EXTRACTION OF GUM FROM TAMARIND (*Tamarindus indica*) SEED AND ITS CHARACTERIZATION

M.Tech. (Agril. Engg.) Thesis

by

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EXTRACTION OF GUM FROM TAMARIND (*Tamarindus indica*) SEED AND ITS CHARACTERIZATION

Thesis

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Rajiv Kumar Kurrey

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CERTIFICATE - I

This is to certify that the thesis entitled **"Extraction of gum from tamarind (*Tamarindus indica*) seed and its characterization"** submitted in partial fulfilment of the requirements for the degree of **Master of Technology in Agricultural Engineering** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Rajiv Kumar Kurrey** under my/our guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma or certificate course. All the assistance and help received during the course of the investigations have been duly acknowledged.

Dharmendra

Chairman

Date: 24.10.2019

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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Member (Er. N. K. Mishra)	

CERTIFICATE - II

This is to certify that the thesis entitled **"Extraction of gum from tamarind (*Tamarindus indica*) seed and its characterization"** submitted by **Rajiv Kumar Kurrey** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfilment of the requirements for the degree of **Master of Technology in Agricultural Engineering** in the department of Agricultural Processing and Food Engineering has been approved by the external examiner and Student's Advisory Committee after oral examination.

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Approved/Not approved

Director of Instructions

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(Rajiv Kumar Kurrey)

Date: 24.10.2019

Place: Raipur

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF NOTATIONS

Notations	Description
%	Percent
&	And
-	Minus
+	Plus
±	Plus-Minus
*	Multiple
ε	Porosity
θ	Angle of repose
π	Pie
°C	Degree celsius
$\rho 1$	Density of water
$\rho 2$	Density of gum sample
ρb	Bulk density
ρt	True density
ρtp	Tapped density
γ1	Surface tension of water
γ2	Surface tension of gum
g	gram
cm	centimeter
cPs	centipoise
Dg	Geometric mean diameter
h	hour
H	Height
i.e.	That is
in	inch
kg	kilogram
L	Length
m	meter

min.	minute
ml	milliliter
mm	millimeter
n1	number of drop of water
n2	number of drop of gum solution
r	radius
SD	Standard Deviation
Sp	Sphericity
T	Thickness
V	Volume
Vd	Displaced volume
viz.	Namely
Vt	Tapped volume
w	width
X_o	Volume of Sample
Xt	Volume of swollen gum

LIST OF ABBREVIATIONS

Abbreviation	Description
Agril.	Agricultural
Agri.	Agriculture
AICRP	All India Coordinated Research Project
AOAC	Association of Official Analytical Chemist
ANOVA	Analysis of Variance
Avg.	Average
C.G.	Chhattisgarh
TSG	Tamarind Seed Gum
Engg.	Engineering
et al.	et alibi
etc.	etcetera
FAE	Faculty of Agricultural Engineering
Fig.	Figure
ICAR	Indian Council of Agricultural Research
IGKV	Indira Gandhi KrishiVishwavidyalaya
M.Tech	Master of Technology
NTFP	Non-Timber Forest Product
PHET	Post-Harvest Engineering and Technology
rpm	revolution per minute
temp	temperature

THESIS ABSTRACT

Title of the Thesis	:	Extraction of Gum from Tamarind (*Tamarindus indica*) Seed and its Characterization
Full Name of the Student	:	Rajiv Kumar Kurrey
Major Subject	:	Agricultural Processing and Food Engineering
Name and Address of the Major Advisor	:	Dr. D. Khokhar Scientist Department of Agricultural Processing and Food Engineering, SVCAET & RS, FAE, IGKV, Raipur (CG)
Degree to be Awarded	:	Master of Technology in Agricultural Engineering

Signature of the Student

Dharmendra 24.10.19

Signature of Major Advisor

Date: 24.10.19

Signature of Head of the Department

ABSTRACT

Chhattisgarh is a one of the major producer state of tamarind. Tamarind seed is mostly produce in rural areas of Jagdalpur, Dantewada, Kanker districts. Tamarind is commonly known as Imli. Tamarind is a nutritional fruit, having high value in vitamins B1, B2, B3. After extraction of tamarind pulp, seed remain as by product having higher carbohydrate content. Normally the seed is used as animal feed after grinding. Tamarind seed gum can be obtained from the endosperm of

tamarind seed. It is used as gelling agent, thickener, stabilizer and binder in food and pharmaceutical industries.

Therefore, the study was aimed to optimize the roasting parameter for gum extraction from tamarind seed *(Tamarindus indica)* and its characterization. Physicochemical properties of tamarind seed, bulk density, tapped density, true density and porosity were 0.739 g/cm^3, 0.777 g/ cm^3, 1.322 g/ cm^3 and 44.019 respectively. The test weight & volume of 100 seed was found to 79.797 g and 108.6 cm^3 respectively. The geometric mean diameter, length, width, thickness, and sphericity found to be 10.020 mm, 14.287 mm, 11.26 mm, 6.305 mm and 0.705 respectively. Compressibility index and Hausner's ratio of tamarind seed powder was found to 18.059 % and 1.221 respectively. Swelling index of tamarind seed powder was found to be 93.49%, pH of 1% tamarind seed powder solution was 5.32.

Tamarind seed contains testa and endosperm. During the experiment testa was removed after roasting the tamarind seed. Only the endosperm, which contains mainly polysaccharides, was used for the production of the tamarind seed gum. Testa was separated from endosperms by scratching between cylinder and concave after roasting the seed. The seeds (500 g) sample of tamarind was roasted at 100 ºC to 200 ºC for 5, 7.5, 10 min. Maximum (55.06 %) endosperm was obtained from the seed roasted at 140 ºC for 5 min and minimum (31.58 %) endosperm was obtained from the seed roasted at 100 º C for 5 min. Maximum testa was found to be 38.05 % in the sample roasted at 180 ºC for 5 min and minimum testa was found to be 21.38% in the sample roasted at 100 ºC for 5 min. Maximum broken was found 11.90 % in the sample roasted at 200 ºC for 10 min and minimum broken was found 1.76 % in the sample roasted at 100 ºC for 7.5 Min.

Tamarind gum extraction method was based on mechanical separation of testa from endosperm, water dissolution of seed powder, centrifugation & precipitation of gum with acetone. The tamarind gum extraction was carried out from the samples treated at different temperature and time. Extracted tamarind gum is odourless having the characteristics taste. Tamarind gum is light brownish in colour with rough texture. The maximum (54.5 %) gum yield was recorded from the sample roasted at 140 ºC for 5 min and minimum (28 %) was recorded from the sample roasted at 200 ºC for 10 min.

Analysis of physico-chemical properties of tamarind gum extracted from the sample roasted at 140 °C for 5 min indicate that bulk and tapped density, compressibility (carr's) index, hausner's ratio, pH, swelling index and surface tension were 0.497g/cm^3, 0.565g/ cm^3, 8.537 %, 1.093, 2.11, 225%, 49.611 dynes/cm.

The extracted gum is soluble in cold & hot water and insoluble in ethanol methanol & acetone .The purity of gum observed by the alkaloid test which is absent and carbohydrate was estimated 58.60 %. Hence, roasting temperature 140°C for 5 min is better in terms of endosperm recovery and gum yield.

शोध का शीर्षक	:	इमली (टैमेरिन्डस इंडिका) के बीज से गोंद का निष्कर्षण और इसकी विशेषता
छात्र का पूरा नाम	:	राजीव कुमार कुर्रे
प्रमुख विषय	:	कृषि प्रसंस्करण और खाद्य अभियांत्रिकी
प्रमुख सलाहकार का नाम	:	डॉ. डी. खोखर वैज्ञानिक कृषि प्रसंस्करण और खाद्य अभियांत्रिकी विभाग एस. वी. सी. ए. ई. टी. और आर. एस., कृषि अभियांत्रिकी संकाय, आई. जी. के. वी., रायपुर (छ. ग.)
डिग्री से सम्मानित किया जाना है	:	कृषि अभियांत्रिकी में प्रौद्योगिकी स्नानकोत्तार

छात्र का हस्ताक्षर

प्रमुख सलाहकार का हस्ताक्षर Dharmendra 24.10.19

विभागाध्यक्ष का हस्ताक्षर

तारीख: 24.10.19

सारांश

छत्तीसगढ़ इमली के प्रमुख उत्पादक राज्य में से एक है। इमली का उत्पादन ज्यादातर जगदलपुर, दंतेवाड़ा, कांकेर जिलों के ग्रामीण क्षेत्र में होता है। टैमेरिन्डस इंडिका को आमतौर पर इमली के रूप में जाना जाता है। इमली एक पोषक फल है, जिसमे विटामिन बी1, बी2, बी3 उच्च मात्रा में पाय जाते है। इमली के गूदे को निकालने के बाद, बीज एक उच्च कार्बोहाइड्रेट सामग्री वाले व्युत्पाद के रूप में रहता है। आमतौर पर बीज को पीसने के बाद पशु आहार या ईंधन के रूप में उपयोग किया जाता है। इमली के बीज के

एंडोस्पर्म से इमली का गोंद प्राप्त किया जा सकता है। इसका उपयोग खाद्य और दवा उद्योगों में जेलिंग एजेंट, थिकनर, स्टेबलाइजर और बाइंडर के रूप में किया जाता है।

अध्ययन का उद्देश्य इमली के बीज (टैमेरिन्डस इंडिका) से गोंद निकालने के लिए अनुकूलन पैरामीटर एवं उसके लक्षण का वर्णन करना था। इमली के बीज के भौतिक और रासायनिक गुण जैसे– बल्क घनत्व, टैप किए गए घनत्व, वास्तविक घनत्व और पोरोसिटी क्रमशः 0.739 ग्राम/सेंटीमीटर^3, 0.777 ग्राम/सेंटीमीटर^3, 1.322 ग्राम/सेंटीमीटर^3 और 44.019 थे। 100 बीज का परीक्षण वजन और मात्रा क्रमशः 79.797 ग्राम और 108.6 सेंटीमीटर^3 पायी गई । ज्यामितीय माध्य व्यास, लंबाई, चौड़ाई, मोटाई और गोलाकारता क्रमशः 10.02 मिमी, 14.28 मिमी, 11.26 मिमी, 6.30 मिमी और 0.70 पाई गई। इमली के बीज के पाउडर का संपीड़न सूचकांक और हसनर का अनुपात क्रमशः 18.059 और 1.221 पाया गया। इमली बीज पाउडर का स्वेलिंग इंडेक्स (फूलना) 93.492 % पाया गया। 1 % इमली बीज पाउडर के विलयन का पीएच 5.32 था।

इमली के बीज में टेस्टा और एंडोस्पर्म होता है। एंडोस्पर्म को इमली के बीज के भुनने के बाद प्रयोग परीक्षण के दौरान निकाला गया था, जिसमें मुख्य रूप से पॉलीसेकेराइड होते हैं, उनको इमली के बीज से गोंद के उत्पादन के लिए उपयोग किया जाता है। बीज को भूनने के बाद रोलर के बीच खरोंच करके टेस्टा को अलग किया गया। इमली के बीज 500 ग्राम नमूने को 100 ºC से 200 ºC पर 5 मिनट, 7.5 मिनट, 10 मिनट के लिए भुना गया। 5 मिनट 140 ºC पर भुना हुआ नमूना में अधिकतम एंडोस्पर्म (55.06 %) पाया गया और 5 मिनट 100 ºC पर भुने गए नमूने में न्यूनतम एंडोस्पर्म (31.58 %) पाया गया। अधिकतम टेस्टा 5 मिनट में 180 ºC पर भुना हुआ नमूना में (38.05 %) पाया गया और न्यूनतम टेस्टा 100 ºC पर 5 मिनट भुना हुआ नमूने में (21.38 %) पाया गया। अधिकतम टूटा हुआ नमूने 200 ºC पर 5 मिनट में (11.90 %) पाया गया और न्यूनतम टूटा हुआ नमूने 100 ºC पर 7.5 मिनट में (1.76 %) पाया गया

इमली के गोंद का निष्कर्षण एंडोस्पर्म के यांत्रिक पृथक्करण, जल विघटन, सेंट्रीफ्यूगेशन और संघनन पर आधारित था। इमली गोंद का निष्कर्षण प्रत्येक तापमान पर भुने हुए नमूने के लिए किया गया था। इमली का गोंद गंध रहित था। इमली का गोंद हल्के भूरे रंग और खुरदरा होता है। अधिकतम गोंद की मात्रा 140 ºC पर 5 मिनट में (54.5 %) और न्यूनतम 200 ºC पर 10 मिनट में (28 %) थी।

इमली गोंद के भौतिक रासायनिक गुणों में पाया गया कि बल्क और टैप किया गया घनत्व, संपीड़ितता सूचकांक, हसनर अनुपात, पीएच, स्वेलिंग इंडेक्स (फूलना)

और सतह तनाव 0.497 ग्राम/सेंटीमीटर^3, 0.565 ग्राम/सेंटीमीटर^3, 8.537, 1.0931, 2.11, 225%, 49.611 डायनस/सेमी क्रमशः 140 डिग्री सेल्सियस पर 5 मिनट भुना हुआ नमूना के लिए पाये गए।

निकाला गया गोंद ठंडे और गर्म पानी में घुलनशील पाया गया और इथेनॉल मेथनॉल और एसीटोन में अघुलनशील पाया गया । गोंद की शुद्धता का परीक्षण एल्कलाइड की अनुपस्थिति व् कार्बोहइड्रेट की उपस्थिति से किया गया। निष्कर्षित गोंद में एल्कलाइड अनुपस्थिति था एव कार्बोहइड्रेट 58.06 % पाया गया। अतः 140 डिग्री सेल्सियस 5 मिनट पर भुने गये बीज से सबसे अधिक एण्डोस्पर्म व् गोंद प्राप्त हुआ ।

CHAPTER-I
INTRODUCTION

The whole world interested in natural products and demand for plant based food ingredients, cosmetic products, medicines, health product etc. is growing in the national and international market.

Tamarind (*Tamarindus indica)* is also known as Imli. It has importance in agriculture due to its nutrition value (Mohite *et al.,* 2015). Tamarind, a beautiful fruiting tree grows up to 25- 30 meters long with dense spreading crown. It is a beneficial tree of which almost every part finds some uses either medicinal or nutritional. Tamarind is a member of dicotyledonous, belongs to leguminosae family. Tamarind fruit contains health benefiting essential minerals like copper, potassium, iron, high in vitamins $B_{1,}$ B_2 & B_3 these vitamins help to body converting food into energy (Yeasmen and Islam, 2015). Tamarind fruit pulp has a acidic taste due to a combination of high contents of reducing sugar & tartaric acid. Its gives the sour taste to food besides. Tamarind pulp is used for flavouring in many dishes, to flavour confections, sauces, candy and curries and is a main component in beverages and juices. Tamarind fruit pulp is used fresh and after made into a tamarind juice and can also be processed into sweets and jam. It is also used as a metal polish to remove tarnish from bronze and copper.

Tamarind originated in Africa but today tamarind grows generally in most tropical and subtropical regions worldwide (Yeasmen and Islam, 2015). The area of production is central African, republic Ethiopia, Guinea, Kenya, Nigeria, Sudan, Uganda, Afghanistan, Bangladesh, Brazil, Cambodia, China, Colombia, Malaysia, Mexico, Myanmar, Pakistan, Philippines, Shree Lanka, India & Thailand. India is largest producer of tamarind in the world (Singh *et al.,* 2007*).*

The preview of spice board, production of tamarind spice is 199860 metric ton during 2017-18 in India. It is particularly produced in Bihar, Andhra Pradesh, Madhya Pradesh, Tamil Nadu Karnataka, west Bengal & Chhattisgarh. Karnataka is largest producer of tamarind in India. In Chhattisgarh state, the annual collection of tamarind by minor forest produce co-operative Ltd. is 3544 tonnes which is used for deferent purpose like processing, selling to other state.

Farmer used to harvest tamarind pods by climbing the trees. Pods and shell is removed by hitting with small wooden piece or some industries used tamarind deseeding machine. After removing pods and shell, pulp are used in pulp industry.

Tamarind seed is a by product of the tamarind pulp industry. Tamarind seed consist of the seed coat or testa (25-30%) and the kernel and endosperm (70-75%). The composition of tamarind kernel contains 15.4% to 22.7% protein, 3 to 74% oil, 7 to 8.2% crude fibres, 61 to 72.2% non fibre carbohydrates, 2.45 to 3.3% ash when it measured on the dry basis (Gerarad, 1980).

Natural gums are polysaccharides consisting large sugar molecules. Gum is used as natural excipient for conventional and novel dosage forms. Many research works have carried out in food processing and pharmaceutical for using natural gum. Plant polysaccharides are a popular natural bio polysaccharide group, which are economically and easily available from the natural sources. Gum has diverse application as emulsifier, thickener, binder, sweeter etc. The synthetic polymer have disadvantages such as toxicity, high cost, pollution during synthesis, poor biocompatibility, non renewable sources but the natural gum is biodegradable, biocompatible & non toxics, low cost, local availability better patient tolerance as well as public acceptance (Goswami and Naik, 2014)

Tamarind gum also called as tamarind seed polysaccharide is a natural polysaccharide which is extracted from endosperm of tamarind seed. Tamarind seed is source of a high molecular weight polysaccharide, separated from tamarind seed powder contains glucose, xylose & galactose (Nayak and Pal, 2017).

