EXTRACTION OF GUM FROM *CHAROTA* (*Cassia tora*) SEEDS AND ITS CHARACTERIZATION

M. Tech. (Agril. Engg.) Thesis

by

Roman Kumar Sonwani

DEPARTMENT OF AGRICULTURAL PROCESSING

AND FOOD ENGINEERING

SWAMI VIVEKANAND COLLEGE OF AGRICULTURAL ENGINEERING & TECHNOLOGY AND RESEARCH STATION

FACULTY OF AGRICULTURAL ENGINEERING

INDIRA GANDHI KRISHI VISHWAVIDYALAYA

RAIPUR (CHHATTISGARH)

2018

EXTRACTION OF GUM FROM *CHAROTA* (*Cassia tora*) SEEDS AND ITS CHARACTERIZATION

Thesis

Submitted to the

Indira Gandhi Krishi Vishwavidyalaya, Raipur

By

Roman Kumar Sonwani

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Master of Technology

in

Agricultural Engineering

(Agricultural Processing and Food Engineering)

Roll No. 220115009 ID No. 20151622685

January, 2018

CERTIFICATE - I

This is to certify that the thesis entitled "**Extraction of gum from Charota (*Cassia tora*) seeds and its characterization**" submitted in partial fulfillment 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 **Roman Kumar Sonwani** under my 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.

15.01.18

Chairman

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Chairman	(Dr. D. Khokhar)	15.01.18
Member	(Dr. S. Patel)	15/1/18
Member	(Dr. R. R. Saxena)	
Member	(Dr. Deo Shankar)	
Member	(Er. N. K. Mishra)	

CERTIFICATE - II

This is to certify that the thesis entitled "**Extraction of gum from Charota (*Cassia tora*) seeds and its characterization**" submitted by **Roman Kumar Sonwani** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur, in partial fulfillment 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.

Signature External Examiner
(Name Dr. Mohan Singh

Date: 31/7/18

Major Advisor _____ 31/07/18

Head of the Department _____ 31/7/18

Faculty Dean _____

Approved/Not approved _____

Director of Instructions _____ 10/9/18

10 SEP 2018

ACKNOWLEDGEMENT

I feel great pleasure in expressing my sincere and deep sense of gratitude to respected Dr. D. Khokhar, Scientist and Chairman of my advisory committee, Department of Agricultural Processing and Food Engineering, SVCAET & RS, FAE, IGKV, Raipur, Major Advisor of my advisory committee, for his valuable guidance, constant inspirations and moral support throughout the research work.

It is beyond my means and my capacity to put in words my sincere gratitude to Co-Advisor of my advisory committee, Dr. S. Patel, Professor & Head, Department of Agricultural Processing and Food Engineering, SVCAET & RS, FAE, IGKV, Raipur, for their valuable suggestions, interest, and guidance. I have a great pleasure in expressing my sincere thanks to my advisory committee members Dr. R. R. Saxena, Professor, Department of Agricultural Statistics, Dr. Deo Shankar, Scientist, IGKV, Er. N. K. Mishra , Department of Agricultural and Food Processing, SVCEAT & RS, FAE, IGKV, Raipur, for their continuous advice, guidance and encouragement throughout the course of investigations.

I am very thankful to Dr V. K. Pandey, Dean SVCAET & RS, FAE, IGKV, Raipur, for his constant encouragement during project completion.

My literacy power is too less to express my gratitude to Dr. S. K. Patil, Hon'ble Vice Chancellor, Dr. S. S. Shaw, Director of Instruction and Dr. S. S Rao, Director Research Services, IGKV, Raipur for their administrative and technical help which facilitated my research work.

I like to express my sincere thanks to Dr. A. K. Dave, Head of Department of Farm Machinery and Power and Dr. M. P. Tripathi, Head of Department of Soil Water Engineering and for their kind support and help at various stages of the study.

I have a great pleasure in expressing my sincere thanks to A. K. Geda, Emeritus Professor, Department of Plant Physiology, Agricultutral Biochemistry Medicinal and Aromatic Plant, Er. P. S. Pisalkar, Assistant Professor, Department of Agricultural Processing and Food Engineering, Er. C. Sahu, Assistant Professor (Dairy Engineering), Er. A. A. Kalne, Assistant Professor, Department of Agricultural Processing and Food Engineering, for their priceless guidance and constant encouragement throughout the project.

I am also thankful to faculty members, Dr. V. P. Verma, Er. A. P. Mukharjee, Er. Md. Quasim, Dr. S.V. Jogdand, Dr. V. M. Victor, Dr. Jitendra Sinha,. Dr. P. Katre, Dr. D. Khalkho, for their timely co-operation during the course of study.

I am also thankful to all technical and clerical staff member and other staff member SVCAET & RS, Faculty of Agricultural Engineering for their kind support and help during entire study.

I am deeply obligate and greateful to head R. H. Richharia research laboratory, Head Department Plant Physiology laboratory, Head Department of Genetics and Plant Breeding and all staff of these laboratories for their timely help and co-operate during experiment work,.

I am also thankful to all the staff members especially to Mr. S. B. Kewat, Er. Geetesh Sinha, Er. Pooja Sahu, Er. Praveen Kumar Nishad and other for their kind support and help at various stages of the study. I avail this pleasant opportunity to express my sincere thanks to all my class mates Bhojram, Bhupendra, Chintaram, Gopikant, Kanhaiya, Mausumi, Roopnarayan, Neelesh, Chandraprakash, Khilendra, Boglamadhu, and my beloved seniors Deepak, Neeraj, Lalit, Anita, Yograj, Jashpal, Navneet, Omprakash, Tirath, My juniors Kishor, Atul, Kapil, Luv, and all my other friends for their love, contribution and timely help during course of study. I also express special thanks to all those who helped directly or indirectly during this study.

I have no words to express my hearty gratitude to my beloved parents, Father Mr. Purushottam Lal Sonwani, and Mother Mrs. Ramkumari Sonwani, my Sister Mrs. Gyan Sonwani, my Brother Mr. Harish Kumar Sonwani and my other family members, whose filial affection, environment, love and blessings have been a beacon of light for the successful completion of this achievement.

Above all, my humble and whole heartily prostration to the almighty for their Blessings.

Place: Raipur *(Roman Kumar Sonwani)*

Date:

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF NOTATIONS/SYMBOLS

%	Percent
&	And
-	Minus
+	Plus
±	Plus-Minus
*	Multiple
ε	Porosity
θ	Angle of repose
π	Pie
°C	Degree celsius
ρ_1	Density of water
ρ_2	Density of gum sample
ρb	Bulk density
ρt	True density
ρtp	Tapped density
γ_1	Surface tension of water
γ_2	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
n_1	Number of drop of water
n_2	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

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
CTSG	*Cassia tora* 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

a)	Title of the Thesis:	Extraction of Gum from *Charota*(*Cassia tora*) Seeds and its Characterization
b)	Full Name of the Student:	Roman Kumar Sonwani
c)	Major Subject:	Agricultural Processing and Food Engineering
d)	Name and Address of the: Major Advisor	Dr. D.Khokhar Scientist, Department of Agricultural Processing and Food Engineering, SVCAET & RS, FAE, IGKV, Raipur
e)	Degree to be Awarded:	Master of Technology in Agricultural Engineering

Signature of the Student

Signature of Major Advisor 15.01.18

Date: 15/1/18

Signature of Head of the Department

ABSTRACT

Cassia tora is produces in rural area of Bastar, Bilaspur, Durg, and Sarguja District of Chhattisgarh. It is commonly known as *Power* (Hindi), and *Charota* (Chhattisgarh), family *Leguminosae.* The Sarguja District accounts for more than 60 % of the *Charota* production of the State. In season of 2016 the production of Jagdalpur District was 300-350 quintals per day. *Cassia tora* has many uses. It is used as a natural pesticide in organic farms and its powder is most commonly used in the pet food industry. The gums have wide indusrial application in pharmaceutical, polymer, textiles, rubber and food confectionary industry. The present study is an effort to establish *Cassia tora* seeds which are normally treated as forest waste; as a natural source of polysaccharides and its characterization for suitability to be used as a pharmaceutical excipient.

During study the physical properties of *Cassia tora* seed was found out that bulk, tapped and true density are 0.87±0.03, 0.89±0.012 and 1.3±0.143 g/ml.

The test weight and volume of 1000 kernel was found to be 13.794 g and 14 ml. The colour of *Cassia tora* seeds was found to be light brown. The geometric mean diameter, length, width, thickness and sphericity were found to be 2.73±0.44 mm, 4.43±0.59, 2.21±0.44, 2.11±0.42 mm and 61.93±7.37.

The endosperm, husk and germ obtained from per 100 g sample of *Cassia tora* seed with respect to 100ºC to 140ºC roasting temperature was 29.74±3.30 and 64.41±2.91, respectively. The endosperm and husk & germ obtained from per 100 g sample of *Cassia tora* seed with respect to 150ºC to 200ºC roasting temperature was 29.34±2.87 and 67.52±2.94, respectively.

Polysaccharides extraction was based on mechanical separation of the endosperm of *Cassia tora* seed, water dissolution, centrifugation, and precipitation with acetone. The Gum extraction was carried out from the samples given maximum recovery of splits for each temperature. The gum obtained from *Cassia tora*s eeds was an amorphous free flowing odourless powder with light brown colour. The yield of gum with different roasting temperature was found to be 25.06±4.29 % w/w. The maximum gum yield was found to be 31.15 % w/w in 140ºC.

The physiochemical properties of gum was found that bulk and tapped density, pH, compressibility (carr's) index, hausner's ratio, swelling index, viscosity, angle of repose and surface tension are 0.608±0.019 and 0.69±0.024 g/ml, 3.01±0.22, 11.71±3.39 %, 1.13±0.04, 334.9±23.6 %, 5-120 cPs, 35.02±0.46º, and 45.61±2.01dynes/cm, respectively. It has found that gum was odourless and neutral in taste. The gum is soluble in cold and hot water and insoluble in ethanol, methanol, ether and acetone. The purity of gum found by the alkaloid test (Wagner's test), which is absent and carbohydrate test (Benedict's test), which is present.

शोध सारांश

क) शोध का शीर्षकः	"चरोटा (कासिया टोरा) बीज से गम का निष्कर्षण और इसके गुणों निर्धारण"
ख) छात्र का पूरा नामः	रोमन कुमार सोनवानी
ग) प्रमुख विशयः	कृषि प्रसंस्करण एवं खाद्य अभियांत्रिकीय
घ) प्रमुख सलाहकार का नाम व पताः	डॉ. डी. खोखर वैज्ञानिक, कृषि प्रसंसकरण एवं खाद्य अभियांत्रिकीय विभाग कृषि अभियांत्रिकीय संकाय, एस.वी.सी.ए.ई.टी. और आर.एस., इंदिरा गांधी कृषि विश्वविद्यालय, रायपुर छ.ग.
ड) डिग्री से सम्मानित किया जाना हैः	कृषि अभियांत्रिकीय में मास्टर ऑफ टेक्नोलॉजी

छात्र के हस्ताक्षर

प्रमुख सलाहकार के हस्ताक्षर 15.01.18

दिनाँकः 15/1/18

विभागाध्यक्ष के हस्ताक्षर

सारांश

कासिया टोरा, बस्तर, बिलासपुर, दुर्ग और छत्तीसगढ़ के सरगुजा जिले के ग्रामीण इलाके में पैदा होता है। यह आमतौर पर पोवर (हिंदी), और चरोटा (छत्तीसगढ़), लेग्यूमिनेसी परिवार के रूप में जाना जाता है। राज्य के 60 प्रतिशत से अधिक चारोटा उत्पादन के साथ सरगुजा जिला अग्रणी है। 2016 के मौसम में जगदलपुर जिले का दैनिक उत्पादन 300–350 क्विंटल था। कासिया टोरा में कई उपयोग हैं, यह जैविक फार्मों में प्राकृतिक कीटनाशक के रूप में प्रयोग किया जाता है और इसके पाउडर को पेट फूड उद्योग में सबसे अधिक उपयोग किया जाता है। फार्मास्युटिकल, पॉलिमर, वस्त्र, रबड़ और खाद्य कन्फेक्शनरी उद्योग में इसके गम का व्यापक औद्योगिक अनुप्रयोग हैं। वर्तमान अध्ययन

कासिया टोरा बीज को स्थापित करने का एक प्रयास है जिसे सामान्य रूप से वन कचरे के रूप में माना जाता हैं; पॉलिसेकेराइड के एक प्राकृतिक स्रोत के रूप में और उपयुक्तता के लिए इसके लक्षण वर्णन के रूप में एक फार्मास्युटिकल एक्सिपिएन्ट के रूप में इस्तेमाल किया जाना है।

अध्ययन के दौरान कैसिया टोरा बीज के भौतिक गुणों का पता चला कि स्थूल, टेप और वास्तविक घनत्व 0.87±0.03, 0.89±0.012 और 1.3±0.143 (ग्राम/एमएल) है। 1000 बीज का परीक्षण वजन और आयतन 13.794 ग्राम और 14 मिलीलीटर है। कासिया टोरा बीज का रंग भूरा होता है। ज्यामितीय माध्य आयाम (लंबाई, चौड़ाई और मोटाई) और गोलाई, 4. 43±0.59, 2.21±0.44 और 2.11±0.42 मिमी और 61.93±7.73 है।

पॉलीसेकेराइड निष्कर्षण कैसिया टोरा बीज के एंडोस्पर्म के यांत्रिक पृथक्करण, जल विघटन, सेंट्रीफ्यूगेशन, और एसीटोन के साथ प्रेसिपिटेषन पर आधारित था। कासिया टोरा बीज से प्राप्त गम हल्का भूरा रंग के साथ एक अनाकार मुक्त बहाव गंधहीन पाउडर था। विभिन्न रोस्टिंग तापमान के साथ गम की 25.06±4.29 प्रतिषत पाया गया। अधिकतम गम उत्पादन 140 डिग्री सेल्सियस में 31.15 प्रतिषत पाया गया।

गम के भौतिक गुणों में पाया गया कि थोक और टेप घनत्व, पीएच, दबाव (कार्स) सूची, हैसनर्स अनुपात, सूजन सूचकांक, ष्यानता, एंगल ऑफ रिपोज और सतह तनाव क्रमशः 0.68±0.019 और 0.69±0.024 (ग्राम/एमएल), 3.01±0.22, 11.71±3.39 प्रतिषत, 1. 13±0.04, 303.5±63.8 प्रतिषत, 5–120 सें़टिपॉइज, 35.02±0.46 डिग्री और 45.61±2.01 डाइन्स/सेंटिमीटर है। गम गंध और स्वाद में तटस्थ था। गम ठंडा और गर्म पानी में घुलनशील है, और इथेनॉल, मेथनॉल, एथर और एसीटोन में अघुलनशील है। गम की शुद्धता एल्कालोइड टेस्ट (वैग्नर टेस्ट) द्वारा पाया गया, जो अनुपस्थित है और कार्बोहाइड्रेट टेस्ट (बेनेडिक्ट टेस्ट), जो मौजूद है।

CHAPTER-I
INTRODUCTION

Cassia tora is a local annual weed found all over in Chhattisgarh, Maharastra and Madhya Pradesh during rainy season. It is commonly known as *Ponwar* (Hindi), *Tarota* (Marathi) and *Charota* (Chhattisgarhi), family *leguminosae*. The legumes bear the seeds. The plant can grow 30-90 cm (12-35 in) tall and consists of alternative pinnate leaves with leaflets mostly with three opposite pairs that are obovate in shape with a rounded tip. The leaves grow up 3-3.5 cm long. The stems have distinct smelling foliage when young. The flowers are in pairs in axis of leaves with five petals and pale yellow in colour. *Cassia tora* yellow flowers occur in pairs with stamens of unequal length producing pods that are somewhat flattened or four angled, 10-15 cm long and sickle shaped, hence the common name sickle pod. There are 30-50 seeds within a pod.

