

# PERFORMANCE REPORT 2018-19



CSIR - Central Food Technological Research Institute Mysuru



# CSIR-CFTRI PERFORMANCE REPORT 2018-19

CSIR-Central Food Technological Research Institute (A constituent laboratory of Council of Scientific & Industrial Research) Mysuru - 570 020, India

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# From Director's Desk.....

It is a happy occasion for me to place the S & T achievements of CSIR-CFTRI for the period 2018-19 in a concise form in this report.

Considerable progress has been achieved with the CSIR Mission projects such as Food & Consumer Safety Solutions (FOCUS) and Nutrition & Nutraceuticals, which include Nutri-breakfast foods for school children. Out of 3 FTT projects, Commercialization of carbonated fruit juice beverages has been realized while other two are pursued for launching in the FTC mode.

The Institute also operated 71 Grant-in-Aid projects from various agencies and 65 Industry projects during this period. Apart from these, 29 inhouse projects were undertaken for furthering R&D in the area of food processing. Large number of publications have emerged while 38 students were awarded doctorate degrees from Mysore University & AcSIR during this period. Entrepreneurship and employment generation got impetus from the institute in terms of technology transfer, skill development programmes with NSDC certification and incubation activities. Further, ECF also showed good rise in terms of returns from all the stakeholders.

Almost 15 tonnes of nutrition food products were

supplied to the flood affected regions of Kerala and Karnataka during National Disaster. Various outreach activities were undertaken to improve the MDM scheme in association with Akshaya Patra Foundation and enhancing the livelihood of farmers.

Overall, it has been one of the most productive years for the Institute and tremendous progress has been made in all fronts while aligning with National Missions and Mandate of the Institute. I thank Director General, CSIR for his whole-hearted support and guidance in realizing various targets set earlier. Further, it is my duty to acknowledge the support received from CSIR Hqs, external funding agencies, academic institutions, State & Central Govt. departments for sustaining the momentum in this journey. Finally, I am extremely grateful to all my staff and students who put their efforts consistently in fulfilling deliverables under various projects / schemes.

I look forward to all your guidance and suggestions in steering the institute into greater heights of performance in the coming years.

> Sd/-(Dr. KSMS Raghavarao) Director, CSIR-CFTRI

Date : Sep 30, 2019



<u>i</u>

and

# Achievements at a Glance

Publicati	Research Papers	111
I ublication	CIIS Reviews	9
	Book Chapters	18





Industrial Development

Patents Filed	2
Technologies Transferred	85
Short Term Courses Conducted	25
New Technologies Released	6



	M.Sc. Passed Out
Human Resource	ISMT Passed Out
Development	Ph.D. Awarded
	Skill Development Training

# Achievements in Brief

#### 1. Research Publications

#### **SCI** Publications

- Abhignan Gurukar, Nandini C.D., *Morus alba* leaf bioactives modulate peroxisome proliferator activated receptor γ in the kidney of diabetic rat and impart beneficial effect, *J. Agricul. Food Chem.*, 2018, 66(30), 7923-7934
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- Arti Pandey, Negi P.S., Phytochemical composition, *in-vitro* antioxidant activity and antibacterial mechanisms of *Neolamarckia cadamba* fruits extracts, *Natural Product Res.*, 2018, **32(10)**, 1189-1192
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#### 2. Patents Filed / Granted in India

#### Filed

- A method of separation of whole wheat germ in a roller flour milling system
- A process of preparation of *Bacillus* antimicrobial peptide (bamp) useful for food industry

#### Granted

- A bioactive fraction from *Zingiber officinale* and a process for the preparation thereof
- A sugar cane juice concentrate and a process for preparation thereof
- A process for preparation of homogeneous blended oil



Lipase catalysed interesterification of blended oil containing red palm oil and soybean oil (20:80).

- 1 Control blended oil having solid and liquid phases
- 2 Interesterified blended oil having single homogeneous liquid phase

#### 3. Processes / Technologies transferred for commercial exploitation

The following eighty five processes were released to 133 parties.

- A-Hango<sup>™</sup>
- Baking powder
- Bioactive molecule rich green coffee extraction
- Bottling of sugarcane juice
- Bread: Production (Brown, plain, sweet, milk, whole wheat, fruit, high fiber, ragi, bajra)
- Carbonated fruit beverages from selected fruits
- Chicken pickle
- Chicken wafers
- Coffee concentrate
- Composite ragi rusk
- Compounded asafoetida
- Decortication of ragi
- Dipping oil formulation for grapes
- Egg less cake premix
- Egg loaf
- Egg wafers



- Fermented & dehydrated ready mixes for idli / dosa batter
- Fermented & dehydrated ready mixes for idli batter
- Flaked jowar Ready to eat sweet & savoury snacks
- Flaking of foxtail millet
- Flaking of ragi
- Food for diabetics
- Fortified sugarcane beverage in glass bottles
- Fruit jam slices
- Fruit jams & jellies
- Fruit syrups & squashes
- Ginger paste
- Groundnut (Peanut) butter
- Heat resistant white sesame seeds
- Instant kesari halwa mix from millets and multimillets semolina
- Instant moringa leaves soup mix
- Instant products from moringa leaves
- Instant rava idli mix from millets and multimillets semolina
- Instant traditional foods: Imli poha
- Instant traditional foods: Puliogre
- Instant traditional foods: Puliogre, pongal, sambar, bisi bele bhath, rasam, urd bhath, imli poha
- Instant upma and rava idli mix from high fiber semolina (sooji/rava)
- Instant upma mix from millets and multimillets semolina
- Instant upma, kesari halva & rava idli mix from high protein semolina (sooji/rava)
- Instant upma, kesari halva & rava idli mix from multigrain semolina (sooji/rava)

- Kokum jelly candy
- Layered parotta (South Indian)
- Low fat extruded green snack using moringa leaves
- Low GI beverage for diabetics
- Malted ragi flour enzyme rich
- Microbial inoculums for the management of coffee pulp effluent
- Millet based cookie
- Modified atmosphere packaging of minimally processed vegetables (carrot, cauliflower, tomato, onion and coriander leaves)
- Moringa seed protein isolate as flocculant
- Nutra chikki with added spirulina
- Online fortification of atta (whole wheat flour) / refined wheat flour (maida)
- Osmo air-dried fruits (Pineapple)
- Paushik atta
- Pickles and chutneys
- Preparation of deep fat fried egg cubes
- Preparation of dehydrated egg cubes
- Preparation of low GI soup mix for diabetics
- Preparation of ready to cook multi grain whole mix for drink/porridge
- Preparation of shelf stable egg albumin & egg yolk cubes
- Preparation of shelf stable roti from nonwheat cereal and millet (ragi, rice, maize, jowar, bajra)
- Preparation of wine from *Garcina Xanthochymus*
- Process for production of semolina (sooji/rava) from millets and preparation of multimillets semolina

- Production of high protein semolina (sooji/rava)
- Production of turmeric powder from fresh turmeric rhizome
- Ready mix: Jamun
- Ready to eat idli batter in retail pack
- Ready to eat shelf stable egg crunchy bite
- Roasted & flavoured cashew kernel
- RTS juice & beverages
- Semolina with multigrains
- Shelf stable biriyani paste
- Shelf stable chapati
- Shelf stable chicken tit-bits
- Shelf stable varieties of curry pastes for vegetarian & non-vegetarian traditional cuisines (chicken curry, mutton curry and fish fry masala)
- Shelf-stable chicken biriyani
- Shelf-stable jowar flour
- Spirulina-choco bar and spirulina-cereal bar
- Sugar free biscuit
- Sugar free bread
- Tamarind juice concentrate
- Tamarind powder
- Tomato products preparation (juice,



