# DEVELOPMENT AND EVALUATION OF BITTER GOURD PULP EXTRACTOR

***by***


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**KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY**

**TAVANUR-679 573, MALAPPURAM**

**KERALA, INDIA**


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**PROJECT REPORT**

**Submitted in partial fulfilment of the requirement for the degree of**

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**DEPARTMENT OF PROCESSING AND FOOD ENGINEERING**

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# DECLARATION

We hereby declare that this project report entitled **"Development and Evaluation of Bitter Gourd Pulp Extractor"** is a bonafide record of project work done by us during the course of project and that the report has not previously formed the basis for the award to us of any degree, diploma, associate ship, fellowship or other similar title of any other university or society.

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Tavanur

Date

# CERTIFICATE

Certified that this project report entitled "**Development and Evaluation of Bitter Gourd Pulp Extractor**" is a record of project work done jointly 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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HE

WHO SERVES

FOOD

REAPS REWARD,HE

WHO GROWS

FOOD

IS THE

GREATEST OFALL.

*THANK YOU,*

*FARMERS*

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## SYMBOLS AND ABBREVIATIONS

| | | |
|---|---|---|
| % | : | Percentage |
| + | : | Add |
| × | : | Multiply |
| / | : | Per |
| 3D | : | Three Dimentional |
| cm | : | Centi meter |
| mm | : | Milli meter |
| kg | : | Kilo gram |
| KAU | : | Kerala Agriculture University |
| rpm | : | Revolution per minute |
| & | : | And |
| Fig | : | Figure |
| hp | : | Horse power |
| et al. | : | And others |
| °C | : | Degree Celsius |
| t/h | : | Tonne per hectare |

# *INTRODUCTION*

# CHAPTER I

# INTRODUCTION

Bitter gourd, botanically known as *Momordica charantia*, is one of the vegetables belonging to the cucurbitaceae family. It is also known as bitter melon, bitter apple, bitter squash and balsam-pear. It is believed to be originated in tropical Asia, particularly in the Indo Burma region. Bitter gourd is widely grown in India, Indonesia, Malaysia, China and Tropical Africa. In India, it is grown in an area of 26,004 ha with an annual production of 16.2 million tonnes (MT) during 2020. The area and production are fast increasing and some of the leading states in the country are Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Orissa, Andhra Pradesh, Tamil Nadu and Kerala ( NHB, 2022).

*Mormodica charantia* L. commonly known as bitter gourd is a widely cultivated cash crop in India with immense medicinal values. India has been one centre of diversification of two prominent taxonomic varieties viz. long fruited variety, *M. charantia var. charantia* (MCC) and small-fruited variety, *M. charantia var. muricata* (MCM). Momordica is a large genus consisting of about 80 species, of which *Momordica charantia L.* is widely cultivated. Pusa Do Mausami, Arka, Balsam Pear Harit, Priya, Coimbatore Long and PusaVisesh are a few of the high-yielding varieties in bitter gourd.

Bitter gourd is usually grown as an annual crop, but it can also perform as a perennial in mild areas and frost-free winters as well. The summer season crop is grown from January to June in the plains, optimum temperature of 25-28˚C is required for the germination of bitter gourd seeds (Peter et al., 1998). Bitter melon is a climacteric fruit that continues to ripen towards physiological maturity after harvest (David Hicks 2002). Hence reducing fruit temperature is important to slow maturity. As it ripens, bitter melon produces ethylene which can cause other bitter melon in close proximity. Optimal storage temperature for fruit is 7-10ºC (Gosbee and Lim, 2000). Fruit can be stored at temperatures down to 4ºC for short periods, but prolonged exposure to low temperatures can cause chilling injury.

Fruit stored above 10ºC continue ripening. Higher temperatures increase the rate of ripening. Bitter gourd is a great source of several key nutrients. One cup (94 g) of raw bitter melon provides 20 calorie, 4grams of carbs, 2grams of fiber, 93 percentage of vitamin C (Reference Daily Intake- RDI),44 percentage of vitamin A (RDI), 17 percentage of folite (RDI) and 8 percentage of potassium(RDI) (Unal *et.al.*, 2013).

Bitter gourd is a well-known medicinal herbal plant with many nutritious benefits, improving the overall health of consumers. It is a good source of fiber, nutrients, moisture, amino acids, beta carotene, vitamin C, vitamin B, folate and minerals such as calcium, sodium, potassium, magnesium, phosphorus, zinc and iron, as well as folic acid, alkaloids, peptides and steroidal saponins. It is a well-known Indian traditional vegetable used by diabetic patients as it contains a component, charantin, that is a hypoglycaemic and antidiabetic agent. Apart from this, bitter gourd possesses many other medicinal activities, such as antiviral, antioxidant, anti-inflammatory, antimutagenic, antiulcerogenic, antimicrobial, anticonstipation, analgesic and anticarcinogenic.

A large number of value added products can be prepared from bitter gourd like bitter gourd juice, pickle, dried rings, chips, etc. These valued products in addition to being healthy are more palatable than raw fruit thus increasing consumption of this bitter fruit. Further, processing of bitter gourd can generate a source of income among farmers and women making their livelihood better. Value addition of bitter gourd can be done by a number of ways. Thin slices can be dehydrated and this technology is adopted in a small scale for domestic purposes. A better quality product can be prepared, if driers are used for dehydration. In addition, fruits can be canned (Krawinkel and Keding, 2006). They are usually blanched or soaked in salt water before cooking to reduce the bitter taste. Incorporating bitter foods in commonly consumed food dishes can mask the bitter taste of bitter gourd (Snee *et al.*, 2011). The seeds of ripe fruits are used as condiment.

Further, bitter gourd is used for juice preparations especially for diabetic patients and may be mixed with other fruit/vegetable juices to improve its palatability for the general consumer. The pulp around the seeds of the mature ripe fruit is a rich source of the carotenoid lycopene.

The primary metabolites in bitter gourd are common sugars, proteins and chlorophyll while secondary metabolites are phenolics, carotenoids, curcubitane triterpenoids, alkaloids, saponins etc. Secondary metabolites are responsible for the nutraceuticals properties of bitter gourd which scarcely contribute to the nutritional value, but produce beneficial physiological effects in the body.

Antifeedant properties refer to the ability of certain substances to deter or discourage feeding by pests, insects, or animals. Bitter gourd pulp is rich in antifeedant properties. Antifeedants are chemicals that act on specific sensory cells called antifeedant receptors in pests. These chemicals exhibit antifeedant properties even at low concentrations. The neurons associated with these antifeedant receptors either prevent insect feeding (feeding deterrent effect) or cause cessation or slowing of further feeding (feeding suppressant effect). Another mode of action of some antifeedants is through an apparent ability to block the function of a herbivore's feeding-stimulant receptors, or an ability to bind directly to its normal feeding cues, such as sugars and amino acids. Insect feeding is influenced by antifeedants and feeding stimulants, and these chemicals from bitter gourd are potential chemicals for insect control.

The ethanol extract of bitter gourd leaves inhibited the ovi position of Liriomyza trifolii imago on bean leaves treated with the extract. Acetone extract of bitter gourd leaves showed toxic activity and greatly impede the ability feeding of the *Spodoptera litura Fab*.Larvae. Bitter gourd fruit juice and hexane extract of bitter gourd fruit serves as a larvicide in mosquito larvae of *Anopheles stephensi*, *Culex quinquefasciatus* and *Aedes aegypti* (Singh, *et al*., 2006), likewise with petroleum ether extract, carbon tetrachloride extract and methanol extract of bitter gourd fruit. Those extracts were also capable of controlling larvae of A. stephensi and C.quinquefasciatus (Maurya, *et al*., 2009). Petroleum ether extract of bitter gourd fruit was more effective than the karbontertraklorida extract in controlling larvae of *A. stephensi* and *C. quinquefasciatus*. Petroleum ether extract has $LC_{50}$ lower than the carbon tetrachloride extract. $LC_{50}$ petroleum ether extract of bitter gourd fruit on the larvae of *Anopheles stephensi* was 27.60 ppm (treatment for 24 hours) and 17.22 ppm (treatment for 48 hours), and $LC_{90}$ petroleum ether extract of bitter gourd fruit on the larvae of Anopheles stephensi was 154.99 ppm and 94.79 ppm respectively for treatment 24 hours and 48 hours. While $LC_{50}$ of carbon tetrachloride extract of bitter gourd fruit for larvae of A. stephensi was 49.58 ppm (treatment for 24 hours) and 16.15 ppm (treatment for 48 hours), and $LC_{90}$ for the treatment of 24 and 48 hours also was 521.02 ppm and 369.99 ppm (Maurya, *et al.*, 2009).

Pulp extraction from bitter gourd seed-pulp mixture can be done either manually or mechanical means. In manual method, harvested bitter gourd is allowed to ripen until it is turned into red colour and soft in texture. The vegetable is subjected to various unit operations including cleaning, washing, sorting and grading and cutting. The pulp-seed mixture is then transferred to a sieve of perforations having size less than that of the seed, and is rubbed over it by hand operation. The main drawbacks of manual method include time consumption, requirement of skilled labour, possibilities of causing injury during handling, less efficiency etc.

Considering the above facts, a study has been undertaken on “Development and Performance Evaluation of Bitter Gourd Pulp Extractor” with the following objectives.

- To study the engineering properties of bitter gourd pulp.
- To develop a pulp extractor for bitter gourd.
- Performance evaluation of the developed bitter gourd pulp extractor in terms of pulp extraction efficiency, seed damage and seed viability.

# *REVIEW OF LITERATURE*

# CHAPTER II

# REVIEW OF LITERATURE

This chapter consists of a detailed literature review of various researchers regarding the agronomical aspects of bitter gourd, anti-bacterial activities of bitter gourd pulp, pulp extraction methods, principle and mechanism of various pulp extractors.

## 2.1 BITTER GOURD

*Momordica charantia* or Bitter Melon, also known as balsam pear of Kerala, is a tropical vegetable. It is a common food in Indian cusine and has been used extensively in folk medicine as a remedy for diabetes. The Latin name *Momordica* means “to bite” (referring to the jagged edges of the leaf, which appear as if they have been bitten). It is a genus of annual or perennial climbers found throughout India and is also cultivated upto an altitude of 1500m. In Ayurveda, the fruit is considered as tonic, stomachic, stimulant, emetic, antibilous, laxative and alterative. Like most bitter-tasting foods, bitter melon stimulates digestion. While this can be helpful in people with sluggish digestion, dyspepsia, and constipation, it can sometimes make heartburn and ulcers worse. (D. Sathish Kumar,2010).

### 2.1.1 History

*M. charantia* is native to Old World tropics and is possibly domesticated in India and southern China. It is now found naturalized in almost all tropical and subtropical regions. It is an important market vegetable in southern and eastern Asia, and wild and cultivated populations can be found in countries such as India, Sri Lanka, Vietnam, Thailand, and Malaysia, southern China and tropical Africa (PROTA, 2014). It is believed that M. charantia was introduced into America from West Africa with the slave trade. In the West Indies, M. charantia was first recorded in Puerto Rico in 1885 (US National Herbarium). By the end of nineteenth century, local cultivars originally from Asia were recorded on small scale cultivations in tropical America and the southern part of the United States (PROTA,2014).

### 2.1.2 Production

Bitter gourd is one of the important vegetable crop. It is also well known for its medicinal value. The leading producing states of bitter gourd in India are Madhya Pradesh, Chhattisgarh, Tamil Nadu, Andhra Pradesh etc. Table 2.1 shows the production estimate of bitter gourd in India for the year 2021-22.

### 2.1.3 Varieties

In our country a wide range of variability in plant and fruit characters exists in bitter gourd. The varieties grown in summer season are small fruited and those grown in rainy season are long fruited. In our country, a wide range of variability in plant and fruit characters exists in bitter gourd. Bitter gourd is essentially a warm-season crop grown mainly in tropical and subtropical regions, However, it can also be grown at slightly lower temperature. The important recommended varieties of bitter gourd are;

#### *2.1.3.1. Pusa Do Mausmi*

This variety has been released by the I.A.R.I., New Delhi. The fruits reach edible maturity, in about 55 days from sowing. Fruits are dark green, long, medium-thick, club-shaped with 7-8 continuous ridges, 18 cm long at the edible stage, and 8-10 fruits weighing about one kilogram.