Tamarind gum is finding more application in deferent industries. The most common use of tamarind seed as a sizing materials in jute and textile industry. Many Industries use the tamarind gum based materials for gelling agent, coating materials, emulsifier, thickener, cosmetic preparation, fabric detergents etc. Tamarind gum is commercially available as a food ingredient for improving the texture and viscosity of processed foods. Incorporation of tamarind gum affects the hardness, thickness and crispness of biscuits whiles the taste and flavours are unaffected.

In pharmaceutical, tamarind seed polysaccharide and its derivatives used as a pharmaceutical excipient as thickening agent, binder, emulsifier, adhesive agents due to their non carcinogenicity, biocompatibility, high drug holding capacity and high thermal stability can function as novel drug delivery system.

Gum extraction process required some pre-treatments such as roasting and removal of seed testa. Polysaccharide degradation due to heat during roasting is one of the major problems.

Work on tamarind gum extraction from tamarind seed has been carried out by few researchers. Detailed gum extraction process is not available for the gum extraction from tamarind seed. In view of the above a standardize process for the gum extraction by optimizing roasting parameter and maintaining gum quality is the need of the day. Therefore the present research work "**Extraction of gum from tamarind (*Tamarindus indica*) seed and its characterization"** is proposed with the following objective.

1. To analyze the physicochemical properties of tamarind seeds.
2. To standardize the gum extraction method from tamarind seeds.
3. To analyze the physicochemical properties of extracted tamarind gum.

CHAPTER-II
REVIEW OF LETRATURE

In this chapter, the previous work done on the processing methods of *Tamarindus indica*, the gum extraction and physicochemical properties of extracted gum are briefly enumerated. Gums are conventionally obtained from plant sources by incising stems or branches in the form of exudates. These gums normally contain polysaccharides which made up of galactose, xylose and glucose. These gums have wide industrial application in pharmaceutical, polymer, textile, rubber, and food confectionary industries. In pharmaceutical industry, the gums are widely used as incipient polymer, suspending and emulsifying agent are known examples.

The review of literature is divided into the following sub divisions.

2.1 Physical properties

2.2 Gum extraction

2.3 Physicochemical properties of gum

2.1 Physical Properties.

Akajiaku *et al*. (2014) studied the mineral, proximate and anti-nutrient composition of roasted & soaked Tamarind seed. For removing testa of tamarind seed soaking was done for 14 days in water & roasting of tamarind seed at 100 °C for 15 min. The mineral present were Na(40.1), K(144.0), P(94.4), Mg(268.0) and Fe(15.2) for roasted sample and were Na(38.2), K(480.0), P(99.4), Mg(220.0) and Fe(15.5) for the soaked sample in mg/100g. In proximate analysis of the soaked and roasted sample, the values of crude protein, moisture, fat, fibre, ash and carbohydrate contents present to be 22.16%, 10.5%, 7.05%, 6.15%, 4.05%, 56.24% and 22.57%, 8.00%, 6.80%, 6.30%, 4.55% and 56.24% respectively. The processing method (roasting) used, affected the nutritional and anti-nutritional composition. Roasting affects various anti-nutritional contents of tamarind seed without affecting the nutritional quality of tamarind seed.

Bagul *et al.* (2015) studied the chemical properties, health benefits and application of tamarind seeds which have to be used as a food ingredient, pharmaceutics, and industrial benefits. Chemical composition of tamarind seed constituent moisture contents is 9.4-11.3 %, protein is 13.2-26.9 %, Fat/oil is 4.5-16.2%, crude fibre is 7.4-8.8% and carbohydrate is 50.0-57.0%. Mineral content of tamarind seeds calcium, phosphorus, magnesium, potassium, sodium, copper, Iron, Zinc, are 9.3, 6.8, 17.5, 272.8, 19.2, 1.6, 65, 2.8mg/100g. Some health benefits of tamarind seed are heart disease, blood pressure, indigestion, diarrhoea, cancer, antibacterial activity. Tamarind seed was used in food industries as a gelling agent, food additive etc.

Bhattacharya *et al.* (1993) studied some physical and engineering properties of *Tamarindus indica* seed. Potassium was high in tamarind seed powder. The shape of the tamarind seed did not follow to any standard shapes. The length, breath, thickness, sphericity, roundness, surface area, average weight and volume per seed were 1.44±0.17cm, 1.05±0.09 cm, 0.63±0.08 cm, 0.73±0.03, 0.72±0.10, 5.37±0.69 cm^2, 0.69±0.15, and 0.48±0.09 cm^3 respectively. The bulk density of raw seed was 821-840 kg/m^3 slightly greater than that of roasted seed were 760-771 kg/m^3. The angle of repose of roasted seeds were (34°-39°) higher than that of the raw whole seeds (31°-35°).

Isa *et al. (*2018) analysed the efficiency of purification & water treatment process of tamarind seed. Tamarind fruit are used for several Nutritional, Herbal, foods and tamarind seeds are disposed as waste. Tamarind seed are used as agent of fluoride removal. Tamarind seed has reported to a effective detergent for treatment of industrial waste water. Many plant materials are reported to accumulate as fluoride removing agents. Tamarind seeds are used as bio sorbents. coagulation- flocculation of the wastewater sample using the tamarind seed powder with optimum pH of 7.2, capacity of COD removal of 97.01% and 24.86% respectively. The turbidity and COD removal of 97.78% and 43.50% were attained at optimum dosage of 400 mg/l. The ability of tamarind to remove fluoride from our water bodies, its antimicrobial properties including organisms and its coagulation potential makes it a good agent.

Ly *et al.* (2017) determine the effect of processing methods on nutrient and tannin content of *Tamarindus indica* seeds for four treatment in the experiment work following are sun dried seeds, Roasted seed, moistening 12 hours & 24 hours. Dry matter content in sun dried seeds kernels are 91.5% and roasted seed increase 7.83% dry matter content but moistening of 12 & 24 hour reduced 27% dry matter content of ground tamarind seeds. Crude protein are 16.2% in sun dried seed but roasted seed increased 1.9% crude protein content and moistening 12 & 24 hours increased 1.1% respectively & 1.4% crude protein content in seed sample. Fat content of sun dried seed was 7.06% but fat content 45.5% was reduced by roasting process but moistening 12 & 24 hours respectively improved 9.9% & 8.8% fat content. Tannin content is high in the tamarind husk 3620 mg/100 g and low 300 mg/100g in the kernel of seed.

Kumar and Bhattacharya (2008) studied on the possibilities of using the tamarind seed in different foods and non-food industries with particular reference to physical and engineering properties. They observed tamarind kernels powder contains 46% to 48% of a gel forming substance gelatinizes with sugar concentrates even in cold water or milk. Tamarind seed polysaccharide can be useful as a gel forming agent and may be alternative for fruit pectin. TKP finds extensive use as a sizing material in the textile & jute industries. Tamarind seed gum is used for finishing textile industries. Tamarind seed powder is used for finishing textiles and in the preparation of printing paste. Tamarind seed is a typical underutilized material. The excellent adhesive & gelling characteristics of tamarind seed powder possess several applications in food & pharmaceutical formulation.

Mohite *et al*. (2016) studied the equilibrium moisture content and drying behaviour of tamarind seed under different condition. Equilibrium moisture content were determined at three different temperature at 30°C, 50 °C, 70°C & three relative humidity (30 to 70%). Seed drying in the temperature are 40°C, 50°C, 60°C and 70°C at constant air velocity of 2 m/s at thin layer in 1, 2, 3 cm depth. The drying rate observed for whole seed were (0.002, 0.003 and 0.006) for 40°C, (0.18, 0.16 & 0.010) for 50°C, (0.77, 0.57 and 0.41) for 60°C, (0.94, 0.75 and 0.69) for 70°C with 1-3 cm thickness of seed bed. Equilibrium moisture content of tamarind seed at different temperature & relative humidity were from 0.2 to 0.3 % db at 30°C to 70°C and 30 to 70 % relative humidity. Results showed the drying rate rise with increase in temperature & decreases with bed thickness for the experimental range (40 to 70°C). Drying at 70°C and air velocity 2m/s is best for 1 cm thickness of tamarind seeds.

Prangpru *et al.* (2017) studied the effect of temperature on the physicochemical properties of tamarind seed powder. The temperature varies from 120°C to 140°C of drum dryer and drum clearance was 0.0254 mm, drum rotation speed was 0.75 rpm. The yield of tamarind kernel powder observed from 32.16% to 77.06%. By the temperature 140°C gave higher of drying yield, total acidity and solubility as compare to the other temperature 120°C and 130 °C. The best processing conditions for the powder production used a temperature of 140°C, which showed better physicochemical properties and good quality tamarind powder with optimum moisture content can be produced by drum drying.

Padiyar *et al.* (2016) analysed to effect of different pre-treatment methods on production of reducing sugar from tamarind seed powder. The tamarind kernel powder will be extracted from tamarind seed. The extracted tamarind kernel powder is subjected to various pre-treatment methods like acid pre treatment, alkaline pre treatment and steam explosion. Tamarind kernel powder major portion contains carbohydrates which can be broken down into reducing sugars. Obtained corresponding reducing sugar yield values have been calculated as acid pre treatment by 0.5 N HCL and 0.5 N H_2SO_4 , acid pre treatment by 0.3 N HCL and 0.3 N H_2SO_4 , basic pre treatment by 0.5 NaOH and steam pre treatment are 21.88%, 25.52%, 21.35%, 27.97% respectively. Maximum amount of reducing sugar was obtain in case of steam pre treatment at 180°C but the steam pre treatment requires higher energy, acid pre treatment of 0.3 N is considered more efficient & economical.

Pulungan *et al*. (2001) determined the best combination of roasting temperature and roasting duration in processing of tamarind kernel as well as the cost analysis of production. Tamarind seed roasted at different temperature such as 140°C, 150°C, 160°C, and 10 min., 15 min., and 20 min. They observed that the inter-relation between roasting temperature and roasting duration increases the characters of tamarind kernel powder. Analysis obtained best alternative of roasting temperature treatment at 140°C for 10 minutes by water level averages to 8,717% bk, viscosity 53,82 cP, starch level 61,18% bk, gel strength 0.0097 mm/g/seconds, production cost in first year is Rp. 525,00 for each 1 kg. Colour is pleasured, but scent is unpleasant.

Rao *et al.* (2015) studied to processing of tamarind seed and by products. In tamarind seed processing, the major operations were roasting, decorticating and colour sorting. Tamarind seed was used after removing outer layer of the seed in different food industries, textile industries, craft industries, furniture industries. The tamarind seed powder mostly used in gum extraction which haves viscous behaviour and capable of forming gel, so it can be used as a rheological modifier in processed food industries.

Sarkar *et al*. (2018) studied the physical properties and nutritional composition of tamarind kernel powder and quality evaluation of tamarind kernel powder. To determine its use, the study was conducted to evaluate the physical properties and nutritional composition of tamarind seed powder. Optimum water uptake and water absorption capacity was recorded as 133 ml and 193% respectively and particle size index was calculated as 11.22. the moisture content, protein, fat, fibre and total ash in TKP was found to be 4.67%, 24.61%, 2.46%, 3.70% and 2.50% respectively. TKP had 62.06% carbohydrate and the physiological energy value was recorded as 369 kcal/100 g. The calcium and iron content in TKP was 145 mg & 15.46 mg per 100 g. physical properties were found to be acceptable and no significant difference.

Wang *et al.* (2017) studied to digestibility, nitrogen balance and ruminal fermentation of tamarind kernel powder extract residue compared to soybean products and their by-products in wethers. Four wethers with initial body weight (BW) of 51.6±5.5 kg were assigned to analysis nutritional characteristics of tamarind kernel powder, dry soybean curd residue, dry heat soybean and soybean meal feeding with ryegrass straw The digestibility of dry matter, crude protein and ether extract of tamarind kernel powder diet were 57.0%, 87.0%, and 86.0%. High non-fiber carbohydrates digestibility was occurred in tamarind kernel powder diet (83.2%) than in soybean diet (73.9%). The tamarind seed powder feeding had higher propionate (C_3) and lower butyrate content, as well as lower acetate to propionate ratio (C_2:C_3) in rumen fluid than SBM feeding at 4 h after feeding .

2.2 Gum Extraction.

Bansal *et al*. (2013) worked on extraction and evaluation of tamarind seed polysaccharide used as a pharmaceutical gel forming formulation. Tamarind seed polysaccharide was extracted by water based extraction method in Soxhlet apparatus and characterization of the extracted tamarind seed polysaccharide by phytochemical and micromeritic properties, swelling index and flow behaviour were observed. Gel forming capacity of polysaccharide was also determined with and without sodium alginate. Observation shows extracted tamarind seed polysaccharide was soluble in hot water and insoluble in cold water and inorganic solvents. Tamarind seed polysaccharide had good flow properties. pH was found 6.1. This polymer can be used to form gel with sodium alginate, so tamarind seed polysaccharide can be used in pharmaceutical to prepare solid and semisolid excipient.

Dev *et al.* (2018) studied to extraction and evaluation of modified tamarind seed gum used as a novel super-disintegrant. The tamarind gum was modified chemically by carboxymethylation to improve the hydrophilic nature of the tamarind gum. The modification of extracted gum, carboxymethyled gum, Calcium complexed gum was studied by FT-IR spectrophotometer. The DSC studies indicate that the changes in melting point of the calcium complexed gum and the carboxymethyled gum as compared to the extracted gum without any chemical modification. The modified tamarind gum was subjected to different studies like colour, pH of gum solution, swelling index etc. The pH value and swelling index of modified gum was found to be 5.4 and 298%. IR spectra for pure gum showed peaks at 3425 cm-1, 2931.8 cm-1 confirmed the presence of carboxyl group and hydroxyl group in the gum. The hardness of all the batches varies from 4.2 to 5.4 kg. Exipient content uniformity was 98% to 99.94%. Tamarind seed gum (7.5%) showed faster disintegration of tablet as compared to the synthetic super disintegrant (Sodium starch glycolate).

Jangdey *et al.* (2016) studied on the extraction of gum from *Tamarindus indica* and evaluation of utilization and value addition of tamarind gum. They suggested that a procedure of extraction method of gum from tamarind seed. Direct value addition of tamarind by collection in proper seasons, Grading & sorting, cleaning, macroscopic and microscopic examination and Indirect value addition by testing of the physicochemical standards like moisture content, foreign matter, ash content, extractives, micro organism. Chemical composition were moisture, tartaric acid, proteins, Ash are 30%, 13%, 13.35%, 2.15%. Tamarind gum is used as a carrier for variety of drugs for sustained/controlled release and different pharmaceutical excipients application.

Chawananorasest *et al.* (2016) extracted tamarind seed polysaccharide from tamarind seed from three different sources with two different methods and characterization its physical and chemical properties. Three different tamarind sources are from a waste from the export tamarind juice industry, paddy farmland & export tamarind powder industries. In first method seed powders are used for gum extraction and defatted seed powder are used in second method. Results showed tamarind seed polysaccharide from tamarind seed which is taken from a waste from the export tamarind juice industry, paddy farmland and the tamarind powder industry gave yields of 31.55%, 26.95% and 17.39% respectively, using method 1 and 11.15%, 53.65% and 54.65% with method 2 respectively, using method 2 gave pure tamarind seed polysaccharide then method 1. Extracted gum from exported tamarind seed powder gave a higher gum yield than the other source.

Nep and Conway (2010) characterized of grewia gum extracted from grewia can used as a pharmaceutical excipient. Grewia gum was extracted from the inner stem bark of *Grewia mollis* and characterized by different techniques such as differential scanning calorimetric (DSC), gas chromatography (GC) and thermo gravimetric analysis of the extracted gum sample. The results showed that grewia gum is a typically amorphous odourless polysaccharide gum containing galactose, glucose and xylose as a neutral polysaccharide. The yields of the extracted gum were 32.4% from the crude inner stem bark of the grewia plant. This is indicative of pseuoplastic flow behaviour, or shear thinning. The high thermal stability of the gum as evidenced by the high oxidation on set of 267±6.2 °C indicates that the gum can be used as excipient even under conditions of high thermal stress. The chromatograph indicates that extracted grewia polysaccharide gum is composed of grewia gum contains glucose, arabinose, rhamnose, xylose and galactose.

Lokesh *et al.* (2014) investigated the effect of agro-climatic influence on tamarind kernel powder processing and tamarind seed gum preparation. The results indicate that 100 seed weight, Seed recovery and Tamarind kernel powder were maximum in seeds collected from Tamil Nadu's Southern Agro climatic zone. The maximum (168.31 g) in Southern Agro- Climatic Zone of Tamil Nadu followed by North Western Zone (167.70 g) and minimum (102.72 g) with respect to Cauvery Delta Zone. Method for processing Tamarind kernel powder, roasting and dehulling have been found to be more significant than wet processing. Out of the different methods tried, the maximum seed recovery (%) after removal of seed testa was reported in dehulling process of Southern Zone (88.33 %) and minimum (63.26 %) in Cauvery Delta Zone. Similarly, in the wet process method, seed recovery (percentage) is the least The results showed that sodium carbonate followed by sodium hydroxide were the best chemicals for the preparation of tamarind seed gum where different properties viz., Texture (Smooth), Color (Creamy), PH range 5.6-6.4 were used in the preparation of tamarind seed gum.

Nagajothi *et al.* (2017) optimized roasting standard in gum extraction method from tamarind seed for improve gum quality. Tamarind seed was roasting under sand medium with time interval 5, 10, 15, 20, 25 & 30 minutes. Results shown that 5 minutes of roasting resulted with the moisture loss 12%, yield 95%, creamy white colour kernels with viscosity of 13.8cp 12% (2.54g TPS of 120 TKP) & maximum polysaccharide yield. The time interval such as 25 & 30 min totally burnt and roasting gave 100 % yield the decorticated seeds were turned to brown which affect the colour of TKP which unsuitable for powder preparation. Roasting of tamarind seeds at 110°C for 5 minutes gave good quality gum in term of high polysaccharide viscosity and acceptable colour.