Rich green coffee extract

ketchup, sauce and ketchup concentrate from tomato paste)

- Tutti-fruity (papaya/carrot)
- Virgin coconut oil
- Wafers (chicken / fish / prawn / pork / egg / meat)

#### 4. Designs / drawings

Two designs / drawings were released for commercial exploitation as detailed below:

- Continuous ragi mudde making machine
- Spouted bed coffee roaster

# 5. New processes ready for commercial exploitation

Six new processes were developed for commercial exploitation as detailed below :

- Shelf stable muffins with natural preservatives
- Process for extension of shelf life of bread with natural preservatives
- Bioactive molecule rich green coffee extract
- Improved process for banana fruit bar
- Instant rava idli mix
- Carbonated fruit beverages from selected fruits (mango, grapes, lime, orange)



Bread with natural preservatives

#### 6. Consultancy/Sponsored/Grant-in-Aid Projects

SI. No.	Type of project	No. of Projects as on 31.3.2019	No. of Projects completed during 2018-19	No. of New Projects initiated during 2018-19
1.	Sponsored	41	12	19
2.	Consultancy	9	3	4
3.	Grant-in-Aid	57	14	21

#### 7. M.Sc. / ISMT / Short-term courses

SI. No.	Academic Programmes	Degree / Certificate Awarded
1.	M.Sc. (Food Technology)	30
2.	Certificate Course in Milling	30
3.	Short-term Courses (25 Nos.)	381

# 8. Symposia, conferences and events organised / sponsored by CFTRI

#### • National Technology Day (May 11, 2018)

As part of the National Technology Day celebration, Dr. P.G. Rao, Former Director, NEIST, Jorhat and Member RC, CSIR-CFTRI delivered the Technology Day address on **"Fun and joy of Science & Technology – Sharing Experiences"**. Highlights of the new technologies developed and released to industries by CSIR-CFTRI during 2017-18 was presented in the function.  Indo-Finnish Joint Workshop -Innovative food concepts and technologies for global nutrition and business (Nutri-Concept) (May 15-16, 2018)

CSIR-CFTRI has been associated with the University of Turku, Turku and Natural Resources Institute, Finland under an ongoing project BEAM (business with impact). The project is titled 'Innovative food concepts and technologies for global nutrition and business (Nutri-Concept). With this background, Indo-Finnish workshop was organized by CSIR-CFTRI, Mysuru, in association with the University of

#### • Awards Day (July 6, 2018)

Prof. T.N. Nagabhusan, Principal, Sri Jayachamarajendra College of Engineering, Mysore graced the occasion as the Chief Guest. Meritorious awards, Medals, Scholarships and Certificates to the outgoing students of M.Sc. (Food Technology) and Flour Milling Certificate Courses were distributed. Dr. R. Subramanian, Chief Scientist & Adviser (M&A) presided over the function.



# • CSIR-CFTRI Student's Symposium (CCSS-2018) (July 13, 2018)

One day CSIR-CFTRI Students' Symposium (CCSS) on the topic "Advances in Biological Research" was organized by the research



scholars and students of the institute in association with AFST(I), Mysuru. The

symposium included student participants for presenting their research work through oral and poster presentations, where the best presenters were awarded. There were more than 230 participants from various Institutes and University of Mysuru.

# • Hindi Fortnight Celebration (September 7-20, 2018)

Hindi Fortnight was celebrated at CSIR-CFTRI from September 7-20, 2018. A variety of competitions in Hindi were conducted for the employees and research students of the Institute during the fortnight. Prizes to the winners of competitions were distributed by Dr. V. Sowbhagyalakshmi, Associate Professor, Maharani Arts College, Mysore. Dr. KSMS Raghavarao, Director, CFTRI & Chairman OLIC presided over the valedictory function.



#### • World Food Day 2018 (October 16, 2018)

Association of Food Scientists & Technologists (I) Hyderabad chapter organised World Food Day-2018 on 16<sup>th</sup> October, 2018 in association with CSIR-CFTRI Resource Centre, Hyderabad. Dr. M.V.R. Prasad, Former Director, DOR, Hyderabad spoke on the World Food Day Theme: '*Our Actions are Our Future: A#Zero Hunger World by 2030 is Possible'*.

#### • CSIR and CSIR-CFTRI Foundation Days (October 29, 2018)

CSIR Foundation Day and CFTRI Foundation Day was celebrated on October 29, 2018. Dr. Anil D Semwal, Director, DRDO-DFRL delivered the Foundation Day Address. Dr. KSMS Raghavarao, Director presided over the function. The Institute also kept open the facilities for general public and students in which over 15000 footprints were recorded.



As a part of the celebrations, the employees who retired in the previous year and those who had completed 25 years of service were felicitated. Prizes were distributed to children of the staff for their outstanding performances in academics/sports and winners of the various competitions held as a part of celebrations. The dignitaries also gave away the Annual Institute Awards on the occasion.

#### Kannada Rajyosthava Day (November 1, 2018)

Kannada Rajyosthava Day was celebrated at the Institute on November 1, 2018 in association with Kannada Sahrudaya Balaga. Honb'le Member of Parliament, Shri Prathap Simha was the Chief Guest of the function. Dr. Raghavarao KSMS, Director, CSIR-CFTRI presided over the function.

#### • IFCoN 2018 (December 12-15, 2018)

The event was jointly organized by the Association of Food Scientists & Technologists (India) AFSTI, CSIR-CFTRI, DRDO, India and Ministry of Food Processing, Govt. of India during December 12-15, 2018 at Mysore. The conference deliberated on the theme "Holistic Approaches for Startup, Food Innovation and Human Resource Training for Agriculture and Food Industry Gemmation" (HASHTAG) in which more than 2000 delegates belonging to research and academic institutes, industry, government and autonomous bodies, and students from food science and technology institutes participated.



#### National Conference on Virgin Coconut Oil (December 26, 2018)

Coconut Development Board in association with CSIR-CFTRI, Mysuru conducted One Day National Conference on Virgin Coconut Oil (VCO) on 26<sup>th</sup> December 2018. The conference was inaugurated by Sri. Raju Narayana Swamy, IAS, Chairman, Coconut Development Board, Govt. of India. Dr. KSMS Raghavarao, Director, CSIR-CFTRI presided over the function. Technical sessions involving presentation by experts on various aspects of VCO manufacturing and value addition were held followed by panel discussion. Eminent scientists and technologists from research institutions, manufacturers of Virgin Coconut Oil, beneficiaries of VCO technologies from CSIR-CFTRI, coconut products manufacturers, FPOs, machinery manufacturers, exporters and prospective entrepreneurs and officials took part in the conference.



#### • NER Twinning Programme and Foldscope Seminar (February 19, 2019)

A foldscope seminar was organized at CSIR-CFTRI, Mysore. Five foldscope coordinators participated as resource persons from Tripura, Mizoram, Manipur, Assam and Andhra Pradesh states and delivered lectures. Young research fellows and graduate scholars from different parts of the country participated in the programme.

#### National Science Day (February 28, 2019)

National Science day celebration was held in the institute on February 28, 2019. Prof. S. Murali, Dept of Computer Science and Engineering graced the occasion as the Chief Guest and delivered the popular lecture. Dr. KSMS Raghavarao, Director, CSIR-CFTRI presided over the function.



