

**DEVELOPMENT AND EVALUATION OF A SEED EXTRACTOR
FOR ASH GOURD AND CUCUMBER**

ANEESH MOHAN

**DEPARTMENT OF POST HARVEST TECHNOLOGY AND
AGRICULTURAL PROCESSING**

**KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND
TECHNOLOGY**

TAVANUR, MALAPPURAM - 679 573

KERALA, INDIA

2012

**DEVELOPMENT AND EVALUATION OF A SEED EXTRACTOR
FOR ASH GOURD AND CUCUMBER**

by

ANEESH MOHAN

(2010 – 18 - 107)

THESIS

Submitted in partial fulfilment of the
requirement for the degree of

Master of Technology
In
Agricultural Engineering

Faculty of Agricultural Engineering and Technology
Kerala Agricultural University

**DEPARTMENT OF POST HARVEST TECHNOLOGY AND
AGRICULTURAL PROCESSING**

**KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND
TECHNOLOGY**

TAVANUR, MALAPPURAM - 679 573

KERALA, INDIA

2012

DECLARATION

I hereby declare that this thesis entitled “**Development and evaluation of a seed extractor for ash gourd and cucumber**” is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other University or Society.

Tavanur

Aneesh Mohan

Date:

2010-18-107

Dr. Santhi Mary Mathew
Professor and Head
Department of Post Harvest Technology &
Agricultural Processing
K.C.A.E.T., Tavanur

Date:

CERTIFICATE

Certified that this thesis, entitled “**Development and evaluation of a seed extractor for ash gourd and cucumber**” is a record of research work done independently by **Mr. Aneesh Mohan (2010-18-107)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

Tavanur

Dr. Santhi Mary Mathew
Chairman
Advisory Committee

CERTIFICATE

We the undersigned members of the advisory Committee of **Mr. Aneesh Mohan (2010-18-107)** a candidate for the degree of **Master of Technology in Agricultural Engineering** majoring in **Agricultural Processing and Food Engineering** agree that this thesis entitled “**Development and evaluation of a seed extractor for ash gourd and cucumber**” may be submitted by **Er. Aneesh Mohan (2010-18-107)**, in partial fulfillment of the requirement for the degree.

Dr. Santhi Mary Mathew
Professor and Head,
Dept. of Post-Harvest Technology &
Agricultural Processing (PHT & AP)
K.C.A.E.T., Tavanur
(Chairperson)

Dr. Habeeburrahman, P.V
Professor & Head
KVK
K.C.A.E.T, Tavanur
(Member)

Dr. Sudheer, K.P.
Associate Professor
Dept. of PHT & AP
K.C.A.E.T, Tavanur
(Member)

Er. George Mathew
Associate Professor
Dept. of PHT & AP
K.C.A.E.T, Tavanur
(Member)

External Examiner

ACKNOWLEDGEMENT

I bow to the lotus feet of '**God the Almighty**' whose grace had endowed me the inner strength and confidence and blessed me with a helping hand at each step during this work.

I am immensely expressing my scrupulous gratitude to **Dr. Santhi Mary Mathew**, Professor and Head, Dept. of Post Harvest Technology and Agricultural Processing, my guide, for her avuncular guidance, unremitting support, bolstering encouragement, indefatigable concern, constructive comments, professional criticisms and in time valuation during the course of this investigation.

I would like to express my sincere thanks to **Dr.M. Sivaswami**, Dean Kelappaji College of Agricultural Engineering and Technology, Tavanur for his constant support during the course of the project work.

I also wish to place in record my sincere thanks to **Dr. Habeeburrahman, P.V**, Professor and Head, KVK, Malappuram, member of Advisory Committee, **Dr. K. Krishnakumari**, Professor, **Dr. Berin Pathrose**, Assistant Professor, KVK, Malappuram for their unrivalled encouragement and valuable helps rendered.

I am immensely thankful to **Er. George Mathew**, Associate Professor and **Dr. Sudheer, K.P**, Associate Professor, Dept. of Post Harvest Technology and Agricultural Processing, members of Advisory Committee and **Dr. Prince, M.V**, Associate Professor, Dept. of Post harvest Technology and Agricultural Processing for their constant backing of constructive suggestions and kind support.

I offer my sincere and well devoted thanks to **Dr. Musthafa Kunnathadi**, Assistant Professor (Agronomy), Department of Supportive and Allied Courses, for immense helps and deemed support to complete the research successfully.

Words would not suffice to express my gratitude to all my friends especially **Er. Edwin Benjamin, Mr. Harris, Er. Pritty S. Babu, Er. Prasanth V. Krishna, Er. Parvathy Lal, Ms. Divyasree**, for their sincere help and co-operation during the entire project work.

My heartfelt gratitude to **Mr. Manohar Krishna, Mr. Asharaf A, Mr. Sathyan N, Mr. Shebin, Mr. B. Muhammdkutty, Mr. Sudheer, Mr. Shaju** and all other workshop staff, cannot be captured in words for their co-operation and assistance during the fabrication of my project work.

I acknowledge my gratitude to **Shri. Krishnan, S.**, Associate Professor, College of Horticulture, Vellanikkara, for his timely help.

I express my thanks to all the faculty **members of Library, KCAET, Tavanur** for their ever willing help and co operation.

I am greatly indebted to my parents for their blessings, prayers, and support, without which I could not have completed this work

I once again bow my head to Him who had been constantly present with me during my work and for invigorating, enlightening and making me confident and optimistic throughout my life.

Aneesh Mohan

CONTENTS

Chapter No.	Title	Page No.
	LIST OF TABLES	VIII
	LIST OF FIGURES	IX
	LIST OF PLATES	XI
	SYMBOLS AND ABBREVIATIONS	XII
I	INTRODUCTION	01
II	REVIEW OF LITERATURE	05
III	MATERIALS AND METHODS	24
IV	RESULTS AND DISCUSSION	43
V	SUMMARY AND CONCLUSIONS	60
	REFERENCES	63
	APPENDICES	69
	ABSTRACT	86

LIST OF TABLES

Table No.	Title	Page No.
2.1	Common varieties of ash gourd grown in India	06
2.2	Common varieties of cucumber grown in India	07
2.3	Composition (per 100 g) of ash gourd and cucumber	11
4.1	Physical properties of ash gourd and cucumber	44
4.2	Performance of manual method of seed extraction	45
4.3	Performance of mechanical method of seed extraction	46
4.4	Optimisation of machine parameters for ash gourd	47
4.5	Optimisation based on germination	59
4.6	Optimisation of machine parameters for cucumber	52
4.7	Optimisation based on germination	54
4.8	Physical properties of ash gourd and cucumber seeds	57

LIST OF FIGURES

Figure No.	Title	Page No.
3.1	Round tip blade	29
3.2	Pointed tip blade	29
3.3	Seed extraction tool	32
3.4	Ash gourd holder	33
3.5	Cucumber holder	34
3.6	Front view of seed extractor	35
3.7	Side view of seed extractor	36
3.8	Top view of seed extractor	37
4.1	Effect of tool speed and blade thickness of round tip blade as extraction time for ash gourd	48
4.2	Effect of tool speed and blade thickness of pointed tip blade as extraction time for ash gourd	59
4.3	Effect of tool speed and blade thickness of round tip blade for germination of ash gourd seed	51
4.4	Effect of tool speed and blade thickness of pointed tip blade for germination of ash gourd seed	52
4.5	Effect of tool speed and blade thickness of round tip blade as extraction time for cucumber	53
4.6	Effect of tool speed and blade thickness of pointed tip blade as extraction time for cucumber	53
4.7	Effect of tool speed and blade thickness of round tip blade for germination of cucumber seed	55

4.8	Effect of tool speed and blade thickness of pointed tip blade for germination of cucumber seed	55
-----	--	----

LIST OF PLATES

Plate No.	Title	Page No.
3.1	Image analysis setup for ash gourd and cucumber	25
3.2	Texture analyzer	26
3.3	Ash gourd seed extraction	27
3.4	Cucumber seed extraction	27
3.5	Ash gourd seed extractor	28
3.6	Round tip blade	29
3.7	Pointed tip blade	29
3.8	Seed extraction tool	32
3.9	Ash gourd holder	33
3.10	Cucumber holder	33
3.11	Front view of seed extractor	35
3.12	Side view of seed extractor	36
4.1	Length and diameter of ash gourd and cucumber	43
4.2	Placental diameter of ash gourd & cucumber	43
4.3	Ash gourd seeds germination	58
4.4	Cucumber seeds germination	58

SYMBOLS AND ABBREVIATIONS

Dept.	Department
<i>et al.</i>	and others
etc.	etcetera
Fig.	figure
h	hour(s)
ha	hectare(s)
hp	horsepower
N	Newton
ϕ	diameter
i.e.	that is
d.b.	dry basis
w.b.	wet basis
KAU	Kerala Agricultural University
K.C.A.E.T	Kelappaji College of Agricultural Engineering and Technology
kg	kilograms
m	metre
q	quintals
min	minute(s)

mm	millimeter
l	litre
ml	milliliter
cc	cubic centimeter
Mt	million tonne
kWh	kilo Watt hour
MS	mild steel
GI	Galavanised Iron
rpm	revolutions per minute
conc.	concentrated
s	second(s)
Sl. No.	Serial number
/	per
%	Per cent
U.K	United Kingdom
viz.,	namely
wt	weight
HCl	Hydrochloric acid
H ₂ SO ₄	Sulphuric acid

CHAPTER I

INTRODUCTION

Vegetables are rich sources of vitamins, minerals and dietary fibres which are essential for the functioning of human body. They are considered as protective foods as their consumption prevent many diseases. Role of vegetables as source of antioxidants in prevention of new generation diseases and in delaying ageing is well recognised. Diverse climatic conditions prevailing in different parts of India ranging from tropical to extreme temperate, offer ideal situation for the cultivation of a variety of vegetable crops. According to 2010–11 statistics of global vegetable production, India is the second largest producer with a production of 137.68 Mt from 14.31 Mha (Anonymous, 2010).

Vegetable crops belonging to the cucurbitaceae family are generally known as cucurbits. The family consists of about 130 genera and 800 species (Dhiman *et al.*, 2012). It is the largest group of summer vegetable crops. These include cucumber, muskmelon, watermelon, bottle gourd, bitter gourd, pumpkin, squashes, and snake gourd (Rahman *et al.*, 2008). It consists of a wide range of vegetables either used for salad purpose (cucumber), cooking (all gourds), pickling (west Indian gherkin), dessert fruit (muskmelon, water melon) or candied or preserved (ash gourd). As a group, cucurbits occupy the largest area in India and other tropical countries. As a family, cucurbits are herbaceous annuals or perennials with a storage root and mostly moist vines. They are mesophytic or xerophytic, mainly tropical or subtropical. They are almost equally distributed in both the eastern and western hemispheres.

In general, the mesocarp of cucurbitaceous fruit can range from fleshy, in the case of cucumbers, to dry, as with certain varieties of squash and pumpkin. The fruit of some members of the family will split open at maturity to release seeds, while others remain sealed and whole. The fruit can contain anywhere from several to hundreds of seeds.

Ash gourd (*Benincasa hispida*) also known as wax gourd is one of the most valuable plants in cucurbit family. It is also known as 'kumbalam' in Malayalam, ash gourd or winter melon in English and 'petha' in Hindi. It is a popular vegetable of Kerala grown in homesteads, rice fallows and in river beds. It is an annual, climbing herb producing large fruits which are fleshy, succulent and densely hairy when young, but thickly covered with white ash like coating on maturity. Ash gourd can be successfully grown during January to March and September to December months. They are grown mainly for edible purpose and also for seed production. Fruits are harvested at both immature and mature stages; the immature one is for curry preparation whereas the mature one is for seed extraction and value addition. The fruit is harvested after completely drying the stalk. The importance of ash gourd as a vegetable crop has been long recognized due to its high nutritional value, medicinal properties and innumerable uses. The famous ayurvedic preparation 'kushmanda rasayanam' which is used as a nerval tonic and health rejuvenator is prepared using fruits of ash gourd. Regular intake of ash gourd juice early in the morning on empty stomach is recommended for fighting obesity as it promotes metabolism and prevents glucose from converting into fat (George, 2008).

Cucumbers (*Cucumis sativas*) are members of the Cucurbitaceae family. It is usually oblong shaped and when young, are covered by translucent spines, which are subsequently shed. Harvesting is done after the fruits have turned pale yellow or golden colour. It has a seed proportion of about 8-10% of the fruit weight. It has a watery unsweetened flesh (5% dry matter) and is eaten as salad or is sometimes cooked. It can be grown during January to February, June to July, and October to November months. Harvesting is done manually by cutting the wine from the fruit stalk (Rahman *et al.*, 2008).

Seed is one of the most important products from the vegetable. Seeds of appropriate characteristics are required to meet the demand of diverse agro-climatic conditions and intensive cropping systems. Sustained increase in agriculture

production and productivity is dependent on development of new and improved varieties of crops and an efficient system for timely supply of quality seeds to farmers.

In India the seed production sector has advanced in parallel with the agricultural productivity. The availability of quality seed of improved varieties and hybrids is grossly inadequate and is one of the major constraints for enhancing production. The studies made by several workers indicate that the farmers are using farm saved seeds resulting in about 80 percent of the area sown with farm saved seeds of old and obsolete varieties. The seed cost alone accounts for 50 percent of the total cost of cultivation (Anonymous, 2011).

Seed is one of the important input, which contribute to 30 % of the total production potential of any crop (Deepthi *et al.*, 1993). Efforts have been made by several researchers to mechanise the process of vegetable seed extraction. However, a deep knowledge in the physical and mechanical properties of vegetables is important to develop a suitable processing machine. In India, seed extraction of vegetables is mostly done by manual method by cutting the fruits into two or more pieces crosswise by knife. Then remove the seed along with pulp and crush with hand in excess quantity of water, remove the floating fraction and collect the seeds settling at the bottom. By doing this, there are chances for discolouration of the fingers and hands of the workers due to the alkaline nature of the juice of ash gourd and cucumber. This method is quite laborious, unhygienic and monotonous. Moreover, the cost of seed extraction from wet vegetables like ash gourd also adds to the total cost of seed production. Manual seed extraction process is quite slow, thus keeping the seeds exposed to weather for a longer period. Also the vegetable seed farmer does not find adequate labourers to get the seed extracted within the shortest possible time. On the other hand, mechanical seed extraction reduces cost of production and increases the rate of seed extraction (Deepak *et al.*, 2004). Many seed extraction machines have been developed in various parts of country for vegetables namely

chilli (Gabani and Siripurapu, 1993), tomato (Kalra *et al.*, 1983), cucumber (Wehner and Humphries, 1995), etc. These machines also cause damage to the extracted seeds since the general method adopted is crushing the whole vegetable with addition of water and pulping it. The crushing affects the seed quality by resulting in a lower germination percentage of the seeds when compared to the manual methods of extraction. The seeds are then separated by sieving. The mesocarp portion is then wasted without any use. This is not affordable in case of ash gourd, as the mesocarp may be utilised for more useful products.

Seed production and trade have not developed in the country on any scientific lines. In view of farmer's growing awareness about the use of quality seeds, mechanization will approve to be an effective solution. The available extractor crushes the mesocarp portion of both these vegetables thereby wasting the input for a variety of value added products. Also the time and cost for seed extraction have to be reduced for a better profit for the small and medium scale seed production firms. Thus it was recognised that an extractor which saves the mesocarp portion without any damage in low time and energy consumption is a necessary requirement of these firms.

Keeping this in view, the study was undertaken with the following objectives

- 1) To study the physical properties of ash gourd and cucumber related to the development of the seed extractor.
- 2) To fabricate a prototype seed extractor.
- 3) To optimise the operating parameters for best performance of the prototype.
- 4) To work out the cost analysis of newly developed seed extractor.

CHAPTER II

REVIEW OF LITERATURE

This chapter deals with a brief review of the crops, manual methods of seed extraction, seed extracting machines and the research works made by various investigators.

2.1 History and origin

2.1.1 Ash gourd

Origination of ash gourd is believed to be in Asia. The crop is widely grown in Uttar Pradesh and Delhi for preparation of 'Agra petha' and in southern states of India for using as vegetable. Ash gourd is cultivated throughout the year generally in area of tropical climate (George, 2008).

2.1.2 Cucumber

Origin of cucumber was in the great Indian center of plant origins which lies between the northern part of the Bay of Bengal and the Himalayas. Cucumber is grown throughout the year in areas having tropical climatic (Gopalakrishnan, 2007).

2.2 Agronomic aspects

Cucurbits are grown in warm soil that is fertile and well irrigated. The climate for large commercial production must be tropical or subtropical because a slight frost will kill the young cucurbits very rapidly. The soil cannot be colder than 15°C and should be between 18°C and 23°C for the most effective seed germination. Soil temperatures between 18°C and 30°C are ideal for maximum plant growth (Deyo and Malley, 2008).

2.3 Varieties

2.3.1 Ash gourd

Variability in ash gourd is limited except for size and shape of fruits. The improved varieties developed in various Institutions in India are given in the Table 2.1.

Table 2.1 Common varieties of ash gourd grown in India

Institution	Variety	Special features
Kerala Agricultural University, Thrissur	<i>KAU Local</i>	Medium sized oval to oblong fruits with high flesh thickness, fruit length 45 - 55 cm, fruit weight 6.1 - 8.1 kg, productivity 28.21 t/ha.
	<i>Indu</i>	Medium sized round fruits, tolerant to mosaic disease. Fruit length 24.3 cm, fruit breadth 23.78 cm, fruit weight 4.82 kg, productivity 24.5 t/ha.
Tamilnadu Agricultural University, Coimbatore, Tamil Nadu	<i>CO 1</i>	Fruits round, average fruit weight 5 - 6 kg, duration 140 days.
	<i>CO 2</i>	Fruits small and long spherical, average fruit weight 3 kg
APAU, Hyderabad	<i>APAU Shakthi</i>	Fruits long and cylindrical, yield 30 - 35 t/ha in 140 - 150 days.
UAS, Bangalore, Karnataka	<i>Karikumbala</i>	Local cultivar having dark green fruits without ashy coat.
	<i>Boodikumbala</i>	Local cultivar where the fruits are covered with ashy coat.

