DEVELOPMENT AND PERFORMANCE EVALUATION OF MULTI-FRUIT SLICER CUM DICER

By

Ciya Paul

Sarath Kumar S

Sreejith C

PROJECT REPORT

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DECLARATION

We hereby declare that this project entitled "**DEVELOPMENT AND PERFORMANCE EVALUATION OF MULTI-FRUIT SLICER CUM DICER**" is a bonafide record of project work done by us during the course of study and that the report has not previously formed the basis for the award to us of any degree, diploma, associateship, fellowship or other similar title of any other University or society.

Ciya Paul
(2014-06-005)

Sarath Kumar S
(2014-06-016)

Sreejith C
(2014-06-018)

Place : Tavanur
Date : 05/02/2018

CERTIFICATE

Certified that this project entitled "**DEVELOPMENT AND PERFORMANCE EVALUATION OF MULTI-FRUIT SLICER CUM DICER**" is a bonafide record of project work jointly done by Ciya Paul, Sarath Kumar S, Sreejith C 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 them.

Dr. Sudheer K P
Professor& Head, Dept. of Agricultural Engineering
Project Coordinator, Centre of Excellence in Post-harvest Technology
College of Horticulture
Vellanikkara, Thrissur-680 656

Place : Tavanur
Date : 05/02/2018

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Ciya Paul

Sarath Kumar S

Sreejith C

Dedicated To All Food Engineers

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SYMBOLS AND ABBREVIATIONS

%	Percentage
°C	Degree Celsius
&	And
/	Per
ή	Efficiency
cm	Centimetre
Er.	Engineer
et al.	And others
g	Gram
K.C.A.E.T.	Kelappaji College of Agricultural Engineering & Technology
mg	Milligram
kg/hr	Kilogram per hour
pp	Page
Rs.	Rupees
s	Seconds
SS	Stainless steel
mm	Millimetre
MS	Mild Steel
Kg	Kilogram
ml	Millilitres
rpm	Revolutions per minute
kJ	Kilo joules
min	Minutes
%D	Percentage damage
EC	Effective capacity
OC	Overall capacity
S^2	Sample variance
hr	Hour

Introduction

CHAPTER I

INTRODUCTION

India's diverse climate ensures availability of all varieties of fresh fruits. It ranks second in fruits production in the world, after China. India ranks first in production of Bananas (22.94%), Papayas (44.03%) and Mangoes (37.57%). India has a record of highest ever production of horticultural produce, including fruits and vegetables in 2016-17. As per National Horticulture Database published by National Horticulture Board, during 2016-17 the total horticultural production was estimated to be 92918 million tonnes which was higher than the production in 2015-16, about 2.9% higher than the previous year production.

Cultivation of fruit crops plays an important role in the prosperity of any nation. It is generally stated that the standard of living of the people can be judged by per capita production and consumption of fruits. No other class of foods has such a variety of pleasant and attractive flavours. With their delicate colouring, fruits please the eye as well as the palate. Modern methods of transport and refrigeration make it possible to have fresh fruit practically all year round.

Fruits are an important supplement to the human diet as they provide the essential minerals, vitamins and fibre required for maintaining health. Many phytochemicals found in fruits act as powerful anti-oxidants protecting cells and organs from damage caused by free radicals, neutralizing their damaging effects. They are the biologically active substances in plants that give them colour, flavour, odour and protection against not only diseases affecting the plants but also human being.

It has been variously estimated that 20 to 30% of the horticultural produce is lost before consumption which accounts for 5000 crores because of poor harvesting, handling, storage, transportation and marketing practices. The fruits are highly perishable commodities and the ambient high temperature obtained in the tropical country like ours makes them more susceptible for rapid senescence, decay and rotting. Both respiratory and transpiratory rates are proportional to temperature change and so that the produce quickly dries, wilts and spoils unless properly preserved.

Being a country having varied climatic conditions ranging from tropical to subtropical and to temperate, India has very immense potential for the production of different fruits and their export. The vast production base offers India tremendous opportunities for export. Mangoes, Walnuts, Grapes, Bananas, Pomegranates account for larger portion of fruits exported from the country.Thus the fruit culture is vital to the health and economy of the nation, from the stand point of increased food production, nutrition, trade and fruit based industries.

1.1 Processing of fruits

Fruit contain protective vitamins and minerals, and dietary fibre but very little protein. The carbohydrates in fruit have a moderate energy value. They are practically fat-free except for avocado and olive. The main sugars present are fructose and glucose. Various organic acids in unripe fruit produce the typical sour taste. Most of the citrus fruits are rich in vitamin C and also supply varying amounts of ß-carotene and the B-complex vitamins. Fruit contribute appreciable amounts of iron and calcium.

Table 1.1 Mean chemical compositions of fresh fruit (content per 100g)

Component	Composition
Water	80-95 g
Carbohydrate	1.5-26 g
Protein	0.5-1.5 g
Vitamin	10-90 mg
Mineral	170.3-500 mg
Energy	6-65 kcal
Fibre	0.2-6.4 g

There is increasing demands for factory made jams, jellies, fruit beverages, dehydrated foods, pickles etc. in the domestic market. Moreover, there is considerable demand for some of these products in foreign markets e.g. mangoes both fresh and canned fruits, fruit juices, salted cashew are good foreign exchange earners. The traditional method of processing fruits is a time-consuming process and causes drudgery. The tedium in manual processing is a major reason for the under-utilisation of the fruit. Thus, effective mechanisation in processing is a need of the hour. The above scenario urgently demands for the development of a mechanical tool for fruit slicing and dicing. This development will reduce the wastage of major quantity of fruits and also helps in preparation of primary processed products that can be used for production of other products.

With this point of view, a project was undertaken at Kelappaji College of Agricultural Engineering and Technology, Tavanur to develop a multi-fruit slicer cum dicer with the following objectives,

1. To develop a mechanical tool for slicing and dicing of fruits and
2. To evaluate the performance of the developed multi-fruit slicer cum dicer

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

This chapter sets out to identify and critically analyse all the previously published literatures. Reviews regarding general information of fruits, physical and mechanical properties of different produces, development and evaluation of related machines and the material selection for equipment fabrication are included in this report. Studies on rehydration ratios, moisture content and cooking quality of the processed fruits are also presented.

2.1 Description and economic importance of fruits selected

2.1.1 Papaya (*Carica papaya* L.)

Papaya is an economically important fruit grown in India, Sri Lanka, Australia and other south east Asian countries. It can grow up to a height of 5-7 metres. The flowers are bored in the axil of the leaves which can be male, female or hermaphrodite. Fruits are either oval or elongated in shape. The stem, leaves and the raw fruits contain white milky latex which can be utilized for extraction of enzymes. Mature fruits found in yellowish orange colour, consists of numerous black seeds. Papain which is a proteolytic enzyme derived from papaya latex, is widely used in the beverage, food and pharmaceutical industries for production of chewing gum, chill-proofing beer, tenderising meat, treat digestive disorders, degum natural silk and extracted fish oil (Amri and Mamboya, 2012).The mean nutritional composition of the fruit is given in table 2.1.

Table 2.1 Nutritional composition of papaya (per 100g)

Nutrient	Composition
Energy	163 kJ
Carbohydrate	15.71 g
Fat	0.140 g
Protein	0.610 g
Vitamin	0.428 g
Minerals	0.299 g

Papaya is a powerhouse of nutrients and is available throughout the year thus it adds to the income of farmers (Bhowmik *et al*., 2013).Papaya is mainly cultivated for its edible fruits as a fresh fruit and for use of drinks, jams, candies and dried fruit. Ripe fruits are usually eaten fresh and green fruits are also used as a cooked vegetable. Papaya also has several industrial uses. Biochemically, its leaves and fruits produce several proteins and alkaloids with important medical and industrial application. It is also used in the cosmetic industry, in soap, shampoo and face lifting preparations (Adam *et al*., 2014).

2.1.2 Banana (*Musa paradisiaca*)

Banana is one of the oldest tropical fruit crop, grown under diverse conditions and there are around 20 different cultivars grown in India. The size, shape and colour of the fruit vary depending upon the species. Banana has a multiplicity of uses including food, beverages (soft and alcoholic), snacks, banana puree, powder, flour, chips, vinegar, jam, jelly ,wine, feed, and industrial spirits. Banana is a highly nutritious fruit which contains an ample proportion of nutritive constituents which are easily digested and absorbed, while available at reasonable cost (Indhulekshmi *et al*., 2010).This is partly because bananas aid in the body's retention of calcium, nitrogen, and phosphorus, all of which work to build healthy and regenerated tissues. Bananas relieve painful ulcer systems, and other intestinal disorders and also promote healing. The fruit is also used as treatment for burns and wounds (Umadevi *et al*., 2012).The table 2.2 given below enlists the composition of banana per 100 g.

Table 2.2 Nutritional composition of banana (per 100g)

Nutrient	Composition
Energy	116 Cal
Carbohydrate	27.60 g
Fat	0.300 g
Protein	1.200 g
Vitamin C	0.007 g
Minerals	0.862 g

2.1.3 Jackfruit (*Artocarpus heterophyllus L.*)

Jackfruit, botanically known as *Artocarpus heterophyllus*, is grown in both tropical and subtropical regions throughout the world. It is used as medicine and also as a source of food. It can be used as raw vegetable and also as ripe fruit. Jackfruit is an extremely versatile and sweet tasting fruit that possess high nutritional value (Amrita *et al*., 2016).Fruits mature 3-8 months from flowering. It should be stored at 85-90% relative humidity and at 11-13°C .