#### *2.1.3.2. Arka Harit*

It has been released by the IIHR, Bangalore. It has medium-sized, spindle-shaped fruits with green skin, thick flesh, moderate bitterness, and fewer seeds. Fruits are ready for harvesting in 12-14 days after pollination. It yields about 120 quintal fruits per hectare in 100-110 days duration. Coimbatore Long, this variety has been released by the Agricultural Research Institute, Coimbatore. Fruits are long, tender, and white in color. This variety is suitable for the rainy season. The vines are prolific and heavy yielders.

#### *2.1.3.3. VK-I (Priya)*

It is a selection from Kerala Agricultural University. The fruits are extra long (about 39 cm long). It takes about 60 days from sowing to the first harvest. On average, there are 55 fruits per plant.

#### *2.1.3.4. Preethi*

High yielding variety released from Kerala Agricultural University. Medium sized greenish white fruits. Average yield is 10-35 t/h. relatively less susceptible to fruit fly attack. Suitable for growing in Trissur, Palakkad and Ernakulam district.

#### *2.1.3.5. MDV- l*

This is a long fruited and high-yielding bitter-gourd variety. It is medium branching and early flowering variety. The vine bears about 20-25 fruits per plant and the per hectare yield is about 250 quintals.

#### *2.1.3.6. Pusa Vishesh*

This variety has been released and recommended for cultivation as a summer season crop by the I.A.R.I., New Delhi. The vine is dwarf and bushy and easy to manage. The fruits are attractive green, fusiform with many irregulars broken smooth and glossy ridges on the surface. They are medium long and thick. It is early in maturity and takes about 55 days to come to harvest after sowing.

**(A) Pusa Do Mausmi** **(B) VK-I (Priya)**

**(C) Arka Harit** **(D) Preethi**

**Plate 2.1 (A) (B) (C)&(D) Varieties of bitter gourd**

**Table 2.1 Production of bitter gourd in India during 2021-22**

| Sl No. | State | Production (in Tonnes) 2021-22 | Share (%) |
|---|---|---|---|
| 1 | Madhya Pradesh | 229.91 | 17.24 |
| 2 | Chattisgarh | 169.89 | 12.74 |
| 3 | Tamil Nadu | 128.91 | 9.67 |
| 4 | Andhra Pradesh | 124.75 | 9.35 |

| | | | |
|---|---|---|---|
| 5 | Orissa | 116.95 | 8.77 |
| 6 | Bihar | 91.73 | 6.88 |
| 7 | Uttar Pradesh | 89.73 | 6.73 |
| 8 | Haryana | 74.20 | 5.56 |

### 2.1.4 Propogation

Approximately 5.0-6.0 kg of seeds is required for cultivating one hectare of land. Soak seeds in 1:10 solution for 3 hours increases germination and seedling vigour. Also soaking in water for 24 hours prior to planting helps in better and quicker germination. In high range zone seedlings can be raised in green houses to ensure good germination and later transplanted to the main field. As seedlings required ample water for quicker germination, giving a pre sowing irrigation 3-4 days before sowing is beneficial. Sow 4 or 5 seeds in a pit at 1-2 cm depth. Deeper sowing delays germination. The seeds will germinate in about 4-5 days. Unhealthy plants are removed after 2 weeks and retain only three plants per pit.

### 2.1.5 Planting

Land is ploughed and brought to a fine tilts by crosswise ploughing and levelling. Furrows are opened at a distance of 1.5-2.5 m depending on the support system to be adopted.

#### *2.1.5.1 Method of Planting*:

In the plains, the summer season crop is sown from January to February, whereas the rainy season crop is sown during the month of May. For planting one hectare area, 4-5 kg of seed is required. Before planting, the seed is treated with sulfur fungicide (3 g/kg of seed).

### *2.1.5.2 Plant Support:*

Bitter gourd being a weak climber needs support for its growth. The plants trailed on the support (bower) continues to give yield for 6-7 months as against 3-4 months when trailed on the ground without support. Such vines are less susceptible to pest and diseases as they do not come in direct contact with the soil. In bower system, planting is done at a spacing of 2.5 x 1m. Furrows are opened up at 2.5 m and irrigation channels are laid out at 5-6 m distance. Wooden poles (3 m in height) are pitched on both the ends of alternate furrows at a distance of 5 m. these poles are connected with wires. The wires along the furrows are further connected with cross wires fastened at 45cm distance so as to form a network of wires. Seeds are dibbled at distance of 1 m along the furrow and covered lightly with soil. The vines take about 1.5-2 months to reach the bower height, hence the vines during the initial stages of growth are trailed on ropes till they reach the bower. Once the vines reach the bower height, the new tendrils are then trailed on the bower.

### 2.1.6. Harvesting

Bitter gourd is grown by seed or seedlings obtained from seeds. Seeds are sown in April or May into containers or directly to the field when the soil temperature rises 8-10℃. Planting seedlings is advisable since the germination rate of seeds is not 100% .The crop of bitter gourd takes about 55-60 days from seed sowing to reach first harvest. Further pickings should be done at an interval of 2-3 days as bitter gourd fruits mature very fast and turn red. Picking of fruit at the right edible maturity stage is dependent upon individual kinds and varieties. Normally the picking is mainly done when fruits are still tender and green so that the fruits do not turn yellow or yellowish orange during transport. Harvesting should be done in the morning hours and the fruits should be stored in shade after harvesting. (Baryeh, 2002)

### 2.1.7 Climate

It is a warm season crop grown mainly in sub-tropical and hot-arid regions. They are susceptible to light frost and are provided with partial protection if grown during winter months. Temperature range of 24- 0 27 C is considered as optimum for the growth of the vines. The seed germinates best when 0 temperatures are higher than 18 C. High humidity at the time of vegetative growth renders the crop susceptible to various fungal diseases.

### 2.1.8. Soil

Bitter gourd can be grown on well drained sandy to sandy loam; medium black soils rich in organic matter. But it will tolerate aby soil that provides a good drainage system ( sandy loam soil, but it will grow in areas with poorer soils.) it should be frost-free area . the soil must be prepared well by adding organic matter before planting . Alluvial soil along the river beds is also good for production of bitter gourds. A pH range of 6.0- 7.0 is considered as optimum. Soil temperature is atleast 20 to 25 ℃.

## 2.2 STRUCTURAL PROPERTIES OF BITTER GOURD

*Momordica charantia* is an annual climbing or trailing herb with stems (vines) up to 5 m long. The stems are ridged, glabrous or hairy, and they bear simple tendrils. The leaves are showy, alternate, simple, borne on 1.5-7 cm long petioles. The leaf-blade can be glabrous or pubescent, deeply palmated, 2.5-10 cm broad x 3-12.5 cm long. The flowers are solitary, unisexual, borne at leaf axils, regular, pentamerous up to 2 cm long, pale yellow to orange yellow; male and female flowers are distinct. The fruit is a pendulous broadly ovoid and beaked berry, up to 11 cm in length × 4 cm in diameter (some cultivars reach up to 45 cm × 9 cm). Immature fruits are green in colour, and then become reddish-orange when ripe. They split open at maturity to release the seeds sheathed in a sticky red pulp. Cultivated fruits have smooth to spiny surface. The seeds are oblong, 10 mm × 5 mm, flattened, white or brown (Njoroge *et al*., 2004).

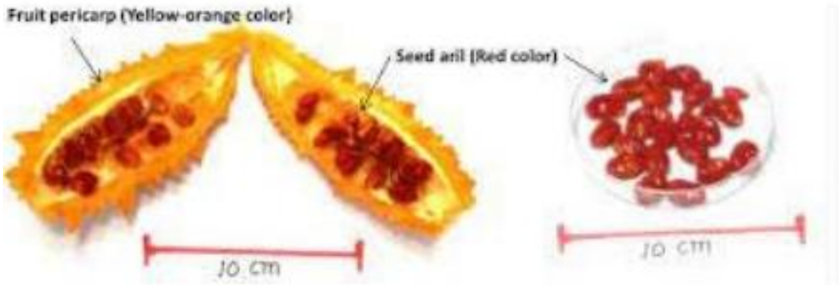



**Plate 2.2  Structure of bitter gourd**

## 2.3 NUTRITIONAL PROPERTIES

Regarding the nutritional composition, *Momordica charantia* contains 91.8% water, 0.20% fat, 4.2% carbohydrates, and 1.4% fiber. The seeds contain nearly 35% to 40% of oil and the fatty acid profile indicates that the seeds contain 3.33% and 36.71% of MUFA (monounsaturated fatty acid) and SFA (saturated fatty acids). Bitter melon has been demanded to comprise glucosides, mineral matters, charantin, steroidal saponin, alkaloids, momordium, carbohydrates, and ascorbic acid, etc. The occurrence of Gallic acid in bitter melon as main phenolic acid has been showed by HPLC examination of phenolic content. Many other phenolic components are found to be present in bitter melon extract such as epicatechin, chlorogenic acid, catechin and gentisic acid and gallic in bitter acid. Fruit pulp of bitter melon contain no free pectic acid, but has soluble pectin. From the pulp of bitter melon, galacturonic acid has also been obtained.(Afzaal *et al*., 2018).

Nutritional compositions of bitter gourd vegetable are shown in Table 1. Ali et al. (2008) reported that bitter gourd is an important source of Carbohydrate, proteins, vitamins, minerals and other nutrients for maintaining proper health. It is a highly nutritious vegetable due to the presence of higher amount of protein, ascorbic acid, calcium, iron, and phosphorus (Assubaie and El-Garawany, 2004).Total fat content of whole fruit ranged from 2.9%-6.4% of dry matter (Chuang *et.al,*. 2006; Habicht *et.al.,* 2011). Bitter gourd also contains high amount of Vitamin A, vitamins B1, B2, B3and B9(Josephand Jini, 2013). It is also good source of inorganic minerals such as Phosphorus, potassium, calcium, magnesium, sodium, Iron and zinc (Islam *et al.,*2011). Bitter gourd vegetables also contain different types of amino acids such as glutmine, asparagines, glycine, lysine, alanine, leucine, valine, arginine, proline, serine, isoleucine, phenylalanine, tryptophan, histidine, threonine, methionine (Islam *et al.*, 2011).

Bioactive compounds of bitter gourd Bitter gourd vegetables are considered significant sources of different bioactive compounds. Many researchers have already identified different bioactive compounds in bitter gourd vegetables (Table 4a-c).The quality and quantity of bioactive compound present in bitter gourd could be depends on many factors such as harvest time, temperature, state of maturity, and post harvest storage as well as size, shape, colour of bitter gourd (Horax *et al.,* 2005; Tan *et al.,* 2014; Sing *et al.,* 2016). In addition, bioactive compounds extraction from bitter gourd depends on temperature, length of extraction, particle size and number of extractions of a sample, water to powder ratio, powder particle size, the ratio of water and plant material and the type of solvents used (Sorifa *et al.,* 2010; Cerda *et al.,* 2013; Tan *et al.,* 2016). Bitter gourd vegetables are a good source of total phenolics which have high antioxidant ativity (Tanet *et.al.,* 2016). The total phenolic content in immature, mature and ripe bitter gourd ranged from 6.9 to 15.7,6.4 to 14.8, and 4.3 to 14.9 mg GAE/g ethanol extract, respectively where as mature and ripe seed ranged from 6.4 to 18.0 and 6.1 to 20.9 mg GAE/g ethanol extract, respectively (Horax *et al.,* 2010). Budrat and Shotipruk (2009) reported that total phenolic contents in subcritical, soxhlet and solvent extraction were 52.63, 6.68, 6.00 mg GAE /g DW respectively.Zhu *et.al,*. ( 2012) showed that total polyphenols and total flavonoids of lyophilized superfine grinding bitter gourd powder had 10.03 and 5.27 mg/g, respectively where as hot air drying bitter gourd powder had 6.43 and 2.09 mg/g. Islam et al. (2011) observed that total phenolic content of oven dried and freeze dried tissues from four varieties ranged from 5.39-8.94 mg CAE/g dry matter and 4.64-8.90 mg CAE/g dry matter.