Source: Gopalakrishnan (2007)

2.3.2 Cucumber

Cucumber cultivars differ in colour of spines, shape, size, colour and shape of fruits at tender stage and mature stage. Different varieties developed in various Institutions of India are given in the Table 2.2.

Table 2.2 Common varieties of cucumber grown in India

Institution	Variety	Special features
IARI Regional Station, Katrain, Himachal Pradesh	<i>Japanese Long</i> <i>Green Straight</i> <i>Eight</i>	This introduced variety is suited to hills. It is very early and fruit length is 30 - 40 cm.
National Seeds Corporation, New Delhi	<i>Poinsette</i>	This is an introduced variety having dark green and 20 - 25 cm long fruits. It has resistance to downey mildew, powdery mildew, anthracnose and angular leaf spot diseases. Yield 20 - 25 t/ha.
Konkan Krishi Vidyapeeth, Dapoli, Maharashtra	<i>Sheetal</i>	Early variety with green fruits of medium length (25 cm) and weight (300 - 350 g). Produces 24 fruits/plant. Yield 30 - 40 t/ha during rainy season and 20 - 23 t/ha during summer in 90 days.
Dr. Y.S. Parmar Univ of Hort. & Forestry, Solan, Himachal Pradesh	<i>K90 K75</i> <i>Solan Hybrid</i>	It is an F1 hybrid suited to temperate conditions.
Tamilnadu Agricultural University, Coimbatore, Tamil Nadu	<i>CO I</i>	A selection from Kanyakumari district. Fruits are long with a characteristic narrow neck at early stage, light green colour at salad stage (7 - 8 days), with dark green strips at vegetable stage (16 days) and bright yellow with greenish yellow stripes at ripening stage. Yield 14 t/ha.

Source: Gopalakrishnan (2007)

2.4 Harvesting

Both ash gourd and cucumber are harvested during the coolest time of the day, if possible in the morning when fruits have their highest water content and are handled carefully to prevent bruising and surface injury. Harvest should not begin until the leaves and fruit have completely dried to avoid the spread of diseases. The

best method to harvest ash gourd and cucumber fruit is to cut the fruit stem from the vine at a point just above the stalk of the fruit. The fruit should never be pulled off the vine, as this will result in damage to the vine or fruit.

2.5 Physical and engineering properties

The determination of physical and engineering properties of different fruits and seeds followed by various research workers were reviewed for the study.

Thompson *et al.* (1982) reported that when piercing force for cucumber fruits is considered, the force was about five times greater for mesocarp than endocarp. This study also concluded that mesocarp and endocarp were firmer near the stem end than near the bottom end.

Zilkah and Klein (1987) reported the shape and size of detached avocado fruit. Calipers were used for determining the fruit length and diameter of the fruit. Formulae and procedures were also developed to calculate the growth kinetics of small and large fruits on the tree.

Owolarafe and Shotonde (2004) reported the physical properties required for the designing of an okra slicer, chopper and grater. The average fruit length, width and thickness were 54.60, 28.60 and 26.70 mm, respectively. True density, bulk density and porosity were also found out as 743.6 kg/m³, 450.42 kg/m³ and 39.43% respectively.

Seyed *et al.* (2006) studied about watermelon seeds of three major local Iranian varieties, *Sarakhsi*, *Kolaleh* and *Red*, at the moisture content of 4.55, 4.75 and 5.02% (w.b.) Major physical properties like linear dimensions, mean diameters, true and bulk densities and porosity were analyzed. Also this study revealed that the physical properties of watermelon seeds vary according to the varieties and is also a function of the seed moisture content, environmental and growth conditions.

Koocheki *et al.* (2007) reported about the physical properties of three common Iranian varieties of melon seeds as a function of seed moisture content varying from 4.75 to 47.6, from 5.02 to 46.81, and from 4.55 to 45.22% (w.b.) for

Ghermez, *Kolaleh* and *Sarakhsi*, respectively. Increasing moisture content was found to increase bulk density and true density. Among the varieties, *Ghermez* had the highest values of geometrical properties, in all moisture contents studied. An increase of surface area with moisture content was also observed. The maximum values of bulk density and true density among the varieties were obtained for *Kolaleh* seeds. *Ghermez* melon seed had the highest porosity which decreased with increase in moisture content.

Milani *et al.* (2007) reported about some physical properties of three common Iranian varieties of cucurbit seeds (*Riz*, *Chiny*, and *Gushty*), such as geometric properties (linear dimensions, sphericity, geometric and arithmetic mean diameters and surface area), gravimetric properties (true density, bulk density and porosity). The results showed that the mean values of all geometric properties increased with increasing moisture content.

Milza *et al.* (2007) investigated the firmness of tomato slices. The firmness of tomato slices was measured by puncture test during storage, using one of three flat-tipped cylindrical probes (3.5, 2.5 and 1.5 mm diameter) in two directions, along or perpendicular to the main axis of the fruit. The same model could be applied to all combinations of probe size and direction with the same correction for shear and compression. It suggests that shear and compression forces decay with storage time according to the same mechanism, irrespective of the measurement direction.

Haque *et al.* (2009) studied about the physical and mechanical properties of seeds of four indigenous plants in Bangladesh, namely the *Jatropha*, *Karanj*, *Castor*, and *Rubber*. Physical properties such as length, width, thickness, weight and bulk density were measured to find out the size, shape and space required by the seeds. *Jatropha* and *Castor* seeds had similar cylindrical shape with rounded tips. *Karanj* seed was found to be circular and flat. Shape of the rubber seed was rectangular, inflated but slightly flattened in thickness. Rubber seed was the heaviest (4.3 g), as its size was also biggest followed by *Karanj* (1.2 g), *Jatropha* (0.8 g) and *Castor* (0.2 g),

respectively.

Davies (2010) studied about the engineering properties of melon seeds for three different varieties: *C. edulis*, *C. vulgaris* and *C. lanatus* at various moisture contents 6.25, 6.33 and 5.21% on dry basis. The axial dimension, mean diameter, porosity, true and bulk density of the three varieties of melon seeds were determined using standard method. The results obtained from the study revealed that length, width, thickness, arithmetic and geometric diameter, ranged from 12.81 to 14.50 mm, 7.02 to 8.42 mm, 2.22 to 2.49 mm, 7.36 to 8.31 mm, 5.84 to 6.54 mm respectively.

Paksoy *et al.* (2010) reported about the physical properties of watermelon seeds depending on moisture contents and mineral compositions. Results showed the average length, width, thickness, the geometric mean diameter, thousand seed weight and unit mass of the seed were found as 10.8, 6.8, 2.3, 5.5 mm, 94.10 g and 0.089 g respectively. The bulk density decreased from 446.4 to 417.68 kg/m³, true density increased from 639 to 732 kg/m³ and porosity increased from 30.79 to 45.46%,

Arumuganathan *et al.* (2010) reported the effect of the drying methods on textural characteristics of mushrooms. The mushrooms dried by the freeze drying method showed the least firmness, with mean firmness force of 1.42 N and firmness strength of 4.27 Nmm. The highest firmness was observed in the osmo - air dried oyster mushrooms. High cutting force of 12.94 N and cutting energy of 14.73 Nmm were observed for those dried by osmo air drying. Lower force of 1.07 N and energy of 1.58 Nmm were sufficient to fracture the freeze dried mushrooms, and the highest fracture force and energy were observed for the fluidized bed dried mushrooms.

2.6 Major composition of ash gourd and cucumber

The main constituents of ash gourd and cucumber are given in the Table 2.3.

Table 2.3 Composition (per 100 g) of ash gourd and cucumber

Constituents	Ash gourd	Cucumber
Water	96.5 g	96.3 g
Fat	0.1 g	0.1 g
Protein	0.4 g	0.4 g
Carbohydrates	0.9 g	2.2 g
Fibre	0.8 g	0.4 g
Minerals	0.3 g	0.3 g

Source: Gopalan *et al.* (1994)

Major component differentiating both the vegetables is carbohydrate, which is more in cucumber. But in case of ash gourd fibre content is slightly higher than cucumber.

2.7 Seed extraction

The different methods adopted by various research workers for the extraction of vegetable seeds are reviewed and presented in this section

2.7.1 Manual Methods of Seed Extraction

Hawthorn and Pollard (1954) described the manual extraction of tomato seeds. The tomato fruits were fermented in water for three days at 20 to 35°C using sodium bicarbonate. The fruits were mixed with 10% solution of the chemical and kept for two days at room temperature. The seeds were separated by repeated washing with water. In hydrochloric acid method, 567 ml of concentrated hydrochloric acid was added to 10 l of seed and pulp mixture. The mixture was allowed to stand for 24 h and then the seeds were separated by washing.

Ritchie (1971) described the various methods of manual tomato seed extraction viz, by fermentation, using sodium carbonate, hydrochloric acid, sulphuric acid and a combination of hydrochloric acid and pectinase. In fermentation method, the seeds and pulp were squeezed from the fruit and left in a warm room for 5 to 6

days. During fermentation, the mucilage was broken down, and the seeds were washed and cleaned. The seed pulp was mixed with equal volume of 10% of sodium carbonate and left for 18 to 24 h and then washed. Exactly 567 ml of conc. HCl was added to 10 kg of fruit, stirred and after 30 min the seeds were washed. Sulphuric acid was also used in the same concentrations. Seed extraction by adding equal volume of 4% HCl acid and 0.6% pectinase enzyme to the slurry was also studied.

Silva *et al.* (1982) reported the effect of extraction procedures on tomato seed germination and vigour. Seeds were extracted by natural fermentation, HCl, pectinase and combination of enzyme and acid. Natural fermentation resulted in poor breakdown of the coating and significantly reduced seed vigour but had no effect on germination. Satisfactory breakdown of the coating was obtained by acid and enzyme treatments.

Jacqueline (1984) described the methods of seed extraction of brinjal. The fruits were beaten with wooden rollers and seeds were obtained after washing. By another method, the fruits were pulped and allowed to stand overnight in a solution of 30 g of sodium bicarbonate in one litre of warm water per kg of cut fruits. The mixture of seed and pulp was treated with 30 ml of conc. HCl per kg of pulp and stirred constantly. After 20 min, the pulp was washed and the seeds were separated. Cut fruits were soaked in equal quantity with water and allowed to ferment for 3 days. Then the fruits were squeezed and seeds were separated. For 1 kg of fruit 250 ml of water was added. The mixture of pulp and seed were washed with water to separate pulp and skin.

Gurmitsingh *et al.* (1985) carried out studies on the effect of germination on the extraction of tomato seeds. The fruits were crushed and the pulp was fermented for 24 to 120 h. Seed germination decreased with the increased duration of fermentation. The best fermentation time was 24 to 48 h.

Raymond (1985) reported wet and dry seed extraction of brinjal. In wet extraction, the fruits were crushed and the resulting mixture of seed, juice and fruit

residues were passed through a screen to separate out the gelatinous seed from the bulk of the remaining material. Extra water was added during and after crushing in order to improve the separation of seeds. In dry seed extraction, the over ripe fruits were dried in the sun until they wrinkled. The drying was accompanied by fading of the skin colour to a coppery brown colour. The fruits were then hand beaten and dried seeds were hand extracted.

Thakur and Upadhy (1990) developed a procedure for the commercial scale extraction of true potato seed from the berries. Mature berries harvested 40 to 50 days after pollination, were stored until they became soft. They are macerated with a hand operated juice extractor and debris was removed using 3.13 mm mesh netting. Seed and pulp mass was treated with 10% HCl for 20 min to free the seeds from the remaining pulp and to sterilize the surface of the seeds. It was concluded that the methods described could be useful for commercial scale extraction of potato seed.

Gowda *et al.* (1991) conducted studies on optimization of seed extraction techniques for tomato by fermentation using HCl, H₂SO₄, Sodium hydroxide and mechanical extraction under various operating conditions. The different techniques were evaluated for their extraction efficiency, quality and cost of operations. Among the different techniques adopted the use of HCl at 5% or H₂SO₄ at 4% for a soaking period of 45 min gave better seed germination. Though the cost of seed extraction was relatively high, the performance of mechanical extraction technique was found to be optimal in terms of seed quality and cost.

Agong (1993) investigated the effects of four different seed extraction procedures on germination and deterioration rates of *Solanum nigrum*. The 5% conc. HCl extraction procedure gave the highest germination (92%) on freshly extracted seeds followed by fermentation method (88%). Addition with 10% sodium carbonate gave a germination rate of 85%. The method of extraction influenced the extent of seed viability with time. The traditional method offered good seed viability after eight months of storage. It was also reported that the use of conc. HCl was appropriate

where seeds are extracted for immediate use.

2.7.2 Mechanical methods of seed extraction

Nicholas (1971) developed a mechanical vegetable seed extracting machine. Its main parts were a horizontal drum and a rotary shaft with beaters. The drum was made of GI sheets. The rotary shaft with beater rotates inside the drum. The beater had a bend MS flat holder welded to the shaft and was arranged spirally on the shaft. To this a replaceable blunt tyne was bolted. A screen holding frame was fitted at the bottom section of the frame to allow the fitting of different screens. Two outlets were provided, one at the bottom of the drum, to collect the extracted seeds and juice, coming out of the screen. The second outlet was provided at the rear end to remove the pulp. A pipe for feeding water was also attached at the top of the drum. Dry feeding of brinjal resulted in 75% seed extraction efficiency. The capacity was 10 kg of seed per hour and 93% germination was obtained.

Reed (1981) developed a pressure spray system in which the fermentation process was eliminated for cleaning the muskmelon seeds. The holes of 3 mm diameter were cut in the edge of fruit. Seeds were flushed out with a stream of water from a tap. The fruit was held over a kitchen strainer with bottom end of the fruit suspended inside the strainer. The water from the tap was fed into the stem end hole and water filled into the seed cavity. Seeds flushed out of the fruit were collected in the strainer. The fruit was then inverted and the process repeated until all seeds were removed.

Kalra *et al.* (1983) developed a tomato seed extractor. It consists of a rotary cylinder with corrugations and a helix fixed on its surface, stationary expanded metal concave, holding frame and the feeding hopper. The cylinder was rotated manually with the help of a handle mounted directly on the shaft of the drum. The tomatoes were fed onto the rotating drum through a hopper. The tomatoes were crushed and the screw conveyer mounted on the rotary cylinder passed the pulp and skin forward which was collected in first tray while the juice and seeds were collected in the

second tray. The seeds were kept for fermentation to remove the gelatinous coat. Thus this machine reduced considerably the bulk mass to be kept for fermentation. The capacity of the machine was 60 kg/h for tomatoes.

Wehner *et al.* (1983) constructed a plot scale extractor for cucumber seeds. The machine was able to extract seeds from matured cucumber fruit at the rate of about 100 fruits per minute. It recovered 98% of the seeds that could be extracted by hand. The machine consists of two counter revolving fruit crushing rollers, a rotating drum for separating the seeds from the pulp and flesh, an inter connecting gravity transfer chute and a seed collecting pan.

Brar and Harisingh (1984) designed the channel method to shorten the time consumed for tomato seed fermentation. The device consists of a thin metal channel 215 cm long, 30 cm wide and 15 cm deep separated into 8 sections by removable cross plates. 5 kg of fermented pulp poured into the first section and water was supplied at 10 to 12 l/min. The device was inclined and during rinsing the seeds are trapped on different cross plates. A 5 kg seed sample processed by this method took 8 to 10 min compared with 15 to 18 min by the conventional fermentation method.

Verma and Harisingh (1986) described a seed extracting machine for tomato, brinjal and chilies. Out of the three workers employed for operating the machine, two workers were for feeding the ripe fruits and one for receiving the seeds at the outlet. The seeds extraction rates for manual extraction were 0.223, 0.151 and 0.019 kg/h for tomatoes, brinjal and chilies, respectively, and for mechanical extractor the corresponding values were 1.25, 1.83 and 3.14 kg/h. Seed germination tests showed only little difference between manually and mechanically extracted seeds.

Kachru *et al.* (1986) reported that a rotary cylinder with corrugations on its surface could be used as seed extractor for tomato. This unit is rotated manually inside a stationary expanded metal concave supported on a holding frame and provided with a feed hopper. The clearance between the cylinder and the concave was varied from maximum 90 mm at the top feeding end to a minimum of 15 mm at the

discharge end. The speed of cylinder was maintained at 40 to 50 rpm by a handle mounted on the drum shaft. During operation, tomatoes were crushed between the corrugated cylinder and the concave metal due to shear. Auger was provided on rotary cylinder to carry the pulp and skin while the juice and seeds were collected at the bottom of the cylinder. The juice and seeds were allowed to ferment for 24 h to remove the gelatinous coat from the seed. The seeds were then separated through screening and washed cleaned and dried.

Steiner and Letizia (1986) constructed a seed cleaning sluice for fleshy fruited vegetables. It consists of three sluice gates with water injector, a water injector mixer, debris discharge unit and sluice drain with screen. Once raw seeds have entered the first sluice separation chamber, the delivery tray injector was turned off and water mixer was produced which suspended small pieces of pulp and immature seeds. When the sluice was drained, the gates were held in a horizontal position, which aids in separation. This separation was accompanied using the differential in buoyancy between fully matured seeds and the debris, pulp and immature seeds.

Kachru and Sheriff (1992) evaluated the performance of an axial flow vegetable seed extractor. Five wet vegetable fruits, viz., tomato, brinjal, watermelon, muskmelon and pumpkin were tested. The capacity of the machine ranged between 220 and 960 kg/h of vegetable fruits. The seed extraction varied from a maximum of 2.81% for brinjal to a minimum of 0.17% for tomatoes. The seed loss and mechanical damage ranged between 0.82 and 15.02% and 0.97 to 5.79% respectively.

Verma *et al.* (1992) designed an axial flow vegetable seed extracting machine. The main component of the machine is a cylindrical casing, a feeding chute, a primary cutting chamber, a crushing cum separation chamber, axially mounted cutting knives and rakes, water sprinkling system, regulating gates and seed and pulp outlets. Ripe fruits were fed into the primary chamber and sliced into small pieces by rotating blades. The fruits were further crushed in the crushing chamber. Separation of seeds from the pulp was accomplished by the water escape through the concave.

Ripe fruits of seven common Indian vegetables and its performance were compared to that of manual seed extraction. The machine facilitates vegetable seed extraction and is cheaper and faster than traditional manual methods. It was concluded that the axial flow vegetable seed extraction machine is suitable for the wet seed extraction of most Indian vegetables.

