STUDY ON EFFECT OF PARTICLE SIZE OF JACKFRUIT SEED FLOUR IN BAKING

A Thesis submitted to the

DR. BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH
DAPOLI – 415712.
Maharashtra State (India)

In the partial fulfillment of the requirements for the degree

of

MASTER OF TECHNOLOGY

(AGRICULTURAL ENGINEERING)

in

PROCESSING AND FOOD ENGINEERING

by

BARGE KIRAN RAVINDRA
(Reg. No. ENDPM-2016/0101)
B.Tech (Agril. Engg.)

DEPARTMENT OF AGRICULTURAL PROCESS ENGINEERING
COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
DR. BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH
DAPOLI – 415712. DIST. – RATNAGIRI. M.S. (INDIA)

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Submitted by
Barge Kiran Ravindra

Approved by

(S. P. Divekar)
Assistant Professor, Dept. of APE
(Chairman and Research Guide)

(S. P. Sonawane)
Professor and Head, Dept. of APE

(Y. P. Khandetod)
Dean,
Faculty of Agricultural Engineering

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June 2018

CANDIDATE'S DECLARATION

I hereby declare that this thesis entitled "Study on Effect Of Particle Size Of Jackfruit Seed Flour In Baking" or part there of has not been submitted by me or any other person to this university or any other University or Institute for any Degree or Diploma.

……..

Place: CAET, Dapoli
Date:

(Barge K. R.)
(Reg. No. ENDPM 2016/0101)

Dr. S. P. Divekar
M.Tech. (IIT), Ph. D. (IARI)

Chairman and Research Guide,
Assistant Professor,
Department of Agricultural Process Engineering,
College of Agricultural Engineering and Technology,
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth,
Dapoli – 415712, Dist. – Ratnagiri. (M. S.)

CERTIFICATE

This is to certify that the thesis entitled, **"STUDY ON EFFECT OF PARTICLE SIZE OF JACKFRUIT SEED FLOUR IN BAKING"** submitted to the Faculty of Agricultural Engineering, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (Maharashtra State) in partial fulfillment of the requirement of award of degree of **Master of Technology (Agricultural Engineering)** in **Processing and Food Engineering,** embodies the result of piece of bonafied research work carried out by **Ms. Barge Kiran Ravindra (**Reg. No.: ENDPM 2016/0101) under my guidance and supervision. The result embodies in this project report has not been submitted to any other university or institute for the award of any degree or diploma.

The assistance and help received during the course of this project work and sources of the literature have been duly acknowledged.

……

Place: CAET, Dapoli **(S. P. Divekar) Date :**
Research Guide

Dr. S. P. Sonawane
M.E. (Ag) in PFE, Ph. D. (PFE)

Professor and Head,
Department of Agricultural Process Engineering,
College of Agricultural Engineering and Technology,
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth,
Dapoli –415712, Dist. –Ratnagiri. (M. S.)

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The assistance and help received during the course of this project work and sources of the literature have been duly acknowledged.

…….

Place: CAET, Dapoli
Date:

(S. P. Sonawane)
Professor and Head
Department of Agricultural Process Engineering

Dr. Y. P. Khandetod
B.Tech. (Agril. Engg.), M. Tech. (P.H.E.), Ph.D. (AGFE)

Dean
Faculty of Agricultural Engineering,
College of Agricultural Engineering and Technology,
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth,
Dapoli- 415 712, Dist. Ratnagiri,
Maharashtra, India

CERTIFICATE

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The assistance and help received during the course of this investigation and source of the literatures have been duly acknowledged.

……..……

(Y. P. Khandetod)

Dean,

Faculty of Agricultural Engineering

Place: CAET, Dapoli.
Date:

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Place: CAET, Dapoli.

Date: (**Barge K. R.)**

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LIST OF SYMBOLS

%	per cent
±	Plus minus
°C	Degree Celsius
×	Multiplication
/	Divided by
=	Equal to

LIST OF ABBREVIATIONS

APE	Agricultural Process Engineering
CAET	College of Agricultural Engineering and Technology
DBSKKV	Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth
Dept.	Department
Engg.	Engineering
et al.	and others
etc.	et cetera
Fig.	Figure
MT/ha	Million tonnes per hectare
Ha	Hectare
Min	Minute
H	Hour
i.e.	That is
Kg	Kilogram
M.C.	Moisture content
N	Newton
G	Gram
Mg	Milligram
Ca	Calcium
K	Potassium
Na	Sodium
Mg	Magnesium
P	Phosphorous
Wt.	Weight
Ml	Milliliter
w.b.	Wet basis
d.b.	Dry basis
kg/m^3	Kilogram per cubic meter
m/s	Meter per second
Cm	Centimeter

g/cm^3	Gram per cubic centimeter
mm^2	Millimeter square
Mm	Millimeter
N	Newton
^{o}	Degree
kg/h	Kilogram per hour
Rpm	Revolution per minute
KN/m^2	Kilo newton per square meter
g/100 g	Gram per 100 gram

ABSTRACT

STUDY ON EFFECT OF PARTICLE SIZE OF JACKFRUIT SEED FLOUR IN BAKING

by

Barge Kiran Ravindra

College of Agricultural Engineering and Technology,
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli
Dist. - Ratnagiri, Maharashtra.
2017

Research Guide : Dr. S. P. Divekar
Department : Agricultural Process Engineering

Jackfruit (*Artocarpus heterophyllus Lam.)* is one of the evergreen tree of family *moraceae* from tropical areas and widely grown in Asia. India has annual production of jackfruit as 1.436 million tons from an area of 0.102 million hectors (Baruah, 2014). On an average, in ripe jackfruit, the bulb, seeds and rind form 29 %, 12 % and 59 % respectively (Jagadeesh *et al.*, 2007). The jackfruit seed contains moisture 61.8 % (wb), protein 11.85 %, fiber 3.19 % and carbohydrate 26.20 %. The calorific value of jackfruit seed is 382.79 kcal/100g. It contains ash and fat as 0.15 % and 1.006 % respectively (Gupta *et al.,* 2011). The Jackfruit seed flour contains an appreciable value of calcium 308.7 mg/100g, Iron 13.07 mg/100g, potassium 1478.1 mg/100g, sodium 6.066 mg/100g, copper 1.045 mg/100g and manganese 0.112 mg/100g.

Jackfruit seeds are a good source of starch (22%) and fiber (3.19%). Extract from jackfruit seed helps in digestion. (Swami *et al*., 2012). The jackfruit seed flour may also be blended with wheat flour to explore the potential of low cost flour from jackfruit seed as an alternative raw material for bakery products like biscuit and cake (Chowdhury *et al.,* 2012).

In this research the effect of concentration of jackfruit seed flour on biscuit and cake and influence of particle size of jackfruit seed flour on biscuit and cake were studied. Effect of concentration of jackfruit seed flour on biscuit and cake were determined by using sensory evaluation. The overall acceptability for biscuits and cake obtained using 20% jackfruit seed flour and 80% refined wheat flour was more compared to other treatment combinations. Influence of jackfruit seed flour particle size on baked product determined

using physical, textural, colour and sensory properties. In physical properties of biscuit the thickness, diameter and spread ratio were determined while for cake weight, volume, specific volume, density, volume index, symmetry index and uniformity index were determined. The textural analysis of baked products were done by using Universal Testing Machine. The colour analysis was measured by using Colour Scanning Machine.

The biscuit with 20% jackfruit seed flour and 80% refined wheat flour with flour particle size of 0.77 mm gave highest sensory scores among all the treatments. The cake with 20% jackfruit seed flour and 80% refined wheat flour with flour particle size of 0.73 mm get highest sensory scores among all the treatment combinations. The biscuit prepared with 20% jackfruit seed flour and 80% refined wheat flour with jackfruit seed flour particle size as 0.77 mm was the best among all the treatment combinations. The cake prepared with 20% jackfruit seed flour and 80% refined wheat flour with jackfruit seed flour particle size as 0.73 mm was found better among all the treatment combinations.

I. INTRODUCTION

Jackfruit (*Artocarpus heterophyllus Lam.)* is one of the evergreen trees of family *moraceae* from tropical areas and widely grown in Asia. India has annual production of jackfruit as 1.436 million tons from an area of 0.102 million hectors (Baruah, 2014). It is widely cultivated in southwestern part of India viz., Goa, Kerala, Tamil Nadu, Karnataka and Maharashtra (Arora and Parle, 2016). India is the second largest producer of jackfruit in the world (Nandkule *et al.,* 2015). Jackfruit is commonly referred to as "Poor Man's Food" (Goswami *et al.,* 2011). The ripe fruit contains flavourful yellow colour bulbs with sweet taste and bulbs contain seed. On an average, in ripe jackfruit, the bulb, seeds and rind form 29 %, 12 % and 59 % respectively (Jagadeesh *et al.,* 2007). Jackfruit contain more protein, calcium, iron, vitamins and other essential nutrients compared to other fruits (Vazhacharickal *et al.,* 2015).

Jackfruit is a composite or multiple fruit (syncarp). It is reported to consist of three regions: the fruit axis, the persistent perianth and the true fruit (Ong *et al*., 2006). The perianth, which constitutes the major bulk of the fruit, comprises a central core, a seed bearing region and the aril (together known as bulbs) and the outer layer in the form of a horny non-edible region. Each seed is covered with a fleshy aril which is golden-yellow in colour and has a strong, sweetish taste. The central fibrous core holds the heavy fruit together. The maximum weight of the fruit is reported to be 50 kg (Morton, 1987). The fruits take 90–180 days to reach maturity (Elevitch and Manner, 2006).

Jackfruit also referred as "nutrients of giants". In general 100 g of raw jackfruit carpel contain 84 g water, 9.4 g of carbohydrate, 3 g of fat and 206 g of protein (Singh *et al.,* 2015). The leaves and stem barks of jackfruit tree have been used to treat anaemia, asthma, dermatosis, diarrhoea, cough (Maia *et al.,* 2004). The seed is 20-40 mm in length and 15-25 mm in diameter. Up to 500 seeds can be found in a single fruit (Islam *et al.,* 2015). The jackfruit is considered to be underutilized fruit where most of the fruit get wasted due to ignorance, lack of post-harvest technology and gap in supply chain system (Vazhacharickal *et al.,* 2015).

The jackfruit seed contains moisture 61.8 % (wb), protein 11.85 %, fiber 3.19 % and carbohydrate 26.20 %. The calorific value of jackfruit seed is 382.79 kcal/100g. It contains ash and fat as 0.15 % and 1.006 % respectively (Gupta *et al.,* 2011). The Jackfruit seed flour contains an appreciable value of calcium 308.7 mg/100g, Iron 13.07 mg/100g, potassium 1478.1 mg/100g, sodium 6.066 mg/100g, copper 1.045 mg/100g and manganese 0.112

mg/100g. The jackfruit seed flour has water absorption capacity 25 %, fat absorption capacity 17.0 % and bulk density 0.80 g/cm^3 (Ocloo *et al*., 2010). Jackfruit seed contains (54 mg/100g) magnesium elements. Jackfruit seed is nutritionally important in the absorption of calcium which help to strengthen the bone and prevents bone-related disorders such as osteoporosis. Seeds also contain 2 lectins namely jacalin and artocarpin. Jackfruit seeds are a good source of starch (22%) and fiber (3.19%). Extract from jackfruit seed helps in digestion. (Swami *et al*., 2012).

Jackfruit seed can be converted into flour and to be used as a protein and carbohydrate supplement in diets or can also used as a functional agent in a variety of formulated foods in bakery product (Otegbayo *et al*., 2013). The flour has good ability to bind water and lipid. (Swami *et al.,* 2012).

Seeds are either discarded or steamed and eaten as a snack or some time seeds are used in some local dishes preparation (Tulyathan *et al*., 2002). As stored seeds are recalcitrant, they germinate immediately after maturity. Therefore, fresh seeds cannot be stored for long time. If seeds are dried to the safe storage moisture content, it can be preserved for longer duration. The seed flour can be an alternative product to be used in some food stuffs such as white bread, cake, extruded product and it can also used as thickening and stabilizing agent. The seed flour can be an alternative intermediatory product, which can be stored and utilized both for value addition and to blend with other grain flours without affecting the functional and sensory profile of the final product (Butool and Butool, 2013). The jackfruit seed flour may also be blended with wheat flour to explore the potential of low cost flour from jackfruit seed as an alternative raw material for bakery products (Chowdhury *et al.,* 2012). It is estimated that about 70% of jackfruit goes waste (Saxena *et al.,* 2011). As jackfruit seed is good source of protein, carbohydrate, fibre, minerals and it goes waste along with the fruit. If the seed is used for value addition, it could be an additional source of income to the food processors and farmers. By considering the importance of jackfruit seed a research was planned and undertaken with following objectives.

Objectives

1. To study the influence of jackfruit seed flour in baked product.
2. To determine sensory properties of biscuit and cake.

II. REVIEW OF LITERATURE

This chapter contains literature regarding importance of jackfruit seed, physical properties of seeds, drying of seed, nutritional and functional properties of jackfruit seed flour and value added product from jackfruit seed flour.

2.1 Jackfruit

Jagadeesh *et al*., (2007) determined chemical composition of jackfruit. Chemical composition of bulbs from 24 different firm-type jackfruit clones was analysed to study the variability. These jackfruits were selected for dessert purposes through an extensive survey in western Ghats, part of India, presumably the centre for origin and diversity of jackfruit. A wide variation in the TSS, acidity, TSS : acid ratio, sugars, starch and carotenoid contents was observed in the bulbs of jackfruit types considered in the present investigation. The results of the study are helpful for attempting crop improvement and selection of superior desirable jackfruit genotypes for bringing to cultivation.

Saxena *et al.,* (2011) studied the important features of jackfruit composition, growth, maturation and harvest. Postharvest handling methodology concentrates on the normal packhouse unit operations with emphasis on packaging of bulbs as a unit package for retail marketing. The chapter further describes various value added products developed from jackfruit such as minimally processed, dehydrated, frozen and canned bulbs as well as ready-to-serve beverages, fruit bars and curry. The various by-products from seeds, unfertilized floral parts, and the outer perianth are also discussed. These products include starch from the seeds, leather-like products from unfertilized fl oral parts and pectin from the outer perianth portion. Finally, future requirements for improving the commercial utility of jackfruit are also highlighted.

Swami *et al*., (2012) studied the functional components of jackfruit related to human health. Jackfruit contains Jackfruit contains vitamin A, vitamin C, thiamin, riboflavin, calcium, potassium, iron, sodium, zinc, and niacin among many other nutrients. Jackfruit has a low caloric content: 100 g of jackfruit only contains 94 calories. Jackfruit is a rich source of potassium with 303 mg found in 100 g of jackfruit. Studies show that food rich in potassium helps to lower blood pressure. Another benefit of eating jackfruit is that it is a good source of vitamin C. The health benefits of vitamin C are that it is an antioxidant that protects the body against free radicals, strengthens the immune system, and keeps our gums healthy. Jackfruit contains phytonutrients: lignans, isoflavones, and saponins that have health benefits

that are wide ranging. These phytonutrients have anticancer, antihypertensive, antiulcer and antiaging properties. The phytonutrients found in jackfruit, therefore, can prevent forming of cancer cells in the body, can lower blood pressure, can fight against stomach ulcers, and can slow down the degeneration of cells that make the skin look young and vitae. Jackfruit also contains niacin that is known as vitamin B_3 and necessary for energy metabolism, nerve function, and the synthesis of certain hormones. A portion of 100 g of jackfruit pulp provides 4 mg niacin.

Total phenolic content in jackfruit is 0.36 mg GAE/100 g DW [milligrams of Gallic acid equivalent per gram of dry weight]. Jackfruit possesses high nutritional value; every 100 g of ripe fruit pulp contains 18.9 g carbohydrate, 1.9 g protein, 0.1 g fat, 77% moisture, 1.1 g fiber, 0.8 g total mineral matter, 20 mg calcium, 30 mg phosphorus, 500 mg iron, 540 I.U. vitamin A, 30 mg thiamin, and 84 calories . The jackfruit also contains useful antioxidant compounds.

Gokhale *et al.,* (2015) evaluated antioxidant potential of jackfruit (artocarpus heterophyllus lam). *Artocarpus heterophyllus* Lam. (Jackfruit) is one of the important horticultural crop of Konkan region of Maharashtra. It has medicinal potential. The leaves of the species are routinely used in local Ayurvedic preparations. Flour is prepared from the bulbs and seeds. It is considered as poor man's food. It is used in preparation of number of dishes. During the present work methanolic extracts of mature and senescent leaves as well as flour of bulbs and seeds were separately evaluated for their antioxidant potential.