 National Workshop on Next Generation Probiotics (March 1, 2019)

One Day National Workshop on Next Generation Probiotics was attended by 80 participants consisting of food industry officers, lecturers, research scholars, project assistants and students from different organizations from across India. The event was inaugurated by Dr. KSMS Raghavarao, Director, CSIR-CFTRI and Dr. Yogesh Shouche, Director of NCCS, Pune was the Chief Guest. Dr. Prakash Halami, Organizing Secretary of the workshop briefly described about the event. Workshop

comprised of two sessions of lectures from the resource persons, practical demonstration on assaying for F6PPK enzyme activity specific for bifidobacteria, poster presentation and evaluation.

### 9. MoU(s) Signed

- JSS Science and Technology University, Mysuru
- Wasuki Farmers Society, Wayanad
- Vectrogen Biologicals Pvt. Ltd., Hyderabad



Signing of MoU between CSIR-CFTRI & JSS Science and Technology University, Mysuru



A view of carbonated fruit juice plant

# 10. Awards and Recognitions

## Ph.D. Degree awarded

## a) University of Mysore

Name of the Student	Title of the Thesis		Guide
Pradeep SR	Beneficial modulation of diabetic nephropathy, cataract and cardio vascular complications by dietary spices	Dr.	Srinivasan K
<ul> <li>Shwetha N</li> </ul>	Studies on biotransformation and sensing of caffeine	Dr.	Praveena B Mudliar
<ul> <li>Inamdar Aashitosh A</li> </ul>	Studies on the influence of processing variations and pre-treatment to Indian wheat on the quality of atta (whole wheat flour)	Dr.	Prabhasankar P
<ul> <li>Shruthi R Raju</li> </ul>	Characterization of protein-polysaccharide complexes from ajowan ( <i>Trachyspermum</i> <i>ammi</i> L.) with reference to their biological activities	Dr.	Muralikrishna G
Archer Ann Catherine	Immunomodulatory effects of probiotic <i>Lactobacillus</i> spp. from dairy and human origin	Dr.	Prakash M Halami
• Kiran G	Structure-function relationship of glycosaminoglycans in liver during diet- induced hypercholesterolemia and modulation by oat bran and curcumin	Dr.	Prasada Rao UJS
<ul> <li>Akshatha HS</li> </ul>	Resveratrol from underutilized fruits and effect of fermentation for functional properties	Dr.	Vijayalakshmi G
Harsha MR	Antiulcer potentials of turmeric ( <i>Curcuma longa</i> ) polysaccharides: elucidation of mechanism of action	Dr.	Shylaja M Dharmesh
Sandeep MS	Effect of diabetes on brain glycosaminoglycans and their modulation by quercetin and naringenin	Dr.	Nandini CD
<ul> <li>Amritha Girish K</li> </ul>	Studies on characterization of phytate dephosphorylating enzymes of lactic acid bacteria for food applications	Dr.	Venkateswaran G

Name of the Student	Title of the Thesis	Guide
Reshmi SK	Food formulations for diabetic population based on the bioactives of <i>Citrus maxima</i> (Burm.) Merr. (Pomelo) fruit	Dr. Shashirekha MN
<ul> <li>Vasantha KY</li> </ul>	Further insights into nigerloxin an aldose reductase inhibitor from <i>Aspergillus niger</i>	Dr. Avinash P Sattur
<ul> <li>Leema Roseline T</li> </ul>	Marine bacterial agarase for the production of bioactive agarooligosaccharides	Dr. Sachindra NM
<ul> <li>Shirish D Mane</li> </ul>	Anti-cancer properties of Vitamin C ester - ascorbyl stearate	Dr. Akhilender Naidu K
<ul> <li>Venugopal KS</li> </ul>	Biotechnological approaches to increase the bioefficacy of proanthocyanidins through fermentation	Dr. Anu Appaiah KA

# b) AcSIR

Name of the Studen	t Title of the Thesis	Guide
<ul> <li>Ram Saran Chaurasiya</li> </ul>	Separation and purification of bromelain from pineapple wastes using nano- particulate reverse micelles	Dr. Umesh Hebbar H
Greeshma M	Nutraceutical modulation of manganese - induced neurodegeneration in animal models	Dr. Rajini PS
<ul> <li>Kiran Kamireddy</li> </ul>	Studies on biosynthetic pathway of a flavour metabolite 2-Hydroxy-4-Methoxy benzaldehyde production in tubers of <i>Decalepis hamiltonii</i>	Dr. Giridhar P
<ul> <li>Shaym Ramkrishna Garud</li> </ul>	Ozonisation in the selected multiphase contactor for the preservation of sugarcane juice	Dr. Navin Kumar Rastogi
Madhuri Arya	Role of alpha beta hydrolase domain containing protein in lipid metabolism and its regulation	Prof. Ram Rajasekharan
<ul> <li>Praveen K Rajvanshi</li> </ul>	Role of stress regulatory transcription factors, Msn2/Msn4 in fatty acid oxidation in budding yeast	Prof. Ram Rajasekharan

Name of the Studen	t Title of the Thesis	Guide
<ul> <li>Angelina</li> </ul>	High cell density fermentation process for polyhydroxyalkanoates production by halophilic bacteria	Dr. Vijayendra SVN
• Vipin AV	Ginger ( <i>Zingiber officinale</i> ):Protective agent against aflatoxin b1 induced hepatotoxicity	Dr. Venkateswaran G
<ul> <li>Jincy M George</li> </ul>	Effect of high pressure processing on infusion and extraction of bioactive compounds from solid food matrix	Dr. Navin K Rastogi
<ul> <li>Priyanka S Sonbarse</li> </ul>	Studies on endophyte mediated signaling to understand regulations of micronutrient in <i>Moringa oleifera</i>	Dr. Giridhar P
<ul> <li>Snehal Dasharath Doke</li> </ul>	Effect of processing on nutritional, nutraceuticals and functional properties of garden cress ( <i>Lepidium sativum L.</i> ) seed and its application in specialty food formulations	Dr. Manisha Guha
<ul> <li>Akshath US</li> </ul>	Synthesis of fluorescent nanoparticles and their application in biosensing and bioimaging	Dr. Praveena Mudliar
Richa Sharma	Sensing of chloramphenicol in food using nanomaterials and optical reporter molecules	Dr. Raghavarao KSMS
<ul> <li>Raksha Rao</li> </ul>	Studies on non-aflatoxigenic <i>Aspergillus</i> <i>flavus</i> mediated pre-harvest management of aflatoxin contamination in groundnut ( <i>Arachis hypogaea</i> )	Dr. Venkateswaran G
Venkateswari V	Lipidome and transcriptome profiling of omega-3 fatty acid rich plant leaves	Dr. Malathi Srinivasan
<ul> <li>Gaurav Kumar Pal</li> </ul>	Fish collagen and microbial collagenase: production, characterization and their potential food applications	Dr. Suresh PV
<ul> <li>Vijayakrishna Raj</li> </ul>	Dietary modulation of inflammatory markers in gluten sensitized animal models	Dr. Prabhasankar P
<ul> <li>Siddharth Priyadarshi</li> </ul>	Characterization, processing and value addition to coriander ( <i>Coriandrum sativum L.</i> ) foliage	Dr. Madhava Naidu M