Deepthi *et al.* (1993) fabricated and tested a power operated axial flow seed extractor for tomato and cucumber. Power requirement of the machine was 2 hp which consumed an additional power of 0.5 hp for sprinkling of water. The rate of seed extraction was 40.97 kg/h and 18.06 kg/h for tomato and cucumber respectively. Percent seed losses were 4.3 and 4.91% for tomato and cucumber, respectively..

Devadas *et al.* (1993) developed a horizontal type tomato seed extractor. Main components were feed hopper, beater assembly and centrifugal basket. It was powered by 1.5 hp motor with a rotor speed of 1440 rpm. The centrifugal basket fixed to a frame collects the pulp and separated seeds. It is a batch type operation and extraction of seeds was carried out without fermenting the pulp. Extraction efficiency was 85% and capacity was 60 kg/h.

Gabani and Siripurapu (1993) fabricated a chilli seed extractor. A hopper fitted on the top of the crushing assembly encompassed a concave and star roller fitted on a shaft. A drum separator assembly, consisting of a screen and flight fitted on a shaft attached below. Here, the chillies were crushed further and the screen separates the seeds from the crushed material. A collecting pan was fitted below to collect the seeds. The mixture of seed and small skin particles was fed to cleaning unit and cleaned seeds were collected at the seed outlet.

More and Kanawade (1994) fabricated a power operated pomegranate seed extractor. The machine consisted of a hopper, shaft with knives, concave outlet chutes for seed and rind and a power transmission system. The machine was tested for its efficiency in separating the seed from a whole pomegranate seed and rind come out from separate outlets. The performance was compared with hand separation

of seeds. The seed separation efficiency of the machine was 86% and average purity of the seed was 96%. Rind separation from the seed was very efficient. The capacity of the machine was estimated as 150 kg/h.

Wehner and Humphries (1995) developed a single fruit seed extractor for cucumber to increase the speed and ease of seed removal from individual, mature cucumbers. The machine comprised of an extractor cone for excavating the seed cavity and a mean to drive it, a pail or containment vessel to collect the seed and a strainer. The machine saved about 47 s per fruit compared with manual methods and was suited for handling single fruits (or batches upto 50) by researchers requiring seeds controlled pollination. In 5 years of use, no reduction in seed recovery or germination was observed using the seed extractor, compared with hand harvest.

Mohanty *et al.* (1997) designed and developed a tomato seed extracting machine. The machine consisted of fixed cylindrical casing with a sieve and rotating shaft with cutting, crushing and conveying blades. Water was sprinkled during seed extraction. The test results of this machine using 0.5 hp motor showed that the capacity was 210.96 kg/h for tomato at 370 rpm with average seed extraction efficiency of 84.7%. The germination percentage of the seed was 82.8% without any visible damage to seeds.

Rani *et al.* (2000) developed a vegetable seed extractor for brinjal. Three important factors affecting the performance of the machine were 2, 4 and 6 mm concave clearance 8.5, 6.8 and 5.7 m/s cylinder peripheral speed and 1.76, 1.90 and 2.00 q/h feed rate. The 8.5 m/s speed provided the fastest seed extraction rate of 2.52 kg/h and highest seed recovery (91.6%). The 2 mm clearance provided a 2.98 kg/h extraction rate and 97.4% recovery. The 1.90 q/h feed rate resulted in the highest extraction rate of 2.24 kg/h. The treatment combination 2 mm clearance with 8.5 m/s cylinder speed and 1.76 q/h feed rate produced the highest seed rate extraction (3.327 kg/h) among treatments.

Kingsly and Kailappan (2001) fabricated a brinjal seed extractor. The extractor consisted of a fruit crushing chamber and seed separation unit. In the crushing chamber the brinjal fruits were crushed into pulp by the crushing rods. The pulped brinjal fruit was fed into the seed separation unit and continuously agitated at a constant agitator shaft rotating at 35 rpm. Due to difference in specific weight, the pulp floats in water and gets separated in the pulp outlet, whereas seeds sink in water and passes through a sieve kept in water and passes through a sieve kept at the bottom of the drum and gets collected in the seed outlet. The seed efficiency of the unit was 98.8 %.

Deepak *et al.* (2004) fabricated an ash gourd seed extractor. In this the cut fruit is fixed in the equipment frame and the seed along with pulp is removed using a rotating blade. The blade is connected to the motor with a flexible rotor shaft. The seed extraction of ash gourd was carried out by piercing the blade into the cut section. The capacity of the machine was 81.39 kg/h and seed extraction efficiency was 97.5%.

Baig and Kailappan (2005) fabricated a tomato seed extractor. The unit consisted of a fruit squeezing chamber, and a seed separation unit. In the fruit squeezing chamber, the tomato fruits were pressed and squeezed by a rotating screw auger and discharged to the seed separation chamber. The studs present in the rotating shaft in the seed separation chamber opens the squeezed fruit and the nozzles provided at the top sprayed water and washed the seed from the fruit flesh. The water carried the seed through the perforated cover and collected them in a removable perforated tank placed inside the main tank. The fruit flesh, after separation of seed, was collected at the end of the seed separation chamber. The fruit flesh collected could then be further processed to any desired value added product. The seed extractor had a seed extraction efficiency of 98.8%.

Kushwaha *et al.* (2005) fabricated an okra seed extractor. Studies were conducted on the effect of different cylinder speeds (5, 6 and 7 m/s), concave

clearances (7, 10 and 13 mm), moisture contents (12.3, 15.8 and 18.8% d.b.) and type of extraction drum at a feed rate of 70 kg/h on machine performance and seed quality. Three types of extractor drums namely; square head bolted, rubberised and rasp bar was used. Seed quality was evaluated for vigour index, dead seed, normal and abnormal germination. The performance of seed extractor was evaluated for its extraction efficiency, cleaning efficiency, seed loss and energy consumption at different crop and machine variables. The average energy consumption per quintal (100kg) seed was found as 1.9 kWh. The best seed quality machine performance was found at 12.3% moisture content (d.b.), 7 mm concave clearance and 5 m/s cylinder speed with the square head bolted drum extraction mechanism.

Oloko and Agbetoye (2006) developed a melon depodding machine. The major components of the machine were a frame, hopper, depodding chamber and discharge outlet. The machine was powered by a 1.5 kW, 1420 rpm single phase electric motor. The performance characteristics of the machine, including depodding efficiency, material discharge efficiency and overall efficiency, were evaluated at six operating speeds (200, 250, 300, 350, 367 and 400 rpm) and one clearance setting (10 mm) between the spiked - screw conveyor and the cylinder wall. The depodding efficiency varies between 31.8% and 62.1% while seed discharge efficiency varies between 29.7% and 74.4%. The pulp discharge efficiency varies between 38.9% and 82.4%, while the overall efficiency varies between 13.1% and 68.8%.

Aviara *et al.* (2008) developed a guna seed extractor. It works on the principle of impact from breaker arms and macerators. The seed extractor consists of a hopper equipped with flow rate control device, a seed extraction unit, winnowing unit and power system. Cleaning efficiency, cleaning loss and material retention in the seed extraction chamber, decreased with the increase in the fruit moisture content for both varieties of guna fruits, but increased with increase in material feed rate and machine speed, while percentage seed retention decreased with increase in moisture content, material feed rate and machine speed. Maximum cleaning loss was less than 30% and

percentage seed retention was high at low fruit moisture content, material feed rate and machine speed. Practically no seed damage was recorded.

Algaadi *et al.* (2011) developed a squash seed extracting machine. The seed extraction was conducted by first crushing the vegetables, then separating seeds from flesh, skin and other vegetable materials. The performance of the developed machine was evaluated based on seed loss, broken seeds, machine extraction efficiency and specific energy requirements. The evaluation was conducted at different operation conditions including different crushing drum speeds (ranging from 5.23 to 9.16 m/s), feed rates (ranging from 300 to 1200 kg/h) and wet basis vegetable moisture contents (ranging from 82.03 to 93.54%). Results revealed that the seed loss was proportional to the feed rate and inversely proportional to the moisture content.

Eliwa and Elfaith (2012) developed and evaluated a water melon seed extractor. The performance of the developed machine was evaluated based on broken seeds, seed loss, size of cutting peel, cutting efficiency machine extraction efficiency and extraction cost comparing with traditional method. It was operated by using an electrical motor 2 hp (1.5 kW). Feed rate were 20, 30 and 40 kg/min, three levels of rotational speeds 150, 250 and 350 rpm (at 1.11, 1.85 and 2.59 m/s forward speeds), two types of perforated concave holes (circular and square) and different time span of extracting after harvesting (0, 2, 4 and 6 days). Results revealed that the seed losses and damage increased with increasing cutting unit speed from 1.11 to 2.59 m/s.

2.7.3 Crop and seed germination studies

Seed quality is a multiple concept comprising several components. For a farmer, quality means suitability for sowing the seeds on his own farm. Seed health is the most important parameter.

For determining the quality by germination test, the extracted seeds have to be dried first. During drying the seed moisture evaporates into the surrounding air. Evaporation continues until the amount of water in the seed is equivalent to or in equilibrium with the amount in the air (relative humidity). This is termed the

equilibrium moisture content of seeds and varies from crop to crop. The rate at which a seed dries is a function of how fast the moisture evaporates from its surface. This in turn depends on the temperature and relative humidity of the drying air, and the rate at which moisture moves from inside the seed to the seed surface.

The ultimate object of testing for germination is to gain information with respect to field planting value of the seed and to provide results which can be used to compare the value of different seed lots. The germination capacity of a lot is the percentage by number of pure seeds which produce normal seedlings in a laboratory test. Seeds which are weak or abnormal in anyway are ignored. The higher the germination capacity, the better is the field establishment. The germination capacity in practice is the best general indication we have of a seed lot's ability to grow in the field and lots of low capacity should be rejected. Germination capacity is influenced by harvesting and subsequent storage conditions and the quality available is liable to vary from year to year.

Morton (1971) studied about the physical, chemical and medicinal properties of ash gourd. The study showed that the ash gourd can be stored safely for 6 to 12 months when kept in a dry, cool atmosphere without any bruising or other injuries.

Kalra *et al.* (1983) developed a tomato seed extractor. The seeds extracted from the machine had a germination rate of 82% against the minimum germination rate of 70% for tomato.

Kachru and Sheriff (1992) evaluated the performance of an axial flow vegetable seed extractor for tomato and brinjal. The germination was 93% for tomatoes and 59.8% for brinjal.

Deepthi *et al.* (1993) fabricated and tested a power operated axial flow seed extractor for tomato and cucumber. Tomato seeds showed a germination of 86% in manual means and 100% in axial flow seed extractor. In case of cucumber the germination were 100 and 78% respectively.

Deepak *et al.* (2004) fabricated an ash gourd seed extractor. The germination

method followed was sand method. The germination studies showed that the mechanically extracted seeds were having a germination of 85.2%.

Nerson (2007) studied seed production and germinability of cucurbit crops. He found that the germination ability of cucurbit seeds is related both to external and internal factors. Variability in germination ability of any seed population harvested at a particular site during a given season is based on inter - plant and within - plant variations. The failure of cucurbit seeds to germinate may at times have no relation to seed quality but may also be due to the lack of specific requirements. Seed quality can be affected by the maternal environment, seed maturity at harvest, extraction procedure, and storage conditions. Primary treatments can improve germination, especially when applied to poor quality seeds, or under stressful environments.

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

In this chapter the constructional features of the seed extractor are outlined. The methodologies followed for the performance evaluation of the seed extractor and for finding the qualities of the seeds extracted are also discussed.

3.1 Test sample

Ash gourd, KAU Local and cucumber, Saubhagya varieties procured from the instructional farm of K.C.A.E.T, Tavanur were used for the study.

The harvested fruits were kept 5 to 7 days for post harvest maturity by spreading in one single layer with a space between the fruits in a shade dry place under ordinary condition (Rashid and Singh, 2000).

3.2 Physical characteristics of ash gourd and cucumber

The major physical properties of ash gourd and cucumber that are required in the development of the seed extractor are fruit length, fruit diameter, fruit placental diameter and firmness. Fifteen number of each fruit were selected at random for measurement of the properties.

3.2.1 Fruit Length

The vertical distance from the fruit stalk is to be considered as the fruit length and it was determined using image analysis method. This was carried out using a standard digital camera, camera stand, computer and the AutoCAD software. The photographs were taken by fixing the camera in stand (Plate 3.1). Images were taken and processed in the computer using AutoCAD software. The outlines of the fruits were drawn. The dimensions were measured by providing proper scale factor. The maximum and minimum fruit lengths, of ash gourd and cucumber were determined (Jahromi *et al.*, 2008).



Plate 3.1 Image analysis setup for ash gourd and cucumber

3.2.2 Fruit diameter

Considering the ash gourd and cucumber as oblong shape, the maximum length between the two opposite points on the curved surface is considered as the diameter of the fruit. This influences the handling of the fruits and in the design of the holders. The maximum and minimum values of the outer diameters of both the fruits were determined using the image analysis technique as discussed in section. 3.2.1.

3.2.3 Fruit placental diameter

Fruit placenta describes the region in the central portion of the fruit where the seeds are attached with the mesocarp. The fruits were cut open and the maximum and minimum values of the placental diameters of both the fruits were accurately determined using the image analysis technique as discussed in section 3.2.1.

3.2.4 Firmness

The firmness of both the vegetables have to be found out in order to determine the penetrating force required for seed extraction. Firmness, the degree of softness is often measured using objective instruments (Mitcham *et al.*, 1996). Firmness of ash

gourd and cucumber samples were determined using a Texture analyzer (Stable Micro Systems, UK) (Plate 3.2). The samples were compressed using the standard cylindrical probe (5 mm diameter) to a depth of 35 mm under measure force in compression mode with a test speed of 2 mm/s. From the force deformation curves, the peak force is designated as firmness.



Plate 3.2 Texture analyzer

3.3 Studies on existing methods of seed extraction

3.3.1 Manual seed extraction method for ash gourd and cucumber

Fruits were harvested manually when they are fully mature and seeds reach their maximum physiological quality. The maturity of the seeds may be confirmed by cutting the fruit longitudinally and determining that the seeds separate easily from the mesocarp (George, 2008). At present the seed extraction of ash gourd and cucumber is done manually by cutting the fruits into two or more pieces as per convenience (Plate 3.3 and 3.4). Then from each cut out sections, the seeds are scraped out using fingers or knives. The extracted seeds are left for fermenting for about one to two days and then washed in water. During washing the dead seeds and pulp are removed. Hydrochloric acid at a concentration of 10% may be used to accelerate fermentation for high quality seed lots (George, 2008).



Plate 3.3 Ash gourd seed extraction Plate 3.4 Cucumber seed extraction

3.3.2 Mechanical seed extraction method for ash gourd

A prototype of ash gourd seed extractor developed in K.C.A.E.T, Tavanur was tested for its performance (Deepak *et al.*, 2004). The important parts of the machine were

- 1) Main frame
- 2) Feeding V - groove
- 3) Outer cover
- 4) Flexible shaft
- 5) Cutting blades
- 6) Seed outlet
- 7) Seed collecting drum
- 8) Power transmission system

The extraction of ash gourd seeds was carried out by cutting the fruit horizontally in to required number as per convenience and placing that section in the feeding V - groove. Then by holding the flexible shaft, the rotating cutting blades (240 rpm) is penetrated to the fruit. This scraps out the seeds from the placenta. The extracted seeds were discharged through the seed outlet to a water filled drum. The capacity, seed extraction efficiency, rate of seed extraction and germination of the extracted seeds were observed. This operation involves a lot of drudgery due to the

vibration and weight of the flexible shaft. Also due to the high rotating speed the chances for seed damages is more.



Plate 3.5 Ash gourd seed extractor

3.4 Development of seed extractor

The seed extractor consists of the following components. Seed extraction tool, motor, vegetable holder, frame and the discharging chute

3.4.1 Seed extraction tool

The seed extraction tool is the important component of the multipurpose seed extractor. Before finalising the tool the important parameters like blade tip shape, blade thickness, and operating speed were optimised.

3.4.1.1 Optimisation of seed extraction tool

3.4.1.1.1 Blade tip shape

Shape of the blade tip is a parameter which affects the speed of the seed extraction. After reviewing, blades with two shapes, a round tip and a pointed tip was

selected for this study (Fig.3.1 and 3.2 and Plate 3.6 and 3.7). Both the tips were made of MS flat having 50 mm length, 50 mm width and 2.5 mm thickness. The optimisation of the tool tip shape was based on the speed of the seed extraction and the germination percentage.

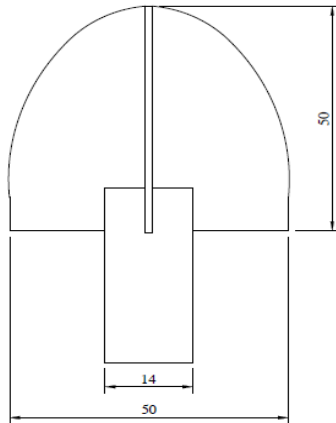


Fig. 3.1 Round tip blade

All dimensions are in mm

Scale 1:1



Plate 3.6 Round tip blade

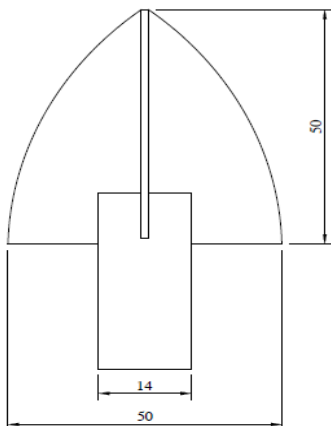


Fig. 3.2 Pointed tip blade

All dimensions are in mm

Scale 1:1



Plate 3.7 Pointed tip blade

3.4.1.1.2 Blade thickness

The thickness of the scraping blades determines the quality of the seeds and its extracting time. Rectangular MS flats with thicknesses 1, 2 and 3 mm were selected for this study. The optimisation of the blade thicknesses was based on considering the above two parameters.

3.4.1.1.3 Operational parameters - The Speed

Speed of rotation of the seed extracting tool is an operational parameter which may affect quality of the seeds, extraction efficiency and the capacity (Wehner and Humphries, 1995). Four rotational speeds 50, 80, 120 and 160 rpm were chosen for the study. The speed of operation is optimized for both the vegetables by considering the above parameters.