**Table 2.2 Nutritional properties of bitter gourd**

| PARAMETERS | Value |
|---|---|
| Moisture (%) | 93.5 |
| Ash (%) | 0.8 |
| Protein (g) | 0.90 |
| Fat (g) | 0.10 |
| Carbohydrate(g) | 0.20 |
| Dietary fibre (g) | 3.30 |
| SDF (% dry basis ) | 14.4 |
| IDF (% dry basis ) | 30.2 |
| Organic acids (g) | 0.11 |
| TSS (°Brix) | 3.2 |
| Acidity (%) | 0.03 |
| Reducing sugars (%) | 2.5 |
| Total sugars (%) | 2.8 |
| Chlorophyll (mg / L) | 10.9 |
| Vitamin C (mg) | 50.0 |
| Vitamin A (mg) | 0.04 |
| Thiamin (mg) | 0.05 |
| Riboflavin (mg) | 0.03 |
| Niacin (mg) | 0.40 |
| Phosphorus (mg/100g) | 69.0 |
| Calcium (mg/100g) | 22.0 |
| Potassium (mg/100g) | 26.0 |
| Magnesium (mg/100g) | 16.0 |
| Iron (mg/100g) | 0.9 |
| Sodium(mg/100g) | 3.0 |
| Zinc (mg/100g) | 0.1 |

### 2.3.1 Health benefits of bitter gourd

*Momordica charantia* or Bitter Melon, also known as balsam pear or Karela, is a Tropical vegetable, is a common food in Indian cusine and has been used extensively in folk medicine as a remedy for diabetes. In Ayurveda, the fruit is considered as tonic, stomachic, stimulant, emetic, antibilous, laxative and alterative. Bitter melon has been used in various Asian traditional medicine systems for a long time. Like most bitter-tasting foods, bitter melon stimulates digestion. While this can be helpful in people with sluggish digestion, dyspepsia, and constipation, it can sometimes make heartburn and ulcers worse. Folk wisdom has it that bitter melon helps to prevent or counteract type-II diabetes. They also improve insulin release from pancreatic beta cells, and repair or promote new growth of insulin-secreting beta cells. Bitter Melon contains four very promising bioactive compounds. These compounds activate a protein called AMPK, which is well known for regulating fuel metabolism and enabling glucose uptake, processes which are impaired in diabetics. So it is essential to extract the pulp without much wastage. Several researchers showed that the various medicinal properties of bitter gourd such as antidiabetic, antihyperglycemic anticancerous,anti-HIV, antitumour, antimutagenic, antibacterial,antiulcerogenic, anti-tumour, antihelminthic,antileukemic, antilipogensis, abortifacient and antifertility (Rathi et al., 2002; Uebanso et al., 2007;Kandangath et al., 2015 ). Some healths benefits are described below especially those have huge health benefit for human being:

Previously many studies have proven that consumption of bitter gourds such as whole fruit, juice, extract and dried powder are very effective in lowering blood glucose level (Basch et al., 2003;Lawrence et al., 2009) and bitter gourd has positive effects on antidiabetic activity. Glycosides, saponins, alkaloids, triterpenes, polysaccharides, proteins, steroids, charantin, a polypeptide-p, momordin Ic, oleanolic acid 3-O-monodesmoside, and oleanolic acid 3-O-glucuronide are found in bitter gourd those compounds have hypoglycaemic activity. Ali et al. (1993) found that insulin-dependent diabetes mellitus (IDDM) rats and normal rats were showed that significant hypoglycemic effect in fasting and post-prandial states after consumed the saponin free methanolic extract of bitter gourd juice than non- insulin-dependent diabetes mellitus (NIDDM) rats. Bitter gourd also enhance glucose tolerance and dominate the postprandial hyperglycaemia in rats (Uebanso et al., 2007; Leung et al., 2009) as well as increase the insulin sensitivity and lipolysis in rat (Leung et al., 2009). Some reviewer also found that similar effects on the hypoglycaemic effects between bitter gourd and oral medications such as tolbutamide, chlorpropamide and glibenclamide (Virdi et al., 2003; Ojewole et al., 2006; Leung et al., 2009). Baldwaet al. (1977) mentioned that 21.5%, 49.2%, 28% reduction in blood glucose at 30 mins, 4 hr and 12 hr respectively after consume of bitter gourd whereas control (placeboijection) showed 5% reduction in glucose level. After consume of fried karela as daily basis also produced significant development in glucose level in diabetic patients subsequently serum insulin levels also did not increase (Leatherdale et al., 1981). Ahmad *et al.* (1999) also found reduction of 86% cases post-prandial serum glucose and 5% reduction of fasting glucose after consume of bitter gourd pulp for 100 cases of moderate NIDDM patient. There are many mechanisms of blood sugar levels and antidiabetic activity with bitter gourd. Bitter gourds enhance the beta cells (Ahmed *et al.*,1998) and acts as vegetable insulin (Leung et al.,2009) as well as bitter gourd could increase the uses of glucose in liver and muscle. (Sarkar *et al.*, 1996). On the other hand, bitter gourd could also destroy of carbohydrate enzyme activity such as hexokinase, glucokinase, phosphofructokinase and substrateglucose-6-phosphate also revived after treatment with bitter gourd in liver of diabetic mice (Rathi et al., 2002).

#### *2.3.1.1 Anti-bacterial activity:*

Water, ethanol and methanol of bitter gourd leaves extract exhibited the inhibition capacity against various microorganisms such as Escherichia coli, Salmonella paratyphi, Shigella dysenterae Streptomyces griseus in vitro (Ogata *et al.,* 1991).Khan et al. (1998) found entire of bitter gourd extract also showed positive activity against Entamoeba histolytica. Helicobacter pylori-organism also could be suppressed using of bitter gourd fruit extract. Frame et al. (1998)

mentioned that Mycobacterium tuberculosis growth might be inhibited using bitter gourd leaves extract through BACTEC 460 method.

***2.3.1.2 Wound-healing activity***:

It was reported that bitter gourd extract have therapeutic agent for tissue regeneration. It posses wound healing properties and stimulated the proliferation of dermal fibroblasts of human (Tan *et al.,* 2016)

***2.3.1.3 Anti-HIV activity*** :

Alpha- and beta-momorcharin protein are present in seeds, fruit, and leaves of bitter gourd /those protein showed Anti HIV activity in vitro(Zheng et al., 1999; Au et al., 2000) and alpha- and beta-momorcharin protein also could suppressed ofHIV-1 integrase (Au *et al.,* 2000). MRK29 protein also found in bitter gourd and MRK29 protein has able to inhibition of viral reverse transcriptase (Wang and Ng, 2001). Tumour necrosis factor (TNF) activity could increase and subsequently HIV-infected cells expressed by viral core protein p24 also 82% reduced using salt-precipitated fraction of MRK29 protein reported by (Jiratchariyakul *et al.,* 2001).

***2.3.1.4 Anticancer and antitumor properties:***

It was found that Thai bitter gourd contained anti-carcinogens and chemopreventive agent whereas Chinese variety did not have that property. Various in vivo as well as in vitro studies demonstrated that bitter gourd extract inhibits cancer cell growth and the development of mammary tumors in mice and liver cancer and leukemia in human (Grover *et al.,* 2004; Fang *et al., 2*012a). MAP30 protein is present in bitter gourd. Various in vivo and in vitro studies suggested that the efficacy and safety of MAP30 against liver cancer (Fang *et al.,* 2012a). 14-kDa Ribonuclease, known as RNase MC2 which is isolated from seeds of bitter gourd and have an activities against MCF-7 breast cancer cells reported by Fang *et al.* (2012b). Fang *et al*. (2012b) also reported that RNase MC2 had the anticarcinogenic effects toward human liver cancer cells. RNase MC2 have an effect on both cytostatic and cytotoxic activity against MCF- 7 breast cancer cells which indicated the apoptotic response of the RNase MC2 in both mice and HepG2 cells which cause nuclear damage resulting in earlyor late aoptotic response. Anticancer mechanisms of bitter gourd have been mentioned elsewhere. Bitter gourd phytochemicals could be inhibited DNA, RNA and cellular protein synthesis as well as bitter gourd also might be suppressed the cell cycle G2 and M phases through inhibit the uptake of thymidine, uridine and leucine into DNA (Claflin *et al.,* 1978). Bitter gourd suppressed the guanylate cyclase activity (Claflinet al., 1978; Takemoto *et al.,* 1982) and promoted the activation of NK cells (Porro *et al*. 1993). Sun et al. (2001) showed induction of apoptosis by treatment with bitter gourd. Bitter gourd also showed modulatory effect on biotransformation and detoxification enzymes.

## 2.4 VALUE ADDED PRODUCTS OF BITTER GOURD

### 2.4.1 Juice and Beverage

Generally bitter gourd juices are unacceptable to various communities due to its tremendous bitter taste. For this reason, it is needed to develop a suitable formulation, processing and storage using bitter gourd fortified juice and thus make it palatable and acceptable to consumers. Kaur and Aggarwal (2014) reported that bitter gourd juice treated potassium metabisulfite (KMS) had higher nutrient stability than Na-benzoate. On the other hand, bitter gourd extract (15%) with artificial sweetener was employed to develop functional and dietetic beverage and preserved at refrigerated temperature for six months with good flavour and palatability as well as other nutritional properties (Din *et al.,* 2011).On the other hand, different concentration of bitter gourd juice, sugar and citric acid was used to prepare ready to serve bitter gourd beverages (Satkar *et al.,*2013). These research groups reported that ready –to- serve bitter gourd beverage could be made using the levels of juice 12.5% sugar -15 g, citric acid 0.29 g and water 76 mL for 100 mL of beverage and kept refrigerated (5±1oC) temperature up to 3 months without changing the chemical and sensory qualities.

### 2.4.2. Fried Bitter Gourd Chips

The bitter gourds are washed and trimmed the ends off. Slice them in half lengthways, remove the seeds and then slice them lengthways into long strips, 0.5cm (1/4-inch) wide and 3.75cm (1/1/2 inches) long, approximately. Place the bitter melon pieces in a bowl, sprinkle liberally with 2% salt and 1% turmeric powder. Keep it for 30 min to reduce the bitterness of bitter gourd. The bitter gourd pieces are kept under running water and drain excess water from them. Bitter gourd slices are allowed to dry either in solar dryer or other mechanical dryer for suitable time. After drying the corn flour is sprinkled on the chips and then fried into deep fat fryer at 1600C for 3 min. After frying chips are removed and then red chilli powder and chat masala may be added for increasing palatability. Bitter gourd chips should be packed into the LDPE bags and sealed with the help of sealing machine and well labelled. Packed bitter gourd chips are stored in the cool or dry place.

### 2.4.3. Bitter Gourd Pickle

Washed bitter gourds are placed in a strainer to drain out remaining water. Cut the bitter gourds into thin round pieces. Put 1 tsp salt to the pieces of bitter gourds and keep aside for 1 hour in a utensil. This releases the bitter water from them, put these salt coated bitter gourds in boiling water and cover for 5 minutes. Keep the bitter gourd pieces in a strainer and remove excess water, keep the pieces on a washed cloth for 2-3 hours in the open/sun to dry the water on them. Roast Heeng, Jeera, Methi and Saunff till they turn light brown. Grind these roasted spices with yellow mustard to a coarse powder. Now keep the bitter gourd pieces in a dry utensil, also put the roasted spices and salt, mix all these ingredients properly. Squeeze the juice from the lemons on the bitter gourd pieces and mix with a spoon. Fill a glass or plastic container with the bitter gourds mixed in spices. We can also keep this container in the sun. Stir the pickle every day for the next 4 days with a clean and dry spoon. Sour bitter gourd pickle with a mouth-watering smell is ready. This pickle can be eaten for 15-20 days. To increase its shelf life, keep the pickle in the fridge or add mustard oil enough to submerge the pickle completely

.

