DEVELOPMENT AND EVALUATION OF EQUIPMENT FOR STARCH EXTRACTION FROM ARROWROOT (KOOVA)

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PROJECT REPORT

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Department of Food and Agricultural Process Engineering

DECLARATION

We hereby declare that this thesis entitled **"DEVELOPMENT AND EVALUATION OF EQUIPMENT FOR STARCH EXTRACTION FROM ARROWROOT (KOOVA)"** is bonafide record of research work done by us during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associate ship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this project report entitled **"DEVELOPMENT AND EVALUATION OF EQUIPMENT FOR STARCH EXTRACTION FROM ARROWROOT (KOOVA)"** is a record of project work done jointly by Faris K (2014-06-006), Rinitha P (2014-06-014), Safvanath P (2014-06-015), Suparna devu S (2014-06-019) under our guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associate ship, fellowship to them.

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Dedicated to

The Food Engineer's

community

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IV. Symbols and Abbreviations

A.O.A.C	:	Association of Official Analytical Chemists
Cm	:	centi metre
et.al	:	and others
etc.	:	et cetera
FAPE	:	Food and Agricultural Process Engineering
Ft	:	Feet
g	:	Gram
g/cc	:	gram per cubic centi meter
g/cm^3	:	gram per cubic centi meter
H_2SO_4	:	Sulphuric acid
hp	:	Horsepower
Hr	:	Hour
hrs	:	Hours
Hz	:	Hertz
KAU	:	Kerala Agricultural University
KCAET	:	Kelappaji College of Agricultural Engineering and Technology
Kg	:	Kilogram

kg/hr	:	kilogram per hour
Kwhr	:	kilo watt hour
M	:	molar
min	:	Minute
MJ	:	Mega Joule
ml	:	Milliliter
mm	:	Millimeter
NE	:	North East
no.	:	Number
no’s	:	Numbers
rpm	:	revolutions per minute
Rs	:	Rupees
SE	:	South East
V	:	Volt
wb	:	wet basis
WSI	:	Water Solubility Index
wt	:	Weight
°C	:	Degree Celsius
%	:	Percentage

+	:	Plus
-	:	Hyphen-minus
=	:	Equals
&	:	Ampersand
±	:	Plus-minus
µ	:	Microns
@	:	Commercial at

INTRODUCTION

CHAPTER I

INTRODUCTION

Plants that produce tubers use the tubers as storage organs, mainly for storing starch. Technically, a tuber is either a modified stem or a modified root are either indigenous or introduced. Few of the indigenous species (*aroids and various yams*) are cultivated on a commercial scale; they are often found wild in secondary jungle, or planted to a very limited extend in home gardens. The introduced types were mostly during the colonial period. Of the introduced species, cassava, sweet potato, yam bean, tannia and arrowroot are tropical in origin, whereas white potato, carrot and radish come from temperate regions.

Arrowroot is a low perennial herb found in rain forest habitats which is often cultivated for starch obtained from its rhizome. It can grow about 2ft. high, has a small white flowers and fruits. According to historians, Arawak people used arrowroot powder to draw out poisonous toxins from those wounded by tip of poisoned arrows. Arrowroot is indigenous in tropical America but has spread to other countries such as Brazil, India, Ceylon, Indonesia, and the Philippines. Arrowroot was first introduced in the Philippines in 1918. The flour is almost similar to corn starch being white, fine and powdery; the arrowroot powder is a healthier alternative. It is the only starch product with calcium ash which is important for the maintenance of proper acid and alkali balances in the human body (Fallon, 2000). The plant possess an erect slender branch which grow up to 90-180 cm in height with fleshy cylindrical rhizomes under the soil. The leaves are oblate long or ovate lanceolate, 30-45 cm long and 5-8 cm broad with acute tip. Flower colour varies based on the variety of the rhizomes pink or violet and white coloured flowers are usually seen. Based on the physical appearance of the plant the harvesting of rhizomes are carried out. At the time of harvesting most of the leaves will be shredded and the green colour leaves will turn out to yellow or brown colour before this stage the starch yield from rhizomes will be very less. It can take 4 – 6 months in between each harvesting season. October to may seasons are the Indian period of arrowroot (koova) harvesting.

Arrowroot powder is twice the thickening power of wheat flour and, because it contains no protein, arrowroot is gluten free. Unlike corn starch, arrowroot powder creates a perfectly clear gel and does not break down when combined with acidic ingredients, like fruit juice. Arrowroot also stands up to freezing, whereas mixtures thickened with corn starch tend to break down after freezing and thawing. Because of the above mentioned properties and its inevitable medicinal properties, it is used in baby weaning foods and other medicinal foods. It is also used for preparation of various products like koova porridge, barfi, jam, desserts etc. It is also having medicinal properties like astringent, aphrodiasic, antidiuretic, emollient, expectorancy etc. *Acharya vagbata* has mentioned it as a remedy for tuberculosis, astma, cough, burning sensations of the body distaste and an elevator of pithadosha. The high digestibility of koova starch the gluten free nature and the cool soothing effect of koova starch make it as an ideal source of food for infants and aged people.

The arrowroot starch can be extracted from different varieties there are two basic varieties of koova starch eastern koova and western koova. The varieties *Curcuma leucorrhizza* and *Curcuma angustifolia* come under eastern koova and *Maranta aurundinacae* is western koova.

The present production of arrowroot starch in small scale units like Kudumbasree, Sreeshakti and individual production units, they are using partially mechanized method which use a rasper or grinder and traditional methods like scrubbing in stone or iron plates. These methods involves the manual labour for squeezing and extracting of starch from the tuber. Also the traditional process can lead to large starch losses and is not hygienic. Considering the above constraints and drudgery in the production koova starch, Kelappaji College of Agricultural Engineering and Technology, Tavanur decided to develop an efficient power operated koova starch extraction machine.

Due to the reason that the recovery of starch from arrow root rhizomes takes more effort and time farmers yield only a less amount of cultivation. Once the starch extraction process is made easy the cultivation of this super crop can be increased and the present rate of koova starch can be reduced making it avail to all. The process involved in starch extraction process are reduction of the rhizomes to increase its surface contact to leach out the starch entangled in the tissues using water. The commercially available starch extraction machine for this purpose is prohibitive to small farmers and cottage industries, a cost effective machinery have been developed which is of low cost, easy to handle one. Which can increase the production of value added products as well. The consumption of time was large in the process of sedimentation since only after 3 to 6 continuous sedimentation process we could get good quality starch since the use of an equipment for this purpose is not affordable by small scale units, the drudgery in leaching out starch should be reduced also the amount of water used to brush out the starch should be lowered, so that the expense of processing of starch can be minimized.

After extraction of starch other than the unit operations such as drying and milling if we are able to produce some value added products out of this emphasizing the values of crops it could further improve the income of koova farmers.

Keeping the above points in mind, our research have undertaken the objectives as follows:

1. To develop an efficient equipment for extraction of starch from koova rhizomes.
2. To carry out performance evaluation of the machine.
3. To study the physical properties of koova rhizomes and Physico-chemical characteristics of koova starch.
4. To develop value added products out of koova starch

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

This chapter includes the agronomical characteristics, yield composition, processing and uses of the East Indian and West Indian varieties of arrowroot which has been taken as our sample crops for the development of the arrowroot (koova) starch extraction equipment.

2.1. Agronomical characteristics

East Indian Arrowroot encompasses the rhizomes from Zingiberecae family. *Curcuma angustifolia* (Manjakoova) and *Curcuma leucorrhizza* (Neelakoova) are used for the starch extraction. Arrow root is an attractive ginger with stout underground rhizomes which lie dormant in winters. In early spring the flowers are produced before the leaves. Very colourful bracts make this a showy species. The shape and colour of the bracts are very variable. The inflorescence lasts in full bloom on the plants for about three weeks and more. Good for cut flower use with a vase life of 10 days and more for fresh cut blooms. Leaves grow to about 2ft tall and die down in autumn. This species is found in the Eastern Himalayas and inhabits bright open hillsides and woods. In Manipur, *pakodas* made using these flowers, are considered a delicacy. East Indian Arrowroot is found in the Himalayas, from Kumaon to NE India and SE Asia, at altitudes of 900-1210m. This is cultivated from its tubers containing starch. Moist and cool situation at altitudes of 450m are suitable for the crop. Planted in late autumn and watered occasionally during the dry period.

West Indian arrowroot – *Maranta aurundinacae* (vellakoova) is apparently originated in tropical South America is a perennial plant growing, to a height of from 3 to 5 ft., which is today largely cultivated for the high grade starch yielded by its rhizomes. The plant, which is generally ratooned is easily propagated by cuttings from the rhizomes or young offshoots; one crop per year is harvested, 9 to 12 months after planting and maximum starch yields are usually obtained when the plants are about a year old. Compared to other tropical starches, arrow root produces a low yield, but the starch has a high maximum viscosity and yields a very smooth jelly or paste which is of particular value for infant foods.

The harvesting season extends from October to May. On the larger estates, the harvesting of the rhizomes usually proceeds from the base of a hill towards the top. Harvesting involves breaking of the rhizome from the shoot. Planting and harvesting are inter relate in that when the rhizomes are harvested the shoot is replanted at the same time. The curcuma sp. which are grown in temperature ranging from 11 to 40ºC which are also suitable from the hilly area for their growth and development as the region receives a well distributed rain fall during the growing season and also the sloppy well drained land with good organic matter content (Pemba H Bhutia, 2017).