Nagajothi *et al*. (2017) worked to examine the effect in tamarind gum yield with respect to different seed sources collected from Tamil Nadu (19), Karnataka (13), Andhra Pradesh (5), Kerala(3) and Extracted gum yield varied from 39% to

50.36%. Aasan which is variety from Karnataka was recorded highest polysaccharide content 50.36% with the value of 2.54g in 5g tamarind kernel powder. Second highest yield found by Gundur variety from Andhra Pradesh is 2.39g which is about 48.72%. the lowest yield of tamarind seed polysaccharide found in Nokkanur variety from Karnataka is 1.98g proceeded by Thumkur variety from Karnataka is 2.1g. Results showed that the source of seed had great influence in tamarind gum yield.

Reddy *et al.* (2015) worked on extraction & characterization of tamarind seed polysaccharide from tamarind that can be used as a pharmaceutical excipient. Extraction method was used for the extraction of tamarind seed polysaccharide is aqueous based non aqueous precipitation extraction. Tamarind seed polysaccharide was characterized for physiochemical properties. The results obtained the yield of tamarind seed polysaccharide was 52%. Swelling index was 70.90%, pH of 1% tamarind seed gum solution was 6.9 ,Bulk density was 1.1036±0.016g/cc, Carr's index was 5.46± 0.017% and true density 1.370±0.036g/cc. results shown that its good mucoadhesive properties, flow rate. So tamarind seed polysaccharide can be used as pharmaceutical exipient.

Singh *et al.* (2011) worked on extraction and characterization of tamarind seed polysaccharide used as a pharmaceutical excipent. Water based extraction procedure was used to tamarind seed polysaccharide from tamarind seed. Extraction of gum by ethyl alcohol the yield of tamarind gum was obtained 18.39% w/w. Gum was odourless, texture & light brownish in colour. ph value of 1% solution of the gum was found to be slightly acidic 6.7. Gum showed gelling behaviour at 8% w/v solution that tamarind seed polysaccharide may be used as natural gelling agents in different pharmaceutical formulation.

Sukhawanli and Thamakorn (2014) studied to the extraction of tamarind seed jelloose at different condition and their rheological properties. The pasting properties of defatted and non defatted tamarind seed powder were compared. Changing an viscosity of tamarind seed powder solution during cooling & heating cycle offered many parameters reflecting the pasting properties for non defatted TSP value of peak viscosity, Breakdown, consistency, setback are 724.00, 151.59, 742, 663.50 BU & for defatted TSP are 959.50, 184.50, 891.50, 891.50,786.50. So lower the pasting temperature and higher for all viscosity parameters of all viscosity parameter of defatted sample higher viscous fluid was obtained in HT jellose group. Extraction temperature had highly effect to the rheological property of extracted jellose when precipitation pH has less influence.

Shulka *et al.* (2018) studied the application of tamarind seed polysaccharide used an co-polymers in controlled drug delivery system. Tamarind seed polysaccharide successfully extracted from tamarind seed by water-based extraction procedure. The extracted tamarind seed polysaccharide was used a gelling agent in different pharmaceutical exipient, for controlled release of both water-soluble and water-insoluble types of drugs. They confirmed that the cross-linked tamarind seed polysaccharide used as an effective controlled drug delivery and can be successfully used in commercial products in pharmaceutical.

Yeasmen and Islam (2015) studeid to the effect of extraction solvents i.e. ethanol & acetone & two extraction techniques i.e. hot extraction at 40°C and cold extraction at 26°C. Physicochemical properties are investigated from of *Tamarindus indica* seed. The recovery percent of extracted gum obtained maximum yield for hot ethanol extract was observed to be 6.43% while minimum yield was obtain from cold acetone extract gum was 4.20%. Total phenolic content obtained that hot ethanol extract gave the high phenolic content 71.68 mg GAE/gm of dry extract and Cold ethanol extract gave 70.44 mg GAE/gm of dry extract. Hot acetone extract gave the total phenolic content with 54.28 mg GAE/gm of dry extract and lowest phenolic content 51.54 mg GAE/gm of dry extract was given by cold acetone extract. Highest TAC was obtained from Hot ethanol extract was 43.80 AAE/g while Cold acetone extract gave lowest valve was 22.75AAE/g. so that ethanol and hot extraction Methods are better to preserve the antioxidant properties of tamarind seed.

2.3 Physicochemical Properties of Gum.

Bisulca *et al.* (2016) worked on o-toluidine test for complex carbohydrates of gum for the identification of mucilage's, gums and starches. The results shown that monosaccharides and disaccharides using the o-toluidine solution reacted as expected, with aldohexoses (galactose, glucose) producing a green colour reaction and aldopentoses (lyxose, xylose, arabinose) a red colour reaction. The exception was the aldohexose mannose, which did not consistently give a green colour. The uronic acids, galacturonic and glucuronic acid produced no colour reaction. The seed endosperm polysaccharides and funori are composed of only aldohexoses and produce an expected green colour reaction. The extracted gums and mucilage's that are composed of aldohexoses and aldopentoses produced a range of brown to red colours, which reflects the monosaccharide compositions of these materials.

Joseph *et al.* (2012) studied to use tamarind seed polysaccharide as a natural excipient for pharmaceutical. Physical properties of tamarind seed polysaccharide true density is 1.015 g/ml, tapped density is 0.363- 0.781 g/ml, angle of repose is 13° -29.5°.Compressibility index is 15.33-16.64 %. Swelling index is 12-17%.

Kumar *et al.* (2010) studied of the emulsifying properties of tamarind seed polysaccharide and find an effective emulsion for the pharmaceutical formulation. For emulsifying studied, castor oil as a model drug & emulsified with tamarind seed polysaccharide was used. To standardize the emulsifying characteristics and stability of TSP by acacia gum as standard emulsifier. Results shown the particle size distribution both the emulsion stabilized by using gum acacia & TSP are within 1 to 10 μm ranges. Emulsion stability by centrifugal method indicate that there is on phase separation results even if with high rpm 3500 at 37°C and the percentage stability was found to be 100% in both. While comparing that the emulsion prepared with 2% w/v of TSP using 10 % w/v of the suitable option to utilize as pharmaceutical exipient.

Katiyar *et al*. (2015) determined the effect of heat on the physical properties of tamarind seed polysaccharide. Tamarind seed were used for isolation of mucilage was modified by using microwave radiation. Results shown the percentage yield of gum was found to be 6.5%. Studied the physical properties of tamarind seed polysaccharide was carried out for angle of repose for Batch A, Batch B, Batch C, Batch D is 3.06°, 3.13°, 2.31° and 2.24°. Carr's index for Batch A, Batch B, Batch C, Batch D is 8.09%, 18.48%, 19.13%, 41.19%. Bulk density for batch A, batch B, batch C, batch D is 0.67g/cm3, 0.66 g/cm3, 0.67 g/cm3, 0.69 g/cm3 respectively. This properties shown tamarind seed polysaccharide has high swelling index, good flow so tamarind seed polysaccharide can be used as a pharmaceutical excipient it can concluded from the thermally treated tamarind seed derived polysaccharide was used as a pharmaceutical formulation.

Klahal *et al.* (2012) worked on tamarind seed gum used for disperse printing seed gum of polyester as thickening agent with comparison to the commercial tamarind kernel powder. Extraction process of gum was stirring of 16 grams of tamarind kernel powder to 200 ml of 8% w/w distilled water with sodium azide 5 ppm. Chemical composition of tamarind seed powder moisture, ash, protein, fat, polysaccharide are 10.78%, 0.39%, 12.53%, 5.64%, 81.62% respectively. Tamarind seed colour strength is 5.97 and handling and sharpness are very good.

Mohamed *et al*. (2015) studied physiochemical properties of tamarind seed polysaccharide. The seed sample of *Tamarindus indica* seed namely light brown and Dark Brown were extracted. The Physicochemical properties were determined and compared to commercial pectin. The moisture content of polysaccharide was 3.81% for LB and 3.80% for DB. Carbohydrate was 88.85% of LB and 85.21% of DB .the extracted yield of tamarind polysaccharide was 34% of LB and 29% of DB. These results showed moisture content (3.81% and 3.80%) which is lower than 5.18% of commercial pectin. the two sample of polysaccharide in carbohydrate content and which was lower than the value of pectin. The tamarind polysaccharides could be used as substitute for commercial pectin.

Nandre *et al.* (2014) analysed the effect of heat on binding properties of natural gum. Pharmaceutical tablet was formulated by using natural gum were studied for various physicochemical evaluation. All formulation were analysis for their tablet hardness (kg/cm^3) properties using by Monsanto hardness tester and average range was found to 3.1 to 6 kg/cm^3 and dis-integration test apparatus is found decreasing from FTP to FT8 formulation. All the results of tablet evaluation it is shown that the disintegration time & hardness decreases. So the binding properties of natural gum decrease to increasing temperature at varies condition as time.

Oomah and Mazza (2001) studied the effect Spray drying on extracted flaxseed gum was optimized by response surface methodology, water seed ratio (7-20), feed temperature (25-100°C) and outlet temperature (60-110°C). Water: seed ratio and outlet temperature were the two major factors affecting the response variables of the yield gum. The highest yield observed in spray dry flax seed gum was achieved at water: seed ratio of 18 l/kg. Maximum gum yield and minimum rheological characteristics were observed at relatively high water: seed ratio less than 18, combined with moderate inlet feed temperature of 61.7 °C and high outlet temperature was of 92 °C.

Pawar *et al.* (2011) estimated the total polysaccharides in *cassia tora* gum by spectrophotometer method. They researched excellent binding, absorption, thickening, stabilizing emulsifying retention and water-holding properties and could be used for pharmaceutical formulation preparation. The gum was extracted by precipitate & estimate of total polysaccharide content in gum using Phenol-sulphuric acid method. Phenol-sulphuric acid technique is one of the simple and accurate spectroscopic techniques for the determination of total polysaccharides in *Cassia tora* seed gum. The total polysaccharide content in *Cassia tora* gum was observed to be 77 % w/w.

Ponnikornkit *et al.* (2014) determined the swelling behaviour of crude tamarind gum from *Tamarindus indica* seed & compared with modified carboxymethylated gum. Carboxymethylation was done at 70°C for 60 min of reaction time and methanol used as solvent media. Results shown that the crude tamarind gum was showed low swelling index while carboxymethylated tamarind gum at both DS values showed high swelling index ranged from 17% to 81%. The weight change percentage of carboxymethylated tamarind gum (DS=0.1756) at 60 min which was greater than that of another one (DS=0.1711) 31%. So carboxymethylated was used to improved properties of crude gum.

Phani *et al.* (2011) studied on the Isolation & analysis of tamarind seed polysaccharide which is used as pharmaceutical formulation. The yield of white mucilage obtained from the tamarind seed was 78 %. Swelling index of the tamarind gum was found to be 1700%, compressibility index, hausner ratio and surface tension were 16.64 ±0.04% and102±0.09 and 83.26 ±0.62 dynes/cm, moisture content was 8.10 ±1.23%. the above results show that tamarind seed polysaccharide has good flow & compatibility, high swelling index & stability of tamarind seed polysaccharide. They proposed that in sustained release system, tamarind seed polysaccharide could be used as pharmaceutical formulation.

Saikia *et al.* (2017) was to isolate and characterise a naturally obtain polysaccharides which have the property to formulate sustain release product. Tamarind Seed Polysaccharides (TSP) was isolated from seed of *Tamarindus indica* by crushed the seed into powder and boiled with water at 45 °C to extract the polysaccharides. After boiling for 12 h the supernatant liquids were collected and stored in cool place. After the liquids become cooled acetone was added and freeze at-40 °C. Freeze materials then lyophilized to extract out the tamarind seed polysaccharides. Yield of polysaccharides was found to be 16.85%. As per the micromeritic property flow of polysaccharides, tapped and bulk density was found in acceptable range. Microbial studies confirmed that TSP doesn't support microbial growth.

Srinivasan *et al.* (2011) worked on evaluation of tamarind seed polysaccharide as a drug release retardant. Isolation of tamarind gums by aqueous extraction-non aqueous precipitation method from tamarind seed powder. Tablet of ketoprofen was prepared of using tamarind seed polysaccharide. Tablets were subject to various evaluation parameters. The tablet hardness was in range 4.5 to 6.5 kg and total weight loss in friability test was in the range 0.24 to 0.27 % that showed good mechanical strength. The uniformity of drug content for all the formulation were between 99.6 to 102.4% thus extracted tamarind seed polysaccharide has used as a drug retardant.

Salehi and Kashaninejad (2018) investigated the influence of different drying techniques on the rheological and texture properties & colour change of basil seed gum. Three different drying method: freeze drying, oven drying (40-80 C), and vacuum oven drying were used. Result observed that the viscosity of gum solution was varied from 0.174 to 0.438 pa.s & freeze dried gum exhibited the high viscosity. The hardness, consistency, stickiness & adhesiveness of basil seed gum get 3% were varies from 42.2 to 75.5g, 362.6 to 803.7g.s, 11.3 to 19.3g & 131.5 to 244.8 g respectively at several drying methods. Results indicated that the freeze dried gum exhibited the highest hardness & consistency. Increasing the temperature had a negative effect on the colour changes & brightness of gum solution.

CHAPTER-III
MATERIALS AND METHODS

This chapter deals with the materials used and procedure adopted to achieve the objectives of the present investigation. This includes the description of experimental set up and methodology used in physical properties of *Tamarindus indica* seed, gum extraction and analyze the physicochemical properties methods.

3.1 Experimental Site

The study was done in the Department of Agricultural Processing and Food Engineering, Swami Vivekananda College of Agricultural Engineering and Technology and Research Station, Raipur, and Department of Plant Physiology, Agriculture Biochemistry, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh).

3.2 Materials

Fresh, healthy and mature tamarind seed was purchased from the local market of the production area. Seed was cleaned by removing foreign materials and broken seed to get uniform seed for gum extraction.

Fig. 3.1: Tamarind seed sample for experiment

3.3 Methods

3.4 Physico-Chemical Properties

3.4.1 Moisture content

Moisture content of tamarind seed was determined by AOAC method (2004). The initial weight of sample was recorded and then kept in a hot air oven, maintained to 105°C for 24 h. After drying, the final weight of sample was recorded. The percentage moisture content (db) was estimated by the following equation.

$$MC\ (db) = \frac{W_1 - W_2}{W_2} \quad \text{…... (3.1)}$$

Where,

MC = Moisture Content (%),

W_1 = Initial weight of sample (g), and

W_2 = Weight of sample after drying (g).

Fig.3.2: Moisture content determination by Hot air oven

3.4.2 Bulk density

Bulk density of tamarind seed or gum determined as accurately weighted sample of tamarind seed divided by the volume of tamarind seed which are measured by 100 ml measuring cylinder and calculated by following equation. (Reddy *et al.*, 2015)

$$\rho_b = \frac{\mathrm{M}}{\mathrm{V_b}} \qquad \text{.....(3.2)}$$

Where,

ρ_b =Bulk density of the sample (g/cm^3),

M = Mass of sample (g), and

V_b = Volume of bulk sample (cm^3).

3.4.3 Tapped density

Tapped density is the ratio of the weight of tamarind seed or gum to its tapped volume. Weighed seed was transferred to graduated cylinder was tapped for fixed number of taps (100). The final volume after 100 tapings was noted and determined by following formula. (Reddy *et al.*, 2015)

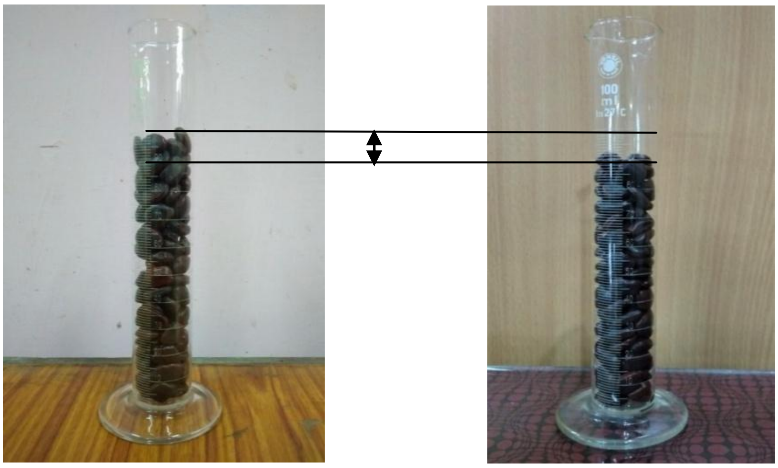
$$\rho_t = \frac{\mathrm{M}}{\mathrm{V_t}} \qquad \text{.....(3.3)}$$

Where,

ρ_t =Tapped density of sample, (g/ cm^3),

M = Mass of sample (g), and

V_t = Volume of tapped sample (cm^3).



(a) Before tapping (b) After tapping

Fig. 3.3: Determination of bulk and tapped density

3.4.4 True density

True density was determined by liquid displacement method. Toluene was selected as the liquid for displacement, because tamarind seed or gum is insoluble in toluene. The tapped density was determined by following formula (Singh & Goswami, 1996)

$$\rho_T = \frac{M}{V} \qquad \text{….. (3.4)}$$

Where,

ρ_T =True density of the sample (g/cm^3),

M = Mass of sample (g), and

V = Volume displaced by sample (cm^3).