Vazhacharickal *et al.,* (2015) reviewed the chemical and medicinal properties of jackfruit. They reviewed that jackfruit (Artocarpus heterophyllus) is commonly grown in home gardens of tropical and subtropical countries. The fruit provide 2 MJ per kg/wet weight of ripe perianth and contain high levels of carbohydrates, protein, starch, calcium and vitamins. Jackfruit has diverse medicinal uses especially antioxidant, anti-inflammatory, antimicrobial, anti-cancer and anti-fungal activity. Jackfruit is considered to be an underutilized fruit where most of the fruits get wasted due to ignorance, lack of post harvest technology and gaps in supply chain systems. Jackfruit contains more protein, calcium, iron, vitamins and other essential nutrients when compared to the common fruits. A wide gap in the marketing of jack fruits and its processed value added products which can be fully explored for additional income as well as food security. Encouragements should be done to the marketing as well as value added food products from this underutilized fruit tree.

Arora and Parle, (2016) studied the geographical distribution of jackfruit and cultivation of jackfruit. Jackfruit is cultivated in tropical, subtropical and temperate region of

the world. It is cultivated in Bangladesh, Malaysia, Burma, Srilanka, Indonesia, in parts of USA, Brazil, Pacific islands, Palau. In India it is widely cultivated in south western parts of India such as Goa, Kerala, Tamil Nadu, Karnataka and Maharashtra. The hot and humid regions of Asia are suitable for growth of jackfruit tree. Jackfruit tree grow well in low land forest up to height 250m (830feet). It thrives best in moist tropical environment below 1000m (3300feet). The tree can grow in light and medium textured soils and tree tolerate moderately acid to neutral soil (ph 5.0-7.5). Annual rainfall of about 1000-2400mm is ideal for growth of the jackfruit tree. The jackfruit tree are effectively irrigated by use of drip irrigation system. The fruit of jackfruit mature 3 to 8 months from flowering. Jackfruit can be stored at 85-90% relative humidity and at 11-13^{0}C.

2.2 Jackfruit seeds

Akhinmutimi (2006) studied the nutritive value of raw and heat processed jackfruit seeds using proximate composition, gross energy, mineral composition and anti-nutritional factors. The raw seed was cooked for 20, 40, 60 min duration. Both raw and processed seed were later dried, milled and chemically analyzed. They resulted that the raw seeds had value significantly higher than roasted seeds with the exception of dry matter for all the parameters considered for proximate analysis and energy content. Seed cooked at 60 min period is most recommended to destroy anti-nutritional factors.

Ocloo *et al*., (2010) determined the physico-chemical and functional properties of jackfruit seed flour. The fruits were cut and the seeds were removed, sliced, dried at 60 °C for 24 hours and milled using hammer mill to pass through a 250 μm sieve, packaged in polyethylene bag and kept in a refrigerator. The chemical properties of jackfruit seed flour reported by Ocloo *et al*., (2010) is given in Table 2.1. Table 2.2 shows the functional properties of Jackfruit seed flour.

They concluded that the flour produced from seed may be used as thickening and binding agent in food systems. Jackfruit seed flour has a lot of potential in the food industry, especially its use as thickener and binding agent in the food systems.

Table 2.1 Chemical properties of jackfruit seed flour

Sr.No.	Properties	Value
1	Moisture content (% wb)	6.09
2	Protein (%)	13.50

3	Fat (%)	1.27
4	Fibre (%)	3.19
5	Carbohydrate (%)	79.34
6	Ash content (%)	2.70
7	Calorific value (kcal/100g)	382.79
8	Potassium (mg/100g)	1478.1
9	Calcium (mg/100g)	308.7
10	Iron (mg/100g)	13.07
11	Sodium (mg/100g)	6.06
12	Copper (mg/100g)	1.04
13	Magnese (mg/100g)	0.11
14	Titrable acidity (%)	1.12

(Ocloo *et al*., 2010)

Table 2.2 Functional properties of jackfruit seed flour

Sr.No.	**Properties**	**Value, %**
1	Foam stability	33
2	Foam capacity	25.34
3	Water absorption capacity	25
4	Fat absorption capacity	17
5	Swelling power	4.77

(Ocloo *et al*., 2010)

Goswami *et al.,* (2011) made an attempt to determine the physical properties and chemical composition of three types of jackfruit seeds (Khaja-firm perianth; Ghila-soft and pulpy perianth; Dorasha-partially firm and soft). Seeds were collected from two growing areas of Bangladesh. They resulted that the size, shape, weight and colour of the seeds were varied from type to type. In addition to starch, jackfruit seeds contain substantial amount of minerals, protein, fibre, and sugars. Furthermore, seeds can also be used to prepare bread or dry food in supplementation with other flours like wheat. The proximate composition of jackfruit seeds was varied from type to type without any strong influence of location.

Gupta *et al.,* (2011) studied nutritional, phytochemical and antioxidant activity of jackfruit seed. From this study analysed that jackfruit seeds were found to be rich source of proteins, carbohydrates and minerals with moderate amount of phytochemicals and strong antioxidant properties. The fat content of the seeds was negligible making it a good

constituent of fat free diet. Therefore, jackfruit seeds could be used in balanced diets and functional foods which can be consumed safely without any concern of health risk.

Menaka *et al*., (2011) compared physicochemical properties of jackfruit seed flour and starch, starch was isolated from jackfruit seeds and purified. The jackfruit seed flour and starch were subjected to check out the parameters like organoleptic characteristics, chemical analysis, limit test, physico-chemical analysis and micrometric properties. The chemical composition of seed flour was carbohydrates, polysaccharides, proteins**,** steroids and various amylase, and content of jackfruit seed starch was carbohydrates, polysaccharides and amylases. Angle of repose o f seeds flour and isolated purified starch showed excellent flowability. Bulk and tapped densities showed good packability of starch.

2.3 Jackfruit Seed Flour

Tulyathan *et al.,* (2002) studied some physicochemical properties of jackfruit (Artocarpus heterophyllus Lam) Seed Flour and Starch. Some physicochemical and rheological properties of jackfruit seed flour and starch, isolated from the flour were investigated. The flour had good capacities for water absorption (205%) and oil absorption (93%). Substitution of wheat flour with the seed flour, at the level of 5, 10 and 20% markedly reduced the gluten strength of the mixed dough. The Brabender amylogram (6% concentration, db) of seed starch showed that its pasting temperature was 81 °C and its viscosity was moderate, remained constant during a heating cycle and retrograded slightly on cooling. The starch showed an A-typed X-ray powder diffraction pattern.

Odoemelom *et al.,* (2005) studied functional properties of raw and heat processed Jackfruit flour. They studied functional properties like oil absorption, gelatinization capacity, bulk density, foaming capacity, emulsification capacity and nitrogen solubility. Heat processing of jackfruit seed flour increases water and oil absorption capacity of flour but lowered nitrogen solubility and emulsification capacity. Water and oil absorption capacities were found as 2.3 ml g^{-1} and 2.8 g ml^{-1} respectively. Bulk density of the flour recorded as 0.61 g ml^{-1}. The foam capacity of the flour was noted 7.1 g ml^{-1} and found gradually decreased to 2.00 g ml^{-1} after 120 min. From this study they concluded that heat processing significantly increase functional properties of jackfruit seed flour except foaming capacity and bulk density of the flour.

Hussain *et al.*, (2008) reported roasted and non roasted full fat or partially defatted flaxseed flours and their proximate composition, mineral profile and functional properties. Significant increase was observed in crude protein, crude fibre, ash and mineral contents in the partially defatted flaxseed flours (both roasted and non-roasted). Partial defatting was improved the foam capacity, foam stability and water absorption capacities while roasting decreased the foam stability and capacity of the flours. Mineral profile and proximate composition of the roasted partially defatted flaxseed flours shows that flour can be added in the many types of food applications. Defattening solves the problem of stability while roasting was effective to reduce the anti-nutritional factors like cyanogenic glycosides contents and improved functional properties of the flaxseed.

Nwosu, (2010) studied effect of processing on functional properties of the oze seeds. Wholesome 'oze' (*Bosqueia angolensis*) seeds were given different treatments, which included blanching, cooking, roasting and malting. The samples obtained from these treatments were analysed for their functional properties. They concluded that the 'oze' seed flour samples have reasonable increases in the proximate composition, amino acid profile and most of the functional properties on processing. The high emulsion, oil and water absorption capacities of the malted samples show that 'oze' seed flour can be good as sausage extenders. Further they concluded that the oze seed has both great nutritional and functional values can be used in various food formulations.

Chowdhury *et al.,* (2012) studied on functional properties of raw and blended jackfruit seed flour for food application. They resulted that lye peeled seeds are low in quality but they have better acceptability for colour and flavour. Blended seed flour with wheat flour has good oil and water absorption capacity which can be used in bakery products. There is no appreciable change in bulk density of raw and blended seed flour but foam capacity increases with blending whereas protein solubility increases as pH of flour increases. From this they concluded that jackfruit seed flour has great formulation along with wheat flour, blending could be suggested to use in developing bread as protein supplements.

Munishamanna *et al.,* (2012) developed value added product from jackfruit seed. Jackfruit (*Artocarpus heterophyllus Lam.)* is one of the evergreen trees of family *moraceae* from tropical areas and widely grown in Asia including India. It is widely cultivated in southwestern part of India such as Goa, Kerala, Tamil Nadu, Karnataka and Maharashtra. India is second largest producer of jackfruit in the world. Although seeds are nutritious, rich in protein, carbohydrate, fibre, vitamins, minerals. Therefore attempt was made to process

and utilize jackfruit seeds for preparation of value added products like seed flour, seed flour chapaties and masala vada.

Sultana *et al.*, (2014) developed chapaties enriched with jackfruit seed flour and Bengal gram flour. Jackfruit seed and Bengal gram are rich of nutrients as protein, crude fibre, minerals, etc. To improve the quality of chapaties, jackfruit seed flour and Bengal gram flour is used along with wholemeal wheat flour. The aim of this study were to enrich the quality of chapaties and to check shelf life of chapaties in ambient and refrigerated condition.

Kumari *et al.*, (2015) developed row jackfruit based noodles. Jackfruit bulb and seed subjected to different treatments for preparation of flour. Bulb and seed were standardised for optimum width, blanching, immersion in different media, drying and milling. Composite flour was prepared by mixing refined flour, bulb flour and seed flour in different combination. Noodles were extruded from this combination. Noodles were evaluated by sensory parameters. Sensory scores indicated that noodles prepared from this combination are acceptable. Therefore noodles prepared with jackfruit seed flour were found to be feasible.

Nandkule *et al.,* (2015) developed and evaluated jackfruit seed flour and soy flour noodles. Different levels of refined wheat flour, jackfruit seed flour and soy flour were added in the ratio of 100:00:00, 90:5:5, 80:10:10, 70:15:15, 60:20:20, 70:10:20 and 70:20:10 for the development of noodles and its quality were analysed. The results of study indicated that samples of jackfruit and soy flour had added noodles, for all addition levels contained more protein, fat, fibre and ash as compared to control sample. The noodles developed with addition of jackfruit and soy flour noodle had desirable organoleptic properties as indicated by the taste panel studies. However, based on sensory analysis noodles with (T1) 90:5:5 refined wheat flour, jackfruit seed flour and soy flour were found more acceptable than other levels and optimum for incorporation in refined wheat flour noodles for development of enriched noodles. Noodles was packed in LDPE and stored at room temperature. The storage studies were conducted at the interval of 0-60 days. Protein, fat, crude fibre, was decreased during storage period.

2.4 Particle size distribution

Sonaye and Baxi (2012) studied on particle size measurement and analysis of flour. The present study emphasizes on the measuring the particle size of organic dust (different

types of flour). Sieve analysis technique is used in the present study for estimation of weight percentage of micron sized (light weight and flyable) flour particles.

2.5 Value added products from jackfruit seed flour

Satarkar *et al.,* (2009) workout profability and studied value addition in jackfruit processing. It was observed that of 60 sample jackfruit processors more than 95% households were preparing jackfruit leather and jackfruit chips. At the overall level, per household quantity and value realized in jackfruit processing for leather was 41.38kg and □4669.10 and 98kh and □14452.08, respectively. This revealed that sample household was □10553 of which 18.51% was fixed capital and 81.49% was working capital. Of the total capital investment share of row material was highest (62.16%) followed by labour charges (19.69%). In case of jackfruit leather and jackfruit chips benefits cost ratio were 2.13 and 1.67, respectively at overall level. Net value addition was 262.70% and 303.54% in same order. Thus jackfruit processing was profitable subsidiary business activity for providing gainful employment and income to processing household.

Faridah *et al.,* (2012) developed an acceptable reduced calorie chocolate cake. The range of the independent variables, namely Jackfruit Seed (JFS) flour (20-25% replacement of wheat flour) and polydextrose (10-15% replacement of sucrose) were identified which affect the volume, specific volume, symmetry and uniformity of the chocolate cake. The coefficient of determination, R2 values for volume, specific volume, symmetry and uniformity were greater than 0.900. The optimum level for replacement of sugar with polydextrose was at 11% and wheat flour with JFS flour was at 16% with calorie reduction approximately 34% from the control cake formulation.

Butool *et al.,* (2013) estimated the physical and functional Properties proximate composition, nutritional quality, and utilization of jack seed flour in convenience food. The seeds were lye peeled, dried and milled into flour. The functional properties of the seed flour were analyzed by standard AOAC method. The total yield of the flour was documented as 67.50 grams. The functional properties indicated that the jack seed flour had 104.30 ml/100 g of water absorption and 116.0 ml/10 g of oil absorption capacity the sensory quality of flour based biscuits decreased with increased incorporation level of seed flour. The overall acceptability of biscuits with jack seed flour below 30 was judged as very good. The 20 per cent seed flour incorporated biscuits were on par with control with respect to sensory

qualities. The color of the biscuit indicated that, the control biscuits were significantly whiter than the rest.

Pinki and Pratima (2014) evaluated value added cakes formulated by incorporating beetroot powder. Beetroots *(Beta vulgaris)* are rich in valuable, active compounds such as carotenoids, saponins, folates, betanin, polyphenols and flavonoids. Therefore, beetroot ingestion can be considered a factor in disease prevention. It also contributes to health because has antioxidants called betalains. Beetroot powder (BRP) was incorporated in cakes at 0, 10, 15, 20, and 25 per cent level .The sensory evaluation revealed that 70 per cent of the panelists liked extremely, the cake with 20 per cent BRP incorporation. Sensory evaluation using Score Card method showed that overall acceptability of cake with 20 per cent BRP was 9.15 out of 10 i.e. maximum. Nutritional evaluation of cakes revealed that as the level of BRP incorporation was increased from 0 to 25 per cent in cakes, crude protein, crude fat, crude fibre and total ash increased from 6.10 to12.4%, 23.5 to29.4%, 1.1to7.4%, 3.5to12.1 % respectively.

Islam *et al*., (2015) analysed functional and chemical properties of jackfruit seed. Jackfruit seed flour was utilized in composite flour biscuit. Biscuits were prepared with 10%, 20%, 30% and 40% jackfruit seed flour and were compare with plain biscuit (0% seed flour) based on chemical properties and sensory properties. Proximate analysis showed that Jackfruit seeds contain 15.88% moisture, 2.49% crude fiber, 5.78% protein but low in fat (1.77%). Among functional properties jackfruit seed flour had higher fat absorption capacity (72%) than water absorption capacity (86%). Jackfruit seed flour also showed 33% dispersibility, 2.31% solubility and 1.46 g/g swelling power. Research revealed that the protein and carbohydrate contents of prepared biscuits decreased with higher replacement of jack seed flour. But moisture, fat, crude fiber and ash content increased with higher replacement of jack seed flour. The sensory parameter indicated that up 20% level incorporation biscuits were not significantly different with 0% jackfruit seed flour (plain biscuit) biscuit based on all sensory parameters. But higher level of jackfruit seed flour biscuit rejected by the panellist as it was dark color and hard texture.

2.6 Sensory properties of baked product

Cloke *et al.,* (1984) estimated volume measurements calculated by several methods using cross-sectional tracing of cake. Formulas were based on assumption of cylindrical shape with spherical and symmetrical cap. General trends in treatment differences detected

by any of the methods, but numerical value, specific differences and variability depended on method chosen.

Hefaz (2012) evaluated some physicochemical and sensory properties of cake supplemented with marjoram as partially substituted of flour at different levels (1, 2 and 3 %). The results showed that phenolic compound of marjoram extract in descending order were ellagic, salicylic, pyrogallol and catechol (157.98, 66.55, 43.24 and 23.86 respectively). While the values of marjoram powder of ellagic, p-oh Benzoic and coumarin in descending manner were 62.20, 55.24 and 33.45 (µg/100g), respectively. The peroxide value and thiobarbituric acid in cakes stored at room temperatures for 28 days of storage period under room temperature decreased with increasing marjoram levels. The crust of the control was lighter and more yellow than any of the other cakes. For crumb color, as the level of marjoram powder increased, the L, a, and b values decreased. No differences were found in crump color, texture and over acceptability in sensory evaluation. While in taste and odour there were significant differences in control and other concentrations but still acceptable. Overall, marjoram cake could be developed as a food with more effective antioxidant properties.