2.2. Yield Composition

Table 2.1 Average chemical composition of East Indian arrow root rhizome (per 100gm edible portion, 12% moisture content)

S.No	Constituents	Amount
1	Moisture	69-70
2	Starch	25-30
3	Crude protein	1.6
4	Fat	0.2
5	Sugar and dextrin	2.1
6	Crude fibre	3.9
7	Ash	0.9

(Deshpande, 2008)

Table 2.2 Average chemical composition of West Indian arrow root rhizome (per 100gm edible portion)

S. no:	Constituent	Percentage (%)
1	Moisture	63
2	Starch	27.17
3	Albumin	1.56
4	Fat	0.2
5	Sugar and dextrin	4.17
6	Crude fibre	0.26
7	Ash	1.23

A Modern Herbal-Mrs M. Grieve, 197

Rewa Kumari and Shrivastava SL (2017) analysed for the proximate composition of *Curcuma angustifolia.* The starch contained 32.30±0.44% amylose, 2.72±0.36% moisture, 0.30±0.04% ash, 97.43±0.52% carbohydrate as starch and negligible amount of fat and protein.

Srivastava AK *et.al* (2006) estimated the volatile composition of *Curcuma angustifolia* rhizome. The rhizome essential oils of Curcuma angustifolia from Central and Southern India were subjected to GC/MS analysis, which resulted in the identification of 81 and 78 constituents, accounting for more than 95 and 99% of the oil contents, respectively. The major constituents in the rhizome oil from Central India were xanthorrhizol isomer (12.7%), methyl eugenol (10.5%), palmitic acid (5.2%) and camphor (4.2%), while the rhizomes oil from Travancore (Southern India) had germacrone (12.8%), camphor (12.3%), isoborneol (8.7%), curdione (8.4%) and 1,8-cineole (4.8%) as major constituents.

Functional properties of Arrowroot starch was evaluated by Albert Linton Charles (2016) and found out that the composite flour/starch gelatinize at relatively low temperatures and uniform swelling of granules occurs. They exhibit a high viscosity profile compared to cereal starches. Addition of Arrowroot starch to Cassava and Sweet potato starches improved gel stability and may find use in modulating gelling properties of these starches in commercial products.

2.3 Characteristics of raw koova rhizomes

Gayatri Nahak and Rajani Kanta Sahu (2011) studied the antioxidant activity in ethanolic extracts of five curcuma species. The antioxidant activity of *Curcuma angustifolia* was found to be 58.35±0.06 %. Antioxidant activity in four species except *Curcuma angustifolia* has strong correlation with curcumin and phenol content. However, *Curcuma angustifolia* may be active due to high aromatic oil content like eugenol, palmitic and camphor etc. The natural oxides of curcuma species can be explained in the field of pharmaceutical areas for their uses in modern health care as phytoprotectants.

Abha Rani and Praveen H Chawhaan (2012) recorded the granular size and shape of starch granules of *Curcuma angustifolia* using Scanning Electron Microscope. The shape of *Curcuma angustifolia* starch granules were small rounded, oval to elliptical, spherical, elongated and 3.32µ to 32.55µ in length and 2.29µ to 8.47µ in width.

Rewa Kumari and Shrivastava SL (2017) characterized the starch from *Curcuma angustifolia* for its physicochemical and functional properties .The starch granules were polyhedral, with a diameter of 9.75 to 20.43µm and 3.409 to 5.272µm in width. Clarity and solubility of tikhur starch was comparable with those of corn and cassava starch. Tikhur starch displayed higher pasting temperature (76.25ºC), suggesting the tendency to form faster paste and stability under high cooking conditions. These properties demonstrated that the untapped potential of tikhur starch for use in food and non-food applications previously dominated by costlier casual starches.

Shankar (2012) studied the collection, characterization and evaluation of 20 genotypes of tikhur. It was found that the maximum starch yield and starch recovery was observed when starch extracted 5 days after harvesting and gradually reduced starch recovery by delay in starch extraction after harvest of rhizome.

Rajeev Kumar (2010) investigated the physicochemical, binding and disintegrating properties of starch isolated from grains of Arrow root. The studies indicated that this starch is quantitatively and qualitatively comparable to corn starch also the rheological and swelling properties.

2.4 Global Scenario

Arrowroot starch is produced primarily in the tropics and historically St. Vincent, West Indies produced over 98% of the supply of arrowroot starch for the United States, Canada, Britain and Europe. Small production capabilities, competition from alternative crops, such as bananas and high labour inputs have resulted in fluctuating supplies of starch (Erdman and Erdman, 1984).

2.5 Processing Method

2.5.1 Traditional Processing method

In traditional practice, fresh rhizome bulbs were separated, cleaned thoroughly and dipped in water for one night. The rhizomes were rubbed on a rough surface stone or sieve. The obtained paste was added with water in the ratio of 1:2 to make solution and passed though muslin cloth. Supernatant part of the solution remained on the cloth was thrown away as the waste. The filtered solution of arrow root powder was collected in an earthen pot. This solution was kept for about 4 to 6 hours to allow settling of the powder particles. Powder mass was settled down in earthen pot as sediment. The decanting of water was done initially after 6 hours. The process of decanting was repeated 6-8 times till the bitterness taste was not experienced.

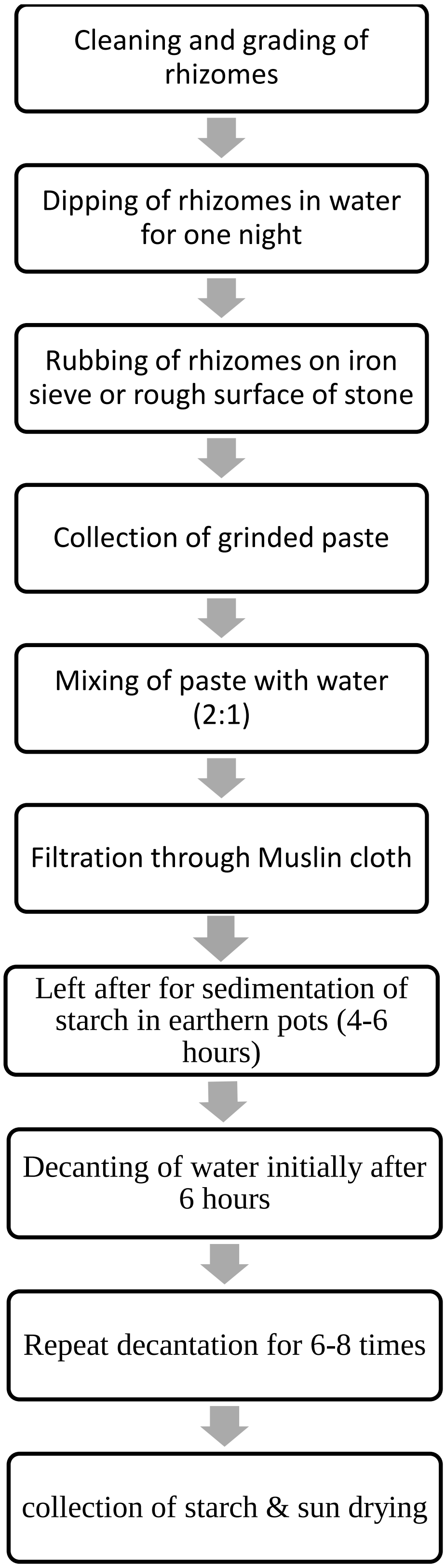
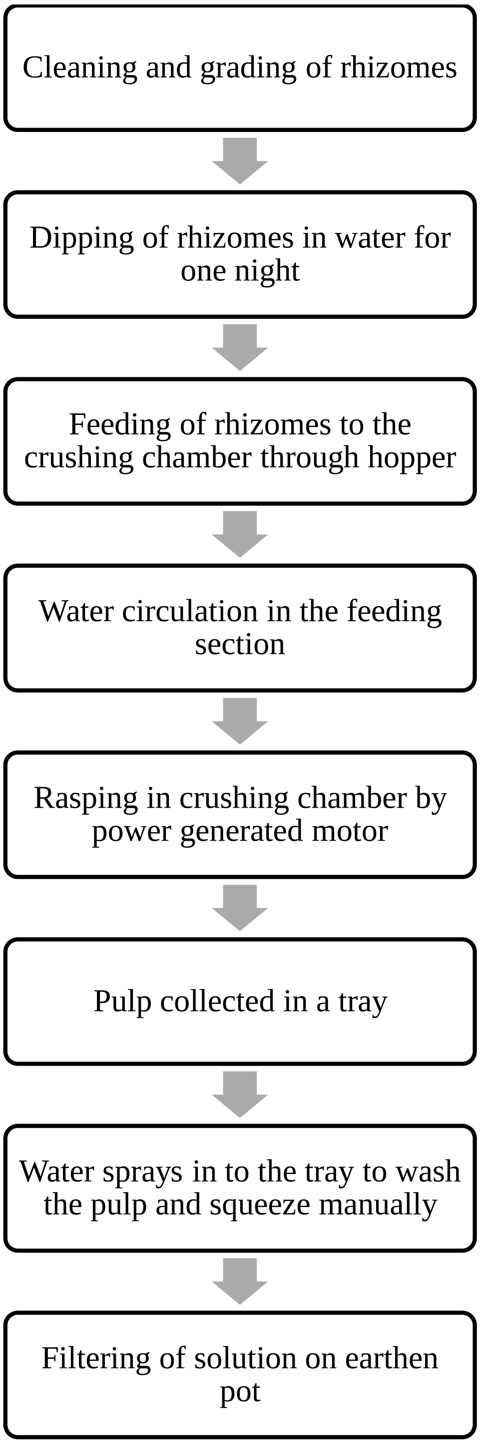


Figure 2.1: Traditional processing method

2.5.2 Partially mechanized method

All the process was similar to that of traditional method except the size reduction of rhizomes by motorized wet grinder and drying by tray drying. All other steps were repeated as in case of traditional method.