Jackfruits have high nutritional and medicinal values. It can strengthen immune system, protect against cancer, aid in healthy digestion, helps to maintain a healthy eye and skin, help to boost energy, lowering high blood pressure, controls asthma, help to strengthen the bone, prevent anaemia and maintain a healthy thyroid .Table 2.3 shows the composition of jackfruit per 100 g . They are rich in dietary fibre and contain simple sugars.

Table 2.3 Nutritional composition of jackfruit (per 100g)

Nutrient	Composition
Energy	50-210 kJ
Fibre	2.6-3.60 g
Carbohydrate	9.4-11.5 g
Fat	0.1-0.60 g
Protein	2.0-2.60 g

2.1.4 Potato (*Solanum tuberosum*)

Potato is grown as a major crop in countries with different climatological zones. In the food sector, potatoes are processed into deep-frozen chips, crisps and mashed potato. By-products such as potato starch, glucose and dextrose are used in biscuit production and also in the brewing industries. In the non-food sector, by-products such as potato starch and dextrins are used as ingredients for the manufacture or cardboard, glues, textiles and paints and in the laundry business (Balogun, 2009).It is a crop of high biological value for its starch, protein and a substantial amount of vitamins, minerals and trace elements.

The potato is a carbohydrate-rich, energy-providing food with little fat. Potato protein content is fairly low but has an excellent biological value of 90-100. Potatoes are particularly high in vitamin C and are a good source of several B vitamins and potassium. The skins provide substantial dietary fibre. Many compounds in potatoes contribute to antioxidant activity (Camire *et al*., 2009).

2.2 Physical properties of fruits

Physical specifications of agricultural products constitute the most important parameters needed in the design of grading, transfer, processing, and packaging systems. Grading and sizing of fruit is a prerequisite to effective processing and proper packaging.

Akram *et al*. (2007) conducted an experiment on physical properties of orange in order to present them in the economical scale. The intermediate and minor diameters of the medium size graded oranges were found and considered for the study.

Toosi *et al*. (2011) reported the physical properties of peach in order to design the equipment of processing. The mean values of big, medium and small diameters of peach were measured using vernier caliper (Shoka Galf, China) with accuracy of ±0.01 mm.

Ashtiani *et al*. (2014) experimented on lemon varieties to study on its physical properties. The shape of the fruit was determined based on the sphericity and the occurrence of projected areas.

Ghaffari *et al*. (2015) studied the physical and mechanical properties of tomato to determine the maturity. In order to measure the fruit length, width and thickness digital calipers (least count 1 mm) were used.

2.3 Mechanical properties of fruits

Mechanical properties of fruits and vegetables can be applied to improve the efficiency of processing equipment. Generally, the efficiency of a mechanical peeler depends on the influence of different forces on machine performance. Useful forces, such as rupture and cutting, are purposely applied for peeling; whereas undesirable forces, such as impact and compression, may reduce the effects of the former forces. The undesirable loads can be also the main reason for common problems such as bruising. Knowing the mechanical properties of agricultural products would help designers to apply forces properly (Emadi *et al*., 2009).

2.3.1 Cutting force and shear pressure

Zhou *et al*. (2006) experimented and analysed the force required during slicing and pressing of cuts. The influence of the blade edge shape and its slicing angle on material were formulated based on the stress analysis. The cutting forces between the blade and material could also be predicted.

Khazaei *et al*. (2011) determined the compression and cutting strength of the whole fruit at different storage times. The maximum cutting force, peel shear strength and strain showed an increasing trend with storage time. However, firmness, bio-yield force, and modulus of elasticity increased and then decreased with storage time.

Linares *et al*. (2013) subjected the sweet passion fruit for characterization of mechanical properties. The test was performed using a texture analyser It was found that the firmness of the fruits in the unidirectional compression, longitudinal direction was 117.4 N, while the force required for a transversal shearing of the skin of the fruit was 43.8 N. The mechanical behaviour of the sweet passion fruit thus corresponds to a viscoelastic, anisotropic and variable material.

Das *et al*. (2016) studied peak cutting force achieved during slicing of potato with varying knife speed and contact area. The cutting force for constant contact area was noticed maximum and minimum for knife speed of 40 and 20 mm/min respectively.

Asghari *et al*. (2017) conducted experiments to study the mechanical properties of banana. Pressure-stress device was used to determine the properties of the fruit at varying load speed and moisture content. The effects on elasticity modulus, shear stress were studied. The best moisture content for cutting banana was 65.58%, since both shear energy and shear stress for the banana were less than for other moisture content levels.

Reddy *et al*. (2017) investigated on the mechanical properties of tomato to determine its maturity. The fruit size and ripening stage individually influenced the static coefficient of friction significantly. The tomato fruit failure stress was found to decrease up to 56.35%, indicating green tomatoes were more firm than the full red tomatoes.

2.4 Slicing and dicing operations for different produces

Size reduction is a most important unit operation which includes slicing, cutting, dicing crushing, chopping, grinding and milling. The reduction in size is brought about by mechanical means without change in chemical properties of the material and uniformity in size and shape of individual units of the end product. Such processes are cutting of fruits or vegetables for canning, shredding sweet potatoes for drying, slicing onion for salad, chopping corn fodder etc. Crispness can be controlled by maintaining uniformity of fruit dice or slice thickness. Surface area exposure is another factor which activates drying of the cut fruits.

2.4.1 Traditional methods

The most widely practiced method of cutting fruits and vegetables in our country is done manually by stainless steel knives to produce thin wafers and cubes. A few entrepreneurs use manually operated platform type manual slicer .

2.4.2 Mechanical methods

Ani *et al*. (2007) constructed a motorised okra slicer. It consisted of a conical hopper and a slicing unit, where a cutting disc installed cuts the fruit by shearing force. It could achieve okra slices of 2 mm average thickness. Power transmission was done by motor, belt and pulley arrangement. The entire machine was supported on a frame and it gave out a capacity of 42.8 kg/hr.

Balogun *et al*. (2009) developed and evaluated a multi crop slicer. The major components of the machine were hopper, mainframe, conveying disc, slicing unit, electric motor base and outlet. The hopper which is bolted at the top of the frame holds the crops which were then moved along feed channels towards the conveying discs. Crops were then guided by the discs to the slicing unit with nine sets of knives arranged by means of spacers. Sliced crops could be collected at the outlet.

Ladwa *et al*. (2009) developed a dry fruit cutting machine. Here betel nuts were cut into diamond shaped pieces by the shearing forces imparted by the blades. The fruits were fed into the machine through a hopper and it gets cut between the stationary and rotary blades. A mesh is also provided to screen the cut fruits based on their size. The machine had a capacity of 2-2.5 kg/hr.

ACTA (2010) modified and developed an automated apple slicer or shredder with a motor, gear and crank mechanism which transforms the rotation moment of the motor to reciprocating motion of the piston, where the apple or other fruits gets pressed under high pressure onto the knife cassette, forming uniformly sliced fruits.

Arahanth *et al*. (2010) developed a potato slicer to deal the problems of chip manufacturers. It had 5 SS blades, potato holder and a circular shaped handle. The housing unit made of mild steel enclosed all the parts within it. When the vegetables slide down from the top, the slicer gave an output of 5 slices in a single slide of 1.2 mm average thickness.

Indulekshmi *et al*. (2010) modified and developed plantain peeler cum slicer with an ability to peel 3 different grades of banana using three peeling units of different sized blades. The feeding unit consisted of 3 cylindrical guides of different diameters placed 120° apart fixed to a sleeve to facilitate rotation.3

circular peeling blades, three splitting blades, set along the guides performed peeling operation. The rack and pinion mechanism resulted in the upward and down ward motion of the piston inside the cylindrical guide. Peeled plantain was fed to the slicing unit. SS blade was mounted over 110 mm diameter disc of 1.8 mm thickness. Slicing was achieved by rotating the disc at 300 rpm.

Sonawane *et al.* (2011) designed and developed a power operated rotary banana slicer. The varieties used were Nendran and Dwarf Cavendish. The slicer was made with 3 bladed cutter of 360 rpm speed. The fruits were fed into the push plate feeder assembly and the power required for the cutter plate shaft was provided by a belt and pulley mechanism. The mean thickness of the cut was found to be 2.00 mm. The machine had a capacity of 100 kg/hr.

Jiang *et al*. (2013) designed a household food slicer in which the material to be sliced are manually fed into the machine through the inlet port. Power is transmitted by an electric motor and a pulley to the shafts which in turn rotates the blade and cuts the required material. The elevator system of slicer is set to produce cuts even thickness and neat cut surface.

Verma *et al*. (2013) designed a hand operated pineapple peeler-cum-slicer. Slicing plate and core remover shaft are the two main important parts of this design. Stainless steel pipe of 22 cm length and 2.5 cm diameter was used for constructing the core remover shaft. One end of the corer was kept with sharp teeth for easy penetration during the coring operation. For constructing slicing plate, the stainless steel plate of 7.0 cm diameter was attached to the pipe in helical manner around the corer with a gap of 1.5 cm between grooves for cutting the pineapple rings. It simultaneously removes the core and produces pineapple rings of uniform thickness and diameter in a single motion. The designed device works satisfactorily with easy operation, efficient, time saving and economical for the farmers.

Anoop *et al*. (2015) designed a manual operated automatic feed copra slicer. The piston-spring assembly within the feeding trough and two radially extended blades carried out the slicing operation. The capacity the machine was 320 copra /hr.