Name of the Studen	t Title of the Thesis	Guide
<ul> <li>Jayaprakash</li> </ul>	Studies on regulation of cell morphology and lipid metabolism in <i>Saccharomyces cerevisiae</i>	Dr. Malathi Srinivasan
<ul> <li>Anikisetty Maheswaraiah</li> </ul>	Physiological significance of diacylglycerol oil and its metabolism	Dr. Vijayaraj P
<ul> <li>Sathya TA</li> </ul>	Construction of soil metagenomic library and screening of pectinase for the synthesis of pectic oligosaccharides	Dr. Mahejibin Khan
• Sunil L	<i>In silico</i> designing, expression, characterization of protein enriched with branched-chain amino acids and <i>in-vitro</i> digestibility studies for its probable utilization the dietary treatment of chronic liver disease	Dr. Prasanna Vasu in
<ul> <li>Rashmi S Shenoy</li> </ul>	Evaluation of antidiabetic potential of <i>Gymnema sylvestre</i>	Dr. Manonmani HK

# c) Other Universities

Name of the Studer	t Title of the Thesis	Name of the University
<ul> <li>Nagaraju VD</li> </ul>	Heat and mass transfer studies in a spouted bed roaster	Visvesvaraya Technological University, Belgaum
<ul> <li>Padmavathi T</li> </ul>	Design & development of food technology knowledgebase information system using semantic web technologies: a modular approach	Bharathiar University, Coimbatore



Vacuum frying machine

- d) CSIR-CFTRI Annual Awards
- Best Contribution Award General Administration
  Binod Dubey
- Best Contribution Award Finance and Accounts
   Pradeep R
- Best Contribution Award Stores & Purchase
  Thomas T Kuriakose
- Best Research Publication Award for Basic Sciences Santhosh Kumar S.C., Negi P.S., Manjunatha J.R., Bettadaiah B.K., Synthesis, antibacterial and antimutagenic activity of zerumbone-bicaronyl analogue, Food Chemistry, 2017, **221**, 576-581
- **Best Publication Award for Applied Research** Akshath U.S., Praveena Bhatt, Supramolecular nanosniffer for ultra sensitive detection of formaldehyde, Biosensors and bioelectronics, 2018, **100**, 201-207
- Best Student Award M.Sc. (Food Technology) Kumari Neha Rawat
- Best Student Award ISMT Hifzur Rahman
- Best Research Fellow Award
  - Aparmita Devi, Department of Microbiology & Fermentation Technology
  - Hrishikesh A Tavanandi, Department of Food Engineering
- Best Technology Transfer Award Dr. V.D. Nagaraju & Team, Design & Fabrication Unit, Design and development of machine for continuous cooking and discharging of ragi mudde/ball making
- Best R&D Department Award
   Flour Milling, Baking and Confectionary Technology Department
- Best Technical Support Staff (Gr. D(NT)) Puttaraju B.V., Department of Technology Scale-up
- Best Technical Support Staff (Gr. I)
   Irudayaraj A., Department of Engineering & Mechanical Maintenance
- Best Technical Support Staff (Gr. II) Dr. Narasing Rao G., Resource Centre – Hyderabad

- **Best Individual Award for Technical Contributions (Gr. III)** Arulalan K., Department of Construction & Civil Maintenance
- Best Individual Award for Scientific Contributions (Gr. III)
   Vanajakshi V., Food Safety & Analytical Quality Control Laboratory
- Best Individual Award for Scientific Contributions (Gr. IV)
   Dr. Nandini C.D., Department of Molecular Nutrition
  - Dr. Aashitosh A. Inamdar, Department of Flour Milling, Baking and Confectionary Technology
- **Best Individual Award for Technical Contributions (Gr. IV)** Keshava Prakash M.N., Central Instruments Facility & Services
- Best Post Doc Fellow Award Dr. Ravindra P.V., Department of Biochemistry
- Individual Award for Maximum ECF generation Dr. Madhava Naidu M., Department of Spices & Flavour Sciences
- Award for outstanding Institutional contribution Dr. Subramanian R, Department of Food Engineering
- Special Award for Speedy Disbursement of 7<sup>th</sup> Pay Commission Arrears to CSIR-CFTR Pensioners

Anupama R., Binod Dubey, Shasikumar P and Roy S.K.

#### e) Individual Awards

	Award Title	Instituted by	Awardee
•	Dr. J. S. Pruthi Award	Association of Food Scientist s and Technologists, India	Dr. Negi PS
•	ABAP – Senior Scientist Award 2018	Association of Biotechnology and Pharmacy India (Amaravati, AP)	Dr. Giridhar P

# f) Recognitions by Academies

Recognition	Instituted by	Awardee
• Fellow	ISPC, Central Plantation Crops Research Institute, ICAR, Kasaragod, Kerala	Dr. Madhava Naidu M
<ul> <li>Subhash Bhatnagar Award</li> </ul>	AFSTI (I), Mysuru	Mrs. Sulochanamma G
<ul> <li>Prof. Wankhede DB Excellence Award 2018</li> </ul>	AFSTI (I), Mysuru	Dr. Walde SG
• Fellow	Institution of Engineers, Kolkata, India	Dr. Rastogi NK
JICA-KIRIN Fellow	Japan International Cooperation Agency, Japan	Dr. Sarma MVRK
<ul> <li>Raman Research Fellowship</li> </ul>	CSIR, New Delhi	Dr. Mukesh Kapoor

## g) Other Recognitions

Awardee		Member / Panel Expert & Host Institution	
•	Dr. Baskaran V	Chairman, IAEC; President, AFST(I)	
•	Dr. Muthukumar SP	<ul> <li>Apiary Industry Technical Committee (FAD3), Bureau of Indian Standards, New Delhi; Board of Studies in Biomedical Sciences, JSS Academy for Higher Education &amp; Research (JSS AHER), Mysuru</li> </ul>	
•	Dr. Umesh Hebbar H	<ul> <li>Chairman, Project Review Committee, TDUPW programme of A2K+ scheme of DSIR</li> </ul>	
		<ul> <li>Member, National Committee of MoFPI under Pradhan Mantri Kisan Sampada Yojana (PMKSY)</li> </ul>	
		Member, Advisory Committee, Institute of Chemical Technology, Mumbai (ICTM)	
•	Dr. Ajay W Tumaney	• FAD 13 BIS; FAD 15 BIS; Expert Panel on Oils and Fats, FSSAI	

	Awardee	Member / Panel Expert & Host Institution
•	Dr. Walde SG	Member, Directorate of Industries, Maharashtra Govt, Mumbai for evaluation of food industrial projects, Member, Export Inspection Agency, Mumbai for evaluating Food Industries for issue of Certificate of Export capabilities
•	Dr. Sarada R	Project Review Board Member, National Institute of Ocean Technology, Chennai
•	Dr. Sridevi A Singh	Task Force on Public Health and Nutrition, DBT; Governing Council, NABI, Mohali
•	Dr. Prakash M Halami	Member, Board of Examiner in Food Technology (PG) Davangere University, Davangere, Karnataka ; External expert in the Doctoral advisory Committee, JSS Academy, Mysuru, External expert for AMR laboratory assessment, IVRI, Kolkata
•	Dr. Vijayendra SVN	Board of Studies in Microbiology, Sri Padmavathi Women's University, Tirupathi, Andhra Pradesh; Board of Studies in Microbiology, Yuvaraja College, Mysuru
•	Dr. Iboyaima Singh Ng.	BOE & BOS in Food Science & Technology, Karnataka State Rural Development & Panchayat Raj University, Gadag
•	Dr. Anu Appaiah KA	Chairman, Sub - Committee on Alcoholic Beverages, BIS; Drinks and Drinking Water Selection Committee, BIS; Expert Group on Alcoholic Beverages FSSAI; Scientific Panel on water (including flavoured water) & Beverages (alcoholic, non- alcoholic), FSSAI, Govt. of India; Panel member of experts by FSSAI to advice States and UT to set up food testing Labs; Member of BoE and BoS of Microbiology and Biotechnology of many Universities
•	Dr. Alok K Srivastava	Chairman, BIS Sectional Committee FAD 28 on Method of Analysis; Rapporteur for FSSAI of Scientific Panel on Method of Sampling and Analysis
•	Dr. Asha Martin	Expert member, Project review and steering group, Ministry of Electronics and Information Technology; Principal Member of the Technical committee on Food Biotechnology (FAD-23) of