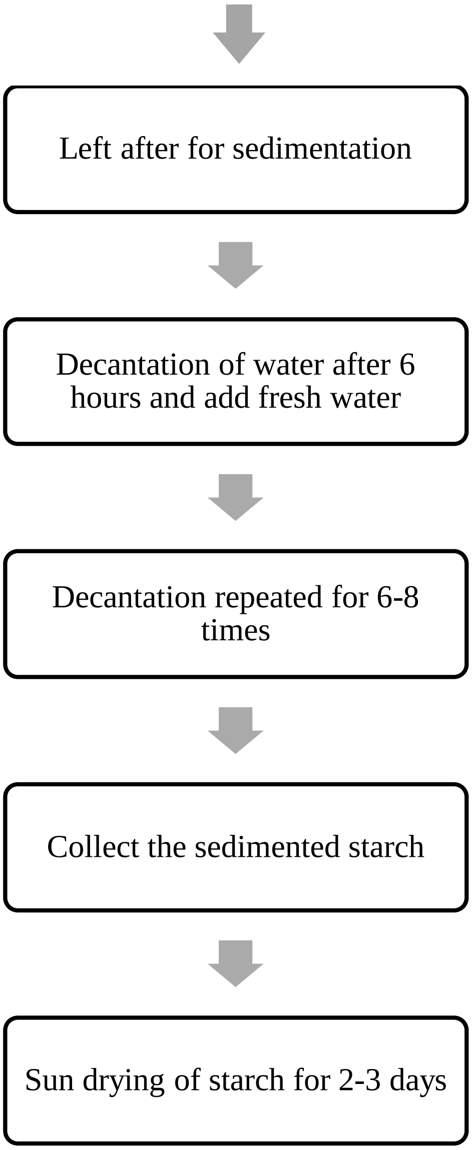


Figure 2.2: Partially mechanized processing method

Sajeev MS & Balagopalan C (2005) developed a multi-purpose mobile starch extraction plant for small scale processing of tuber crops. The major components of the machine are hopper to feed the tubers, crushing disc or cylinder with nail punched protrusions rotating inside a crushing chamber to crush the tubers, sieving tray to remove the fibrous and other cellulosic materials, plastic tanks to collect and settle the sieved starch suspension, tuber storage chamber, handle and wheels for easy transportation from place to place and a frame to support these components. Addition of water during the processing can be controlled through a water pipe with holes fixed inside the hopper along its length and during sieving by a shower attachment connected to the water line. It is operated by a single phase electric motor of 1 hp and 1425 rpm.

Figure 2.3: Arrow root starch extraction machine (CTCRI)

C. K. Paikra, and S. Patel (2014) carried out the performance evaluation of arrow root starch extraction machine and their data revealed that there is no significant difference in the starch recovery due to rasper speed and rhizome sizes. The capacity of machine increased with the rasper speed but decreased with increase in rhizome size.

Tiwari and Patel (2013) conducted a comparative study on the traditional and partially mechanised processing of arrowroot. The study showed that there was no significant increase in the starch yield by partial mechanisation. However, the processing cost of arrowroot was reported to be reduced significantly in case of partially mechanized method.

Michael V. Capiña and Verna Liza L. Capiña (2017) extracted starch from arrowroot using a prototype grinding machine. The extraction process is laborious and tedious while a manual and inefficient mechanical extraction process result to low percentage of starch recovery of about 10-20%.

Adegun (2011) developed a cassava processing plant for improved stone free gari. The procedure included the design, construction and testing to estimate the products of cassava processing. The plant was made up washing, grating, dewatering, sieving and frying units. Samples of 20kg, 25kg and 30kgof peeled cassava roots were fed into the washing unit and afterwards grating, dewatering, sieving and frying that resulted to obtain 11.5kg, 14.4 kg and 17.3 kg of stone-free gari as final products respectively. The grater and sieve efficiencies were estimated as 95% and 93% respectively.

Olawale John Olukunlea, and Oluwatoyin Folake Olukunleb (2007) developed a sustainable system for cassava starch extraction. . The machine consists of a specialised serrated auger, tuber inlet, water delivery system, perforated cage, and an arrangement of sieves, starch delivery outlet, fibre delivery outlet and the power source. The machine is conceived as a low cost equipment to enhance productivity at the small to medium scale levels in developing countries.

Abha Rani and Praveen H Chawhaan (2012) studied the extraction of starch in *Tikhur* using 1% ammonium oxalate and 0.03M ammonia solution and 1% ammonium oxalate. The yield of starch in 0.03 ammonia solution and 1% ammonium oxalate was obtained 38.46% and 37.64% respectively. The study demonstrated that for extraction of starch from *Curcuma angustifolia*, 0.03M ammonia solution method described is best and yields significant quantity of starch.

Olutayo L.A *et.al*(2015) designed and fabricated a cassava starch extraction machine. The working principle of the machine is by feeding cassava mash and water through the hopper, under gravity they both fall freely into the mixing unit, the rotated stirrers mixed the mash and water properly before it is discharged to the extraction chamber where the screw conveyor move and rotates it over a sieve thereby causing the moist starch to vibrate. The machine had an output capacity of 20.2kg/hr. with extraction efficiency of 80%.

Figure 2.4: Cassava starch extraction machine

Other than the above mentioned researches and developments we have a couple of machines developed for starch recovery from koova which have a similar principle of these raspers and grinders.

Kanchana saengchan *et.al* (2011) done a comparison of centrifugation and filtration techniques for starch granule produced by the pulp extraction during tapioca starch production process. They took various crushed size of tapioca root for starch extraction and applied relative centrifugal force and pressure drop across filtering system. And found that a small crushed size contained a lower fibre content than that of the larger one, a very high relative centrifugal force and pressure drop across filtering system decreased cake porosity, permeability and starch extraction efficiency. Since Arrowroot starch extraction process is similar to that of tapioca starch other than using gravitational sedimentation method it might be possible to use centrifugal separation also.

Darma (2014) developed Sago starch extractor with stirrer rotary blade for improving extraction performance. In the experiment three rotating speeds (100 rpm, 150 rpm and 200 rpm) and four levels of stationary blade numbers (0, 4, 8, and 12) were examined. The higher the rotating speed the lower the starch left in *hampas* and the greater the number of stationary blades the higher the extraction rate, starch yield and lower starch left in *hampas.*

2.6 Uses

Rhizome is demulcent, nutritious, contains starch which is used for children due to easily digestible. The powder of rhizomes with honey is applied on the mucous membrane of the oral cavity in stomatitis. It also promotes the healing of stomach ulcers. It is good for diarrhoea, dysentery and colitis as it is astringent. It is also an effective remedy in oedema due to cardiac debility as it accords diuretic action. Rhizome is stimulant, carminative and stomachic. It is highly valued as an article of diet. It is an excellent diet in the form of conjee in case of dysentery, dysuria, gonorrhoea etc. Useful in typhoid fevers, ulceration of the bowels & bladder. In case of difficult and painful maturation it can be used in the form of thin conjee prepared like barley water with milk & sugar added. It is nutritive and is used as an agreeable non irritating diet in certain chronic diseases during convalescence form fevers.

Arrow root refreshes and nourishes the body. It is a rich source of calcium, potassium, manganese phosphorus etc. It cools the body, reduces urinary symptoms like burning micturition, dysuria etc. It prevents stone formation also. It is good for genital, urinary and reproductive systems. It improves quality and quantity of semen. Reduces dysuria and leucorrhoea, fever, vomiting, diarrhoea, measles, chickenpox, burns, post-surgical etc. As it belongs to curcuma family it has got a unique property of removing toxins from our body. Toxins accumulated in our body are metabolic by-products of alcohol and drugs, colouring agents and preservatives of packed food products, insecticides and pesticides in vegetables and fruits etc. detoxification process is being carried out in livers. We can make delicious recipe like puddings, halwas, jams etc.

Arrowroot is a starch rich, underground creeping rhizome. Its powder is one of nature's finest carbohydrates. With qualities such as easy digestibility and ability to mix well with a wide range of food ingredients, arrowroot is the most sought after starch in infant formulas and confectionary. In general, arrowroot flour is added as thickener, colloidal stabilizer, binding agent in liquid-based recipes. It has several advantages over other starch flours. It mixes well in low temperature cooking and gives uniform viscosity to recipes. It has a neutral taste, prevents dextrinization (breaking carbohydrates to dextrins), and can be added to acidic-based recipes. However, it does not mix well with dairy-based recipes as it turns them slimy. One tablespoonful of flour is enough for the thickening one cup of liquid. Arrowroot starch is more translucent than corn starch and does not gel or beep when cooled. The thickening power of arrowroot is 0.5.

The starch extracted from *Maranta aurundinacae* L. Starch can be extracted and characterised for application in edible films. Gislaine Ferreira Nogueira (2017) evaluated different concentration of starch (2.59 to 5.41 %, mass/mass) and concentrations of glycerol (9.95 to 24.08 %, mass/starch mass) on films properties by a rotational central composite 2^2 experimental design. Arrowroot starch showed high amylase content (35%). Low values were found for the swelling power and solubility index. The X-ray diffraction showed “C” type crystalline structures. The films were homogenous transparent and manageable. Therefore, Arrowroot is very promising starch source for application in films.