### 2.4.4 Dehydrated products

Solar drying, low temperature drying and cabinet drying was applied to manufacture the bitter gourds and found that the cabinet drying method was the best method for making or drying of bitter gourd because the retention of all the bioactive compounds such as ascorbic acid, total carotenoids, β-caroteneand total chlorophyll content than those of other drying methods (Singh and Sagar, 2013). Kumar *etal*. (2016) produced osmo-air drying of bitter gourd chips using soaking with 0.2% KMS for 10 mins followed by 2%, 6%, 10% of NaCl and 1%, 3% and 5% acetic acid for 90 mins, blotting and dried at 600C for 8 hr. These research groups revealed that bitter gourd chips prepared with 10% NaCl had better in color and over all acceptability and might be kept at ambient conditions for 3 months without loss of organoleptic quality and microbiologically safe. Lyophilized and hot-air dried superfine powder was produced using bitter gourd reported by Zhu et al. (2012). These research groups also demonstrated that lyophilized superfine powder had a higher anti-diabetic activity than hot-air dried powder because of reducing fasting blood glucose level was higher in lyophilized powder as compared to hot-air dried powder. Therefore bitter gourd powder could be used as suitable functional food ingredients. (Horax et al., 2005; Horax et al., 2010).


**Plate2.3. Bitter gourd juice**

**Plate2.4.Bitter gourd chips**

**Plate 2.5 Dehydrated bitter gourd** **Plate 2.6. Bitter gourd powder**

## 2.5. BITTER GOURD PLANT DISEASES

### 2.5.1. Red pumpkin beetle

*(Aulacophorafoveicollis,A.lewisii)*

**Nature of Damage :** Adults feed on the foliage, buds and flowers. Grubs feed on roots. .

**Control Measures:**

- Preventive measures like burning of old creepers, ploughing & harrowing of field after harvest of crop to destroy the stages of pest.
- Collection & destruction of beetle in early stage of infestation.
- Spraying with 0.05% malathion or dusting with 5% malathion dust @ 10 kg/ha.

### 2.5.2. Melon Fruit fly *(Dacus cucurbitae)*

**Nature of Damage:** Active during March-May.Reddish dark brown flies with hyaline wings, lay eggs under the skin of the fruits; Maggots feed on the pulp of fruits. Infested fruits start rotting and rendered them unfit for human consumption; Fruits show dark-brown, rotten, circular patches and fall off prematurely

**Control Measures:**

- Clean cultivation, i.e. removal and destruction of fallen & infested fruits daily.
- Deep ploughing to expose hibernating stages.
- Application of spray baits.
- Spraying with 0.05% malathion or 0.2% carbaryl at flowering.

**2.5. 3 Aphids** *(Aphis gossypii)*

**Nature of Damage:** Colonies of nymphs and adults attack leaves and tender shoots and suck the sap; Leaves curl and dry up.

**Control Measures:**

- Remove infested leaves and shoots in the initial stage;
- Spray 0.02% Pyrethrins or 0.05% Malathion or Dichlorvoe (DDVP)

**2.5.4 Powdery Mildew** (Sphaerotheca fuligine)

**Nature of damage**: This disease is favored by high humidity and tends to occur on older leaves first. Symptoms first appear as white powdery residue primarily on the upper leaf surface. On the lower surface of the leaves circular patches or spots appear. In severe cases, these spread, coalesce and cover both the surfaces of the leaves and spread also to the petioles, stem, etc. Severely attacked leaves become brown and shrivelled and defoliation may occur. Fruits of the affected plants do not develop fully and remain small.

**Control Measure**: Carbendazim (1ml/litre of water) or Karathane (0.5 ml/litre of water) is sprayed immediately after the appearance of the disease. 2-3 sprays are taken at an interval of 15 days.

### 2.5.5.Downnmidew

Downy mildew is caused by the fungus *Pseudoperonospora cubensis*. It is prevalent in areas of high humidity, especially when summer rains occur regularly. The disease is first seen as yellow angular spots on the upper surface of the leaves. Under conditions of high humidity, whitish powdery growth appears on the lower surface of the leaves. The disease spreads rapidly killing the plant quickly through rapid defoliation.

**Management:** Excellent control of this disease can be achieved with Ridomil (1.5 g/litre of water) which must always be used simultaneously with a protectant fungicide such as Mancozeb (0.2%) to prevent the development of resistant strains.

### 2.5.6 Bitter gourd mosaic

This virus disease is mostly confined to the leaves with symptoms appearing on the leaves in the secondary branches produced at the apical end of the plant. Small irregular yellowish patches are seen on the leaves. Some leaves show vein clearing in one or two lobes of the leaf and severely infected plants show reduction in leaf size and elongation and/or suppression of one or two lobes. Young developing leaves are completely distorted and malformed with considerable reduction in their size. Some of the leaves show marked reduction in the development of lamina resulting in a shoe- string effect. The virus is transmitted by five species of aphids.

**Management**: Spraying the crop just after germination with Monocrotophos (0.05%) or Phosphamidon (0.05%) at 10-day intervals prevents aphid vectors.

## 2.6. PULP EXTRACTION METHODS

Pulp extraction of bitter gourd can either be done manually or by mechanical means.

### 2.6.1. Manual method

Harvested bitter gourd is allowed to ripen until it is turned into red colour and soft in texture. Unit operations including cleaning, washing, sorting, grading and cutting are done. The materials (pulp with seeds) are then transferred to a sieve of perforations having size less than that of the seed, is rubbed over it by hand operation. The main drawbacks of manual method include time consuming, skilled labor is required, possibilities of causing injury during handling, efficiency is less. Various manually operating pulp extractor :

#### ***2.6.1.1 Hand Presser and Pulper*** :

Hand presser or revolving citrus 'rose' was used for naturally juicy fruits such as citrus fruits. Soursop, strawberry, pineapple, guava, mango fruits need to be pulped to release the juice. In such cases, the pulp was formed by pressing the fruit pieces through a punched metallic plate. Sometimes liquidizer was used to turn the fruits into pulp and retained fruit pieces were removed by filtration. Hand-powered pulper, fruits were forced through substitutable metallic strainers to obtain a pulp was specially recommended for minor fruit juice processors.

#### ***2.6.1.2. Rotary Juice Press*** :

Fruits served to the machine through a feed hopper. The juice extraction proceeds as the handle attached to the machine rotates. This machine can be practiced for all fruit varieties. Hardwood tubing was fabricated with eight rows of stainless steel tines attached to it. The Basket was fed directly with pulp fruits. The basket has a capacity of 0035 m3 (Christopher, 2011).

### *2.6.1.3.Victorio Strainer :*

Squashy vegetables and fruits were processed through these machines. This machine mechanically separates seeds from juices and fruits hence no need for special coring or peeling. Handle rotates once the fruits and vegetables introduced in it. Cores, rinds, and seeds were interminably parted from the puree. The machine functioned more efficiently and finely with apples and tomatoes (Christopher, 2011)

### *2.6.1.4. Domestic Rubber-Type Extractor :*

The domestic rubber-type extractor was superior as compared to juice extraction with bare hands. This was in the form of a cone shape fabricated of plastic or rubber. It was utilized for household applications instead of the commercial scale. The peeled fruits parted into two splits placed on the top of the instrument and where it was continuously weighed down. It gets spin till the entire juice was released through punched holes and was collected in a small collector tank beneath it.. Generally, the problem arises with this type of extractor was numerous blockages of the holes during functioning which embarrass juice extraction. In addition to it, high energy consumed during accurate functioning. Once the juice collection tank was completely filled, the upper portion of the machine can be separated (Christopher, 2011).

### *2.6.1.5. Multi-fruit Juice Extractor :*

Multipurpose juice extractor was developed using locally obtainable material which consists of a cylindrical drum having a size 30 cm length x 20cm diameter, a screw rod of 28 cm long, sieve, and a hopper with dimensions 10.2cm x 6.4 cm x 7.5 cm. The turning of the screw rod rotates the cylinder drum which compresses the fruits fed in the hopper and squeezes the fruit to squeeze the juice. Then it gets passed through the openings present at the base of the cylinder drum designed for sieving purpose. And finally, filtered juice collected in the collector container. The machine was evaluated with the use of unpeeled and peeled samples of watermelon, orange, and pineapple. Sieves with mesh opening diameter 0.5, 1, 1.5, and 2 mm were practiced for evaluation in both unpeeled and peeled cases. In the case of peeled fruits, the percentage peak juice yield and extraction efficiencies were 45 and 46.5 for orange, 55.3, and 47.6 for pineapple, and 31.8 and 46.3 for watermelon respectively. Similarly in the unpeeled fruits, category peak juice yield and extraction efficiencies were 50.8 and 60.1 for orange, 67.4, and 50.8 for pineapple, and 38.2 and 52.2 for watermelon respectively. The uppermost extraction efficiency and juice yield were found by a 2mm diameter sieve (Aremu *et al.*, 2016).

### 2.6.2. Mechanical Methods

Juice extractors are designed in different types including continuous screw expellers (Ihekoronye and Ngoddy, 1985), taglith-type extractor, roller-press, plunger-type press, halving and burring machine, and rotary juice extractor (Hans and Joachin, 1986). Oyeleke and Olaniyan (2008) performed experiments in the laboratory on a small scale fruit juice extracting unit for different fruits to determine the juice yield of tangerine, water melon, pine apple and grapes. Aviara et al. (2013) designed, constructed and evaluated multi-fruit juice extractor using orange, pineapple, and melon. The machine operated on the principle of shear and compressive squeezing force. Olaniyan (2010) worked on designing and fabrication of a small scale motorized orange juice extractor. The main components of the extractor were hopper, worm shaft, sieve mesh, collector, main frame, waste outlet and pulleys. The worm shaft propels, crushes, and squeezes the fruit to extract juice from it. Chuba et al. (2019) developed a device to pulp bocaiuva. Immanvel et al. (2014) designed and fabricated a pomegranate pulp extractor with an efficiency of 75% extraction of fruit seed while focusing on the hygiene standards. Matthew et al. (2014) designed and developed small scale mango juice extractor using screw shaft as major juice extracting component. The unit has an average juice yield (34.56%), extraction efficiency (55.14%) and extraction loss (10.15%). Sonar *et al.* (2018) designed and fabricated brush type mango pulp extraction machine having brush linkage fitted on a shaft that rotates inside a fixed tube called the perforated sheet. Till date work has been done on fruit processing units having feed regulation screw (Matthew and Ibafemi, 2014) and brush type beaters having separate cutting mechanism (Sonarl *et al*., 2018). A highly effective beater type continuous pulp extracting unit was developed which is easy to operate. Conventional designs of feed regulation screw and brush type beaters having separate cutting mechanism were replaced by innovative design of new rotary beater with built-in knives for cutting purpose thus reducing the size and weight of the machine as well as its fabrication and operational costs.( Shafi *et al*., 2016).

The fruit juice extractor is a machine that employs the pressing mechanism to draw out juices from various fruits. These operations of crushing, squeezing, and pressing of whole fruits or part of fruits to get the liquid content i.e juice (Nnamdi *et a*l., 2020).Presses are the common and outdated method of removing juice from fruit and vegetable materials. The physical or outdated technique includes softening fruit with hand or peeling, slicing, blending, and pressing. This technique is extremely labor demanding, and time consuming as compared to mechanical extraction (Adonis *et al.*, 2016).People of all ages are strongly attracted with fruit juices because of their healthier profile (Mushtaq, 2018).

Juice extraction was done in earlier years with hand extraction which is quite low, tiresome and unhygienic and as a result, the use of extractor came into a trend as juice extraction continued to increase (Jiang, 2014). As the extractor came into action for the extraction purpose a lot of benefits have been achieved that is, it saves time improves efficiency increases capacity and reduces spoilage and waste. a manually operated juice extractor was developed and manufactured from resources obtained nearby feeding unit, extraction unit, juice collector, waste outlet, frame, and bearings comprise in these extractors (Eyeowa *et al*., 2017). They are economical compared to all other electrically powered juice extractors, but they have limited yields. Electrically powered juice extractors consist of a hopper, a cylindrical main casing, a shaft with well-arranged presses, a hollow screen, and an outlet. Those kinds of machinery powered by an electric motor with support of V-belts and pulleys and are of high capacity (Olabisi and Adelegan, 2015). Juice extraction is the active processing and storage of fresh fruits and veggies, thus it prevents preventable waste. Hence it is a better means of salvation of fruits nutrients for an extended period for months or even for years before the date of expiration(Abulude *et al*., 2007).As well as it is one of the right ways of protecting fruits for financial assistance to the farmers and also for the overall population(Olaniyan, 2010).