Pinki and Pratima, (2012) determined sensory and nutritional evaluation of value added cakes formulated by incorporating beetroot powder. Beetroots (Beta vulgaris) are rich in valuable, active compounds such as carotenoids, saponins, folates, betanin, polyphenols and flavonoids. Therefore, beetroot ingestion can be considered a factor in disease prevention. It also contributes to health because has antioxidants called betalains. Beetroot powder (BRP) was incorporated in cakes at 0, 10, 15, 20, and 25 per cent level .The sensory evaluation revealed that 70 per cent of the panellists liked extremely, the cake with 20 per cent BRP incorporation. Sensory evaluation using Score Card method showed that overall acceptability of cake with 20 per cent BRP was 9.15 out of 10 i.e. maximum. Nutritional evaluation of cakes revealed that as the level of BRP incorporation was increased from 0 to 25 per cent in cakes, crude protein, crude fat, crude fibre and total ash increased from 6.10 to12.4%, 23.5 to 29.4%, 1.1 to 7.4%, 3.5 to 12.1 % respectively. Among minerals (mg/100g) i.e., iron, calcium, and phosphorus increased from 0.1 to 2.7, 32.0 to 64.0, and 310 to532 respectively. Total Antioxidant Activity increased from 5.5 to 47% and Folic Acid from 0.24to1.9 mg/100g with the increase in BRP incorporation. Cake formulated using20 per cent BRP had protein, fat, fibre ,iron, calcium, folic acid and total antioxidant activity as 11%, 29.2%, 6.7%, 1.8mg/100g, 52mg/100g, 1.55mg/100g, 29.4% respectively.

Pereira *et al.*, (2013) Given the importance of the cookies of type Maria worldwide, and considering the absence of any scientific study setting out their main features, it becomes important to identify the differentiating characteristics of several commercialized brands, in particular related to the chemical, physical and sensory characteristics. In this way, the aim of this work was to study and compare eight different brands of cookies of type Maria. The elemental chemical analysis (moisture, ash, protein, fat, fibre and carbohydrates contents), determination of physical parameters (volume, density, texture and colour) and sensory evaluation of studied cookies were performed. Multivariate statistical methods (Pearson correlation, principal component analysis and cluster analysis) were applied to estimating relationships in analysed data. The results for the elemental analysis showed that the samples were very similar in terms of some components, like for example ashes, while quite different in terms of other components, such as moisture and fat contents. With respect to texture and colour the samples showed, in general, some important differences. In terms of sensory evaluation, the sample C was the one that in most sensory tests gathered the preference of the panellists. The cluster analysis showed that the sample A was much different from the other samples. The results of principal component analysis showed that the main component explains 32.6 % of the total variance, and is strongly related to variables associated to colour.

Onabanjo and Ighere, (2014) determined nutritional, functional and sensory properties of biscuit produced from wheat-sweet potato composite. Sweet potato was processed into flour and it was used to substitute wheat flour at different ratios (100:0, 90:10, 70:30, 60:40 and 50:50), and was used to prepare biscuits. The nutritional, functional and sensory properties of biscuits produced from different ratios of wheat-sweet potato composite flour was investigated. The results reveal that, the value of protein ranged between 4.50g/100g and 8.92g/100g, and value of fat (10.97g/100g to 18.93g/100g) in the biscuits decreased as the quantity of potato flour used in supplementing wheat flour increased. The crude fiber value ranged between 3.16g/100g and 5.10g/100g, the highest value of crude fiber was present in the sample with ratio 50:50 wheat-potato flour. Moisture content and carbohydrate values increased as more sweet-potato flour was introduced into the biscuits. The mineral values of calcium (26.20mg/100g to 28.10mg/100g), magnesium (7.30mg/100g to 9.60mg/100g), potassium (4.60mg/100g to 6.20mg/100g), sodium (9.77ppm to 11.564ppm) and phosphorus (49.675ppm to 56.322ppm) were higher in biscuits produced from ratio 90:10, 70:30, 60:40 and 50:50 wheat-sweet potato composite flour than biscuits produced from ratio 100:0 of wheat-sweet potato composite flour. Sensory analysis revealed that there were no significant differences ($p \geq 0.05$) in taste between biscuits produced from ratio 100:0, 90:10 and 70:30 of

wheat-potato flour, but there were significant differences in taste between biscuits made from ratio 100:0 and biscuits made from ratio 60:40 and 50:50 wheat-potato composite flour. The experiments produced biscuits of acceptable qualities from all ratios of wheat-potato flour that was used.

Bala *et al.,* (2015) studied Functional and sensory properties of cookies prepared by supplementing different proportions of cassava flour (CF) and water chestnut flour (WCF) blends (0–100%) to wheat flour (WF). Seven formulations of cookies were prepared from (a) Control (100% WF), (b) 30% WF, 35% WCF and 35% CF, (c) 27% WF, 37.5% WCF and 37.5% CF, (d) 20% WF, 40% WCF and 40% CF, (e) 15% WF, 42.5% WCF and 42.5% CF, (f) 10% WF, 45% WCF and 45% CF, and (g) 0% WF, 50%WCF and 50% CF. Cookies were subjected to physical analysis (cookie diameter, cookie thickness, spread ratio, bulk volume, bulk density, breaking strength, and color analysis) and evaluated for consumer acceptance by descriptive sensory analysis. Cookies prepared from water chestnut and cassava flour had low moisture content (5.63%), low fat (24.87%), higher spread ratio (8.148), decreased L, a and b values (dark colour), and low breaking strength than control ones. Sensory evaluation established that cookies prepared from 50% WCF and 50% CF were more acceptable than cookies prepared from other formulations.

III. MATERIAL AND METHODS

This chapter deals with the material and equipment used, methodology followed and experimental techniques adopted for conducting various experiments. The study involved a series of investigations *viz.*, the determination of particle size of jackfruit seed flour, preparation of baked product, finding out the influence of particle size of jackfruit seed flour on baking. In this experiment a filler trial for biscuit and cake was conducted to finalize the flour combination. After preparation of biscuit and cake a sensory evaluation was conducted. As per the result of sensory evaluation the refined wheat flour and jackfruit seed flour percentage was fixed as 80:20 respectively. Thereafter to find the effect of particle size of jackfruit seed flour the further experiment were conducted. In which four different particle size of jackfruit seed flour were selected and used for preparation of biscuit and cake. The physical, textural, colour properties of baked product were determined and sensory evaluation was conducted. The experiment was conducted in Bakery Unit of Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Dapoli.

3.1 Materials

The different experiment required various materials. The details of the materials is as discussed below:

3.1.1 Materials used for preparation of jackfruit seed flour

1. Jackfruit seeds
2. 3% Sodium hydroxide solution.
3. Knife
4. Weighing balance
5. Tray dryer
6. Pulveriser
7. Sieve shaker
8. 200 gauge polypropylene bags

3.1.2 Material used for preparation of biscuit and cake

1. Refined wheat flour (Maida)
2. Jackfruit seed flour
3. Sugar
4. Dalda / Fat
5. Eggs
6. Baking powder

7. Salt
8. Essence
9. Milk powder
10. Planetary mixer
11. Biscuit cuter
12. Cake mould
13. 200 gauge polypropylene bags

3.1.3 Material used to measure different properties of biscuit and cake

1. Vernier Calliper
2. Universal testing machine (Textural Analyzer)
3. Colour scanning machine

3.2 Methods

These materials were used for conducting the experiment. The methods followed for the experiments are discussed as follows. The methods used for jackfruit seed flour preparation and baking is discussed as follow. The seeds need pretreatment before pulverization. The details of the pretreatment is as follow.

3.2.1 Pretreatment Jackfruit Seed

The procurement of jackfruit seeds were collected from the local market of Dapoli. These seeds were cleaned manually. White arils get separated in cleaning. To separate the spermoderm, five percent solution of sodium hydroxide was used. The seeds deeped in this solution for 3-5 minutes at 80ºC temperature. Thereafter the solution drained out and the seeds rubbed between the palms. On rubbing the spermoderm get separated from the endosperm. These rubbed seeds brought under running water so that the separated spermoderm get washed.

3.2.2 Preparation of jackfruit seed flour

The pretreated seeds became moist. For further processing, the moist seeds were cut and dried at 70ºC in tray dryer. The cut seeds are shown in Fig. 3.3. Then the cut pieces of seeds were used for pulverization.

3.2.2.1 Tray Dryer

Manufacturing Company – Rotex Industries
Capacity – 60 kg
Trays – 24
Size of tray – 54cm×50cm×2cm

Fig 3.1 Jackfruit Seeds

Fig 3.2 Drying of jackfruit seed in tray dryer

Fresh cut jackfruit seed **Dried Jackfruit seed**

Fig 3.3 Cut dried jackfruit seed

3.2.3 Pulverization of Jackfruit seeds

The dried jackfruit seeds were pulverized in the pulverizer. Total four sieves were used during the experiment. The sieves are categorized by the manufacturer and shown in Fig No, 3.5 as (a) No. 0, (b) No. 1, (c) No. 2, and (d) No. 3. The numbers are provided based on the size. On visual observation, it is clear that, as the number of sieves increases the mesh size also increases.

3.2.3.1 Pulverizer

Manufacturing Company – M/S Mangal metal works

Capacity – 50 kg/hr

Power – Single phase electric motor

Material – Stainless Steel

3.2.5 Jackfruit seed flour

The pulverized flour as shown in Fig 3.6, was cooled at room temperature and sealed in 200 gauge polypropylene bags.

3.2.6 Particle size analysis

The sieves viz. Sieves No. 0, 1, 2 and 3 provided by the manufacturer with the pulverizer were used to get the jackfruit seed flour. The particle size analysis was done with the help of Ro-tap manually operated sieve shaker (Fig 3.7). On sieve shaker a set of IS sieve no. 100, 70, 50, 40, 30, 20 and 15 were arranged. Total four different lots of jackfruit seed flour with three replication each were taken to the sieve shaker.

3.2.6.1 Procedure of particle size analysis

The sample of 250 g jackfruit seed flour was taken for the particle size analysis. The sample was poured in top sieve of the Tylor sieve set and sieve was closed by the lid. Then the sieve shaking operation was performed for 10 minutes duration. Thereafter the samples retained on each sieves weighted separately to determine the fineness modulus. The value of fineness modulus was kept in following formula to get average particle size of jackfruit seed flour.

$$D = 0.135\ (1.366)^{F.M.} \quad \text{----------(3.1)}$$

Where F.M. = Fineness modulus

D = Average particle size, mm

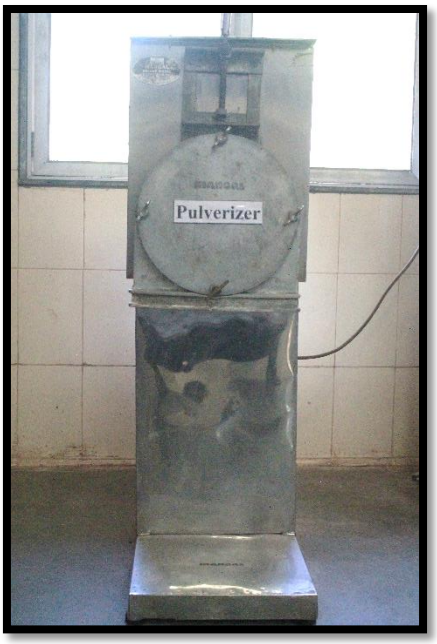
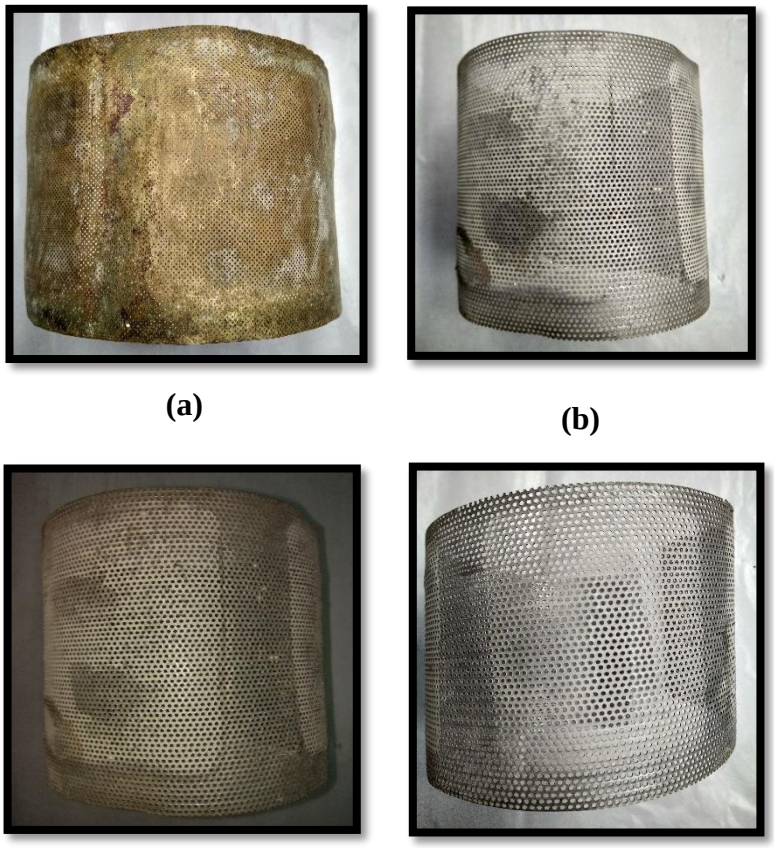


Fig 3.4 Pulverizer



(a) **(b)**

(c) **(d)**

Fig 3.5 Sieves of pulverizer

(a) Sieve No. 0 (b) Sieve no. 1 (c) Sieve no. 2 (d) Sieve no. 3

Fig 3.6 Pulverized jackfruit seed flour

Fig 3.7 Ro-tap Sieve Shaker

3.2.7 Biscuit making procedure

Biscuits are popular as quick breads in different forms throughout the world. It is made from a combination of flour, shortening agent, leavening agent and milk or water.

3.2.7.1 Planetary Mixer

Manufacturing Company – M/S Jmb Bakers Pride

Model – SP-800A

Capacity – 8 lit

Power – 0.20Kw, 230V/50Hz single phase

3.2.7.2 Convection Oven

Manufacturing Company – M/S Orange Foodstuff Equipment Pvt. Ltd.

Model – SO-01

Power – 0.6 Kw, 220V/50Hz

Tray Size - 400×600 in mm/ 5 trays

Outer Dimensions - 980×1000×780H in mm

The procedure for biscuit making is shown with help of the flow chart as shown in Fig 3.8

At the beginning the refined wheat flour, sugar and other ingredients were cleaned with the help of sieve. The cleaned ingredients then put into the pot of the planetary mixer. The mixing was done for 10 minutes at 30 rpm. Then the mixed dough is removed from the pot and placed on the sheet table. This dough was manually converted into a thin sheet with the help of wooden roller. It was made sure that the thickness of the sheet is uniform throughout the sheet. The biscuit cutter was used to cut sheet in desired shape. Then the number of biscuits count was done. These biscuit then were placed in the pre-greased baking tray. The greasing was done using vegetable oil. Then the trays were placed in the pre-heated convection baking oven. The pre-heating temperature was set as 70ºC. While baking the biscuit were closely observed through the glass provided with the oven door. The time required to get desired colour the noted. The baked biscuit trays then removed from the oven and placed on table to get it cooled at room temperature. These cooled samples were packed in the 200 gauge polypropylene bags and used for the further study.

IV. RESULTS AND DISCUSSION

This chapter includes results of experimental observations and discussion based on these results. The data is analyzed and discussed with the appropriate supportive findings from literature. It includes preparation of jackfruit seed flour, particle size analysis of jackfruit seed flour, textural and sensory properties of baked product.

4.1 Influence of jackfruit seed flour on sensory qualities of baked product

4.1.1 Influence of jackfruit seed flour on sensory qualities of biscuit

The sensory evaluation of prepared biscuit was performed using nine point Hedonic scale. The quality attributes studied were appearance, colour, crispiness, texture, taste and overall acceptability.

Table 4.1 Sensory Evaluation of biscuit with different concentration of jackfruit seed flour

Sample Code	Sensory Parameters					
	Appearance	Colour	Crispiness	Texture	Taste	Overall Acceptability
B_1	6.0	6.5	6.3	6.5	6.7	7.3
B_2	6.3	6.9	6.5	7	6.9	7.5
B_3	6.5	7	6.3	4.0	5.2	5.8
B_4	6.6	7.1	6.2	4.6	4.6	4

The above biscuit were used for sensory evaluation. A panel of 30 people of different age group evaluated the prepared biscuits. The result of sensory scores is reported in the Table 4.1.