Fig. 3.4: Determination of true density

3.4.5 Porosity

Porosity is defined as the percentage of void space in the bulk grain which is not occupied by the sample was calculated using the following equation (Singhal and Samuel, 2003).

$$\text{Porosity} = \left(1 - \frac{\rho_b}{\rho_T}\right) 100 \qquad \text{…..(3.5)}$$

Where,

ε = Porosity,

ρ_b = Bulk density (g/cm^3), and

ρ_T= True density (g/cm^3).

3.4.6 Weight of 100 seed

Determination of 100 seed weight was computed as described by ISTA (1996). Tamarind seed sample were taken from source and weighted in weighing machine of sample and recorded in gram (g) (Nagajothi *et al.*,2017)

Fig. 3.5: Weighted samples of tamarind seed

3.4.7 Volume of 100 seed

The volumes of 100 tamarind seeds are measured by measuring cylinder. It is the volume in ml of 100 seed.

Fig. 3.6: Volume of tamarind seed

3.4.8 Geometric mean diameter

It is mean or average, which indicates the central tendency or typical value of a set of number by using the product of their values. The geometric mean diameter (GMD) of seed was found using the relationship given (Ghadge and Prasad, 2012) as:

$$D_g = (LWT)^{\frac{1}{3}} \qquad \text{…..(3.6)}$$

Where,

D_g= Geometric mean diameter (mm),

L = Length of seed (mm),

W = Width of seed (mm), and

T = Thickness of seed (mm).

(a) Length of tamarind seed

(b) Width of tamarind seed

(c) Thickness of tamarind seed

Fig. 3.7: Measurement of dimension of tamarind seed

3.4.9 Sphericity

Spericity may be defined as the ratio of the diameter of a sphere of the same volume as that of particle and the diameter of the smallest circumscribing sphere or generally the largest diameter of the particle (Singhal and Samuel,2003). The sphericity was computed as

$$\text{Sphericity} = \frac{(LWT)^{\frac{1}{3}}}{L} \times 100 \qquad \text{….. (3.7)}$$

Where,

L = Length (mm),

W = Width (mm), and

T = Thickness (mm).

3.4.10 Compressibility (Carr's) index

Compressibility is directly related to flow rate, cohesiveness and particle size. Based on the apparent bulk density and tapped density, compressibility index of tamarind seed powder or gum was determined by following equation (Reddy *et al*., 2015).

$$I = \left(\frac{\rho_t - \rho_b}{\rho_t}\right) \times 100 \qquad \text{…..(3.8)}$$

Where,

I = Compressibility (Carr's) index (%),

ρ_t = Tapped density of tamarind seed powder (g/cm^3), and

ρ_b = Bulk density of tamarind seed powder (g/cm^3).

Table 3.1: compressibility % limits with respect to flow ability

Compressibility %	Flow property
5-15	Excellent
12-16	Good
18-21	Fair
23- 28	Poor
28-35	Very poor
35-38	Very very poor
>40	Extremely poor

3.4.11 Hausner's ratio (H)

Hausner's ratio indicates the flow properties of powder. Hauser' ratio is measured by the ratio of tapped density to bulk density of sample. Hausner's ratio was calculated by following formula (Reddy *et al*., 2015).

$$H = \frac{\rho_t}{\rho_b} \qquad \text{.....(3.9)}$$

Where,

H= Hausner's ratio (H),

ρ_t = Tapped density of Tamarind seed powder (g/cm^3), and

ρ_b = Bulk density of Tamarind seed powder, (g/cm^3).

Table 3.2: Limits of Hausner's Ratio

Hausner's Ratio	Flow property
<1.25	Good
1.25 – 1.5	Moderate
>1.5	Poor

3.4.12 pH value

The pH valve was determined by weighted tamarind gum and dissolved in distilled water separately to get a 1% w/v solution. The pH of solution was determined using digital pH meter (Singh *et al.*, 2011).

Fig. 3.8: Digital pH meter

3.4.13 Swelling index

Swilling index of tamarind powder or gum was determined by using method reported by Gauthami & Bhat. One gram of tamarind seed was weighed and transferred to 100 ml stoppered measuring cylinder. The initial volume of the sample was noted. The volume was made up to 100 ml mark with distilled water. The cylinder was stoppered , shaken gently and set aside for 24 h. the volume occupied by the powder sediment was noted after 24 h. swelling index is calculated by following equation (Phani *et al.*, 2011).

$$SI = \left(\frac{X_t - X_0}{X_o}\right) \times 100 \qquad \text{…..(3.10)}$$

Where,

SI = Swelling index (%),

X_o= Initial height of the gum, ml in graduated cylinder (ml), and

X_t= Height occupied by swollen powder after 24 h (ml).

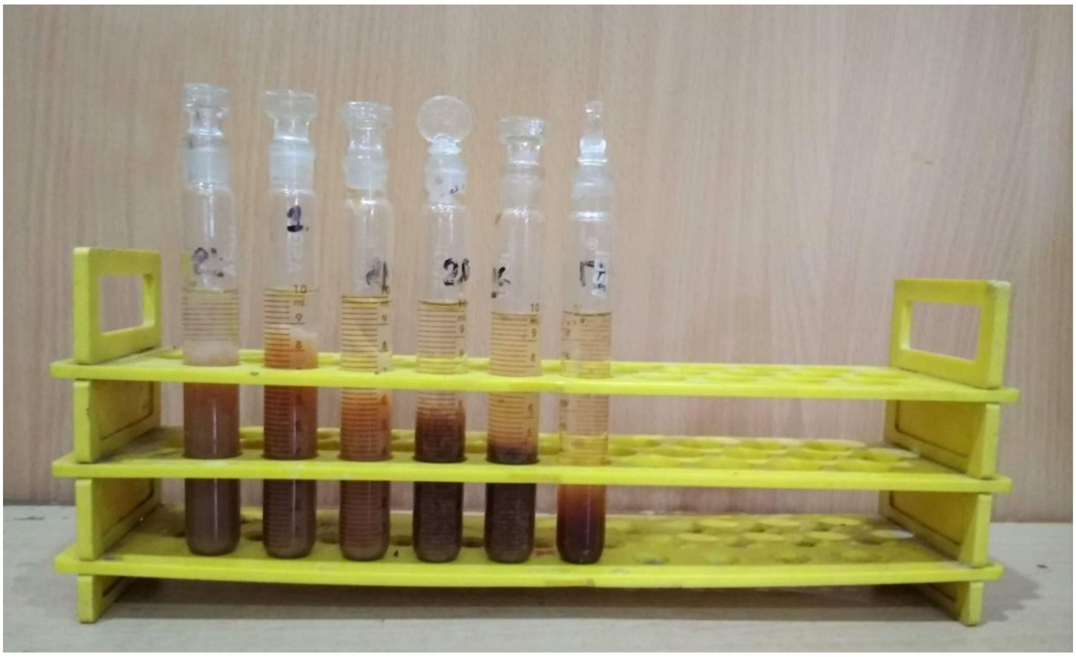


Fig. 3.9: Swelling index of tamarind seed powder

3.4.14 Surface tension

Surface tension of tamarind gum was determined by drop count method, using a Stalagmometer. The Stalagmometer was filled with purified water above the upper mark. Using the screw pinch cork, the flow was adjusted to 10-15 drops/ min. then number of drops of water was counted between the mark of the Stalagmometer (n_1). The water was removed and the Stalagmometer was filled with the gum solution (0.1% w/v) and number of drops was count (n_2). Surface tension was calculated by following (Phani *et al.*, 2011)

$$\gamma_2 = \frac{n_1 \rho_2 \gamma_1}{n_2 \rho_1} \quad \text{….. (3.16)}$$

Where,

γ_2 = surface tension (dynes/cm),

n_1 = number of drops of water,

n_2 = number of drops of sample,

ρ_1 = density of water (0.9956 g/ml),

ρ_2 = density of sample (g/ml), and

γ_1 = surface tension of water (71.18 dynes/cm).

Fig. 3.10: Surface tension of tamarind gum solution

3.6.15 Solubility test

The solubility of the gum was determined in cold and hot distilled water, acetone, ether, methanol and ethanol. 1.0 g sample of the gum was added to 50 ml of each of the above mentioned solvents and left overnight. 25 ml of the clear supernatants were taken in small pre weighted evaporating dishes and heated to dryness over a digital thermostatic water bath. The weights of the residue with reference to the volume of the solutions were determined using a digital top loading balance and expressed as the percentage solubility of the gums in the solvents (Eddy *et al*., 2012).

3.5 Qualitative Phytochemical Analysis.

3.5.1 Test of alkaloid

Mayer's Test : 5 milligram of gum or tamarind was taken separately in 5 ml of 1.5% v/v hydrochloric acid and filtered. These filtrates were then used for testing alkaloids. (Thakur *et al.*,2015). Filtrates were treated with Mayer's reagent (Potassium Mercuric Iodide). Formation of a yellow colored precipitate indicates the presence of alkaloids.

Fig 3.11: Mayer's test of tamarind seed powder

3.5.2 Test of carbohydrate

Molisch's test : 5 mg of the test residue was placed in a test-tube containing 0.5 ml of water, and it was mixed with 2 drops of Molisch's reagent. To this solution, was added 1 ml of concentrated sulphuric acid from the side of the inclined test-tube, so that the acid formed a layer beneath the aqueous solution without mixing with it. if a red brown ring appears at the common surface of the liquids, sugars are present. (Thakur *et al.*,2015).

3.6 Quantitative Phytochemical Analysis.

3.6.1 Estimation of the alkaloid (John *et al.*, 2014)

3.6.1.1 Preparation of brombcresol green solution

Bromocresol green solution(BCG) was prepared by heating at 50-60°C at 10-15 min 34.9 mg bromocresol green with 1.5 ml of 2 N NaOH and 5 ml distilled water until completely dissolved and the solution was diluted to 500 ml with distilled water.

3.6.1.2 Preparation of buffer solution

Phosphate buffer solution (pH 4.7) was prepared by adjusting the pH of 2 M sodium phosphate (35.8 g Na_2HPO_4 in 500 ml distill water) to 4.7 (4.5 to 4.9) with 0.2 M citric acid (21.01 g citric acid in 500 ml distilled water).

3.6.1.3 Preparation of stock solution

A standard solution of berberine chloride (100µg/ml) was prepared by dissolving 1 mg of accurately weight berberine chloride in 10 ml of volumetric flask using methanol.

3.6.1.4 Calibration curve of berberine chloride

Suitable aliquat (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1 ml) of the above standard stock solution was transferred to separating funnel. Add 2.5 ml of buffer solution pH 4.7 and 2.5 ml of bromocresol green (BGC) solution. The mixture was shaken & complex formed was extracted with 2.5 ml of chloroform. Chloroform layer was collected in 5ml of volumetric flask & make the volume up to mark with chloroform. Absorbance was taken at 415 nm against the blank. The calibration curve was constructed by absorbance versus concentration of berberine chloride as standard (mg/ml). By using calibration curve equation y = 0.025x+0.485.

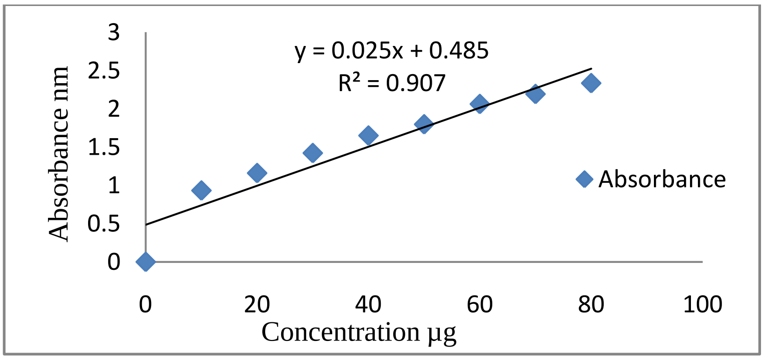


Fig 3.12: Standard curve for the estimation of alkaloid

3.6.1.5 Estimation of total alkaloid in seed powder

2 g of the tamarind seed powder and its formulation were extracted separately with 20 ml of methanol three times at 50-60 ml. collect & combined methanol extract and evaporated to dryness to get the residues. The residue was dissolved in 2 N of hydrochloric was dissolved in 2 N of hydrochloric acid and them filtered.

1 ml of above test solution was transferred to separating funnel & Add 5 ml of bromocresol green solution. The mixture was shaken & complex formed was extracted with 5 ml of chloroform.

Chloroform layer was collected & make up the volume to 5 ml with chloroform. Absorbance was taken 415 nm against blank. The solutions were stable for 2h. The total alkaloids were determined by the regression equation.

3.6.2 Estimation of total carbohydrates in tamarind seed powder and tamarind gum (Pawar and Mello, 2011)

3.6.2.1 Preparation of blank solution

To take 1 ml of distilled water in tube and added 1 ml of 5% phenol followed by 5 ml of concentrated H_2SO_4.

3.6.2.2 Preparation of standard solution

A stock solution 100 µm/ml of glucose was prepared in distilled water.

3.6.2.3 Calibration curve of glucose

Solution to obtain sugar concentration 10-100 µm/ml. 1 ml of 5% phenol solution was added to 1 ml of sugar solution to 1 ml of sugar solution & 5 ml of concentration H_2SO_4. The absorbance was measured after 10 minutes at 488 nm against block.

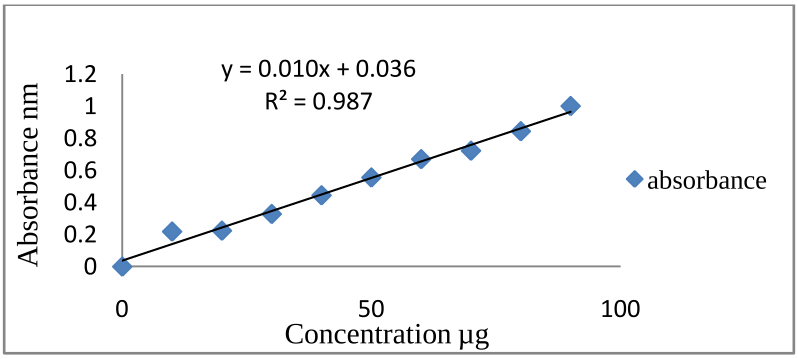


Fig. 3.13: Standard curve for the estimation of total carbohydrate

3.6.2.4 Estimation of total carbohydrates in tamarind seed powder

Extracted from 0.025 g Tamarind seed powder with 10 ml 80 % ethanol from this 1ml was used for sugar solution analysis. To estimate the carbohydrates content in tamarind seed 1 ml of 5% phenol added to the 1ml of tamarind seed extract & 5ml concentrated H_2SO_4. The absorbance was measured after 10 minutes at 488 against blank. The experiment was carried out in triplicate. The calibration curve for a glucose standard for the determination of carbohydrate was y =0.01x+0.044 Where y is absorbance at 415 mn & x is concentration in µg /ml.

Fig. 3.14: Determination of carbohydrate % by using Spectrophotometer

3.6.2.5 Estimation of total carbohydrates in tamarind gum:-

100 mg gum was dissolved in 100 ml of distilled water from this 1ml was used for sugar analysis. To estimate the carbohydrates content in tamarind seed 1 ml of 5% phenol added to the 1ml of tamarind seed gum solution & 5ml concentrated H_2SO_4. The absorbance was measured after 10 minutes at 488nm against blank. The experiment was carried out in triplicate.

3.7 Extraction Method

3.7.1 Preparation of tamarind seed powder

Tamarind seed consist of the seed coat or testa (30-40%) and the kernel and endosperm (60-70%). Only endosperm or split contains mainly polysaccharides which are used for the production of tamarind gum. Removal of testa from the seed is a difficult process, the testa was tenaciously held to the endosperms and it should be removed without damage to endosperm. The peeling of testa of seeds was done by uniform roasting with sand media of seeds (Nagajothi *et al.*, 2017).

500 g of matured uniform tamarind seed are roasting in 100 °C, 120 °C, 140 °C, 160 °C, 180 °C, 200 °C at 5 min, 7.5 min, 10 min respectively in perfura made tamarind seed roasting machine. After roasting, roasted seed was decorticated in Perfura made tamarind seed decorticator. Testa will be separated from seed by rubbing and hammering action of cylinder. Testa will be separated through concave & sieving. Endosperm and testa are collect separately. Endosperms are subjected in mixer grinder to grind fine tamarind seed powder. Fine powder was sieved through sieve no 20 (Bansal *et al.*, 2013) and stored in air tight container the powder was used further process.

3.7.2 Extraction of tamarind gum

The gum was extracted from endosperm using solvent precipitation method. 10 g Tamarind seed powder was soaked in 150 ml of distilled water and stirred in magnetic stirrer for 3 hours. Viscous solution obtain was filtered through muslin cloth. The marc obtain was not discarded but it was sent for further extraction in two times with 100 ml distilled water and stirred in magnetic stirrer for 30 min at 70 °C. All the viscous solution obtain were mixed together. An equal quantity of 10 % Trichloroacetic acid was added to resultant viscous mixture for precipitate protein. The solution was centrifuged at 5000 rpm for 10 min and collect supernatant. Supernatant was precipitate out by addition of acetone in the ratio 1: 0.5 with continue stirring. Precipitate gum was separated by filter through muslin cloth. Separated gum was dried in hot air oven at temperature 60 C. then dried tamarind gum was powdered through mini grinder and stored in air tight container at room temperature.