Cassia tora is produced in rural area of Bastar, Bilaspur, Durg, and Sarguja District of Chhattisgarh. The Sarguja District accounts for more than 60 % of the *Charota* production of the State. In season of 2016 the production of Jagdalpur District is 300-350 quintals per day and the market price of *Cassia tora* seed in recent is 4000-5000 Rs. Per quintals or 40-60 Rs. Per kg. The demand of *Cassia tora* seed is increasing in recent five years.

Cassia tora has many uses. It is used as a natural pesticide in organic farms and its powder is most commonly used in the pet food industry. The seeds and leaves are also used to treat skin disease and its seed can be utilized as a laxative. It has been used for treating skin diseases such as leprosy, ringworm, itching and psoriasis and also for snakebites. *Cassia tora* tea is an herbal, pure, natural and non-polluted green health beverage.

Cassia tora is available at very low price (Rs. 20-40 per Kg) in the local areas at the harvesting time. As the production is higher in forest area specifically in Bastar region, it may be great benefit to the economical section. Families of sustenance farmers or urban families can benefit from the medicinal and nutritional uses that it has because they would not have to spend as much money

on buying goods such as laxatives, medicinal creams and ointments, coffee, and some vegetables.

Apart from domestic consumption; there are now noteworthy exports of *Cassia* powder of the international standard to various countries. This includes the United States of America, Australia, Germany, France, Spain, Denmark, Italy, Netherlands, Belgium, New Zealand, The United Kingdom, Singapore and Japan. The export value of *Cassia tora* has been progressively increasing over the last five years.

Gums are conventionally obtained from plant sources by incising stems or branches in the form of exudates. These gums normally contain polysaccharides like glucomannon and galactomannon. These gum 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. *Cassia* gum is currently (mid-2009) being used in mainly pet food applications.

Cassia tora seeds gum are extracted by aqueous extraction and the gum is precipitated by adding excess of semi-polar solvent. The seeds were found to yield substantial quality of gum 13.5 % w/w (Joshi *et al.* 2015*).*

The galactomannans (a form of polysaccharide) from *Cassia tora* (CT-gum), after proper processing and chemical derivatization (converting chemical into a product of a similar structure), could function as an improved and more economical thickener than *Locustbean* gum for textiles, because of the bean gums current high price (Rs. 1159.74/kg) and limited availability. The total fixed capacity in the country is 0.2 million tone for splits and 59,000 for powder based on *Cassia tora* seeds. The capacity utilization in the industry has been around 70 % for the last three years.

However, plant parts other than the stems and branches may also contain such gums. The possibility of occurrence of gums in seed and fruits is still not extracting various seed gums from locally available plant species in order to explore their industrial potential. The present work is designed to develop

technology for gum extraction from seed and their chemical characterization in order to utilize the seeds as an alternative source of gum which is otherwise unutilized for this purposed and treated as animal feed and forest waste.

Hence, keeping above points in mind the present research entitled, **"Extraction of Gum from *Charota (Cassia tora)* Seeds and its Characterization"** has been undertaken with the following objectives:

1. To study the physical properties of *Cassia tora* seeds.
2. To standardize the gum extraction method from *Cassia tora* seeds.
3. To analyze the physiochemical properties of extracted gum.

CHAPTER-II
REVIEW OF LITERATURES

In this chapter, the previous work done on the processing methods of *Cassia tora*, the gum extraction and physiochemical 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 like glucomannon and galactomannon. These gum 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 Physiochemical properties of gum.

2.1 Physical properties:

Chauhan (2006)studied that *Cassia tora*, is a native plant in South East Asia, very common Indian herb belong to the family of *Cesalpinaceae*. *Cassia tora* possess wide range of medicinal values and possess pharmacological activities. *Cassia tora* in many countries have recommended for primary health care to treat bacterial infections and various skin diseases like acne, wounds and psoriasis etc. *Cassia tora* is a very widespread Indian herb having antibacterial, antifungal activities and used as an antiallergic, antimutagenic, radical scavenging, antiperiodic and wound healing. It is also used in ayurvedic preparation "Dadrughan-vati" which is used to cure ringworm and leucoderma

Density of food material is useful in mathematical conversion of mass to volume and vice versa. It is also an important parameter to assess the quality of food materials, density data of foods are requires in pneumatic and hydraulic transport of seeds (Mohsenin, 1970). It has been reported that bulk and true density of kidney bean cultivars varied from 0.45-0.47 g/ml and 1.18-1.15 g/ml,

respectively (Altuntas and Demirtola, 2007). Isik and Unal, (2007, 2011) reported that bulk density in the range of 0.56-0.68 g/ml and true density from 1.13-1.36 g/ml at varying moisture contents. Bulk and true densities of common beans (*Phaseolusvulgais L*.) decreased from 0.81-0.68 g/ml and 1.38-1.21 g/ml, respectively as the moisture content increased from 7.5-19.8 % (Ozturk*et al.* 2009, 2010 b).

Deshpande *et al*. (1993) measured the linear dimension of grain with micrometer (reading to 0.01 mm) and used the relation [Sphericity $=(LWT)^{1/3}/L$, Where L= length, W= width, and T= thickness].

Foster and Chongxi (1992)ayurvedic oil of this plant has a compound "Chakramardhatailamu" which is very beneficial in eczema and other skin diseases. *Cassia tora* seeds have antioxidant properties and contain active substance including chrysophenol, emodin, rhein etc. which are used in skin disease, eye diseases, liver complaint, earache and leprosy. According to ancient Chinese literature seeds of *Cassia tora* are used to improve vision, lowering cholesterol and tumbling blood pressure other uses of this plant are in abnormal child birth, in bone fracture, cold, epilepsy, night blindness, scabies, scorpion bite, stomachache, and vermicide as ancillary for coffee.

Kadiri*et al*. (1996) toxicological screening on seeds of five wild leguminous plants: *Delonixregia*, *Cassia tora*, *Sesbaniasesban*, *Crotalaria naragutensis* and *Tamarindusindica*. The animals used in the toxicological screening were mice and rats. The leguminous seeds had varied protein contents i.e. 21.1 % for *Sesbaniasesban* and 47.7 % for *Crotalaria naragutensis*, while the mineral elements detected in appreciable quantities were calcium, magnesium, potassium, iron, copper, zinc, phosphorus and sodium. Oxalate contents were very low, between 0.03 % for *Sesbaniasesban* and 0.09 % for *Cassia tora*.

Pandey and Gupta (2000), observed the milling characteristics of eighteen varieties of paddy grown in India and estimated their physical characteristics namely length, width and thickness of brown rice and milled rice. The rice yield varied from 75.1 % to 79.60 %, whereas the milling yield ranged from 67.01 % to 75.45 % at constant time of polishing.

Sheela*et al*. (2004) identify and analyze the various underutilized green leafy vegetables for their nutrient content from selected regions of southern Karnataka. Samples of 38 underutilized green leafy vegetables including *Cassia tora* were identified. Out of all these 38 foods it was reported that moisture, protein, fat, fiber, carbohydrate and energy content of Cassia tora was 85 %, 0.7 g, 2.0 g, 0.9 g, 1.4 g, 17 Kcal respectively.

Selvi*et al*. (2006) studied on the physical properties of linseed as function of moisture content. As the moisture content increased from 8.25 to 22.25 % dry basis (d.b.), the average length, width, thickness and geometric mean diameter varied from 4.57 to 4.86, 2.40 to 2.59, 1.03 to 1.13 and 2.24 to 2.43 mm, respectively. In the same moisture range studies on rewetted linseed showed that sphericity, surface area and 1000 seed mass and true density increased from 49.09 % to 49.94 %, 15.83 mm^2 to 18.56 mm^2, 6 to 6.7 g, 1010.1 to 1020.4 kg/m^3, respectively. As the moisture content increased from 8.25 to 22.25 % d.b., bulk density was decrease from 690.5 to 545 kg/m^3whereas the angle of repose, terminal velocity and porosity were found to increase from 21.59 to 26.85 e, 2.46 degrees$ms^{-1}$to 3.82 ms^{-1}, 31.64 % to 46.59 %, respectively.

Tomar*et al*. (1996) biological evaluation of some forest tree seeds (viz. *Cassia tora, Delonixregia, Crotalaria laburnifolia, Acacia leucophloea, and Albiziaprocera*), with a view to determining their nutritional qualities. All seeds were rich in protein, with the highest protein content in *Crotalaria laburnifolia* (39.02 %) and *Albiziaprocera* (35.35 %), with the remaining species showing a range of 21-25 % protein. Carbohydrate contents were in the range of 41.81-55.78 %. All the species were poor in fat (2.56-5.32 %). Fiber content varied from 2.75 to 5.21 %, and ash content from 3.25 to 5.29 %. Calcium was high in *Acacia leucophloea*, and phosphorus and iron in *Albiziaprocera.*

2.2 Gum extraction:

Adeleye*et al*. (2015) investigated the physiochemical and rheological characterization of *Cissuspopulnea* gum extracted by different solvents at Ogun State in Nigeria. The yield for both extracts of the gum was high, with the water extract being significantly higher. The swelling index, moisture content and

moisture absoption capacity of the gum was high. The viscosity of the two extracts of *Cissus*gum increased with increase in concentration at room temperature. The yield for both extracts of the gum was high and heavy metals were absent which makes it desirable for use as and excipient in pharmaceutical industries. The high swelling index of *Cissus* gum suggests that it may be used as a sustained release excipient in a matrix tablet system. Both extracts of *Cissus* gum possessed fundamental characteristics that would make them suitable as pharmaceutical excipients in the formulation of solid, semi-solid and liquid dosage forms and also in sustained release formulations.

Jong *et al*. (1995) investigated the effects of roasting on volatile flavour compounds in *Cassia tora* seeds. After roasting (190-230°C for 10-40 min), volatile flavour compounds were extracted from seeds by a steam distillation-extraction method and identified. Raw seeds contained 7 volatile flavour compounds. Roasted seeds 5 contained 38 volatile flavour compounds, including 3 pyrazines, 4 pyrroles or pyridines, 4 alcohols, 11 aldehydes or ketones, 9 furans or phenols and 7 others. Many other flavour compounds were also formed during the roasting process. Pyrazines and furans were the major volatile flavour compounds in roasted *Cassia tora* seeds, and their contents increased with increasing roasting time; contents of aldehydes, ketones, alcohols and pyridines did not increase significantly.

Joshi and Biyani (2015) studied that the physiochemical properties of extracted *Cassia tora*seed gum. *Cassia tora* seeds gum are extracted by extraction and the gum is precipitated by adding excess of semi-polar solvent. The seeds were found to yield substantial quality of gum (13.5 % w/w),the extracted gum was used for further studies such as bulk and tapped densities, compressibility index, Hussner's ratio, angle of repose, swelling index, pH, surface tention of polysaccharide and viscocity. Thus it is concluded that the seeds of *Cassia tora* can be used as an alternative source of gum which can be used as an excipient in pharmaceutical formulations.

Pawar and Lalitha (2015) studied that extraction, characterization, and molecular weight determination of *Sennatora (L.)* seed polysaccharide.

Polysaccharide extraction was based on mechanical separation of the endosperm of seeds of *Sennatora*, water dissolution, centrifugation, and precipitation with acetone. Standard procedures were used to study the viscosity, micromeritic properties, and microbial bioburden. Accelerated stability study was carried out on isolated polysaccharide for six months at 40ºC/75 RH as per ICH guidelines. The gum obtained from *S. tora* seeds was an amorphous free flowing odourless powder with dull brown colour (yield = 35 % w/w). The bulk and tapped density, and angle of repose data reveal that *S. tora*gum possesses good flow property. The intrinsic viscosity obtained was 1.568 dL/g. the average molecular weight of purified *S. tora* gum was found to be 198 kDa by instrinsic viscosity method.

Yadav*et al*. (2015) studied that comparative study of mucilage exracted from seeds of *Cassia fistula*and gum *karaya* in India. Both the mucilageare extracted from different methods. Ethyl alcohol and acetone were used in the extraction of mucilage. The extraction of *Karaya* gum mucilages and *Cassia fistula* were carried out and the yield of the extracts was found to be 12 & 21 % w/w, respectively. The pH of the isolated mucilages from *karaya*gum and *Cassia fistula* were found to be in the range between 6.5 and 6.2, respectively. The ash value of the mucilage of *karaya*gum and *Cassia fistula* were found to be 3.53 and 3.56, respectively. It was found that the *Karaya*gum mucilage powder shows poor flow property in contrast with that the mucilage extracted from the *Cassia fistula* have excellent flow property. The solubility was also determined using the ash of isolated mucilage and the result was that the ash of the extract was in-soluble in the acetone, ethanol, petroleum ether and benzene.

2.3 Physiochemical properties of gum:

Ameh (2012) studies on the physiochemical properties and rheological behavior of *Fiscusglumosa* gum in aqueous solution. He has concluded that the following points: (1) *Fiscusglumosa*gum occurs as pale yellow, translucent tears, the mucilage has a bland taste, and is odourless, and mild acidic with a pH of at 29.85ºC. It is soluble in water, sparingly soluble in ethanol and practically insoluble in acetone and chloroform. (2) The mineral elements composition of the gum are within the range specified by WHO and FAO, hence *Fiscusglumosa*gum

exudates can be used as an additive in food and other industries. (3) *Fiscusglumosa*gum is a macromolecule whose viscosity depends on temperature, concentration, speed of rotation and pH. (4) The rheological properties of the gum can be adequately modeled using the Aeehenius model, Huggins model, Kreamer model, Tanglertpaibul and Rao models. The excellent correlation between the values of (η) computed from the various methods used in evaluating intrinsic viscosity indicates tie consistency of the methods for the study of intrinsic viscosity of the systems.

Braminas*et al*. (1999) analyzed mineral composition of 6 wild or semi-wild leafy vegetables commonly eaten in rural areas of Nigeria. Vegetables studied were: *Amarathusspinosus*, baobab (*Adansoniadigitata*), *Cassia tora*, (*Colocasiaesculenta*), *Corchorustridens* and *Moringaoleifera. Amarathusspinosus* and baobab leaves contained the highest levels of iron (38.4 and 30.6 mg/100g dry wt., respectively). All vegetables studied contained high level of calcium, compared with common vegetable. Zink content was highest in *Moringaoleifera*, baobab and *Cassia tora* leaves (25.5, 22.4 and 20.9 mg/100g dry wt., respectively). Mean daily intake of phosphorus, magnesium, calcium, Iron, Copper and zinc were lower than their RDA values. Daily intake of manganese was not, however, significantly different ($P \leq 0.05$) from the RDA value.