Food and Agriculture Division, BIS

	Awardee	Member / Panel Expert & Host Institution
•	Dr. Prasanna Vasu	<ul> <li>Rapporteur, FSSAI's Scientific Panel for Sweets, Confectionery, Sweeteners Sugar and Honey, FSSAI; Member, Technical committee on Stimulant Foods (FAD-6) of the Food and Agriculture Division, BIS; Member, FAD 28 'Test Methods for Food Products Sectional Committee,' Food and Agriculture Division, BIS</li> </ul>
•	Dr. Negi PS	<ul> <li>Member, APEDA; Expert member of Technical Advisory Committee (TAC), Technology Development and Utilization Programme for Women (TDUPW), DSIR; Member of Scientific Panel for Fruits and Vegetables and their Products (including dried fruits and nuts, salt, spices and condiments), FSSAI; Member of BoS Department of Agribusiness Management and Food Technology, North-Eastern Hill University, Meghalaya</li> </ul>

#### h) Best Research Papers / Posters Awards

# International Food convention (IFCON 2018) on December 12-15, 2018 at CSIR-CFTRI Mysore

- Theertha D.P., Manivannan S., Ezhil Vendan S., Can quinone secretion in flour beetle exhibit commodity specific variation?
- Ramesh G, Jagannatha, Srirama R., Manonmani H.K., Design and Development of table top fruits and vegetable washer domestic gadget
- Ravindra P.V., Janhavi P., Divyashree S., Muthukumar S.P., Antifatigue and energyrich gel blocks improve endurance performance in mouse models
- Anitha R.E., Naveen J., Madan Kumar P., Baskaran V., Lactucaxanthin, a lettuce carotenoid as food based inhibitor for oxidative stress induced angiogenesis in ARPE19 cells

- Veeresh T., Madan Kumar P., Baskaran V., Chitosan-oleic acid-sodium alginate nanocarrier for enhanced stability and bioavailability of angioprotective carotenoid lutein
- Sidiqat Adamson Shodehinde, Indrani D., Prabhasankar P., African yam bean – It's rheology, nutrition and quality characteristics
- Anil Kumar K., Manan Borana, Shivakumar L., Nagarajan S., Evaluation of cumin (*Cuminum cyminum* L.) seeds by physicochemical and infrared spectroscopic analysis
- Varun Kumar, Purnima Kaul Tiku, Peptides from pigeon pea by-products inhibit 3hydroxy-3-methylglutaryl CoA reductase via sterol regulatory element- binding protein-2 dependent mechanism in HepG2 cells
- Cathrine M.S.B., Gowthami J.P., Siewe Fabrice Bruno, Tanaji G. Kudre, Optimization of antioxidant hydrolysate production from

fish/ meat processing wastewater proteins using response surface methodology

- Steiji Raphael, Antimicrobial activity of *Bacillus licheniformis* MCC 2514: mode of action and partial genomic analysis
- Aditi Goel, Prakash M. Halami, Mode of action studies of AMC producing native isolates of LAB by pathway specific cell reporter assay
- Vallamkondu Manasa, Ajay W. Tumaney, Physicochemical characterization and nutraceutical potentials of the fixed oil from Indian spices
- Tavanandi H.A., Raghavarao K.S.M.S., Process integration for extraction and purification C-PC from dry biomass of *Arthrospira platensis*
- Sidiqat Adamson Shodehinde, Indrani D., Prabhasankar P., Use of African yam flour for nutritional enrichment of bread
- Suruchi Nautiyal, Roopa B.S., Iboyaima Singh Ng., Shelf life extension of avocado fruit without compromising on sensory and physico-chemical properties

#### IUFoST 2018 - 19<sup>th</sup> World Congress of Food Science and Technology, held from October 23 - 27, 2018, Navi Mumbai, India

- Arpitha Das, Baskaran V., Integration of traditional Indian food therapy system with modern science: Nutritional and functional property of cereal and herd based antidiabetic food formulation
- Veeresh T., Baskaran V., Chitosan-oleic acidsodium alginate nanocarrier for improved bioavailability of macular carotenoid lutein

- Usha Devi A., Sathish H.S., Roopa B.S., Roopavati M., Pseudocereal - An untapped resources for Indian RTC/RTE processed food industry
- Aishwarya Jaiswal, Jyothi Lakshmi A., Promotive effect of selected spices on the digestibility of nutrients in supplementary food mixes
- Sandopu Sravan Kumar, Nandini P. Shetty, Giridhar P., Unraveling the potential benefits of Malabar spinach fruits: A food technology perspective
- Bhavya M.L., Punil Kumar H.N., Umesh Hebbar H., Photodynamic inactivation of *Escherichia coli* in fruit juices using blue light and exogenous photosensitizer
- Mohd. Shakeb, Mohd. Hasan Khan, Mohd. Kafeel Khan, Sathyendra Rao B.V., Srinivas A., Performance studies on modified pedal operated millet dehuller

#### Indo Finnish Workshop on Nutri-concept : Innovative food concepts and technologies for global nutrition and business, May 15-16, 2018, CSIR-CFTRI, Mysuru

- Vidya C.H., Sridevi A. Singh, Fungal enzymes–potential applications in specialty food ingredients and functional foods
- Nida Ume Salma, Govindaraju K., Jyothi Lakshmi A., Preparation of high fischer ratio protein hydrolysate from flaxseed
- Tavanandi H.A., Prasad V., Chandralekha A., Mittal R., Lamdande A.G., Raghavarao, K.S.M.S., Green method for extraction of chlorophyll from spent biomass of *Arthospira platensis* obtained after recovery of phycobiliproteins
### International Conference on Research Interventions and Advancements in Life Sciences, Pune, August 1-3, 2018

- Nivas M. Desai, Karthik Iyer, Chakravarthy A., Pushpa S. Murthy, Chlorogenic acid (CGA) enriched carbonated and non carbonated beverages from green coffee
- Siridevi G.B., Pushpa S. Murthy, *In-silico* interaction of enzymes in coffee fermentation

### National Symposium on Advances in Biological Research, CSIR-CFTRI, Mysuru July 13, 2018

- Sandopu Sravan Kumar, Monisha Arya, Giridhar P., Characterization of a red-violet natural pigments as a food colourant
- Amal Mani, Jayadeep A., Quality characteristics of beta-carotene fortified rice analogue

### Research Papers / Poster awards in other conferences

- Narsing Rao G., Sridhar R., Srinivasulu K., Prabhakara Rao P.G., Math R.G., Preparation, standardization, physicochemical characterization, antioxidant activity, sorption isotherms of instant tomato spice mix for snacks, 50<sup>th</sup> Annual International Conference of NSI- Hyderabad, November 15-17, 2018
- Debika Ojha, Neelakanteshwar Patil K., Molecular characterisation of *Listeria monocytogenes* RecA protein: Implication in recombination and antimicrobial resistance, International conference on Chromosome Stability, JNCSAR, Bangalore, December, 14-18, 2018
- Kalaivani Paramasivan, Sarma Mutturi, Metabolic engineering of yeast for squalene

synthesis, International #Biotweet18 Twitter Conference, Amity University, Mumbai, September 28-29, 2018