Seed

↓

Roasting

(100°C, 120ºC, 140°C, 160ºC, 180°C, 200°C)

(Time 5 min, 7.5 min, 10 min)

↓

Decorticating

↓

Grinding and sieving

(Sieving by 20 BIS sieve size)

↓

Stirring with distill water

(150 water+10g seed powder)

↓

Filtration

(by Muslin cloth)

↓

Collect the filtrate and extract residue

with water again two times

↓

Collect all the filtrate and add equal amount of

10 % Trichloroacetic acid

↓

Centrifuge at 5000 rpm for 10 min.

↓

Collect supernatant

↓

Add acetone to supernatant

↓

Separate precipitated gum using muslin cloth

↓

Drying

↓

Grinding

↓

Sieving

Flow chart of extraction method from Tamarind seeds

(a) Roasting

(b) Decorticating

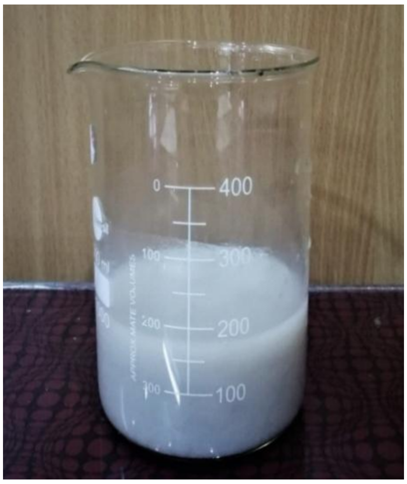
(c) Grinding

(d) Tamarind seed powder

(e) Stirring

(f) Filtration

Fig. 3.15: Gum extraction process



(a) Extract

(b) Trichloroacetic acid

(c) Centrifuge

(d) Supernatant

(e) Acetone

(f) Precipitate

Fig. 3.16: Gum extraction process

(a) Precipitate filtration (b) Drying

Fig. 3.17: Gum extraction process

CHAPTER-IV
RESULTS AND DISCUSSION

This chapter deals with the results of the investigate ion carried out on different physical and physicochemical properties of *Tamarindus indica* seed and its gum powder. The chapter also explains decorticating of *Tamarinus indica* seed with respect to different heat treatment and standardization for the method of gum extraction. This complete work was done at Department of Agricultural Processing and Food Engineering, SVCEAT & RS, and Department of Plant Physiology, Agril. Bio-Chemistry, Medicinal and Aromatic Plants, IGKV, Raipur (Chhattisgarh).

4.1 Physical Properties of Tamarind Seed

All the observations recorded for physicochemical properties of tamarind seeds are given in table 4.1.

4.1.1 Moisture content

The moisture content of the tamarind seed was 10.174 % on dry basis. Minimum and maximum value of moisture content of tamarind seed on dry basis were 8.034% and 12.556% respectively. Moisture content on dry basis of the sample was lower than the range 10.99 % to 11.21 % reported by Mohamed *et al. (2015)* and higher than the value of 9.4% estimated by Mararangoni *et al*. (1988).

4.1.2 Bulk density

The bulk density of tamarind seed was 0.739 g/ cm^3. It was observed that the minimum and maximum value of bulk density of tamarind seed were 0.703 g/ cm^3 and 0.773 g/cm^3 respectively. Bhattacharya *et al.* (1993) also reported bulk density of tamarind seed in the range of 0.821-0.840 g/cm^3.

4.1.3 Tapped density

The tapped density of tamarind seed was 0.777 g/ cm^3. It was found to be minimum and maximum value of tapped density of tamarind seed were 0.760 g/ cm^3 and 0.796 g/ cm^3 respectively.

4.1.4 True density

The true density of tamarind seed was 1.322 g/cm^3. Minimum and maximum values of true density of tamarind seed were 1.263 g/cm^3 and 1.443 g/cm^3 respectively. Similar value of true density reported by Bhattacharya *et al.* (1993) was 1.370-1.432 g/cm^3.

4.1.5 Porosity

The mean porosity of tamarind seed was 44.019%. Minimum and Maximum values of porosity of tamarind seed were 39.802% and 50.020 % respectively. Porosity of tamarind seed is slightly higher than 40.7% estimated by Bhattacharya *et al.* (1993).

4.1.6 Weight of 100 seed

100 seed weight of tamarind seed was 79.797 g. Minimum and maximum values of 100 seed weight were 77.746 g and 81.795 g respectively. These finding are in conformity with the observation of Nagajothi *et al.* (2017).

4.1.7 Volume of 100 seed

Volume of 100 seed of tamarind was 108.6 cm^3. Minimum and maximum values of 100 seed volume were 105 cm^3 and 112 cm^3 respectively.

4.1.8 Geometric mean diameter

Geometric Mean Diameter (GMD) of tamarind seed indicates the central tendency. The GMD of tamarind seed were ranged between 8.995 & 11.192 mm with mean value of 10.020 it was found to be length width and thickness of tamarind seed was 14.287 mm, 11.26 mm, 6.30 mm respectively. The minimum and maximum value of length width and thickness was found to be 10.640 mm, 8.4 mm, 5.41 mm and 16.88 mm, 14.23 mm, 7.43 mm respectively. Similar to our observations, length width and thickness of seed, 14.4±0.77 mm, 10.5±0.09 mm and 6.30±0.08 mm respectively reported by Bhattacharya *et al.*(1993).

4.1.9 Sphericity

Sphericity values of tamarind seed was 0.705 with different length ranges of tamarind seed. The minimum and maximum value of sphericity was 0.604, 0.852 respectively. Sphericity of tamarind seed was 0.77 reported by Bhattacharya *et al.*(1993).

Table 4.1: Physical properties of tamarind seed

Physical parameter	Maximum value	Minimum value	Mean
Moisture content, (%)	12.556	8.034	10.174
Bulk density, (g/cm^3)	0.773	0.703	0.739
Tapped density, (g/cm^3)	0.796	0.760	0.777
True density, (g/cm^3)	1.443	1.263	1.322
Porosity, (%)	50.020	39.802	44.019
Weight of 100 seed,(g)	81.795	77.746	79.797
Volume of 100 seed, (cm^3)	105	112	108
Geometric mean diameter, (mm)	11.192	8.995	10.020
Sphericity	0.852	0.604	0.705

4.2 Physicochemical Properties of Tamarind Seed Powder

4.2.1 Bulk density and tapped density

The bulk density of tamarind seed powder was 0.745 g/ cm^3. It was observed that the minimum and maximum value of bulk density of tamarind seed were 0.717 g/ cm^3 and 0.769 g/cm^3 respectively.

The tapped density of tamarind seed powder was 0.910 g/ cm^3. It was found to be minimum and maximum value of tapped density of tamarind seed were 0.885 g/ cm^3 and 0.938 g/ cm^3 respectively

4.2.2 Compressibility (Carr's) index

Compressibility (Carr's) index of tamarind seed powder is dependent on bulk density or tapped density and its value was 18.06. Minimum and Maximum values of Compressibility (Carr's) index were 15.00 and 21.95 respectively.

Compressibility (Carr's) index up to 15% usually results in good to excellent flow properties (Reddy *et al.*, 2015). Compressibility (Carr's) index of tamarind seed powder show the fair flow properties.

4.2.3 Hausner's ratio (H)

The hausner's ratio is an indirect index of ease of powder flow. The hausner's ratio of tamarind seed powder is depended on bulk and tapped density and its values was 1.221. Minimum and maximum values of hausner's ratio of tamarind seed gum were found 1.176 and 1.281 respectively. The hausner's ratio indicates better flow properties than higher ones.

Hausner's ratio less than 1.25 indicate better flow properties (Reddy *et al.*, 2015). Hausner's ratio of tamarind seed (1.221) suggest that tamarind seed powder had good flow properties

4.2.4 pH value

The pH value was observed by digital pH meter. The obtained pH value of tamarind seed powder was 5.32.

4.2.5 Swelling index

Swelling index of the tamarind seed polysaccharide was found to be 93.49 %. Minimum and maximum values of swelling index were 83.33 % and 122.22 %. High value of swelling index revealed the high swelling ability of tamarind seed powder. The swelling index revealed the high swelling ability of any sample depends upon its water retention capacity or water absorption capacity.

4.3 Qualitative Phytochemical Analysis

4.3.1 Alkaloid test

The alkaloid test for tamarind seed powder was done by Mayer's test. Yellow coloured precipitate was observed in samples indicate the presence of alkaloid in tamarind seed powder.

Fig. 4.1: Mayer's test of tamarind gum

4.3.2 Carbohydrate test

The carbohydrate test for tamarind seed powder was done by Molisch's test. A red brown ring appears at the common surface of the sample was observed which indicate the presence of carbohydrate in seed powder.

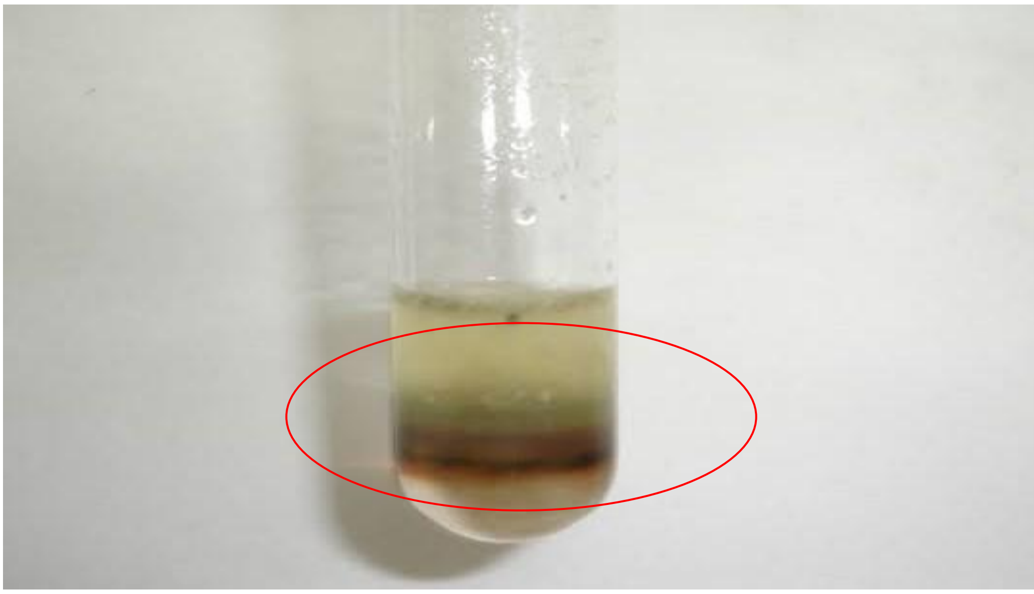


Fig. 4.2: Molisch's test of tamarind gum

4.4 Quantitative Phytochemical Analysis

4.4.1 Alkaloid test

Alkaloid was estimated by spectrophotometer method. Alkaloid value was obtained 8.27 mg/100g. The value was lower than the 3.4% estimated by Akajiaku *et al.* (2014).

4.4.2 Carbohydrate test

Carbohydrate was estimated by spectrophotometer method .Total carbohydrate values were observed 51.466 % in the tamarind seed powder. The values were slightly lower than the 59.30 ±0.4041 % obtained by Mohamed *et al.* (2015).

Table 4.2: Physicochemical properties of tamarind seed powder

Parameter	Mean
Bulk density, g/cm^3	0.745
Tapped density, g/cm^3	0.910
Compressibility(Carr's) index, (%)	18.059
Hausner's ratio	1.221
pH value	5.32
Swelling index, (%)	93.49
Carbohydrate test, (%)	51.466
Alkaloid test, mg/100g	8.27

4.5 Extraction Method

4.5.1 Recovery of endosperm from roasted tamarind seed

The tamarind seed consists of an outer testa and Endosperm. Only the endosperm or split, which contains mainly polysaccharides, is used for the production of the tamarind seed gum. Uniform roasting with sand media in roaster was done at temperature ranges from 100 ºC to 200 ºC with respect to 5, 7.5 and 10 min respectively in Perfura made roaster. Yield of endosperm, husk, broken in 500g seed given in table 4.3 was estimated after decortication of roasted seed in tamarind seed decorticator. Maximum endosperm 55.06 % were obtain when the seed roasted at 140ºC for 5 min where as minimum endosperm 31.58 % was found in the sample roasted at 100ºC for 5 min. Maximum testa was found to be 38.05 % in the sample roasted at 180ºC For 5 min where minimum testa was found to be 21.38 % in the sample roasted at 100 ºC For 5 Min. Maximum broken was found 11.90 % in the sample roasted at 200 ºC for 10 min and minimum broken was found 1.76 in the sample roasted at 100 ºC For 7.5 min.

Despite high temperature and time e.g. 160 ºC, 180 ºC, 200 ºC roasting gave 100 % decortications, however, roasting at lower temperature e.g. 100 ºC, 120 ºC, 140 ºC did not give 100 % decortication. Over roasted decorticated seed colour was turn to brown and gum colour is affected. At roasting temp 200 ºC for 10 min puffing was occurred which makes seed unsuitable for gum production. Water molecules are evaporated during the roasting. Hence, roasting decreases moisture content of seed. Loss of moisture content during the roasting was calculated by initial weight of seed and weight after roasting. Basic colour of tamarind powder (in best quality) is creamy white (Fig. 4.4). From the observations it can be inferred that roasting at low temperature provides low decortications efficiency along with low endosperm yield and roasting at higher temperature gives complete decortications of seed with higher percentage of broken and less yield of endosperm (Fig. 4.1).

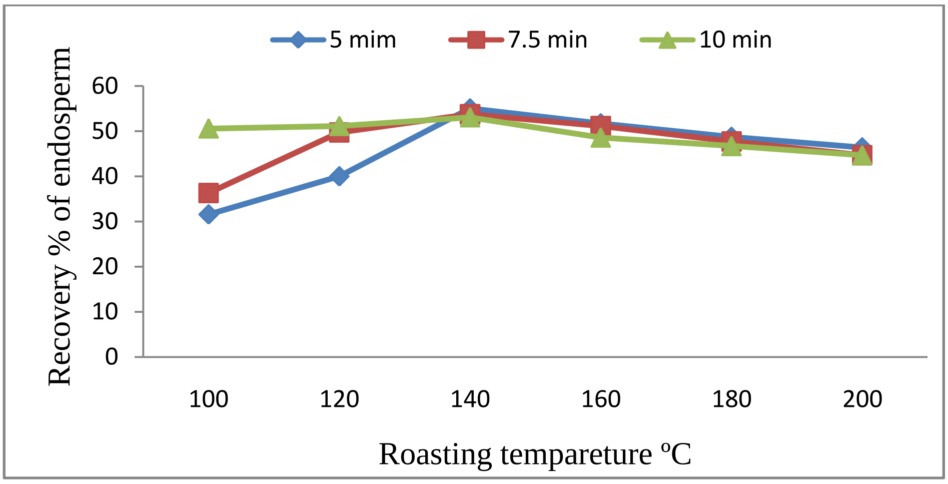


Fig 4.2: Recovery of endosperm from roasted tamarind seed

(a) At 100 °C

(b) At 120 °C

(c) At 140 °C

(d) At 160 °C

(e) At 180 °C

(f) At 200 °C

Fig. 4.4: Tamarind seeds after different roasting treatment for 5 min.

(a) At 5 min

(b) At 7.5 min

(c) At 10 min

Fig.4.5: Tamarind seed powder from different roasting treatment

Table 4.3: Product obtain from roasted seed sample

SN	Roasting Temp.	Roasting Time	Initial Weight	Final weight	Loss of Moisture Content (%)	Product			
						Unhusk seed (%)	Endosperm (%)	Testa (%)	Broken (%)
		5		495.5	0.9	43.54	31.58	21.3	2.60
1	100	7.5	500	494.0	1.20	34.04	36.30	26.7	1.76
		10		482.0	3.44	9.08	50.64	32.9	3.86
		5		490.7	1.86	29.42	40.02	26.7	1.96
2	120	7.5	500	486.8	2.64	14.26	49.76	30.5	2.84
		10		468.9	6.22	0.90	51.18	32.9	5.96
		5		478.8	4.24	5.66	55.06	31.1	3.94
3	140	7.5	500	471.8	5.64	1.62	53.80	34.1	4.84
		10		468	6.40	0.75	53.10	34.4	5.30
		5		467.8	6.44	000	51.74	35.6	6.22
4	160	7.5	500	464.7	7.06	000	51.18	34.7	7.06
		10		461.3	7.74	000	48.62	36.0	7.60
		5		465.6	6.88	000	48.75	38.0	6.32
5	180	7.5	500	455.9	8.82	000	47.78	35.3	8.08
		10		451.3	9.74	000	46.74	33.8	9.66
		5		452.7	9.46	000	46.42	33.6	10.52
6	200	7.5	500	446.9	10.62	000	44.72	33.8	10.82
		10		442.5	11.50	000	44.70	31.9	11.90

4.5.2 Extracted Tamarind Gum

Gum extraction was carried out from the tamarind seed of all the roasted samples of each temperature and time. Gum obtained from tamarind seed was an amorphous free flowing odourless powder with light brown colour. Temperature and time of roasting had a notable influence on the yield of gum (Table 4.4). It can be observed from the table that yield of gum was initially increased but it was decreased from a certain roasting temperature and time. Maximum gum yield was found 54.5 % and 53.1 % at 140 ºC for 5 min and 120 ºC for 10 min respectively (Fig. 4.5). Minimum gum yield was found 28 % at 200ºC for 10 min. Extracted gum yield was higher than 52 % as reported by Reddy *et al.* (2015), 35 % reported by Kumar *et al.* (2010) and 30 % - 50.36 % from different seed source reported by Nagajothi *et al.*(2017).