Dafam*et al.* (2013) reported that quantitiveevalution of some physical and chemical properties of the gum-mucilage of *Anacardium Occidental* L (Anacardiaceae) at Zaria in Nigeria. The result of tested gum showed that the Moisture content was 11.68±0.11 %w/w for cashew gum and 9.0±0.58 %w/w for gum Arabic (used as standard); Total ash value (0.75±0.03 % w/w); Acid insoluble ash value (0.10±00 % w/w); Water soluble ash value (0.76±0.03 % w/w); Swelling index (3.19±0.19 %w/w and 5.68±0.048 %w/w for test gum and gum Arabic respectively); Alcohol extractive value (0.09±00 % w/w for test sample and 0.60±0.12 %w/w for gum Arabic) and Water extractive value (15.92±0.24 % w/w for cashew gum and 6.20±0.23 %w/w for gum *acacia*). The acid value was found to be 4.49 and 3.93 for A. occidentale and gum Arabic respectively; Saponification value was 11.22 for *A. occidentale* and 22.44 for the

gum *Arabic*; Refractive index for test gum was 1.36 while the gum *arabic* has refractive index of 1.33.

Farooq*et al.* (2014) found that extraction and characterization of *artocarpus integer* gum as pharmaceutical excipient using water based extraction method, the yield of gum was found to be 2.58 %. The result showed that extracted *kathal* gum exhibited excellent flow properties. It had a good swelling index (13±1). The pH and surface tension of the 1% gum solution were found to be 6±0.5 and 0.0627 J/m^2, respectively. The ash values such as total ash, acid insoluble ash, and water soluble ash were found to be 18.9 %, 0.67 % and 4 %, respectively. Loss on drying was 6.61 %. The extracted gum was soluble in warm water and insoluble in organic solvents. The scanning electron micrograph (SEM) revealed rough and irregular particles of the isolated polymer. The results of the evaluated properties showed that *kathal*-derived gum has acceptable pH and organoleptic properties and can be used a pharmaceutical excipient to formulate solid oral dosage forms.

I *et al.* (2014) studied that characterization and standaridazation of gum *Karaya*in India. In FTIR spectra, the amide band is split for Gum *Karaya*. The XRD, SEM results indicate that Gum *Karaya*is a crystalline polymorph because of its parallel structure. Gum Karaya produced from microwave heating reduced the time of deacetylation within few minutes (~14 min) to reach to the DDA% of 64%. Gum Karaya is an abundant natural polymer, obtained from sterculia gum, is the dried exudate of SterculiaUrens, a tree native to India. The physical and chemical properties of Gum Karaya, such as inter-and intramolecular hydrogen bonding and the cationic charge in acidic medium, makes this polymer attractive for the development of floating drug delivery system. Being a natural polymer and having all desired properties, Gum Karaya can be used as a good candidate for oral floating drug delivery. Also, because of its favorable biological properties such as non-toxicity, biocompatibility, and biodegradability, Gum Karaya is a promising candidate for the enhancement of absorption of drugs through floatation using floating drug delivery system.

Parveen*et al*. (2014) studied that physiochemical characterization of gum exuded from *Prosopis cineraria* and *Prosopisglandulosa* species of Thar Desert of Pakistan. Comparative assessment of data indicated that *P. cineraria* gum was of better quality as compared to that of *P. glandulos* and that the application of classification procedure has effect on gum quality and potential to make *P. cineraria* gum as suitable substitute of gum Arabic. The hot and dry weather of Thar Desert offers ideal conditions for *prosopis* species to exude gums of varying quality in fairly reasonable quantities. *P. cineraria* gums have high potential for use as food additives provided samples are classified carefully. Quality wise *P. cineraria* gum is better than *P. glandulosa* gum samples bear some difference in their color with regard to its origin making it easier to identify the area from where gum samples belonged , but do not exhibit any significant changes in their chemical composition. It is also concluded that as with gum Arabic the Prosopis gums should also be subjected to the application of classification and sorting procedures in order to utilize maximum quantities of these natural exudates of wildly growing plants.

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 *Cassia tora* seed, gum extraction and analyze the physiochemical properties methods.

The study was done in the Department of Agricultural Processing and Food Engineering, Swami Vivekananda College of Agricultural Engineering and Technology and Research Station, Faculty of Agricultural Engineering, Raipur, and Department of Crop Physiology, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh). The quality analysis were done in the R.H. Richharia Research Laboratory of the Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh).

3.1 Procurement of sample

The fresh *Cassia tora* seed was collected from the local site of Bhanpuri, District Raipur (C.G.) during the month of December 2016 and was used in the given experiment. The raw seed was cleaned manually to get rid of dust, dirt and other foreign material by using sieving and grading. The undesirable and undeveloped seed were removed manually and then the cleaned seed were dried in shed drying.

3.2 Physical properties *Cassia tora* seeds

3.2.1 Bulk density

Bulk density of *Cassia tora* seed was determined by bulk density apparatus. Density can be calculated as weight acquired of the seed divided by the volume of the seed which is measured by 100 ml measuring cylinder. The SI unit of density is g/ml. (Yadav *et al.*, 2015).

$$\text{Bulk density, } \rho b = \frac{M}{V}$$

Where,

M = bulk weight of seed, g

V = apparent volume of seed, ml

3.2.2 Tapped density

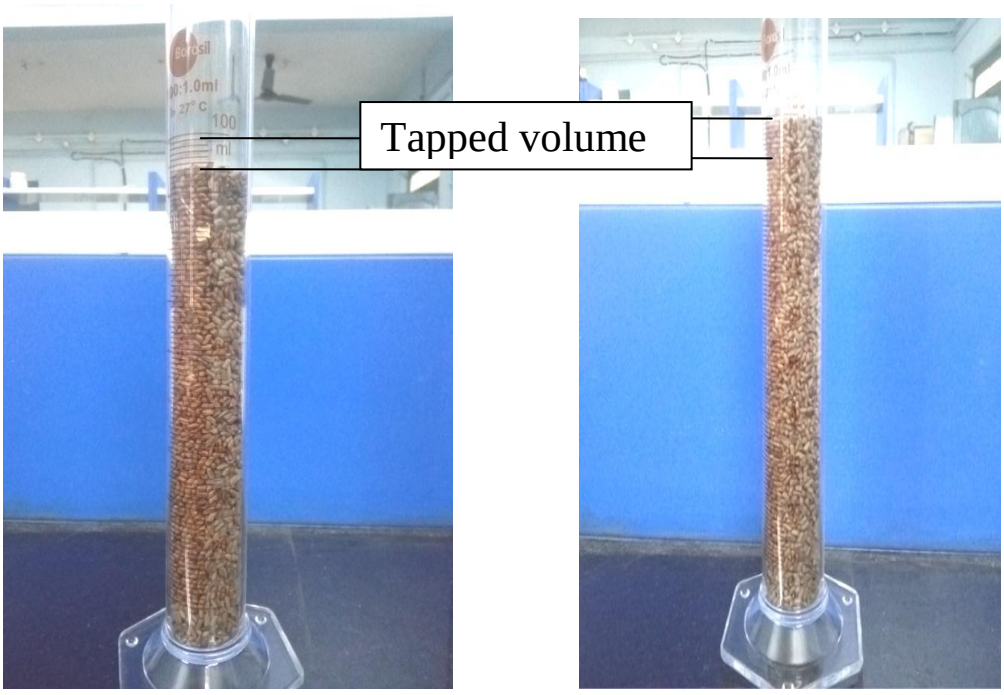
The difference between the bulk density and tapped density is only that, in bulk density we have to use the bulk volume whereas in the tapped density we have to use tapped volume which can be obtained by 50 times tapings of measuring cylinder. (Yadav *et al.*, 2015)

$$\text{Tapped Density, } \rho tp = \frac{M}{Vt}$$

Where,

M = bulk weight of seed, g

Vt = volume of seed after tapping, ml



a) After tappping b) Before tapping

Fig. 3.1 Volume after and before tapping

3.2.3 True density

Among the various methods available for the determination of true density, the liquid displacement method is the simplest method and was used in the present

study (Farooq *et al.*, 2014). Toluene was selected as the liquid for displacement, because *Cassia tora* is insoluble in toluene. It is expressed in g/ml.

$$\text{True density, } \rho t = \frac{\text{Weight of } Cassia\ tora \text{ seed}}{\text{Displacement volume}}$$

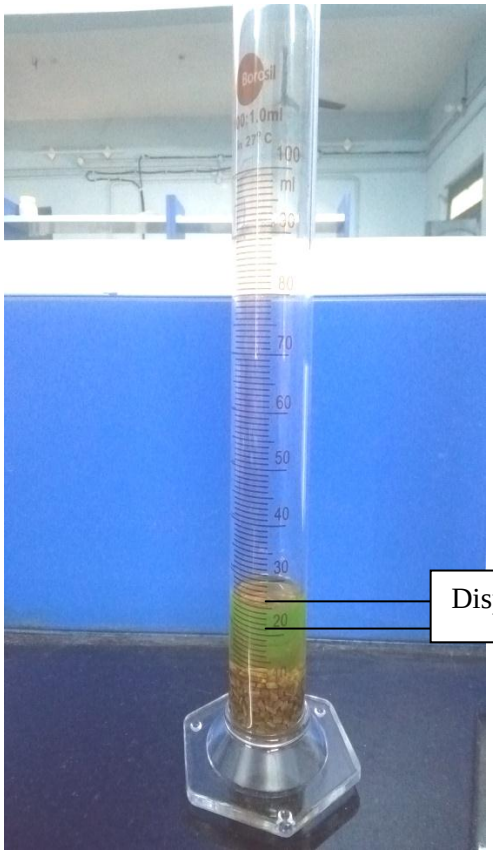


Fig. 3.2 Volume displaced by *Cassia tora* seeds

3.2.4 Porosity

The porosity may be defined as the ratio of difference between true density and bulk density of grits and true density. According to Mohsenin (1978), porosity (ε) can be expressed as follows:

$$\varepsilon = (1 - \frac{\rho b}{\rho t}) \times 100$$

Where,

ρb = bulk density, g/ml

ρt = true density, g/ ml

3.2.5 Test weight

The test weight (1000 kernel weight), weight is a measure of seed size. It is the weight in g. The 1000 kernel weight can vary from one crop to another, varieties of the same crop and even from year to year or from field to field of the same variety. Because of this variation in seed size, the number of plants in a pound or a bushel of seed is also highly variable (Joshi and Biyani, 2015*)*.

3.2.6 Volume

The volume (1000 kernel volume), volume is measure of 1000 kernel seeds volume by measuring cylinder. It is the volume in ml of 1000 seeds (Joshi and Biyani, 2015*)*.

3.2.7 Geometric mean diameter

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

$$Dg = (LWT)^{⅓}$$

Where,

L = length in mm

W = width in mm

T = thickness in mm

a) Length of *Cassia tora* seed

b) Width of *Cassia tora* seed

c) Thickness of *Cassia tora* seed

Fig. 3.3 Length, width and thickness of *Cassia tora* seed

3.2.8 Sphericity

It 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 (Singh and Sahay, 2008). The sphericity (Sp) was accordingly computed as (Ghadge and Prasad, 2012):

$$Sp = \frac{(LWT)^{1/3}}{L} \times 100$$

Where,

L = length in mm

W = width in mm

T = thickness in mm

3.2.9 Colour

Cassia tora seed is the ripe seed of the annual plant *Cassia obtusifolia Linn. or Cassia tora Linn.* The seeds of *Cassia tora* are rhombohedral and brown in colour. It grows wild in India. This is an upright plant with compound leaves in groupings of six bears 10-15 cm pods which contain many cylindrical seeds.

Fig. 3.4 *Cassia tora* seed

3.3 Gum Extraction

3.3.1 Splitting of *Cassia tora* seeds

The seed consists of an outer husk, an endosperm (split) and the ovary or germ. Only the endosperm or split, which contains mainly polysaccharides, is used for the production of the *Cassia* gum. Both husk and germ are removed in the de-husking and splitting process. The impact of the splitting procedure is that both husk and germ are loosened from the endosperm and made brittle by roasting and can be removed in the subsequent screening and cleaning procedure after grinding by mixer grinder. The split (endosperm), however, remains intact at these temperatures. Due to its much greater particle size, the split can be separated from husk and germ particles though a couple of physical cleaning steps.

The splitting procedure starts with roasting of the seeds. All seeds are heated for several roasting temperature and time. During the roasting process the endosperm (split) remains intact and flexible, while husk and germ, which are more sensitive to heat, become brittle. The split (endosperm) however, remains intact at this grinding machine or not completely grinded in powder form due to gummy layer or smooth faced, but husk and germ are easily grinded in powder form. The split can be separated from husk and germ particles through a couple of physical cleaning steps (i.e. screening by sieve size 35 BIS).

A composite sample is examined to ensure the material meets the specifications for splits intended for use in the production of refined *Cassia* gum. The content of material other than *C. tora* and *C. obtusifolia* has to be zero.

Fig. 3.5 Grinding of roasted seeds

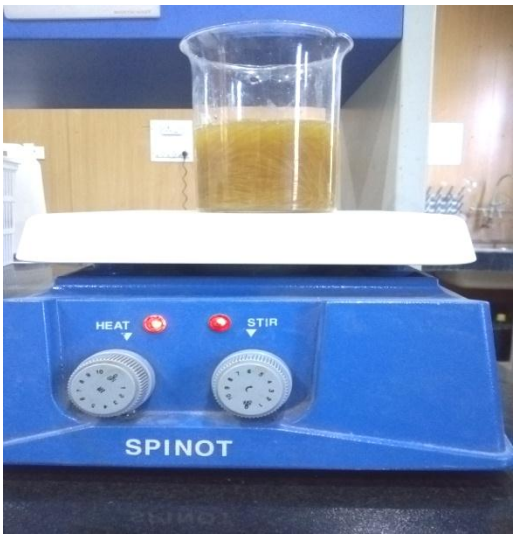
3.3.2 Gum Extraction method

The gum was extracted from endosperm using solvent precipitation method. The dried seeds were de-husked and de-germed by mechanical treatment followed by milling and screening of the endosperm. The coarsely grind powdered of endosperm splits were defatted using hexane. The endosperm powder of *Cassia*

tora seeds (10 g) was soaked in 200ml of distilled water and stirred under overhead stirrer for 3-4 h. The viscous solution obtained was passed though the muslin cloth. The marc obtained was pressed to remove the mucilage and boiled with 200 ml of water for 1 h. Viscous solution obtained was filtered though muslin cloth. The marc obtained was not discarded but it was sent for multiple extractions with decreasing quantity of extracting solvent, that is, water with the increase of number of extractions. The Extraction was continued until the material becomes free from mucilage. All the viscous solutions obtained were mixed together. An equal quantity of 10% trichloroacetic acid was added to the mixture to precipitate protein. The solution was centrifuged and the supernatant was precipitated out by addition of acetone in the ratio 1:0.5 with continuous stirring. The coagulated mucilage, which formed as a white mass, was transferred to an evaporating dish and dried in hot air oven at 40ºC, powdered, and stored in airtight containers (Pawar and Lalitha, 2015).