Mohanan *et al*. (2015) modified and developed a rotary banana slicer .The thickness of the slice was adjustable according to the shape and size of the bananas selected. Steel chutes with spring loaded mechanism hold the banana. Continuous feeding could be done through SS chutes. An oil coated flexible brush given cleaned the cutting edge by wiping away the sap. A tilting arrangement was provided to the stand which helps the shred banana to fall into the frying pan. Speed could be varied using a variable speed motor and the average capacity was found to be 90-100 kg/hr.

Hareesh *et al*. (2016) constructed a jackfruit peeler, corer cum cutter with a rotating disc to carry the jackfruit on a horizontal plan by four blades. A screw shaft provided the linear motion to peeler arm to which the blade is attached. Peeling was done helically due to the linear motion of the blade. Similarly cutting-coring operation was performed by converting the rotary motion of pulley into linear motion with the help of screw mechanism. During cutting-coring operation core removing tool which is attached to the screw shaft was pressed against the fruit. The bulbs separation of four cut portion jackfruit was done manually after the completion of above operations. It had an efficiency of 82.8%.

Shinde *et al*. (2016) designed an automatic pneumatic operated lemon cutting machine. Double acting cylinders, pneumatic solenoid valves, time based control system are found to be the main units of the system. Lemon which is put into the tray mounted on the frame is lifted up, by which lemon is guided towards double acting cylinders.Lemon gets cut by the cylinders due to their pneumatic action. The cut lemon pieces are collected in the tray.

2.5 Material Selection

Materials used for product contact must have adequate strength over wide temperature range, reasonable life, non-toxic, non-staining, non-absorbent, resistant to cracking, chipping, flaking corrosion and abrasion, prevent penetration of unwanted matter under intended use and be easily cleaned and capable of being shaped. Stainless steel usually meets all these requirements and there are various grades of stainless steel which are selected for their particular properties to meet operational requirements. Elastomers and polymers should retain their surface and conformational changes when exposed to conditions encountered in production, cleaning and decontamination (Holah, 2000).

Jullien *et al*. (2002) research work was carried to identify the surface characteristics relevant to the hygienic status of stainless steel for the food industry. It was investigated by number of residual adhering Bacillus cereus spores after a complete run of soiling and cleaning in place procedure. The 14 materials tested (304, 316 and 430 grades; pickling (2B), bright annealed (2R) and electro polished finishes) were shown to be highly hygienic with slight differences in adhering spores. However, tested materials were grouped into different classes according to their hygienic status.

EHEDA (2007) reported the expected behaviour of materials found on food and their consequences on human health. They investigated the effectiveness of metals, elastomers and plastics by food contact approval-extraction testing.

According to British stainless steel association (2012), food contact equipment could be manufactured from either 304 or 316 type austenitic stainless steels. More over effective cleaning and maintenance of the equipment could be easily achieved.

Patel *et al*.(2015) studied different physical and metallurgical properties of stainless steel to be used in equipment fabrication in food processing sectors. Using stainless steel, helped to prevent corrosion and also ensured purity of the food handled.

2.6 Blanching

Blanching is a unit operation prior to freezing, canning, or drying in which fruits or vegetables are heated for the purpose of inactivating enzymes; modifying texture; preserving colour, flavour, and nutritional value; and removing trapped air. Hot water and steam are the most commonly used heating media for blanching in industry. Blanching facilitates peeling and dicing, and is also accompanied by microbial load reduction. Fruits are usually not blanched, or blanched under mild (low temperature) conditions prior to freezing because blanching produces undesirable texture changes. Before drying, fruits and vegetables are sometimes blanched.

Raghavan *et al*. (2007) carried out investigations to study the effects of selected blanching treatments on the quality of carrots over a temperature range of 80–100°C. The most effective blanching treatment was 5 min in hot water at 95°C.

Ghoul *et al*. (2013) studied blanching of different fruits and vegetables in order to prevent oxidative reactions induced by various enzymes. It may affect the colour and other nutritional losses, leading to enzymatic browning.

Pilli *et al*. (2015) compared and analysed the influence of different blanching methods on some functional properties of broccoli. The effectiveness of each blanching process was performed measuring the loss of peroxidase activity, that results more rapidly in microwaves and steam treatments (50 and 60 s respectively) than in boiling water treatment (120 s).

Mujumdar *et al*. (2017) investigated the importance of thermal blanching and the criteria that led to the selection of polyphenol oxidase (PPO), peroxidase (POD), ascorbic acid, colour, and texture as indicators to evaluate blanching process.

2.7 Drying and dehydration

The main cause of perishability of fruits and vegetables are their high water content. To increase the shelf life of these fruits and vegetables many methods or combination of methods had been tried. Drying is one of the earliest techniques practised.

Osmotic dehydration is also a best and suitable method to increase the shelf life of fruits and vegetables. This process is preferred over others due to their vitamin and minerals, colour, flavour and taste retention property.

Yadav *et al*. (2012) studied osmotic dehydration of various fruits and vegetables. It was found that osmosis was found at approximately 40°C, 40°B of osmotic agent and in near about 132 min. Pre-treatments also lead to increase in the osmotic process.

Maleki *et al*. (2015) compared the microwave drying and hot air drying treatments on apple slices were in terms of drying kinetics and critical physicochemical quality attributes. The temperature, microwave power, air velocity, and pulse ratio (PR) applied in the experiments were 40–80°C, 200–600 W, 0.5–2 m/s, and 2–6, respectively. Results showed that microwave treatments were more effective than hot air.

Bourdox *et al*. (2016) evaluated the performance of drying on fruits and vegetables to ensure the microbial safety. This review presented traditional and emerging technologies to dry fruits, vegetables, herbs, and spices and discusses their potential to inactivate bacteria and viruses throughout the drying process.

Taskin *et al*. (2016) inspected the effects of freeze, microwave (120 and 350 W) and hot air (60, 70 and 80°C) drying techniques on various parameters .It was concluded that microwave drying at 350 W is able to yield high-quality mango slices with the extra advantage of shortened drying time in relation to hot air and freeze drying.

2.8 Moisture content

Water is an important constituent of all foods we eat. On a lighter note, moisture in foods can be considered as necessary evil. The palatability freshness and the very appearance of the fruits and vegetables are enhanced by the presence of water. On the other hand, the spoilage and the rate of spoilage are directly proportional to the water content of foods. Fruits and vegetables are often dried to enhance their shelf life. The moisture content of fruits and vegetables are determined for various reasons.

Senthilkumar *et al*. (2000) evaluated the moisture content in fruits and vegetables using a microwave oven. The samples were dried at 180 and 270 W power levels. The time required for determining the moisture content using 270 W power level was 35 min for potato, onion, and cucumber, and 30 min for banana. At 180 W power level the time required was 85 min for potato and onion and 70 min for cucumber and banana.

Ashaye *et al*. (2006) the moisture content of Roselle jam from dark-red Roselle calyx under cold storage was significantly higher than other Roselle jam samples at 2^{nd}, 4^{th} and 6 weeks of storage. The dry matter content of stored Roselle jams was less than 72% with that processed from light red variety and stored under cold temperature being significantly higher than other jam samples at 2^{nd} and 4^{th} week of storage. There was also no definite pattern in the dry matter content of the jams.

2.9 Re-hydration

Rehydration is an important quality attribute for dried products. Rehydration characteristics indicate the physical and chemical changes during drying as influenced by processing conditions, pre-treatment, and composition of samples.

Panesar *et al*. (2007) studied the rehydration kinetics of un-osmosed and pre-osmosed carrot cubes by subjecting them to 10% NaCl solution, 55°brix sucrose syrup and 50°brix syrup with 10% NaCl at temperatures of 35, 45 and 45°C, for durations of 90, 180 and 180 minutes, respectively, with sample to solution ratio 1:5. The convective dehydration was performed in cabinet drier at 65°C temperature up to final moisture content of 4-5% (wet basis). The beakers containing water and fruit were kept in water bath pre-set at 30°C. The approximate ratio of dried fruit and water volume was kept as 1:30. During the rehydration, the carrot cubes, osmotically pretreated with sucrose-salt samples give a lower water uptake as compared to samples treated with sucrose solution followed by samples treated with salt and un-osmosed ones.

Abano *et al*. (2011) studied the drying characteristics of banana slices to determine the re-hydration ratio. The 5 mm thick slices at a drying air temperature of 70°C dried better than the others. The minimum re-hydration ratio of 1.215 was obtained for 7 mm thick slices treated with ascorbic acid and the maximum re-hydration ratio of 1.716 was obtained for lemon juice samples.

Sagar *et al*. (2011) performed studies on physico-chemical properties of dried fruits and estimated their rehydration ratios. It was found that vacuum oven drying was superior to other mode of drying as it holds maximum nutrients like acidity, ascorbic acid, sugar, water removal, rehydration ratio and moisture ratio of products.

Kalyani *et al*. (2013) carried out osmotic dehydration of papaya slices. The product osmo- treated at 60^0brix at 50^0C temp showed the better rehydration property along with better nutrient retention, texture, colour, taste and overall acceptability.

Taiwo *et al*. (2013) investigated on the rehydration characteristics of dried pineapple slices. The slices were dehydrated (4 hr), oven dried (60°C for 27 hr) and were rehydrated at 90°C for 15 min and at room temperature for 6 hr.

Doymaz (2014) conducted the drying of pre-treated mushroom slices in a cabinet dryer and the re-hydration ratio was calculated. It was observed that the rehydration ratio of pre-treated samples resulted in the highest rehydration, compared to the control samples.

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

This chapter deals with fabrication procedure for development of the multi-fruit slicer cum dicer, the details of the components and the procedures adopted for evaluation. It also describes about the procedures and techniques adopted to study the drying characteristics.