Polysaccharides degrade during the roasting. Higher temperature is related with molecular structure modification and depolymerisation which obviously results in decreased viscosity. Roasting temperature 120 ºC and 140 ºC gave good tamarind gum yield.

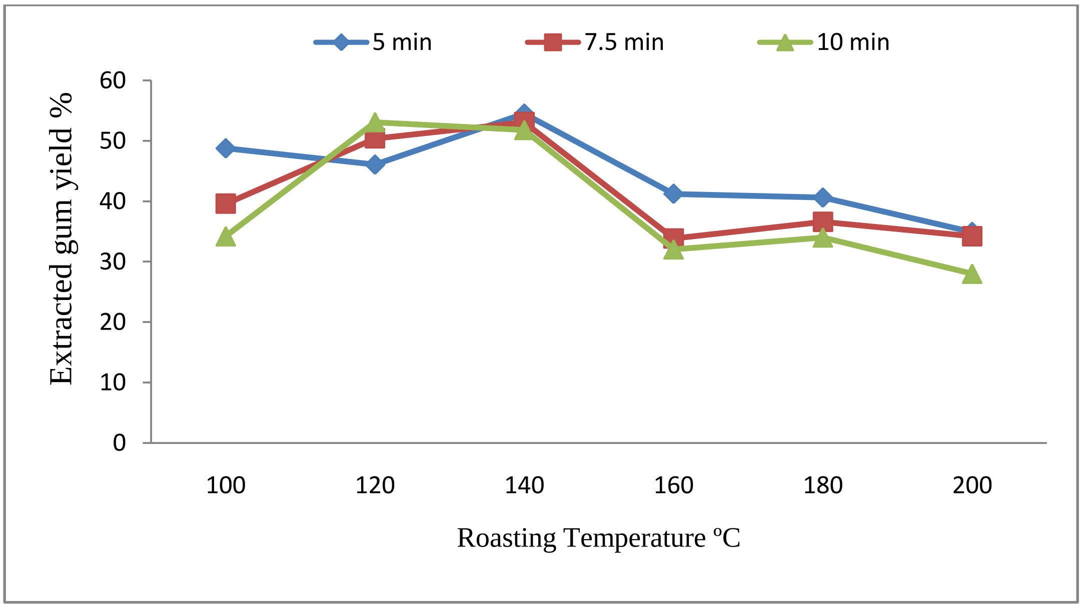
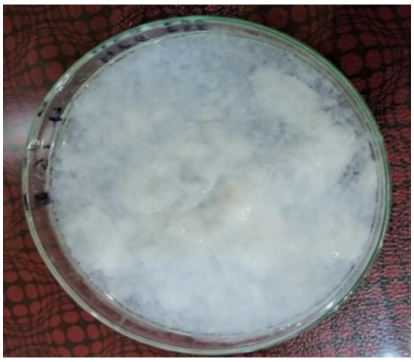
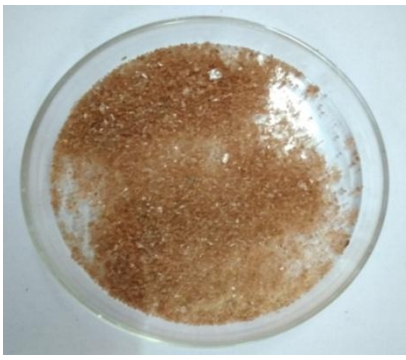


Fig. 4.6: Gum yield (%) from roasted tamarind seed

a) White mass mucilage b) Tamarind seed gum

Fig. 4.7: Tamarind gum

Table 4.4: Gum yield from roasted seed sample

SN	Roasting temperature (°C)	Roasting time (min)	Gum yield in 10 g	Gum yield %
1	100	5	4.87	48.76
		7.5	3.96	39.60
		10	3.42	34.2
2	120	5	4.60	46.06
		7.5	5.04	50.4
		10	5.31	53.1
3	140	5	5.45	54.5
		7.5	5.31	53.1
		10	5.18	51.8
4	160	5	4.12	41.23
		7.5	3.38	33.85
		10	3.20	32.03
5	180	5	4.06	40.06
		7.5	3.66	36.60
		10	3.40	34.00
6	200	5	3.49	34.90
		7.5	3.42	34.20
		10	2.80	28.00

4.6 Physicochemical Properties of Extracted Gum

4.6.1 Bulk and tapped density

The bulk density of tamarind gum was 0.497 g/cm^3. The minimum and maximum values of bulk density of tamarind gum were 0.367 g/cm^3 and 0.658 g/cm^3 respectively. Bulk density of tamarind gum was 0.580 g/cm^3 reported by Kumar *et al.* (2010).

The tapped density of tamarind gum was 0.565 g/cm^3. The minimum and maximum value of tapped density of tamarind gum were 0.408 g/cm^3 and 0.694 g/cm^3 respectively, was higher than the value of 0.760 g/cm^3 estimated by Kumar *et al.* (2010).

4.6.2 Compressibility (Carr's) index

Compressibility (Carr's) index of tamarind gum powder is dependent on bulk density or tapped density. Minimum value of Compressibility (Carr's) index were 5.263 was found at roasting temperature 160 ºC for 10 min and maximum value 23.188 was found at roasting temperature 180 ºC for 7.5 min. Minimum value was slightly higher than the finding of Singh *et al. 2011* and Maximum valve was higher than the reported by Phani *et al.* (2011).

Compressibility (Carr's) index values up to 15 % usually results in good to excellent flow properties & indicate desirable packing characteristics. Compressibility index above 25% are often sources of poor tableting qualities. Compressibility index 5.479 at 120 ºC for 10 min and 8.537 at 140 ºC for 5 min roasted sample may have excellent flow properties. Compressibility (Carr's) index of 10 min roasted samples may have excellent flow properties and 140 ºC, 160 ºC, 180 ºC for 7.5 min, 120 ºC for 5 min showed fair and poor flow properties of tamarind gum powder.

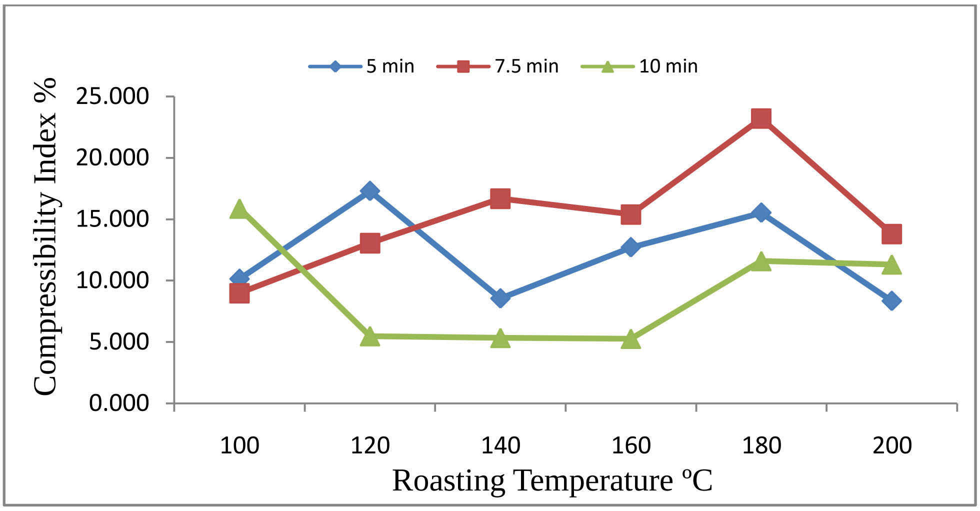


Fig 4.8: Effect of roasting temperature on compressibility index

4.6.3 Hausner's ratio (H)

Hausner's ratio of tamarind seed powder is an indirect indicator of ease of powder flow. The hausner's ratio of tamarind seed powder is dependent on bulk and tapped density. Minimum value 1.056 of tamarind gum powder was found in the samples roasted at 160 ºC for 10 min. maximum value 1.302 of hausner's ratio of tamarind gum powder was found at 160 ºC for 7.5 min. These value was slightly higher than 1.05±0.0019 as reported by Reddy *et al.* (2015).

The hausner's ratio less than 1.25 indicates better flow properties. Hausner's ratio 1.058 and 1.093 was observed in the samples roasted at 120 ºC for 10 min and 140 ºC for 5min. Tamarind gum powder extracted by roasting sample at 160 ºC for 7.5 min can have moderate flow properties. Other tamarind gum powder can have good flow properties.

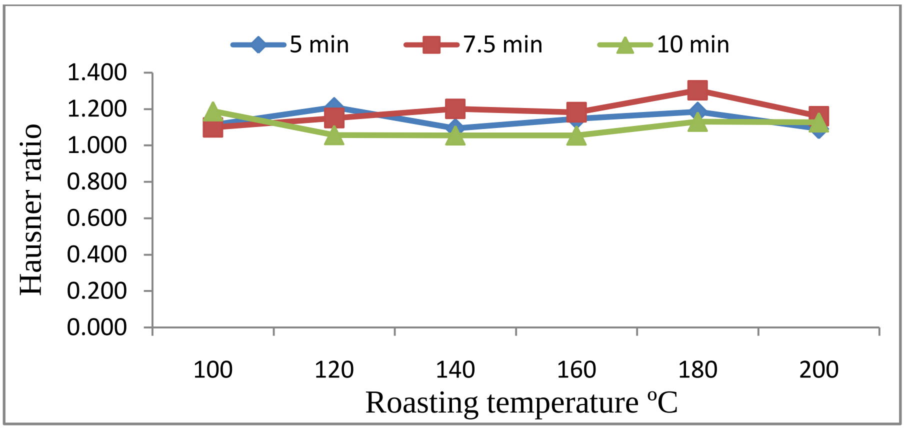


Fig 4.9: Effect of roasting temperature on Hausner's ratio.

4.6.4 Swelling index (SI)

Swelling index of the tamarind seed polysaccharide was found maximum 344.44 % at 200 ºC roasting temperature and minimum value was 15.38 % at 100 ºC roasting temperature. Maximum and minimum value of swelling index was lower than 1700 % which is reported by Phani *et al.* (2011) and higher than 70.95% which is reported by Readdy *et al.* (2015).

High value of swelling index revealed the high swelling ability of tamarind seed powder. The swelling index revealed the high swelling ability of any sample depends upon its water retention capacity or water absorption capacity.

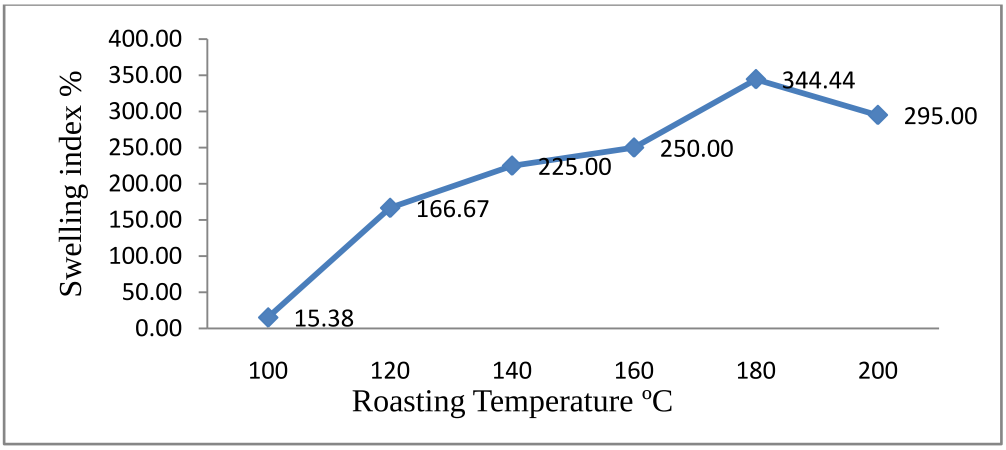


Fig. 4.10: Swelling index of tamarind gum roasted sample at 5 min

Table 4.5: Swelling index of tamarind seed gum

S N	Sample	Wt of Sample	Volume of sample	Made up with distilled water	Volume of swollen gum	Swelling Index %
1	100	1.046	2.6	10	3.0	15.38
2	120	1.057	2.1	10	5.6	166.66
3	140	1.041	1.6	10	5.2	225
4	160	1.023	2.0	10	7.0	250
5	180	1.024	1.8	10	8.0	344.44
6	200	1.47	2.0	10	7.9	295

4.6.5 pH value

The pH value was observed by digital pH meter. The obtained pH value of tamarind seed gum obtains from different roasted seed sample which indicate the gum was acidic in nature. The highest value 2.37 in 140ºC, 5 min tamarind gum and lowest value was 1.99 in 180ºC, 5min tamarind gum sample

Table 4.6: pH value of tamarind gum solution

S N	Roasting Temperature °C	Time Min.	pH
1	100	5	2.17
		7.5	2.19
		10	2.23
2	120	5	2.20
		7.5	2.02
		10	2.87
3	140	5	2.37
		7.5	2.02
		10	2.10
4	160	5	2.24
		7.5	2.14
		10	2.12
5	180	5	2.14
		7.5	2.10
		10	1.99
6	200	5	2.08
		7.5	2.15
		10	1.92

4.6.6 Surface tension

Surface tension of the selected 1 % tamarind gum solution was determined by drop count method using a Stalagmometer and the highest value obtained was 49.611 dynes/cm where lowest value was 41.680 dynes/cm. Surface tension of gum of sample roasted at 140 ºC was 49.611 dynes/cm. This value was lower than 83.26±0.62 as reported by Phani *et al.* (2011).

Table 4.7: Surface tension of tamarind gum solution

S. N.	Roasting Temperature (°C)	Number of drops of sample n^1	Number of drops of sample n^2	Surface tension $= \frac{n_1 \rho_2 \gamma_1}{n_2 \rho_1}$
1	100	68	57	41.680
2	120	69	53	45.484
3	140	71	50	49.611
4	160	72	58	43.370
5	180	70	54	45.289
6	200	73	52	49.047

4.6.7 Solubility test

The solubility of tamarind seed gum was determined by using various solvent such as hot water, cold water, ethanol, methanol and acetone and obtained results are summarized in table. In case of water as solvent, it was found that the sample of tamarind seed gum first swell up in water and after that it became soluble. Tamarind seed gum was more soluble in hot water (49.6% solubility) than cold water (19.6%). The sample of tamarind gum was insoluble in case of other solvent like ethanol, methanol, Acetone. Similar solubility behaviour was observed by Phani *et al.*, 2011.

Solubility study showed that it was sparingly soluble and form viscous colloidal solution in warm water where insoluble in ethanol, acetone, benzene, ether & methanol. Solubility is the most reliable criteria to evaluate the behaviour of powder in aqueous solution.

Table 4.8: Solubility of tamarind gum solution

Solvent	Solubility behaviour	Solubility %
Hot water	Soluble	49.6
Cold water	Soluble	19.6
Ethanol	Insoluble	0
Acetone	Insoluble	0
Methanol	Insoluble	0

4.7 Purity of tamarind gum

4.7.1 Alkaloid test

The purity of the gum was tested by performing phytochemical tests. Alkaloid was tested by Mayer's test. Yellow coloured precipitate was not observed in gum samples indicate the absence of alkaloid. The observation of absence of alkaloid in tamarind gum is similar to observation recorded by Kumar *et al.*, 2010.

4.7.2 Carbohydrate test

Molisch's test indicate the presence of carbohydrate in tamarind gum. Carbohydrate estimation was carried in all the extracted gum samples by Spectro-photometric method. Highest carbohydrate was obtain 58.60 % in the gum extracted from the seed roasted at 100 ºC for 5 min while lowest carbohydrate (11 %) was obtained from the gum extracted from the seed roasted at 200 ºC for 10 min. The values were lower than the 88.85±0.600 % obtained by Mohamed *et al. (2015).*

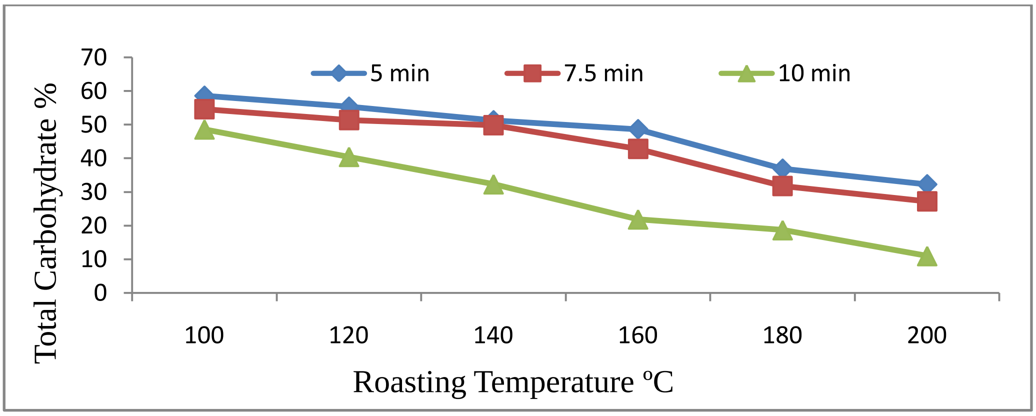


Fig 4.11: Effect of roasting temperature in total carbohydrate

Table 4.9: Total carbohydrate of tamarind gum solution

S.N.	Tem. (°C)	Time (min)	Carbohydrate %
1	100	5	58.60
2	120	5	55.35
3	140	5	51.30
4	160	5	48.65
5	180	5	36.90
6	200	5	32.25
7	100	7.5	54.65
8	120	7.5	51.45
9	140	7.5	49.90
10	160	7.5	42.85
11	180	7.5	31.80
12	200	7.5	27.20
13	100	10	48.65
14	120	10	40.50
15	140	10	32.35
16	160	10	21.90
17	180	10	18.70
18	200	10	11

CHAPTER-V
SUMMARY AND CONCLUSIONS

The present study entitled **"Extraction of gum from tamarind *(Tamarindus indica)* seed and its characterization"** was carried out in the Department of Agricultural Processing and Food Engineering, Swami Vivekanand College of Agricultural Engineering and Technology and Research Station, Faculty of Agricultural Engineering, IGKV, Raipur, (C.G.) and Department of Plant Physiology, Agril. Bio-Chemistry, Medicinal and Aromatic Plants, College of Agriculture, IGKV, Raipur, (C.G).