Tian xiang Wu et.al (2010) done research on using Arrowroot as a novel substrate for ethanol production by solid state simultaneous saccharification and fermentation. There was no waste water produced in the process of ethanol production.

2.5 Products

The various products that can be prepared out of koova starch are cookies, dessert, kanji, cake, payasam, halwa, jam, thickener in yogurt, pancakes etc. The commercially available arrowroot starch brands are Redmill and Koova.

MATERIALS & METHODS

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials and methods used during project experiments. The determination of various physical and chemical properties of fresh koova rhizomes and Arrowroot (koova) powder of two varieties was done using standard techniques. The studies and experiments was conducted in FAPE laboratory, KCAET, Tavanur. The fabrication of machine was done in Balakrishna Engineering, Coimbatore.

3.1 Collection of Rhizomes

The koova rhizomes of three different varieties namely *Curcuma leucorrhizha (eastern arrowroot), Maranta aurundinacae (western arrowroot)* where collected from Malappuram and Palakkad districts of Kerala.

Fig 3.1: ***Curcuma leucorrhizza***

Fig 3.2: ***Maranta aurundinacae***

3.2 Physical properties of raw koova rhizomes

3.2.1 Colour of rhizomes

Colour of rhizome was recorded on visual basis after the harvesting of koova plant.

3.2.2 Dry matter per cent in rhizomes

Just after harvesting, 10 g rhizomes per samples from randomly selected heap were taken. Then simultaneously after washing rhizomes were sliced by knife and dry in hot air oven which leads to estimation of dry weight of rhizomes. Dry matter per cent of rhizomes was calculated on the basis of following formula:

Dry matter (%) = Dry weight of rhizomes / Fresh Wt. of Rhizomes x 100

3.2.3 Length and thickness of rhizomes

A sample of each variety is taken from a huge heap and the length and thickness where measured using a meter scale and vernier caliper respectively.

(a)

(c)

(b)

(d)

Plate 3.1: (a), (b) Length measurement (c), (d) Thickness measurement

3.3 Starch extraction methods

3.3.1 Mechanical methods

3.3.1.1 Using wet grinder

The cleaned rhizomes where skinned and cut into small pieces and are grinded in a mixer with water in the ratio 1:2 for 2 parts of rhizomes. The grind mix is then poured into a muslin cloth and squeezed to separate the starch liquid. The liquid is then mixed with more amount of water two to three times for western arrowroot and for at least 6 times for eastern arrowroot, it is simultaneously washed and sedimented to obtain the starch. It is then sun dried and milled.

3.3.1.2 Starch extraction using screw extractor (developed by KAU)

Experiments were carried out to extract starch from *koova* rhizomes. This method was used in the present work. In this method *koova* rhizome was cleaned, cut and the starch was squeezed with the help of starch extraction machine. After the starch separation, sedimentation and drying was carried out. With three times the amount of starch milk obtained from western arrowroot and five times the amount for eastern varieties.

3.4 Performance of the koova starch extraction machine.

3.4.1 Table top starch extraction machine

The major components of the table top starch extraction machine are a helix screw, hopper, water inlet valve, extracting body, fibre separation port, filter with an itched arc to provide abrasive force to the rotating rhizomes, bag to collect fibres, jar to collect the starch extract and a filter plate with 0.75 mm holes provided at the base of helix screw to strain the starch extract. Overall dimension of the machine is 500 x 260 x 570 (mm) the dimension of helix screw is 353 (mm) in overall length. Addition of water during the processing is done at hopper end. It is operated by a single phase electric motor of 0.5 hp. The power consumed is 230V, 50 Hz.

Plate 3.2: KOOVA Starch Extractor

Plate 3.3: Extractor screw

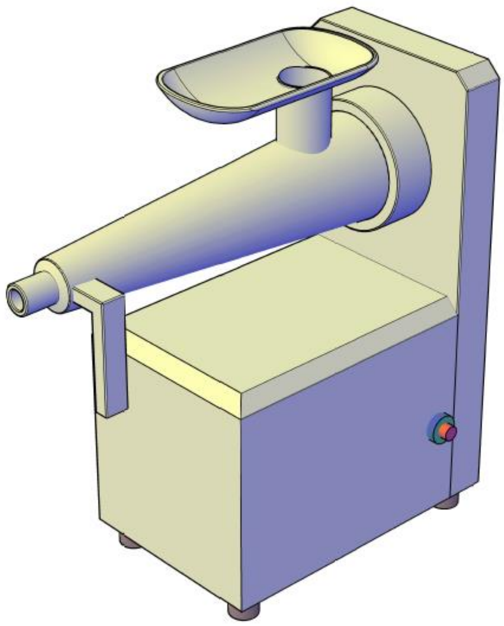


Figure 3.3: KOOVA Starch Extractor Drawing

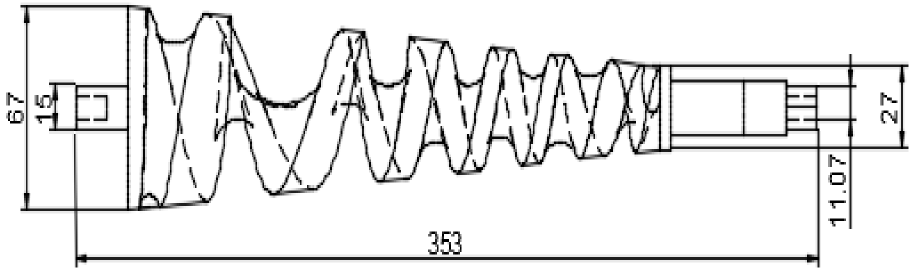
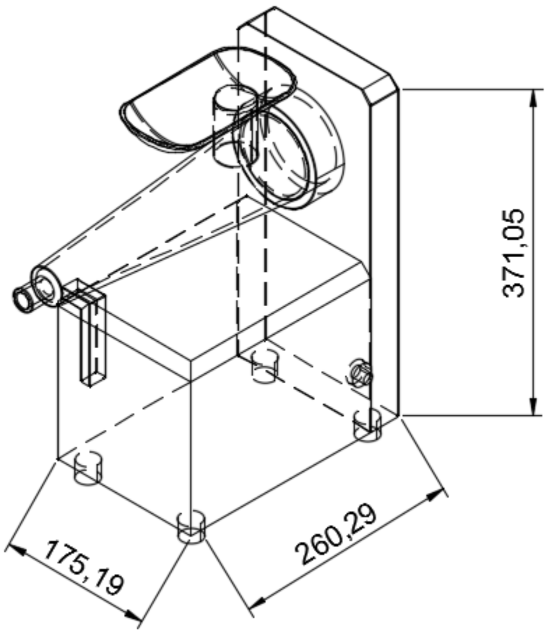


Figure 3.4: Extractor screw drawing



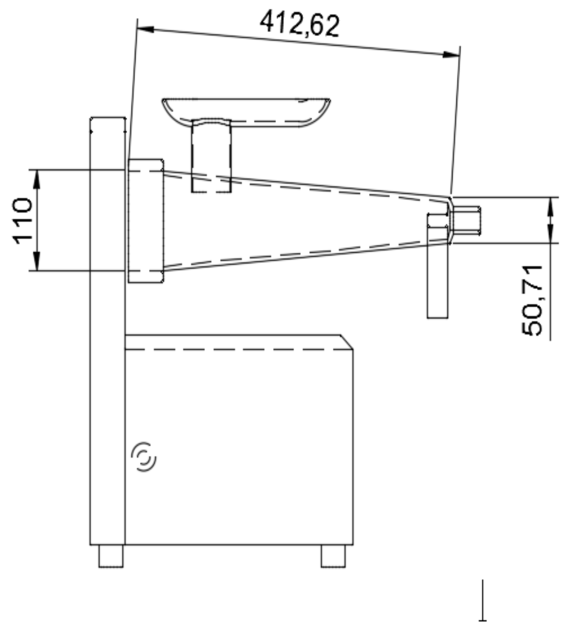


Figure 3.5: Isometric view **Figure 3.6: Front view**

3.4.1.1 Installation

- Attach the filter for starch extraction in the groove provided.
- Fix the fibre collecting bag at the fibre outlet port.
- Connect the water inlet tube to the valve.
- Connect the water line to the water source or manual feeding (2-3 times the tuber fed).
- Place the plastic jar just below the extractor outlet.

- Assembling of the parts should ensure vibration free operation.

3.4.1.2 Operation

Place the machine on a levelled surface and operate the machine using the motor/generator. The tubers after cleaning for removing the dirt or adhering foreign materials are cut into 3-5 cm pieces, again washed and fed to the extraction chamber through the hopper. The helix screw is rotated to cause crushing and squeezing of the starch from the rhizomes. The water added in order to wash out the adhering starch in the fibres, water about equal amount that of the tubers are added. The starch milk is then mixed with more amount of water and allowed to settle for 2hr interval with change of water for 3 times or 6 times respectively. After draining the supernatant liquid, the wet starch is scooped out and dried (sun dried or mechanically dried).

3.4.1.3 Precautions

- The screw should be rotated in the direction specified.
- Do not let water to flow on motor.
- Always cover the motor and belt regions.
- Do not feed the material directly to the screw bare handed.
- If the machine stops due to excessive fibre at the fibre outlet, immediately stop the machine dismantle the screw and remove the fibre to clean it.
- Do not alter the original design of machine.
- After extraction clean the machine by removing the screw and the filter from it.
- Make sure the screw and filter placed properly after cleaning.