3.4.1.2 Shaft

A shaft was made out of MS rod having a length of 364 mm and diameter of 12 mm. The shaft along with the blade assembly and blade expanding mechanism has to be connected to the motor for rotating the shaft.

3.4.1.3 Penetrating tip and flexible blade assembly

Penetrating tip was made out of two pieces of MS flat having 2.5 mm thickness in a triangular shape having a base width of 50 mm and height of 50 mm. The two sides of each blade were slightly curved for easy penetration into the vegetable. One piece of the blade was cut into two equal halves and welded onto either sides of the other piece at right angle. The penetrating blades were inserted and welded firmly to a hollow bush made of MS having an internal diameter of 12 mm. The flexible blade assembly is also made of MS flat which consists of two sets of rectangular blades. First set consists of long blades having 10 x 15 x 2 mm dimensions and second consists of shorter blades with 75 x 15 x 2 mm dimensions. The longer blades were pivoted to the surface of the penetrating tips. The shorter blades were pivoted to the other end of the longer blades. Another hollow bush having an internal diameter of 12.5 mm was made and inserted to the shaft. It acts as

the follower of the blade assembly. This follower is free to slide back and forth through the shaft. Four wings were made out of MS and were welded at right angles on the outer surface of the follower. The free ends of the shorter blades were pivoted to these four wings. A compression spring having internal diameter of 12 mm was inserted between the penetrating blade and the follower. This helps in the easy returning of the follower when adjusting the tool diameter. When the follower is kept in its initial position the blade assembly has a diameter of 52 mm and when it is pushed completely towards the tip, has a diameter of 170 mm. This adjustment of the tool along with the rotary motion aids in the extraction of the seeds from ash gourd or cucumber having different ranges of seed placental diameter.

3.4.1.4 Blade expanding mechanism

The blade expanding mechanism consists of two concentric metallic cylinders made of MS. The surface of the inner cylinder is threaded externally with 8 threads per inch and the outer cylinder is threaded internally with the same pitch. The outer surface of the outer cylinder is provided with knurling for grip. The diameters of the inner and outer cylinder are 35 and 42 mm and the lengths were 100 and 80 mm respectively. This mechanism is attached to the shaft using two ball bearings of size 6001. It is connected with the blade assembly on rear side of the follower by a thrust bearing of size 51202. Rotation of the external bush clockwise or anticlockwise causes the expansion or contraction of the blades. The minimum and maximum diameter range of the tool is 52 mm to 170 mm. This helps in scraping out of the seeds from wide varieties of ash gourd and cucumber.

After optimizing, the tool was electroplated using stainless steel.

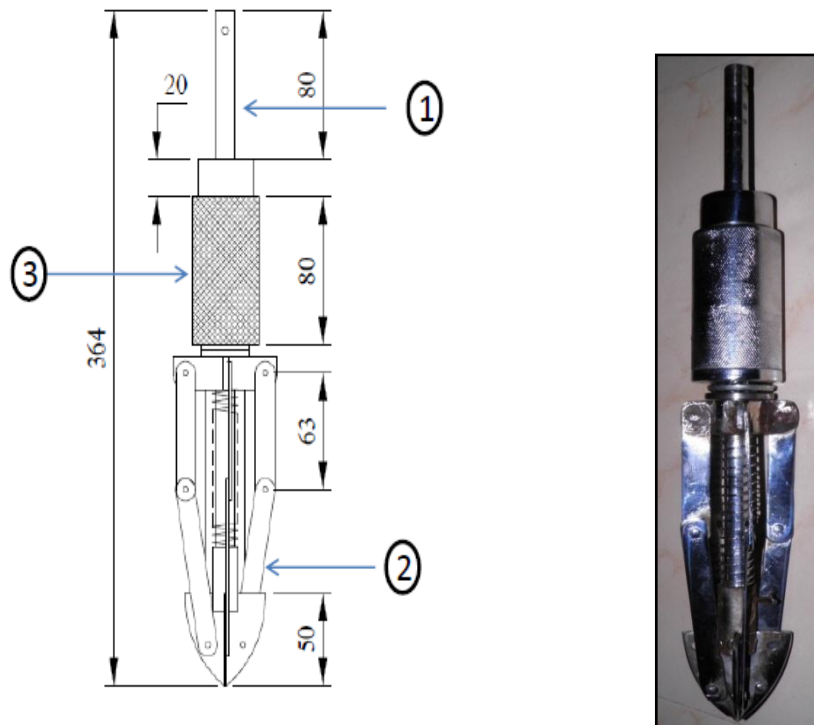


Fig. 3.3 Seed extraction tool

Plate 3.8 Seed extraction tool

All dimensions are in mm, Scale 1:3

- 1- Shaft, 2- Penetrating tip and flexible blade assembly, 3- Blade expanding mechanism

3.4.2 Motor

The free end of the shaft is connected with the motor through a bush for obtaining the rotary motion to the tool. The motor was selected based on the optimized speed of the extraction tool. The speed was optimised using a 1 hp single phase variable speed motor of 800 rpm.

3.4.3 Vegetable holder

In order to reduce the drudgery in operation, holders having the shape of an inverted frustum with MS were fabricated based on the structure and the diameter of ash gourd and the cucumber. The studies regarding the physical properties of these

fruits showed a significant difference in their diameters. Thus two separate holders were made. The diameters of the metal rings of ash gourd were 200, 165 and 125 mm and height 140 mm whereas the metal rings of cucumber holder have 132, 115 and 95 mm diameter and 140 mm height. On the top ring of the ash gourd holder four rectangular metal flats with slots were provided for adjusting the geometrical centre of vegetables in line with the tool tip. The cucumber holder was attached on the ash gourd holder and the centering and extraction can be done easily without removing it.

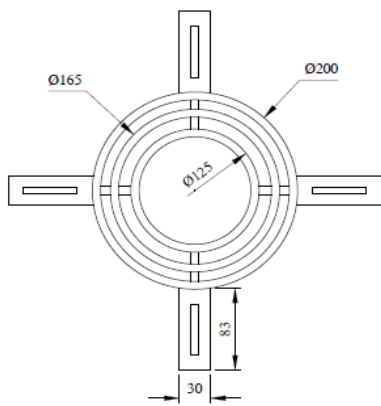


Fig. 3.4 Ash gourd holder

All dimensions are in mm; Scale 1:5



Plate 3.9 Ash gourd holder

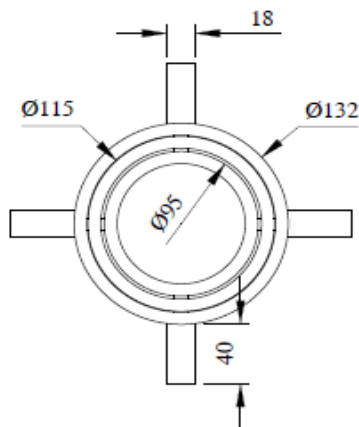


Fig. 3.5 Cucumber holder

All dimensions are in mm; Scale 1:5



Plate 3.10 Cucumber holder

3.4.4 Frame

The frame is made of 1.5 inch MS angle (35 x 35 x 5 mm). The upper portion of the frame is having a rectangular shape of 605 × 450 mm with a central square hollow portion (275 x 275 mm) for fixing the holders. Four rectangular slots each of 68 × 7 mm size are made in four sides of the square frame which are meant for attaching the holders. On the two sides of the square portion beside the center of the slots, two GI pipes each of diameter 25 mm and length 800 mm is welded at right angles to the supporting frame. These standing pipes act as the tracks for the up and down movement of the seed extracting tool along with the motor. On the central portion of the rear side of the frame another pillar made of square pipe of cross section 25 x 25 mm which acts as the hitch point for pivoting the handle for moving up and down the motor and the tool assembly. The motor is connected to the GI pipes by a connecting frame. Two bushes having 27 mm diameter and length 150 mm which are joined together by a pipe having 25 mm diameter and 440 mm length. Then the two bushes at the ends are inserted around the standing pipes and thus the connecting frame can be moved up and down through the standing pipes freely. For preventing the vibration of these pipes during lowering and rising of the tool assembly a MS flat of 25 x 5 mm and length of 450 mm is connected between the standing pillars by screwing it at its top most part.

Compression springs having 25 mm internal diameter are put around the standing pipe below the connecting frame aiding in its easy lifting. In the central portion of lower side of the connecting frame a holder for fixing the motor is attached. The handle pivoted from the square pillar is connected above the connecting frame and it is used for lowering and lifting of the tool assembly.

3.4.5 Discharging chute

The received seeds along with the pulp and water from the vegetables are directed to the seed collection vessel through the discharging chute. The dimensions of the chute were 320 x 180 mm.

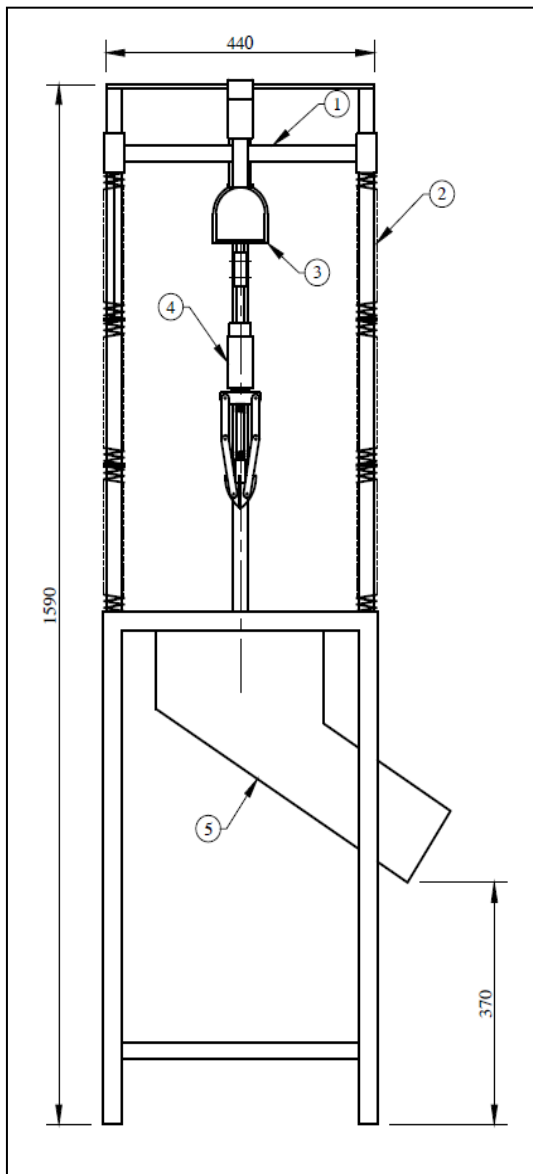


Fig. 3.6 Front view of seed extractor

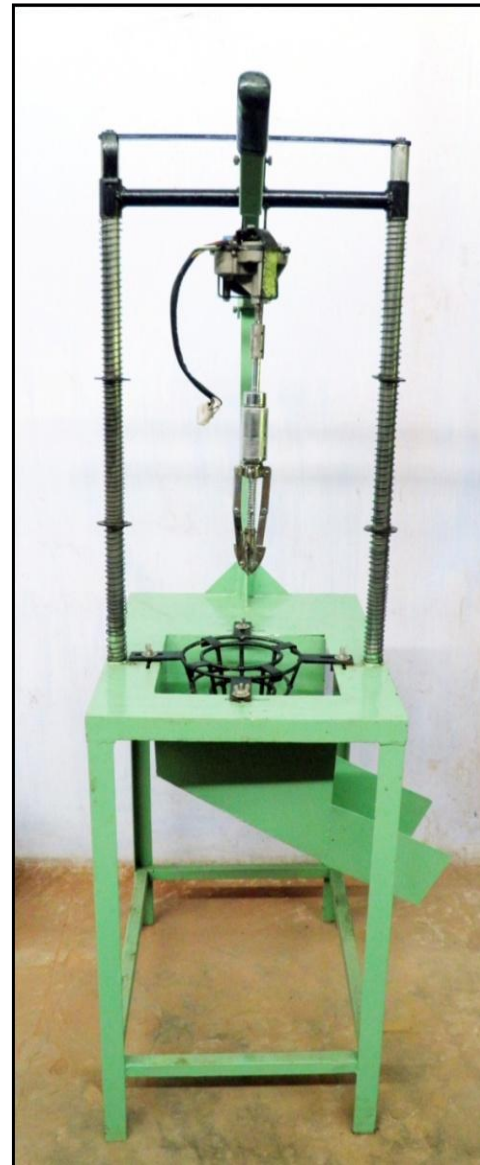


Plate 3.11 Front view of seed extractor

All dimensions are in mm, Scale 1:10

1- Connecting frame, 2- GI pipe track, 3- Motor, 4- Tool, 5- Discharging chute,
6- Handle, 7- Vegetable holder

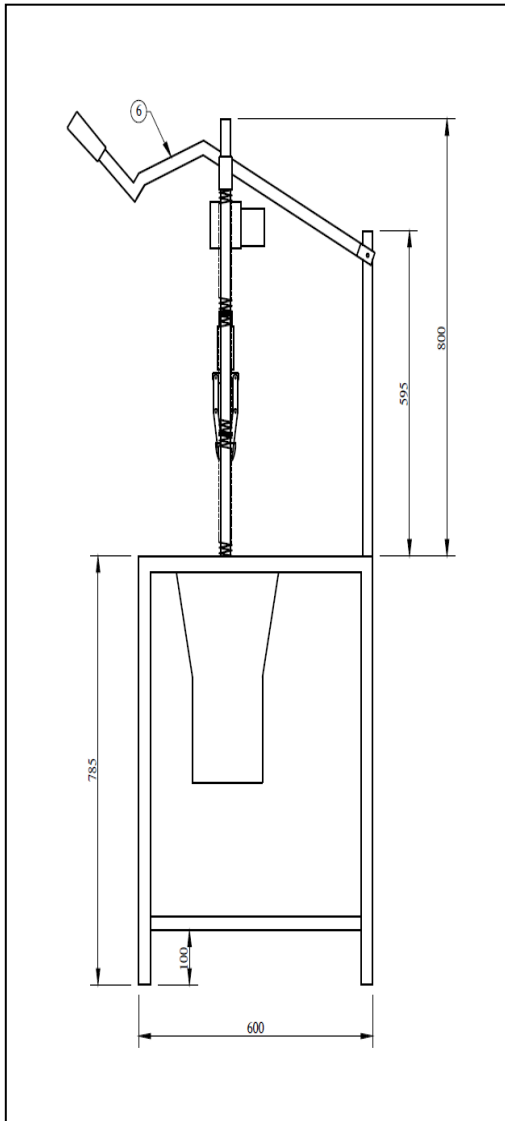


Fig. 3.7 Side view of seed extractor

All dimensions are in mm

Scale 1:10



Plate 3.12 Side view of seed extractor

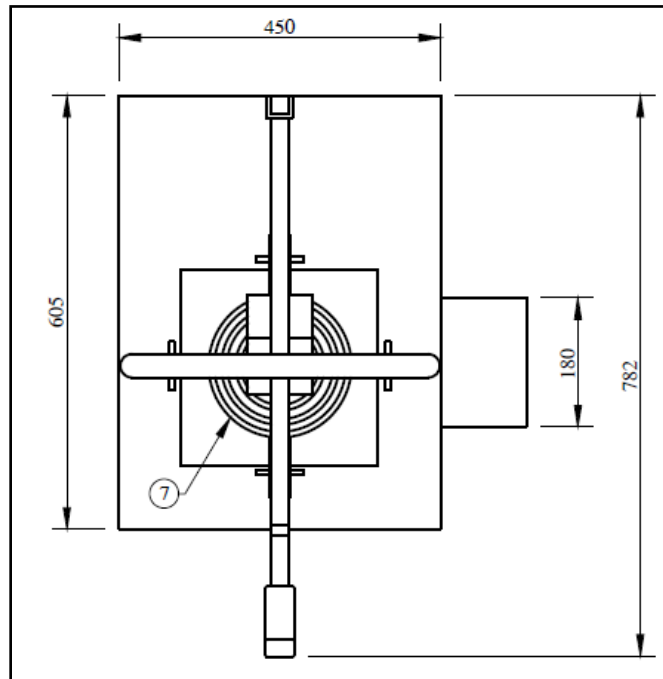


Fig. 3.8 Top view of seed extractor

All dimensions are in mm

Scale 1:8

3.5 Experimental design

The experiment was conducted as a 3 factor experiment in completely randomized design. Two blade shapes, three blade thickness and four rotational speeds were chosen whose details are given below. For each experiment, the number of replications was three.

I. Independent variables Levels of treatment

- Blade tip shape - S1(Round edged) and S2 (Pointed edged)
- Blade thickness (mm) - 1, 2 and 3
- Rotational speed (rpm) - 50, 80, 120 and 160

II. Dependent variables:

- Capacity
- Rate of seed extraction
- Seed extraction efficiency
- Seed germination

3.6 Performance evaluation of the seed extractor

The important part of the machine is the extracting tool whose diameter can be varied according to the placental diameter of the fruits. The principle is to penetrate the rotating tool with a handle, in to the placental region after adjusting its diameter which helps in scraping out the seeds along with the pulp from the centre and surrounding mesocarp portion. The seeds are then transferred to the collection vessel through the collecting chute. This is achieved by the mechanism of the seed extraction tool whose blade diameter can be varied with in a wide range of diameter (52 - 170 mm) and it can be maintained in a particular diameter for the required time.

Both the ends of the fruit which does not containing the seeds, are cut before loading to the vegetable holder. The vegetable taken for extraction is then inserted in the vegetable holder. Switch on the motor and adjust the blade diameter. Lower the handle downwards which in turn lowers the motor and the tool assembly. The rotating tool is lowered through the central portion of the vegetable and it scraps out the seeds from the surrounding mesocarp. This operation is continued until it makes a hole through it and then the scraped out seeds are discharged into the chute. Then lift the handle upwards and lock in the top most position. Repeat the experiment with the other vegetable.