The Table 4.1 shows that the appearance of biscuit prepared with treatment B_4 got 6.6 as a highest value followed by B_3 with 6.5 value. The colour of biscuit from treatment B_4 got highest value as 7.1 which was followed by biscuit with treatment B_3. Where as the crispiness got 6.5 as highest value for treatment B_2 which among the treatments this was followed by B_1 and B_3 with value 6.3 and 6.3 respectively. Similarly the highest sensory

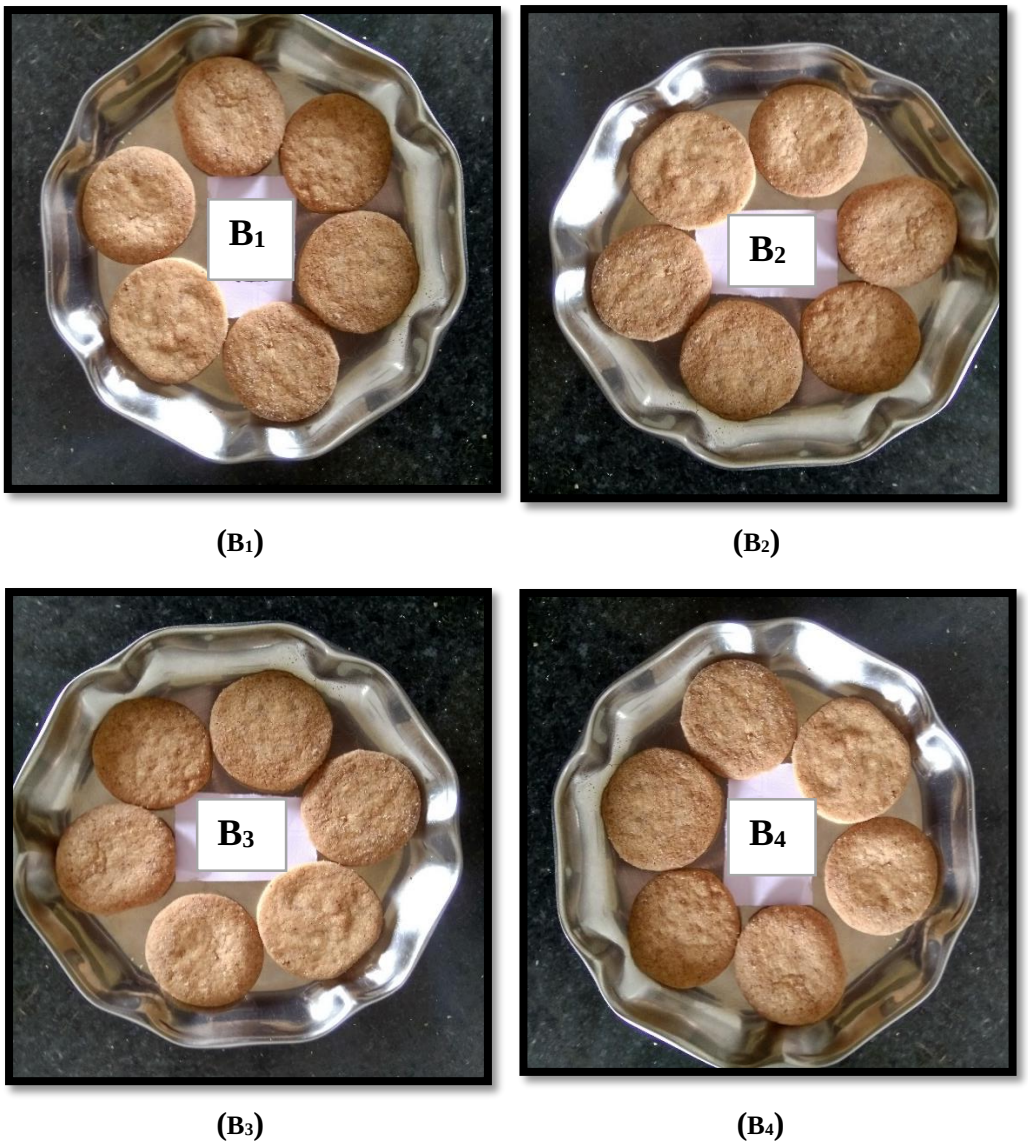


Fig 4.1 Use of jackfruit seed flour in biscuit making

(B_1 = 90% refined wheat flour and 10% jackfruit seed flour, B_2 = 80% refined wheat flour and 20% jackfruit seed flour, B_3 = 70% refined wheat flour and 30% jackfruit seed flour, B_4 = 60% refined wheat flour and 40% jackfruit seed flour

scores for texture of the biscuit was found to be 7.0 for treatment B_2 which was followed by treatment $B_1$with score 6.5. The scores for taste shown that treatment B_2 has highest value as 6.9 which was followed by treatment B_1 had score 6.7. The highest overall acceptability score for B_2 treatment was 7.5 which was followed by other treatments. The sensory scores for most of the attributes and overall acceptability score indicates that the biscuit prepared with

treatment B_2 were better compared to the other treatments. Similar results have been reported by Butool S. and M. Butool (2013) and also by Islam *et al*., (2015).

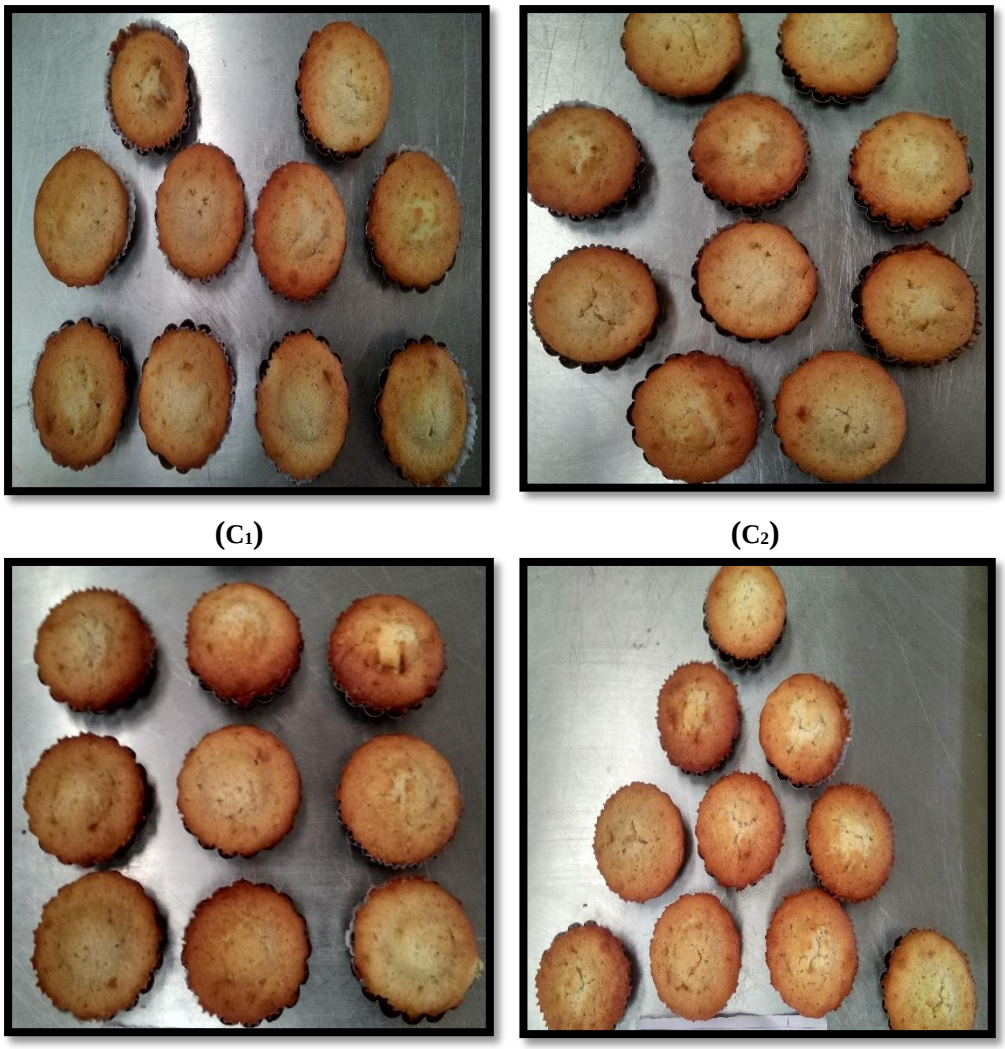
Based on sensory scores, the jackfruit seed flour percentage was fixed to 20 % of the refined wheat flour and further experimentations were carried out. Table 4.2 shows the ANOVA for the sensory analysis of the scores obtained for biscuit. It is clear from the table that the effect of concentration of jackfruit seed flour on biscuit preparation found non-significant at 5% level of significance.

Table 4.2 ANOVA for the sensory analysis of the scores obtained for biscuit with different concentration of jackfruit seed flour

Source of Variation	***SS***	***DF***	***MS***	***F***	***P-value***	***Fcrit***
Rows	8.061667	3	2.687222	3.60298	0.031419	1.695833
Column	4.628333	5	0.925667	0.908011	0.497523	1.640988
Error	10.28833	15				
Total	22.97833	23				

4.1.2 Influence of jackfruit seed flour on sensory qualities of cake

The sensory evaluation of prepared cup cake was performed using nine point Hedonic scale. The quality attributes studied were appearance, colour, sponginess, texture, taste and overall acceptability.



(C_1) **(C_2)**

(C_3) **(C_4)**

Fig 4.2 Use of jackfruit seed flour in cake making

(C_1 = 90% refined wheat flour and 10% jackfruit seed flour, C_2 = 80% refined wheat flour and 20% jackfruit seed flour, C_3 = 70% refined wheat flour and 30% jackfruit seed flour, C_4 = 60% refined wheat flour and 40% jackfruit seed flour)

Table 4.3 Sensory Evaluation of cake with different concentration of jackfruit seed flour

Sample Code	Sensory Parameters					
	Appearance	Colour	Sponginess	Texture	Taste	Overall Acceptability
C_1	6.9	6.5	7.3	7.4	7.2	7.4
C_2	6.7	7.1	7.1	7.5	7.4	7
C_3	6.5	6.8	6.5	6.5	6.2	6.8
C_4	6.6	6.9	6.2	6.3	6	6

These cake further used for sensory evaluation. A panel of 30 people of different age group evaluated the prepared cupcakes. The result of sensory scores is reported in the Table 4.3. The Table 4.3 shows that the appearance of cake prepared with treatment C_1 got 6.9 value followed by C_2 with 6.7 value. The colour of cake from treatment C_2 get 7.1 value which is followed by cake with treatment C_4. Where as the sponginess get 7.3 value for treatment C_1 which is followed by C_2 with value 7.1. Similarly sensory scores for texture of the cake was found to be 7.5 for treatment C_2 which is followed by treatment C_1. The scores for taste shown that treatment C_2 has value 7.4 which is followed by treatment C_1. All the sensory scores gave average score which is considered as score for overall acceptability. The overall acceptability scores for C_1 treatment was 7.4 which followed by treatment C_2. The sensory scores for most of the attributes and overall acceptability score indicates that the cake from treatment C_2 are better compared to the other treatments. Based on sensory scores, the jackfruit seed percentage fixed to 20% of the refined wheat flour and further experimentation carried out. Table 4.4 shows the ANOVA for the sensory analysis of the scores obtained for cake treatment. It is clear from the table that the effect of concentration of jackfruit seed flour on cake preparation found significant at 5% level of significance.

Table 4.4 ANOVA for the sensory analysis of the scores obtained for cake

Source of Variation	*SS*	*DF*	*MS*	*F*	*P-value*	*Fcrit*
Rows	2.9433	3	0.98111	10.1669	0.00028	1.6958
Column	0.163333	5	0.032667	0.124841	0.984933	1.640988
Error	1.456667	15				
Total	4.14	23				

4.2 Effect of particle size of jackfruit seed flour on sensory qualities of baked product

4.2.1 Particle Size Analysis

The obtained flour further used to analyse the particle size. The particle size of jackfruit seed flour obtained from different sieves of pulverizer determined with the help of sieve shaker (Ro-tap). Total three replications of each treatment were taken.

Table 4.5 Fineness modulus of jackfruit seed flour

Treatment	**Fineness Modulus**
G_1	5.264
G_2	5.421
G_3	5.595
G_4	5.789

The values of fineness modulus are as shown in Table 4.5. It was observed from the table that the fineness modulus is increases from G_1 to G_4. These value of fineness modulus were used for particle size determination of jackfruit seed flour. The formula $D=0.135 (1.366)^{F.M}$ where, D is average particle size in mm and F.M. is fineness modulus, on keeping values in this formula average particle size of the jackfruit seed flour was determined. The average particle size of the jackfruit seed flour is as shown in Table 4.6.

Table 4.6 Particle size of jackfruit seed flour

Treatment	Average particle diameter, mm
G_1	0.69
G_2	0.73
G_3	0.77
G_4	0.82

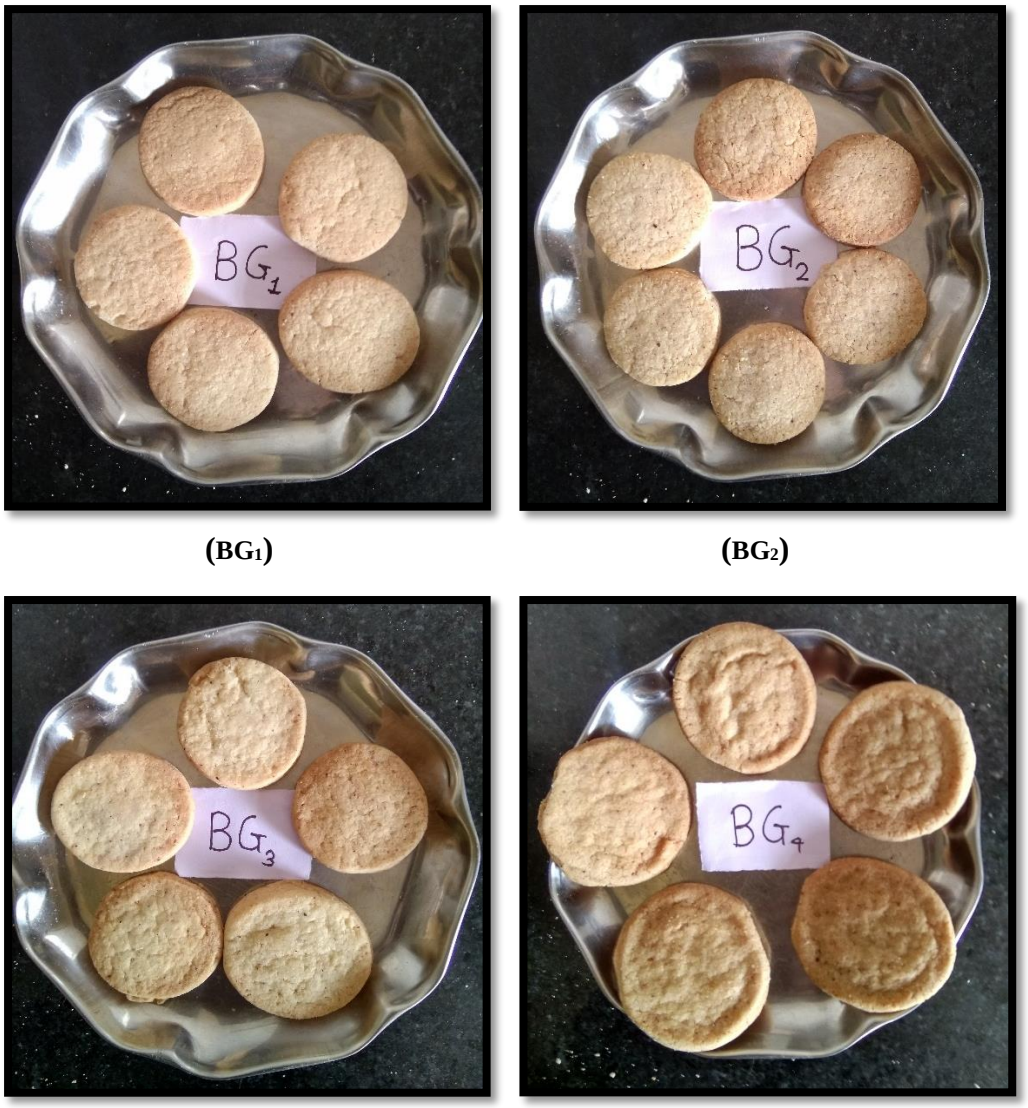
The above values indicates that the average particle diameter of the jackfruit seed flour were 0.69 mm for treatment G_1 , 0.73 mm for G_2, 0.77 mm for G_3 and 0.82 mm for G_4. The G_4 shown biggest particle diameter i.e. 0.82 mm. The flour obtained from different treatments further used for biscuit and cake preparation.