The process of gum extraction from *Cassia tora* splits or endosperm is given in below-

a) Defatting

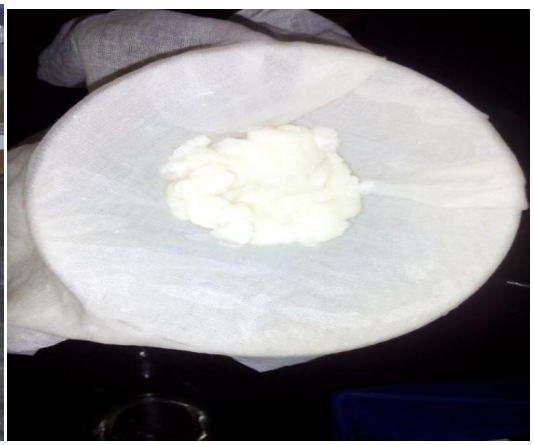


b) Stirring

c)Extracted muscilage

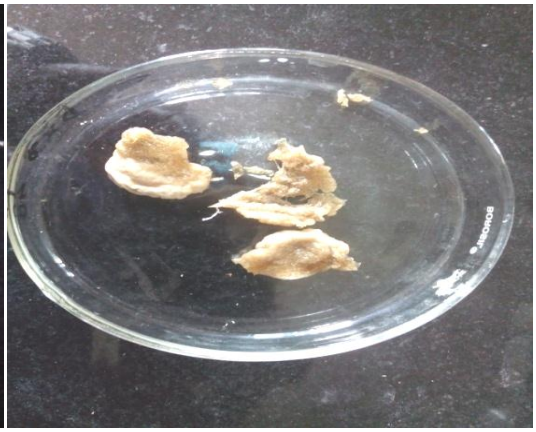
d) Centrifuge

e) Precipitation

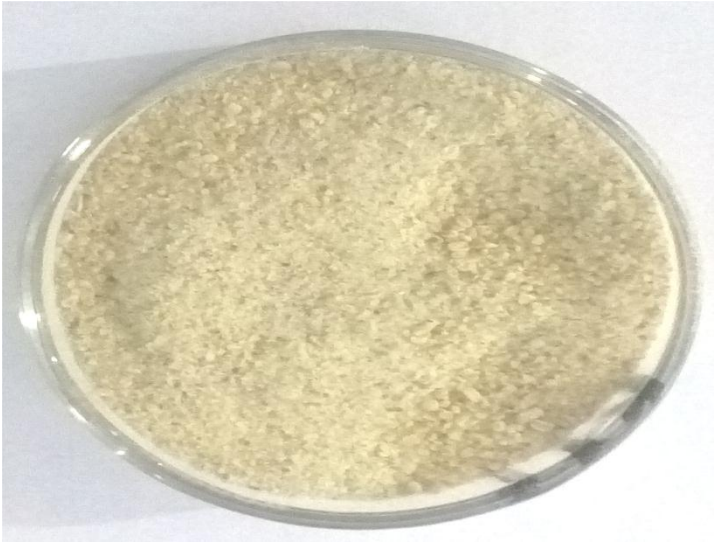


f) Filtration

g) White mass muscilage



h) Dried muscilage



i) *Cassia tora* seed gum powder

Fig. 3.6 Gum Extraction process

3.3.3 Grinding of *Cassia tora* seed gum

The extracted *Cassia tora* gum was subjected in mini grinder to grind fine *Cassia tora* gum powder. The fine powder was sieved though sieve no. 100 and stored in air tight containers. The powder was evaluated further for the following properties.

3.3.4 Flow chart of *Cassia tora* seed gum processing

Raw *Cassia tora* seeds

↓

Cleaning

(Removing dust, impurities and immature seeds)

↓

Roasting

(At 100 ºC-200 ºC for 2-10 min.)

↓

Grinding and sieving

(Grinded by mixer grinder and sieving by 35 BIS sieve size)

↓

Defatted with solvent

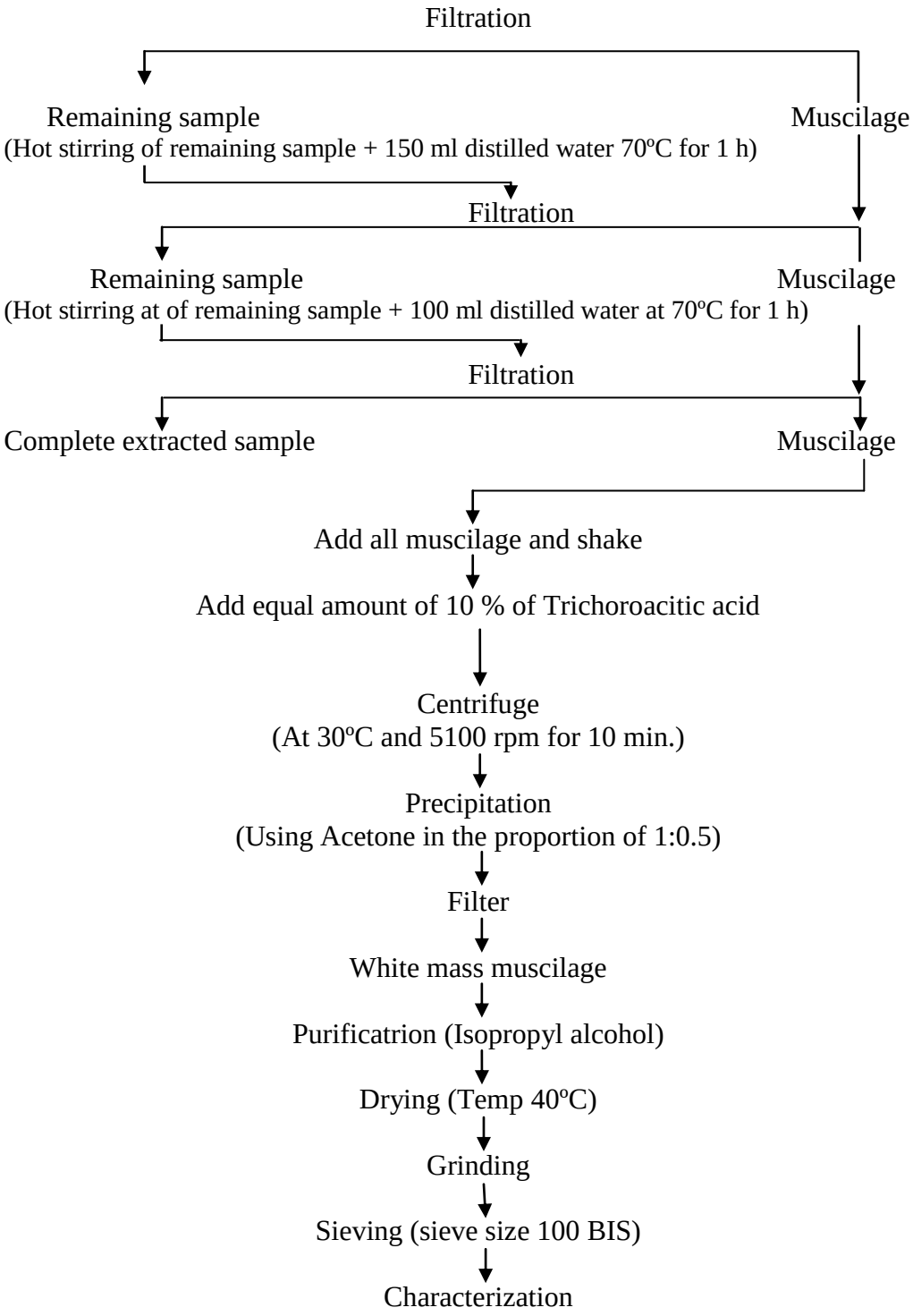
(Using Hexane solvent in Socsplus apparatus)

↓

Gum extraction

(Cold stirring of 10 g defatted sample + 200 ml distilled water for 3-4 h)

↓


Filtration
Remaining sample
Muscilage
(Hot stirring of remaining sample + 150 ml distilled water 70ºC for 1 h)
Filtration
Remaining sample
Muscilage
(Hot stirring at of remaining sample + 100 ml distilled water at 70ºC for 1 h)
Filtration
Complete extracted sample
Muscilage
Add all muscilage and shake
Add equal amount of 10 % of Trichoroacitic acid
Centrifuge
(At 30ºC and 5100 rpm for 10 min.)
Precipitation
(Using Acetone in the proportion of 1:0.5)
Filter
White mass muscilage
Purificatrion (Isopropyl alcohol)
Drying (Temp 40ºC)
Grinding
Sieving (sieve size 100 BIS)
Characterization

3.4 Physiochemical properties of *Cassia tora* seed gum

3.4.1 Angle of repose

The flow characteristics were measured by angle of repose. Improper flow of powder is due to frictional forces between the particles. These frictional forces are quantified by angle of repose. It can be calculated by the following formula:

$$\tan\theta = \frac{H}{r}$$

or

$$\theta = \tan{-1}\left(\frac{H}{r}\right)$$

Where,

H is the height of pile, r is the radius of the base of the pile, and θ is the angle of repose.

A dry and clean funnel was fixed on to a burette stand at particular height (2-3 cm). A graph paper was placed on the flat surface and a sufficient quantity of the powder (10 g) was allowed to flow slowly through the funnel until the heap touched the tip of the funnel. The circumference of the heap was drawn and the midpoint was located and its radius was measured. The experiment was repeated thrice and the average height and radius were calculated. Using these readings and the above formula, the angle of repose was calculated (Pawar and Lalitha, 2015).

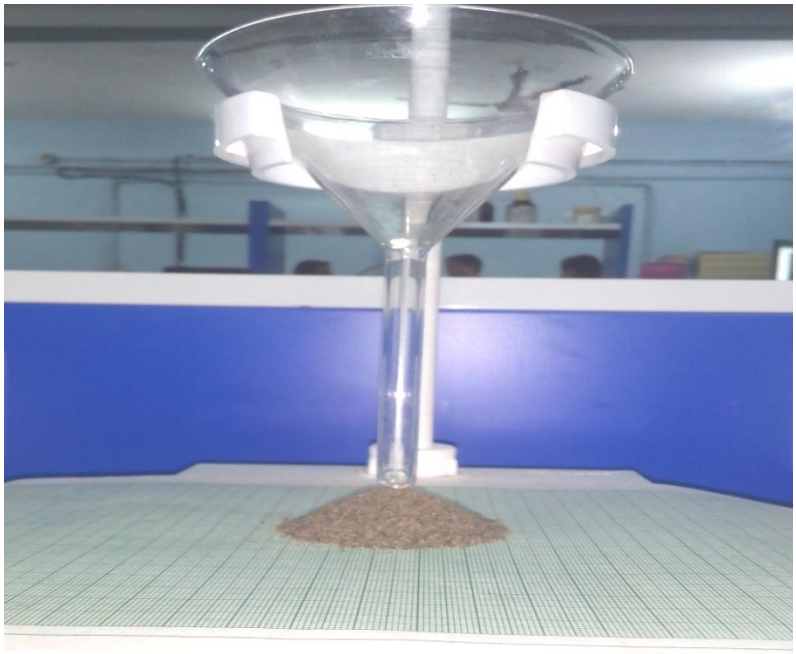


Fig. 3.7 Angle of repose of *Cassia tora* seed gum

3.4.2 Bulk and tapped density

A 10g quantity of gum powder was placed in a 50 ml measuring cylinder and the volume occupied by gum powder without tapping was noted. After 50 taps, the occupied volume was read. The bulk and tap densities were calculated as the ratio of weight to volume as reported in literature (Emeje *et al.*, 2009).

$$\text{Bulk density, } \rho b = \frac{M}{V1} \text{ and}$$

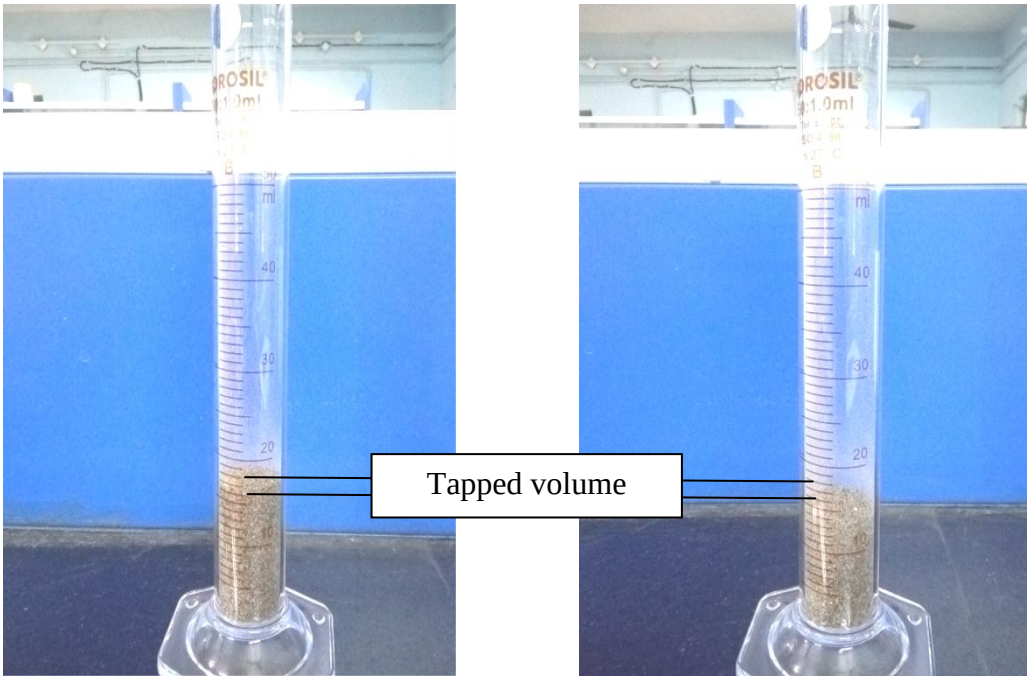
$$\text{Tapped Density} = \frac{M}{V2}$$

Where,

M = bulk weight of powder, g

V1 = apparent volume of powder, ml

V2 = volume of powder after tapping, ml



a) Before tapping b) After tapping

Fig. 3.8 Volume of *Cassia tora* seed gum before and after tapping

3.4.3 Compressibility (Carr's) index

The simplest method of measurement of free flow of powder is compressibility, an indication of the ease with which material can be induced to flow is given by compressibility index (I) which is reported in literature (Joshi and Biyani, 2015) and is calculated as follows,

$$I = [(\rho t - \rho b)/ \rho t] \text{ X } 100$$

Where,

ρt indicates the tapped density, g/ml and

ρb indicates the bulk density, g/ml

3.4.4 Hausner's ratio

This is an indirect index of ease of powder flow. It is calculated by the following formula (Joshi and Biyani, 2015).

$$\text{Hausner's ratio} = \rho tp / \rho b$$

Where,

ρtp = indicates the tapped density of gum, g/ml and

ρb = indicates the bulk density of gum, g/ml

3.4.5 Swelling index (SI)

Swelling index of *Cassia tora* gum powder was determined by using modified method reported. 0.15 g of *Cassia tora* gum powder was accurately weighed and transferred to a 15 ml stoppered measuring cylinder. The initial volume of the powder in the measuring cylinder was noted. The volume was made up to 15 ml mark with distilled water. The cylinder was stoppered, shaken gently and set aside for 24 h. The volume occupied by the gum sediment was noted after 24 h. Swelling index (SI) is expressed as a percentage and calculated according to the following equation (Joshi and Biyani, 2015).

$$SI = [(X_t - X_o)/ X_o] x\ 100$$

Where,

Xo = initial height of the gum, ml in graduated cylinder and

Xt = the height, ml occupied by swollen gum after 24 h.