- Ezhil Murugan R., Ramesh G., Girish K.G., Nagaraju V.D., Design and development of continues ragi mudde (finger millet ball) making machine and ball making unit, International Conference on Recent Advances in Food Processing Technology (ICRAFPT-2018), IIFPT, Thanjavur, Tamil Nadu, August 17-19, 2018
- Ashwini M., Prakash M. Halami, Vanitha Reddy P., Sumana K., Studies on transmissible antibiotic resistance in probiotic bacteria, National workshop on Next Generation Probiotics, CSIR-CFTRI, March 01, 2019
- Uma Manjappara, Obestatin: A versatile emerging peptide, 11<sup>th</sup> National Women's Science Congress, JSS Women's College, Mysore, November 9-11, 2018
- Theertha D.P., Manivannan S., Krishnaiah H.E., Ezhil Vendan S., Investigating the microstructures in surfaces of integuments in stored product insect pests using foldscope, National Conference on Advances in Microscopy and Foldscope, Motilal Nehru National Institute of Technology (MNNIT), Allahabad, Uttar Pradesh, March 15-16, 2019 (Young Scientist Award)

### i) Editors / Editor-in-Chief / Co-Editor / Executive Editor / Associate Editors of reputed journals

- Indian Food Industry, Published by AFST(I), Mysore (Negi P.S.)
- BMC Complementary and Alternative Medicine, BMC-Series Journals, Published by BioMed Central, Part of Springer Nature, New York, US (Negi P.S.)

- International Journal of Genuine Traditional Medicine Published by Association of Humanitas Medicine, Republic of Korea (Negi P.S.)
- Indian Food Industry, Published by AFST(I), Mysore (Anu Appaiah K.A.)
- Indian Food Industry, Published by AFST(I), Mysore (Vijayendra S.V.N.)
- Indian Food Industry, Published by AFST(I), Mysore (Suresh D Sakhare)
- Journal of Food Measurement and Characterization, Published by Springer (Prabhasankar P)
- Journal of Laboratory Animal Science, Published by Laboratory Animal Scientists Association, India (Muthukumar S.P.)
- Non-coding RNA research, Published by KeAi (Syed Musthapa M)
- Journal of Food Process Engineering, John Wiley, USA. (Navin K. Rastogi)
- International Journal of Membrane Sci. Technol., Cosmos, (Navin K. Rastogi)
- Journal of Food Biology, Published by Scholar journals, Elsevier (Raghavarao K.S.M.S.)
- Research & Reviews in Biosciences, Trade Science Inc. (Muniasamy N)

### j) Editorial and Advisory Boards

- Blue Biotechnology, Nova Publishers, USA (Prabhasankar P)
- Research and Reviews: Journal of Food Science and Technology (Prabhasankar P)
- International Journal of Immunology (Prabhasankar P)

- Signpost Open Access Journal of Organic and Biomolecular Chemistry, Research Signpost, India (Negi PS)
- Frontiers in Microbiology, U.K. (Rajagopal K)
- EC Nutrition, Ecronicon (Sudheer Kumar Y)
- International Journal of Food Science and Nutrition (Sudheer Kumar Y)
- International Journal of Food Science and Nutrition Engineering, Scientific & Academic Publishing Co. Rosemead, CA, 91731, USA (Matche RS)
- International Journal of Agriculture Food Science & Technology (IJAFST), Research India Publications, Delhi (Matche RS)
- International Journal of Knowledge Management and Information Technology (IJKMIT), Research India Publications, Delhi (Matche RS)
- Indian Journal of Nutrition, Open Science Publications, Hyderabad (Matche RS)
- Journal of Engineering, Hindawi (Navin K Rastogi)
- The Scientific World Journal, Hindawi (Navin K Rastogi)
- Research & Reviews: J. Food Sci & Technol, STM (Navin K Rastogi)
- Journal of Membrane Science & Technology, Omics (Navin K Rastogi)
- Journal of Food Research and Technology, Jakraya (Navin K Rastogi)
- Biotechnology Advances, Elsevier (Raghavarao KSMS)
- Current Biochemical Engineering, Bentham Science (Raghavarao KSMS)

### **11. Participation in Exhibitions**

- Technology Sourcing Fest for MSMEs : Organized by CSIR-NIIST, Thiruvanantha puram, June 12, 2018
- CSIR Industry Meet: Organized by CSIR at Guwahati, June 28-29, 2018
- State Level Science Conference/ Exhibition: Organized by Kuvempu Rangamandira, Shivamoga, June 29-30, 2018
- Workshop on Commercialization of CSIR Technologies: Organized by JSS RUSET Institute, Mariyala, Chamarajanagar, July 4, 2018
- Siridhanya Mela: Organized by Dept. of Agriculture, Bagalkot, July 29-30, 2018
- India International Science Festival (IISF-2018 and EXPO): Organized by Vigyan Bharty, New Delhi and Ministry of Science and Technology, New Delhi and UPCST, Govt. of UP Lucknow at Indira Gandhi Prathisthan, Lucknow, October 4-8, 2018
- 7<sup>th</sup> Indian Chitin and Chitosan Society Symposium: Organized by Indian Chitin and Chitosan Society, Erode, Tamil Nadu and CSIR-NCL at Pune, October 11-13, 2018
- 19<sup>th</sup> World Congress of Food Science and Technology EXPO: Organized by IUFoST at Mumbai, October 23-27, 2018
- 7<sup>th</sup> International Food Fest 2018: Organized by Key2 Green, New Delhi at Ram Bharose College Ground Lucknow, November 16-18, 2018
- JSS Nutri Expo: Organized by JSS college, Mysuru, November 24, 2018

- Empowering Field Army through Food Technology: Organized by ASC Centre and College, Bengaluru, September 11-12, 2018
- National Level Workshop on Nutri -Cereals: Organized by Govt of Maharashtra and IIMR, Pune, September 28, 2018
- IFCoN 2018: Organized by CSIR-CFTRI, AFST(I), Mysore & DFRL, Mysuru, December 12-15, 2018
- Platinum Jubilee Celebrations: Organized by DVS College, Shimoga, December 15-16, 2018
- CSIR Pavilion Exhibition during 106 Indian Science Congress: Organized by Indian Science Congress at Lovely Professional University, Jalandhar, January 3-7, 2019
- Genomics 2019: Organized by Genotypic Technologies, Bangalore, January 23-25, 2019
- Udyam Samaagam cum Industrial Exhibition: Organized by MSME, Govt of India Kanpur at Thakur Yugraj Singh PG College, Fatehpur, February 21, 2019
- Global R&D Summit: Organized by FICCI, New Delhi at Hotel Marriott, Hyderabad, February 21-22, 2019
- India Food Expo, 2019: Organized by Horticultural & Food Processing, Govt. of UP and Indian Industry Association, Lucknow at Indian Industry Association, Bhawan, Lucknow, February 22-24, 2019
- North East Innovators Meet & Technology Innovation Entrepreneurship (TIE) Expo : Organized by Govt. of Meghalaya at NEHU, Shillong, February 28 – March 1, 2019
- Kisan Mela: Organized by CSIR-CIMAP, Lucknow, March 31, 2019