4.2.2 Effect of particle size of jackfruit seed flour on sensory qualities of biscuit

The sensory evaluation of prepared biscuit was performed using nine point Hedonic scale. The quality attributes studied were appearance, colour, crispiness, texture, taste and overall acceptability. The prepared biscuit are shown in Fig 4.3. A panel of 30 people of different age group evaluated the prepared biscuits. The result of sensory scores is reported in the Table 4.7

Table 4.7 Sensory Evaluation of biscuit with different particle size of jackfruit seed flour (80:20)

Sample Code	Sensory Parameters					
	Appearance	Colour	Crispiness	Texture	Taste	Overall Acceptability
BG_1	6.96	7.15	6.75	6.59	7.06	6.91
BG_2	6.96	7.30	7.10	6.86	7.10	7.30
BG_3	6.93	7.13	7.26	6.83	7.06	7.32
BG_4	6.90	6.83	7.13	6.53	6.60	6.64



(BG_1) **(BG_2)**

(BG_3) **(BG_4)**

Fig 4.3 Biscuit prepared with different particle size of jackfruit seed flour

(BG_1 = Biscuit with jackfruit seed flour of 0.69mm particle size, BG_2 = Biscuit with jackfruit seed flour of 0.73mm particle size, BG_3 = Biscuit with jackfruit seed flour of 0.77mm particle size,.BG_4 = Biscuit with jackfruit seed flour of 0.82mm particle size)

The appearance of biscuit prepared with treatment BG_1 and BG_2 got 6.96 as a highest value followed by BG_3 with 6.93 value. The colour of biscuit from treatment BG_2 got 7.30 as highest value which was followed by biscuit with treatment BG_3 had 7.15 score. Whereas the crispiness highest value was observed as 7.26 for treatment BG_3 which was followed by BG_1 with value 7.13. Similarly the highest sensory score for texture of the biscuit was found as 6.86 for treatment BG_2 which was followed by treatment treatment BG_3 with score 6.83. The

scores for taste shown that treatment BG_2 had highest value of 7.10 which was followed by treatment BG_1 and BG_3 with value 7.06. The highest overall acceptability score obtained for BG_3 treatment as 7.32 which was followed by treatment BG_2 with value 7.30.

The sensory scores for most of the attributes and overall acceptability score indicates that the biscuit prepared from treatment BG_3 were best compared to the other treatments. Based on sensory scores, the jackfruit seed particle size fixed 0.77 mm to make biscuit and further experimentation carried out. A panel of 30 people of different age group evaluated the prepared biscuits. The result of sensory scores is reported in the Table 4.7. Table 4.8 shows the ANOVA for the sensory analysis of the scores obtained for biscuit. It is clear from the table that the effect of particle size of jackfruit seed flour on biscuit preparation found significant at 5% level of significance.

Table 4.8 ANOVA for the sensory analysis of the scores obtained for biscuit

Source of Variation	***SS***	***DF***	***MS***	***F***	***P-value***	***Fcrit***
Rows	0.457752	3	0.152584	3.802133	0.026286	1.695833
Column	0.414631	5	0.082926	1.764921	0.171056	1.640988
Error	0.387992	15				
Total	1.260376	23				

4.2.3 Effect of particle size of jackfruit seed flour on sensory qualities of cake

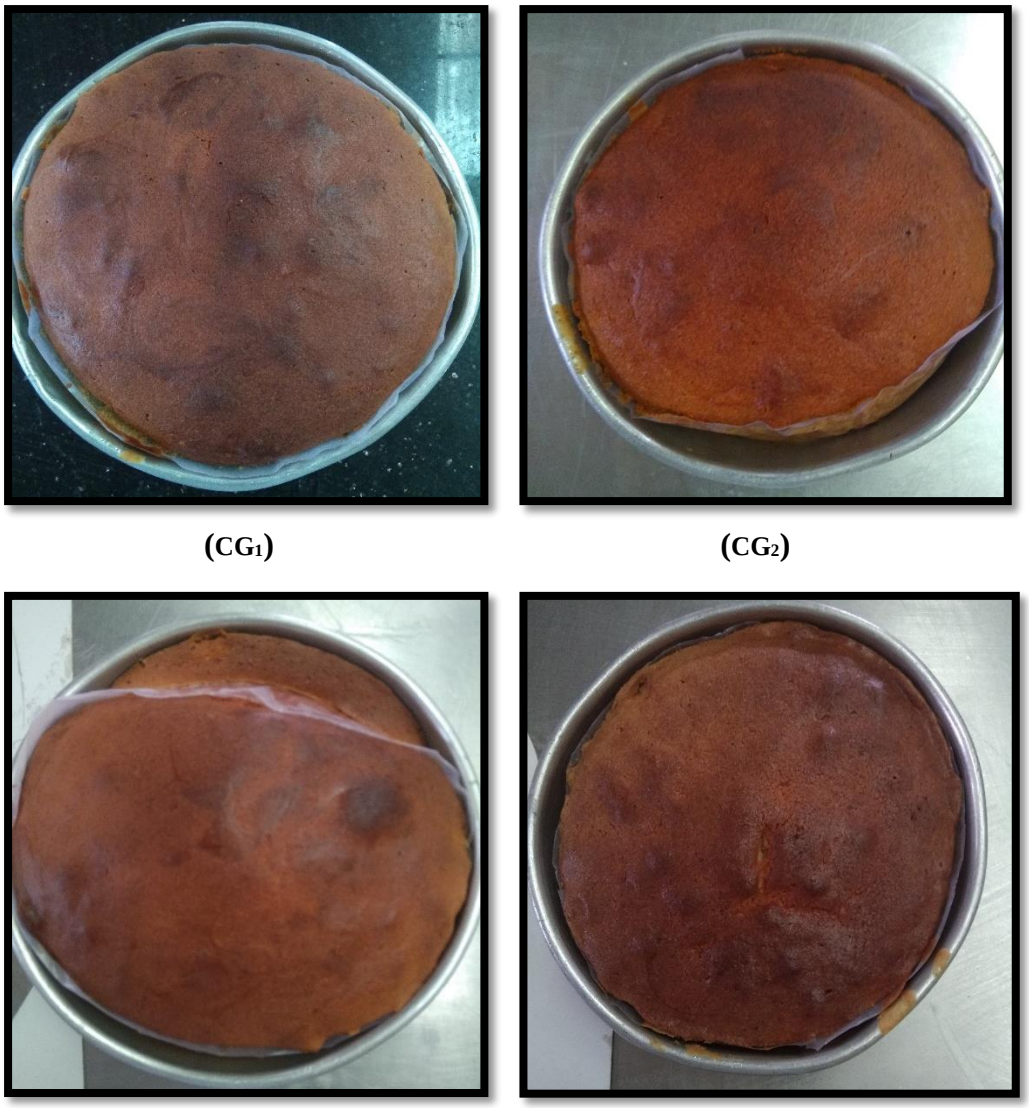
The sensory evaluation of prepared cake was performed using nine point Hedonic scale. The quality attributes studied were appearance, colour, sponginess, texture, taste and overall acceptability.

Table 4.9 Sensory Evaluation of cake with different particle size of jackfruit seed flour

Sample Code	Sensory Parameters					
	Appearance	Colour	Sponginess	Texture	Taste	Overall Acceptability
CG_1	6.83	6.96	7.10	7.10	7.23	7.05
CG_2	7.16	7.50	7.20	7.33	7.63	7.72
CG_3	7.06	7.36	7.00	7.03	7.36	7.34
CG_4	7.01	7.45	6.91	6.88	7.35	7.14

These cake further used for sensory evaluation. A panel of 30 people of different age group evaluated the prepared cake. The result of sensory scores is reported in the Table 4.9.

The Table 4.9 shows that the appearance of cake prepared with treatment CG_2 got 7.16 value followed by CG_3 with 7.06 value. The colour of cake from treatment CG_2 get 7.50 value which is followed by cake with treatment CG4. Where as the sponginess get 7.20 value for treatment CG2 which is followed by CG1 with value 7.10. Similarly



(CG_1) **(CG_2)**

(CG_3) **(CG_4)**

Fig 4.4 Cake prepared with different particle size of jackfruit seed flour

(CG_1 = Cake with jackfruit seed flour of 0.69mm particle size, CG_2 = Cake with jackfruit seed flour of 0.73mm particle size, CG_3 = Cake with jackfruit seed flour of 0.77mm particle size,.CG_4 = Cake with jackfruit seed flour of 0.82mm particle size.)

sensory scores for texture of the cake was found to be 7.33 for treatment CG_2 which is followed by treatment CG_1. The scores for taste shown that treatment CG_2 has value 7.63 which is followed by treatment CG_3 and CG_4. All the sensory scores gave average score which is considered as score for overall acceptability. The overall acceptability scores for CG_2 treatment was 7.72 which followed by treatment CG_3 . The sensory scores for most of the attributes and overall acceptability score indicates that the cake from treatment CG_2 are better compared to the other treatments. Based on sensory scores, the jackfruit seed particle size fixed 0.73mm to make cake and further experimentation carried out. Table 4.10 shows the ANOVA for the sensory analysis of the scores obtained for cake. It is clear from the table

that the effect of particle size of jackfruit seed flour on cake preparation found non-significant at 5% level of significance.

Table 4.10 ANOVA for the sensory analysis of the scores obtained for cake

Source of variation	*SS*	*DF*	*MS*	*F*	*P-value*	*Fcrit*
Rows	0.316918	3	0.105639	2.440924	0.094163	1.695833
Column	0.468062	5	0.093612	2.358567	0.081968	1.640988
Error	0.397508	15				
Total	1.182488	23				

4.3 Physical properties of baked product

4.3.1 Biscuit

The physical properties of the prepared biscuits were measured with the help of vernier caliper. The properties measured were biscuit diameter and thickness.

4.3.1.1 Biscuit diameter and thickness

Biscuit diameter and thickness was measured with the help of vernier caliper. The results are shown in Table 4.11. It was observed from table that the diameter of the biscuit was increased from 42.74 mm to 47.98 mm and thickness of baked biscuit decreased from 8.32 mm to 6.91mm.

Table 4.11 Diameter and thickness of biscuits

Treatment	**Biscuit**	
	Diameter, mm	**Thickness, mm**
BG_1	42.44±1.73	8.32±0.76
BG_2	45.35±1.02	8.11±0.83
BG_3	47.04±1.15	7.21±1.05
BG_4	47.98±0.97	6.91±0.89

The Table 4.11 shows the diameter and thickness of biscuit. The diameter and thickness of baked biscuit varied between 40.71 mm to 48.89 mm and 6.36 mm to 9.08 mm

for all treatments (BG_1 to BG_4) respectively. The diameter and thickness of biscuit for treatment BG_1 was ranges from 40.71 mm to 44.17 mm and 8.24 mm to 8.81 mm respectively. For treatment BG_2 the diameter and thickness ranges from 44.36 mm to 46.41 mm and 7.64 mm to 9.08 mm respectively, for treatment BG_3 the diameter and thickness ranges from 44.79 mm to 48.69 mm and 7.02 mm to 7.56 mm respectively. And for treatment BG_4 the diameter and thickness ranges from 46.29 mm to 48.89 mm and 6.36 mm to 7.25 mm respectively.

The biscuit diameter was maximum (48.89 mm) for treatment BG_4 and minimum (40.71 mm) for treatment BG_1. The biscuit thickness was maximum (9.08 mm) for treatment BG_2 and minimum (6.36 mm) in biscuit treatment BG_4. This values of diameter and thickness used for finding out spread ratio. Table 4.11 and 4.13 shows the ANOVA for change in diameter at varied particle size of jackfruit seed flour, at 0.69mm, 0.73mm, 0.77mm and 0.82mm for jackfruit seed flour biscuit. It is clear from the table that the effect of particle size of jackfruit seed flour on biscuit diameter found non-significant at 5% level of significance. Table 4.11 and 4.13 shows the ANOVA for change in thickness at varied particle size of jackfruit seed flour, at 0.69mm, 0.73mm, 0.77mm and 0.82mm for jackfruit seed flour biscuit. It is clear from the table that the effect of particle size of jackfruit seed flour on biscuit thickness found non-significant at 5% level of significance.

4.3.1.2 Biscuit spread ratio

The Table 4.12 shows the spread ratio of raw and baked biscuit. The spread ratio of baked biscuit varied between 4.94 to 7.40 for all treatments (BG_1 to BG_2). The spread ratio of biscuit for treatment BG_1 was ranged from 4.94 to 5.13. For treatment BG_2 it was ranged from 4.95 to 5.98, whereas for treatment BG_3 spread ratio ranged from 5.92 to 6.73, and the treatment BG_4 shown spread ratio in the range of 6.37 to 7.40. It was observed that the biscuit spread ratio was maximum as 7.40 for the treatment BG_4 and the minimum found for treatment BG_1 as 4.94. The results of spread ratio indicates that as the particle size of jackfruit seed flour increases the spread ratio of the biscuit also increase**.** Table 4.12 and 4.13 shows the ANOVA for change in spread ratio at varied particle size of jackfruit seed flour, at 0.69mm, 0.73mm, 0.77mm and 0.82mm for jackfruit seed flour biscuit. The increase in spread ratio with increase particle size was significant at $p \leq 0.01$ for jackfruit seed flour biscuit. Table 4.12 and 4.13 shows the ANOVA for change in spread ratio at varied particle size of jackfruit seed flour, at 0.69mm, 0.73mm, 0.77mm and 0.82mm for jackfruit seed flour

biscuit. It is clear from the table that the effect of particle size of jackfruit seed flour on biscuit spread ratio found non-significant at 5% level of significance.

Table 4.12 Spread ratio of biscuits

Treatment	Spread Ratio
BG_1	5.01±0.65
BG_2	5.62±0.42
BG_3	6.53±0.77
BG_4	6.95±0.59

Table 4.13 ANOVA for physical properties biscuit

Source of Variation	*SS*	*DF*	*MS*	*F*	*P-value*	*F crit*
a. Biscuit diameter						
Treatments	78.77466	3	26.25822	15.54493	5.32E-05	1.73555
Replications	12.28915	4	3.072288	0.492815	0.741202	1.710342
Error	14.73777	12				
Total	105.8016	19				
b. Biscuit thickness						
Treatments	8.480095	3	2.8266983	20.350966	1.042E-05	1.7355496
Replications	0.88073	4	0.2201825	0.3362685	0.8492673	1.7103416
Error	1.34163	12				
Total	10.7024	19				
c. Spread ratio						
Treatments	11.4642	3	3.821399	31.02371	6.68E-07	1.73555
Replications	0.939008	4	0.234752	0.281792	0.885195	1.710342
Error	1.03182	12				
Total	13.43503	19				

4.3.1.3 Textural properties of biscuit

The effect of different particle sizes on textural properties of biscuit was studied by objective method. The textural analysis performed with the help of Universal Testing

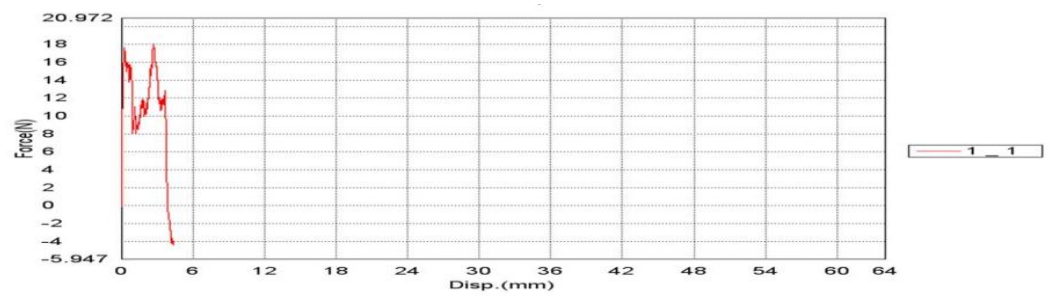
Machine. A probe of 5mm diameter was selected while performing the experiment on hardness of biscuits. The speed of the load cell was maintained as 10mm/min. The graph plotted between force and the distance penetrated. The graph shows that the peak force of 18.09 N required to penetrate into biscuit. As the biscuit has stickiness property, the second peak while returning back was observed.

Table 4.14 Texture analysis of biscuit

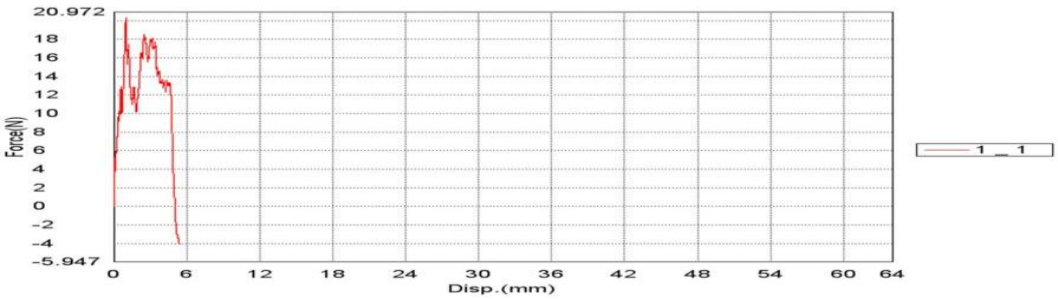
Biscuit treatment	Maximum force, N
BG_1	18.0917
BG_2	20.2994
BG_3	5.33279
BG_4	10.9948

The second biscuit tested was a treatment BG_2. The graph obtained shows that the peak force required to penetrate the biscuit was 20.29 N which is slight higher than the force required for treatment BG_1.