3.4.2 Performance indicators

3.4.2.1 Starch recovery (%)

Starch recovery from koova was estimated after extraction of starch from rhizomes using wet grinder method and screw extractor method. Taken 1000g fully matured koova rhizomes of two different varieties (white, blue) for starch extraction. Extracted starch was dried and weighed. Starch recovery was calculated by the given formula.

$$\text{Starch recovery (\%)} = \frac{w_s}{w_r} * 100$$

Where, w_s = weight of extracted starch.

w_r = weight of rhizomes taken.

3.4.2.2 Capacity

Capacity of the machine was estimated by calculating the time required for extraction of starch milk from 1000g of koova rhizomes and expressed in kg/hr.

3.4.2.3 Energy Consumption

Energy Consumption was calculated by following steps:

Total weight of the machine = W kg

Annual working hours;

(D) Days x (I) Hours per day = H hrs.

$$\text{Electricity consumed per day (kWhr/motor)} = \frac{\text{motor input in watts x operation time (hr)}}{1000}$$

Human energy = Time required (hr) x Energy equivalent

3.4.3 Cost of processing.

Investment cost = Rs. P

Expected life (L) = 10 years

Hourly use / year (N) = 200 h/year

Salvage value (S) = 10% of total investment cost

Interest (R) = @10%

I. Fixed cost

a) Depreciation = (P-S)/(N x L)

b) Annual interest @ 10% in investment

Interest = (P+S) x R/2 N 100

c) Miscellaneous (housing and insurance)

II. Variable cost

a) Repair & maintenance cost @ 5% initial cost

Initial cost x annual working hour

b) Labour charge @ Rs.80 per day

c) Electricity charge.

III. Total cost

Total cost = Fixed cost + Variable cost.

3.5 Standardization of the process.

3.5.1 Size of the rhizome

The rhizomes were cut into 3 different sizes after cleaning, sizes of below 2 cm, 3 cm, and 5 cm. Each sample was subjected into the screw extractor. The time consumed for extraction of milk from each sample was observed. It was noted that as the size reduced the time for milk extraction also reduced, since it was easy for the rhizomes to pass through the helical screw.

3.6 Physico – chemical properties of starch obtained.

3.6.1 Moisture content

The moisture content was determined, following the method described in A.O.A.C. (1995). To determine the moisture content, initially the oven was pre heated at 100°C for 30 min. About 5 g of sample starch powder was kept in the oven for 3 h at 100±1°C. Samples were then brought out from the oven and weighed. Immediately after weighing the samples were replaced in the oven for further removal of water. The method was continued till the entire moisture was evaporated and there was no appreciable difference between two consecutive weighing. The moisture content was calculated using the following formula:

$$\text{Moisture (\%)} = \frac{\text{Weight of moisture evaporated}}{\text{Initial weight of the sample}} \times 100$$

$$\text{Moisture content (\%)} = \frac{w_1 - w_2}{w_1 - w} \times 100$$

Where, w_1 = Weight of the dish with the material before drying, g

w_2 = Weight of the dish with the material after drying, g

w = Weight of the empty dish, g

3.6.2 Determination of pH

1g of starch was mixed with 10 ml of distilled water and a litmus paper was dipped in this solution.

.

Plate 3.4 : pH Paper

3.6.3 Titrable acidity

The titrable acidity was estimated using the steps provided by Ranganna (1986). The powder (10g) was mixed with 200 ml of lukewarm distilled water and titrated against 0.1 N sodium hydroxide using phenolphthalein as indicator.

$$\text{Percentage titrable acidity} = \frac{T \times N \times V \times E \times 100}{v \times W \times 1000}$$

Where,

T = Titre value (ml)

N = Normality of alkali

V = Volume made up (ml)

E = Equivalent weight of acid (g)

V = Volume of sample (ml)

W = Weight of sample taken (g)

3.6.4 Protein

The total protein content was calculated using difference method mentioned in A.O.A.C (1995). After determining the percentage of moisture, protein, fat, and total ash content.

Total carbohydrate (%) = [100 – (A + B + C + D)] %

Where,

A = Percentage of moisture

B = Percentage of total protein

C = Percentage of fat

D = Percentage of total ash

3.6.5 Fat content

The total fat content was calculated by the Soxhelt method as described in the A.O.A.C. (1995) method no. 920.39C. In this technique 2 g of sample was taken into the thimble. With the help of anhydrous ether (boiling point 60 – 80 °C) and "*Socs Plus*" (extraction equipment) fat was extracted. The amount of fat was calculated by the following formula:

$$\text{Fat content (\%)} = \frac{\text{weight of fat}}{\text{weight of sample}} \times 100$$

$$= \frac{B-A}{W} \times 100$$

Where,

A = Initial weight of beaker, g

B = Final weight of beaker, g

W= Weight of the sample, g

Plate 3.5 : Soxhelt Apparatus

3.6.6 Ash content

Ash content of starch was estimated by the dry ash method as described in the A.O.A.C. (1995). 5 g of sample was taken into the pre dried crucible and it was kept into the muffle furnace at 550 °C for 18 – 19 hours. Calculation was done by the following formula:

Ash content (%) = 100 X $\frac{w_1 - w}{w_2 - w}$

Where,

w = Weight of the empty crucible, g

w_1= Weight of the crucible with the ash, g

w_2 = Weight of the crucible with the dried material taken for the test, g

3.6.7 Total carbohydrate

The total carbohydrate content was determined using anthrone reagent method. 2g of sample was diluted into 10ml of dilute water and further diluted twice in 10 ml of water from this 1ml of sample along with 4ml of anthrone reagent and 1ml of 75% H_2SO_4 was added and read in the spectrophotometer at 560 nm.

Total carbohydrate (%) in 100mg of sample

$$= \frac{\text{mg of starch}}{\text{volume of test sample}} \text{ x } 100$$

Plate 3.6: Spectrophotometer

3.6.9 Bulk density

Bulk density was determined by filling a 100 ml measuring jar with starch powder and it is then poured to a plane surface freely on the top of the heap formed was strike off and the remaining powder is weighed. The ratio of weight of the sample and the volume occupied by it is expressed as bulk density of the product.

$$\text{Bulk density } (D_b) \text{ g/c}m^3 = \frac{\text{m}}{\text{v}}$$

3.6.10 True density

The true density of the sample was measured using a specific gravity bottle filled with toluene as displacement fluid. An empty 50 ml specific gravity bottle was weighed (W1), filled with toluene and then weighed (W2). 2g of sample weighed (W3) and transferred to the bottle. The excess fluid wiped of and weighed (W4). The particle true density was calculated by:

$$\text{True density } (D_t) \text{ g/c}m^3 = \frac{\text{W}_2 \text{ X W}_3}{50\ (\text{W}_3 - \text{W}_4 + \text{W}_2 + \text{W}_1)}$$

3.6.11 Water solubility index

Water Solubility Index was determined by the method of Anderson (1982 a). A 2.5g sample of each sample was taken in 50ml distilled water and then stirred continuously for 30 min using a glass rod. The dispersion was made to 32.5 gram and then centrifuged at 4000rpm for 15 min. the supernatant was removed and the sediment was weighed. WSI was calculated as:

$$\text{WSI (\%)} = \frac{\text{weight of solid dissolved in supernatnt (g)}}{\text{weight of dried solids (g)}} \text{ X } 100$$

3.6.12 Fibre content

2g of residue from crude fat determination was weighed and transferred in to a digestion flask and 200ml of sulphuric acid was added and mixed for 30 minutes. After adding 200ml of NAOH solution it is boiled for 30 minutes, the residue obtained was kept in the muffle furnace and dried at 100°C. The difference in residue weights and ash represents the weight of fibre.

$$\text{\% Fibre} = \frac{\text{loss in weight noted}}{\text{weight of sample taken}} \text{ x } 100$$

3.7 Product development

3.7.1 Arrowroot Cake (Gluten free cake)

Arrowroot starch is an ideal alternative for Maida to produce gluten free cakes. The gluten protein present in Maida can cause various health problems since it is not fully digested by the body also Maida cannot be consumed by persons who are suffering from the disease of gluten intolerance which is a common disease seen in northern parts of India. In order to replace Maida we used arrowroot starch with varying ratio of Maida to arrowroot starch. The ratios used were 1:1, 3:2, 1:4 and without Maida solely with koova starch (arrowroot).

Cake recipe

Arrowroot starch + Maida	100g
Egg	1 no's
Milk	2 table spoon
Butter	45g
Sugar	100g
Flavour (Vanilla)	½ teaspoon
Baking powder	2 pinch

- The arrowroot starch from both the varieties of western and eastern were taken in equal amounts along with Maida in four different ratios (1:1, 3:2, 1:4, and arrowroot alone).
- Pre heat the oven at 180°C for 20 minutes.
- The egg was beat for 10 minutes until it forms a peak.
- The flours along with baking powder was sifted.
- A bowl was taken and the sugar was mixed with butter to a smooth mix, to this sifted flour is added in little amount along with the beaten egg foam with continuous beating.
- To the smooth cake mix add the flavour and milk and beaten for a minute.

