1.0*10^{1}$	$. 8 * 10^{1}$	$. 7 * 10^{1}$
5	$2.6*10^{1}$	$2.6*10^{1}$	$2.4*10^{1}$	$2.3*10^{1}$	$2.4*10^{1}$	$2.2*10^{1}$	$2.2*10^{1}$	$2.1*10^{1}$

B. TPC of scraped coconut at cold storage (15°C)

No. of Days	Total Plate Count (cfu / g)							
	Control		Hot water		Salt soln		Citric acid soln	
	UB	B	UB	B	UB	B	UB	B
1	$.24*10^{1}$	$.15*10^{1}$	$.20*10^{1}$	$.13*10^{1}$	$.19*10^{1}$	$.12*10^{1}$	$.18*10^{1}$	$.1*10^{1}$
3	$.46*10^{1}$	$.44*10^{1}$	$.45*10^{1}$	$.44*10^{1}$	$.43*10^{1}$	$.42*10^{1}$	$.40*10^{1}$	$.39*10^{1}$
5	$.79*10^{1}$	$.77*10^{1}$	$.76*10^{1}$	$.76*10^{1}$	$.75*10^{1}$	$.74*10^{1}$	$.74*10^{1}$	$.72*10^{1}$
7	$1.18*10^{1}$	$1.17*10^{1}$	$1.15*10^{1}$	$1.14*10^{1}$	$1.14*10^{1}$	$1.13*10^{1}$	$1.12*10^{1}$	$1.1*10^{1}$
10	$1.64*10^{1}$	$1.63*10^{1}$	$1.63*10^{1}$	$1.62*10^{1}$	$1.61*10^{1}$	$1.6*10^{1}$	$1.6*10^{1}$	$1.58*10^{1}$
15	$2.61*10^{1}$	$2.6*10^{1}$	$2.6*10^{1}$	$2.6*10^{1}$	$2.59*10^{1}$	$2.58*10^{1}$	$2.56*10^{1}$	$2.54*10^{1}$

C. TPC of scraped coconut at 3°C

No. of days	Total Plate Count (cfu / g)							
	Control		Hot water		Salt soln		Citric acid soln	
	UB	B	UB	B	UB	B	UB	B
1	$.24*10^1$	$.15*10^1$	$.20*10^1$	$.13*10^1$	$.19*10^1$	$.12*10^1$	$.18*10^1$	$.1*10^1$
3	$.43*10^1$	$.42*10^1$	$.42*10^1$	$.42*10^1$	$.41*10^1$	$.41*10^1$	$.39*10^1$	$.37*10^1$
5	$.71*10^1$	$.71*10^1$	$.7*10^1$	$.69*10^1$	$.69*10^1$	$.68*10^1$	$.68*10^1$	$.65*10^1$
7	$1.0*10^1$	$1.0*10^1$	$1.0*10^1$	$1.0*10^1$	$0.9*10^1$	$0.9*10^1$	$0.9*10^1$	$0.8*10^1$
10	$1.4*10^1$	$1.4*10^1$	$1.4*10^1$	$1.4*10^1$	$1.3*10^1$	$1.3*10^1$	$1.3*10^1$	$1.2*10^1$
15	$2.1*10^1$	$2.1*10^1$	$2.1*10^1$	$2.0*10^1$	$2.0*10^1$	$2.0*10^1$	$2.0*10^1$	$1.9*10^1$
30	$2.6*10^1$	$2.6*10^1$	$2.6*10^1$	$2.6*10^1$	$2.5*10^1$	$2.5*10^1$	$2.4*10^1$	$2.4*10^1$

D. TPC of scraped coconut at -20°C

No. of days	Total Plate Count (cfu / g)							
	Control		Hot water		Salt soln		Citric acid soln	
	UB	B	UB	B	UB	B	UB	B
1	$.2*10^1$	$.2*10^1$	$.2*10^1$	$.2*10^1$	$.2*10^1$	$.2*10^1$	$.1*10^1$	$.1*10^1$
10	$.5*10^1$	$.5*10^1$	$.5*10^1$	$.5*10^1$	$.5*10^1$	$.4*10^1$	$.4*10^1$	$.3*10^1$
15	$.8*10^1$	$.8*10^1$	$.8*10^1$	$.8*10^1$	$.7*10^1$	$.7*10^1$	$.7*10^1$	$.6*10^1$

30	$1.1*10^1$	$1.1*10^1$	$1.1*10^1$	$1.1*10^1$	$1.1*10^1$	$1.0*10^1$	$1.0*10^1$	$.9*10^1$
60	$1.5*10^1$	$1.5*10^1$	$1.5*10^1$	$1.5*10^1$	$1.4*10^1$	$1.4*10^1$	$1.4*10^1$	$1.3*10^1$
120	$2.1*10^1$	$2.1*10^1$	$2.1*10^1$	$2.1*10^1$	$2.1*10^1$	$2.0*10^1$	$1.9*10^1$	$1.9*10^1$
180	$2.7*10^1$	$2.7*10^1$	$2.7*10^1$	$2.7*10^1$	$2.5*10^1$	$2.5*10^1$	$2.4*10^1$	$2.4*10^1$