### 12. EDPs Conducted by Resource Centres

No. of EDPs conducted	:	12
No. of beneficiaries	:	595

## 13. Visit of International Delegation & Training

- A team of International delegates from University of Turku and Natural Resources Institute, Helsinki, Finland participated in the Indo-Finland Collaborative symposium (May15-16, 2018)
- A team of 20 Sri Lankan officials visited the Institute (May 16, 2019)
- A team of 21 International delegates from Afro-Asian countries visited the Institute for one day training programme (May 25, 2018)
- Mr. Ralph Jerome, Vice President and Mr. John Thamm, R&D Programme Leader MARS Inc, USA visited the institute and had interaction pertaining to pilot plant facilities (June 20, 2018)
- Visitors from the Coconut Development Authority, Sri Lanka attended a short term training programme on Food Analysis (October 10-14, 2018)

- Team of 30 International delegates from developing countries visited the Institute (October 15, 2018)
- A team of 17 International visitors (Graduates and Staff) from the College of Agriculture, Food and Environmental Sciences, University of Wisconsin - River Falls, USA attended 'Study Abroad' programme at Institute (January 10-17, 2019)
- Mr. Kamaljit Singh Grewal, General Manager, Golden Grain Flour Mills Pvt. Ltd, Victoria, Australia along with team visited the Institute and had discussion pertaining to flour milling facilities (February 3, 2019)
- Visitors from International Bruker NMR visited the Institute and had Interaction with Scientists on NMR analysis (March 5, 2019)
- A team from Italy visited the Institute for studying about spirulina production unit (March 22, 2019)
- Mr. Brendan Spellman Eappen, Cofounder, Fortify Health, USA along with his team visited the Institute and had discussion with scientists pertaining to Flour fortification technology (March 26, 2019)



SDP in progress at RC-Lucknow

#### 14. Support Department Activities

Renovation of laboratory, resurfacing of road and redundant power supply to Computer Centre & Central Instruments Facility were completed

Access to around 4183 e-journals through CSIR network was offered to the users of the library. Other services include new arrivals of journals, new books additions, publication alert and analytics through campus blog was introduced. Biometric system for users, News section and Entrepreneurship books corner were created in the library.

A total of 2525 students from various parts of the country were showcased the facilities of the Institute

New CCTV network for surveillance were initiated with 12 cameras covering the whole campus

A portal for sharing the existing high-end Sophisticated Analytical Instruments with students and staff of Universities / National Laboratories in India was launched. The Instruments facility can be booked through the SAIF Portal (https://sifp.cftri.com). Further AnalytiCSIR Portal (https:// www.analyticsir.in) and i-STEM Portal https://www.istem.gov.in were facilitated.





Dr. Raghavarao KSMS, Director, CSIR-CFTRI receiving the National Siridhanya Award during Organic and Millet International Trade Fair 2019 at Bengaluru

# Societal Programmes

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### • Relief food supplies to the flood affected States, Kerala and Karnataka

In the aftermath of nature's fury and floods in Kerala and Karnataka during August 2018, the Institute decided to contribute towards supply of relief food items. The Institute had also done similar exercises recently during Chennai and Uttarkhandfloods. After an internal meeting chaired by Dr. R. Subramanian, Chief Scientist & Advisor, along with Senior Scientists in consultation with the then Director, CSIR-CFTRI, Shri Jitendra J Jadhav, it was decided to prepare selected nutritious food items at Institute's Pilot Plants. Further it was decided to source a few food items prepared using CFTRI technologies by licensees.

From the logistics point of view, contacts were established with the State Nodal Officers in Kerala through a Letter of Intent for preparing relief food supplies to the Chief Secretary of Kerala and necessary follow up was done



with CSIR-NIIST, Thiruvananthapuram. Subsequently, guidance was taken from Dr V Venu, IAS, Secretary, Govt. of Kerala who was one of the primary Nodal Officers overseeing the flood relief operations. Similarly,Dr Pankaj Kumar Pandey, IAS, Commissioner of Food Safety, Govt. of Karnataka also contacted us with a request for relief supplies. The office of the MP for Mysore-Kodagu constituency, Shri Pratap Simha also got in touch with our office.

It was decided to send relief food materials to the worst affected areas of Kerala (Ernakulam / Trivandrum and Waynad) and also Kodagu regions of Karnataka. Accordingly, the food items were identified and logistics were worked out for transporting food packets to the following locations.

- Airlifted to Ernakulam (Kerala) (joint operation with DRDO-DFRL, Mysuru)
- By road to Wayanad, Kodagu and Trichur



The food items comprised of rehydrate and consume Wheat Rawa Upma; Rehydrate and consume Imli Poha; Ready-to-eat chapatis; high protein biscuits; rusks; tomato curry, pickles, jam, chutney and water bottles.

A total of 51500 meals were dispatched during Aug 19-23, 2018 in five consignments. The operations were carried out in association with DRDO-DFRL with support from Appolo Hospital, CSIR-CFTRI, Pensioners Association and Travel Parks Ltd., Mysore.

#### Skill Development Programmes

### Study Abroad programme for Students of University of Wisconsin-River Falls, USA

Under the Study Abroad programme, graduate students from The College of Agriculture, Food and Environmental Sciences, University of Wisconsin-River Falls, USA attended the training during January 10-17, 2019. The team consisted of 15 graduate students and 2 faculty members. Apart from lectures, students had hands on experience on mixed fruit jam, Tomato ketchup preparations, Indian traditional bakery products and Ginger processing. Field visits were also arranged to Central Horticultural Experiment Station and Coffee Research station, Chettalli, Coorg and also Jaggery making plants in Mandya.



### Skill Development Program on Microbial Food Safety and Fermentation

CSIR-CFTRI conducted a 5 week Skill Development Program (SDP) on "Microbial Food safety and Fermentation". A total of 15 candidates (shortlisted based on the criteria outlined by NSDC) across India, participated. The course was divided into two modules namely Microbial Food Safety and Microbial Fermentation.

### Skill Development Program on Baking Technology

A 5-week Skill development programme on 'Baking Technology' was conducted under the aegis of "National School of Baking Technology" with NSQF-4 certification. Totally 14 prospective entrepreneurs from various regions of the country participated.





### CSIR-800 Activities

a) Assessment of Akshaya Patra Foundation existing kitchen infrastructure and logistics for improvisation of food quality and safety

As part of the collaboration with Akshaya Patra Foundation (APF), assessment of centralized kitchen for supporting MDM operations in the



district was undertaken. These included the study of the existing kitchen infrastructure, possible modification for ensuring quality and hygiene of the food supply. A continuous vessel sterilization unit was proposed to overcome the drawbacks of the existing system. Further modification was suggested for the container to minimize heat loss during transportation. Also a Leak proof Hygiene Friendly Storable Container (LHSC) for easy dispensing of liquid foods such as Rasam, Sambar into bowls during serving was conceptualized.

### b) Menu Diversification of mid-day meal programme and minimising the food wastage

Survey was made on menu diversification of Mid-day meal served to the schools at Mysore by Akshaya Patra Foundation. There is a total of 150 schools in which MDM is implemented by Akshaya Patra in Mysore, out of which 15



schools were selected for the study. Data was collected from 2,415 students and 90 staff members in concluding the study.

### c) Shelf-life Extension of fresh Neera to benefit farmers

Neera, commonly called as sweet toddy, is an unfermented sap extracted from the inflorescence of various species of toddy palms. Neera is a natural drink with many beneficial properties. However, collection and processing are the major challenges faced by farmers. The current study was aimed at helping the farmers at field level by developing convenient and effective methods for improving the shelf life of Neera. With this, the study found that pasteurization enhanced the shelf life for up to 4 days and 2 days for coconut and Date neera respectively. Further, overall methodology was disseminated with interested farmers and FPOs.