Fig. 3.9 Swelling index of *Cassia tora* seed gum

3.4.6 pH value

The extracted seed gum (0.3 g) was stirred with 30 ml water for 5 min. The pH of 1% solution of the selected polysaccharide was determined using a digital pH meter (Joshi and Biyani, 2015).

Fig. 3.10 pH measurement of *Cassia tora* seed gum

3.4.7 Surface tension

The surface tension of the selected polysaccharides was determined by drop count method, using a stalagmometer .The stalagmometer was filled with purified water above the upper mark. Then, number of drops of water was counted between the marks of the stalagmometer (n1). The water was removed and the stalagmometer was filled with the polysaccharide solution (0.1% w/v) and number

of drops was counted (n2). The surface tension of the polysaccharide was determined using formula given below (Joshi and Biyani, 2015).

$$\text{Surface tension } (\gamma_2) = n_1\rho_2\gamma_1/n_2\rho_1$$

Where,

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

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

Fig. 3.11 Measurement of surface tension of *Cassia tora* seed gum

3.4.8 Viscosity measurement

The viscosity of 1 % w/v solution of *Cassia tora* seed gum was measured by Brookfield viscometer at 5-50 rpm using spindle number 64 (Pawar and Lalitha, 2015).

Fig. 3.12 Measurement of viscosity of *Cassia tora* seed gum

3.4.9 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).

3.4.10 Odour test and taste of (CTSG)

Muscilage isolated from *Cassia tora* splits by precipitation method. The odour and taste of *Cassia tora* seed gum powder (CTSG) is observed neutral as reported in literature (Mahungu and Meyland, 2008).

3.4.11 Determination of purity of gum

3.4.11.1 Alkaloid test

Wagner's Tests (solution of iodine in potassium iodide): The test was prepared by take 1 ml of gum extract in a test tube, add 3 ml of wagner’s reagent (iodine in potassium iodide). The acid layer with Wagner's reagent gives reddish

brown coloured precipitate, if alkaloid is present as reported in literature (Joshi and Biyani, 2015).

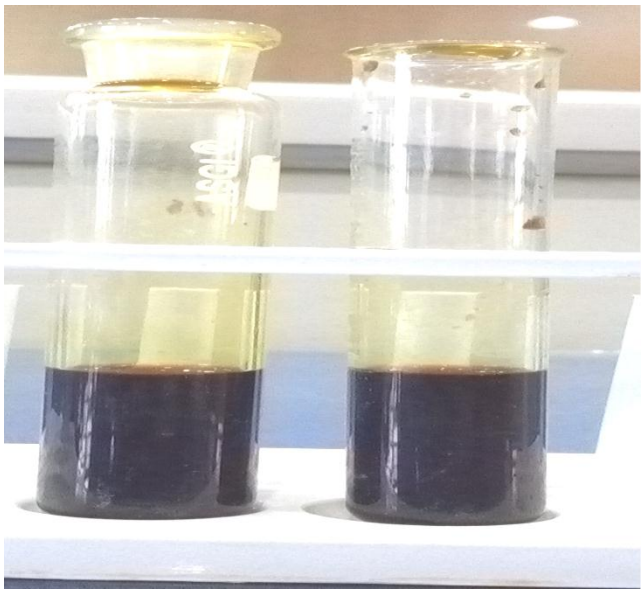
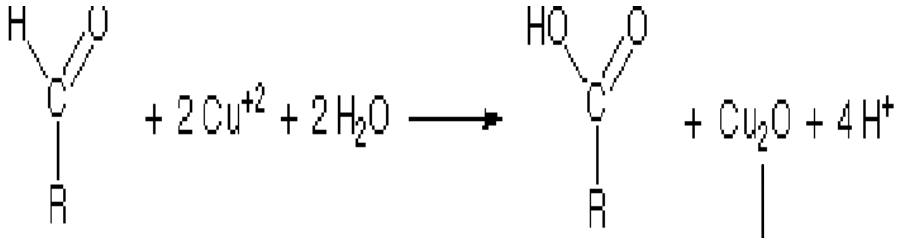


Fig. 3.13 Akaloids test of gum solution

3.4.11.2 Carbohydrate test

The copper sulfate ($CuSO_4$) present in Benedict's solution reacts with electrons from the aldehyde or ketone group of the reducing sugar in alkaline medium. Reducing sugars are oxidized by the copper ion in solution to form a carboxylic acid and a reddish precipitate of copper (I) oxide.



Reducing sugar Carboxylic acid

Reddish precipitate (copper oxide)

One ml of *Cassia tora* seed gum solution (1% w/v) is taken in a test tube and add 2 ml of benedict's reagent. The solution is then heated in boiling water bath for 5 min. The positive test is indicated that formation of blue *colour* precipitation (sucrose) as reported in literature (Joshi and Biyani, 2015).

Fig. 3.14 Carbohydrates test of gum solution

CHAPTER – IV
RESULTS AND DISCUSSION

This chapter deals with the results of the investigation carried out on different physical and physiochemical properties of *Cassia tora* seed and its gum powder. The chapter also explains dehusking of *Cassia tora* 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 *Cassia tora* seed gum

4.1.1 Bulk density

The bulk density values of *Cassia tora* seed were 0.87±0.03 g/ml (Table 4.1). Minimum and maximum value of bulk density of *Cassia tora* seed were 0.831 g/ml and 0.904 g/ml, respectively. The value of bulk density of *Cassia tora* seed was lower than tapped density and true density of *Cassia tora* seed.

4.1.2 Tapped density

The tapped density values of *Cassia tora* seed were 0.89±0.012 g/ml (Table 4.1). It was found to be minimum and maximum value of tapped density of *Cassia tora* seed were 0.874 g/ml and 0.913 g/ml, respectively. The value of tapped density of *Cassia tora* seed was higher than bulk density and lower than true density of *Cassia tora* seed.

4.1.3 True density

The true density values of *Cassia tora* seed were 1.3±0.143 g/ml (Table 4.1). It was found to be minimum and maximum value of tapped density of *Cassia tora* seed were 1.020 g/ml and 1.416 g/ml, respectively. The value of true density of *Cassia tora* seed was higher than both the bulk and tapped density of *Cassia tora* seed.

4.1.4 Porosity

The porosity values of *Cassia tora* seed lies between 15.21 to 41.25 % with mean value 31.9±8.85 % (Table 4.1). The porosity is dependent on bulk

density and true density. The value of porosity is increase with the decrease in bulk density or value of porosity is increase with increase in tapped density value.

4.1.5 Geometric mean diameter

Geometric Mean Diameter (GMD) of *Cassia tora* seed indicates the central tendency. The GMD of *Cassia tora* seed were ranges between 2.02 to 3.62 with mean value of 2.73±0.44 mm (Table 4.1). It was found to be length, width and thickness of *Cassia tora* seed ranges between 4.43±0.59 mm, 2.21±0.44 mm, and 2.11±0.42 mm, respectively. The minimum and maximum value of length, width and thickness was found to be 2.65 to 5.87 mm, 1.5 to 3.28 mm and 1.43 to 2.99 mm, respectively.

4.1.6 Spheicity

The sphericity values of *Cassia tora* seed lies between 61.93±7.37 with different length ranges of *Cassia tora* seed sample and obtained results are summarized in (Table 4.1). The value of sphericity was found to be minimum and maximum, 49.58 and 84.09, respectively.

4.1.7 Test weight

The test weight (1000 kernel weight), weight is a measure of seed size. It is the weight in g. Test weight of *Cassia tora* seed was found to be 13.794 g (Table 4.1). The test weight can vary from one crop to another, varieties of the same crop and even from year to year or from field to field of the same variety. Because of this variation in seed size, the number of plants in a pound or a bushel of seed is also highly variable (Joshi and Biyani, *2015).*

4.1.8 Volume

The volume (1000 kernel volume), volume is measure of 1000 kernel seeds volume by measuring cylinder. It is the volume in ml of 1000 seeds (Joshi and Biyani, 2015*)*. The volume of *Cassia tora* seed was found to be 14 ml (Table 4.1).

4.1.9 Color

Cassia seed is the ripe seed of the annual plant. The seeds of *Cassia tora* are rhombohedral and its color was found to be brown (Table 4.1).

Table 4.1: Physical properties of *Cassia tora* seed

Parameters	**Results**
Bulk density (g/ml)	0.87±0.03
Tapped density (g/ml)	0.89±0.012
True density (g/ml)	1.3±0.143
Porosity (%)	31.9±8.85
Length (mm)	4.43±0.59
Width (mm)	2.21±0.44
Thickness (mm)	2.11±0.42
GMD	2.73±0.44
Sphericity	61.93±7.37
Test weight (g)	13.794
Volume (ml)	14
Colour	Brown

4.2 Gum Extraction

4.2.1 Splitting of *Cassia tora* seeds

The seed consists of an outer husk, an endosperm (split) and the ovary or germ. Only the endosperm or split, which contains mainly polysaccharides, is used for the production of the *Cassia* gum.

The roasting experiment in respect to temperature was divided in to two parts on the basis of prior trial. First temperature ranges from 100ºC to 140ºC and the second ranges from 150ºC to 200ºC.

The endosperm, husk and germ obtained from per 100 g sample of *Cassia tora* seed ranged from 29.74±3.30 and 64.41±2.9, respectively for100ºC to 140ºC roasting temperature. Maximum endosperm 35.12 g were obtained when the seed roasted at 110ºC for 10 min., whereas minimum endosperm 25.28 g was found in the sample roasted at 140 ºC for 5 min. Maximum husk & germ was found to be 69.46 g in the sample roasted at 130ºC for 5 min., whereas minimum husk & germ was found to be 58.88 g in the sample roasted at 110ºC for 10 min (Fig. 4.1).

Table 4.2: Product obtained from *Cassia tora* seed roasted at 100ºC to 140ºC temperatures for various time.

S.N.	Temp. (ºC)	Time (min.)	Sample weight (g)	Product (g)	
				Endosperm (Splits)	Husk & germ
1.	100	5	100	25.31	67.18
		7.5	100	27.35	64.41
		10	100	30.67	61.32
2.	110	5	100	31.26	63.68
		7.5	100	33.39	61.12
		10	100	35.12	58.88
3.	120	5	100	30.14	65.29
		7.5	100	32.54	63.78
		10	100	34.62	61.22
4.	130	5	100	25.63	69.46
		7.5	100	27.45	67.59
		10	100	30.85	65.69
5.	140	5	100	25.28	67.29
		7.5	100	27.13	65.64
		10	100	29.39	63.61

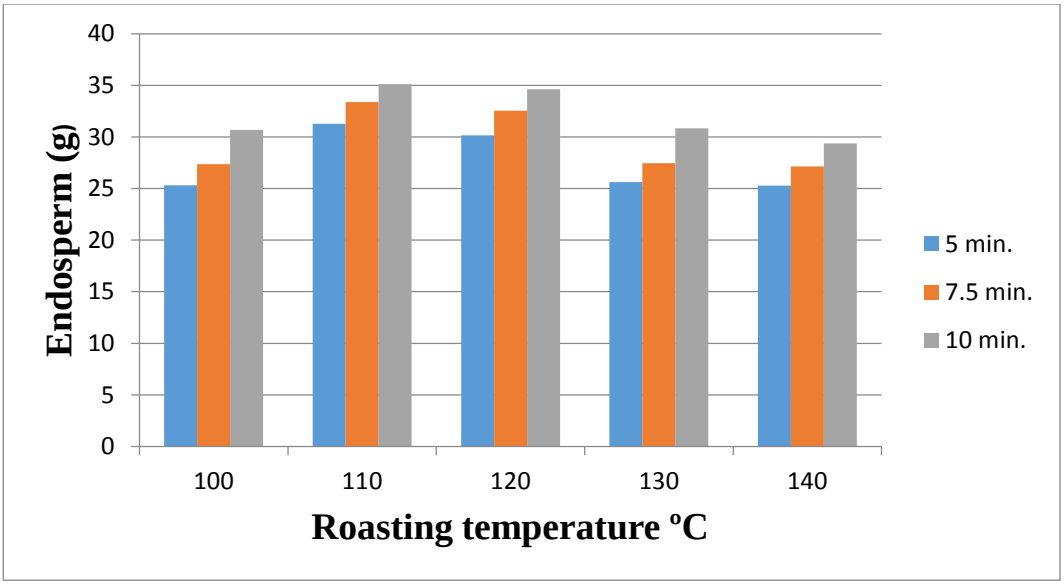


Fig. 4.1 Endosperm obtained from *Cassia tora* seed with respect to 100ºC to 140ºC roasting temperature at different time

The endosperm, husk and germ obtained from per 100 g of *Cassia tora* seed ranged from 29.34±2.87 and 67.52±2.94, respectively. Maximum endosperm 34.75 g were obtained when the seed roasted at 180ºC for 2 min., whereas minimum endosperm 24.36 g was found in the sample roasted at 200 ºC for 5 min. Maximum husk & germ was found to be 72.65 g in the sample roasted at 200ºC

for 5 min., whereas minimum husk & germ was found to be 61.93 g in the sample roasted at 170ºC for 2 min. (Fig. 4.2).

Table 4.3: Product obtained from *Cassia tora* seed roasted at 150ºC to 200ºC temperatures for various time.