3.1 Procurement of fruits

Matured, unripe and semi-ripe fruits of different varieties like papaya, banana, jackfruit, potato and pineapple harvested from the instructional farm or purchased from the market, were used for the study of the machine.

3.2 Study of the existing methods for development of slicer cum dicer

The existing methods used for slicing and dicing of different produces were analysed.

3.3 Development of model

The multi-fruit slicer cum dicer consists of blade drums, conveying drums, feed conveyor belt, power transmission system, and collecting tray. The power transmission is made possible using an electric motor and it consists of gears and pulleys to facilitate the rotation of shafts in the required velocity ratio and torque ,which is then transferred to the blade assembly by shafts. The blade drums are connected on to the shaft. The conveying drums are also attached to the shafts held adjacent to the blade drums. Supporting unit comprises of frame. All the parts are connected to each other by nuts and bolts for the purpose of dismantling Bearings are used to support the shafts in the machine. Entire unit is made by stainless steel (SS 304). The schematic diagram of multi-fruit slicer cum dicer is shown in figure 3.1.

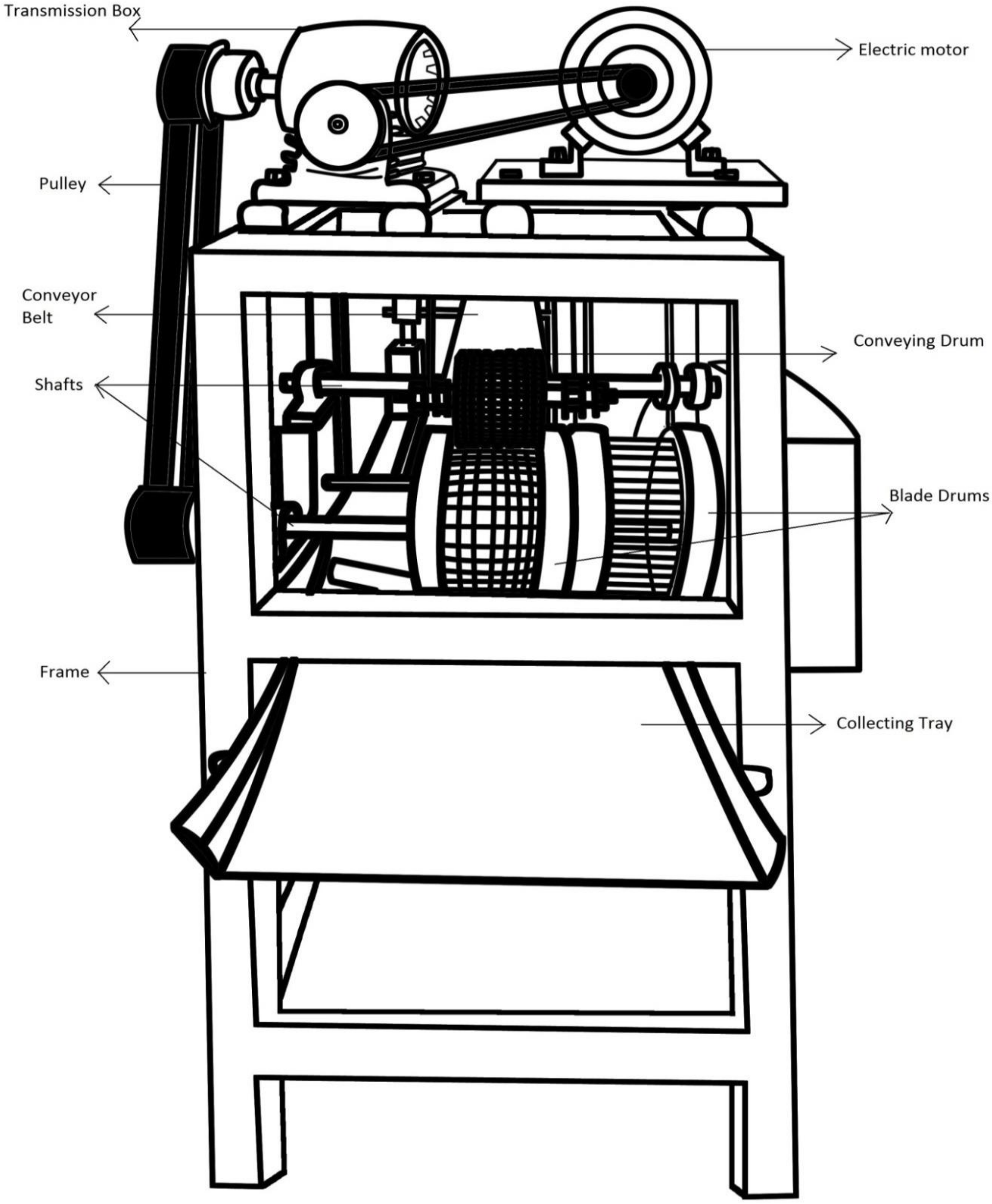

Fig 3.1 Multi-fruit slicer cum dicer

3.4 Major Parts

3.4.1 Supporting unit

It consists of a frame to support the entire machine component to perform its operation satisfactorily. The entire unit is made up of stainless steel. On to this frame assembly, units like feed conveyor belt, transmission system, blade drum and conveying drums were mounted. The overall dimension of the frame assembly is 560 x 560 x 1120 mm where the values correspond to overall length (mm), overall width (mm) and overall height (mm) of the machine respectively.

3.4.2 Power Transmission System

It consists of motor, gear box, belt and pulleys. The primary function of motor is to convert electrical energy to mechanical energy. A 0.5 hp motor was used to supply power to the transmission box and it gives a speed output of 1440 rpm to the gears. The electric motor was mounted above the frame assembly. Gear box is used to maintain a definite velocity ratio.

The power transmitted by the motor to the transmission system is brought down to the blade and conveying drums by means of shafts provided. Belt and pulley is also used to transmit power from one shaft to another.

3.4.3 Blade drums

Two hollow cylindrical blade drums are used. Slicer blade drum of 80 cm diameter consists of 79 horizontal SS blades. The length of each blade is 9 cm. Dicer blade drum of 80 cm diameter consist of 66 horizontal and 7 circular SS blades. The fruits when fed come in contact with the uniformly spaced blades resulting in uniform slices and due to the cutting action. The blades are made of stainless steel.

3.4.4 Conveying drums

Three types of solid cylindrical conveyor drums are used. The larger conveying drum of 80 cm is the same for both the slicing and dicing purposes. The smaller conveying drums are of diameter 33 cm and 33.5 cm for slicer and dicer respectively. The drums are made out of nylon material. Conveying drums along with the blade drums resulted in uniform fruit slices and dices. The drums helped the fruits to be intact with the blade drum for the proper.

3.4.5 Feed conveyor belt

A feed conveyor belt is provided for feeding fruits in between conveying and blade drums. The length of the belt is 80 cm and the width is 13 cm. The belt is kept close to the conveying drum so that the fruits that were fed would slide in between the conveying and blade drums.

3.4.6 Collecting tray

A collecting tray is provided right below the drums which is slightly inclined. It is made out of stainless steel grade SS 304.