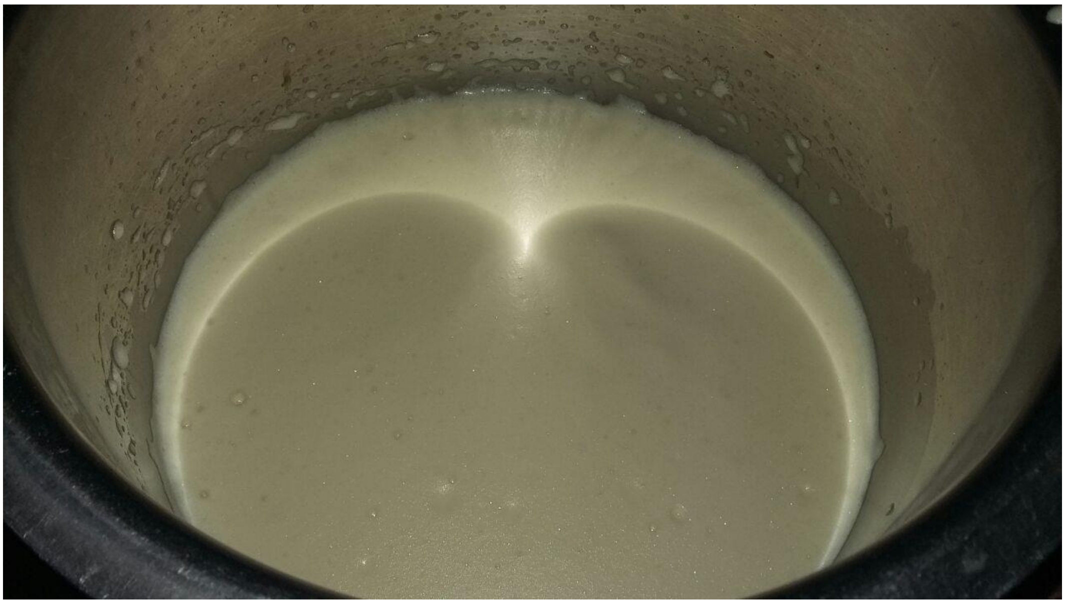
- The mixture is transferred to a mould which has been coated with butter and placed inside the preheated oven.
- Bake the cake at 130°C for 5 minutes bottom heat, 5 minutes top heated, 5 minutes side heated and 15 minutes even heating.
- Take the cake from oven and allow it to cool for 10 minutes and then transfer it to plate.
- The cake can be cut and used.

Flours used for preparation of koova

Sifted flour and baking powder

Milk

Baking powder, butter



Beaten egg

Plate 3.7 : Ingredients used for preparing gluten free cake

RESULTS & DISCUSSIONS

CHAPTER IV

RESULTS AND DISCUSSIONS

In this chapter the results and discussion are presented which were obtained during the experimental work. The chapter deals with the study related to the performance of starch extraction machine and the physical and chemical properties of obtained starch. The study also explains about sensory evaluation of value added products.

4.1 Physical properties of raw koova rhizomes

4.1.1 Colour of rhizome

Outer skin colour of Western Arrowroot and Eastern Arrowroot are whitish yellow and brown respectively. The flesh colour of Western Arrowroot is a cream colour followed by pale yellow and yellowish cream and that of Eastern Arrowroot is a pale blue followed by greenish cream. The results were recorded by naked eye observation

4.1.2 Dry matter per cent in rhizomes

Dry matter content in Western Arrowroot and Eastern Arrowroot were 25.66% and 23.7% respectively. Similar results were recorded by Chavindra Kumar for Western Arrowroot and its average dry matter was 27.44 %.

4.1.3 Length and thickness of rhizomes.

The average lengths of Western and Eastern varieties were 7.1 cm and 9.3 cm and thickness were 2.4 cm and 3.15 cm respectively. But the findings given by Chavindra Kumar for Western Arrowroot was an average length of 6.9 cm and an average thickness of 1.708 cm.

Table 4.1: Length and Thickness of rhizomes

Variety	dry matter %	length (cm)	thickness (cm)
Curcuma leucorrhizza	23.7	9.3	3.15
Maranta aurundinacae	25.66	7.1	2.4

4.2 Starch extraction methods

4.2.1 Mechanical Method

4.2.1.1 Using wet grinder

The average recovery of starch 10% was recorded for both the varieties which was similar to traditional extraction method.

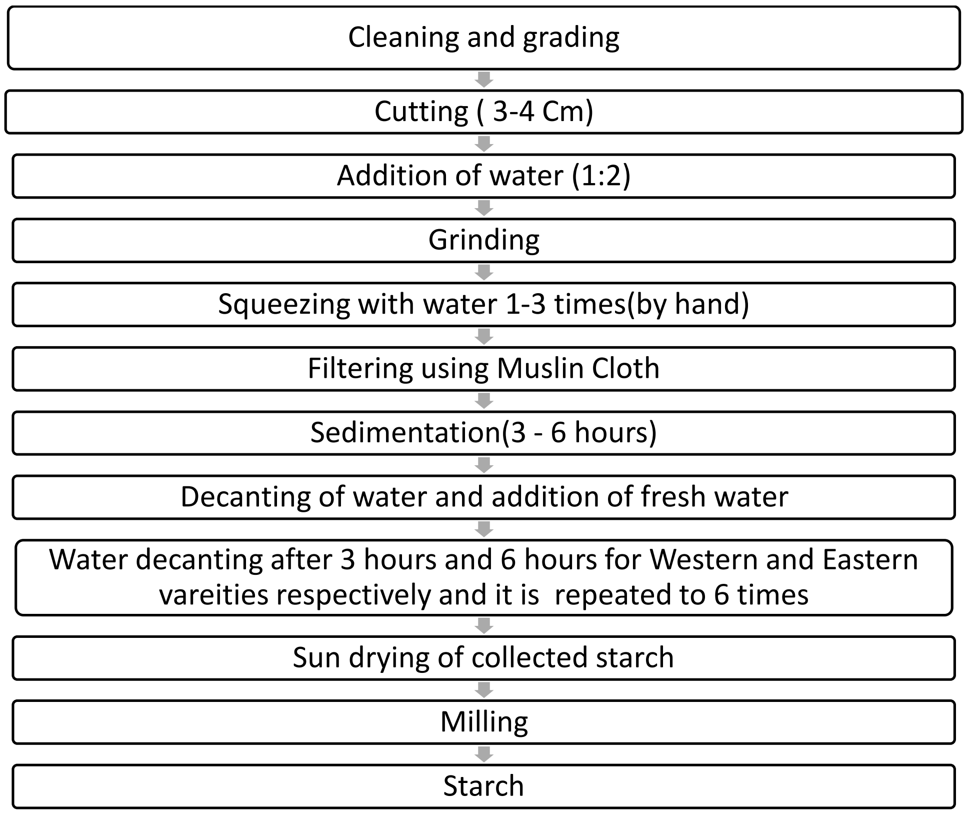


Figure 4.1: Flowchart of wet grinding

(1) Waste removed

(2) Grinding in wet grinder

(3) Squeezing manually

(4) Filtering and Washing

(5) Milled starch powder

Plate 4.1: Wet grinding method

4.2.1.2 Starch extraction using screw extractor (Developed by KAU)

In this method, the extraction were carried out for both Eastern and Western varieties of Arrow root. The collected rhizomes were cleaned and washed thoroughly. The rhizomes were cut into size of 5cm in length and fed into the extractor. After a few minutes of extraction, there is a simultaneous supply of water through the inlet provided at the end of the machine. As the extraction proceeds, the starch milk and fibre were collected in separate outlets. For the efficient extraction, the collected fibre is again fed into the extractor. The collected starch milk is allowed to sediment 3 hours for Western variety and 6 hours for Eastern variety. The process is followed by decantation of water and the sediment starch is mixed with fresh water. Then it is allowed to stand 3 hours and 6 hours for western and eastern varieties respectively. The process is continued 6 times for both the varieties. The collected starch is allowed to be dried within a tray dryer at a temperature of 60^{0}C for 5 hours.

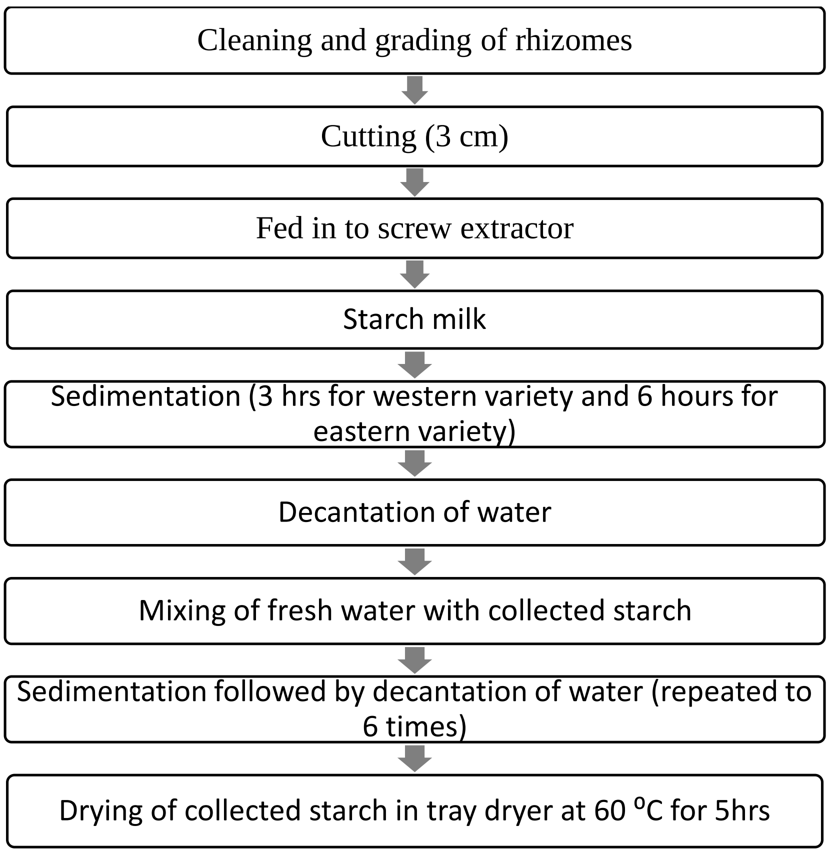


Figure 4.2: Flow chart of Starch extraction using screw extractor

(1) Cleaned rhizomes

(2) Washing of rhizomes

(3) Size reduced

(4) Starch milk extraction

(5) Filtration and sedimentation

(6) Milled starch

(7) Fibre collected

Plate 4.2: koova starch screw extraction method

4.3 Performance of koova starch extraction machine

4.3.1 Starch recovery (%)

The data collected on the performance of koova starch extraction machine using wet grinder and screw extractor is given in Table 4.2. The maximum recovery of starch was about 10.67% for western variety and 10.3% for eastern variety by wet grinding. Whereas by means of screw extractor, the starch recovery were 10.1% and 9.83% for eastern and western varieties respectively.