Tamarind gums was extracted from tamarind seed powder. For removing testa of tamarind seed, seeds were roasted at 100 ºC, 120 ºC, 140 ºC, 160 ºC, 180 ºC and 200 ºC temperature for 5, 7.5, 10 min. Tamarind seeds were decorticated by tamarind seed decorticator and grinded to powder. Powder was used for further processing and gums extraction. Based on the experimental observation following results were obtained.

- Moisture content of the tamarind seed was 10.174 % on dry basis. Minimum and maximum value of moisture content of tamarind seed on dry basis were 8.034% and 12.556% respectively.
- Bulk density, tapped density, true density and porosity of tamarind seed were found to be 0.739 g/cm^3, 0.777 g/cm^3, 1.322 g/cm^3 and 44.01 % respectively.
- Weight and volume of 100 seed sample were 79.79 g and 108.6 cm^3 respectively.
- The length, width and thickness were measured to determine the size of tamarind seed. The average length, width and thickness were found 14.28 mm, 11.26 mm and 6.30mm respectively. Geometric mean diameter and sphericity were found 10.02 mm and 0.0705.
- Compressibility (carr's) index, Hausner ratio, pH value, swelling index, total carbohydrate and alkaloid of tamarind seed powder were found to be 18.05 %, 1.22, 5.32, 93.49 % , 51.46 % and 8.27 mg/100 g respectively.

- Only endosperm which contains mainly polysaccharides was used for extraction of tamarind seed gum. For removing testa or husk, seeds were roasted with sand as medium. Maximum endosperm 55.06 % were obtained when the seed roasted at 140ºC for 5 min where as minimum endosperm 31.58 % was obtained from the sample roasted at 100 ºC for 5 min. Maximum testa was found to be 38.0 % in the sample roasted at 180 ºC For 5 min whereas minimum testa was found to be 21.3 % in the sample roasted at 100 ºC for 5 Min. Maximum broken was found 11.90 % in the sample roasted at 200 ºC for 10 min and minimum broken was found 1.76 in the sample roasted at 100 ºC For 7.5 min.
- Gum was extracted from all the seed samples treated for various time and temperature. Gum obtained from tamarind seed was an amorphous free flowing odorless powder with light brown color. Temperature and time of roasting had a notable influence on the yield of gum. Gum yield increased as the temperature and time is increased up to 120 ºC. Maximum gum yield (54.5 %) was observed at 140 ºC and on further increasing the temperature, gum yield decreased up to 28 %. at 200 ºC.
- The bulk density and tapped density of tamarind gum was 0.497 g/cm^3, 0.565 g/cm^3 respectively.
- Compressibility (Carr's) index of tamarind gum, maximum value was 23.188 at 180°C for 7.5 min and minimum value was 5.263 at 160 °C for 10 min. Hausner's ratio of tamarind gum, maximum value was 1.302 at 160°C for 7.5 min and minimum value was 1.056 at 160 °C for 10 min. Swelling index of the tamarind gum was found to be 225 % at 140°C for 5 min.
- The solubility of tamarind gum was determined by using various solvent such as hot water, cold water, ethanol, methanol and acetone. Tamarind seed gum was more soluble in hot water than cold water. Tamarind gum was insoluble in case of other solvent like ethanol, methanol and acetone.
- The pH value was observed by digital pH meter. The obtained pH value was 2.11 of tamarind seed gum.

- Surface tension of the selected 1 % tamarind gum solution was determined by drop count method using a Stalagmometer and the highest value obtained was 49.611 dynes/cm for the gum extracted from seed roasted at 140 °C.
- Mayer's test indicates the absence of alkaloid. Molisch's test indicate the presence of carbohydrate in tamarind gum. Highest carbohydrate values are obtained 58.60 % in the gum extracted by treating seed at 100°C for 5min while lowest carbohydrate was obtain 11 % in the gum extracted by treating seed at 200 °C for 10 min.

Conclusions

Tamarind gum can be successfully extracted from tamarind seed using water based extraction procedure. Roasting at 140 °C, 5 min. for gum extraction was found optimum for tamarind gum production. Roasting at higher or lower temperature is not good for gum extraction purpose as indicated by low yield of gum. Physico-chemical properties of extracted gum indicate that the tamarind gum is suitable for thickening, binding agent.

Suggestion for future work

1. The work may be carried out to find out the replacement of acetone for precipitation of gum.
2. The work may be carried out to develop a pilot scale plant.
3. Drying characteristic of extracted gum mucilage can be studied.

REFERENCES

Akajiaku, L. O., Nwosu, J. N., Onuegbu, Njoku, N. E. and Egbeneke, C. O. 2014. Proximate, mineral and anti-nutrient composition of processed (Soaked and Roasted) Tamarind *(Tamarindus indica)* seed net. Current Research in Nutrition and Science, 2(3):136-145.

AOAC method: Official methods of analysis of AOAC international, Edited by PatricaCunniff, AOAC International Publication, 16th Edition, Vol.II, Chapter 37:4.

Bagul, M., Sonawane, S. K. and Arya S. S. 2015. Tamarind seeds: chemistry, technology, application and health benefits: A review Indian food Industry Magazine, 3(34).

Bansal, J., Kumar, N., Malviya, R. and Sharma, P. K. 2013. Extraction and Evaluation of tamarind seed polysaccharide as pharmaceutical in situ Gel forming system. American-Eurasian J. of Science Research, 9(1):01-05.

Bisulca, C., Odegaard, N. and Zimmt, W. 2016. Testing for gums, starches, and mucilage's in artifacts with o-toluidine. J. of the American Ins. for Conservation, 55(4).217-227.

Bhattacharya, S., Bal, S. and Mukherjee, R. K. 1993 Some physical and engineering properties of tamarind (*Tamarindus indica*) seed. J. of food engineering, 18 :77-89.

Chawananorasest, K., Saengtongdee, P. and Kaemchantuek, P. 2016. Extraction and Characterization of tamarind (*Tamarind indica L.)* seed polysaccharides (TSP) from three Difference sources. www.mdpi.com/journal/molecules.

Dev, D., Rehal, D. K. and Prasad, D. N. 2018. Preparation and evaluation of modified tamarind seed gum as a novel super disintegrant. J. of Drug Delivery and Therapeutics, 8(5):372-377.

Eddy, N. O., Ameh, P. O., Gimba, C. E. and Ebenso, E. E. 2012. Rheological modeling and characterization of *Ficusplatyphylla* gum exudates. J. of Chemistry. Hindawi Publishing Corporation, 2013: 1-10.

Goswami, S. and Naik, S. 2014. Natural gums and its pharmaceutical application. J. of Sci. and Innovation Research, 3(1):112-121.

Ghadge, P. N. and Prasad, K. 2012. Some Physical Properties of Rice Kernels: Variety PR-106. J. Food Proce. & Tech., 3(8): 01-05.

Gerarad T. Handbook of Water soluble gums and resins. New York : McGraw Hill; 1980, chapter 23.

Isa, A., Idris, M. M. Karamba, H. and Ayoubi, R. 2018 Tamarindus indica.- A review paper on efficacy of tamarind plant in water treatment and purification. Int. J. of sci. & Engineering Research, 9(10):1-10.

ISTA (International seed testing association) 1996. A guide for seed testing : an overview. 12-18

Jangdey, M. S., Gupta, A., Kaur, C. D. and Saraf, S. 2016. Assessment of Utilization, Value addition and characterization of Tamarind: A Natural Gum of Chhattisgarh. Int. J. of Pharmaceutical Research & Allied Sciences, 5(2):323-334.

John, B., CT, S., George, S. and Reddy, V. R. K. 2014. Spectrophotometric Estimation of total alkaloids in selected justicia species. Int. J. of pharmacy and pharmaceutical sciences, 6(5): 647-648

Joseph, J., Kanchalochana, S. N., Rajalakshmi, G, Hari, V. and Durai R. D. 2012. Tamarind seed polysaccharide: a promising natural excipient for pharmaceuticals. Int. J. of green pharmacy, 170-178.

Katiyar, N., Malviya, R. and Sharma, P. K. 2015. Effect of heating conditions on physical properties of tamarind seed polysaccharide. Global J. of Pharmacology, 9(1):47-50.

Kakade, A.P. 2004. Studies on storage of tamarind and processing of value added tamarind products. unpublished M. Tech. (Agril. Engg.) thesis, Indira Gandhi Krishi Vishwavidyalaya, Raipur, P 13.

Kumar, C. S. and Bhattacharya, S. 2008. Tamarind seed: Properties Processing and Utilization. Critical Reviews in Food Science and Nutrition, 48(1): 1-20

Kumar, R., Patil, S. R., Patil, M. B., Paschapur, M. S. and Mahalaxmi, R. 2010. Isolation and evaluation of the emulsifying properties of tamarind seed polysaccharide on castor oil emulsion. Scholars Research Library, 2(1):518-527.

Klahal, K., Pikul, J., Sittikijyothin, W. and Mongkholrattanasit, R. 2012. Thickening agent based on tamarind seed gum for disperse printing of polyester. RMUTP International conference: Textiles & Fashion 2012. Bangkok Thailand.

Ly, J., Sjofjan, O., Djunaidi, I. H. and Suyadi. 2017. Effect of processing methods on nutrient and tannin content of tamarind seeds. Tropical Drylands, *1(2):78-82*

Lokesh, S. L., Balasubramanian, D. and Durairasu, p. 2014. Effect of agro-climatic influence on processing and preparation of tamarind kernel powder and seed gum. Journal of international academic research for multidisciplinary, 2(5): 412-419.

Marangoni, A., Ali, L., Kermasha, S. 1988. Composition and properties of seeds of the true legume tamarindus indica. J. of food science, 53:1452-1455.

Mohamed, H. A., Mohamed B. E. and Ahmed K. E. 2015. Physicochemical Properties of Tamarind (Tamarindus indica) Seed Polysaccharides. J. of Food Processing & Technology, 6(6):1-5

Mohite, A. M., Mishra, A. and Sharma, N. 2016. Equilibrium moisture content and drying behaviour of tamarind seed under thin layer condition. Int. J. seed spices, 6(2):19-23.

Nagajothi, M.S., Balasubramanian, A., Thombare, N. and Renganayaki, P. R. 2017. Effect of different seed sources on tamarind kernel powder and seed gum yield. Int. J. of Current Microbiology and Applied Sciences, 6(7):318-323.

Nagajothi, M.S., Balasubramanian, A., Renganayaki, P. R. and Sudha, S. 2017.Optimizing Roasting Standard for Quality Gum Production in Tamarind Seed Gum Production. Int. J. of Current Microbiology and Applied Sciences, 6(5):1964-1968.

Nayak, A. K. and Pal, D. 2017.Tamarind Seed Polysaccharide: An Emerging Excipient for Pharmaceutical Use. Indian J. of Pharmaceutical Education and Research, 51(2):S136-S146.

Nandi, R.C.1975. A process for preparation of polyose from the seeds of *Tamarindus indica.* Indian Patent, 142092.

Nandre, R. S., Bhamre, V. G. and Rajbhoj, S. S. 2014. Effect of temperature on binding properties of natural gum. Int research J. of pharmacy, 5(8): 633-635.

Nep, I. E. and Conway, B. R. 2010. Characterization of grewia gum, a potential pharmaceutical excipient. J. Excipients and Food Chem, 1(1) 30 - 40.

Oomah, B. D. & Mazza G. 2001.Optimization of a spray drying process for flaxseed gum. Int. J. of Food Science and Technology, (36):135-143.

Phani, G. K., Battu, G. and Kotha, N. S. 2011. Isolation and evaluation of tamarind seed polysaccharide being used as a polymer in pharmaceutical dosage froms. Research J. of pharmaceutical, biological and chemical sciences, 2(2): 274-290.

Ponnikornkit, B., Ngamsalak, C., Huanbutta, K. and Sittikijyothin, W. 2014. Swelling behaviour of carboxymethylated tamarind gum. Advanced Materials Research, 1060:137-140.

Pawar, H. A. and Mello, P. M. D.2011. Spectrophotometric estimation of total polysaccharides in Cassia tora gum. J. of Applied Pharmaceutical Sci, 01(03):93-95.

Padiyar, A., Hegde, S., Abhishek, K., Bhutada, M. and Patil, J. H. 2016. Effect of pretreatment methods on production of reducing sugars from tamarind kernel powder. J. of Chemical and Pharmaceutical Research, 8(8): 929-932.

Prangpru, N., Treeamnuk, T., Jaito, K. and Vanmontree, B. 2017. Effect of temperature on the physicochemical properties of tamarind (*Tamarindus indica*) powder. Int. J. of Food Engineering, 3(2):127-131.

Pulungan, H. M., Sukardi, Sri Maryani, E. F., Atifah, N. sucipto. 2001. Tamarind kernel powder (*Tamarindus indica*) processing (Reviews on roasting temperature and roasting duration). J.l Teknologi Pertanian, 2(3) :150-158.

Rao, A. S., Kumar, A. A. and Ramana, M. V. 2015. Tamarind seed processing and by-products. CIGR J. Open access at http://www.cigrjournal.org 17(2): 200-204

Rao. P.S., Ghosh, T.P. and Krishna S.1946. Extraction and purification of tamarind seed polysaccharide. J Sci Ind Research.

Rao, P.S. and Srivastava, H.C.1973. Tamarind, In: Whistler RL (ed), Industrial gums, 2nd ed, New York: Academic Press.369-411. https://doi.org/10.1016/ B978-0-12-746252-3.50022-8.

Reddy, M. S., Bhoni, K. and Kuppala K. 2015. Extraction and characterization of tamarind seed polysaccharide as a pharmaceutical excipient. Int J. of Innovative Pharmaceutical Sci. and Research, 3(9):1244-1253.

Sahay, K.M. and Singh, K.K. 1994. Unit Operations of Agricultural Processing, Vikas Publishing House Pvt. Ltd, New Delhi 112.

Sarkar, B. R., Awasthi, P. and Joshi, H. 2018. Physical Properties and nutritional composition of tamarind kernel powder and quality evaluation of instant chutney mix prepared incorporating tamarind kernel powder. J. of pharmacognosy and phytochemistry,*7(6):1342-1346.*

Salehi, F. and Kashaninejad, M. 2018. The Effect of thermal treatment on the rheological behavior of basil seed (Ocimum basilicum) and balangu seed (Lallemantia royleana) Gums. J. of food biosciences and technology, *8(1):35-46.*

Srinivasan, B., Ganta, A., Rajamanickam, D., Veerabhadraiah, B. B. and Varadharajan, M. 2011. Evaluation of tamarind seed polysaccharide as a drug release retardant. Int. J. of Pharmaceutical Sciences Review and Research, 9(2):27-31.

Singh, D., Wangchu, L. and Moond, S. K. 2007. Processed product of tamarind. Natural product Radiance, 6(4): 315-321.

Singh, R., Malviya, R. and Sharma, P. K. 2011. Extraction and characterization of tamarind seed polysaccharide as a pharmaceutical excipient. Pharmacognosy Journal, 3(20):17-19.

Singh, K. K. and Goswami, T. K. 1996. Physical properties of cumin seed. J of Agricultural Engineering Research, 64(2):93-98.

Singal, O. P. and Samuel, D. V. K. 2003. Engineering properties of biological materials. Saroj prakashan, katra Allahabad, 211002.

Sukhawanli, S. and Thamakorn, P. 2014. Extraction of tamarind seed jellose under different conditions and their rheological properties. Food and Applied Bioscience J, *2(1):61-68.*

Shukla, A. J., Bishnoi, R. S., Kumar, M., Fenin, V. and Jain, C. P.2018. Applications of tamarind seeds polysaccharide-based copolymers in controlled drug delivery: An overview. Asian J. of Pharmacy and Pharmacology, 4(1): 23-30.

Saikia, T., Ali, J. and Das, B. 2017. Isolation and characterization of tamarind seed polysaccharides–a natural release retardant. International Journal of Current Pharmaceutical Research, 9(4): 114-117.

Thakur, N., Mittal, P., Kaur, R. and Goswami, M. 2015. Phytochemical screening of gum extracted from curcuma amada. Int. J. of Pharmacognosy, 2(8): 419-425.

Wang, L., Nakanishi, T., Sato, Y., Oishi, K.,Hirooka, H. and Kumagai, H. 2017. Effect of feeding tamarind kernel powder extract residue on digestibility, nitrogen availability and ruminal fermentation in wethers. Asian-Australasian Journal of Animal Sciences, 00:1-7

Yeasmen, N. and Islam, M. N. 2015. Ethanol as a solvent and hot extraction technique preservedthe antioxidant properties of tamarind (*Tamarindus indica)* seed. J. Advanced Veterinary and Animal research, 2(3):332-337.