3.5 General layout of multi fruit slicer cum dicer

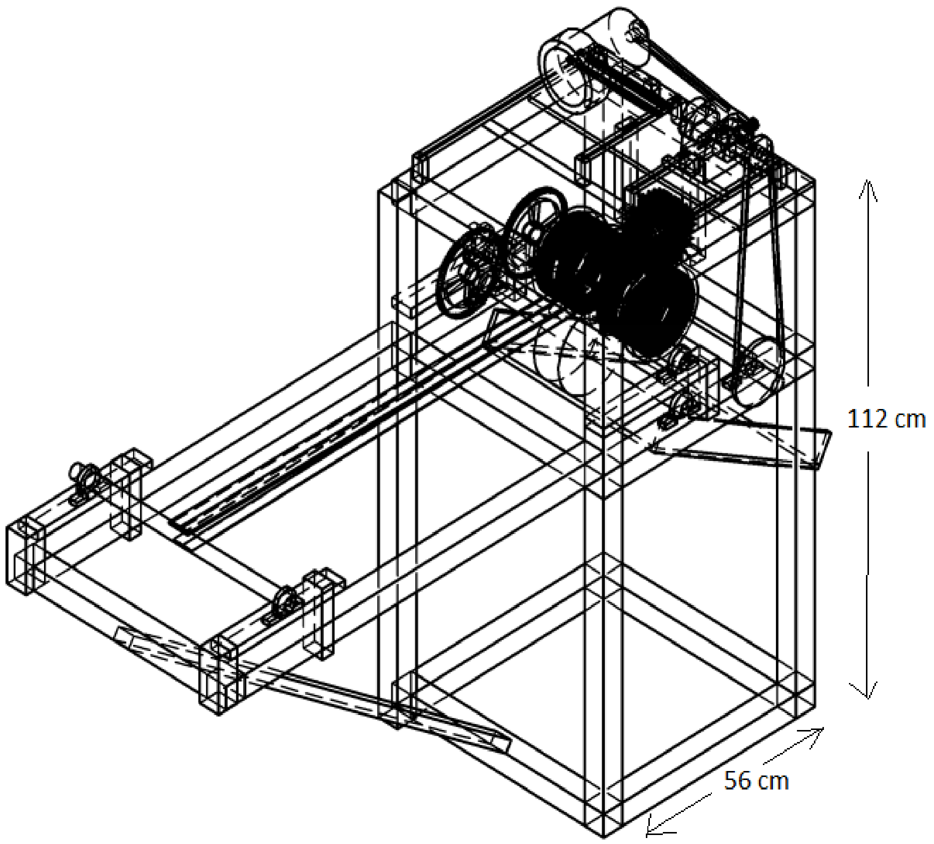

Fig 3.2 Isometric view of multi-fruit slicer cum dicer

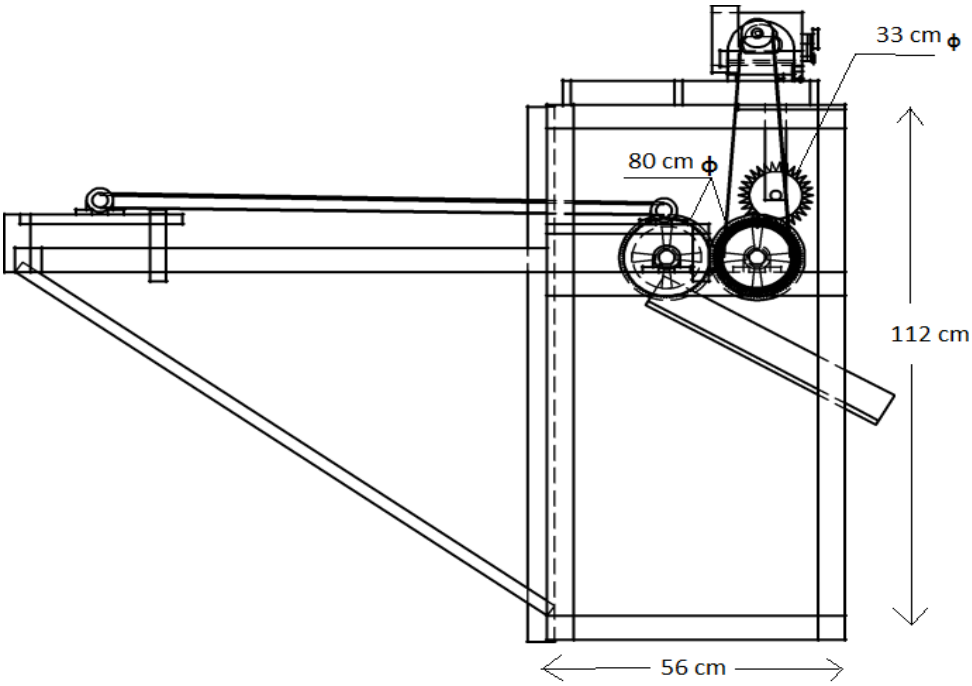

Fig 3.3 Side view of multi-fruit slicer cum dicer

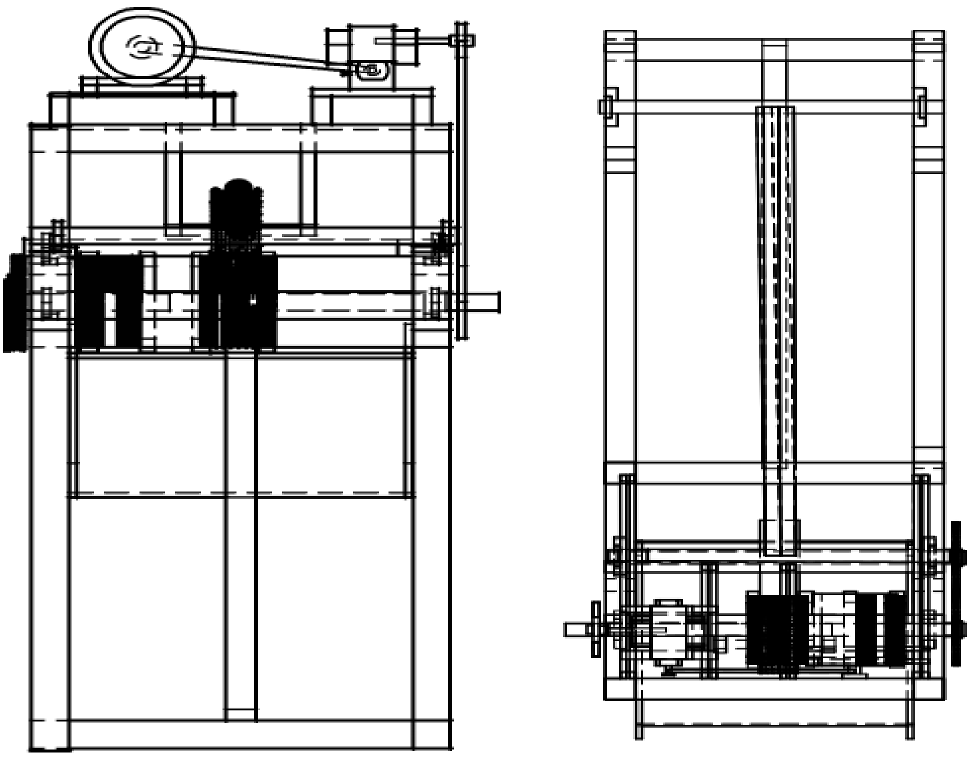

Fig 3.4 Front and top views of multi-fruit slicer cum dicer

3.6 3D CAD drawing of multi fruit slicer cum dicer

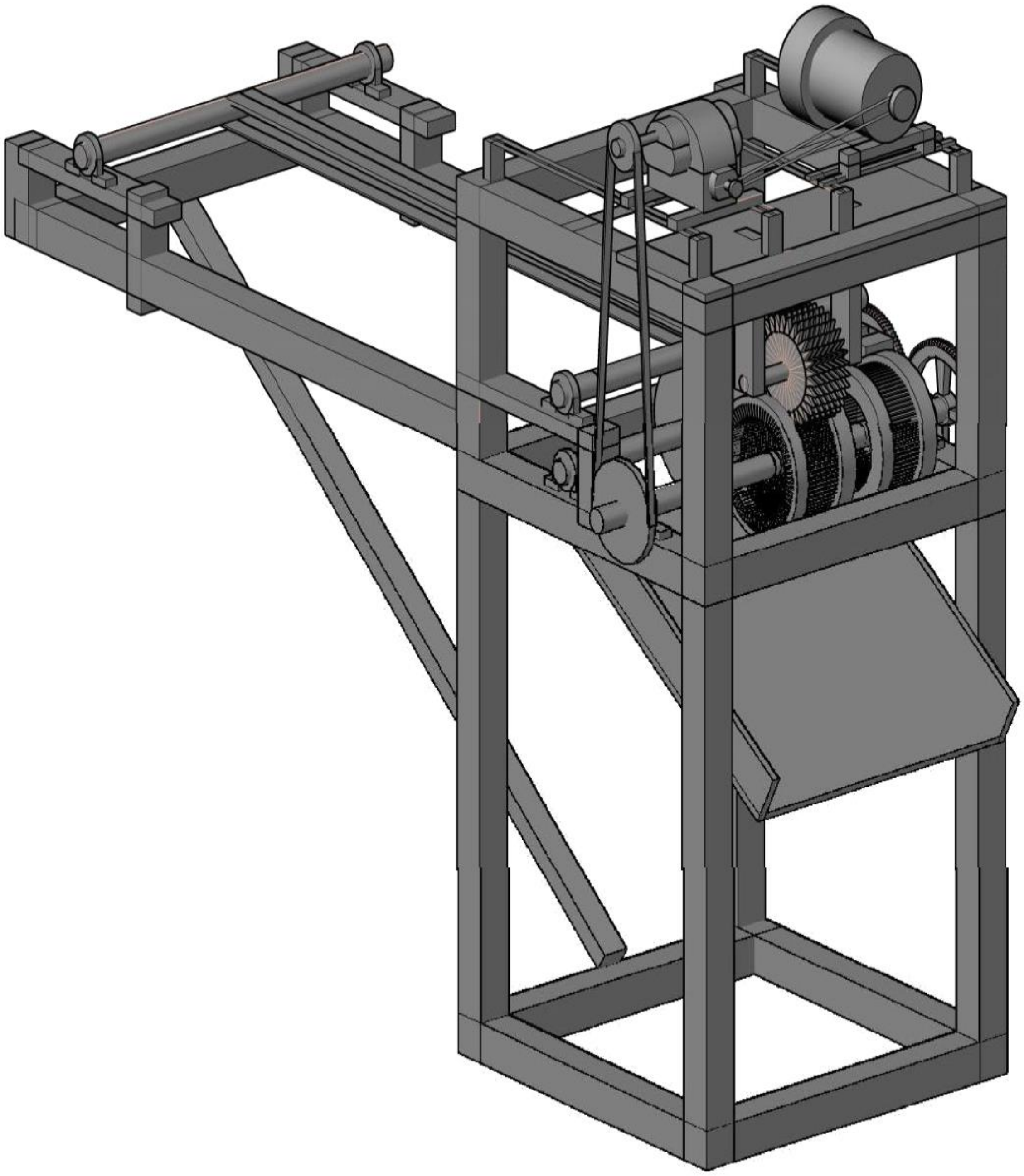

Fig 3.5 CAD Multi-fruit slicer cum dicer

3.7 Operational procedure for the machine

The fruits after cleaning and peeling were fed continuously through the feed conveyor belt. The electric motor supplies power for the working of gears which in turn rotates the conveyor drums and blade drum. The principle of working was cutting and shearing action. The fruits that gets entrapped in between the conveyor and blade drums gets sliced and diced. The blades were arranged in such a way to get uniform thickness for the slices and the dices. The cut fruits were then collected in the tray beneath the drums .Both the blade drum and conveying drums are to be exchanged for slicing and dicing of the fruits.