### 2.6.2 Power Operated Juice Extractors

#### *2.6.2.1. Mini Juice Extractor :*

Mechanical extraction device developed and yield evaluation did using pineapple fruits. The juice extraction device was operated via a 2 horsepower singlephase electric motor. The machine consisted of a chopping unit where perfect cutting of pineapple proceeds and also an extraction unit where fruits pressed and squashed to remove the liquid. The performance test result was found to be 75 percent juice yield, 4.8 percent extraction loss, and 71 percent extraction efficiency. It was appropriate for small to medium scale farmers to produce small to medium scale juice yielding around 18 liters/s (Adonis *et al.*, 2016)

#### *2.6.2.2.Multi-fruit Juice Extractor :*

Multi-fruit purpose juice extractor was designed and estimated using pineapple, orange, and melon fruits. The machine functioning on the principle of compressive and shear force applied by an auger transmission system. Tool frame, juice extraction encasement, screw conveying tapered shaft, perforated screen base, collection chute, gearbox, and electric motor were the major components of the machine. The extractor was assessed and results showed that percentage juice yield for pineapple was 79.1 and 68.7%, for orange 77 and 69.2%, and for watermelon 89.5 and 89.7% for peeled and unpeeled fruits respectively. Extraction efficiency in the case of peeled fruits of pineapple, oranges, and watermelon was 96.9%, 94.3%, and 96.6% respectively while 83.6%, 84.2%, and 97.1% respectively in the case of unpeeled fruits. For both peeled and unpeeled fruits, the extraction loss 2.1 and 2.7% for pineapple, 2.1 and 2.5% for orange, and 2.9 and 2.6% for watermelon respectively. The functioning of the machine was simple to run and maintenance-friendly thus it was commended for minor households and native fruit juice retailers (Ndubisi et al., 2013)**.**

### 2.6.3 Centrifugation

Industrially, centrifuges are used for a variety of purposes related to separation of materials on the basis of density. This separation usually involves separation of insoluble particulates from supernatant liquids, but can also include extraction of dissolved substances from one immiscible liquid to another of different density, separating the mixed liquids centrifugally. The blending of the liquids, transfer of the solute and separation of the immiscible phases are sequentially carried out in the same machine at high speed. Generally, centrifuges are used throughout many manufacturing industries to separate suspended solids from liquid utilizing the centrifugal acceleration of the suspended particles directed outward from the axis of rotation. This force initiates the particle movement to the centrifuge periphery where it is trapped or contained by the wall of the rotating body. Alternatively, a density difference between two immiscible liquids is exploited to accelerate separation of the liquids (i.e. fat separation in dairies for cream or butter manufacture). A specialized use involves separation of water from fresh-cut vegetables before modified atmosphere packaging. Much experience and information related to industrial-scale centrifugation exists within companies manufacturing the centrifugal machinery and these sources should not be overlooked when seeking information. The Internet itself should not be overlooked as a source of information: simply typing the word ‘centrifuges’ in the request space of one search engine provided over 25,000 items for perusal. Centrifugation is treated as a separation unit operation in chemical engineering and the article in Dahlstrom *et al.,* (1997) by Leung on centrifuges should be consulted for an engineering perspective (see Further Reading). For a comprehensive treatment of industrial centrifugation technology, Leung's book on industrial centrifugation technology should be consulted.

Over the past 10-15 years the growing uses for centrifuges industrially has resulted in a plethora of special centrifuges designed and adapted to particular uses. Centrifuges fall into two general classifications, termed sedimentation centrifuges and filter centrifuges. In sedimentation centrifuges, solids are transported to the periphery wall of the rotating machine bowl and collected against this surface; liquid is removed from the solids by the close packing of the individual particulates. In filter centrifuges the solids are transported to the surface of a filter element and the solids trapped on this filter, while the liquid drains through the particulates and exits through the filter surface. The mechanism of solids drying is thus quite different between the two types of machine and the types of material each would be expected to treat most efficiently also differ considerably. The other important parameter is whether or not the machines are fed continuously or in batch mode. Generally, batch-mode machines are often considered obsolete for large scale separations, with the important exceptions of the continuing use of batch-mode basket centrifuges for the last recovery stages for white sugar and in the fresh-cut vegetable industry. Other exceptions also exist. The list is not exhaustive but examples of most types of centrifuge, along with an estimate of the range of g forces available from each machine type, is provided for purposes of illustration and estimation of requirements. Basket centrifuges are normally of low speed and provide maximum g forces in the 1500-2000 range. It appears in heavy industrial uses such as sugar and oil refining and in light industrial separations such as dewatering of vegetables. Performance demands also vary widely, ranging from high g applications required in isolating and manufacturing the diverse products of biotechnology to dewatering hundreds of tons of municipal sewage per day using machines of relatively low g capability. This is made possible by the wide variety of machines available. The recent application of decanters as press replacements in the fruit and vegetable juice industry required the independent development and widespread use of pectin-digesting enzymes (pectinases) for routine juice production.

## 2.7 . RESPONSE SURFACE METHODOLOGY (RSM)

Response Surface Methodology (RSM) is a collection of statistical and mathematical methods that are useful for the modelling and analyzing engineering problems. The design procedure of RSM is as follows :

(i) Designing of a series of experiments for adequate and reliable measurement of the response of interest.

(ii) Developing a mathematical model of the second order response surface with the best fittings

(iii) Finding the optimal set of experimental parameters that produce a maximum or minimum value of response.

(iv) Representing the direct and interactive effects of process parameters through two and three dimensional plots.

RSM designs allow us to estimate interaction and even quadratic effects, and therefore give us an idea of the (local) shape of the response surface under investigation. Box-Behnken designs and central composite designs are efficient designs for fitting second order polynomials to response surfaces, because they use relatively small number of observations to estimate the parameters. Rateability is a reasonable basis for the selection of a response surface design. The purpose of RSM is optimization and the location of optimum is unknown prior to running the experiment, it makes sense to use a design that provides equal precision of estimation in all directions. For such purposes, Central Composite Design (CCD) - spherical or face centered and Box – Behnken design are the commonly used experimental design models for three level three factor experiments.(Joseph et al., 2008).

The optimization approach provided by the Box–Behnken design (BBD), which is a response surface methodology (RSM) is proposed [11]. For applying the approach, Design-Expert software (Version 7.0.0, Stat-Ease Inc., Minneapolis, USA), was used. On the basis of the BBD, the process parameters in the turning process could be optimized with a minimum number of runs with an objective of achieving better extraction and higher efficiency resulting in overall cost-advantage. As a collection of statistical and mathematical techniques for developing, improving, and optimizing processes, RSM is specifically applied in situations where several input variables potentially influence a performance measure or quality characteristic of the product or process.

Box and Behnken proposed three level designs for fitting response surfaces. These designs are formed by combining 2k factorials with incomplete block designs. It can be noticed that the Box-Behnken design is a spherical design with all points lying on a sphere of radius 2. Also the Box – Behnken design does not contain any point at the vertices of the cubic region created by the upper and lower limits for each variable. This could be advantageous when the points on the corners of the cube represent factor level combinations that are impossible to test due to physical process constraints or prohibitively expensive. Its "missing corners" may be useful when the researcher should avoid combined factor extremes. This property prevents a potential loss of data in those cases. Box-Behnken designs require fewer treatment combinations than a CCD, in problems involving 3 or 4 factors. The Box-Behnken design is rotatable (or nearly so) but it contains regions of poor prediction quality like the CCD. In this study, the experiments were planned and conducted according to a Box-Behnken type response surface design ( Joseph *et al*., 2008).

| Run | $x_1$ | $x_2$ | $x_3$ |
|---|---|---|---|
| 1 | −1 | −1 | 0 |
| 2 | −1 | 1 | 0 |
| 3 | 1 | −1 | 0 |
| 4 | 1 | 1 | 0 |
| 5 | −1 | 0 | −1 |
| 6 | −1 | 0 | 1 |
| 7 | 1 | 0 | −1 |
| 8 | 1 | 0 | 1 |
| 9 | 0 | −1 | −1 |
| 10 | 0 | −1 | 1 |
| 11 | 0 | 1 | −1 |
| 12 | 0 | 1 | 1 |
| 13 | 0 | 0 | 0 |
| 14 | 0 | 0 | 0 |
| 15 | 0 | 0 | 0 |

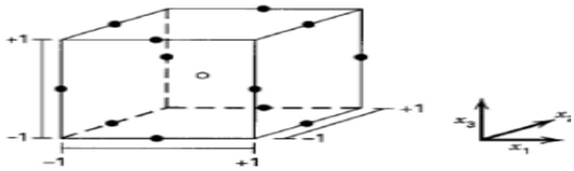



**Fig2.1 Three factor  box-behnken design**

# *MATERIALS AND METHOD*

# CHAPTER III

# MATERIALS AND METHOD

This chapter provides the detailed information regarding the materials used and the methodology adopted for the project work entitled "Development and Evaluation of Bitter Gourd Pulp Extractor". The research work was carried out in the Department of Processing and Food Engineering, Kelappaji college of Agricultural Engineering and Technology, Tavanur, Kerala. The development of pulp extractor and its evaluation procedures are also included in this chapter.

## 3.1 RAW MATERIAL

Matured and ripened bitter gourd was procured from Aromatic and Medicinal Plants Research Station (AMPRS), Odakkali, Ernakulam as well as College of Agriculture, Kerala Agricultural University, Thrissur. *Preeti* variety of bitter gourd was selected for the evaluation. It has an average yield of 10-35 t/ha and relatively less susceptible to fruit fly attack. The fruits are extra long having an yield of 55 fruits per plant and takes about 60 days from sowing to the first harvest.

### 3.1.1 Preparation of sample

Ripened bitter gourd was harvested from the field. It was cleaned manually and cut into halves and collected the pulp along with its seed. It was kept undisturbed and allowed it to ferment for a day. The cross sectional view of ripened bitter gourd is shown in Plate 3.1.

**Plate 3.1 Cross sectional view of ripened bitter gourd**

## 3.2 DETERMINATION OF ENGINEERING PROPERTIES OF BITTER GOURD PULP AND SEED

Engineering properties of agricultural produce are generally useful in the design and development of farm machinery/post harvest machine. Prior to the development of pulp extractor, various engineering properties of bitter gourd and its pulp were studied. Physical properties viz. length, width and thickness of the seed, diameter of the seed , weight of the seed, colour of pulp , sphericity, roundness , water activity , pH and moisture content were determined as per standard procedures.

### 3.2.1 Length, width and thickness

Length, width and thickness of the seed were calculated using a digital vernier caliper . The dimensions are expressed in mm.

### 3.2.2 Bulk density of bitter gourd pulp

Bulk density ($\rho b$) of bitter gourd pulp was measured by following the procedure reported by Himjyoti (2016). Bitter gourd pulp was filled in a measuring cylinder up to a known volume and the top level was adjusted by gentle tapping. The weight of the filled pulp was determined and bulk density was calculated using the equation given below.

Bulk density of pulp (g/cm³) = $\frac{mass\ of\ the\ pulp}{volume\ occupied}$ ..........3.1

### 3.2.3 Bulk density of bitter gourd seed

Bulk density is the ratio of grain mass to the volume of the sample container**.** It is found by using the following procedure.Bitter gourd seeds was filled in a measuring cylinder up to a known volume and the top level was adjusted by gentle tapping. The weight of the filled seeda was determined and bulk density was calculated using the equation given below.