APPENDIX – A

Data sheet 1

Moisture content of tamarind seed

S. N	Wt of sample (g)	Wt of dry sample (g)	Moisture content (db)	Moisture content (%)
1	20.68	18.552	0.115	11.5
2	20.3	18.560	0.095	9.5
3	20.28	18.352	0.105	10.5
4	20.08	17.840	0.126	12.55
5	20.36	18.846	0.080	8.034
6	20.68	18.955	0.091	9.101
Average				10.174
Minimum				8.034
Maximum				12.556

Bulk density and tapped density of tamarind seed

S N	Volume (cm^3)	Tapped volume (cm^3)	Weight (g)	Bulk density (g/cm^3)	Tapped density (g/cm^3)
1	100	98	76.0	0.760	0.776
2	100	94	71.4	0.714	0.760
3	100	93	71.9	0.719	0.773
4	100	97	75.0	0.750	0.773
5	100	96	75.3	0.753	0.784
6	100	98	77.3	0.773	0.786
7	100	95	75.6	0.756	0.796
8	100	91	70.3	0.703	0.773
9	100	94	72.1	0.721	0.767
10	100	95	73.7	0.737	0.776
	Average	95.1	73.9	0.739	0.777
	Minimum	91	70.3	0.703	0.760
	Maximum	98	77.3	0.773	0.796

Data sheet 2

True density and Porosity of tamarind seed

S. N.	Weight (g)	Toluene (ml)	Displaced volume (ml)	True density (g/cm^3)	Bulk density (g/cm^3)	Porosity (%)
1	10.1	30	8	1.263	0.760	39.802
2	10	30	7	1.429	0.714	50.020
3	10.3	30	8	1.288	0.719	44.155
4	10.4	30	8	1.300	0.750	42.308
5	10.1	30	8	1.263	0.753	40.356
6	10.1	30	7	1.443	0.773	46.426
7	10.3	30	8	1.288	0.756	41.282
8	10.3	30	8	1.288	0.703	45.398
9	10.8	30	8	1.350	0.721	46.593
10	10.5	30	8	1.313	0.737	43.848
		Average	7.8	1.322	0.739	44.019
		Minimum	7	1.263	0.703	39.802
		Maximum	8	1.443	0.773	50.020

Data sheet 3

Geometric mean and Sphericity of tamarind seed

S.N.	Length (mm)	Width (mm)	Thickness (mm)	Geometric mean GMD= (LWT)⅓ (mm)	Sphericity S = (LWT)⅓ ÷ L
1	13.52	11.55	5.91	9.736	0.720
2	15.36	9.43	6.38	9.740	0.634
3	16.26	11.43	5.67	10.176	0.626
4	15.48	10.97	5.61	9.840	0.636
5	14.26	10.73	5.92	9.676	0.679
6	12.97	11.95	6.22	9.879	0.762
7	12.42	11.10	6.54	9.661	0.778
8	14.53	8.40	7.43	9.679	0.666
9	13.05	11.48	6.20	9.757	0.748
10	13.19	10.17	6.24	9.424	0.715
11	13.94	11.96	5.67	9.814	0.704
12	13.16	10.85	6.57	9.789	0.744
13	15.19	10.71	5.96	9.898	0.652
14	13.04	12.81	5.96	9.985	0.766
15	13.70	10.79	6.39	9.812	0.716
16	13.21	11.65	6.64	10.072	0.762
17	14.72	10.32	6.79	10.104	0.686
18	14.35	13.40	6.75	10.908	0.760
19	14.36	14.23	6.77	11.143	0.776
20	15.05	11.54	6.36	10.337	0.687
21	12.16	11.86	6.8	9.935	0.817
22	13.90	12.01	6.33	10.186	0.733
23	12.73	10.46	6.50	9.530	0.749
24	15.80	10.89	6.17	10.201	0.646
25	13.23	9.94	7.01	9.732	0.736
26	15.20	11.46	6.75	10.555	0.694
27	14.83	13.03	6.97	11.043	0.745
28	12.48	11.29	5.87	9.387	0.752
29	15.88	9.30	6.29	9.757	0.614
30	14.58	11.63	6.16	10.146	0.696
31	16.00	9.22	6.11	9.660	0.604
32	15.92	11.37	6.25	10.420	0.655
33	14.47	12.05	6.28	10.307	0.712
34	14.28	10.86	6.52	10.037	0.703
35	13.58	12.50	6.64	10.407	0.766
36	14.36	10.72	6.55	10.028	0.698

37	12.94	11.28	6.70	9.926	0.767
38	15.58	11.22	6.10	10.216	0.656
39	14.18	12.09	5.75	9.952	0.702
40	14.70	12.00	6.70	10.573	0.719
41	15.18	10.62	6.28	10.041	0.661
42	13.26	12.70	6.68	10.400	0.784
43	14.80	8.92	6.59	9.546	0.645
44	16.62	13.18	6.01	10.960	0.659
45	13.96	13.03	5.97	10.279	0.736
46	12.33	11.84	6.01	9.573	0.776
47	16.88	11.79	6.04	10.633	0.630
48	14.77	9.92	6.20	9.685	0.656
49	13.94	10.03	5.41	9.111	0.654
50	13.70	11.73	5.73	9.729	0.710
51	15.75	10.30	6.32	10.084	0.640
52	14.77	10.78	5.85	9.766	0.661
53	14.06	12.38	5.98	10.135	0.721
54	16.42	11.84	5.95	10.497	0.639
55	15.47	11.19	6.37	10.331	0.668
56	14.20	13.51	7.13	11.101	0.782
57	13.33	10.21	7.16	9.914	0.744
58	13.19	12.74	6.40	10.245	0.777
59	13.73	12.15	6.24	10.135	0.738
60	15.66	11.08	6.57	10.446	0.667
61	15.93	11.09	6.58	10.515	0.660
62	14.17	10.72	7.02	10.216	0.721
63	16.46	13.09	5.94	10.857	0.660
64	15.92	11.44	5.82	10.196	0.640
65	13.98	9.82	6.15	9.451	0.676
66	15.18	13.23	6.38	10.861	0.716
67	15.62	10.76	6.54	10.320	0.661
68	15.23	12.06	6.14	10.409	0.683
69	12.66	12.22	6.00	9.755	0.771
70	15.55	10.84	5.88	9.970	0.641
71	13.30	9.63	6.98	9.633	0.724
72	14.64	12.28	5.61	10.028	0.685
73	13.95	11.38	5.83	9.745	0.699
74	14.02	8.74	6.86	9.438	0.673
75	13.78	12.22	5.50	9.748	0.707
76	15.78	11.31	5.90	10.174	0.645
77	15.14	13.29	6.44	10.902	0.720
78	14.70	13.22	6.38	10.743	0.731
79	15.02	9.61	6.04	9.553	0.636
80	14.16	11.96	6.48	10.315	0.728

81	13.60	9.54	7.05	9.707	0.714
82	13.20	12.38	6.42	10.161	0.770
83	12.30	10.70	5.82	9.150	0.744
84	13.73	10.68	6.25	9.713	0.707
85	14.80	8.87	5.81	9.137	0.617
86	15.05	13.74	6.78	11.192	0.744
87	14.93	11.22	5.98	10.006	0.670
88	16.52	10.37	6.46	10.344	0.626
89	13.18	12.41	5.98	9.926	0.753
90	12.80	9.82	5.79	8.995	0.703
91	13.50	10.33	7.16	9.995	0.740
92	13.89	10.51	6.21	9.678	0.697
93	14.23	9.80	6.44	9.648	0.678
94	10.64	10.16	6.88	9.060	0.852
95	13.23	11.61	6.67	10.081	0.762
96	13.33	13.07	5.51	9.865	0.740
97	14.41	8.61	6.79	9.444	0.655
98	13.75	10.86	6.69	9.997	0.727
99	12.95	11.26	5.79	9.451	0.730
100	12.90	11.10	6.18	9.601	0.744
Average	14.287	11.265	6.305	10.020	0.705
Minimum	10.640	8.400	5.410	8.995	0.604
Maximum	16.880	14.230	7.430	11.192	0.852

Weight and Volume of 100 seed tamarind

S N	Number of seed	Weight of 100 seed (g)	Volume of 100 seed (ml)
1	100	81.431	105
2	100	78.759	108
3	100	77.746	112
4	100	81.795	110
5	100	79.254	108
Average		79.797	108.6
Minimum		77.746	105
Maximum		81.795	112

Data sheet 4

Compressibility index and Housner Ratio of tamarind powder

S N	Weight (g)	Volume (ml)	Tapped Volume (ml)	Bulk Density (g/ml)	Tapped density (g/ml)	compressibility index (%)	Hausner ratio (%)
1	30.1	41	34	0.734	0.885	17.073	1.206
2	30.2	40	34	0.755	0.888	15.000	1.176
3	30.3	40	33	0.758	0.918	17.500	1.212
4	30.1	40	33	0.753	0.912	17.500	1.212
5	30.2	41	34	0.737	0.888	17.073	1.206
6	30	40	32	0.750	0.938	20.000	1.250
7	30	39	32	0.769	0.938	17.949	1.219
8	30	40	33	0.750	0.909	17.500	1.212
9	30.1	42	34	0.717	0.885	19.048	1.235
10	30	41	32	0.732	0.938	21.951	1.281
Average	30.1	40.4	33.1	0.745	0.910	18.059	1.221
Minimum	30	39	32	0.717	0.885	15.000	1.176
Maximum	30.3	42	34	0.769	0.938	21.951	1.281

Data sheet 5

Swelling Index of tamarind seed powder

S.N.	Weight g	Volume of sample ml	Distill water ml	Volume of swollen ml	Swelling index %
1	1	2.8	10	5.2	85.71
3	1	2.7	10	6	122.22
4	1	2.1	10	4	90.48
5	1	2.1	10	3.9	85.71
6	1	2.4	10	4.4	83.33
Average		2.420	10	4.7	93.492
Minimum		2.1	10	3.9	83.33
Maximum		2.8	10	6	122.22

Estimation of carbohydrate of tamarind seed powder-

Seed sample extract 0.00025 g in 10 ml distilled water then 1ml take absorbance.

S.N.	Absorbance, y	Concentration x	Carbohydrate %
1	0.165	12.067	51.46

Estimation of alkaloid of tamarind seed powder-

Seed sample extract 2 g in 5 ml Methanol then 1ml take absorbance.

S.N.	Absorbance, y	Concentration x	Alkaloid %
1	1.312	33.080	8.27 mg/ 100 g

Data sheet 6

Product obtain from tamarind seed roasted at 100 °C to 200 °C

S N	Roasting Temp. °C	Roasting Time min	Initial Weight (g)	Final Weight (g)	Loss of Moisture Content (%)	Product			
						Unhusk seed (%)	Endosperm (%)	testa (%)	Broken (%)
		5		495.5	0.9	43.54	31.58	21.3	2.60
1	100	7.5	500	494.0	1.20	34.04	36.30	26.7	1.76
		10		482.0	3.44	9.08	50.64	32.9	3.86
		5		490.7	1.86	29.42	40.02	26.7	1.96
2	120	7.5	500	486.8	2.64	14.26	49.76	30.5	2.84
		10		468.9	6.22	0.90	51.18	32.9	5.96
		5		478.8	4.24	5.66	55.06	31.1	3.94
3	140	7.5	500	471.8	5.64	1.62	53.80	34.1	4.84
		10		468	6.40	0.75	53.10	34.4	5.30
		5		467.8	6.44	000	51.74	35.6	6.22
4	160	7.5	500	464.7	7.06	000	51.18	34.7	7.06
		10		461.3	7.74	000	48.62	36.0	7.60
		5		465.6	6.88	000	48.75	38.0	6.32
5	180	7.5	500	455.9	8.82	000	47.78	35.3	8.08
		10		451.3	9.74	000	46.74	33.8	9.66
		5		452.7	9.46	000	46.42	33.6	10.52
6	200	7.5	500	446.9	10.62	000	44.72	33.8	10.82
		10		442.5	11.50	000	44.70	31.9	11.90

Data sheet 7

Gum yield from different roasting temperature seed sample

S N	Temp (°C)	Time (Min)	Gum yield in 10 g	Gum yield (%)
		5	4.87	48.76
1	100	7.5	3.96	39.60
		10	3.42	34.2
		5	4.60	46.06
2	120	7.5	5.04	50.4
		10	5.31	53.1
		5	5.45	**54.5**
3	140	7.5	5.31	53.1
		10	5.18	51.8
		5	4.12	41.23
4	160	7.5	3.38	33.85
		10	3.20	32.03
		5	4.06	40.06
5	180	7.5	3.66	36.60
		10	3.40	34.00
		5	3.49	34.90
6	200	7.5	3.42	34.20
		10	2.80	28.00

Data sheet 8

Bulk density, Tapped density, Compressibility index and Hausner Ratio of Tamarind Gum

S. No.	Tem. (°C)	Time (Min)	Weight (g)	Volume (ml)	Tapped volume (ml)	Bulk density (ml)	Tapped density (ml)	Compressibility index (%)	Hausner ratio
1	100	5	2.9	7.9	7.1	0.367	0.408	10.127	1.113
2	120	5	3.3	8.1	6.7	0.407	0.493	17.284	1.209
3	140	5	5	8.2	7.5	0.610	0.667	8.537	1.093
4	160	5	2.8	6.3	5.5	0.444	0.509	12.698	1.145
5	180	5	3.1	5.8	4.9	0.534	0.633	15.517	1.184
6	200	5	3.2	6	5.5	0.533	0.582	8.333	1.091
7	100	7.5	3.4	7.8	7.1	0.436	0.479	8.974	1.099
8	120	7.5	4.2	9.2	8	0.457	0.525	13.043	1.150
9	140	7.5	4	8.4	7	0.476	0.571	16.667	1.200
10	160	7.5	2.9	6.5	5.5	0.446	0.527	15.385	1.182
11	180	7.5	3	6.9	5.3	0.435	0.566	23.188	1.302
12	200	7.5	3	5.8	5	0.517	0.600	13.793	1.160
13	100	10	2.7	6.3	5.3	0.429	0.509	15.873	1.189
14	120	10	4.2	7.3	6.9	0.575	0.609	5.479	1.058
15	140	10	4.3	7.5	7.1	0.573	0.606	5.333	1.056
16	160	10	5	7.6	7.2	0.658	0.694	5.263	1.056
17	180	10	4	6.9	6.1	0.580	0.656	11.594	1.131
18	200	10	2.5	5.3	4.7	0.472	0.532	11.321	1.128
					Average	0.497	0.565	12.134	1.141
					Minimum	0.367	0.408	5.263	1.056
					Maximum	0.658	0.694	23.188	1.302

Data sheet 9

Swelling Index of Tamarind gum

S. N.	Tem (°C)	Time (Min)	Weight (g)	Add distill water (ml)	volume of sample (ml)	swelling volume (ml)	swelling Index (%)
1	100	5	1.046	10	2.6	3	15.38
2	120	5	1.057	10	2.1	5.6	166.67
3	140	5	1.041	10	1.6	5.2	225.00
4	160	5	1.023	10	2	7	250.00
5	180	5	1.024	10	1.8	8	344.44
6	200	5	1.047	10	2	7.9	295.00
						Average	**216.08**

pH value of Tamarind gum :-

S n	Tem °C	Time (min)	pH
1	100	5	2.17
2	120	5	2.2
3	140	5	2.37
4	160	5	2.24
5	180	5	2.14
6	200	5	2.08
7	100	7.5	2.19
8	120	7.5	2.02
9	140	7.5	2.02
10	160	7.5	2.14
11	180	7.5	2.1
12	200	7.5	2.15
13	100	10	2.23
14	120	10	1.87
15	140	10	2.1
16	160	10	2.12
17	180	10	1.99
18	200	10	1.92
		Average	2.11

Data sheet 10

Surface Tension of tamarind Gum

S N	Roasting temperature (°C)	Number of Water drops	Number of Sample drops	Surface Tension y2= (n1*p2*y1)/n2*p1
1	100	68	57	41.680
2	120	69	53	45.484
3	140	71	50	49.611
4	160	72	58	43.370
5	180	70	54	45.289
6	200	73	52	49.047
		Average		45.747

Solubility of tamarind gum:-

S. N.	Solubility behaviour	Supernatant (ml)	Wt of petridish (g)	Dry sample wt with petridish (g)	Dry weight (g)	Solubility (%)
1	Cold water	25	112.045	112.143	0.098	19.6
2	Hot water	25	107.25	107.498	0.248	49.6
3	Ethanol	25	110.12	110.12	0	0
4	Methanol	25	107.36	107.36	0	0
5	Acetone	25	119.66	119.66	0	0

Data sheet 11

Estimation of Carbohydrate of tamarind gum :-

Tamarind gum extract 0.010 g in 100 ml distilled water them 1 ml take for absorbance.

S.N.	Tem.	Time	Carbohydrate (%)
1	100	5	58.60
2	120	5	55.35
3	140	5	51.30
4	160	5	48.65
5	180	5	36.90
6	200	5	32.25
7	100	7.5	54.65
8	120	7.5	51.45
9	140	7.5	49.90
10	160	7.5	42.85
11	180	7.5	31.80
12	200	7.5	27.20
13	100	10	48.65
14	120	10	40.50
15	140	10	32.35
16	160	10	21.90
17	180	10	18.70
18	200	10	11

RESUME

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