Plate 3.1 Multi-fruit slicer cum dicer

3.8 Machine calibration

3.8.1 Speed of rotation

Tachometer is an instrument measuring the rotation speed of a shaft or disk, as in a motor or other machine. A tachometer (Model-DT-2235) was used for measuring the rotational speed of the developed machine. Reading was obtained in rpm in a calibrated analogue dial. Tachometer readings for the blade drums were 17.9 rpm before loading and 17.6 rpm after loading.

3.8.2 Uniformity of product

A vernier calliper is a precision instrument that used to measure internal and external distances extremely accurately. The sliced and diced fruits were randomly selected to measure the thickness. 10 samples were randomly selected from the sliced and diced fruits and measured using the vernier caliper. The end portion thickness and middle portion thickness were calculated. The readings were measured in mm. The caliper had a least count of 2 mm.

3.9 Performance evaluation

Matured unripe or semi-ripe fruits procured from the local market were used for conducting the experiment. The fruits were first of all cleaned and they were peeled off manually. The machine was then turned ON , fruits were fed into the gap between blade drum and the conveying drum. The time required for the operation to completely slice or dice out the fruits was noted and the capacity was calculated. Various other parameters like slicing efficiency, percentage damage, sample thickness variance, rehydration ratio cooking quality and shelf life characteristics were then evaluated.

3.9.1 Overall capacity (OC)

The operating capacity of the fabricated machine was calculated by weighing the cut fruits per unit time.

3.9.2 Efficiency (η)

Efficiency of machine was evaluated by weighing the damaged and round slices or dices separately using the following expression,

$$\text{Efficiency, } \eta = \frac{W - W_d}{W} \times 100 \qquad \text{…….. 3.1}$$

Where,

W = weight of all slices or dices

W_d = weight of damaged slices or dices

3.9.3 Percentage damage (%D)

The percentage damage of the machine was evaluated using the expression,

$$\text{Percentage damage, \%D} = \frac{W_d}{W} \text{ X } 100 \qquad \text{……. 3.2}$$

Where,

W = weight of all slices or dices

W_d = weight of damaged slices or dices

3.9.4 Effective capacity (EC)

After having noted the efficiency and overall capacity of machine, the effective capacity was found out by the expression,

$$EC = \frac{OC \text{ X } \eta}{100} \qquad \text{…….3.3}$$

Where,

OC = overall capacity

η = efficiency

3.9.5 Sample variance (S^2)

The variance of the thickness of cut fruits were evaluated by the expression,

$$S^2 = \frac{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}{n-1} \qquad \text{…….3.4}$$

Where,

x = thickness of the fruits

n = number of samples

3.10 Blanching

The fruits fed into the machine were received in the collecting tray. The fruits were then immediately subjected to steam blanching in order to prevent enzymatic browning. Blancher cum drier equipment set at 70°C was used to perform the experiment. The blanching treatments conducted on different fruits are as below in the table 3.1.

Table 3.1 Blanching time for different fruits

Fruits	Blanching time (min)
Jackfruit	3
Papaya	4
Potato	5
Banana	10

3.11 Estimation of drying characteristics

3.11.1 Moisture content

Moisture content of sliced or diced fruits were determined by using hot air oven method. 10 g of sample was taken and placed in the oven for several hours. The weight of the samples were measured after each hours and process was continued until a constant weight of the sample could be recorded.The moisture content was then calculated in wet basis using the following expression,

$$\text{Moisture content \% (w.b)} = (M_i - M_f)/M_i \qquad \text{.......3.5}$$

Where,

M_i - Initial weight of sample

M_f - Final weight of sample

3.11.2 Osmotic dehydration treatment

The osmotic agent used was sucrose and the osmotic solution was prepared by dissolving the required quantity of sugar in distilled water to make 64°brix solution. Papaya fruit slices, previously weighed and identified, were immersed in the osmotic solution of given concentration.The weight ratio of osmotic medium to fruit samples was 4:1 to avoid significant dilution of the medium and subsequent decrease of the driving force during the process. After removing from the sugar solution, samples were drained and the excess of solution at the surface was removed with absorbent paper for posterior weight. The dried samples were stored in an airtight polythene bag for further use.

3.11.3 Re-hydration ratio

The re-hydration tests were conducted to assess the reconstitution qualities of the dried fruit slices and dices. Rehydration experiments for dried samples at 70 °C were carried out in distilled water bath at temperature of 27°C and 100°C. Dried samples were soaked in enough amount of water for different time periods at specified temperatures. Approximately 1 g of dried samples was added to 100 ml distilled water, in a 250 ml beaker. The sample was withdrawn from the liquid and excess water was carefully removed, before weighing. Weights of dried and rehydrated samples were measured. The ratio of mass of re-hydrated and dried samples was used to determine the re-hydration ratio.

$$\text{Re-hydration ratio} = \frac{W_r}{W_d} \qquad \text{.......3.6}$$

Where,

W_r is the weight of sample after rehydration (% wb)

W_d is weight of dried sample (%wb)

Results and Discussions

CHAPTER IV

RESULTS AND DISCUSSIONS

This chapter deals with the result of experiments conducted to evaluate the performance of the developed multi-fruit slicer cum dicer. It also illustrates the results of the physico-chemical properties.

4.1 Performance and Evaluation of Multi-fruit slicer cum dicer

The fabricated machine was evaluated for its overall capacity, slicing efficiency, percentage damage, effective capacity and thickness variance.

4.1.1 Overall capacity

The operating capacity of the fabricated machine was calculated by conducting the trials using fruits like papaya, banana, jackfruit, pineapple and potato. The overall capacities, when tested with these fruits are listed in the table 4.1.Jackfruit when sliced gave 26 kg/hr and when dicing was done using papaya the capacity was found to be 26 kg/hr. From the trials conducted jackfruit showed higher capacity for slicing whereas papaya showed higher capacity while dicing. Ani *et al*. (2007) developed a motorised okra slicer with a capacity of 50 kg/hr.

Table 4.1 Overall capacity of the multi-fruit slicer cum dicer

Operation	Fruits	Weight (kg)	Time (min)	Capacity (kg/hr)
Slicer	Jackfruit	4.3	10.0	26.0
	Papaya	2.0	5.0	20.0
	Banana	2.0	5.3	22.5
	Potato	2.0	5.0	24.0
Dicer	Jackfruit	3.2	10.0	19.4
	Papaya	5.2	12.1	26.0
	Banana	2.0	5.2	20.0
	Potato	1.2	3.0	24.2

Plate 4.1 Papaya slices

Plate 4.2 Papaya dices

Plate 4.3 Potato slices

Plate 4.4 Papaya dices

Plate 4.5 Banana dices

4.1.2 Slicing efficiency

For the determination of slicing efficiency, three samples of each fruit varieties were taken. Observations were made on weight (g) basis. The slicing efficiency of the machine using different fruits was calculated using the equation 3.1. The slicing efficiency was found to be 92%. Among the fruit varieties, jackfruit showed more slicing efficiency. It was due to the thin bulbs of jackfruit collected unlike other fruit varieties. The results are shown in table 4.2. The results were similar to those of Balogun *et al*. (2009) on multi-crop slicer which showed an efficiency of 96%. The results were similar to those of Kachru *et al.* (1996) on electrically operated rotary slicer for raw banana.

Table 4.2 Slicing efficiency of the multi-fruit slicer cum dicer

Fruits	Weight of all slices (g)	Weight of damaged slices (g)	Slicing efficiency (%)
Jackfruit	120.0	7.0	94.4
Papaya	50.0	7.0	86.0
Banana	50.0	3.3	93.3
Potato	100.0	6.3	93.7

4.1.3 Dicing efficiency

Dicing efficiency was determined similar to that of slicing efficiency. It was calculated using the equation 3.1 and the efficiency of the dicer was found to be 92.5%.Also, the jackfruit was observed to have the maximum dicing efficiency. The results are shown in table 4.3.

Table 4.3 Dicing efficiency of the multi-fruit slicer cum dicer

Fruits	Weight of all dices (g)	Weight of damaged dices (g)	Dicing efficiency (%)
Jackfruit	306.3	15.0	95.1
Papaya	137.0	12.3	91.0
Banana	73.3	7.0	90.5
Potato	75.0	5.0	93.8

4.1.4 Percentage damage

The percentage damage was obtained based on observations collected from 3 samples of 100 g each. This value was calculated on weight basis. The damage of the machine was calculated using the formula 3.2. The average percentage damage was found to be 6.5% for diced and sliced fruits. Papaya slices and banana dices were observed to have the highest damage and that was due to the non-uniform sized fruits fed into the machine. Dayana Paul *et al.* (2007) reported a potato slicer shows minimum percentage damage of 4.02%. The results are shown in table 4.4 and 4.5.

Table 4.4 Percentage damage in slicing

Fruits	Weight of all slices (g)	Weight of damaged slices (g)	Percentage damage (%)
Jackfruit	120	7.0	6.0
Papaya	50.0	7.0	14.0
Banana	50.0	3.3	7.0
Potato	100.0	6.3	6.3

Table 4.5 Percentage damage in dicing

Fruits	Weight of all dices (g)	Weight of damaged dices (g)	Percentage damage (%)
Jackfruit	306.3	15.0	5.0
Papaya	137.0	12.3	9.0
Banana	73.3	7.0	10.0
Potato	75.0	5.0	6.2

4.1.5 Effective capacity

Table 4.6 Effective capacity of multi-fruit slicer cum dicer

	Overall capacity (kg/hr)	Slicing /dicing efficiency (%)	Effective capacity (kg/hr)
Slicer	23.0	92.0	21.1
Dicer	22.3	93.0	21.0

The effective capacity of the machine was calculated from overall capacity (kg/hr) and slicing efficiency (%) using the formula 3.3.The effective capacity was found to be 21 kg/hr . The results are shown in the above table 4.6.