### 3.2.4 True density of bitter gourd seed

True density in $g/cm^3$ is defined as the ratio of the weight of the sample to its true volume. It was determined by the toluene displacement method. Bitter gourd seed of known weight was dipped in a known volume of toluene taken in a measuring cylinder. To release any possible air gap present in the seed, the cylinder was gently agitated. The volume of toluene displaced by the seed was then recorded.

$$\text{True density of seed } (g/cm^3) = \frac{mass\ of\ the\ seed}{volume\ of\ the\ seed} \quad ...........3.2$$

### 3.2.5 Porosity of bitter gourd seed

Porosity is the ratio of the difference in true density and bulk density to the true density value of seed and it is expressed in percentage.

$$\text{Porosity} = \frac{true\ density - bulk\ density}{true\ density} \quad ............3.3$$

### 3.2.6 Roundness

Roundness is a measure of sharpness of the solid material. The roundness and roundness ratio were found out using the following equation (Singh and sahay, 2015).

$$\text{Roundness} = \frac{\text{largest projected area of particle when it is in natura lrest position ,AP}}{\text{area of smallest circumscribing circle ,AC}} \quad .....3.4$$

Roundness ratio = $\frac{\text{radius of curvature of the sharpestcorner}}{\text{mean radius of the particle,R}}$ .........3.5

### 3.2.7 Sphericity

Sphericity may be defined as a ratio of the diameter of the sphere of the same volume as that of the particle and the diameter of the smallest circumscribing sphere or generally the largest diameter of the particle. The sphericity of bitter gourd pulp was found out using the following equation (Singh and sahay, 2015)

Sphericity = $\frac{\sqrt[3]{L.W.T}}{L}$ ................3.6

L=length of bitter gourd seed

W= width of bitter gourd seed

T = thickness of bitter gourd seed

### 3.2.8 Water activity

Water activity is a fundamental property of aqueous solution and by definition is the ratio of the vapour pressure of the water in the substrate to that of pure water at the same temperature . the bitter gourd pulp was determined using water activity meter (M/s. Aqua lab, Decagon Devices Inc., Pullman (Wa), USA) (Perez-Tinoco *et al.*, 2008).The instrument has a water activity measuring range of 0.030 to 1.000 aw .

Turn the sample drawer knob to the open or load position and pull the drawer open. Place the prepared sample in the drawer. Check the top lid of the cup to make sure it is free from sample residue carefully slide the drawer closed. Turn the sample drawer knob to read the position to seal the sample cup with the chamber. The obtained result was displayed in the screen. The experiment was repeated for three times and mean value was noted.

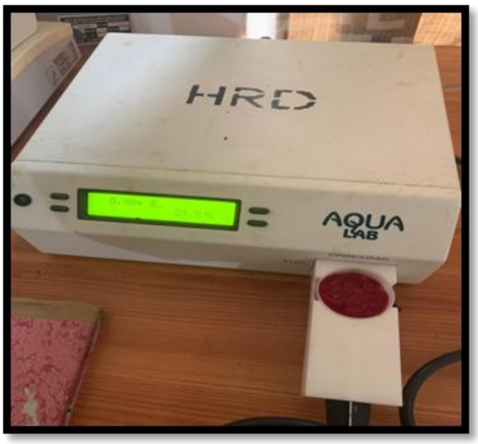




**Plate 3.2. Water activity meter** **Plate 3.3. Toluene displacement method**

**Plate 3.4. Infrared moisture meter**

### 3.2.9 Moisture content of seed

Moisture content of bitter gourd seeds was determined as per A0AC (2005) method. 4-5 seeds of bitter gourd seeds was taken into petri dishes and weighed. After weighing, the samples were placed in the hot air oven at 105℃ and dried to constant weight, which took about 30-40min. The moisture content of the bitter gourd seed was expressed as percentage wet basis (%w.b). The percentage of moisture constant was determined by the following equation.

Moisture content (%wb) = $\frac{Wi - Wf}{Wi} \times 100$ .................3.7

Where

$W_i$ – initial weight of bitter gourd seeds, g

$W_f$ - dry weight of bitter gourd seeds, g

## 3.3 DEVELOPMENT OF BITTER GOURD PULP EXTRACTOR

Fabrication of bitter gourd pulp extractor was carried out in the Department of Processing and Food Engineering workshop of Kelappaji College of Agricultural Engineering and Technology, Tavanur. Food grade stainless steel material (SS-304) was selected for the fabrication of the machine. The developed machine consists of a) cylindrical sieve b) outer cylinder c) scrapper d)discharge outlet e) motor and variable frequency drive f) frame assembly

### 3.3.1 Cylindrical sieve

This is the main component as well as the working part of the bitter gourd pulp extractor. It consists of a perforated stainless steel (SS 304 grade) cylindrical chamber. It was fabricated using stainless steel perforated sheet welded in the form of cylindrical shape. The bottom side of the cylindrical chamber also made with perforated SS sheet for the easy draining of pulp. The height, inner diameter and outer diameter of the chamber was 26.4 cm, 18.2 cm and 20.5 cm, respectively.

### 3.3.2 Outer Cylinder

It was made of stainless steel sheet of 3.4 grade having 1.5 mm thickness .The top of the chamber was covered using stainless steel lid.

### 3.3.3 Scrapper

It is attached to the outer surface of strainer having a rubber lining on the top and bottom of the scrapper. The purpose of this is to wipe down the pulp which gets stuck to the cylinder.

### 3.3.4 Discharge outlet

The pulp outlet was attached to the pulp collection compartment available under the cylindrical sieve for pulp collection. It is situated below the cylinder having a width of 9.5 cm and length of 23.3 cm.

### 3.3.5 Motor and variable frequency drive

The power unit consists of a 1 hp electric motor with belts and pulleys. The pulley that is mounted on the shaft of available motor provides necessary power to the belt. The rpm of the motor could be varied using a variable frequency drive. VFD is a type of drive used in electro-mechanical drive system to control AC motor speed and torque by varying motor input frequency and voltage .

### 3.3.6 Frame assembly

The frame assembly was fabricated from stainless steel. These parts provide support for both pulp extractor and the electric motor. The frame also provides rigidity when the machine is in operation.

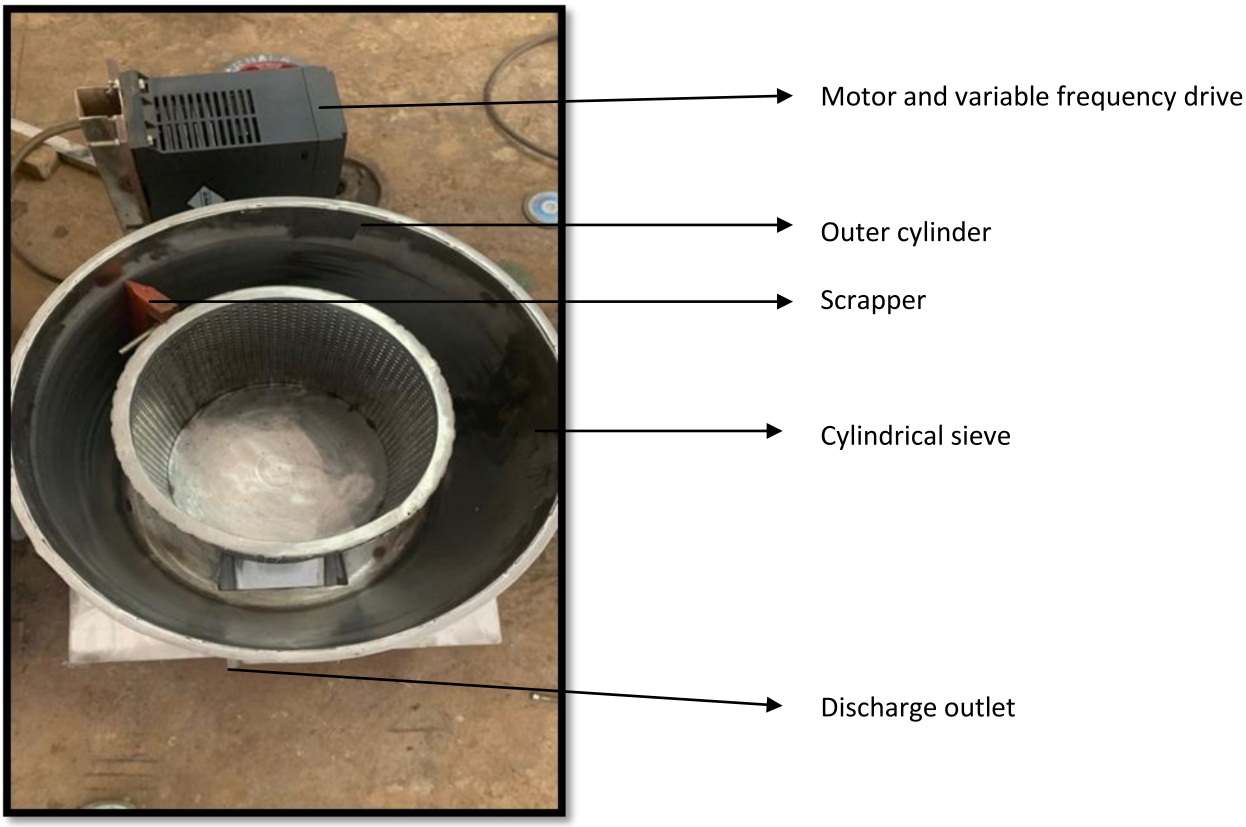



**Plate 3.5. Bitter gourd pulp extractor**

## 3.4 OPERATIONAL PROCEDURE

Fully ripened freshly harvested bitter gourds were selected for this study. Bitter gourd pulp along with seeds was removed manually and was fed into the perforated inner cylinder of the machine upto three fourth volume. The top side of outer cylinder was properly covered with stainless steel lid. Testing was done at three different frequencies (25Hz, 27Hz, and 30Hz) and at three different time durations (1min, 2min, 3min). The basic principle of extractor is centrifugation and abrasive effect. With this effect, the seeds are separated from the pulp and the pulp is collected at the outlet.

## 3.5 PERFORMANCE EVALUATION OF BITTER GOURD PULP EXTRACTOR

### 3.5.1 Experimental Design

The independent and dependent variables considered in the study are given below.

#### *3.5.1.1 Independent variables*

Time of extraction and frequency of rotation were taken as independent variables. Design expert software (version 12) was used for the optimization of process variables. 13 tests were conducted with various combinations of time (3 levels) and frequency (3 levels).

a) Time of extraction (min)

- $t_1$ = 1 min
- $t_2$ = 3 min
- $t_3$ = 5 min

b) Frequency of rotation (Hz)

- $F_1$=25 Hz
- $F_2$= 27 Hz
- $F_3$=30 Hz

#### *3.5.1.2. Dependent variables*

Extraction efficiency, percentage seed damage and seed viability were taken as dependent variables.

**a) Extraction efficiency**

Extraction efficiency is the ratio of the pulp extracted by the machine to the sum of pulp extracted by machine and remaining pulp extracted manually which is expressed in percentage. The extraction efficiency will directly depend on the independent parameters .

**Extraction efficiency(%)=** $\frac{\text{pulp extracted by machine}}{\text{pulp extracted by machine+remaining pulp extracted manually}}$ 100 ...3.8

**b) Percentage seed damage**

Percentage seed damage is the ratio of number of damaged seeds to the total number of seeds fed in the machine which is expressed in percentage.

Percentage seed damage (%) $=\frac{\text{number of damaged seeds}}{\text{total number of seeds}}\times 100$ ......3.9

**c) Seed viability**

Seed viability determines the percentage of seeds that are alive in any seed lot. The level of germination in association with seed vigor which provides a very good estimate of the potential field performance. While the speed of germination varies slightly across varieties, seeds should absorb moisture within two days and produce a root and the first leaf within four days. At this point, the seed is considered to have germinated.

Seed viability $= \frac{\text{number of seeds that germinated}}{\text{number of seeds on the tray}} \times 100$ .........3.10

The seed viability test was carried in the department of vegetable science, KAU using a seed germinator. It is a machine used for the germination of different types of seeds in laboratories .These machines are specifically designed growth chambers that create artificial environment (optimum temperature, humidity and light)for germination of seeds .These chambers play an important role in crop production. The seeds were kept in the germinator for about a week and the observations were photographed and are displayed below.

.

**Plate 3.6. Seeds germinated on a pot tray** **Plate 3.7. Seed germinator**

**Plate 3.8. Germination studies using seed germinator**

### 3.5.2Optimization of process parameters of bitter gourd pulp extractor

The process parameters were standardized using RSM method. RSM designs allow estimating interaction and even quadratic effects, and therefore giving us an idea of the (local) shape of the response surface under investigation. Box-Behnken designs and central composite designs are efficient designs for fitting second order polynomials to response surfaces, because they use relatively small number of observations to estimate the parameters. Rateability is a reasonable basis for the selection of a response surface design. The purpose of RSM is optimization and the location of optimum is unknown prior to running the experiment, it makes sense to use a design that provides equal precision of estimation in all directions. For such purposes, Central Composite Design (CCD) - spherical or face centred and Box – Behnken design are the commonly used experimental design models for three level three factor experiments(Joseph et al., 2008). Considering time and frequency as factor 1 and factor 2 respectively, 13 different combinations were obtained using central composite method.