3.6.1 Capacity of the seed extractor

Capacity is defined as the ratio of total weight of ash gourd or cucumber taken for seed extraction to the total time taken for the seed extraction. It is expressed in kilogram per hour.

$$\text{Capacity} = \frac{\text{Total weight of ash gourd or cucumber extracted (kg)}}{\text{Time taken for extraction(h)}} \dots\dots 3.4$$

The ash gourd and cucumber were weighed separately and the total time taken for extraction was recorded.

3.6.2 Rate of seed extraction

Rate of seed extraction was determined as the ratio of total weight of seeds extracted to the total time taken for extraction.

$$\text{Rate of seed extraction} = \frac{\text{Total weight of the seeds extracted (kg)}}{\text{Time taken for extraction (h)}} \dots\dots 3.5$$

3.6.3 Determination of seed extraction efficiency

The seed extraction efficiency was calculated from the formula

$$\text{Seed extraction efficiency (\%)} = \frac{S1}{S1 + S2} \times 100 \dots\dots 3.6$$

S1= weight of the seeds collected from seed outlet (g)

S2= weight of the seeds remaining in the fruit after extraction (g)

3.7 Quality analysis of the extracted seeds

3.7.1 Physical properties of ash gourd and cucumber seeds

The physical properties of both the seeds are determined as per the procedure given by Mohsein (1970).

3.7.1.1 True density

A jar of 100 cc volume was filled with 50 g of seeds. Similarly toluene was taken in another measuring jar of 100 cc. Then the toluene was poured into the jar containing the seeds such that it displaces the entire quantity of air in the jar containing seeds. The volume of toluene transferred to the first jar from the second jar was noted. The true density was determined based on the observations from the formula given below

$$\begin{aligned} \text{True Density} &= \frac{W_p}{V_j - V_t} && \dots\dots\dots 3.1 \\ &= \frac{W_p}{V_p} \end{aligned}$$

where,

W_p = Weight of seeds (kg)

V_t = Volume of toluene in the jar containing seeds (m^3)

V_j = Volume of the jar (m^3)

$V_p = V_j - V_t$

=Volume of the seeds (m^3)

3.7.1.2 Bulk density

The bulk density of the seeds was determined by filling seeds in circular container of known volume of 100 cc and weighing the content. The measurements were replicated. Bulk density was calculated as the ratio between the mass of seeds and volume of the container.

3.7.1.3 Porosity

Porosity is the percentage of volume of voids present in the test sample at given moisture content. It was computed from the value of true density and bulk density using the equation,

$$\text{Porosity} = 1 - \frac{\text{Bulk Density}}{\text{True Density}} \quad \dots\dots\dots 3.2$$

3.7.2 Moisture content of seeds

The moisture content after the extraction is determined as per the standard procedure given by Associates of Official Analytical Chemists (AOAC, 1975) using oven dry method. About 4 to 5 g seeds were kept in an oven maintained at a

temperature $103 \pm 1^\circ\text{C}$ for seventeen hours. The moisture content as a percentage of weight is calculated by means of the following formula.

$$\text{Moisture content (\%)} = \frac{M_2 - M_3}{M_2 - M_1} \times 100 \quad \dots\dots\dots 3.7$$

M_1 = Weight of the container and its cover (g)

M_2 = Weight of the container, cover and its contents before drying (g)

M_3 = Weight of the container, cover and its contents after drying (g)

3.7.3 Seed germination studies

After extraction allow seeds are kept along with the pulp at room temperature for 1 to 2 days. The good seeds will sink to bottom while remaining debris and immature seeds can be rinsed away.

Seeds collected are dried under shade in a thin layer on a smooth earthen floor or straw matting in shade for 3 to 4 days. The temperature should not exceed 45°C . The seeds are dried until the moisture content reaches 7% (Rashid and Singh, 2000).

The sand method of germination was followed for this study. Representative seed samples obtained by manual method, mechanical extractor, and also from the new multipurpose seed extractor were taken for the germination studies. Plastic trays were taken and fine river sand was used, after washing as germination medium. About 75 ml of water was added to the sand and make it to three fourth depth of the tray. The seeds were sprinkled with water as and when needed. The seedlings were evaluated on the tenth day of the emergence of the first seedling (final count day) and total numbers of normal seedlings were recorded. The mean number of normal seedlings emerged to the total number of seed sown was expressed as germination percentage (Agrawal, 1980).

3.8 Power requirement

Power requirement is required for calculating the cost economics of the seed extractor. Energy required at no load and loaded conditions were determined using an

energy meter by connecting in series with the motor.

3.9 Cost economics

Based on the material cost and the cost of fabrication, the total cost of the machine was worked out. Total operating cost of machine for ash gourd and cucumber were found out. The cost of seed extraction per kilogram for both the fruits by the developed seed extractor and manual method was also calculated.

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

Results and discussion of the experiments carried out on the development of a multipurpose seed extractor for ash gourd and cucumber are presented in this chapter. In this study ash gourd, KAU Local variety and cucumber, Saubhagya procured from the instructional farm of K.C.A.E.T, Tavanur were used. Also the performance of the newly developed seed extractor is discussed.

4.1 Physical characteristics of ash gourd and cucumber

Out of the fifteen samples of ash gourd and cucumber the maximum and minimum values for the length, diameter and placental diameter were found out using image analysis method as explained in 3.2.1 to 3.2.3 and are tabulated in Table 4.1



Plate 4.1 Measurement of length and diameter of ash gourd and cucumber



Plate 4.2 Measurement of placental diameter of ash gourd and cucumber

Table 4.1 Physical properties of ash gourd and cucumber

Physical properties		Ash gourd	Cucumber
Length (mm)	Minimum	190	178
	Maximum	395	258
Diameter (mm)	Minimum	156	96
	Maximum	205	147
Placental diameter (mm)	Minimum	96	55
	Maximum	147	73
Firmness (N)	Minimum	11.6	7.6
	Maximum	15.6	11.2

The length and diameter of the fruit is important in fixing the tool length and height of the vegetable holder. Here the length of ash gourd varied from 190 to 395mm whereas in cucumber it was found as 178 to 258 mm. The placental diameter of ash gourd and cucumber were determined in order to fix the maximum and minimum diameter of the tool such that it could be used for seeds extraction of both these fruits.

The minimum and maximum values of length were found out for fixing the tool length and height of the vegetable holder whereas the values of the fruit diameter were found out to fix the diameter of the holder. Similarly the minimum and maximum placental diameters were found to fix the minimum and maximum diameter of the tool. The firmness of both fruits was measured to determine its resistance to compression.

4.2 Studies on existing methods of seed extraction

4.2.1 Manual method

The seeds from the fruits were extracted manually and the capacity, rate of seed extraction, seed extraction efficiency germination percentage and time taken per kilogram for extraction were determined and presented in Table 4.2.

**Table 4.2 Performance of manual method
of seed extraction**

Item	Ash gourd	Cucumber
Capacity (kg/h)	112.0	86.6
Rate of seed Extraction (kg/h)	5.1	6.2
Seed Extraction Efficiency (%)	100	100
Germination (%)	99.5 ± 0.5	99.0 ± 0.8
Time taken per kg of fruit (s)	42.0	41.6

The performance of manual method showed that capacity of ash gourd and cucumber were 112 and 86 kg respectively. The capacity is the ratio of total weight of the fruit processed for extraction to the total time taken for extraction. The rate of seed extraction was 5.1 and 6.2 kg for ash gourd and cucumber. This is because the amount of seed per kilogram of cucumber is more than that of ash gourd. The unit weight of seed obtained per kilogram of cucumber is more than ash gourd.

The manual method gave a maximum values for both seed extraction efficiency (100%) and germination percentage (99 to 99.5%). This reveals that the seed damage in manual seed extraction is zero percent. The times taken for processing unit weight of fruit for both the vegetables are almost same (42 s).

4.2.2 Mechanical method

Before fabricating the seed extractor, a trial was conducted using the ash gourd seed extractor (Deepak *et al.*, 2004) developed in K.C.A.E.T, Tavanur and the results are given in the table 4.3.

Table 4.3 Performance of mechanical method of seed extraction

Item	Ash gourd
Capacity (kg/h)	84.3
Rate of seed Extraction (kg/h)	1.7
Seed Extraction Efficiency (%)	96.8
Germination (%)	92 ± 1.4
Time taken per kg of fruit (s)	42.0

As per the trials conducted with the above mentioned extractor the capacity was found to be 84.3 kg/h with the rate of seed extraction 1.7 kg/h which is significantly lesser than the values obtained by manual method.

Even though the efficiency of this machine is around 97%, the germination percentage is low (92%) when compared with the manual method. This may be due to the sudden impact on the seeds by the rotating blades at 240 rpm. The time taken per kilogram extraction of ash gourd is same as the manual method. In view of improving the extraction efficiency maintaining the seed germination a new mechanical seed extractor was designed and developed.

4.3 Optimisation of tool parameters for ash gourd and cucumber

The optimisation tests for the seed extractor were conducted in the laboratory to optimize the shape, thickness and the speed of rotation of the seed extracting tool for better extraction time.

4.3.1 Ash gourd

Table 4.4 Optimisation of machine parameters for ash gourd

Sl No	Treatments	Shape	Thickness (mm)	Tool speed (rpm)	Time of extraction (s)	Seed extraction efficiency (%)
1	S ₁ T ₁ N ₁	Round Edge	1	50	75.6	100.0
2	S ₁ T ₁ N ₂	Round Edge	1	80	71.0	100.0
3	S ₁ T ₁ N ₃	Round Edge	1	120	64.6	99.6
4	S ₁ T ₁ N ₄	Round Edge	1	160	57.6	100.0
5	S ₁ T ₂ N ₁	Round Edge	2	50	78.6	99.9
6	S ₁ T ₂ N ₂	Round Edge	2	80	74.3	100.0
7	S ₁ T ₂ N ₃	Round Edge	2	120	67.3	100.0
8	S ₁ T ₂ N ₄	Round Edge	2	160	61.3	100.0
9	S ₁ T ₃ N ₁	Round Edge	3	50	77.0	99.6
10	S ₁ T ₃ N ₂	Round Edge	3	80	72.3	100.0
11	S ₁ T ₃ N ₃	Round Edge	3	120	67.3	100.0
12	S ₁ T ₃ N ₄	Round Edge	3	160	60.3	100.0
13	S ₂ T ₁ N ₁	Pointed Edge	1	50	57.6	99.5
14	S ₂ T ₁ N ₂	Pointed Edge	1	80	53.3	100.0
15	S ₂ T ₁ N ₃	Pointed Edge	1	120	48.6	100.0
16	S ₂ T ₁ N ₄	Pointed Edge	1	160	41.6	100.0
17	S ₂ T ₂ N ₁	Pointed Edge	2	50	51.3	100.0
18	S ₂ T ₂ N ₂	Pointed Edge	2	80	48.3	100.0
19	S ₂ T ₂ N ₃	Pointed Edge	2	120	43.3	100.0
20	S ₂ T ₂ N ₄	Pointed Edge	2	160	38.3	100.0
21	S ₂ T ₃ N ₁	Pointed Edge	3	50	51.0	100.0
22	S ₂ T ₃ N ₂	Pointed Edge	3	80	46.6	99.7
23	S ₂ T ₃ N ₃	Pointed Edge	3	120	44.3	100.0
24	S ₂ T ₃ N ₄	Pointed Edge	3	160	39.3	99.5

S₁ and S₂ = Round tip and pointed tip ; T₁, T₂ and T₃ = 1, 2 and 3 mm thickness ;

N₁, N₂, N₃ and N₄ = 50, 80, 120 and 160 rpm

Critical difference = 1.59

Minimum extraction time and maximum germination percentage are the two important parameters determining the quality of a seed extractor. All the machine parameters should be optimised based on these two parameters. Statistical analysis was conducted based on considering the above two parameters.

In the case of ash gourd the analysis of variance revealed that the pointed tip took the minimum time of extraction when shape alone was considered. This may be due to the slight difficulty in penetrating the vegetable if the round tipped tool is used. When the effect of the pointed shape along with speed was considered minimum time was achieved in the case of 160 rpm followed by 120 rpm and 80 rpm.

From the Table 4.4 the critical difference is obtained as 1.59. When the effect of all the three parameters namely shape, thickness and the tool speed was considered the minimum extraction time was achieved with pointed tip blade at 2 mm thickness and 160 rpm, followed by the pointed tip blade with 3 mm thickness and 160 rpm (38.3 and 39.3 s respectively). Since the critical difference is 1.59, the combinations $S_2T_2N_4$ and $S_2T_3N_4$ are statistically on par. Both these combinations were significantly different from the all other combinations. Thus the combination $S_2T_2N_4$ was selected.

Fig. 4.1 and Fig. 4.2 represents the effect of two blade tip shapes on the three blade thicknesses and four tool speeds on extraction time.

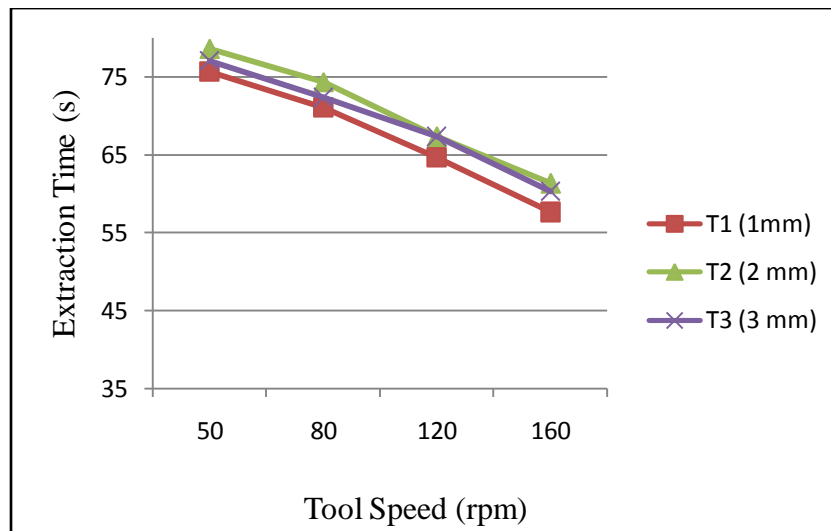


Fig. 4.1 Effect of tool speed and blade thickness of round tip blade as extraction time for ash gourd

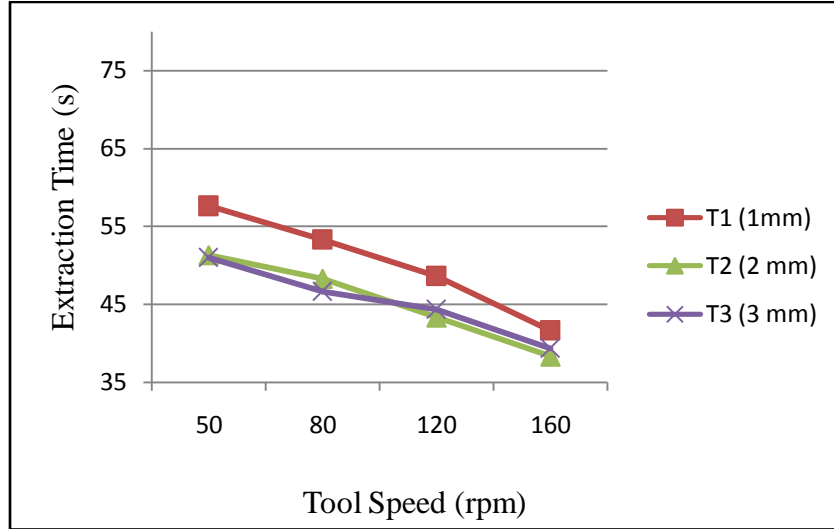


Fig. 4.2 Effect of tool speed and blade thickness of pointed tip blade as extraction time for ash gourd

The utility of an extractor could not be judged only with the minimum extraction time, but also with the quality of the seed i.e. germination percentage. So the germination studies were also conducted as per the procedure explained in section 3.9.2. For germination the ANOVA table is given in the Appendix B.2.

Table 4.5 Optimisation of ash gourd based on germination

Sl No	Treatments	Germination (%)
1	$S_1T_1N_1$	82.0
2	$S_1T_1N_2$	81.2
3	$S_1T_1N_3$	79.5
4	$S_1T_1N_4$	78.5
5	$S_1T_2N_1$	88.0
6	$S_1T_2N_2$	86.5
7	$S_1T_2N_3$	84.0
8	$S_1T_2N_4$	81.5
9	$S_1T_3N_1$	84.0
10	$S_1T_3N_2$	84.5
11	$S_1T_3N_3$	82.0
12	$S_1T_3N_4$	81.0

13	$S_2T_1N_1$	88.5
14	$S_2T_1N_2$	87.5
15	$S_2T_1N_3$	86.5
16	$S_2T_1N_4$	85.5
17	$S_2T_2N_1$	95.5
18	$S_2T_2N_2$	95.0
19	$S_2T_2N_3$	91.0
20	$S_2T_2N_4$	85.5
21	$S_2T_3N_1$	86.5
22	$S_2T_3N_2$	85.5
23	$S_2T_3N_3$	84.0
24	$S_2T_3N_4$	81.0

S_1 and S_2 = Round tip and pointed tip ; T_1 , T_2 and T_3 = 1, 2 and 3mm thickness ;
 N_1 , N_2 , N_3 and N_4 = 50, 80, 120 and 160 rpm

Critical difference = 1.24

From the Table 4.5 the critical difference is obtained as 1.24. Maximum germination for ash gourd seeds was obtained when the pointed tip was used, with the blade thickness 2 mm and 80 rpm tool speed. When higher speeds were used it caused impact on the seeds which also affected the germination. When thin blades (1 mm) were used, it caused breakage in the seeds and a higher thickness (3 mm) caused more extraction time due to difficulty in rotation of the penetrated tool when entered inside the fruit.

The combinations $S_2T_2N_1$ and $S_2T_3N_2$ are statistically on par. Both these combinations were significantly different from the all other combinations. Thus the combination $S_2T_2N_2$ was selected based on considering both the extraction time and germination percentage.

Fig. 4.3 and Fig. 4.4 represents the variation of seed germination with two blade tip shapes, three blade thicknesses and four tool speeds for ash gourd.