4.1.6 Sample variance

Sample variance of sliced or diced fruits was determined from 10 randomly selected samples. The thickness of the slices at end and middle portions were measured using a vernier caliper. The length and breadth of the diced cubes were also taken. The variance of the sliced fruits and that of the cubes were evaluated using the formula 3.4 and is given in tables 4.8 and 4.10 below. The thickness of sliced fruits at end and middle portions results are shown in table 4.7 and the dimensions of obtained cubes are also given in table 4.9.

Table 4.7 Thickness of slices

	Sample	End Portion (mm)	Middle Portion (mm)
Jackfruit	1	8.6	8.9
	2	7.4	7.6
	3	8.5	8.6
	4	7.4	7.5
	5	8.7	8.9
Papaya	1	7.4	6.1
	2	6.9	6.7
	3	7.6	8.0
	4	8.9	8.0
	5	8.4	7.8
Banana	1	8.5	9.9
	2	12.5	11.4
	3	9.9	9.6
	4	7.6	8.7
	5	6.1	7.0
Potato	1	8.3	8.4
	2	8.5	8.1
	3	8.1	8.1
	4	8.0	8.6
	5	7.9	8.0

Table 4.8 Sample variance of slices

Fruits	Variance	
	End Portion	Middle portion
Jackfruit	0.22	0.23
Papaya	0.92	0.93
Banana	2.86	1.58
Potato	0.37	0.64

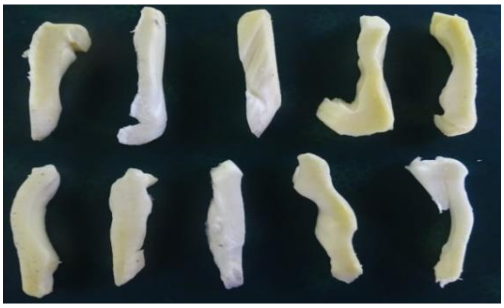

Plate 4.6 Jackfruit slices

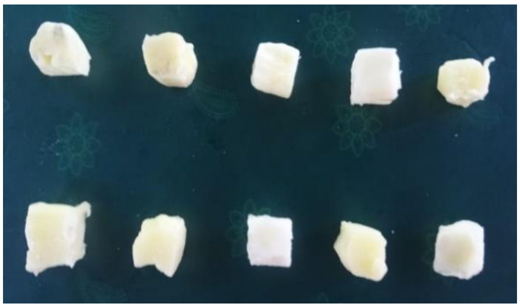

Plate 4.7 Jackfruit dices

Table 4.9 Thickness of dices

	Sample	Length of dice (mm)	Breadth (mm)
Jackfruit	1	11.0	10.0
	2	11.0	9.1
	3	11.5	9.0
	4	10.9	8.9
	5	9.8	10.8
Papaya	1	10.4	10.4
	2	9.9	10.7
	3	10.4	10.6
	4	11.3	10.4
	5	10.4	9.3
Banana	1	10.6	11.1
	2	10.9	9.8
	3	10.2	9.9
	4	11.4	9.9
	5	10.4	9.9
Potato	1	10.2	9.9
	2	10.4	9.3
	3	11.2	9.3
	4	9.8	10.8
	5	10.1	9.1

Table 4.10 Sample variance of dices

Fruits	Variance	
	Length	Breadth
Jackfruit	0.39	0.39
Papaya	0.72	0.23
Banana	0.25	0.25
Potato	0.33	0.35

4.2 Drying characteristics

4.2.2 Rehydration Ratio

The rehydration ratio test was conducted by taking 5g of sample in 100 ml of boiling water for about 30 min. Re-hydration ratios of the tested fruits were determined. The graph below represents rehydration ratios of different fruits in fig 4.2.

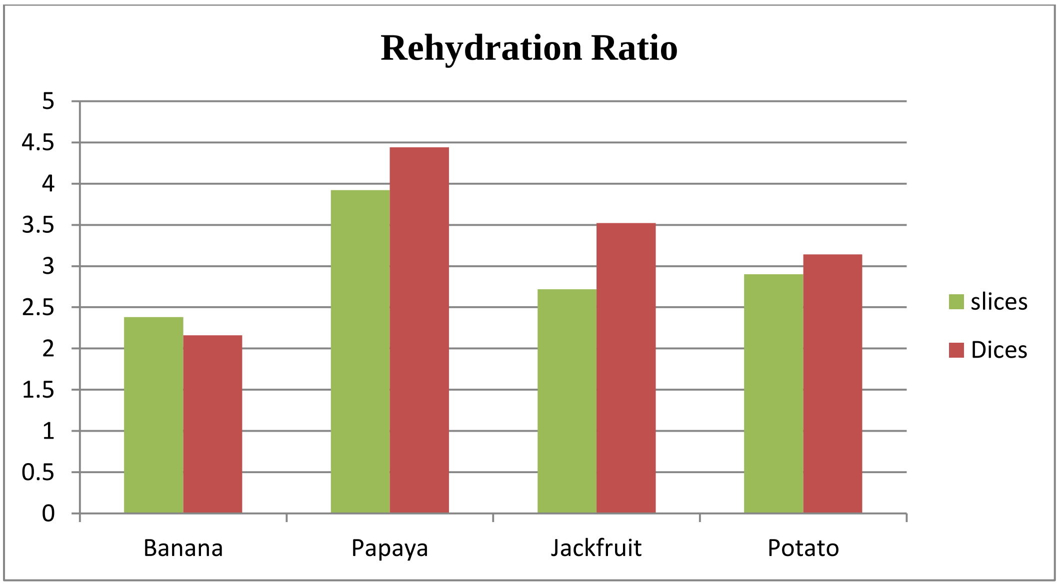

Fig 4.1 Rehydration ratio

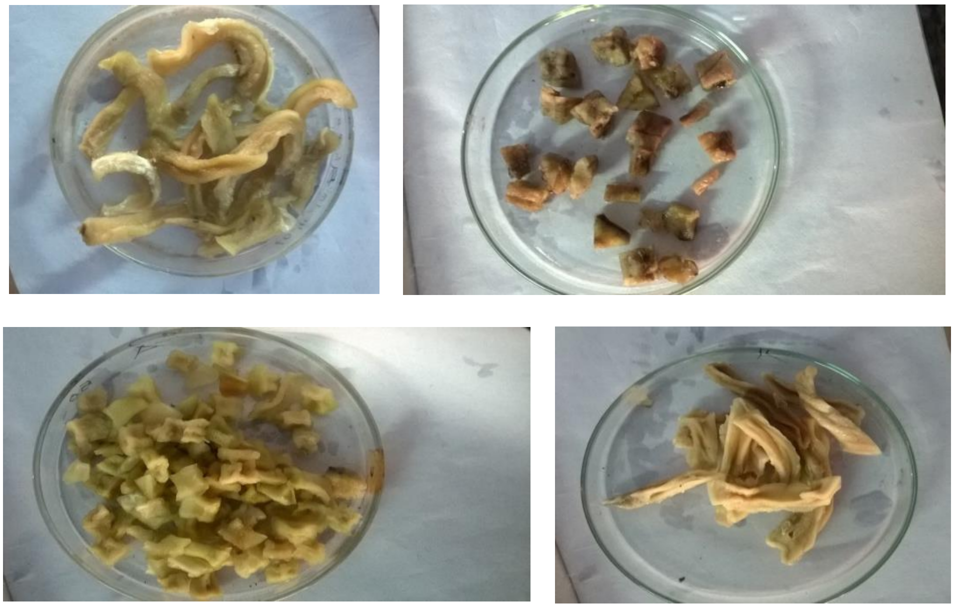

Plate 4.8 Re-hydrated samples

The minimum re-hydration ratio of 2.16 was obtained for 10 mm thick dices of banana and the maximum re-hydration ratio of 4.44 was obtained for papaya samples. Kalyani *et al*. (2015) conducted studies on rehydration characteristics of dry papaya slices and the rehydration ratio was 2.3. The slices treated with 60^{o} brix sucrose solution at 50^{o}C temperature and cabinet drying at 70^{o} C temperature showed the better rehydration characteristics.