**Table 3.1 Independent variables for optimization**

| **Factor 1**<br>**A: Time (min)** | **Factor 2**<br>**B: Frequency(Hz)** |
|---|---|
| 5.082843 | 27.5 |
| 3 | 27.5 |
| 3 | 27.5 |
| 3 | 31.0355 |
| 3 | 27.5 |
| 5 | 30 |
| 3 | 27.5 |
| 5 | 25 |
| 3 | 27.5 |
| 1 | 25 |
| 1 | 30 |
| 3 | 23.9645 |
| 0.171573 | 27.5 |

# ***RESULTS AND DISCUSSION***

# CHAPTER IV

# RESULTS AND DISCUSSION

This chapter deals with the results obtained from various experiments conducted to determine the engineering properties of bitter gourd pulp, fabrication and performance evaluation of bitter gourd pulp extractor and germination studies of bitter gourd seeds recovered after extraction.

## 4.1 ENGINEERING PROPERTIES

The physical properties of bitter gourd pulp/seed viz. length, width, weight, true density, bulk density, porosity, sphericity, roundness, surface area of bitter gourd seeds, water activity and moisture content were studied. The results obtained in the study are shown in the Table 4.1.

**Table 4.1 Engineering properties**

| SL NO | PROPERTY | RANGE | AVERAGE OBSERVED VALUE |
|---|---|---|---|
| 1 | Length | 12.79 – 15.03 mm | 14.81 mm |
| 2 | Width | 6.34 – 9.21 mm | 8.31 mm |
| 3 | Thickness | 3.22 – 5.05 mm | 4.73 mm |
| 4 | True density | 0.714 – 0.771 $g/cm^3$ | 0.75 $g/cm^3$ |
| 5 | Bulk density of pulp | 0.377 – 0.418 $g/cm^3$ | 0.40 $g/cm^3$ |
| 6 | Bulk density of seed | 0.919 – 1.659 $g/cm^3$ | |
| 6 | Porosity | 2.4 – 2.5 | 2.5 |

| | | | |
|---|---|---|---|
| 7 | Sphericity | 1-2 | 1.68 |
| 8 | Geometric mean diameter | 7.47-8.68 | 8.34 |
| 9 | Roundness | 0.2 - .42 | 0.309 |
| 10 | Surface area | 10-12 | 11.6 |
| 11 | Moisture content of pulp | 80-87.5 | 80.49 |
| 12 | Water activity | 0.8-0.95 | 0.934 |

From the experimental analysis, the length of the bitter gourd seed (variety *preeti*) was found to be 12.79 – 15.03 mm and the average length observed was 14.81mm. The width of the bitter gourd seed (variety *preeti*) was found to be 6.34 – 9.21 mm and the average width observed was 8.31 mm. The thickness of the bitter gourd seed (variety *preeti*) was found to be 3.22- 5.05mm and the average thickness observed was 4.73mm. The true density of the bitter gourd seed (variety *preeti*)was found to be 0.714 – 0.771g/cm$^3$ and the average true density observed was 0.75g/cm$^3$. the bulk density of the bitter gourd seed (variety *preeti*) was found to be 0.377 – 0.418g/cm$^3$ and the average bulk density observed was 0.40g/cm$^3$.the porosity of the bitter gourd seed (variety *preeti*)was found to be 2.4-2.5 and the average porosity observed was 2.5. the sphericity of the bitter gourd seed (variety *preeti*) was found to be 1-2 and the average sphericity observed was 1.68.the geometric mean diameter of the bitter gourd seed (variety *preeti*)was found to be 7.47-8.68 and the average geometric mean diameter observed was 8.34.the roundness of the bitter gourd seed (variety *preeti*)was found to be 2 - .42 .and the average roundness observed was .309. the surface area of the bitter gourd seed (variety *preeti*)was found to be 10 – 12 cm$^2$. The average surface area observed was 11. 6 cm$^2$. The moisture content of pulp (variety *preeti*)was found to be 80-87.5% and the average moisture content of pulp was found to be 80.49%.the water activity of pulp (variety *preeti*)was found to be .8 - .95. The observed value of water activity was 0.934 .

## 4.2 DEVELOPMENT OF BITTER GOURD PULP EXTRACTOR

The samples were obtained from KAU Mannuthy, Thrissur. It was cleaned and extracted the ripened pulp along with seeds. It was allowed to ferment for a day. The fermented pulp was fed into the bitter gourd pulp extractor which works on the principle centrifugation and abrasive effect. The major parts of the machine are outer cylinder, cylindrical sieve, stainless steel lid, scrapper, motor and variable frequency drive and frame assembly. Performance evaluation of the machine was conducted on different parameters. The optimization of the parameters was done using the software RSM.

### 4.2.1 Design of experiments

RSM designs allow us to estimate interaction and even quadratic effects, and therefore give us an idea of the (local) shape of the response surface under investigation. Box-Behnken designs and central composite designs are efficient designs for fitting second order polynomials to response surfaces, because they use relatively small number of observations to estimate the parameters. The design layout after specifying the independent and dependent parameters was obtained using the software. About 13 experimental combinations were obtained and its results are given in the table below.

### 4.2.2 Effects of time and frequency of rotation on various dependent parameters

The effects of frequency and time on the considered parameters such as extraction efficiency, seed viability and percentage seed damage were statistically analyzed. 13 experiment combinations were found by using central composite method. The results revealed that both factors had a significant effect on the evaluated parameters. It is shown in the table 4.2. The 3D surfaces of all the responses were obtained using the software is shown below. From the graphs and the results obtained it is understood that the extraction efficiency was maximum at a rotational frequency of 30Hz and time 5 minutes. The independent variable viz. Frequency and time had negligible effects on percentage seed damage (1.6 – 2.9 %). The seed viability was found to be in the range of 87-91 %.

**Table 4.2 Effects of time and frequency of rotation on various dependent parameters**

| **Factor 1 A: time (min)** | **Factor 2 B: Frequency (Hz)** | **Response 1 Yield %** | **Response 2 Seed viability%** | **Response 3 Seed damage%** |
|---|---|---|---|---|
| 1 | 30 | 90 | 92.8 | 2.2 |
| 3 | 27.5 | 88 | 93.5 | 1.9 |
| 3 | 27.5 | 88 | 93.5 | 1.9 |
| 3 | 27.5 | 88 | 93.5 | 1.9 |
| 5 | 30 | 91 | 92 | 2.5 |
| 5 | 25 | 87.6 | 94 | 1.9 |
| 3 | 23.9645 | 86.3 | 95.6 | 1.5 |
| 0.171573 | 27.5 | 87.2 | 90 | 1.8 |
| 3 | 27.5 | 88 | 89 | 1.6 |
| 3 | 31.0355 | 90.5 | 92.3 | 2.3 |
| 1 | 25 | 87 | 94.3 | 1.7 |
| 5.82843 | 27.5 | 89.6 | 93 | 2 |
| 3 | 27.5 | 88 | 93.5 | 1.9 |

#### *4.2.2.1. Extraction efficiency*

The figure 4.1(A) displays the effect of time and frequency on extraction efficiency. It was observed that upon increasing time and frequency, the extraction efficiency was also increasing. The result revealed that both the time and frequency had significant effects on extraction efficiency. The calculation was done using the equation (4.1).

$$\text{Extraction efficiency(\%)} = \frac{\text{pulp extracted by machine}}{\text{acted by machine} + \text{remaining pulp extracted manually}} \times 100 \quad \text{......4.1}$$

The extraction efficiency ranged between 87 -91 %. The maximum of 91 % was obtained for frequency of 30Hz and time of 5 minutes.

#### *4.2.2.2. Seed viability*

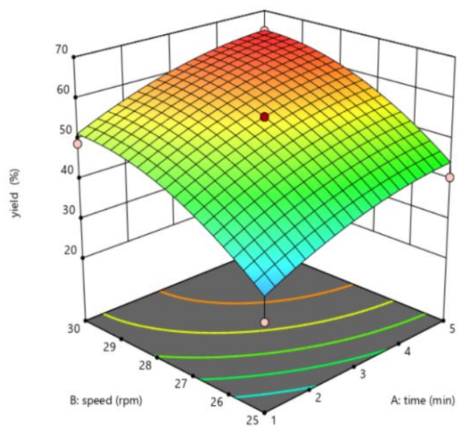
The effect of process parameters on bitter gourd seed viability is shown in the figure 4.1 (B). It was observed that the seed viability decreased with increase in time and frequency of operation. However the results revealed that both the time and frequency had a significant effect on seed viability.

The seed viability ranges between 89 – 95.6%. The maximum viability was observed at the frequency of 25Hz and time 1 minute.

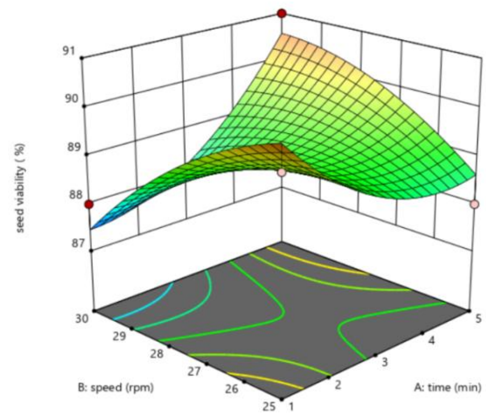
#### *4.2.2.3. Percentage seed damage*

The figure (4.1) displays the effect of time and frequency on the percentage seed damage. It is observed that upon increasing time and frequency the seed damage was increasing. The results revealed that they have a significant effect though the effects were negligible.

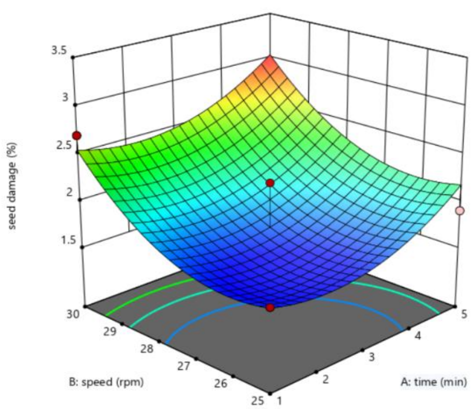
The seed damage ranged between 1.5 – 2%. The minimum damage was observed for frequency of 23 Hz and 1 minute.