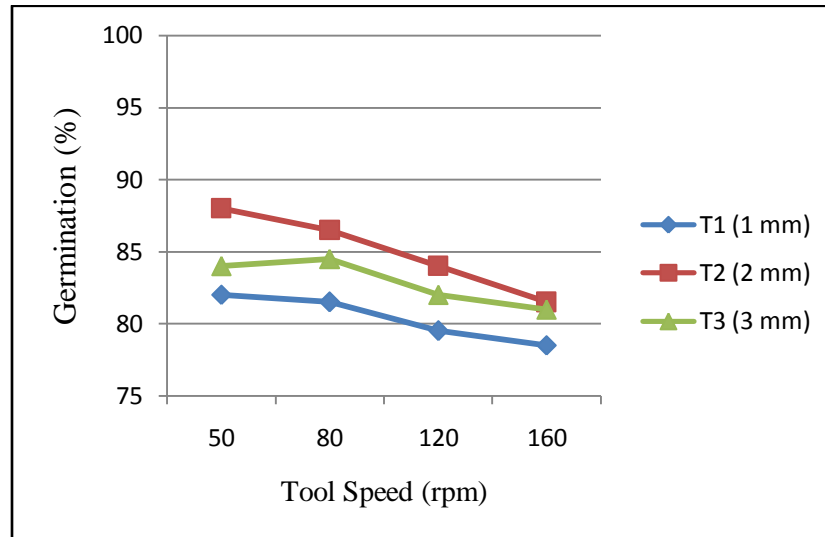


Fig. 4.3 Effect of tool speed and blade thickness of round tip blade for germination of ash gourd seed

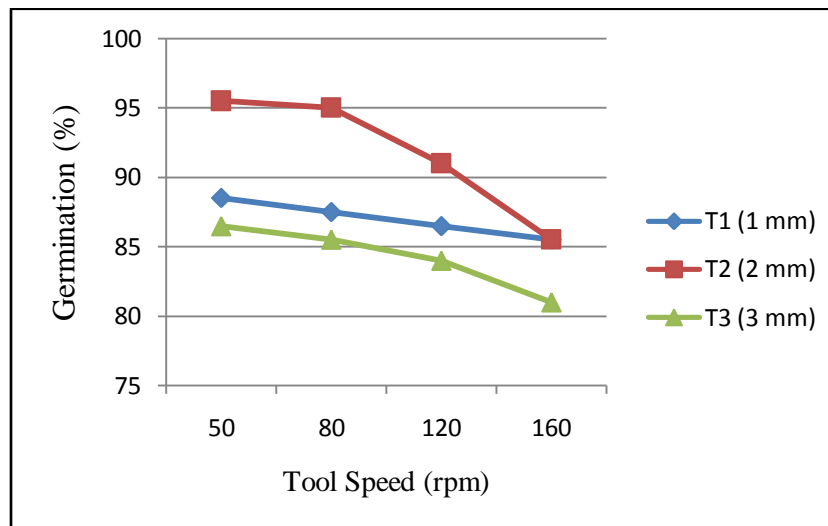


Fig. 4.4 Effect of tool speed and blade thickness of pointed tip blade for germination of ash gourd seed

4.3.2Cucumber

Table 4.6 Optimisation of machine parameters for cucumber

Sl No	Treatments	Shape	Thickness (mm)	Tool speed (rpm)	Time of extraction (s)	Seed extraction efficiency (%)
1	S ₁ T ₁ N ₁	Round Edge	1	50	31.3	99.7
2	S ₁ T ₁ N ₂	Round Edge	1	80	27.3	100.0
3	S ₁ T ₁ N ₃	Round Edge	1	120	24.6	100.0
4	S ₁ T ₁ N ₄	Round Edge	1	160	19.6	99.5
5	S ₁ T ₂ N ₁	Round Edge	2	50	30.6	100.0
6	S ₁ T ₂ N ₂	Round Edge	2	80	28.6	99.7
7	S ₁ T ₂ N ₃	Round Edge	2	120	24.3	100.0
8	S ₁ T ₂ N ₄	Round Edge	2	160	20.3	100.0
9	S ₁ T ₃ N ₁	Round Edge	3	50	32.6	100.0
10	S ₁ T ₃ N ₂	Round Edge	3	80	30.0	100.0
11	S ₁ T ₃ N ₃	Round Edge	3	120	28.3	100.0
12	S ₁ T ₃ N ₄	Round Edge	3	160	25.3	99.8
13	S ₂ T ₁ N ₁	Pointed Edge	1	50	28.0	100.0
14	S ₂ T ₁ N ₂	Pointed Edge	1	80	25.0	100.0
15	S ₂ T ₁ N ₃	Pointed Edge	1	120	22.6	100.0
16	S ₂ T ₁ N ₄	Pointed Edge	1	160	18.3	100.0
17	S ₂ T ₂ N ₁	Pointed Edge	2	50	22.3	100.0
18	S ₂ T ₂ N ₂	Pointed Edge	2	80	18.6	100.0
19	S ₂ T ₂ N ₃	Pointed Edge	2	120	13.3	100.0
20	S ₂ T ₂ N ₄	Pointed Edge	2	160	11.3	99.7
21	S ₂ T ₃ N ₁	Pointed Edge	3	50	25.3	100.0
22	S ₂ T ₃ N ₂	Pointed Edge	3	80	23.6	100.0
23	S ₂ T ₃ N ₃	Pointed Edge	3	120	21.6	100.0
24	S ₂ T ₃ N ₄	Pointed Edge	3	160	18.6	100.0

S₁ and S₂ = Round tip and pointed tip ; T₁, T₂ and T₃ = 1, 2 and 3mm thickness ;

N₁, N₂, N₃ and N₄ = 50, 80, 120 and 160 rpm

Critical difference = 1.59

In the case of cucumber when the effect of all the three parameters namely shape, thickness and the tool speed was considered minimum extraction time was achieved by the combinations S₂T₂N₄ (11.3 s), followed by S₂T₃N₃ (13.3 s).

From the Table 4.6 the critical difference is obtained as 1.59. Since the critical difference is 1.593, the combinations S₂T₂N₄ and S₂T₃N₃ are statistically on par. Both

these combinations were significantly different from the all other combinations. Thus the combination $S_2T_2N_4$ was selected.

Fig. 4.5 and Fig. 4.6 represents the variation of extraction time with blade shapes, blade thicknesses and tool speed for cucumber.

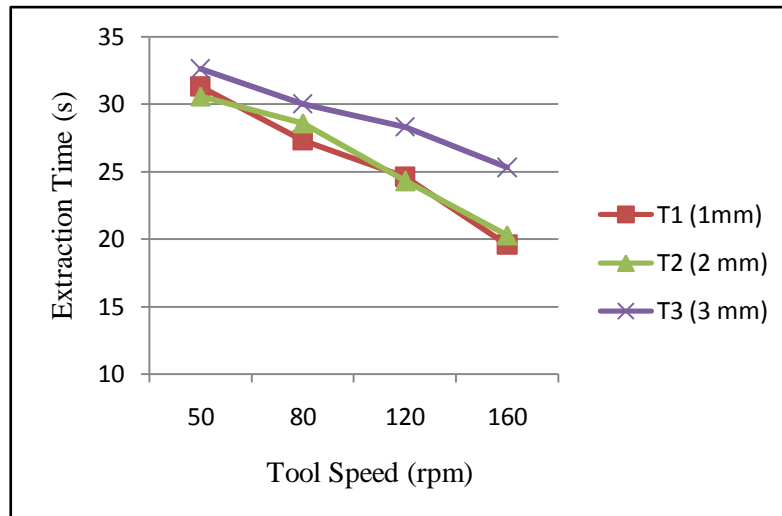


Fig. 4.5 Effect of tool speed and blade thickness of round tip blade as extraction time for cucumber

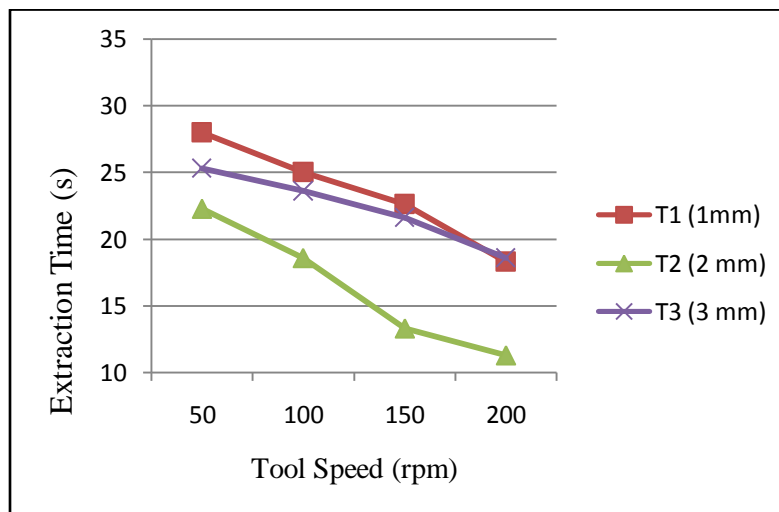


Fig. 4.6 Effect of tool speed and blade thickness of pointed tip blade as extraction time for cucumber

Since the utility of an extractor could not be judged only with the minimum extraction time, the germination studies were also conducted as per the procedure explained in section 3.9.2. The germination percentages of the seeds were considered to fix the optimal shape, thickness and tool speed. The ANOVA table for germination is given in Appendix C.2.

Table 4.7 Optimisation of cucumber based on germination

Sl No	Treatments	Germination (%)
1	S ₁ T ₁ N ₁	81.4
2	S ₁ T ₁ N ₂	79.5
3	S ₁ T ₁ N ₃	79.0
4	S ₁ T ₁ N ₄	79.5
5	S ₁ T ₂ N ₁	89.5
6	S ₁ T ₂ N ₂	83.0
7	S ₁ T ₂ N ₃	81.5
8	S ₁ T ₂ N ₄	81.5
9	S ₁ T ₃ N ₁	83.5
10	S ₁ T ₃ N ₂	84.0
11	S ₁ T ₃ N ₃	81.0
12	S ₁ T ₃ N ₄	81.0
13	S ₂ T ₁ N ₁	88.0
14	S ₂ T ₁ N ₂	87.0
15	S ₂ T ₁ N ₃	84.5
16	S ₂ T ₁ N ₄	84.0
17	S ₂ T ₂ N ₁	96.0
18	S ₂ T ₂ N ₂	96.0
19	S ₂ T ₂ N ₃	92.5
20	S ₂ T ₂ N ₄	88.0
21	S ₂ T ₃ N ₁	86.5
22	S ₂ T ₃ N ₂	85.0
23	S ₂ T ₃ N ₃	84.0
24	S ₂ T ₃ N ₄	82.5

S₁ and S₂ = Round tip and pointed tip; T₁, T₂ and T₃ = 1, 2 and 3mm thickness;

N₁, N₂, N₃ and N₄ = 50, 80, 120 and 160 rpm

Critical difference = 1.38

From the Table 4.7 the critical difference is obtained as 1.38. Maximum

germination for cucumber seeds was obtained when the combinations $S_2T_2N_1$ and $S_2T_2N_2$ were used. Both these combinations are statistically on par and were significantly different from all other combinations. So the combination $S_2T_2N_2$ was selected based on considering the germination percentage and extraction time.

Fig. 4.7 and Fig. 4.8 represents the variation of blade shapes, blade thicknesses and tool speed with the germination percentage for cucumber.

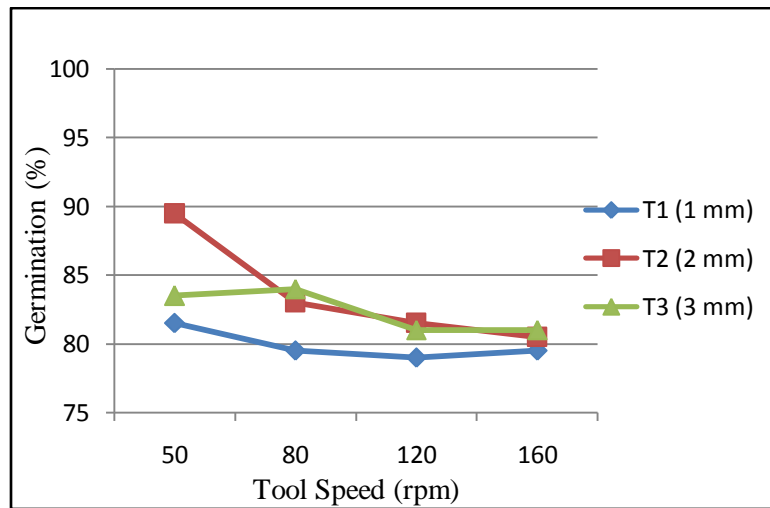


Fig. 4.7 Effect of tool speed and blade thickness of round tip blade for germination of cucumber seed

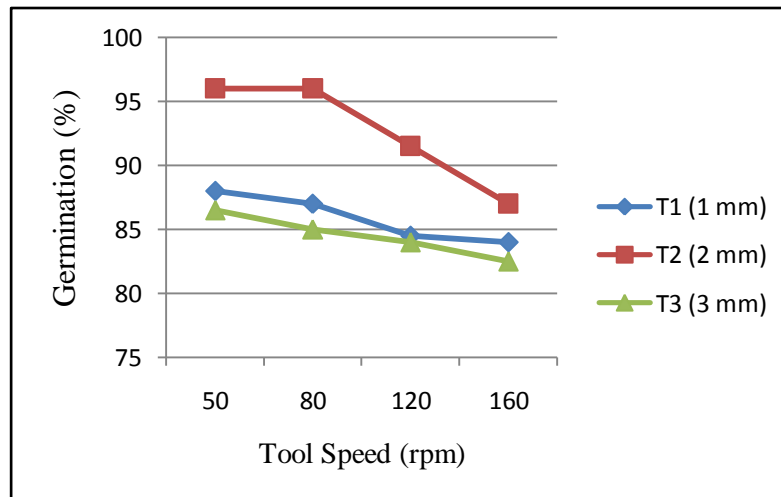


Fig. 4.8 Effect of tool speed and blade thickness of pointed tip blade for germination of cucumber seed

In ash gourd and cucumber, the tool took more time for penetration when the round edged tip was used because the load was acting on the vegetable through a larger area and the effort for the penetration was more. This was avoided by using the pointed tip blade in which the load is acted through a relatively lower area than the previous one. Thickness was another important factor determining the quality of the extracted seeds. A lower thickness of 1 mm caused injury and breakage of seeds due to the sharpness of the edge whereas a higher thickness of 3 mm caused impact damage to the seeds. So a thickness of 2 mm was optimized for further studies. A lower speed of the tool increased the time of extraction whereas a higher speed caused a shearing force in the blades which resulted in the sudden impact and crushing of the seeds. So a speed of 80 rpm was optimised for this study.

The seed extraction tool is designed in such a way that it will extract the seeds from the core of the fruit without disturbing the mesocarp. This portion will be kept intact and may be further used for production of various value added products.

4.4 Capacity of the seed extractor

The capacity of the machine for ash gourd and cucumber were determined as per the equation 3.4. For ash gourd the average capacity of the machine was 350 kg/h and for cucumber it was 219 kg/h. The time of extraction for cucumber was found to be low compared to ash gourd because of the difference in moisture content and cell structure. Also the firmness values obtained as per the texture studies as shown in Table 4.1 is higher for ash gourd than cucumber. Hence the time of extraction was found to be lesser for cucumber. But as mentioned in the section 4.2.1 the net weight of seed per kilogram of fruit is higher for cucumber when compared to ash gourd. Therefore the capacity of ash gourd seed extraction is higher than cucumber.

The capacity of the machine depends on the stage of maturity of the fruits and the skill of the operator.

4.5 Rate of seed extraction

The rate of seed extraction for ash gourd and cucumber were determined as

per the equation 3.5. The average seed extraction rate for ash gourd was 8.53 kg/h and for cucumber 16.24 kg/h.

4.6 Seed extraction efficiency

The seed extraction efficiency of the machine was calculated using the equation 3.6. For ash gourd the value is 99.8% and cucumber it is 99.9%. The results show that the seed extractor has the extractor efficiency almost 100%. This is achieved by the peculiarity of the tool by which the diameter can be varied to the required size and if any seeds are remaining in the vegetable it can be scraped out.

4.7 Quality analysis of the extracted seeds

4.7.1 Physical properties of ash gourd and cucumber seeds

The values of physical properties true density, bulk density and porosity of ash gourd and cucumber seeds were calculated. The values are mentioned in table 4.8

Table 4.8 Physical properties of ash gourd and cucumber seeds.

Physical properties	Ash gourd	Cucumber
True Density (g/cc)	0.66 ± 0.02	1.05 ± 0.01
Bulk Density (g/cc)	0.26 ± 0.01	0.55 ± 0.01
Porosity (%)	60.60 ± 1.7	48.20 ± 1.0

4.7.2 Moisture content of seeds

Moisture content was determined using oven dry method as explained in section 3.6.5.1. The moisture content of ash gourd seeds were 29% and cucumber were 31%. After this the seeds are dried to a moisture content of 7% for sowing.

4.7.3 Percentage of seeds germination

The extracted seeds are dried as described in the section 3.7.3. Fifty seeds from each treatment were sown in trays with four replications. The experiment in which the maximum germination percentage obtained is given in the Plate 4.3 and Plate 4.4 (ash gourd and cucumber).

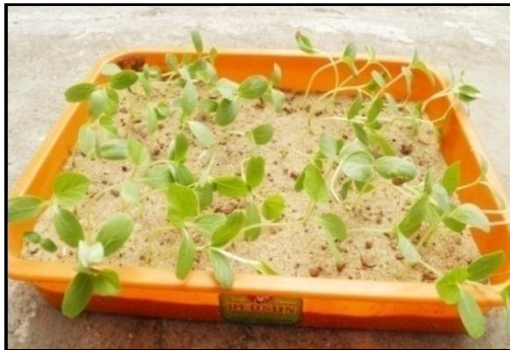


Plate 4.3 Ash gourd seeds germination Plate 4.4 Cucumber seeds germination

The maximum germination percentage with lowest extraction time was obtained when the combination $S_2T_2N_2$ was used for both ash gourd and cucumber. The average germination percentage of ash gourd seeds obtained is $95 \pm 0.5\%$ and that of cucumber seeds is $96 \pm 0.8\%$.

4.7 Power requirement

Energy required at no load and loaded conditions were determined using an energy meter. The energy meter was connected in series with the motor by running the unit without load and with load and the corresponding readings are given in the appendix D.2 and D.6. The average power consumption observed for ash gourd in loaded condition is 0.105 ± 0.001 kWh and for cucumber is 0.102 ± 0.001 kWh.