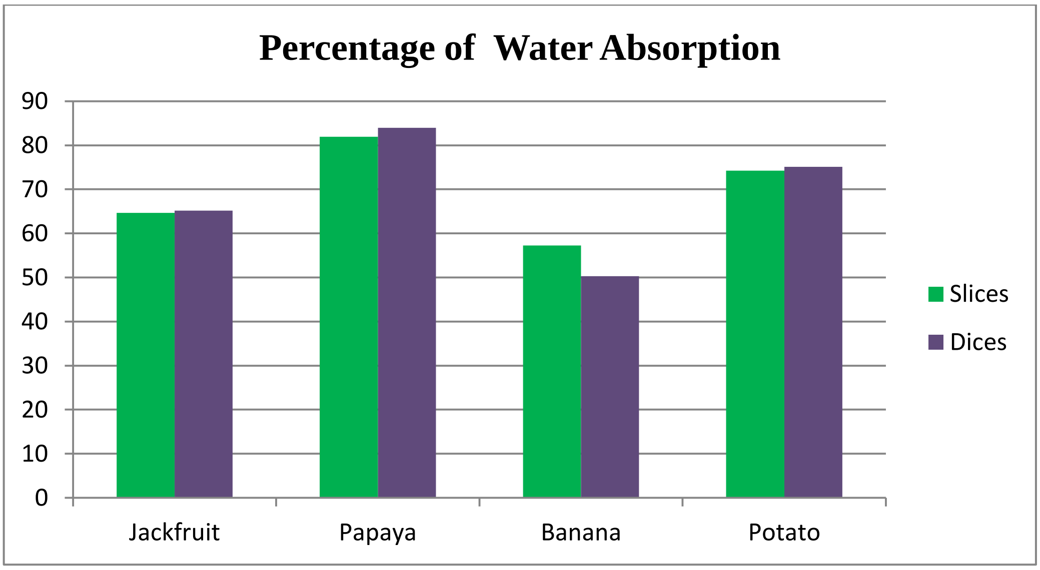

Fig 4.2 Percentage water absorption

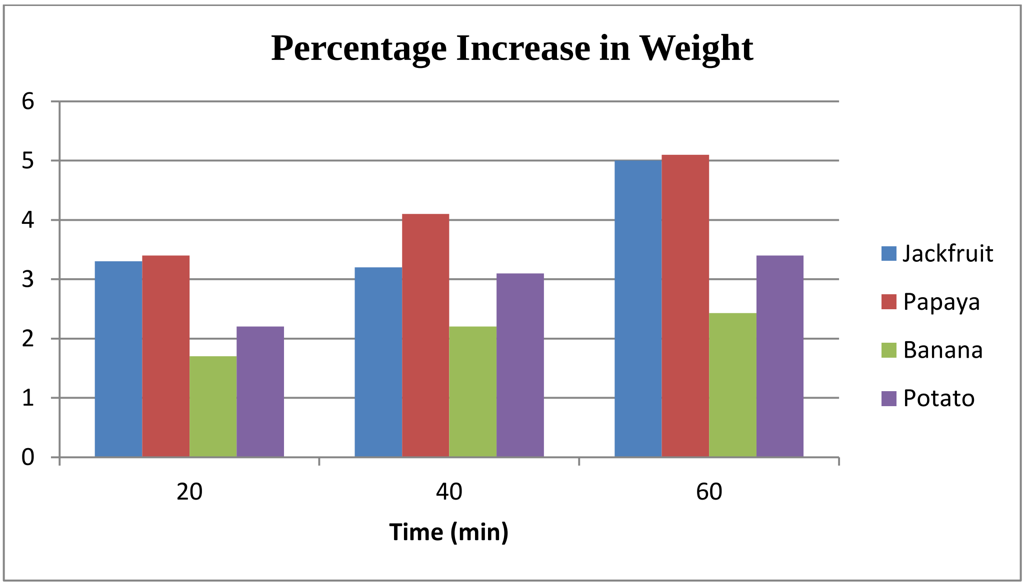

Fig 4.3 Percentage increase in weight

After the fruit samples were re-hydrated, the percentage of water absorbed into each variety were calculated.10g of sample was soaked in 100 ml of water for about 3 hours to study the absorption of water in selected fruits. Papaya slices and dices had highest amount of water absorbed and the results were in accordance with that of Abano *et al.* (2011). Fig 4.3 shows the graph plotted for water absorption of different fruits.

Fruits were also tested in boiling water at specific time intervals. About 1 g of sample was immersed in 100 ml of boiling water and the increase in weight after certain intervals was noted. The studies were conducted to determine the parameters that could accelerate the re-hydration. It was found that increased temperature made the rehydration process faster without affecting the quality of the fruits. The percentage increase in weight of the fruits is represented in fig 4.4.

Summary and Conclusions

CHAPTER V

SUMMARY AND CONCLUSIONS

Fruit constitutes a significant part of human nutrition and is highly recommended for a healthy, balanced diet. Worldwide, more than 675 million metric tons of fruit are produced each year. The greatest annual fruit harvest in the world occurs in Asia. India has emerged as the second largest producer of fruits and vegetables in the world only next to China, and in terms of total area and production our country is designated as "fruit and vegetable basket" of the world. India estimated its production of fruits, vegetables and spices to be marginally higher in 2016-17, according to the first advance released by the Department of Agriculture and Farmers Welfare.

Fruits, being nutritionally important component of human diet, but possess very short post-harvest shelf-life. As they ripen, become very soft and more prone to injuries, which make them highly perishable. In India, around 30 per cent of the total produce is wasted due to spoilage. Hence, there is an urgent need to develop technologies to overcome post-harvest losses of fruits, as these raw materials perish due to their harvest, storage, grading, transport, packaging and distribution.

In recent years, the major driving forces for innovation in food packaging technology is perhaps due to the increase in demand for minimally or lightly processed foods. Minimal processing means application of operations like washing, sorting, trimming, peeling, slicing or chopping and preventing browning that affect the freshness of fruits and vegetables. Fresh cut fruits and vegetables are produce that are minimally processed and altered by peeling, slicing or chopping with or without washing. Cutting, slicing, dicing, and shredding are non-thermal food operations for size reduction. The cut tissues results in reduced respiration and enzymes activity, thus retarding rapid spoilage and increases shelf life. This process also reduces the preparation time by consumers but is found to be a cumbersome, time consuming and labour intensive job. Therefore automisation in this particular field can be very effective.

Raw or ripe fruits of different varieties obtained from the market, were used for the study. Appropriate materials that could be used for food contact equipment were selected. Analysis of the existing available methods for cutting of fruits was also done. The developed machine could produce cuts of uniform size at capacity higher than manual work. The machine requires one person to operate. It is simple in construction and operation and therefore technically feasible and economically viable. The capacity of this machine was 25 kg/hr. The cut fruits were subjected to blanching and drying. The drying characteristics of the fruits were also reported. It is suggested for the modification of the machine, which could further improve its efficiency and performance.

1. The machine should be equipped with an automatic cleaning mechanism.

2. Thickness of the blade and also the cutting force should be increased to enable slicing or dicing of thicker fruits.

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Appendices

APPENDIX I

CALCULATION OF OPERATING COST

Initial Cost (C)

Fabrication cost of multi-fruit slicer cum dicer machine including cost of material

= Rs 65,000/-

Average life of machine (L) = 15 years

Working hours per year (H) = 2400

Salvage value (S) = 10% of initial cost

(A) Fixed cost

1. Depreciation = C- S/L x H

= 65 000-6500/ 15 x 2400

= 1.625/ hour

2. Interest on investment at 12% = (C +S) x 12 /(2x H)

= (65 000+ 6500) x 12/(2x 2400 x 100)

= 1.7875/ hour

Total fixed cost = depreciation+ interest on investment at 12%

= 1.625+ 1.7875

= 3.4125/ hour

(B) Variable cost

1. Labour wages

Wages of a labour = Rs 500 / 8 hour

= Rs 62.5/hour

2. Repair and maintenance cost

@ 10% of initial cost per annum = (65000 x 10)/ (2400 x 100)

= 2.7083/ hour

Total variable cost = 65.2083/ hour

Total operating cost(Rs.) = Total fixed cost + total variable cost

= 65.2083 + 3.4125= 68.6208/ hour

APPENDIX II

Rehydration ratio of 5g fruits in 100 ml boiling water for 30 min

	Fruits	Final weight (g)	Rehydration ratio
Slices	Jackfruit	13.6	2.7
	Papaya	19.6	3.9
	Banana	11.9	2.4
	Potato	14.5	2.9
Dices	Jackfruit	17.8	3.5
	Papaya	22.2	4.4
	Banana	10.8	2.12
	Potato	15.7	3.1

Water absorption of 10g of samples in 100 ml for 3 hours

	Fruits	Final weight (g)	Rehydration ratio	Water Absorption (%)
Slices	Jackfruit	28.3	2.8	64.6
	Papaya	55.3	5.5	81.9
	Banana	23.4	2.3	57.3
	Potato	38.8	3.9	74.2
Dices	Jackfruit	28.7	5.7	65.2
	Papaya	62.3	6.2	83.9
	Banana	20.1	2.0	50.3
	Potato	40.3	4.0	75.1

Table 4.14 Percentage increase in weight of 1g of sample in boiling water

	Fruits	Weight after		
		20 (min)	40 (min)	60 (min)
Slices	Jackfruit	2.8	3.5	3.5
	Papaya	3.4	5.1	5.1
	Banana	1.6	2.4	2.5
	Potato	2.3	3.3	3.4
Dices	Jackfruit	3.3	3.2	5
	Papaya	4.1	3.6	4.3
	Banana	1.7	2.6	2.2
	Potato	3.2	3.4	3.44

Abstract

DEVELOPMENT AND PERFORMANCE EVALUATION OF MULTI-FRUIT SLICER CUM DICER

By

Ciya Paul

Sarath Kumar S

Sreejith C

ABSTRACT

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Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

Department of Food and Agricultural Process Engineering

Kelappaji College of Agricultural Engineering & Technology

Tavanur P.O.-679573 Kerala, India

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ABSTRACT

Importance of minimally processed fruits has already attained a very stable position in the market. Fresh-cut products are preferred over processed one because consumers are now aware of the commonly nutritional losses, desired sensory attributes such as colour and flavour and increased demand for 'natural-like' attributes. The cut fruits are also used in preparation of chips, dry products salads and a wide variety of products. But the cutting of fruits and other vegetables were done manually which was found to be a difficult job at the same time affected the quality and uniformity of the products. Thus, the need of the hour was to develop a multi-fruit slicer cum dicer which could minimise all the mentioned problems. The fruits to be sliced or diced were fed into the machine using a belt conveyor towards the blade drums. The conveying drums properly guided the fruits into the blade. Later, the slices and dices could be collected from the collecting tray. The capacity of the machine was 25 kg/hr and could be used very easily by common people.