S.N.	Temp. (ºC)	Time (min.)	Sample weight (g)	Product (g)	
				Endosperm (Splits)	Husk & germ
1.	150	2	100	31.31	65.57
		3	100	29.51	67.43
		5	100	27.36	69.58
2.	160	2	100	29.17	66.87
		3	100	27.58	68.15
		5	100	25.39	70.57
3.	170	2	100	33.57	61.93
		3	100	32.81	63.49
		5	100	30.26	65.91
4.	180	2	100	34.75	63.13
		3	100	32.16	65.53
		5	100	30.29	67.84
5.	190	2	100	30.07	67.18
		3	100	28.46	69.34
		5	100	26.59	71.70
6.	200	2	100	28.38	68.37
		3	100	26.14	70.15
		5	100	24.36	72.65

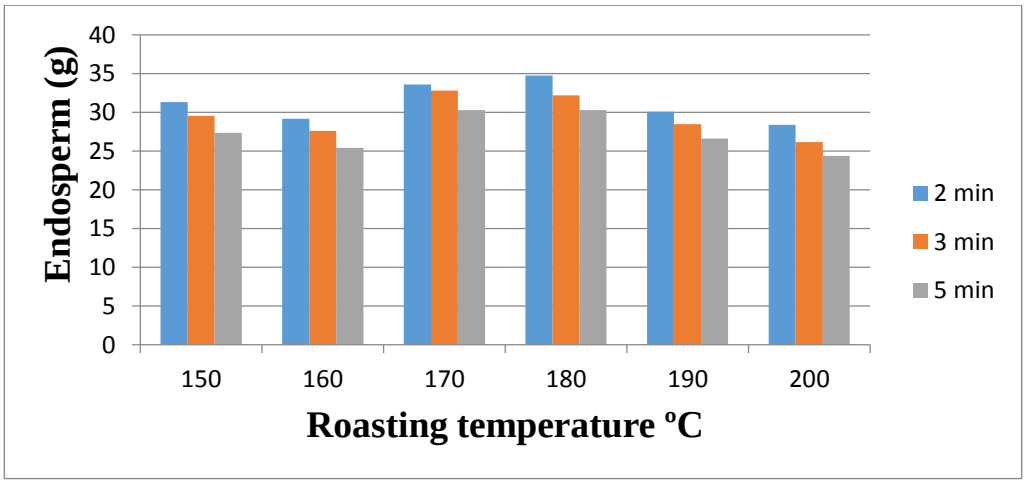


Fig. 4.2 Endosperm obtained from *Cassia tora* seed with respect to 150ºC to 200ºC roasting temperature at different time

After roasting the roasting the roasted samples were grinded in the mixer grinder to get endosperm (gum splits). During the grinding process the husk and

germ converts into powder and the gummy layer (endosperm) remains intact. Splits were separated using sieve (35 BIS).

a) Endosperm (splits)

b) Husk and germ

Fig. 4.3 Cleaned *Cassia tora* splits (endosperm) and husk

4.2.2 Defatting of *Cassia tora* splits

Splits obtained after raosting and grinding were subjected to defatting before gum extraction and the results shows that the fat content ranges from 0.45±0.10, respectively.

4.2.3 Gum yield

The Gum extraction was carried out from the samples given maximum recovery of splits for each temperature. Gum obtained from *Cassia tora* seeds was

an amorphous free flowing odourless powder with brown colour and substantial amount of gum and the gum yield was lies between 25.06±4.29% w/w. Maximum gum yield was found in 140ºC roasted sample, which is 31.15 % w/w per 100 g of raw sample, whereas minimum gum yield was found in 120ºC roasted sample which is 17.62 % per 100 g of raw sample.

The gum yield was found in maximum in 140ºC roasted sample, which is 3.115 g per 10 g defatted sample and 31.15 g per 100 g of raw sample. Whereas minimum gum yield was found in 120ºC roasted sample, which is 1.762 g per 10 g of defatted sample and 17.62 g per 100 g of raw sample (Fig. 4.4).

Table 4.4: Gum yield from different roasting temperature

S. N.	**Sample (°C)**	**Gum yield (g) Per 10 g of sample**	**Gum yield (%) Per 100 g of sample**
1.	100	2.218	22.18
2.	110	2.235	22.35
3.	120	1.762	17.62
4.	130	1.980	19.80
5.	140	3.115	31.15
6.	150	2.651	26.51
7.	160	2.735	27.35
8.	170	2.523	25.23
9.	180	2.981	29.81
10.	190	2.439	24.39
11.	200	2.930	29.30

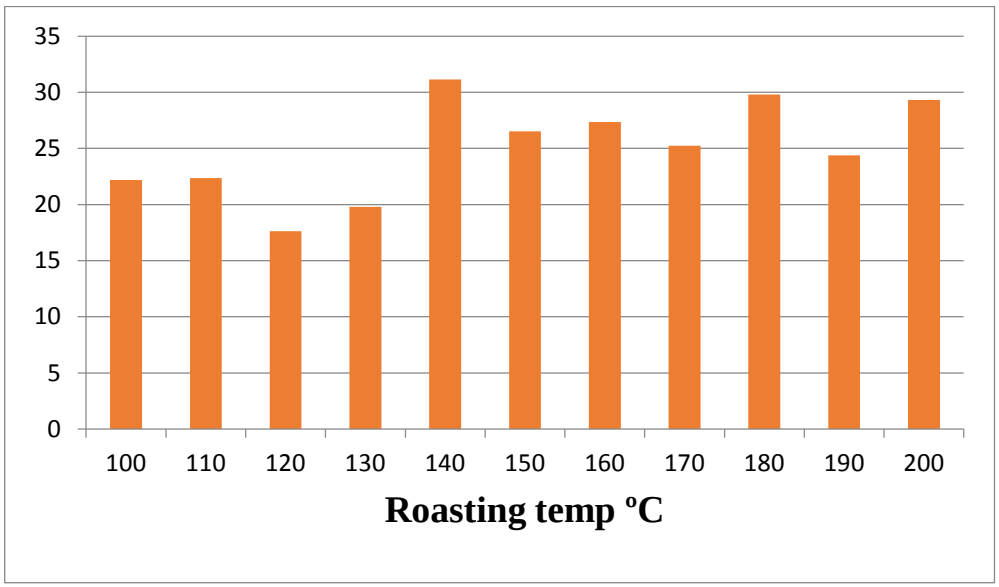


Fig. 4.4 Gum yield (%) from different samples roasted at different temprature

Table 4.5: Gum yield (%) from different samples roasted at different temprature

S.N.	Roasted Sample (°C)	Splits yield per 100 g	Gum yield (%)
1.	100	30.67	22.18
2.	110	35.12	22.35
3.	120	34.62	17.62
4.	130	30.85	19.80
5.	140	29.39	31.15
6.	150	31.31	26.51
7.	160	29.17	27.35
8.	170	33.57	25.23
9.	180	34.75	29.81
10.	190	30.07	24.39
11.	200	28.28	29.30

4.3 Physiochemical properties of extracted gum

4.3.1 Swelling index

Swelling index (SI) of *Cassia tora* seed gum was determined by using modified method reported with respect to gum obtain from different roasted sample. Swelling index of *Cassia tora* seed gum was found to be 334.9±23.6 %

(Table 4.9). The highest swelling index was found 362 % in 100ºC gum sample. Whereas the lowest swelling index was found 290 % in 200ºC gum sample (Fig. 4.5).

Table 4.6: Swelling index of *Cassia tora seed* gum

S. N.	Sample (ºC)	Wt. of Sample (g)	Volume of Sample (X_o)	Made up with distilled water	Volume of swollen gum (Xt)	Swelling index (%) $=[\frac{Xt-X_o}{X_o}] * 100$
1.	100	0.15	0.5	15	2.31	362
2.	110	0.15	0.5	15	2.29	358
3.	120	0.15	0.5	15	2.26	352
4.	130	0.15	0.5	15	2.25	350
5.	140	0.15	0.5	15	2.23	346
6.	150	0.15	0.5	15	2.21	342
7.	160	0.15	0.5	15	2.18	336
8.	170	0.15	0.5	15	2.15	330
9.	180	0.15	0.5	15	2.10	320
10.	190	0.15	0.5	15	1.99	298
11	200	0.15	0.5	15	1.95	290

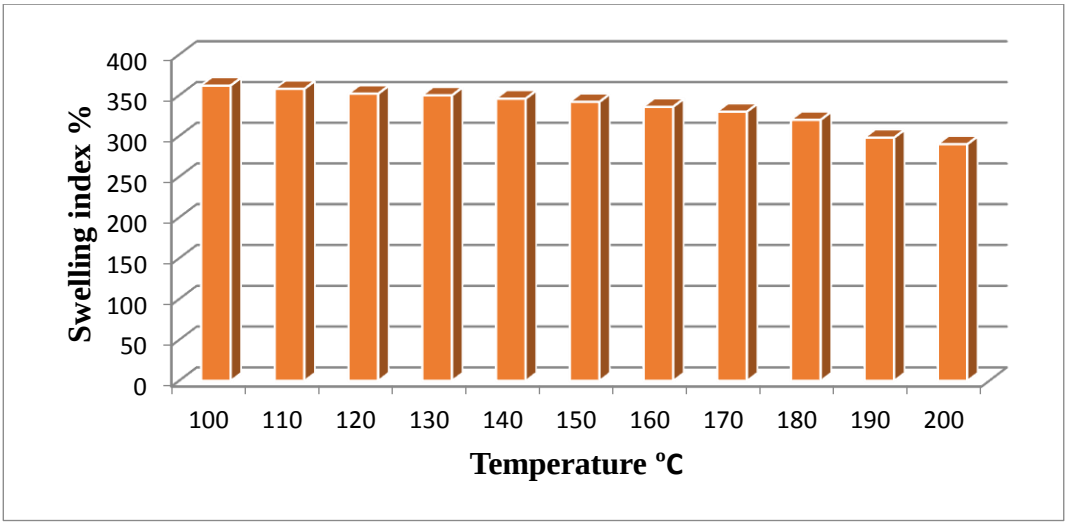


Fig. 4.5 Swelling index of *Cassia tora seed* gum

4.3.2 pH value

The pH value was observed by digital pH meter with respect to gum obtain from different roasted sample and the obtained value was 3.01±0.22 (Table 4.9),

which indicate the gum was acidic in nature. The highest (3.34) value of pH of gum was reported in 170ºC gum sample, whereas the lowest (2.56) value was reported in 200ºC gum sample (Fig. 4.6).

Table 4.7: pH of gum sample obtained from different roasted sample

S. N.	Sample (ºC)	Wt. of sample (g)	Distilled water (ml)	pH
1.	100	0.3	30	3.19
2.	110	0.3	30	3.16
3.	120	0.3	30	2.94
4.	130	0.3	30	3.09
5.	140	0.3	30	2.79
6.	150	0.3	30	3.03
7.	160	0.3	30	3.14
8.	170	0.3	30	3.34
9.	180	0.3	30	2.87
10.	190	0.3	30	2.97
11.	200	0.3	30	2.56

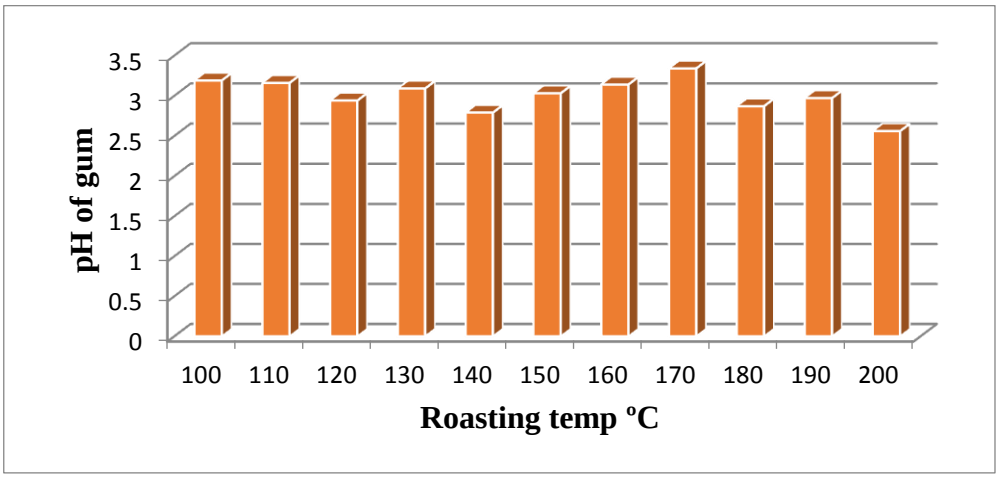


Fig. 4.6 pH of gum sample obtained from different roasted sample

4.3.3 Viscosity measurement

The viscosity of 1% w/v solution of *Cassia tora* seed gum was measured by Brookfield viscometer at various speeds of rotation i.e. 5 to 50 rpm with only one spindle (no. 64) and at room temperature (approximately 29.8ºC) shows the

plot of viscosity versus the rotation speed at 1% concentration of gum solution. From (Fig. 4.7), it was observed that the viscosity of gum decrease with increase in speed of rotation (rpm). The values of viscosity were obtained 120, 58, 30, and 12 cPs for rotational speed 5, 10, 20, and 50 rpm.

Spindle – 64

Temperature – 29.8 ºC

Table 4.8: Viscosity of *Cassia tora* seed gum

Rotational Speed (rpm)	Viscosity (cPs)
5	120
10	58
20	30
50	12
100	0

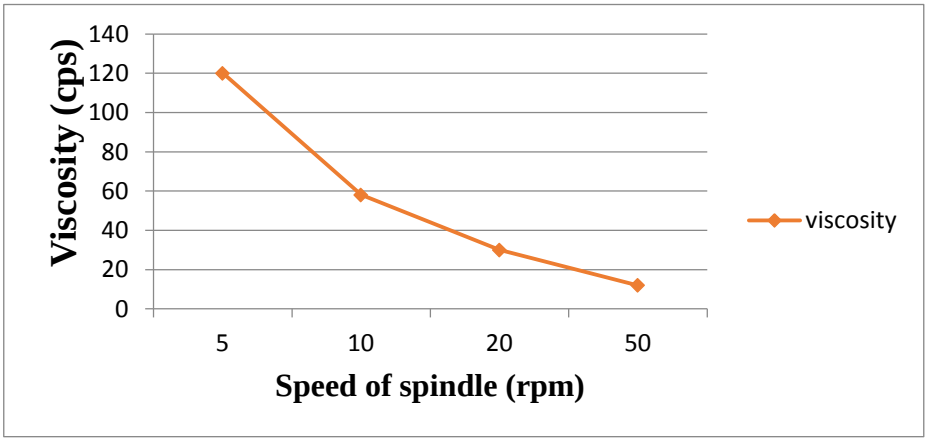


Fig. 4.7 Viscosity (cPs) of *Cassia tora* seed gum

4.3.4 Angle of repose

Angle of repose of *Cassia tora* seed gum was evaluated and value was 35.02±0.46° (Table 4.9). The maximum value was 35.53º, whereas minimum value was 34.14º.

4.3.5 Bulk and tapped density

The bulk density values of *Cassia tora* seed gum were 0.608±0.019 g/ml (Table 4.9). It was found to be minimum and maximum value of bulk density of *Cassia tora* seed gum were 0.588 g/ml and 0.628 g/ml, respectively.

The tapped density values of *Cassia tora* seed gum were 0.690±0.024 g/ml (Table 4.9). It was found to be minimum and maximum value of tapped density of *Cassia tora* seed gum were 0.718 g/ml and 0.0.667 g/ml, respectively.