4.8 Cost economics

The cost economics for the developed seed extractor was calculated by taking the cost of one unit of electricity at ` 5.5 per kWh. Therefore the energy cost at ` 5.5 per kWh for ash gourd is ` 0.57 and cucumber is ` 0.56. Total operating cost of machine for ash gourd is ` 52.79/- and that of cucumber is ` 52.78/-. The cost of seed extraction per kilogram for ash gourd is ` 0.15/- and per kilogram for cucumber is ` 0.24/-. The cost of seed extraction per kilogram for ash gourd and cucumber by manual method is ` 0.45 and ` 0.58 respectively. The cost of seed production per kilogram for ash gourd is ` 10.3 /- and for cucumber is ` 3.0/-.

4.9 Comparison of new seed extractor with the existing methods

The capacity of the new seed extractor for ash gourd was obtained as 350 kg/h whereas the existing methods (manual and mechanical) had only 112 and 84 kg/h respectively. When the rate of seed extraction was considered, the new extractor has got 8.5 kg/h whereas the existing methods (manual and mechanical) have 5 and 2 kg/h respectively. Seed extraction efficiency and germination percentage of new extractor was around 100% and 95% which is a better result than the existing machine (96% and 92%). The time taken for extraction per kilogram of the fruit is 10.6 s for the new extractor whereas 42 s for existing methods.

In case of cucumber the capacity of new seed extractor was obtained as 218 kg/h whereas the manual method has only 87 kg/h. When the rate of seed extraction was considered, the new extractor has got 16.2 kg/h whereas the manual method has 6.2 kg/h. Seed extraction efficiency of both methods were around 100%. The germination percentage of new extractor was around 96% and the manual method was 99%. The time taken for extraction per kilogram of the cucumber is 16.6 s for the new extractor whereas 41 s for the manual method.

Thus the seed extractor for ash gourd and cucumber has got better results when most of the parameters were considered and so it may be recommended for extraction in small and medium scale farms.

Summary and Conclusions

CHAPTER V

SUMMARY AND CONCLUSIONS

The main problems faced by the small and medium scale seed production firms are the unavailability of labour and the day to day hike in labour charges. The extractors available did not complement the labour unavailability and the high seed production cost. More over the principle of seed extractors developed by various researchers is by crushing the valuable mesocarp which can be utilised for various value added products. Here is the importance of a seed extracting machine which saves time, labour charges and which can be adopted by the small and medium scale firms. To get the first hand information before fabrication of the new machine, a trial was conducted with the existing methods of seed extraction. Manual method of seed extraction and the existing ash gourd seed extractor developed in K.C.A.E.T, Tavanur were evaluated.

The manual seed extraction of ash gourd and cucumber was done by cutting the fruits into two or more pieces as per convenience using knife. Then the seeds were removed along with pulp and were rubbed with hand using water and kept for a day or two for fermenting. The seeds were washed and separated. Manual seed extraction process is quite slow, thus keeping the seeds exposed to weather for a longer period. On the other hand, mechanical seed extraction reduces cost of production and increases the rate of seed extraction. The operation of different seed extraction machines currently available involves crushing the whole fruit and the seeds are then separated using water. But the valuable mesocarp is then wasted, which is not affordable in case of ash gourd, as it can be utilized for edible purposes or for making value added products.

Keeping this in view, the study was undertaken with the following objectives

- 1) To study the physical properties of cucumber and ash gourd related for the development of the seed extractor.
- 2) To fabricate a prototype of the seed extractor.

- 3) To optimize the operating parameters for best performance of the prototype.
- 4) To work out the cost analysis of newly developed seed extractor.

Ash gourd, KAU Local and cucumber, Saubhagya variety, procured from the instructional farm of K.C.A.E.T, Tavanur were used for the study. The major physical properties of both fruits were determined. The minimum and maximum values of length were found out for fixing the tool length and height of the vegetable holder. The minimum and maximum values for the diameter were found to fix the diameter of the holder. Similarly the minimum and maximum placental diameters were found to fix the minimum and maximum diameter of the tool.

Statistical analysis was done to optimize the extraction time and germination. The experiment was conducted as a 3 factor experiment in completely randomized design. Two blade shapes, three blade thicknesses and four rotational speeds were chosen. The analysis revealed that, maximum germination percentage for ash gourd and cucumber seeds were obtained by the extraction tool when the pointed tip, 2 mm thick blades and 80 rpm tool speed were used. For seed extraction the vegetables were taken and the portion near the top and bottom ends which does not contain seeds were cut and removed. The vegetable taken for extraction is then inserted in the holder. Switch on the motor and adjust the blade diameter. Lower the handle downwards which in turn lowers the motor and the tool assembly. The rotating tool is lowered through the central portion of the vegetable and it scraps out the seeds from the surrounding mesocarp. This operation is continued until it makes a hole through it and then the scraped out seeds are discharged into the chute. Then lift the handle upwards and is locked in the top most position. Then by changing the vegetable, the extraction is repeated with the next vegetable.

According to the performance evaluation conducted, the seed extraction of ash gourd was achieved with the mean time of 48.3 s and that of cucumber with 18.6 s. The seed extraction efficiencies of both these vegetables are around 100%. The

germination studies revealed that the ash gourd seeds got 95% and cucumber seeds 96%. The capacity of the extractor for ash gourd is 350 kg/h and that of cucumber is 219 kg/h. The average energy requirement per hour for seed extraction of ash gourd is 0.105 kWh and for cucumber is 0.102 kWh. The cost of seed extraction per kilogram for ash gourd was ` 0.15/- and per kilogram for cucumber was ` 0.24/-. The cost of seed production per kilogram for ash gourd is ` 10.3 /- and for cucumber is ` 3.0/-.

The performance of this machine can be improved by incorporating a motor with more power instead of the present one by which the capacity and rate of seed extraction could be increased for both the vegetables.

References

REFERENCES

- Agong, S.G. 1993. Seed extraction procedures for long term conservation of *Solanum nigrum*. *Seed Sci. and Technol.* 21: 447-451.
- Agrawal, R.L. 1980. Seed Technology. Oxford IBH publishing Co, New Delhi.
- Algaadi, K.A., Marey, S.A. and Ahmed, S. 2011. Development and performance evaluation of a squash seed extracting machine. *Middle-East J. Sci. Res.* 7(3):352-361.
- [Anonymous]. 2010. *Farmers participatory seed production* [on line]. University of Agricultural Sciences, Dharwad. Available: <http://www.seedunituasd.in/seedunits/FormersParticipation.aspx>
- [Anonymous]. 2011. *India's fruit's and vegetable production* [on line]. Commodity Online, New Delhi. Available: <http://www.commodityonline.com/news/india-s-fruits-and-vegetable-production-register-37-growth-42155-3-42156.html>
- AOAC. 1975. Official methods of analysis. Associates of Official Analytical Chemists, Benjamin Franklin Station, Washington, 563.
- Aviara, N.A., Shittu, S.K. and Haque, M.A. 2008. Development of a guna seed extractor. *Agric. Engng. Int: The CIGR Electronic J.* Manuscript.
- Arumuganathan, T., Manikantan, M.R., Indurani, C., Rai, R.D. and Kamal, S. 2010. Texture and quality parameters of oyster mushroom as influenced by drying methods. *Int. Agrophys.* Polish Academy of Sciences. 24: 339-342.
- Baig, P.B. and Kailappan, R. 2005. Fabrication and performance evaluation of tomato seed extractor. *Agric. Mechanization in Asia, Africa, and Latin America.* 36 (2):62-66.
- Brar, P.S. and Harisingh. 1984. A new technique for tomato seed separation. *J. Res.* Punjab Agricultural University. 21(3): 463-464.
- Davies, R.M. 2010. Engineering properties of three varieties of melon seeds as potentials for development of melon processing machines. *Advance J. Fd. Sci. and Technol.* 2(1): 63-66.

- Deepak, E., Jyothilakshmi, C. and Shifa, T.D. 2004. Development and testing of a power operated ash gourd seed extractor. Unpublished B.Tech (Ag.Engg) project. Kerala Agricultural University, Thrissur.
- Deepthi, P.E., Jacintha, K. J. and Ali, M. 1993. Fabrication and testing of a power operated axial flow seed extractor. Unpublished B.Tech (Ag.Engg) project. Kerala Agricultural University, Thrissur.
- Devadas, C.T. Sivakumar, S.S. and Gothendapani, L. 1993. Tomato seed extractor. *Invention Intell.*7: 139-140.
- Deyo, A. and Malley, B.O. 2008. Cucurbitaceae. *Food for Thought: The Science, Culture, & Politics of Food*. Hamilton College.
- Dhiman, K.A., Gupta, D.K., Sharma, N.S.G. and Goyal, A. 2012. A review on the medicinally important plants of the family cucurbitaceae. *Asian J. Clin. Nutr.* 4:16-26.
- Eliwa, A.A. and Elfatih, A. 2012. Developing a local extraction watermelon seeds machine. *J. Appl. Sci. Res.* 8(1): 474-482.
- Gabani, S. H. and Siripurapu, S.C.B. 1993. Chilli seed extractor. *Spice India.* 9: 5-8.
- George, T.E. 2008. Ash gourd, High Nutritional. *Kerala Calling.* 28(11): 35-37.
- Gopalakrishnan, T.R. 2007. *Horticulture sciences series, Vegetable Crops*. New India Publishing Agency, Pitam Pura, New Delhi.
- Gopalan, C.G., Rama, B.V. and Balasubramaniam, S.C. 1994. Nutritive value of Indian foods. *National Institute of Nutrition*. Indian Council of Medical Research, Hyderabad.
- Gowda, J., Talukdar, S.K.C. and Ramaiah, H. 1991. Optimization of seed extraction techniques in tomato. *Seeds and Farms.* 17 (3):15-17.
- Gurmitsingh, Harisingh and Dillon, T.S. 1985. Some aspect of seed extraction in tomato. *Seed Res.* 13(2): 67-72.
- Haque, M.A., Islam, M. P., Hussain, M.D. and Khan, F. 2009. Physical, mechanical properties and oil content of selected indigenous seeds available for biodiesel

- production in Bangladesh. *Agric. Engng. Int: The CIGR Electronic J. Manuscript*.
- Hawthorn, L.R. and Pollard, L.H. 1954. Vegetable and flower seed production. The Blakiston Company Inc. New York . pp: 208-238.
- Jacqueline, A.S. 1984. Studies on certain aspects of production, processing and storage of Brinjal seed. Unpublished Ph.D thesis. Tamil Nadu Agricultural University, Coimbatore.
- Jahromi, M.K., Jafari, A., Rafiee, S., Mirasheh, R. and Mohtasebi, S.S. 2008. Mass modeling of date fruit with some physical characteristics. *American-Eurasian J. Agric. & Environ. Sci.* 3 (1): 127-131.
- Kachru, P.P. and Sheriff, J.T. 1992. Performance evaluation of axial flow vegetable seed extractor. *Indian J. Agric. Engng.* 2(1): 37-40.
- Kachru, R.P., Srivastava, K., Bisht, B.S. and Ojha, T.P. 1986. IARI Tomato seed extractor. *100 Bankable Post harvest equipments developed in India*, Central Institute of Agricultural Engineering, Bhopal. pp: 278.
- Kalra, S.M., Kaul, K.K. and Srivastava, R. (1983). Development of tomato seed extractor. *J. Agric. Engng.* 20(3)4: 183-186.
- Kingsly, R.P. and Kailappan, R. 2001. Fabrication and performance evaluation of brinjal seed extractor. *Agric. Mechanization in Asia Africa, and Latin America.* 32(1):38-42.
- Koocheki, A., Razavi, S.M.A., Milani, E., Moghadam, T.M., Abedini, M., Alamatyian, S. and Izadkhah, S. 2007. Physical properties of watermelon seed as a function of moisture content and variety. *Inst. Agrophy. Polish Acad. Sci.* 21: 349-359.
- Kushwaha, H. L., Srivastava, A.P. and Harpalsingh. 2005. Development and performance evaluation of okra seed extractor. *Agric. Engng In: The CIGR Electronic J. Manuscript* .

- Milani, E., Seyed, M. and Razavi, A. 2007. Moisture dependent physical properties of cucurbit seeds. *Inst. Agrophy. Polish Acad. Sci. Lublin, Poland.* 21(2):157-168.
- Milza, M.L., Leopold, M.M.T. and Anemarie, T. 2007. Measurement of firmness of fresh cut sliced tomato using puncture tests – studies on sample size, probe size and direction of puncture. *J. of Texture Studies.*31: 601-618.
- Mitchem, M., Cantwell, M. and Kader, A. 1996. Methods for determining quality of fresh commodities. *Perishables Handling Newsletter.*88:1-5.
- Mohanty, S.K., Nanda, S.K. and Das, D.K. 1997. Design, development and testing of a low cost vegetable seed extracting machine. *Agric. Mechanization in Asia, Africa and Latin America.* 28(4): 53-56.
- Mohsein, N.N. 1970. Physical properties of plants and animal materials. *Gordan and Breach Science Publication.* pp: 10-105.
- More, H.G. and Kanawade, C.R. 1994. Design, fabrication and testing of pomegranate seed extractor [abstract]. In: *Abstracts, International Agricultural Engineering Conference*; 399-400, December, 1994, Bangkok.
- Morton, J.F. 1971. The wax gourd, a year round Florida vegetable with unusual keeping quality. *Florida State Hort. Soc.* pp: 104-109.
- Nerson, M. 2007. Seed production and germinability of cucurbit crops. *Seed Sci. and Biotechnol.* Global Science Books. 1(1): 1-10.
- Nicholas, L. 1971. A machine for vegetable seed extraction. *J. Agric. Engng.* 8(3): 87-91.
- Oloko, S. and Agbetoye, L. 2006. Development and performance evaluation of a melon depoding machine. *Agric. Engng. Int: The CIGR Electronic J. Manuscript.*
- Owolarafe, O.K. and Shotonde, H.O. 2004. Some physical properties of fresh okra fruit. *J. Fd. Engng.* 63(3): 299-302.

- Paksoy, M., Aydin, C., Turkmen, O. and Seymen, M. 2010. Modeling of some physical properties of watermelon seeds depending on moisture contents and mineral compositions. *Pak. J. Bot.* 42(4): 2775-2783.
- Rahman, A.H., Anisuzzaman, M. and Ahmed, F. 2008. Study of nutritive value and medicinal uses of cultivated cucurbits. *J. Appl. Sci. Res.* 4(5): 555-558.
- Rani, V., Sharma, T. R. and Singh, S. 2000. Testing and evaluation of vegetable seed extractor for brinjal. *Haryana Agric. Univ. J. Res.* 30 (1): 19-24.
- Rashid, M.A. and Singh, D.P. 2000. *A manual on vegetable seed production.* Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur.
- Raymond, A.T.G. 1985. *Vegetable seed production.* Longman publishers, London. pp: 223-229.
- Reed, G.L. (1981). Pressure sprayer eliminates fermentation process for cleaning muskmelon seed. *Hort. Sci.* 16 (2): 1-91.
- Ritchie, D.B. 1971. Tomato seed extraction. *Hort. Res.* 11: 127-135.
- Seyed, M.A., Razavi and Milani, E. 2006. Some physical properties of the watermelon seeds. *African J. Agric. Res.* 1(3):65-69.
- Silva, R.F., Koch, R.B. and Moore, E.L. 1982. Effect of extraction procedures on tomato seed germination and vigour. *Seed Sci. and Technol.* 10: 187-191.
- Steiner, J.J and Letizia, B.F. 1986. A seed cleaning sluice for fleshy fruited vegetables from small plots. *Hort. Sci.* 2(4): 1066-1067.
- Thakur, K.C. and Upadhyaya, M.D. 1990. Extraction and processing of true potato seed. *Seed Sci. and Technol.* 18(3): 589-596.
- Thompson, R.L., Fleming, H.P., Hamann, D.D. and Monroe, R.J. 1982. Method for determination of firmness in cucumber slices. *J. Texture Studies.* 13:311-324.
- Verma, S.R. and Harisingh. 1986. A seed extraction machine for tomato, brinjal and chillies. *Indian Fmg.* 36(7): 23-24.

- Verma, S.R., Harisingh and Kalkat, H.S. 1992. Design aspects and performance of an axial flow vegetable seed extracting machine. *Agric. Mechanization in Asia, Africa and Latin America*. 23(2): 21-24.
- Wehner, T.C. and Humphries, E.G. 1995. A single fruit seed extractor for cucumbers. *Hort. Technol.* 5(3): 268-273.
- Wehner, T.C., Tolla, G.E. and Humphries, E.G. 1983. A plot scale extractor for cucumber seeds. *Hort. Sci.* 18(2): 246-247.
- Zilkah, S. and Klein, S. 1987. Growth kinetics and determination of shape and size of small and large avocado fruits cultivar 'Hass' on the tree. *Sci. Hort.* 32:195-202.