4.3.2 Capacity

In screw extractor process, it was possible to handle 2kg/hr. of raw rhizomes for complete extraction of starch milk. Even though it was possible to handle same amount of raw rhizome by wet grinding, it takes further 5 to 7 hours for the complete extraction of starch milk.

Table 4.2: Performance indicators of koova starch extraction

Methods	Varieties	Size of rhizome (cm)	Starch recovery %	Capacity kg/h	Time taken for complete starch recovery (hr.)
Screw extractor	*Maranta aurundinacae*	5	9.83	2	6
	Curcuma leucorrhizza	5	10.1	2	6
Wet grinder	*Maranta aurundinacae*	3-4	10.67	2	13
	Curcuma leucorrhizza	3-4	10.3	2	11

4.3.3 Energy consumption

The energy consumption per 1000g of koova for both the varieties took 0.1864 kWh/ motor machine energy and 5.88 MJ Human energy (Appendix I).

4.3.4 Cost of processing

The fixed cost for the machine was 3.28 rupees, the variable cost sums up to an amount of 150 per day for processing 2kg koova, therefore the total cost of processing was calculated approximately as 135 rupees /day/ 2kg koova (Appendix II).

4.4 Standardization of the process

4.4.1 Size of rhizome

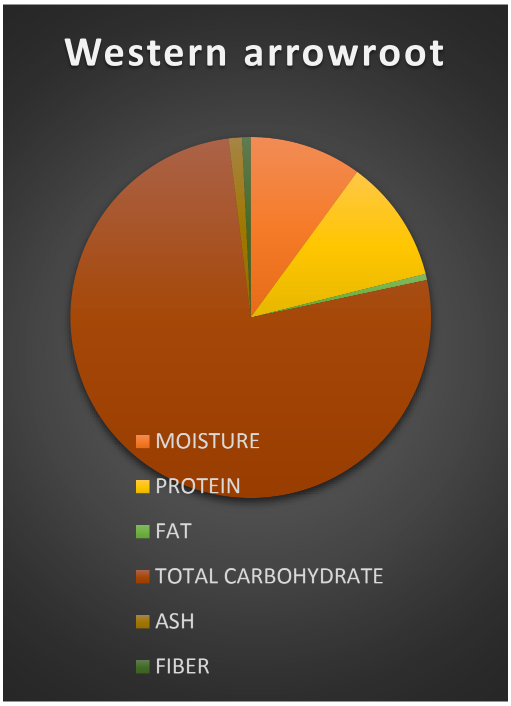
The rhizome of sizes below 2 cm was easy to crush but the problem raised was the crushing causes the formation of paste and clogging of the sieve before retrieval of fibre. The size of 3 cm took 30 minutes for the processing of 1000g of koova in both varieties. The 5 cm rhizomes took much more time for taking the fibre out of the fibre port.

4.5 Physico-chemical properties of obtained starch

The arrowroot starch powders obtained after drying were taken for determination of proximate composition. It is possible to dry the powder up to 10% and 4% moisture content (wb) for western and eastern varieties respectively. Table 3 shows the results of proximate analysis. Average composition of starch powder contains 11% protein, 0.55 % fat, 76% carbohydrate and 1.2 % ash for Western arrowroot whereas the starch of Eastern Arrowroot have 15.07 %protein, 0.2 % fat, 79% carbohydrate and 0.9 % ash. Chavindra Kumar Paikra (2014) reported that the proximate composition of arrowroot starch of western variety at 12.6% moisture content was 0.39% protein, 0.39% fat, 85.6% carbohydrate and 1.02% ash. Variation in the result possibly based on the location, soil fertility and environmental condition etc.

Table 4.3: Physico-chemical properties of starch

S.NO	Constituents	Percentage (%)	
		Maranta aurundinacae (Western)	*Curcuma leucorrhizza* (Eastern)
1	Moisture	10	4
2	Protein	11	15.07
3	Fat	0.55	0.2
4	Total carbohydrate	76	79
5	Ash	1.2	0.9
6	Fibre	0.77	0.81



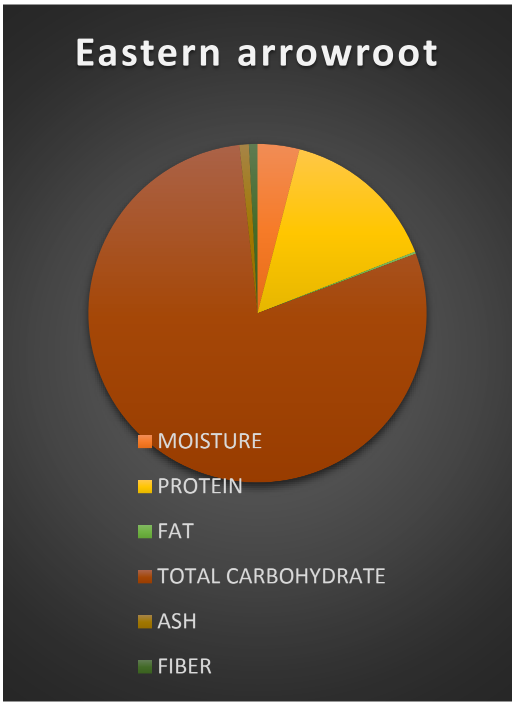


Figure 4.3: Pie chart for Physico chemical properties of two koova varieties

4.5.2 Attributes of Arrowroot starch

The attributes of Arrowroot starch were observed from the table 4.4 and figure 4.4. The titratable acidity was recorded slightly higher for Eastern variety (0.18%) at a pH 5.4 than Western variety (0.16%) at pH 7.Western arrow root showed bulk density and true density of 0.68g/cc and 1.62g/cc, whereas 0.384g/cc and 0.723g/cc for Eastern arrow root respectively. Solubility index was recorded 72 % and 85% for Western and Eastern arrow root respectively.

Table 4.4: Attributes of starch

	Maranta aurundinacae (Western)	*Curcuma leucorrhizza* (Eastern)
pH	7	5.4
Titratable acidity %	0.16	0.18
Bulk density, g/cc	0.68	0.384
True density, g/cc	1.62	0.723
Solubility index %	72	85
Colour	White	White