4.3.6 Compressibility (Carr's) index

The compressibility (Carr's) index of *Cassia tora* seed gum is dependent on bulk and tapped density and its value was lies between 11.71±3.39 % (Table 4.9). It was found to be minimum and maximum value of Carr's index of *Cassia tora* seed gum were 6.27 % and 17.69 %, respectively.

The value below 15% indicates a powder which usually gives rise to excellent flow characteristics, whereas above 25% indicates poor flow ability (Joshi and Biyani, 2015).

4.3.7 Hausner's ratio

The hausner's ratio is an indirect index of ease of powder flow. The hausner's ratio of *Cassia tora* seed gum is dependent on bulk and tapped density and its value was lies between 1.13±0.04 (Table 4.9). It was found to be minimum and maximum value of hausner's ratio of *Cassia tora* seed gum were 1.07 and 1.21, respectively. The hausner's ratio (<1.25) indicates better flow properties than higher ones (>1.25) (Joshi and Biyani, 2015).

4.3.8 Surface tension

The surface tension of the selected polysaccharides was determined by drop count method using a stalagmometer and it was lies between 45.61±2.01 dynes/cm (Table 4.9). The highest value obtained was 48.54 dynes/cm, whereas lowest value was 43.47 dynes/cm.

4.3.9 Solubility test

The solubility of *Cassia tora* seed gum was determined by using various solvent such as hot water, cold water, ethanol, methanol, ether and acetone and obtained results are summarized in (Table 4.10). In case of water as solvent, it was

found that the sample of *Cassia tora* seed gum first swell up in water and after that it became soluble. *Cassia tora* seed gum was higher soluble in hot water than cold water. The samples of *Cassia tora* seed gum was found insoluble in case of other solvent like ethanol, methanol, ether and acetone.

Table 4.9: Physiochemical properties of *Cassia tora* seed gum

Parameter	**Results**
Angle of repose (degree)	35.02±0.46
Bulk density (g/ml)	0.608±0.019
Tapped density (g/ml)	0.690±0.024
Carr's index (%)	11.71±3.39
Hausner's ratio	1.13±0.04
Swelling index (%)	334.9±23.6
pH	3.01±0.22
Surface tension (dynes/cm)	45.61±2.01
Viscosity (cPs)	5-120
Odour	Neutral
Taste	Neutral

Table 4.10: Solubility behavior of *Cassia tora* seed gum

Solvent	**Solubility behavior**	**Solubility (%)**
Cold water	soluble	38.80
Hot water	Soluble	41.35
Ethanol	Insoluble	0.00
Methanol	Insoluble	0.00
Ether	Insoluble	0.00
Acetone	insoluble	0.00

4.3.10 Odour test and taste

Muscilage isolated from *Cassia tora* splits by precipitation method. The odor and taste of *Cassia tora* seed gum powder is observed neutral as reported in literature (Mahungu and Meyland2008).

4.3.11 Determination of purity of gum

4.3.11.1 Alkaloid test

The purity of the gum was tested by performing phytochemical tests. The results of the test indicate the absence of alkaloids. The results are summarized in (table 4.11). The results of alkaloids absence in *Cassia tora* seed gum was similar reported in literature (Joshi and Biyani, 2015).

4.3.11.2 Carbohydrate test

The purity of the gum was tested by performing phytochemical tests. The results of the test indicate the presence of carbohydrates. The result indicates that the extracted gum is a pure carbohydrate and is summarized in (table 4.6). The results of carbohydrate presence in *Cassia tore* seed gum was similar reported in literature (Joshi and Giyani, 2015).

Table 4.11: Determination of purity of *Cassia tora* seed gum

Tests	**Results**
Tests for alkaloids (Wagner's test)	Absence
Tests for carbohydrates (Benedicts test)	Presence

CHAPTER-V
SAMMARY AND CONCLUSION

*Cassia tora*is a local annual weed found all over in Chhattisgarh during rainy season and it is commonly known as *Charota* in C.G.). Plant can grow 30-90 cm (12-35 in) tall. *Cassia tora* produce pods that are somewhat flattened or four angled, 10-15 cm long and sickle shaped, hence the common name sickle pod. There are 30-50 seeds within a pod (Source- Wikipedia.org 2016). The seeds yield gum. The gum has high market value, therefore the study was aimed to standardize the processing of roasting and gum extraction from the seeds and to determine the physical properties of seeds, gum extraction and physiochemical properties of gum powder.

The present study entitled **"Extraction of gum from *Charota (Cassia tora)* seeds 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, Bio-Chemistry, Medicinal and Aromatic Plant College of Agriculture, IGKV, Raipur, (C.G). Based on the experimental observations the following results were obtained:

- The value to bulk, tapped and true density of *Cassia tora* seed was found to be 0.87±0.03 g/ml, 0.89±0.012 g/ml, and 1.3±0.143 g/ml, respectively. The porosity of *Cassia tora* seed was found 15.21 to 41.25 %.
- The geometric mean diameter (GMD) were ranges between 2.02 to 3.62 with mean value of 2.73±0.44 mm. The length, width and thickness of *Cassia tora* seed was found 4.43±0.59 mm, 2.21±0.44 mm, and 2.11±0.42 mm, respectively.
- The value of sphericity of *Cassia tora* seed was obtained 61.93±7.37.The test weight and volume (1000 kernel weight and volume) was obtained 13.794 g and 14 ml, respectively. The color of *Cassia tora* seed was found brown.

- The endosperm, husk and germ obtained from per 100 g sample of *Cassia tora* seed with respect to 100ºC to 140ºC roasting temperature was 29.74±3.30 and 64.41±2.91, respectively. Maximum endosperm 35.12 g were obtained when the seed roasted at 110ºC for 10 min., whereas minimum endosperm 25.28 g was found in the sample roasted at 140 ºC for 5 min. Maximum husk & germ was found to be 69.46 g in the sample roasted at 140ºC for 5 min., whereas minimum husk & germ was found to be 58.88 g in the sample roasted at 110ºC for 10 min.
- The endosperm, husk and germ obtained from per 100 g sample of *Cassia tora* seed with respect to 150ºC to 200ºC roasting temperature was found 29.34±2.87 and 67.52±2.94, respectively. Maximum endosperm 34.75 g were obtained when the seed roasted at 180ºC for 2 min., whereas minimum endosperm 24.36 g was found in the sample roasted at 200 ºC for 5 min. Maximum husk & germ was found to be 72.65 g in the sample roasted at 200ºC for 5 min., whereas minimum husk & germ was found to be 61.93 g in the sample roasted at 180ºC for 2 min.
- The fat content ranges from 0.45±0.10.
- The Gum extraction was carried out from the samples given maximum recovery of splits for each temperature. The gum yield was obtained 25.06±4.29% w/w. The highest gum yield was obtained 31.15% w/w, in 140ºC roasted sample, whereas the lowest gum yield was obtained 17.62 %, in 120ºC roasted sample. From the above it can be suggested that for getting the higher amount of split roasting should be done at 110 ºC for 10 min and to get the highest gum yield roasting should be done at 140 ºC 5 min.
- The angle of repose of *Cassia tora* seed gum was found 35.02±0.46°.The bulk and tapped density of *Cassia tora* seed gum was found 0.608±0.019 g/ml and 0.690±0.024 g/ml, respectively.
- The compressibility (Carr's) index of *Cassia tora* seed gum was found 11.71±3.39%.The hausner's ratio *Cassia tora* seed gum was found 1.13±0.04.

- The swelling index of *Cassia tora* seed gum was found 334.9±23.6 %. The highest and lowest swelling index was found 362%, in 100ºC gum sample and 190 %, in 200ºC gum sample, respectively.
- The pH value of *Cassia tora* seed gum was obtained 3.01±0.22, which is acidic in nature. The highest and lowest pH value was obtained 3.3, in 170ºC gum sample and 2.56 in 200ºC gum sample.
- The surface tension of *Cassia tora* seed gum was obtained 45.61±2.01 dynes/cm.
- The viscosity of *Cassia tora* seed gum was obtained 12-120 cPs using Brookfield viscometer spindle no. 64 at 5 to 50 rpm.
- The solubility of *Cassia tora* seed gum was determined by using various solvent such as hot water, cold water, ethanol, methanol, ether and acetone. The maximum (41.35 % per 100 ml) soluble was found at hot water.
- It was found that *Cassia tora* seed gum was odourless and neutral in taste.
- The purity (Alkaloid and Carbohydrate) of *Cassia tora* seed gum was tested. The results was obtained that alkaloid was absent and carbohydrate was present.

5.2 Suggestion for future work

1. The work may be carried out to get replacement of acetone for precipitation of gum to reduce processing cost and to save environment.
2. The work may be carried out to develop a pilot plant for the developed process.
3. It may provide an alternative to synthetic or semi-synthetic polymer.
4. Thus there is need to investigate further *Cassia tora* seed gum as an polymer.

REFERENCES

Adeleye, O. A., Femi-Oyewo, M. M. and Odeniyi, M. A. 2015. Physiochemical and Rheological Characterization of *CissusPopulnea* Gum Extracted by Different Solvents. *West African J. of Pharmacy,* 26(1):113-126.

Ameh, P. O. 2012. Physiochemical Properties and Rheological Behavior of *Ficusglumosa* Gum in Aqueous Solution. *International J. of Modern Chemistry,* 2(3):84-99.

Ansari H.S. 2004.Plant Profile of *Cassia tora*, The Ayurvedic Plants, Delhi Satguru Publication, 334-339.ISBN 81-7030-797.

Dafan, D.G., Abubakar, M.S., Nuhu, H., Ajima, U., and Okwori, V. 2013.Quantitative Evaluation of Some Physical and Chemical Properties of the Gum-Mucilage of Anacardium accidental L. (Anacardiaceae). *International J. of Pharmaceutical Science Invention,* 2(9): 46-48.

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.

Emeje, M., Nwabunike, P. and Isimi, C. 2009.Isolation, Characterization and Formulation Properties of a new Plant Gum Obtained from *Cissus references*. *Int. J. Green Pharmacy.* 3(1):16-23.

Farooq, U., Malviya, R. and Sharma, P. K. 2014. Extraction and Characterization of *Artocarpus Integer* Gum as Pharmaceutical Excipient. *Polim.Med.* 44(2): 69-74.

Gaisford, S. E., Harding, S. E., Mitchell, J.R. and Bradley, T.D. 1986. "A C omparison Between the Hot and Cold Water Soluble Fractions of two *Locust bean* Gum Samples," *Carbohydrate Polymers,* vol. 6(6): 423–442.

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

Ingle, A., Ranaware, P., Ladke, A. and Damle, M. 2012. "*Cassia tora*: Phytochemical and Pharmacological Activity," *International Imperial Journal of Pharmacognosy & Natural Products*, 2(1): 14–23.

Joshi, U.M. and Biyani, K.R. 2015.Extraction of Novel Seed Gum from *Cassia tora* Seeds and its Characterization. *Int. J. Pharmacy & Pharmaceutical Res*., vol. 4 (1)

Mann, A.S., Jain N.K. and Kharya M.D., 2007.Evaluation of the Suspending Properties of *Cassia tora* Mucilage on Sulphadimidine Suspension. *Asian J. Exp. Sci.* 21(1):63-67.

Mhinzi, G. S. 2001. Properties of Gum Exudates from Selected *Albizia* Species from Tanzania. Food Chem. 77(2002): 301-304.

Munoz, Jose, Rincon, Fernando, Alfaro, M. Carmen, Zapata, Isabel, Fuente, Julia de la, Beltran, Olga and Pinto, Gladys Leon de. 2007. Rheological Properties and Surface Tension of *Acacia tortuosa* Gum Exudate Aqueous Dispersion. Carbohydrate Polymers, vol. 70(2): 198-205.

Pawar, H. and D'Mello, P.M.2004. Isolation of Seed Gum From *Cassia tora* and Preliminary Studies of its Application as Binder for Tablets. Indian Drugs, 41 (8): 465.

Pawar, H.A. and Lalitha, K.G. (2014).Isolation, Purification and Characterization of Galactomannans as ans Excipient from *Sena tora* Seeds. *International J. of Biological Macromolecules.* Vol. 65: 167-175.

Selvi, K.C., Yunus, P., Elcin, Y. 2006. Some Physical Properties of *Linseed*. *Biosystems Engineering*, 95(4): 607-612.

Soni, P.L. and Pal, R. 1996. Industrial Gum from *Cassia tora* Seeds. *Trends in Carbohydrates Chemistry,* 2: 33-44.

Upadhyay, S.K. and Singh, V. 1986. Phytochemical Evaluation of *Cassia obtusifolia* and *Cassia tora.* Proc. *Indian Acad. Sci., Plant Sci.,* 96 (4): 321-326.

Wilkinson, R. E. and Hardcastle, W. S. 1969. “Comparative Fatty Acid Content of Various Organs of *Cassia tora* L.,” *Botanical Gazette*, vol. 130(4): 254–258.

Yadav, S., Sharma, P. K. and Goyal N. K. (2015).Comparative study of Mucilage Extracted from Seeds of *Cassia fistula* and Gum *Karaya*. *Advances in Biological Res.* 9(3): 177-181.