APPENDIX V

CALCULATION OF OPERATING COST

A. Operational cost for Model 1

Initial cost (C)

Fabrication cost of coconut scraper including cost of material (F)	=	Rs. 8000/-
Average life of machine (S)	=	10 years
Working hours per year (C)	=	5000 hr
Salvage value (L)	=	10 % of initial cost

A) Fixed cost

1. Depreciation (D) $= \frac{\text{C-S}}{\text{LH}}$

$$= \frac{8000-800}{10\times5000}$$

$$= 0.144$$

2. Interest on investment at 12% (E) $= \frac{(\text{C+S})\times12}{2\times\text{H}\times100}$

$$= \frac{(8000+800)\times12}{2\times5000\times100}$$

$$= 0.1056$$

Total fixed cost = (D+E+F)

= 0.2496

B) Variable cost

1. Labour wages

Wages of labour (G)	=	Rs. 550/day of 8h
	=	Rs. 68.75/h

2. Cost of electrical energy

Unit cost of electricity	=	Rs 7/kwh
Energy consumption of machine	=	0.300 kwh
Cost of electricity (H)	=	Rs. 2.10/h

3. Repair and maintenance cost

At 10 % of initial cost p.a. (I)	=	$\frac{5000\times10}{800\times100}$
	=	0.625/hr
Total variable cost	=	(G+H+I)
	=	68.75 + 2.10 + 0.625
	=	71.475/-
Total operating cost	=	0.2496 + 71.475
	=	71.725/-

B. Operational cost for Model 2

Initial cost (C)

Fabrication cost of coconut scraper including cost of material (F)	=	Rs. 3500/-
Average life of machine (S)	=	3 years

Working hours per year (C) = 5000 hr

Salvage value (L) = 10 % of initial cost

A) Fixed cost

1. Depreciation (D) = $\frac{\text{C-S}}{\text{LH}}$

$$= \frac{3500-350}{10\times5000}$$

$$= 0.063$$

2. Interest on investment at 12% (E) = $\frac{(C+S)\times12}{2\times H\times100}$

$$= \frac{(3500+350)\times12}{2\times5000\times100}$$

$$= 0.0462$$

Total fixed cost = (D+E+F)

= 0.1092

B) Variable cost

4. Labour wages

Wages of labour (G) = Rs. 550/day of 8h

5. Cost of electrical energy

Unit cost of electricity = Rs 7/kwh

Energy consumption of machine = 0.300 kwh

Cost of electricity (H) = Rs. 2.10/h

6. Repair and maintenance cost

At 10 % of initial cost p.a. (I) = $\frac{3500\times10}{5000\times100}$

	=	0.7/-
Total variable cost	=	(G+H+I)
	=	71.55/-
Total operating cost	=	71.66/-

Abstract

ABSTRACT

Scraped coconut is an inevitable ingredient in south Indian dishes like chutneys, *puttu*, confectionaries, and sweet items. This is also used for the production of coconut milk, which is a common ingredient in various food items and used for the preparation of virgin coconut oil and other products. Due to the high perishability of these products, usually these are prepared instantly. Scraping with mechanical scrapers/ traditional method is tedious and less comfortable. The drudgery in the production of scraped coconut necessitated to explore the alternate possibilities for the development of mechanical devices for the same. The study also investigated the suitable packaging method and storage temperature to enhance the shelf life of the highly perishable scraped coconut.

Keeping this in mind, two models of coconut scrapers were developed and their performance evaluation was conducted based on time of scraping, efficiency and cost analysis. Analysis of shelf life of the product was also done using LDPE packaging film. Preliminary tests were done for the standardisation of preservatives, selection of packaging material, packaging method, and optimum storage conditions with respect to temperature. The quality of stored products were analysed for colour, pH, a_w, and total plate count. Sensory analysis of the scraped coconut was also performed based on taste and odour.

The results revealed that the performance of the two newly developed machines (model 1 and model 2) was found to be more efficient than existing machineries. The performance of the machine was better in terms of easiness of operation, time consumption and efficiency. The storage life of fresh scraped coconut could be increased using suitable preservatives, temperature and packaging methods. The shelf life of the product increased with decrease in temperature of storage. Citric acid was found to be the best preservative among the tested preservatives. The product could be stored for one to three days at room temperature. The samples could be stored for 30 days in cold storage condition (15^{o}C). The shelf life was increased to 90 days at 3°C, whereas at -20°C, the shelf life was increased to 180 days. However, thawing decreased the quality of the product.