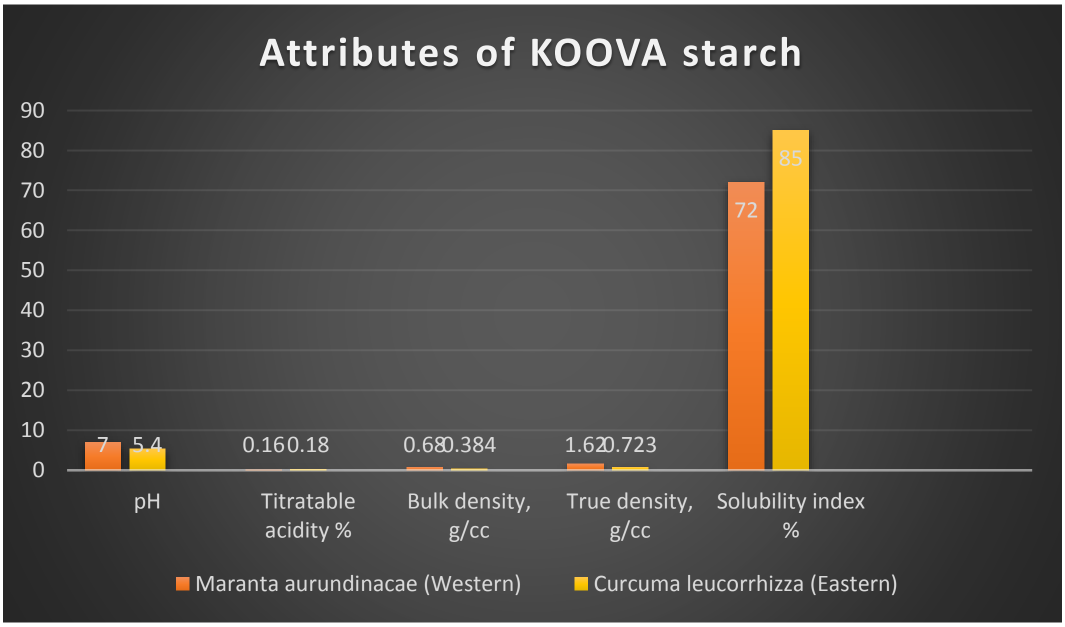


Figure 4.4: Bar chart for attributes of two koova varieties

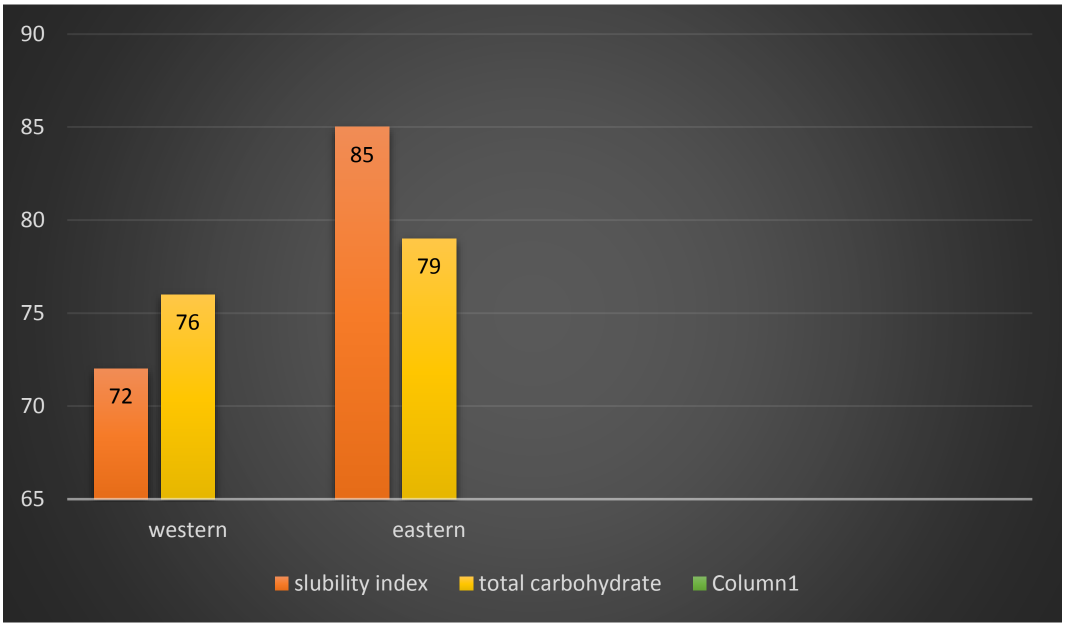


Figure 4.5: Bar chart for carbohydrate and solubility of koova starch

4.6 Product development

4.6.1 Gluten free koova cake

Plate 4.3: arrowroot cake preparation and tooth pick test for doneness

Plate 4.4: Arrowroot Cake

4.6.2 Sensory evaluation

Table 4.5 Sensory evaluation (Appendix III)

S.No	Sample	Average : mark given
1	1:1	
2	2:3	
3	1:4	
4	Koova alone	

SUMMARY

CHAPTER V

SUMMARY & CONCLUSION

Arrowroot is a low perennial herb found in rain forest habitats which is often cultivated for starch obtained from its rhizomes. It can grow two feet high, has a small white flowers and fruits. Arrowroot is indigenous in tropical America but has spread to other countries such as Brazil, Ceylon, and Indonesia. It is the only starch product with calcium ash which is important for the maintenance of proper acid and alkali balance in the human body. There are two varieties of Arrowroot in existence, Western Arrowroot which are the *Maranta aurundinacae* and Eastern Arrowroot which are *Curcuma leucorrhizza* and *Curcuma angustifolia* varieties, commonly known as white, blue and yellow Arrowroot (vella koova, neela koova and manja koova) respectively. The extraction of starch from koova is done traditionally by the method of stone scrubbing and grater scrubbing. The partially mechanised method which is in existence use rasper which have 31.01 kg/hr. at 1000 rpm rasper speed, which consumes minimum 15.5 kWh for 100 kg, the cost of the machine is 1 lakh rupees and the processing cost may range up to 100 rupees per kg starch powder per hour. The starch recovery was estimated as 7.53 to 8.28 % for different rasper speed (Chavindra kumar paikra, 2014).

Considering the above facts we developed a starch extraction machine absorbing the idea of screw expeller for extraction of juice, using this machine it is possible to extract the starch milk so that the labour for brushing out the starch which is being entangled in the rhizome fibre becomes an easy process. The machine has been standardised for the size of the rhizome, to be taken as 3cm for both the Arrowroot varieties. It yields 10.1 for vella koova and 9.83 for neela koova. The starch powder from both the varieties have been analysed for its physical and chemical properties which shows an increased moisture, carbohydrate and ash content in Western Arrowroot than in Eastern variety. But from the interaction with farmers we come to know about the medicinal quality of Eastern over Western.

The starch can be used in the development of products as a replacement of corn starch as well as to produce gluten free products like cookies, cake, barfi etc. The common use of Arrowroot starch is in the preparation of baby foods.

As a progress of this project we can find methods for the easy separation of starch from its milk using some unit operations like centrifugal separation, using vibratory sieve separation or some other novel technologies. The starch is being used in the production of edible films so we can extend in that direction also. The starch which is not removed from the fibre (1-2%) can be used for ethanol production too.

The modification that can be done to this extractor in future is

- To have a variable speed regulator – gear system.
- To incorporate a double filter for efficient filtration.

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APPENDIX I

CALCULATION OF ENERGY CONSUMPTION

Total weight of the machine = 31.8 kg

Annual working hours;

(D) Days x (I) Hours per day = 4 hrs.

Electricity consumed per day (kWhr/motor) = $\frac{\text{motor input in watts x operation time (hr)}}{1000}$

$= \frac{0.5*4}{1000}$ = 0.002 kWh/motor

Human energy = Time required (hr.) x Energy equivalent

= 4*1.96

=7.84 MJ

APPENDIX II

CALCULATION OF OPERATING COST

Initial cost (C)

Fabrication cost of

Including cost of material = Rs. 24500

Average life of machine =20 years

Working hours per year =1344

Salvage value =10% of initial cost

A) Fixed cost

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

$= \frac{24500 - 2450}{20 * 1344}$

=0.821

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

$= \frac{24500 + 2450}{2 * 1344 * 100}$

=0.100

Total fixed cost =0.921

B) Variable cost

1. Labour wages

Wages of labour = Rs. 300/day of 4 h

2. Cost of electrical energy

Unit cost of electricity = Rs. 7/kwh

Energy consumption of machine = 0.100

Cost of electricity = 0.7/4h

3. Repair and maintenance cost

@ 10% of initial cost p.a. $= \frac{24500*10}{1344*100}$

= 7.26/4h

Total variable cost = 312.4/4h

Total approximate cost per hr. = 135/h

APPENDIX III

SENSORY EVALUATION

Name of judge- **date:**

Product Code	A (1:1)	B (2:3)	C (4:1)	D (koova alone)
Appearance				
Colour				
Flavor				
Texture				
Taste				
Overall acceptability				

Taste samples and check how you like or dislike each one. Use the appropriate scale to show your attitude by checking at the point that best describe you're feeling about the samples.

Hedonic Scale

9. Like extremely
8. Like very much
7. Like moderately
6. Like slightly
5. Neither like nor dislike
4. Dislike slightly
3. Dislike moderately
2. Dislike very much
1. Dislike extremely

Signature of judge:

APPENDIX III-B

Table – Average point given by judges to each sample

Product code	Quality attributes	J1	J2	J3	J4
A	Appearance	3	3.5	3	2
	Colour	3	3	2.5	2.5
	Flavor	2	3	3	3
	Texture	2	2	2	2
	Taste	2	2	2	2
	OAA	2	2.5	2	2
B	Appearance	3	3	3	2.75
	Colour	3	2	2.5	3
	Flavor	2	2.5	2.25	2
	Texture	2	2.5	3	2.25
	Taste	2	2	2	3
	OAA	2	2	1	2.75
C	Appearance	2	2	2	1
	Colour	2	2.5	2	2
	Flavor	2	2	2	2
	Texture	2	2	2	2
	Taste	1	1	1	1
	OAA	1	1	1	1

D	Appearance	2	2	1	1
	Colour	2	1	2	1
	Flavor	2	1	2	2
	Texture	2	1	1	1
	Taste	1	1	2.5	1
	OAA	1	1	1	1

DEVELOPMENT AND EVALUATION OF EQUIPMENT FOR STARCH EXTRACTION FROM ARROWROOT (KOOVA)

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ABSTRACT

Submitted in partial fulfillment of the requirement for the degree of

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IN

FOOD ENGINEERING

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ABSTRACT

Arrowroot is a rich source of starch which is a best alternative for corn starch and Maida which is gluten free and the only starch having calcium ash. It have medicinal properties too. The main problem in the value addition of this starch and the less consumption is due to its cumbersome extraction procedure and hence the increased price. The koova starch extractor developed, can produce koova starch with less extraction procedures and also it can be used for small scale units with less labor and time. The screw type starch extractor consist of a variable pitch screw and a sieve with arch to facilitate abrasion. Starch is extracted in the form of starch milk which can be further mixed with water and filtered and sedimented for extracting starch out of it. The capacity of machine for efficient extraction of starch from koova is 2kg/hr. The machine run with a 0.5hp motor.

The study of two different varieties of koova resulted in a large starch recovery from western variety than from eastern koova, but the medicinal value of eastern is greater. The use of koova starch as an alternative to Maida flour can produce a superior quality products such as cakes, cookies etc.