In case of treatment BG_3 showed peak force required to penetrate the probe was 5.33N. It was comparatively lower compared to treatment BG_1 and BG_2. The treatment BG_4 showed peak force as 10.99N. The second peak is absent for treatment BG_3 and BG_4. It shows that, as particle size of jackfruit seed flour decreases the force required to penetrate into the biscuit increases. And the stickiness of the biscuit increases on decrease in particle size of jackfruit seed flour. The result indicates that the biscuit with smaller particle sizes jackfruit seed flour are harder compared to coarser particle biscuit.



a)



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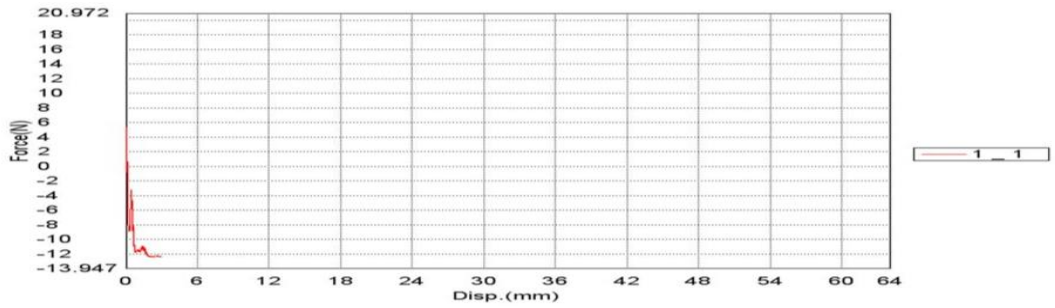

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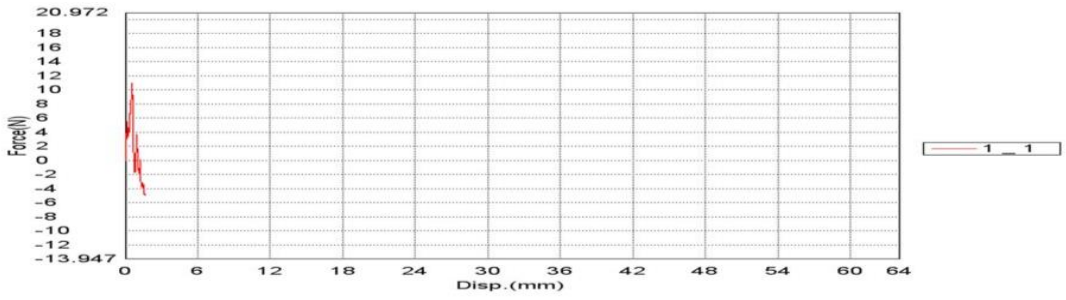


d)

Fig 4.5 Texture analysis of biscuit prepared with different particle size of jackfruit seed flour using fixed type penetration rod a) a) BG_1 b) BG_2 c) BG_3 d) BG_4

4.3.1.4 Colour measurement of biscuit

The colour of biscuit measured on Colour Scanning Machine. The result obtained were in the form L^*, a^* and b^* values shown in Table 4.15. The biscuit of treatment BG_1 gave L* value as 69.54, a* value as 2.59 and b* values as 20.48. It indicates that the biscuit is light in colour, inclined toward little redness and yellowness. The second biscuit of treatment BG_2 shows comparative less lightness, more redness and almost some yellowness. Compared with treatment BG_2 it was more lighter and less red. The biscuit of treatment BG_4 has shown yellowness same that of previous three treatments, whereas the redness resembles with BG1 and BG_3. It is more lighter than BG_2 and less lighter than BG_1 and BG_3.

The colour values shows that the biscuit with particle smallest particle size of jackfruit seed flour i.e. 0.69 mm shown light in colour compared with other treatments.

Table 4.15 Colour measurement of biscuit

Biscuit Treatment	Observations		
	L^*	a^*	b^*
BG_1	69.544	2.592	20.418
BG_2	63.848	5.075	20.195
BG_3	68.110	2.028	20.011
BG_4	66.615	2.950	20.067

4.3.2 Cake

4.3.2.1 Weight

To measure weight of the cake electrical weighing balance was used having least count of 2 gm. The weight loss in cake batter after baking was observed 18 to 20%. The weight of cake is shown in table no. 4.16. The weight of cake varied between 3.15g and 336g for all treatments (CG_1 to CG_4). The weight of cake for treatment CG_1 was ranges from 3.19 g to 335 g, for CG_2 from 324 g to 336 g, for CG_3 from 315 g to 328 g, for CG_4 from 316 g to 336 g respectively. The cake weight was maximum (336 g) in treatment CG_2 and minimum (315 g) in cake treatment CG_3. Table 4.16 and 4.23(a) shows the ANOVA for change in weight of cake at varied particle size of jackfruit seed flour, at 0.69mm, 0.73mm, 0.77mm and 0.82mm for jackfruit seed flour cake. It is clear from the table that the effect of particle size of jackfruit seed flour on weight of cake found non-significant at 5% level of significance.

Table 4.16 Weight of cake

Treatment	Weight of cake, g
CG_1	327±8
CG_2	330±6
CG_3	322.5±7.5
CG_4	324±9.5

4.3.2.2 Volume

The Table No. 4.17 shows the volume of cake. The volume of cake varied between 567.77cm^3 and 626.97cm^3 for all treatments (CG_1 to CG_4). The volume of cake for treatment CG_1 was ranges from 567.77 cm^3 to 614.83 cm^3, for CG_2 from 600.42 cm^3 to 601.56 cm^3, for CG_3 from 595.58 cm^3 to 626.97 cm^3, for CG_4 from 569.03 cm^3 to 614.83 cm^3 respectively. The cake volume was maximum (626.97 cm^3) in treatment CG_3 and minimum (567.77 cm^3) in cake treatment CG_1. Table 4.17 and 4.23(b) shows the ANOVA for change in volume of cake at varied particle size of jackfruit seed flour, at 0.69mm, 0.73mm, 0.77mm and 0.82mm for jackfruit seed flour cake. It is clear from the table that the effect of particle size of jackfruit seed flour on volume of cake found non-significant at 5% level of significance.

Table 4.17 Volume of cake

Treatment	Volume of cake, cm^3
CG_1	591.30 ±23.53
CG_2	600.99 ±0.57
CG_3	602.97 ±7.39
CG_4	607.63±7.21

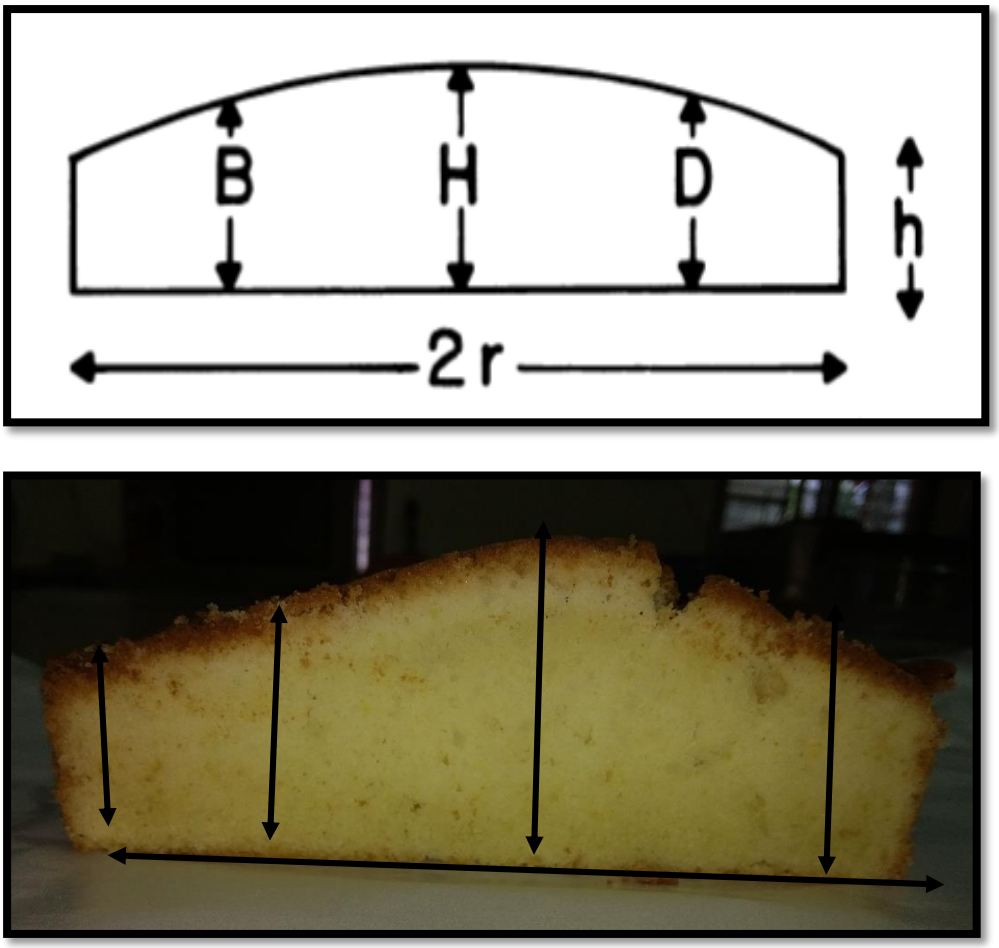


Fig 4.6 Cross section of cake

4.3.2.3 Specific Volume

The specific volume of cake was measured by using method shown in 3rd chgapter. The Table No. 4.18 shows the specific volume of cake. The specific volume of cake varied between 1.69cm^3/g and 1.99cm^3/g for all treatments (CG_1 to CG_4). The specific volume of cake for treatment CG_1 was ranges from 1.69 cm^3/g to 1.87cm^3/g, for CG_2 from 1.79cm^3/g to 1.85cm^3/g, for CG_3 from 1.80cm^3/g to 1.99cm^3/g, for CG_4 from 1.69cm^3/g to 1.89cm^3/g respectively. The cake specific volume was maximum (1.99cm^3/g) in treatment CG_3 and minimum (1.69cm^3/g) in cake treatment CG_1. Table 4.18 and 4.23(c) shows the ANOVA for change in specific volume of cake at varied particle size of jackfruit seed flour, at 0.69mm, 0.73mm, 0.77mm and 0.82mm for jackfruit seed flour cake. It is clear from the table that the effect of particle size of jackfruit seed flour on specific volume of cake found non-significant at 5% level of significance.

Table 4.18 Specific Volume of cake

Treatment	Specific Volume of cake, cm^3/g
CG_1	1.78 ±0.09
CG_2	1.85 ±0.03
CG_3	1.87 ±0.06
CG_4	1.88±0.1

4.3.2.4 Density

The Table No. 4.19 shows the density of cake. The density of cake varied between 0.52 g/cm^3 and 0.59 g/cm^3 for all treatments (CG_1 to CG_4). The density of cake for treatment CG_1 was ranges from 0.53 g/cm^3 to 0.59 g/cm^3, for CG_2 from 0.53 g/cm^3 to 0.55 g/cm^3, for CG_3 from 0.50 g/cm^3 to 0.55 g/cm^3, for CG_4 from 0.52 g/cm^3 to 0.58 g/cm^3 respectively. The cake density was maximum (0.59 g/cm^3) in treatment CG_1 and minimum (0.52 g/cm^3) in cake treatment CG_4. Table 4.19 and 4.23(d) shows the ANOVA for change in density of cake at varied particle size of jackfruit seed flour, at 0.69mm, 0.73mm, 0.77mm and 0.82mm for jackfruit seed flour biscuit. BG_4 showed peak force as 10.99N. The second peak is absent for treatment BG_3 and BG_4. Table 4.19 and 4.23(d) shows the ANOVA for change in density of cake at varied particle size of jackfruit seed flour, at 0.69mm, 0.73mm, 0.77mm and 0.82mm for jackfruit seed flour cake. It is clear from the table that the effect of particle size of jackfruit seed flour on density of cake found non-significant at 5% level of significance.

Table 4.19 Density of cake

Treatment	Density of cake, g/cm^3
CG_1	0.56 ±0.03
CG_2	0.54 ±0.01
CG_3	0.52 ±0.025
CG_4	0.55 ± 0.04

4.3.2.5 Volume Index

The Table No. 4.20 shows the volume index of cake. The volume index of cake varied between 13.4 and 15 for all treatments (CG_1 to CG_4). The volume index of cake for treatment CG_1 was ranges from 13.4 to 14.6, for CG_2 from 13.9 to 14.1, for CG_3 from 14.5 to 15, for CG_4 from 14.3 to 14.4 respectively. The cake volume index was maximum (15) in

treatment CG_3 and minimum (13.4) in cake treatment CG_1. Table 4.20 and 4.23(e) shows the ANOVA for change in volume index of cake at varied particle size of jackfruit seed flour, at 0.69mm, 0.73mm, 0.77mm and 0.82mm for jackfruit seed flour cake. It is clear from the table that the effect of particle size of jackfruit seed flour on volume of cake found non-significant at 5% level of significance.

Table 4.20 Volume Index of cake

Treatment	Volume Index of cake
CG_1	14 ± 0.6
CG_2	14 ± 0.1
CG_3	14.75 ±0.25
CG_4	14.35 ± 0.05

4.3.2.6 Symmetry Index

The Table No. 4.21 shows the symmetry index of cake. The symmetry index of cake varied between -1.8 and -0.9 for all treatments (CG_1 to CG_4). The symmetry index of cake for treatment CG_1 was ranges from -1.4 to -1.0, for CG_2 from -1.3 to -0.9, for CG_3 from -1.8 to -1.5, for CG_4 from -1.7 to -1.2 respectively. The cake symmetry index was maximum (-0.9) in treatment CG_2 and minimum (-1.8) in cake treatment CG_3. Table 4.21 and 4.23(f) shows the ANOVA for change in symmetry index of cake at varied particle size of jackfruit seed flour, at 0.69mm, 0.73mm, 0.77mm and 0.82mm for jackfruit seed flour cake. It is clear from the table that the effect of particle size of jackfruit seed flour on symmetry index of cake found significant.