Appendices

APPENDIX A

Table A.1 Physical properties of ash gourd

Sl No	Length (mm)	Diameter (mm)	Placental diameter (mm)
1	220	156	96
2	280	163	100
3	190	160	110
4	330	184	125
5	360	190	134
6	390	198	145
7	320	184	122
8	280	170	110
9	290	175	112
10	325	190	128
11	360	186	140
12	380	192	142
13	395	205	147
14	350	203	139
15	295	177	105

Table A.2 Firmness of ash gourd

Sl No	Firmness (N)		
	R1	R2	R3
1	11.8	12.5	15.6
2	12.3	13.8	14.5
3	11.6	14.1	13.5

Firmness - Maximum value =15.6 N

Minimum value = 11.6 N

Table A.3 Physical properties of cucumber

Sl No	Length (mm)	Diameter (mm)	Placental diameter (mm)
1	210	96	63
2	190	100	68
3	225	110	69
4	185	125	71
5	194	134	73
6	232	145	72
7	178	122	67
8	192	110	64
9	215	112	66
10	223	128	69
11	228	140	71
12	218	142	69
13	195	147	71
14	188	139	68
15	185	105	62

Table A.4 Firmness of cucumber

Sl No	Firmness (N)		
	R1	R2	R3
1	7.9	11.2	8.5
2	8.2	10.9	7.6
3	8.1	10.6	9.3

Firmness - Maximum value = 11.2 N
 Minimum value = 7.6 N

APPENDIX B**Table B.1 Analysis of variance for optimising the extraction time of ash gourd**

K value	Source	DF	SS	MS	F Value	CD	Sig
2	Blade Shape (A)	1	8690.014	8690.014	9067.8406	0.460	**
4	Blade Thickness (B)	2	27.444	13.722	14.3188	0.563	**
6	AB	2	234.111	117.056	122.1449	0.796	**
8	Tool Speed (C)	3	2393.819	797.940	832.6329	0.650	**
10	AC	3	42.264	14.088	14.7005	0.920	**
12	BC	6	22.222	3.704	3.8647	1.127	**
14	ABC	6	5.111	0.852	0.8889	1.593	**
-15	Error	48	46.000	0.958			
	Total	71	11460.986				

DF= Degrees of Freedom, SS= Sum of Squares, MS= Mean Square

Coefficient of Variation: 1.69%; **: Significance at 1% level

Table B.2 Analysis of variance for optimising the seed germination of ash gourd

K value	Source	DF	SS	MS	F Value	CD	Sig
2	Blade Shape (A)	1	155.042	155.042	199.3393	0.359	**
4	Blade Thickness (B)	2	133.396	66.698	85.7545	0.440	**
6	AB	2	41.646	20.823	26.7723	0.622	**
8	Tool Speed (C)	3	121.708	40.569	52.1607	0.507	**
10	AC	3	7.208	2.403	3.0893	0.717	*
12	BC	6	31.354	5.226	6.7187	0.879	**
14	ABC	6	15.604	2.601	3.3438	1.243	**
-15	Error	72	56.000	0.778			
	Total	95	561.958				

DF= Degrees of Freedom, SS= Sum of Squares, MS= Mean Square

Coefficient of Variation: 2.07%; **= Significance at 1% level;*= Significance at 5% level

APPENDIX C

Table C.1 Analysis of variance for optimising the extraction time of cucumber

K value	Source	DF	SS	MS	F Value	CD	Sig
2	Blade Shape (A)	1	690.681	690.681	720.7101	0.460	**
4	Blade Thickness (B)	2	264.778	132.389	138.1449	0.563	**
6	AB	2	164.111	82.056	85.6232	0.796	**
8	Tool Speed (C)	3	889.153	296.384	309.2705	0.650	**
10	AC	3	1.931	0.644	0.6715	0.920	**
12	BC	6	42.556	7.093	7.4010	1.127	**
14	ABC	6	8.111	1.352	1.4106	1.593	*
-15	Error	48	46.000	0.958			
	Total	71	2107.319				

DF= Degrees of Freedom, SS= Sum of Squares, MS= Mean Square

Coefficient of Variation: 4.11%; **: Significance at 1% ; *= Significance at 5% level

Table C.2 Analysis of variance for optimising the germination of cucumber

K value	Source	DF	SS	MS	F Value	CD	Sig
2	Blade Shape (A)	1	225.094	225.094	234.0325	0.399	**
4	Blade Thickness (B)	2	168.146	84.073	87.4116	0.488	**
6	AB	2	66.063	33.031	34.3430	0.691	**
8	Tool Speed (C)	3	91.281	30.427	31.6354	0.564	**
10	AC	3	11.365	3.788	3.9386	0.798	*
12	BC	6	24.438	4.073	4.2347	0.977	**
14	ABC	6	20.354	3.392	3.5271	1.382	**
-15	Error	72	69.250	0.962			
	Total	95	675.990				

DF= Degrees of Freedom, SS= Sum of Squares, MS= Mean Square

Coefficient of Variation: 2.31%; **= Significance at 1% level; *= Significance at 5% level

APPENDIX D

Table D.1 Performance evaluation of new seed extractor for ash gourd

Sl No.	Wt. of ash gourd (kg)	Time taken for extraction (s)	Wt of seeds obtained S1(g)	Wt of seeds Remaining S2 (g)	Efficiency (%) $\frac{S1}{S1 + S2}$
1	5.5	53	118	1.5	98.7
2	4.1	49	104	0	100.0
3	6.2	58	129	1.1	99.2
4	5.9	54	125	0	100.0
5	4.4	49	110	0	100.0
6	3.9	47	102	0.9	99.1
7	5.3	55	115	1.25	98.9
8	5.9	63	121	0	100.0
9	6.05	65	128	0	100.0
10	5.4	52	119	0	100.0
11	4.8	48	114	0	100.0
12	5.1	55	110	0	100.0
13	4.6	48	108	0	100.0
14	5.9	56	122	0.8	99.4
15	6.0	59	126	0	100.0
16	4.9	49	114	0	100.0
17	6.25	66	135	0	100.0
18	5.7	58	122	0	100.0
19	4.6	46	105	0	100.0
20	6.4	72	144	0	100.0

Capacity = 350.5 kg/h

Rate of seed extraction = 8.53 kg/h

**Table D.2 Power requirement of the seed extractor
for ash gourd**

Sl No	No Load (kWh)	Full load (kWh)
1	0.081	0.105
2	0.082	0.105
3	0.081	0.103
4	0.083	0.107
5	0.082	0.105
Average	0.081 ± 0.001	0.105 ± 0.001

**Table D.3 Germination per 50 seeds extracted by using new seed
extractor**

Method	Replications				Germination (%)
	R1	R2	R3	R4	
Multipurpose seed extractor	48	47	48	47	95 ± 0.5

Table D.3 Performance evaluation of manual method for ash gourd seed extraction

S1 No.	Wt. of ash gourd (kg)	Time taken for extraction (s)	Wt of seeds obtained S1(g)	Wt of seeds Remaining S2 (g)	Efficiency (%) $\frac{S1}{S1 + S2}$
1	4.8	162	115	0	100
2	5.9	185	129	0	100
3	5.1	170	119	0	100
4	6.2	191	135	0	100
5	4.9	164	118	0	100
6	4.6	160	108	0	100
7	5.5	174	122	0	100
8	5.3	171	121	0	100
9	5.9	181	131	0	100
10	5.8	179	127	0	100
11	4.9	165	112	0	100
12	5.9	181	130	0	100
13	6.1	190	135	0	100
14	5.2	172	118	0	100
15	4.7	159	110	0	100

Capacity = 111.7 kg/h

Rate of seed extraction =5.12 kg/h

Table D.4 Germination per 50 seeds of ash gourd extracted using manual method

Method	Replications				Germination (%)
	R1	R2	R3	R4	
Manual	49	50	50	50	99.5 ± 0.5

Table D.3 Performance evaluation of ash gourd seed extractor

SI No.	Wt. of ash gourd (kg)	Time taken for extraction (s)	Wt of seeds obtained S1(g)	Wt of seeds remaining S2 (g)	Efficiency (%) $\frac{S1}{S1 + S2}$
1	5.1	228	105	3.0	97.2
2	5.3	235	108	3.5	96.8
3	5.9	240	119	4.2	96.5
4	5.8	232	115	3.2	97.3
5	4.9	220	108	3.5	96.8
6	5.5	241	114	4.6	96.1
7	5.05	225	108	2.5	97.7
8	5.4	236	112	3.0	97.3
9	6.1	251	125	4.8	96.3
10	5.8	235	119	4.2	96.5
11	5.15	223	106	3.1	97.1
12	5.3	230	109	3.6	96.8
13	4.7	218	102	2.6	97.5
14	6.0	246	121	4.1	96.7
15	5.85	238	117	3.8	96.8

Capacity = 84.3 kg/h

Rate of seed extraction = 1.7 kg/h

Table D.4 Germination per 50 seeds extracted using ash gourd seed extractor

Method	Replications				Germination (%)
	R1	R2	R3	R4	
Mechanical	46	48	45	45	92.0 ± 1.4

Table D.5 Performance evaluation of new seed extractor for cucumber

Sl No.	Wt. of cucumber (kg)	Time taken for extraction (s)	Wt of seeds obtained S1 (g)	Wt of seeds Remaining S2 (g)	Efficiency (%) $\frac{S1}{S1 + S2}$
1	0.89	16	78	0.0	100.0
2	1.3	20	94	0.0	100.0
3	1.25	20	92	0.5	99.4
4	1.6	23	102	0.0	100.0
5	0.95	18	85	0.0	100.0
6	1.45	22	98	0.8	99.2
7	1.15	20	89	0.0	100.0
8	1.62	23	105	0.0	100.0
9	1.44	22	95	0.0	100.0
10	1.05	19	89	0.0	100.0
11	0.98	18	83	0.0	100.0
12	1.3	21	94	0.0	100.0
13	1.52	24	101	0.0	100.0
14	1.4	22	97	0.0	100.0
15	1.5	23	102	0.0	100.0
16	0.84	18	81	0.4	99.5
17	1.12	20	86	0.0	100.0
18	0.97	19	85	0.0	100.0
19	1.32	21	94	0.0	100.0
20	1.2	21	91	0.0	100.0

Capacity = 218.8 kg/h

Rate of seed extraction = 16.24 kg/h

**Table D.6 Power requirement of the seed extractor
for cucumber**

Sl No	No Load (kWh)	Full load (kWh)
1	0.082	0.102
2	0.083	0.102
3	0.083	0.104
4	0.082	0.101
5	0.084	0.103
Average	0.082 ± 0.001	0.102 ± 0.001

**Table D.7 Germination per 50 seeds extracted by using new seed
extractor**

Method	Replications				Germination (%)
	R1	R2	R3	R4	
Multipurpose seed extractor	48	47	48	49	96.0 ± 0.8

Table D.7 Performance evaluation of manual method for cucumber seed extraction

Sl No.	Wt. of cucumber (kg)	Time taken for extraction (s)	Wt of seeds obtained S1 (g)	Wt of seeds Remaining S2 (g)	Efficiency (%) $\frac{S1}{S1 + S2}$
1	1.25	51	92	0	100
2	0.91	44	80	0	100
3	1.15	48	86	0	100
4	1.32	55	94	0	100
5	1.17	48	85	0	100
6	1.44	59	95	0	100
7	1.61	62	106	0	100
8	0.95	46	84	0	100
9	1.25	52	91	0	100
10	1.38	58	98	0	100
11	1.35	56	94	0	100
12	1.5	61	102	0	100
13	1.42	58	98	0	100
14	1.55	60	105	0	100
15	1.18	50	86	0	100

Capacity = 86.6 kg/h

Rate of seed extraction = 6.2 kg/h

Table D.8 Germination per 50 seeds extracted using manual method

Method	Replications				Germination (%)
	R1	R2	R3	R4	
Manual	50	49	49	50	99.0 ± 0.5

APPENDIX E

Cost analysis of the seed extractor for ash gourd and cucumber

Multi seed extractor

A. Basic information

1. Fabrication cost of the machine including the cost of material, C

• Viper motor (17 W)	=	` 1466/-
• Ball bearings (2 No.s)	=	` 60/-
• Thrust bearing (1)	=	` 60/-
• Spring (6 No.s)	=	` 500/-
• Tool electroplating	=	` 525/-
• GI pipe (2 m)	=	` 250/-
• Cost of material including labour charge	=	` 2000/-

Therefore, $C = 1466 + 60 + 60 + 500 + 525 + 250 + 2000 = \text{` } 4861/-$

2. Assumptions

i. Yield per acre for ash gourd	=	4.2 tonnes
ii. Yield per acre for cucumber	=	3.3 tonnes
iii. Number of seasons for ash gourd cultivation	=	3
iv. Number of seasons for cucumber cultivation	=	4
v. Working hours per year, H	=	105 h
vi. Average life in years, L	=	6 years
vii. Salvage value @ 10 % of cost of machine, S	=	` 486.1/-
viii. Interest on investment, i	=	12 %
ix. Number of labourers required	=	1
x. Labour wages per day of 5 h	=	` 200/-
xi. Repair and maintenance cost	=	10% of the machine cost
xii. Insurance and shelter	=	1.5 % of average cost

3. Cost calculation

1. Fixed cost per year

$$\begin{aligned}
 \text{(i) Depreciation cost, A} &= \frac{C-S}{L} \\
 &= \frac{4861-486.1}{10} \\
 &= \text{` } 437.49/-
 \end{aligned}$$

$$\begin{aligned}
 \text{(ii) Interest on investment, B} &= \frac{C+S}{2} \times \frac{i}{100} \\
 &= \frac{4861+486.1}{2} \times \frac{12}{100} \\
 &= \text{` } 321 \text{ /-}
 \end{aligned}$$

$$\begin{aligned}
 \text{(iii) Insurance, shelter etc., C} &= \frac{4861+486.1}{2} \times \frac{1.5}{100} \\
 &= \text{` } 40 \text{ /-}
 \end{aligned}$$

$$\begin{aligned}
 \text{Total fixed cost per year} &= A + B + C \\
 &= 437.49 + 321 + 40 \\
 &= \text{` } 798 \text{ /-}
 \end{aligned}$$

$$\begin{aligned}
 \text{Total fixed cost per hour} &= 798 \div 105 \\
 &= \text{` } 7.6 \text{ /-}
 \end{aligned}$$

2. Variable cost per hour

$$\begin{aligned}
 \text{(i) Labour cost, D} &= 200 \div 5 \\
 &= \text{` } 40 \text{ /-}
 \end{aligned}$$

$$\begin{aligned}
 \text{(ii) Repair and maintenance, E} &= 4861 \times \frac{10}{105 \times 100} \\
 &= \text{` } 4.62 \text{ /-}
 \end{aligned}$$

$$\text{(iii) Energy cost @ ` 5.5 kWh, F1 for ash gourd} = 0.105 \times 2.5 = \text{` } 0.57 \text{ /-}$$

$$\text{Energy cost @ ` 5.5 kWh, F2 for cucumber} = 0.102 \times 2.5 = \text{` } 0.56 \text{ /-}$$

$$\begin{aligned}
 \text{Total variable cost per hour for ash gourd} &= D + E + F1 \\
 &= 40 + 4.62 + 0.57
 \end{aligned}$$

$$= \text{` } 45.19 \text{ /-}$$

$$\begin{aligned} \text{Total variable cost per hour for cucumber} &= D + E + F2 \\ &= 40 + 4.62 + 0.56 \\ &= \text{` } 45.18/- \end{aligned}$$

$$\begin{aligned} \text{Total operating cost of machine for ash gourd} &= \text{Fixed cost} + \text{Variable cost} \\ &= 7.6 + 45.19 \\ &= \text{` } 52.79/- \end{aligned}$$

$$\begin{aligned} \text{Total operating cost of machine for cucumber} &= 7.6 + 45.18 \\ &= \text{` } 52.78/- \end{aligned}$$

- Weight of ash gourd processed per hour = 350 kg
 - Weight of cucumber processed per hour = 219 kg
- Assuming 7 working hours per day
- Weight of ash gourd processed per day = $350 \times 7 = 2450$ kg
 - Weight of cucumber processed per day = $219 \times 7 = 1533$ kg
 - Cost of seed extraction of ash gourd per kilogram = $52.79 \div 350$
= ` 0.15/-
 - Cost of seed extraction of cucumber per kilogram = $52.78 \div 219$
= ` 0.24/-
 - Weight of seed per kilogram of ash gourd = 0.025 kg
 - Ash gourd seed produced per day = 61 kg
 - Cost of seed production per kilogram for ash gourd = ` 6.5 /-
 - Weight of seed per kilogram of cucumber = 0.08 kg
 - Cucumber seed produced per day = 122 kg
 - Cost of seed production per kilogram for cucumber = ` 3.0 /-

C. Manual seed extraction

- Number of labourers = 1
- Working hours per day = 7

- Labour charges per day = ` 200 /-
- Labour charges per hour = ` 29/-
- Weight of ash gourd processed per day = $112 \times 7 = 784$ kg
- Weight of cucumber processed per day = $86 \times 7 = 602$ kg
- Cost of seed extraction of ash gourd per kilogram = ` 0.26 /-
- Cost of seed production per kilogram for ash gourd = ` 10.3 /-
- Cost of seed extraction of cucumber per kilogram = ` 0.34/-
- Cost of seed production per kilogram for cucumber = ` 4.26 /-

**DEVELOPMENT AND EVALUATION OF A SEED EXTRACTOR
FOR ASH GOURD AND CUCUMBER**

by

ANEESH MOHAN

(2010 – 18 - 107)

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the
requirement for the degree of

Master of Technology
in
Agricultural Engineering

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

**DEPARTMENT OF POST HARVEST TECHNOLOGY AND
AGRICULTURAL PROCESSING**

**KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND
TECHNOLOGY**

TAVANUR, MALAPPURAM - 679 573

KERALA, INDIA

2012

ABSTRACT

A seed extractor was developed for ash gourd and cucumber. The important part of the machine is the extraction tool whose diameter can be varied (52 -160 mm) according to the placental diameter of the fruit and it can be maintained at that diameter for the required time. The principle of operation is to penetrate the rotating tool with handle, into the placental region after adjusting its diameter which helps in scraping out the seeds along with the pulp from the centre and surrounding mesocarp portion. The experiment was conducted as a completely randomized design with three factors. Two blade shapes (round edged and pointed edged), three blade thicknesses (1, 2 and 3 mm) and four rotational speeds (50, 80, 120 and 160 rpm) were chosen. For each experiment, the number of replications were three. Before loading the vegetables to the holder for seed extraction the top and bottom ends which do not contain the seeds were cut and removed for easy penetration of the tool. By adjusting the blade diameter to required size, the rotating tool is lowered through the central portion of the vegetable and it scraps out the seeds from the surrounding mesocarp. The seeds are discharged into the chute.

The seed extraction of ash gourd was achieved by a mean time of 10.6 s/kg and that of cucumber with 16.6 s/kg. The seed extraction efficiencies of both these vegetables were in the range of 99 to 100%. The germination rates were 95% for ash gourd seeds and 96% for cucumber seeds. The capacity of the extractor for ash gourd is 350 kg/h and that of cucumber is 219 kg/h. The average energy consumption at loaded condition for seed extraction of ash gourd is 0.105 kWh and for cucumber is 0.102 kWh. The cost of seed extraction per kilogram for ash gourd is ` 0.15/- and for cucumber is ` 0.24/-. The cost of seed production per kilogram for ash gourd is ` 10.3 /- and for cucumber is ` 3.0/-.