(A)




(B)

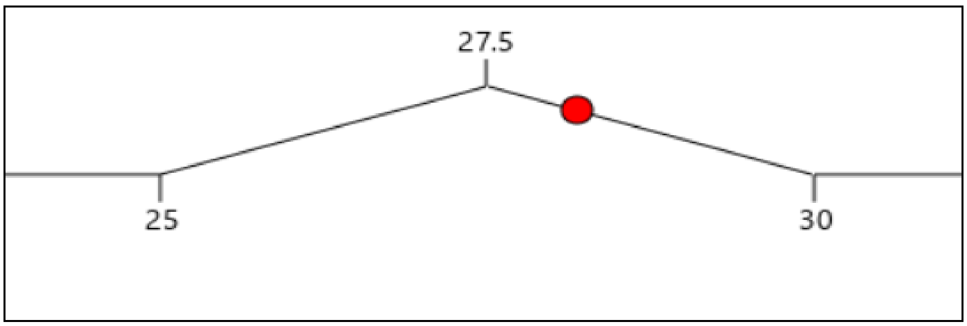



**(C)**

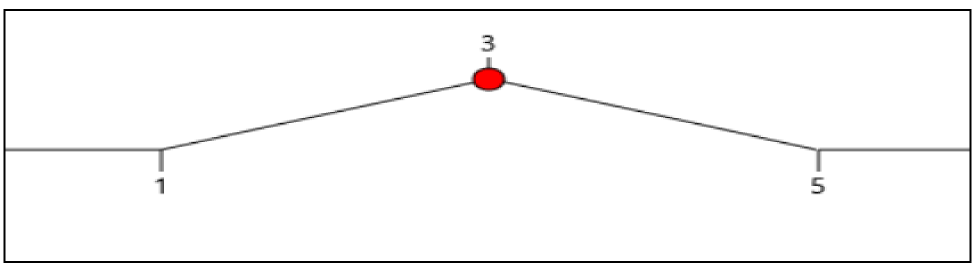
**Fig 4.1. (A) (B) (C) Effects of time and frequency on various dependent parameters during extraction**

### 4.2.3. Optimization of process parameters

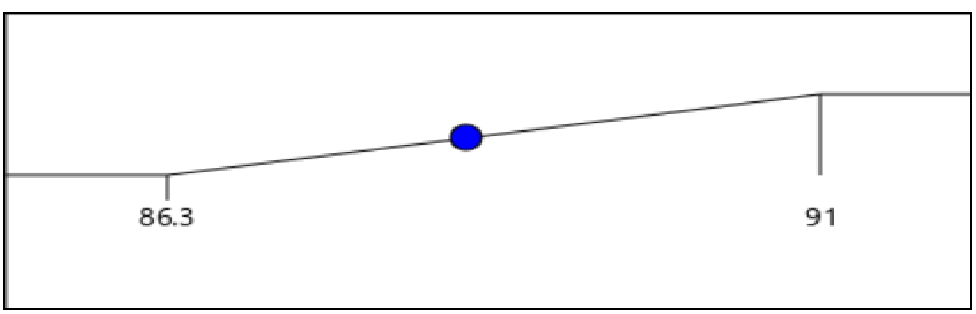
Using the RSM software the parameters were optimized. The optimum frequency attained was 28.19 Hz [figure4.2 (A)]. The optimum time attained was 3 minutes [ figure 4.2 (B)]. The average extraction efficiency attained for the optimum frequency and time was 88.45 % [figure4.2 (C)]. The average seed damage and seed viability of seed extractor were found to be 1.92 % and 92 %, respectively.



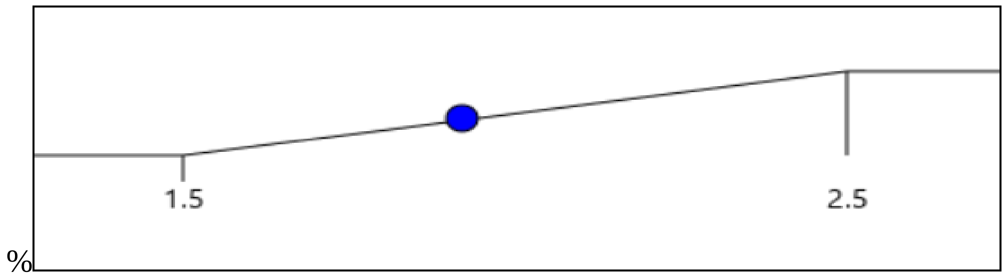

(A)B: Frequency = 28.1978 Hz



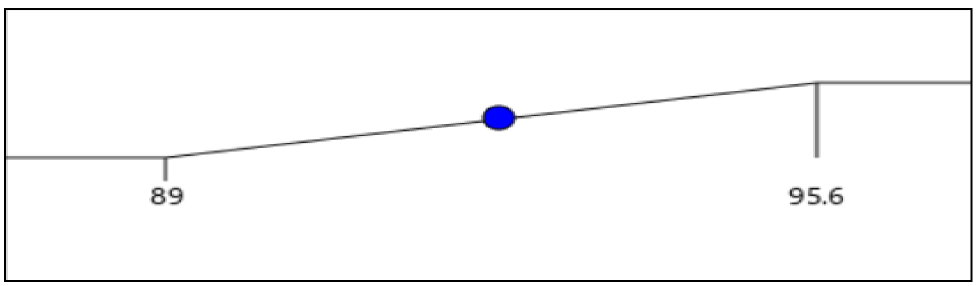

(B) A: time = 3 min




(C) Extraction efficiency = 88.4559




(D) Percentage seed damage = 1.9236%




(E) Seed viability = 92.3789%

**Fig 4.2. Graphical representation of optimization of different parameters**

# *SUMMARYANDCONCLUSION*

# CHAPTER V

## SUMMARY AND CONCLUSION

Bitter gourd, botanically known as *Momordica charantia,* is one of the vegetables belonging to the cucurbitaceae family. It is also known as bitter melon, bitter apple, bitter squash and balsam-pear. It is believed to be orginated in tropical Asia, particularly in the Indo Burma region. Bitter gourd is widely grown in India, Indonesia, Malaysia, China and Tropical Africa. In India, it is grown in the area of 26, 004 ha with an annual production of 1.62 tonnes.(NHB,2022)

Bitter gourd is a well-known medicinal herbal plant with many nutritious benefits, improving the overall health of consumers. It is a good source of fiber, nutrients, moisture, amino acids, beta carotene, vitamin C, vitamin B, folate and minerals such as calcium, sodium, potassium, magnesium, phosphorus, zinc and iron, as well as folic acid, alkaloids, peptides and steroidal saponins. Bitter gourd is rich in antifeedant property. antifeedants as those chemicals that have antifeedant properties at low concentration, and that act on very specific sensory cells (antifeedant receptors) in the pest. The neurons associated with these antifeedant receptors either prevent insect feeding (feeding deterrent effect) or cause cessation or slowing of further feeding (feeding suppressant effect).these properties let to the development of the extractor.

In the present study, bitter gourd pulp extractor was developed and its performance evaluation was carried out based on various engineering properties. The developed bitter gourd pulp extractor consists of cylindrical sieve, outer cylinder, scrapper, discharge unit , power unit , frame and stand . The unit was fabricated using food grade material SS 304, to ensure safety. Bulk quantities of fully ripened freshly harvested bitter gourds were collected. After washing and cleaning the bitter gourds the damaged fruits was discarded. The pulp along with the seeds was introduced into the cylindrical sieve of the machine. When the pulp along with the seed was centrifuged at a specific frequency the denser substance settled at the centre and the lighter substance moved away from the central axis. The seed being the heavier particle got settled down at the bottom of the strainer whereas the pulp being lighter oozed out through the perforations. The extracted pulp was collected through the discharge outlet. The test was done at different frequency and different time.

The optimization was done using RSM software. The method adopted was central composite method. 13 combinations of experiments were conducted for different time and frequency. The results obtained were significant for all the responses. The optimum frequency and time of operation attained were 28.19 Hz and 3 minutes, respectively. The average extraction efficiency of 88.45% was attained for the optimized conditions. The seed damage and seed viability of the pulp extractor were obtained as 1.92% and 92%, respectively.

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# ***APPENDIXES***

# APPENDIX - A

**Table A.1 : Response 1: Extraction efficiency**

**Fit statistics**

| | | | | |
|---|---|---|---|---|
| **Std. Dev.** | 4.00 | | **$R^2$** | 0.9265 |
| **Mean** | 50.83 | | **Adjusted $R^2$** | 0.8740 |
| **C.V. %** | 7.88 | | **Predicted $R^2$** | 0.4774 |
| | | | **Adeq Precision** | 12.5125 |

**Coefficient in terms of coded factors**

| Factor | Coefficient Estimate | df | Standard Error | 95% CI Low | 95% CI High | VIF |
|---|---|---|---|---|---|---|
| Intercept | 55.60 | 1 | 1.79 | 51.37 | 59.83 | |
| A-time | 6.75 | 1 | 1.42 | 3.40 | 10.10 | 1.0000 |
| B-speed | 10.27 | 1 | 1.42 | 6.92 | 13.61 | 1.0000 |
| AB | -0.0500 | 1 | 2.00 | -4.78 | 4.68 | 1.0000 |
| $A^2$ | -2.69 | 1 | 1.52 | -6.28 | 0.8949 | 1.02 |
| $B^2$ | -5.05 | 1 | 1.52 | -8.64 | -1.46 | 1.02 |

**Table A.2 : Response 2 : seed viability**

**Fit statistics**

| | | | | |
|---|---|---|---|---|
| **Std. Dev.** | 0.5724 | | **$R^2$** | 0.8538 |
| **Mean** | 89.18 | | **Adjusted $R^2$** | 0.7493 |
| **C.V. %** | 0.6419 | | **Predicted $R^2$** | -0.0399 |
| | | | **Adeq Precision** | 8.8339 |

**Coefficient in terms of coded factors**

| Factor | Coefficient Estimate | df | Standard Error | 95% CI Low | 95% CI High | VIF |
|---|---|---|---|---|---|---|
| Intercept | 89.00 | 1 | 0.2560 | 88.39 | 89.61 | |
| A-time | 0.3018 | 1 | 0.2024 | -0.1767 | 0.7803 | 1.0000 |
| B-speed | -0.2816 | 1 | 0.2024 | -0.7601 | 0.1969 | 1.0000 |
| AB | 1.25 | 1 | 0.2862 | 0.5733 | 1.93 | 1.0000 |
| $A^2$ | 0.7313 | 1 | 0.2170 | 0.2181 | 1.24 | 1.02 |
| $B^2$ | -0.4437 | 1 | 0.2170 | -0.9569 | 0.0694 | 1.02 |

**Table A.3 : Response 3 : Percentage seed damage**

**Fit statistics**

| | | | | |
|---|---|---|---|---|
| **Std. Dev.** | 4.00 | | **$R^2$** | 0.9265 |
| **Mean** | 50.83 | | **Adjusted $R^2$** | 0.8740 |
| **C.V. %** | 7.88 | | **Predicted $R^2$** | 0.4774 |
| | | | **Adeq Precision** | 12.5125 |

**Coefficient in terms of coded factors**

| Factor | Coefficient Estimate | df | Standard Error | 95% CI Low | 95% CI High | VIF |
|---|---|---|---|---|---|---|
| Intercept | 1.72 | 1 | 0.1229 | 1.43 | 2.01 | |
| A-time | 0.2445 | 1 | 0.0972 | 0.0146 | 0.4743 | 1.0000 |
| B-speed | 0.4268 | 1 | 0.0972 | 0.1969 | 0.6566 | 1.0000 |
| AB | 0.0000 | 1 | 0.1375 | -0.3250 | 0.3250 | 1.0000 |
| $A^2$ | 0.2838 | 1 | 0.1042 | 0.0373 | 0.5302 | 1.02 |
| $B^2$ | 0.3588 | 1 | 0.1042 | 0.1123 | 0.6052 | 1.02 |

# *ABSTRACT*

# ABSTRACT

*Momordica charantia*, commonly known as bitter gourd has been traditionally used in Ayurvedic and Chinese medicine to treat diabetes and its complications. Several medicinal properties of the bitter gourd have been studied such as anti-diabetic, anti-ulcerogenic, antimutagenic, antioxidant, anti-tumour, anti lipolytic, analgesic, abortifacient, anti-viral, hypoglycemic and immunomodulatory. In vitro studies reveals that the bitter gourd proteins (α-and β-monorcharin) have inhibitory effect against HIV virus. A large number of value added products can be prepared from bitter gourd like bitter gourd juice, pickle, dried rings, chips, etc. The physical properties of bitter gourd relevant to design and develop a bitter gourd pulp extractor were determined. The developed bitter gourd pulp extractor consists of cylindrical sieve, outer cylinder , scrapper , discharge unit , power unit , frame and stand. The machine was fabricated using food grade material SS 304, to ensure safety. Bulk quantities of fully ripened freshly harvested bitter gourds were collected. After washing and cleaning, the bitter gourds were subjected to pulping process. The crushed pulp along with seeds was introduced into the cylindrical sieve of the machine. The basic principle behind this extractor is centrifugation and abrasive effect. When the pulp along with the seed was centrifuged at a specific frequency the denser substance got settled at the centre and the lighter substance moved away from the central axis. The seed being the heavier particle got settled down at the bottom of the strainer whereas the pulp being lighter oozed out through the perforations. The extracted pulp was collected through the discharge outlet. The test was done at different frequency and different time. The optimization was done using RSM software. The method adopted was central composite. 13 combinations of experiments were conducted for different time and frequency. The results obtained were significant for all the responses. The optimum frequency and time of operation attained were 28.19 Hz and 3 minutes, respectively. The average extraction efficiency of 88.45% was attained for the optimized conditions. The seed damage and seed viability of the pulp extractor were obtained as 1.92% and 92%, respectively.