Table 4.21 Symmetry Index of cake

Treatment	Symmetry Index of cake
CG_1	-1.2 ± 0.2
CG_2	-1.1 ± 0.2
CG_3	-1.65 ±0.15
CG_4	-1.45 ±0.25

4.3.2.7 Uniformity Index

The Table No. 4.22 shows the uniformity index of cake. The uniformity index of cake varied between -0.2 and 0.3 for all treatments (CG_1 to CG_4). The uniformity index of cake for treatment CG_1 was ranges from -0.2 to 0.2, for CG_2 from -0.2 to -0.1, for CG_3 from -0.1 to 0.2, for CG_4 from -0.2 to 0.3 respectively. The cake uniformity index was maximum (0.3) in treatment CG_4 and minimum (-0.2) in cake treatment CG_1, CG_2, CG_4. Table 4.22 and 4.23(g) shows the ANOVA for change in uniformity index of cake at varied particle size of jackfruit seed flour, at 0.69mm, 0.73mm, 0.77mm and 0.82mm for jackfruit seed flour cake. It is clear from the table that the effect of particle size of jackfruit seed flour on uniformity index of cake found non-significant at 5% level of significance

Table 4.22 Uniformity Index of cake

Treatment	Uniformity Index of cake
CG_1	0
CG_2	-0.15±0.05
CG_3	0.05±0.15
CG_4	0.05±0.25

Table 4.23 ANOVA for physical properties of cake

Source of Variation	*SS*	*DF*	*MS*	*F*	*P-value*	*Fcrit*
a. Weight						
Treatments	56.25	3	18.75	0.279851	0.83858	1.951253
Replications	111.5	2	55.75	1.043682	0.391169	1.934861
Error	424.5	6				
Total	592.25	11				
b. Volume						
Treatments	983.7795	3	327.9265	0.808366	0.523878	1.951253
Replications	1105.644	2	552.8219	1.59291	0.255708	1.934861
Error	2139.684	6				
Total	4229.107	11				

c. Specific Volume						
Treatments	0.001054	3	0.000351	0.493371	0.696753	1.951253
Replications	0.001015	2	0.000507	0.795548	0.480681	1.934861
Error	0.004684	6				
Total	0.006753	11				
d. **Density**						
Treatments	0.001054	3	0.000351	0.509919	0.686486	1.951253
Replications	0.000991	2	0.000495	0.800194	0.478788	1.934861
Error	0.004519	6				
Total	0.006564	11				

e. **Volume index**						
Treatments	1.249167	3	0.416389	3.353468	0.076014	1.951253
Replications	0.105	2	0.0525	0.221053	0.805901	1.934861
Error	0.888333	6				
Total	2.2425	11				
f. **Symmetry Index**						
Treatments	0.489167	3	0.163056	3.836601	0.056964	1.951253
Replications	0.071667	2	0.035833	0.425743	0.665784	1.934861
Error	0.268333	6				
Total	0.829167	11				
g. **Uniformity index**						
Treatments	0.0625	3	0.020833	0.581395	0.643621	1.951253
Replications	0.111667	2	0.055833	2.115789	0.176538	1.934861
Error	0.175	6				
Total	0.349167	11				

4.3.2.8 Textural properties of cake

The textural analysis of jackfruit seed flour based cake was done. The effect of different particle sizes on textural properties was studied. The textural analysis was performed on Universal Testing Machine. A probe of 5mm diameter was selected while performing the experiment. The speed of the load was maintained as 10mm/min. The graph

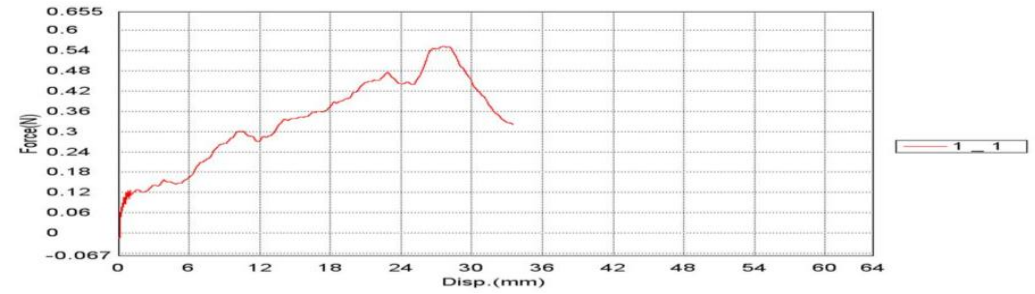
was plotted between force and the distance penetrated into the cake. The graph shows is figure 4.7 can shows the result of CG_1 treatment (CG_1 = Cake with 20 % jackfruit seed flour of 0.69 mm particle size). It was observed from the graph that the peak force required to penetrate the probe inside the cake was 0.552 N. As the cake has stickiness property it shows one more peak force while the probe returning. The thickness of cake was 43 mm. The graph shows the probe travelled 34 mm distance inside the cake.

Table 4.24 Texture analysis of cake

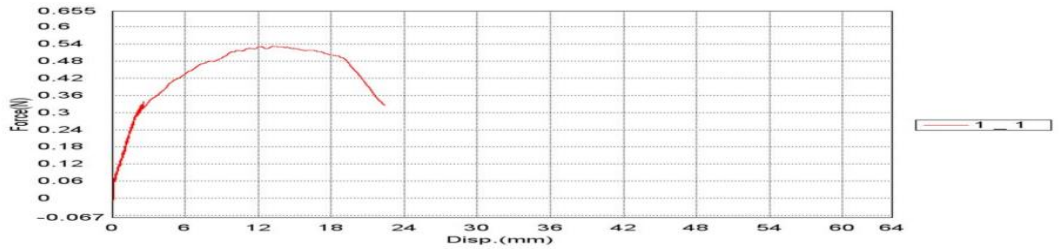
Cake treatment	Maximum force
CG_1	0.55250
CG_2	0.53190
CG_3	0.59748
CG_4	0.56937

The second cake tested was a treatment CG_2 (CG_2 = Cake with 20% jackfruit seed flour of 0.73 mm particle size). The graph obtained shows that the peak force required to penetrate the cake was 0.531 N which is slight less than the force required for treatment CG_1. Here also stickiness property allowed to develop second peak it means that the force was also required to remove the probe.

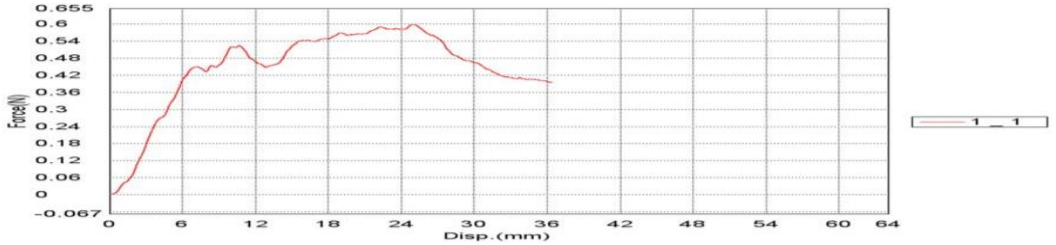
In case of treatment CG_3 (CG_3 = Cake with 20% jackfruit seed flour of 0.77 mm particle size) showed peak force required to penetrate the probe was 0.597N. It was comparatively higher compared to treatment CG_1 and CG_2. The treatment CG_4 (CG_4= Cake with 20% jackfruit seed flour of 0.82mm particle size) showed peak force as 0.569N. The second peak were not that developed in CG_2 and CG_4 as compared to CG_1 and CG_3. It shows that as particle size of jackfruit seed flour increases the force required to penetrate into the cake increases. If the penetration force is more means the softness of the cake is less. The result indicates that the cake with larger particle sizes jackfruit seed flour are harder compared to the smaller particle size of jackfruit seed flour.



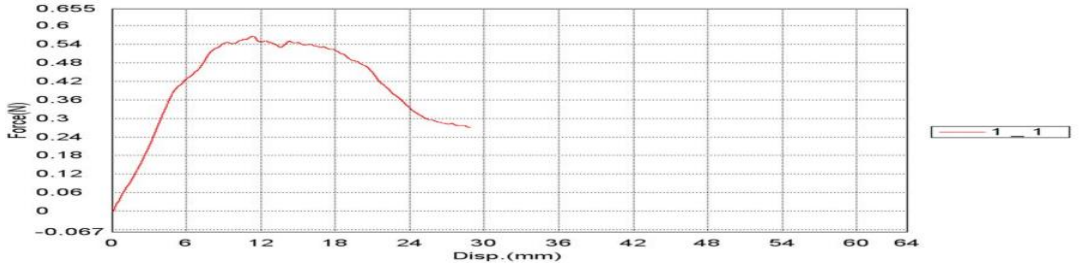
(a)



(b)



(c)



(d)

Fig 4.7 Texture analysis of cake prepared with different particle size of jackfruit seed flour using fixed type penetration rod a) CG_1 b) CG_2 c) CG_3 d) CG_4

4.4.2.9 Colour measurement of cake

The colour of cake were measured on Colour Scanning Machine. The result obtained in this machine was in terms of L^*, a^* and b* values. After calibration the cake were placed on the machine one by one and the colour values noted down. The cake of treatment CG_1 (CG_1 = Cake with 20 % jackfruit seed flour of 0.69 mm particle size) gave L^* value as 65.65, a^* value as -0.307 and b^* values as 19.413. It indicates that the cake is light in colour, inclined toward little redness and yellowness. The second cake with treatment CG_2 (CG_2 = Cake with 20% jackfruit seed flour of 0.73 mm particle size) shows comparative less lightness, more redness and almost some yellowness. The cake of treatment CG_3 (CG_3 = Cake with 20% jackfruit seed flour of 0.77 mm particle size) shows more lightness, less redness and more yellowness. Compared with treatment CG_1 and CG_2 it was more lighter and less red. The cake of treatment CG_4 has shown yellowness same as previous three treatments, while the redness is higher (0.656). It is more lighter than CG_2 and CG_1 and less lighter than CG_3. The colour values shows that the cake with particle size of jackfruit seed flour as 0.73mm i.e. smallest shown light in colour.

Table 4.25 Colour measurement of cake

Cake Treatment	Observations		
	L^*	a^*	b^*
CG_1	65.650	0.307	19.413
CG_2	63.469	0.203	18.002
CG_3	68.869	0.412	19.534
CG_4	67.140	0.656	19.775

4.4 Nutritional properties of baked product

The nutritional properties of baked product include the protein, fat, fiber, ash, moisture and carbohydrates.

4.4.1 Biscuit

Table No. 4.26 shows the nutritional properties (i. e. protein, fat, fibre and carbohydrate) of jackfruit seed flour based biscuit (BG_3)

Table 4.26 Nutritional properties of jackfruit seed flour based biscuit (BG_3)

Sr. No.	Properties (%)	Biscuit (BG_3)
1.	Moisture	4.06
2.	Protein	8.76
3.	Fat	28.67
4.	Fiber	0.75
5.	Carbohydrate	55.33
6.	Ash	2.68

The moisture content in biscuit were 4.06 %. Protein content of biscuit samples were 8.76%. The fat content in biscuit were 28.67 %. The fiber content in biscuit were 0.75 % and ash content of biscuit were 2.68 %. The carbohydrate content in biscuit were 55.33 %.

4.4.2 Cake

Table No. 4.27 shows the nutritional properties (i.e. protein, fat, fibre and carbohydrate) of jackfruit seed flour based cake (CG_2)

Table 4.27 Nutritional properties of jackfruit seed flour based cake (CG_2)

Sr. No.	Properties (%)	Cake (CG_2)
1.	Moisture	24.98
2.	Protein	12.50
3.	Fat	12.88
4.	Fiber	2.52
5.	Carbohydrate	49.14
6.	Ash	1.29

The moisture content in cake were 24.98 % respectively. Protein content cake were 12.50 %. The fat content in cake were 12.88 % respectively. The fiber content cake were 2.52 % and ash content cake were 1.29 %. The carbohydrate content in cake were 49.14

V. SUMMARY AND CONCLUSIONS

This chapter deals with the summary of the results obtained during the experimental work carried out and the conclusion from the research work. The present investigations were carried out in the NAIP Laboratory of Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra during 2017 and 2018. The study was "Studies on effect of particle size of jackfruit (Artocarpus heterophyllus L.) seed flour in baking."

The entire experiment was divided into three parts:

Part I : Determination of particle size of jackfruit seed flour made through different pulverizer sieves.

Part II : Incorporation of jackfruit seed flour with different concentration 10, 20, 30 and 40 percent in different baked products to finalize concentration.

Part III : Incorporation of jackfruit seed flour of different particle size 0.69 mm, 0.73 mm, 0.77 mm, 0.82 mm in different baked products to study the effect on their physical, sensory, textural properties.

5.1 Summary

The jackfruit seed were soaked in 5% sodium hydroxide solution for 3 to 5 mintes at 80º. The soaked jackfruit seeds were cut into small pieces. The soaked jackfruit cut seeds were dried from an initial moisture content of 101% (db) to 9.0% (db). The jackfruit seed slices were dried at 60ºC in 12h.

The jackfruit seed were grinded in pulverizer using four different sieves. The particle size of jacjfruit seed flour were determined by sieve analysis. The particle size of jackfruit seed flour taken were 0.69mm, 0.73mm, 0.77mm and 0.82mm obtained from pulverizer sieves (no. 0, 1, 2 and 3 respectively).

The flour combinations for baked product for biscuit (B_1 to B_4) and for cake (C_1 to C_4) with refined wheat flour and jackfruit seed flour in praportions of 90:10, 80:20, 70:30, 60:40. For mixing of dough and batter of biscuit and cake planetary mixer were used. The baking temperature for biscuit and cake were 170ºC and 180ºC respectively. The time required for baking of biscuit and cake were 20 and 30 minutes respectively. Convection oven was used for baking of biscuit and cake.

Optimum combination of flour composition for biscuit (B_1 to B_4) and for cake (C_1 to C_4), is based on the desirable sensory properties of biscuit and cake i.e. appearance,

crispiness, sponginess, texture, colour, taste, overall acceptability. The treatment B_2 of biscuit (refined wheat flour: jackfruit seed flour- 80:20) had the maximum sensory scores i.e. appearance 6.3, colour 6.9, texture 7.0, crispiness 6.5, taste 6.9 and overall acceptability 7.5. The treatment C_2 of cake (refined wheat flour: jackfruit seed flour- 80:20) had the maximum sensory scores i.e. appearance 6.7, colour 7.1, texture 7.2, sponginess 7.1, taste 6.9 and overall acceptability 7.0. So the flour composition of refined wheat flour to jackfruit seed flour (80:20) was finalized for further experimentation.

The particle size of jackfruit seed flour for baked product (BG_1 to BG_4 for biscuit and CG_1 to CG_4 cake) were 0.69mm, 0.73mm.0.77mm and 0.82mm. For mixing of dough and batter of biscuit and cake planetary mixer were used. The time requited for mixing of dough and batter of biscuit and cake were 10 min and 20 min (at 30 rpm), respectively. The baking temperature for biscuit and cake were 170ºC and 180ºC, respectively. The time required for baking of biscuit and cake were 20 and 30 minutes, respectively. Convection oven was used for baking of biscuit and cake.

Optimum particle size of jackfruit seed flour incorporated in baked product (BG_1 to BG_4 for biscuit and CG_1 to CG_4 cake), is based on the desirable sensory, physical, textural properties of biscuit and cake i.e. appearance, crispiness, sponginess texture, colour, taste, overall acceptability. The treatment BG_2 (refined wheat flour: jackfruit seed flour- 80:20, jackfruit seed flour particle size -0.73mm) and BG_3 (refined wheat flour: jackfruit seed flour- 80:20, jackfruit seed flour particle size -0.77mm) was found at par. The treatment BG_2 of biscuit (refined wheat flour: jackfruit seed flour- 80:20, jackfruit seed flour particle size -0.73mm) had the sensory scores i.e. appearance 6.96, colour 7.3, texture 6.86, crispiness 7.1, taste 7.1 and overall acceptability 7.3 out of 9. The treatment BG_3 of biscuit (refined wheat flour: jackfruit seed flour- 80:20, jackfruit seed flour particle size -0.77mm) had maximum sensory scores i.e. appearance 6.93, colour 7.13, texture 6.83, crispiness 7.26, taste 7.06 and overall acceptability 7.32 out of 9. The treatment had nearly same sensory scores in sensory evaluation for cake product. The treatment CG_2 of cake (refined wheat flour: jackfruit seed flour- 80:20 and particle size of jackfruit seed flour – 0.73mm) had the maximum sensory scores i.e. appearance 7.16, colour 7.1, texture 7.3, sponginess 7.2, taste 7.63 and overall acceptability 7.72 out of 9.

The physical dimensions of biscuit were determined. The biscuit diameter, thickness and spread ration varies from 42.74 to 47.98 mm, 8.32 to 6.91mm

and 4.94 to 7.40 respectively. The biscuit treatment BG_1 showed minimum diameter and maximum thickness while treatment G_4 had maximum diameter and minimum thickness. It could be concluded that the spread ratio of biscuit increased with increases in particle size on incorporation of jackfruit seed flour. In textural analysis the BG_3 treatment BG_3 required lowest peak force to break biscuit. Also in colour analysis the treatment has good value of L^*, a^* and b^*. So according subjective and objective method of analysis the treatment BG_3 is was found as best treatment. The nutritional composition of biscuit treatment BG_3 had moisture 4.06%, protein 8.7%, fat 28.67%, crude fiber 0.75%,, carbohydrate 55.33% and ash content 2.68%.

The weight of cake varied between 3.15g and 336g for all treatments (CG_1 to CG_4). The cake weight was maximum (336g) in treatment CG_2 and minimum (315g) in cake treatment CG_3. The volume of cake varied between 567.77cm^3 and 626.97cm^3 for all treatments (CG_1 to CG_4). The cake volume was maximum (626.97 cm^3) in treatment CG_3 and minimum (567.77 cm^3) in cake treatment CG_1. The specific volume of cake varied between 1.69cm^3/g and 1.99cm^3/g for all treatments (CG_1 to CG_4). The cake specific volume was maximum (1.99cm^3/g) in treatment CG_3 and minimum (1.69cm^3/g) in cake treatment CG_1. The density of cake varied between 0.52g/cm^3 and 0.59g/cm^3 for all treatments (CG_1 to CG_4). The cake density was maximum (0.59g/cm^3) in treatment CG_1 and minimum (0.52g/cm^3) in cake treatment CG_4. The volume index of cake varied between 13.4 and 15 for all treatments (CG_1 to CG_4). The cake volume index was maximum (15) in treatment CG_3 and minimum (13.4) in cake treatment CG_1. The symmetry index of cake varied between -1.8 and -0.9 for all treatments (CG_1 to CG_4). The cake symmetry index was maximum (-0.9) in treatment CG_2 and minimum (-1.8) in cake treatment CG_3. The uniformity index of cake varied between -0.2 and 0.3 for all treatments (CG_1 to CG_4). The uniformity index of cake for treatment CG_1 was ranges from -0.2 to 0.2, for CG_2 from -0.2 to -0.1, for CG_3 from -0.1 to 0.2, for CG_4 from -0.2 to 0.3 respectively. The cake uniformity index was maximum (0.3) in treatment CG_4 and minimum (-0.2) in cake treatment CG_1, CG_2, CG_4. The texture of cake treatment BG_2 required peak force 0.531 N which was less than other treatment. The second cake with treatment CG_2 shows comparative less lightness, more redness and almost some yellowness. So according to subjective and objective method of analysis the treatment BG_3 of biscuit and treatment CG_2 of cake has found as best treatment. The cake treatment CG_2 has optimum nutritional properties i.e. moisture 24.98%, protein 12.50%, fat 12.88%, crude fiber 2.52%,, carbohydrate 49.14% and ash content 1.29%.