Appendix-A

Table: 1) Bulk and Tapped density of *Cassia tora* seeds

S. N.	Volume (V)	Tapped volume (Vt)	Weight (w)	Bulk density (ρb) =w/V	Tapped density (ρtp)= w/Vt
1.	100	95	83.063	0.831	0.874
2.	100	94	83.279	0.832	0.885
3.	100	96	85.167	0.851	0.887
4.	100	98	88.930	0.889	0.907
5.	100	99	89.471	0.894	0.904
6.	100	98	88.671	0.887	0.905
7.	100	97	88.092	0.881	0.908
8.	100	99	88.724	0.887	0.896
9.	100	98	88.710	0.887	0.905
10.	100	99	90.461	0.904	0.913

Table: 2) True density of *Cassia tora* seeds

S. N.	Mass (w)	Toluene(ml)	Displaced volume (Vd)	True density (ρt)= w/Vd
1.	5.549	20	4	1.387
2.	5.666	20	4	1.416
3.	5.102	20	5	1.020
4.	5.441	20	4	1.360
5.	5.452	20	4	1.363
6.	5.231	20	5	1.046
7.	5.319	20	4	1.330
8.	5.362	20	4	1.341
9.	5.509	20	4	1.377
10	5.456	20	4	1.364

Table: 3) Porosity of *Cassia tora* seeds

S. N.	Bulk density (ρb)	True density(ρt)	Porosity (ε) % = (1- ρb/ ρt)*100
1.	0.831	1.387	40.08
2.	0.832	1.416	41.25
3.	0.851	1.020	16.59
4.	0.889	1.360	34.64
5.	0.894	1.363	34.40
6.	0.887	1.046	15.21
7.	0.881	1.330	33.73
8.	0.887	1.341	33.83
9.	0.887	1.377	35.59
10.	0.904	1.364	33.72

Table: 4) Geometric mean dimension of *Cassia tora* seeds

S. N.	Length (L)	Width (W)	Thickness (T)	Geometric mean diameter GMD= (LWT)⅓	Sphericity S = (LWT)⅓ ÷ L
1.	4.04	1.86	1.85	2.40	59.51
2.	5.48	2.17	2.10	2.92	53.34
3.	3.59	1.57	1.58	2.07	57.74
4.	3.88	1.71	1.52	2.16	55.68
5.	4.78	2.58	2.55	3.16	66.03
6.	3.49	1.69	1.43	2.04	58.32
7.	5.74	2.91	2.70	3.56	56.40
8.	4.74	2.03	1.90	2.63	55.58
9.	4.55	2.40	2.31	2.93	64.46
10.	5.05	2.92	2.97	3.52	69.80
11.	4.56	2.71	2.69	3.22	70.51
12.	4.41	2.70	2.70	3.18	72.19
13.	3.68	2.09	1.96	2.47	67.13
14.	4.45	2.14	2.05	2.69	60.51
15.	3.99	1.60	1.57	2.16	54.04

16.	3.46	2.19	2.18	2.55	73.60
17.	3.80	2.24	1.86	2.51	66.08
18.	4.51	2.66	2.31	3.03	67.09
19.	5.09	2.22	1.96	2.81	55.17
20.	4.31	1.70	1.64	2.29	53.14
21.	5.50	2.71	2.69	3.42	62.22
22.	4.59	1.87	1.82	2.50	54.46
23.	4.58	2.11	2.16	2.75	60.11
24.	4.68	2.41	2.13	2.89	61.66
25.	4.19	1.50	1.49	2.11	50.31
26.	5.29	2.54	2.53	3.24	61.24
27.	2.65	1.82	1.70	2.02	77.38
28.	4.55	2.32	2.06	2.79	61.34
29.	4.31	1.73	1.63	2.30	53.34
30.	3.15	2.06	2.02	2.36	74.85
31.	4.18	2.01	1.94	2.54	60.66
32.	4.65	2.03	1.84	2.59	55.69
33.	5.30	2.70	2.80	3.42	64.56
34.	4.61	1.82	1.80	2.47	53.61
35.	4.80	2.65	2.42	3.13	65.29
36.	3.73	2.78	2.68	3.03	81.21
37.	5.73	2.54	2.31	3.23	56.33
38.	4.37	1.69	1.43	2.19	50.21
39.	4.23	1.88	1.85	2.45	57.93
40.	5.21	1.86	1.78	2.58	49.59
41.	4.51	2.24	1.95	2.70	59.88
42.	3.98	1.90	1.86	2.41	60.65
43.	4.66	2.94	2.86	3.40	72.89
44.	4.23	2.19	2.15	2.71	64.08
45.	3.87	1.68	1.62	2.19	58.59
46.	5.83	2.79	2.76	3.55	61.03
47.	4.39	2.77	2.74	3.22	73.29

48.	4.02	1.77	1.77	2.33	57.87
49.	4.38	2.18	2.17	2.75	62.71
50.	5.02	2.41	2.39	3.07	61.14
51.	4.66	2.99	2.67	3.34	71.64
52	4.29	2.07	1.68	2.46	57.38
53.	4.59	1.69	1.62	2.32	50.65
54.	4.09	2.07	1.92	2.53	61.94
55.	3.96	1.76	1.69	2.28	57.46
56.	4.22	1.96	1.89	2.50	59.25
57.	3.99	2.15	1.94	2.55	63.98
58.	4.33	1.81	1.80	2.42	55.80
59.	5.28	2.49	2.47	3.19	60.42
60.	4.82	2.04	2.02	2.71	56.19
61.	4.96	3.13	2.71	3.48	70.12
62.	3.93	2.15	2.05	2.59	65.84
63.	4.40	2.79	2.60	3.17	72.09
64.	5.60	3.28	2.58	3.62	64.62
65.	3.93	1.97	1.90	2.45	62.34
66.	3.78	1.84	1.87	2.35	62.21
67.	4.32	2.66	2.58	3.10	71.64
68.	3.96	2.33	2.05	2.66	67.28
69.	3.92	1.75	1.79	2.31	58.85
70.	3.76	2.94	2.86	3.16	84.09
71.	4.30	2.18	2.07	2.69	62.49
72.	3.90	1.96	1.99	2.48	63.53
73.	5.36	3.04	2.90	3.62	67.45
74.	4.45	1.91	1.90	2.53	56.8
75.	4.40	1.79	1.78	2.41	54.8
76.	4.74	2.02	2.11	2.72	58.41
77.	4.98	2.73	2.63	3.29	66.15
78.	3.98	1.87	1.85	2.40	60.22
79.	5.20	2.79	2.65	3.38	64.91

80.	5.07	2.96	2.79	3.47	68.49
81.	4.38	2.32	2.00	2.73	62.31
82.	3.78	1.71	1.74	2.24	59.27
83.	4.69	2.75	2.52	3.19	68.04
84.	3.53	2.34	2.32	2.68	75.81
85.	4.05	2.01	2.00	2.53	62.58
86.	4.96	2.96	2.99	3.53	71.12
87.	4.19	1.88	1.87	2.45	58.51
88.	3.80	1.78	1.73	2.27	59.75
89.	4.80	2.95	2.73	3.38	70.44
90.	3.48	2.37	2.24	2.64	79.63
91.	5.87	2.36	2.24	3.14	53.53
92.	4.51	1.84	1.79	2.46	54.51
93.	4.29	1.93	2.01	2.55	59.51
94.	4.39	1.77	1.80	2.41	54.88
95.	4.47	1.85	1.87	2.49	55.74
96.	4.94	1.68	1.46	2.30	51.38
97.	4.33	1.61	1.59	2.23	51.49
98.	4.64	1.63	1.61	2.30	49.58
99.	4.06	1.97	1.78	2.42	59.69
100.	4.11	1.82	1.81	2.38	57.99

Appendix-B

Table 5) Product obtained from *Cassia tora* seed roasted at 100ºC to 140ºC temperatures for various time

S.N.	Temp. (ºC)	Time (min.)	Sample weight (g)	Product (g)	
				Endosperm (Splits)	Husk & germ
1.	100	5	100	25.31	67.18
		7.5	100	27.35	64.41
		10	100	30.67	61.32
2.	110	5	100	31.26	63.68
		7.5	100	33.39	61.12
		10	100	35.12	58.88

		5	100	30.14	65.29
3.	120	7.5	100	32.54	63.78
		10	100	34.62	61.22
		5	100	25.63	69.46
4.	130	7.5	100	27.45	67.59
		10	100	30.85	65.69
		5	100	25.28	67.29
5.	140	7.5	100	27.13	65.64
		10	100	29.39	63.61

Table 6) Product obtained from *Cassia tora* seed roasted at 150ºC to 200ºC temperatures for various time

S.N.	Temp. (ºC)	Time (min.)	Sample weight (g)	Product (g)	
				Endosperm (Splits)	Husk & germ
		2	100	31.31	65.57
1.	150	3	100	29.51	67.43
		5	100	27.36	69.58
		2	100	29.17	66.87
2.	160	3	100	27.58	68.15
		5	100	25.39	70.57
		2	100	33.57	61.93
3.	170	3	100	32.81	63.49
		5	100	30.26	65.91
		2	100	34.75	63.13
4.	180	3	100	32.16	65.53
		5	100	30.29	67.84
		2	100	30.07	67.18
5.	190	3	100	28.46	69.34
		5	100	26.59	71.70
		2	100	28.38	68.37
6.	200	3	100	26.14	70.15
		5	100	24.36	72.65

Table 7) Product obtained from *cassia tora* seed and gum yield

S. N.	Sample wt. (g)	Roasting of sample		Endosperm (g)	Husk & Germ (g)	Wt. of Defatted sample (g)	Gum yield (g) Per 10 g of defatted sample
		Temp. (◦C)	Time (min.)				

1.	100	100	10	30.67	61.32	10	2.218
2.	100	110	9	35.12	58.88	10	2.235
3.	100	120	8	34.63	61.22	10	1.762
4.	100	130	7	30.85	65.69	10	1.980
5.	100	140	6	29.39	63.61	10	3.115
6.	100	150	5	31.31	65.57	10	2.651
7.	100	160	5	29.17	66.87	10	2.735
8.	100	170	5	33.57	61.93	10	2.523
9.	100	180	5	34.75	63.13	10	2.981
10.	100	190	5	30.07	67.18	10	2.439
11.	100	200	5	28.38	68.37	10	2.930

Table 8) Fat content roasted *Cassia tora* splits

S.N.	Sample (ºC)	Sample wt. (w)	Initial wt. of dish (w_1)	Final wt. of dish (w_2)	Fat content(%) $= \frac{(w2 - w1)}{w} * 100$
		4.039	76.418	76.435	0.421
1.	100	4.081	81.580	81.601	1.004
		4.064	78.575	78.585	0.246
				Fat content	0.557 ± 0.397
		4.021	76.516	76.534	0.447
2.	110	4.093	81.610	81.631	0.513
		4.075	78.618	78.627	0.221
				Fat content	0.394 ± 0.153
		4.068	74.517	74.532	0.368
3.	120	4.019	81.643	81.659	0.398
		4.043	78.612	78.636	0.593
				Fat content	0.453 ± 0.122
		4.013	74.437	74.451	0.348
4.	130	4.025	81.623	81.641	0.447
		4.031	78.591	78.613	0.545

				Fat content	0.447 ± 0.099
		4.249	76.536	76.557	0.494
5.	140	4.515	74.741	74.758	0.376
		4.368	76.268	76.283	0.342
				Fat content	0.404 ± 0.080
		5.070	73.310	73.330	0.390
6.	150	5.040	74.450	74.470	0.396
		5.050	76.180	76.210	0.590
				Fat content	0.459 ± 0.114
		4.050	76.422	76.446	0.583
7.	160	4.020	74.844	74.872	0.686
		4.04	76.177	76.204	0.658
				Fat content	0.642 ± 0.053
		4.027	74.427	74.452	0.620
8.	170	4.000	81.601	81.622	0.525
		4.126	78.587	78.598	0.266
				Fat content	0.642 ± 0.053
		4.013	76.416	76.423	0.174
9.	180	4.015	81.601	81.625	0.597
		4.031	78.635	78.651	0.396
				Fat content	0.389 ± 0.212
		4.012	7.414	76.432	0.448
10.	190	4.102	81.572	81.580	0.195
		4.061	78.563	78.573	0.246
				Fat content	0.221 ± 0.036
		4.070	76.441	76.462	0.448
11.	200	4.15	74.863	74.895	0.195
		4.38	76.197	76.215	0.246
				Fat content	0.296 ± 0.134

Appendix-C

Table: 9) Swelling index *Cassia tora* seed gum

S. N.	Sample (ºC)	Wt. of Sample (g)	Volume of Sample(X_o)	Made up with distilled water	Volume of swollen gum (Xt)	Swelling index (%) $=[\frac{Xt-X_o}{X_o}] * 100$
1.	100	0.15	0.5	15	2.31	362
2.	110	0.15	0.5	15	2.29	358
3.	120	0.15	0.5	15	2.26	352
4.	130	0.15	0.5	15	2.25	350
5.	140	0.15	0.5	15	2.23	346
6.	150	0.15	0.5	15	2.21	342
7.	160	0.15	0.5	15	2.18	336
8.	170	0.15	0.5	15	2.15	330
9.	180	0.15	0.5	15	2.10	320
10.	190	0.15	0.5	15	1.99	298
11	200	0.15	0.5	15	1.95	290

Table: 10) pH value of *Cassia tora* seed gum

S. N.	Sample (ºC)	Wt. of sample (g)	Distilled water (ml)	pH
1.	100	0.3	30	3.19
2.	110	0.3	30	3.16
3.	120	0.3	30	2.94
4.	130	0.3	30	3.09
5.	140	0.3	30	2.79
6.	150	0.3	30	3.03
7.	160	0.3	30	3.14
8.	170	0.3	30	3.34
9.	180	0.3	30	2.87
10.	190	0.3	30	2.97
11.	200	0.3	30	2.56

Table: 11) Bulk density, Tapped density, Compression ratio and Hausner's ratio of *Cassia* tora seed gum

S. N.	Weight (w)	Volume (V)	Tapped volume (Vt)	Bulk density (ρb) =m/V	Tapped density (ρtp)= m/Vt	Compressibility (I) = ($\frac{\rho tp-\rho b}{\rho tp}$)*100	Hausner'sratoio (H) = $\frac{\rho tp}{\rho b}$
1.	10.00	16	14	0.625	0.714	12.46	1.14
2.	10.01	16	14	0.626	0.715	12.45	1.14
3.	10.05	16	15	0.628	0.670	6.27	1.07
4.	10.00	16	15	0.625	0.667	6.30	1.07
5.	10.05	17	14	0.591	0.718	17.69	1.21
6.	10.00	17	15	0.588	0.667	11.84	1.13
7.	10.04	16	14	0.628	0.717	12.41	1.14
8.	10.04	17	15	0.591	0.669	11.66	1.13
9.	10.01	17	15	0.589	0.667	11.69	1.13
10.	10.06	17	15	0.592	0.691	14.33	1.13

Table: 12) Angle of repose of *Cassia tora* seed gum

S. N.	Sample wt. (g)	Height (H)	Radius (r)	Angle of repose $\theta° = \tan^{-1}(\frac{H}{r})$
1.	10	2	2.80	35.53
2.	10	2	2.80	35.53
3.	10	2	2.85	35.06
4.	10	2	2.95	34.14
5.	10	2	2.90	34.59
6.	10	2	2.90	34.59
7.	10	2	2.85	35.06
8.	10	2	2.85	35.06
9.	10	2	2.80	35.53
10.	10	2	2.85	35.06

Table: 13) Solubility behavior of *Cassia tora* seed gum

S. N.	Solvent	Solubility behavior	Solubility percentage
1.	Cold water	Soluble	38.80
2.	Hot water	Soluble	41.35
3.	Ethanol	Insoluble	0.00
4.	Methanol	Insoluble	0.00
5.	Ether	Insoluble	0.00
6.	Acetone	Insoluble	0.00

Table: 14) Surface tension of *Cassia tora* seed gum

S. N.	Number of drop of water (n1)	Number of drop of sample (n2)	Surface tension $Y2 = \left(\frac{n1*\rho2*y1}{n2*\rho1}\right)$ dynes/ cm
1.	67	60	48.54
2.	59	55	46.63
3.	54	54	43.47
4.	52	51	44.32
5.	56	54	45.08

RESUME

Name	:	Roman Kumar Sonwani
Date of Birth	:	12- September - 1991
Present Address	:	H.N.-225, Bhatapara, Vill.- Serikhedi, P.O.- Mandir Hasoud, Distt.-Raipur, Chhattisgarh Pin. – 492101
Mobile No.	:	9685639797
E. mail	:	romiiisonwani@gmail.com
Permanent Address	:	H.N.-225, Bhatapara, Vill.- Serikhedi, P.O.- Mandir Hasoud, Distt.-Raipur, Chhattisgarh Pin. – 492101

Academic Qualification

Exam/Degree	Year	University/Institute
B.Tech (Agril. Engg.)	2015	IGKV, Raipur
HSSC	2009	CGBSE, Raipur
HSC	2007	CGBSE, Raipur

Signature