5.2 Conclusions

(1) The overall acceptability for biscuits and cake obtained using 20% jackfruit seed flour and 80% refined wheat flour was more compared to other treatments.

(2) The biscuit with treatment BG_3 (proportion of refined wheat flour: jackfruit seed flour as 80:20, jackfruit seed flour particle size as 0.77mm) gave highest sensory scores *viz.,* appearance 6.93, colour 7.13, crispiness 7.26, texture 6.83, taste 7.06 and overall acceptability 7.32 among all the treatments.

(3) The biscuit with treatment BG_3 (proportion refined wheat flour: jackfruit seed flour as 80:20, jackfruit seed flour particle size as 0.77mm) has optimum nutritional properties i.e., moisture 4.06%, protein 8.7%, fat 28.67%, crude fiber 0.75%,, carbohydrate 55.33% and ash content 2.68%.

(4) The cake with treatment CG_2 (proportion of refined wheat flour: jackfruit seed flour as 80:20 and particle size of jackfruit seed flour as 0.73mm) gave highest sensory scores *viz*., appearance 7.16 , colour 7.50, sponginess 7.20, texture 7.33, taste 7.63 and overall acceptability 7.72 among the treatments.

(5) The cake with treatment CG_2 (proportion of refined wheat flour: jackfruit seed flour as 80:20 and particle size of jackfruit seed flour as 0.73mm) has optimum nutritional properties *viz*., moisture 24.98%, protein 12.50%, fat 12.88%, crude fiber 2.52%, carbohydrate 49.14% and ash content 1.29%.

(6) The biscuit prepared with 20% jackfruit seed flour and 80% refined wheat flour having particle size of jackfruit seed flour as 0.77mm was found best among the treatments.

(7) The cake prepared with 20% jackfruit seed flour and 80% refined wheat flour having particle size of jackfruit seed flour as 0.73mm was found best among the treatments.

APPENDIX A

Appendix A: Particle Size of jackfruit seed flour

Appendix A.I: Particle Size of jackfruit seed flour (Flour obtained from sieve no. 0)

	IS Sieve No	Sieve Size		Weight of material retained on screen	Percentage material retained on screen	Finess modulus	Average Particle size, mm
Replication 1	100	0.85	7	0.1	0.28	5.265	0.698
	70	0.3	6	74	177.6		
	50	0.15	5	170	340		
	40	0.125	4	5	8		
	30	0.106	3	0.5	0.6		
	20	0.053	2	0.1	0.08		
	15	0.043	1	0	0		
	pan		0	0	0		
	Total			249.7	526.56		
Replication 2	100	0.85	7	0	0	5.263	0.697
	70	0.3	6	83	199.2		
	50	0.15	5	157	314		
	40	0.125	4	8	12.8		
	30	0.106	3	0.2	0.24		
	20	0.053	2	0.1	0.08		
	15	0.043	1	0	0		
	pan		0	0	0		
	Total			248.3	526.32		
Replication 3	100	0.85	7	0.1	0.28	5.265	0.697
	70	0.3	6	85	204		
	50	0.15	5	155	310		
	40	0.125	4	7	11.2		
	30	0.106	3	0.8	0.96		
	20	0.053	2	0.1	0.08		
	15	0.043	1	0	0		
	pan		0	0	0		
	Total			248	526.52		
Average Particle Size							0.698

Appendix A.II: Particle Size of jackfruit seed flour (Flour obtained from sieve no. 1)

	IS Sieve No	Sieve Size		Weight of material retained on screen	Percentage material retained on screen	Finess modulus	Average Particle size, mm
Replication 1	100	0.85	7	0.36	1.008	5.433	0.735
	70	0.3	6	118	283.2		
	50	0.15	5	124	248		
	40	0.125	4	6.18	9.888		
	30	0.106	3	1	1.2		
	20	0.053	2	0.122	0.0976		
	15	0.043	1	0	0		
	pan		0	0	0		
	Total			249.662	543.3936		
Replication 2	100	0.85	7	0.2	0.56	5.419	0.731
	70	0.3	6	124	297.6		
	50	0.15	5	110	220		
	40	0.125	4	14	22.4		
	30	0.106	3	1	1.2		
	20	0.053	2	0.2	0.16		
	15	0.043	1	0	0		
	pan		0	0	0		
	Total			249.4	541.92		
Replication 3	100	0.85	7	0.22	0.616	5.411	0.730
	70	0.3	6	122	292.8		
	50	0.15	5	116	232		
	40	0.125	4	8.3	13.28		
	30	0.106	3	2	2.4		
	20	0.053	2	0.1	0.08		
	15	0.043	1	0	0		
	pan		0	0	0		
	Total			248.62	541.176		
Average Particle Size							0.732

Appendix A.III: Particle Size of jackfruit seed flour (Flour obtained from sieve no.2)

	IS Sieve No	Sieve Size		Weight of material retained on screen	Percentage material retained on screen	Finess modulus	Average Particle size
Replication 1	100	0.85	7	3.48	9.744	5.517	0.754
	70	0.3	6	142	340.8		
	50	0.15	5	92	184		
	40	0.125	4	9	14.4		
	30	0.106	3	2	2.4		
	20	0.053	2	0.5	0.4		
	15	0.043	1	0.1	0.04		
	pan		0	0	0		
	Total			249.08	551.784		
Replication 2	100	0.85	7	3.883	10.8724	5.647	0.785
	70	0.3	6	163	391.2		
	50	0.15	5	78	156		
	40	0.125	4	3.5	5.6		
	30	0.106	3	0.802	0.9624		
	20	0.053	2	0.1	0.08		
	15	0.043	1	0	0		
	pan		0	0	0		
	Total			249.285	564.7148		
Replication 3	100	0.85	7	3.5	9.8	5.622	0.779
	70	0.3	6	158	379.2		
	50	0.15	5	82	164		
	40	0.125	4	4.6	7.36		
	30	0.106	3	1.5	1.8		
	20	0.053	2	0.1	0.08		
	15	0.043	1	0	0		
	pan		0	0	0		
	Total			249.7	562.24		
Average Particle Size							0.773

Appendix A.IV: Particle Size of jackfruit seed flour (Flour obtained from sieve no.3)

	IS Sieve No	Sieve Size		Weight of material retained on screen	Percentage material retained on screen	Finess modulus	Average Particle size, mm
Replication 1	100	0.85	7	20.343	56.9604	5.755	0.812
	70	0.3	6	166	398.4		
	50	0.15	5	58	116		
	40	0.125	4	2	3.2		
	30	0.106	3	0.7	0.84		
	20	0.053	2	0.2	0.16		
	15	0.043	1	0	0		
	pan		0	0	0		
	Total			247.243	575.5604		
Replication 2	100	0.85	7	22.343	62.5604	5.822	0.829
	70	0.3	6	168	403.2		
	50	0.15	5	55	110		
	40	0.125	4	2.7	4.32		
	30	0.106	3	1.8	2.16		
	20	0.053	2	0	0		
	15	0.043	1	0	0		
	pan		0	0	0		
	Total			249.843	582.2404		
Replication 3	100	0.85	7	22.06	61.768	5.791	0.821
	70	0.3	6	170	408		
	50	0.15	5	52	104		
	40	0.125	4	2.2	3.52		
	30	0.106	3	1.5	1.8		
	20	0.053	2	0.1	0.08		
	15	0.043	1	0	0		
	pan		0	0	0		
	Total			247.86	579.168		
Average Particle Size							0.821

APPENDIX B

Appendix B: Sensory Evaluation of baked product

Appendix B.I: Sensory Evaluation Score Sheet for biscuit

Sample code	Appearance	Colour	Crispiness	Texture	Taste	Overall acceptability
110						
111						
112						
113						

Name : ..... Age : .....

Biscuits

Score index and degree of liking

Like Extremely - 9

Like Very Much - 8

Like Moderately - 7

Like Slightly - 6

Neither Like Nor Dislike - 5

Dislike Slightly - 4

Dislike Moderately - 3

Dislike Very Much - 2

Dislike Extremely - 1

Signature

Appendix B.II: Sensory Evaluation Score Sheet for cake

Name : ..... Age : .....

Cake

Sample code	Appearance	Colour	Crispiness	Texture	Taste	Overall acceptability
110						
111						
112						
113						

Score index and degree of liking

Like Extremely - 9

Like Very Much - 8

Like Moderately - 7

Like Slightly - 6

Neither Like Nor Dislike - 5

Dislike Slightly - 4

Dislike Moderately - 3

Dislike Very Much - 2

Dislike Extremely - 1

Signature

APPENDIX C

Appendix C: Data of Sensory evaluation of biscuits

Appendix C.I: Sensory evaluation of biscuit (% of jackfruit seed flour)

Sample Code	Flour composition (Refined wheat flour: jackfruit seed flour)	Sensory Parameters					
		Appearance	Colour	Crispiness	Texture	Taste	Overall Acceptability
B_1	90:10	6.0	6.5	6.3	6.5	6.7	7.3
B_2	80:20	6.3	6.9	6.5	7	6.9	7.5
B_3	70:30	6.5	7	6.3	4.0	5.2	5.8
B_4	60:40	6.6	7.1	6.2	4.6	4.6	4

Appendix C.II: Sensory evaluation of biscuit (particle size of jackfruit seed flour)

Sample Code	Flour composition (Refined wheat flour: jackfruit seed flour)	Particle size of jackfruit seed flour, mm	Sensory Parameters					
			Appearance	Colour	Crispiness	Texture	Taste	Overall Acceptability
BG_1	80:20	0.69	6.96	7.15	6.75	6.59	7.06	6.91
BG_2	80:20	0.73	6.96	7.30	7.10	6.86	7.10	7.30
BG_3	80:20	0.77	6.93	7.13	7.26	6.83	7.06	7.32
BG_4	80:20	0.82	6.90	6.83	7.13	6.53	6.60	6.64

APPENDIX D

Appendix D: Physical properties of biscuits

Treatment	Replication	Raw biscuit			Baked biscuit		
		Diameter	Thickness	Spread ration	Diameter	Thickness	Spread ration
BG1	1	40	7.5	5.333	43.55	8.69	5.011
	2	40	7.5	5.333	40.71	8.24	4.940
	3	40	7.5	5.333	44.17	8.81	5.013
	4	40	7.5	5.333	41.69	8.36	4.986
	5	40	7.5	5.333	43.61	8.5	5.130
Avg		**40**	**7.5**	**5.333**	**42.74**	**8.52**	**5.016**
BG2	1	40	7.5	5.333	46.41	8.03	5.779
	2	40	7.5	5.333	45.68	7.64	5.979
	3	40	7.5	5.333	44.95	9.08	4.950
	4	40	7.5	5.333	44.36	8.16	5.436
	5	40	7.5	5.333	45.88	7.67	5.981
Avg		**40**	**7.5**	**5.333**	**45.45**	**8.116**	**5.625**
BG3	1	40	7.5	5.333	46.23	7.25	6.376
	2	40	7.5	5.333	48.69	7.02	6.935
	3	40	7.5	5.333	47.71	7.14	6.682
	4	40	7.5	5.333	44.79	7.56	5.924
	5	40	7.5	5.333	47.82	7.1	6.735
Avg		**40**	**7.5**	**5.333**	**47.04**	**7.214**	**6.530**
BG4	1	40	7.5	5.333	48.84	7	6.977
	2	40	7.5	5.333	48.89	7.1	6.885
	3	40	7.5	5.333	48.87	6.87	7.113
	4	40	7.5	5.333	46.23	7.25	6.376
	5	40	7.5	5.333	47.07	6.36	7.400
Avg		**40**	**7.5**	**5.333**	**47.98**	**6.916**	**6.950**

APPENDIX E

Appendix E: Sensory evaluation of cake

Appendix E.I: Sensory evaluation of cake (% of jackfruit seed flour)

Sample Code	Flour composition (Refined wheat flour: jackfruit seed flour)	Sensory Parameters					
		Appearance	Colour	Sponginess	Texture	Taste	Overall Acceptability
C_1	90:10	6.9	6.5	7.3	7.4	7.2	7.4
C_2	80:20	6.7	7.1	7.1	7.5	7.4	7
C_3	70:30	6.5	6.8	6.5	6.5	6.2	6.8
C_4	60:40	6.6	6.9	6.2	6.3	6	6

Appendix E.II: Sensory evaluation of cake (particle size of jackfruit seed flour)

Sample Code	Flour composition (Refined wheat flour: jackfruit seed flour)	Particle size of jackfruit seed flour, mm	Sensory Parameters					
			Appearance	Colour	Sponginess	Texture	Taste	Overall Acceptability
CG_1	80:20	0.69	6.83	6.96	7.10	7.10	7.23	7.05
CG_2	80:20	0.73	7.16	7.50	7.20	7.33	7.63	7.72
CG_3	80:20	0.77	7.06	7.36	7.00	7.03	7.36	7.34
CG_4	80:20	0.82	7.01	7.45	6.91	6.88	7.35	7.14

APPENDIX F

Appendix F: Physical properties of cake

Appendix F. I : Volume of cake

Treatment	Replication	H, cm	B, cm	D, cm	H, cm	R, cm	r2, cm^2	Volume, cm^3
CG1	1	5.2	4	4.2	3.3	6.5	42.25	567.7772
	2	5.6	4.6	4.4	3.6	6.5	42.25	614.837
	3	5.2	4.2	4.2	3.3	6.5	42.25	567.7772
	Avg	**5.333333**	**4.266667**	**4.266667**	**3.4**	**6.5**	**42.25**	**583.4638**
CG2	1	5.4	4.3	4.4	3.6	6.5	42.25	600.4268
	2	5.5	4.2	4.2	3.5	6.5	42.25	601.5621
	3	5.4	4.2	4.4	3.6	6.5	42.25	600.4268
	Avg	**5.433333**	**4.233333**	**4.333333**	**3.566667**	**6.5**	**42.25**	**600.8052**
CG3	1	5.6	4.8	4.6	3.8	6.5	42.25	626.9767
	2	5.5	4.6	4.4	3.4	6.5	42.25	595.585
	3	5.5	4.5	4.6	3.4	6.5	42.25	595.585
	Avg	**5.533333**	**4.633333**	**4.533333**	**3.533333**	**6.5**	**42.25**	**606.0489**
CG4	1	5.4	4.6	4.3	3.6	6.5	42.25	600.426
	2	5.6	4.4	4.4	3.6	6.5	42.25	614.837
	3	5.3	4.4	4.6	3.8	6.5	42.25	605.777
	Avg	**5.433333**	**4.466667**	**4.433333**	**3.666667**	**6.5**	**42.25**	**607.0138**

Appendix F.II : Volume, weight, specific volume and density, volume index, symmetry index and uniformity index of cake

Treatment	Replication	Volume	Weight of cake	Specific volume	Density	Volume index	Symmetrical index	Uniformity index
CG1	1	567.7772	335	1.694857	0.59002	13.4	-1	-0.2
	2	614.837	328	1.874503	0.533475	14.6	-1.4	0.2
	3	567.7772	319	1.779866	0.56184	13.6	-1.2	0
	Avg	**583.4638**	**327**	**1.784293**	**0.560446**	**13.86667**	**-1.2**	**0**
CG2	1	600.4268	324	1.853169	0.539616	14.1	-1.3	-0.1
	2	601.5621	336	1.790363	0.558546	13.9	-0.9	0
	3	600.4268	330	1.819475	0.549609	14	-1.2	-0.2

	Avg	**600.8052**	**330**	**1.850622**	**0.549263**	**14**	**-1.13333**	**-0.1**
CG3	1	610.368	315	1.937676	0.516082	15	-1.8	0.2
	2	595.585	330	1.804803	0.554077	14.5	-1.5	0.2
	3	595.585	328	1.815808	0.550719	14.6	-1.6	-0.1
	Avg	**606.0489**	**324**	**1.870521**	**0.53461**	**14.7**	**-1.63333**	**0.1**
CG4	1	600.426	316	1.842753	0.542666	14.3	-1.5	0.3
	2	614.837	324	1.897645	0.526969	14.4	-1.2	0
	3	605.777	332	1.824631	0.548056	14.3	-1.7	-0.2
	Avg	**607.0138**	**324**	**1.883499**	**0.533761**	**14.33333**	**-1.46667**	**0.033333**