### d) Creating SoPs for disaster flood relief operations, logistics and collection of ground level data from the flood affected areas

CFTRI as the Food Research Institute has always given helping hand for the needy during natural calamities. The survey was aimed to obtain feedback from people affected by disaster where the Institute's relief material was served. Under this CSIR-800 program, quality, nutrition & logistics followed in supplying the food items to Kodagu and Wayanad Districts were surveyed. Structured questionnaire was prepared to collect the data from affected families. CFTRI had distributed more than 50,000 food packets during flood relief operations in August 2018.



### e) Survey of breakfast food habits in selected schools in Mysore

A Survey was carried out on current breakfast scenario related to breakfast preference, dietary intake of healthy foods, nutritional awareness and health status on school children. Data was collected from over 850 students and survey report was prepared. The age group studied ranged from 6-15 years school going children in semi urban area and 74% were children of labour class.

### f) Nutritional Evaluation of Breakfast/Nutri mixes

Overview of breakfast food from different States in India, commercially available and CFTRI developed breakfast food mixes, technologies and nutritional quality of breakfast food mixes were studied. Survey led to acquire a brief overview of commercially available and CFTRI technologies of breakfast food mixes. Nutritional evaluation has showed that traditional food mixes have less nutritional content to meet the RDA of certain nutrients. It is suggested that to improve the nutritional intake, combination of traditional food mixes need to be used. Region wise convenience breakfast food mixes using the local agri-resources need to come up with fortification to improve the micronutritional quality.

#### g) Foldscope Outreach Programme

The foldscope outreach programme was conducted at Government Higher Primary School, Soorahalli, Nanjangud, Mysore District. During the programme, lectures were arranged and provided hands-on training to the teachers and students. About 50 students participated with their teachers in the programme. As outcome of the programme, the participants were trained to assemble foldscope and to observe the biological samples using foldscope.

#### Incubation Centre Activities

Nutra-Phyto Incubation Centre and Common Instrumentation Facility (NPIC-CIF) was started in the year 2016 with an area of 3000 Sq. ft. and 3 Incubatee Suites with the support of KITS, Govt. of Karnataka. The Centre has been expanded now to 8500 Sq. ft. to accommodate 10 suites. The Centre has Analytical Instrumentation,

Common Wet Labs, Conference Room and other amenities. Three incubatees have successfully exited and 4 incubatees are functioning currently with NPIC. The incubatees have been provided access to Pilot Plant facilities and Sophisticated Analytical Instruments Facility (SAIF) for scale-up and higher-end services.

Further, as an extension of the incubation services, CFTRI initiated the Food Business Accelerator (FBA) in which one startup started functioning. The facility is of 1650 Sq. ft. area and can support maximum of 7 incubatees.

#### • Farmer Centric Activities

As a part of Farmer centric activities training was conducted on a regular basis which encompasses a range of activities like value addition to their agri-horticultural produce by technology know how or addressing the specific needs of a cluster. The main objectives of Farmer Centric Activities & Cluster Formation at CFTRI are :

- Empowerment of farmer communities through training cum workshop on Food processing
- Dissemination of practical knowledge to the farmers on value addition processes for certain food products that are grown by them
- Extending helping hand for enabling cluster formation and subsequently to start their own enterprises.

The training programmes were customized addressing the problems or exposing them to newer technologies based on their specific needs. During this period more than 19 customised training programmes were conducted in the field of Processing and Value addition in fruits (mango, pineapple, sapota, grapes, banana, kokum, jackfruit, custard apple, etc.), Vegetables, Spices (Turmeric, ginger, minor spices, etc.), Plantation products (coffee, cashew nut, sugarcane, etc.), Pulses (ground nut, soyabean, etc.), Grains (millets, rice, sacha inchi, etc.), others (cultivation of Spirulina and its products, jaggery, honey, bakery, fish and traditional breakfast foods). Majority of these farmers training programmes were sponsored by the respective district of the States under ATMA scheme. These custom made farmer programmes had been designed for a duration of 1 to 3 days and trained more than 430 farmers which include women, progressive farmers, FPOs, SHGs, and youth who are eager to understand more about value addition of agriproduce.

Efforts were made to create awareness about the plant and machinery needed for a specific processing technology, financial commitment needed to set up central facilities or manufacturing units based on the capacity etc. These programmes have enhanced the farmertechnologist interface for development of innovative technologies. This has also helped in building a number of clusters with specific role which has made a greater impact on the livelihood of the farmers.

The training also makes them aware of the food packaging, quality control, food laws and food safety norms that need to be integrated during the production process.

A facility named "Food processing learning centre for Farmers" equipped with food processing machineries for better understanding of the technologies was created. The newly created centre will help the farmers during the training programmes for hands-on experience.

### JIGYASA

"JIGYSASA" is a joint program conceived by CSIR and Kendriya Vidyalaya Sanghatan (KVS) to inculcate scientific temper and motivate students at the high school level. "JIGYASA-2019" was conducted at CSIR-CFTRI on March 25-26, 2019. Hundred students from class IX-XI and six teachers from four KVS namely, KV-Mysuru, KV-Kodagu, KV-Hassan and KV-Chamarajanagara participated in the event. Dr. KSMS Raghavarao, Director CSIR-CFTRI and Mrs. Nirmala Kumari, Principal KV-Mysuru,



inaugurated the event and conveyed their messages and best wishes to the participants. The students were introduced to research activities and technologies such as Jam making, Dosa machine, Bioplates, Vacuum packaging, Baking and millet milling technologies developed at CFTRI. They were shown simple experiments to detect food adulteration. Students performed hands on experiments with Thin Layer Chromatography, Plasmid extraction and microbiology. A science quiz was conducted and prizes were given to three winning groups.



# Progress Under R&D Projects

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### Extraction, concentration and encapsulation of biological active compounds from natural resources (*Rastogi NK*)

Extraction of phycocolloides and phycobiliproteins from micro and macro-algae for food and allied applications: The algal biomass of macro algae Gelidium pusillum was employed as a source of phycobiliproteins (R-Phycoerythrin). Integration of method (precipitation + ultrafiltration + ATPE) resulted in an increase in R-PE purity by 17-fold with 61% yield. The extract was concentrated to 8fold by DO and OMD. Fractionation of C-PC and A-PC could be achieved in PEG 4000/potassium phosphate ATPS at the standardized conditions. 'Ultrasonication + freezing and thawing' resulted in higher extraction efficiency (96.31%). Addition of silver NP resulted in the yield of 34.12 mg/g (d.b) and 23.71 mg/g (d.b) and purity of 2.3 and 1.2 of C-PC and A-PC, respectively.

Aromatic turmerone, Nano-pytosomes of Ar-Turmerone using supercritical CO<sub>2</sub> and solvent resistant nano-filtration (SRNF) techniques: Turmeric powder extracted with petroleum ether resulted in extract rich in Ar-turmerone (55.3%). The extract was subjected to several steps of preparative silca gel chromatography to obtain purified Ar-turmerone. Nanoemulsions containing Ar-turmerone (from turmeric) with droplet sizes 115-150 nm were obtained using ultrasonication and microfluidizer. The emulsions were found stable under simulated gastro-intestinal conditions. Carbonated beverage prepared using nanoencapsulated Ar-turmerone was found sensorially acceptable.

### Engineering Sciences

SRNF technology for processing turmeric oil: Recent studies have shown that the combination of curcuminoids and turmeric oil is efficient in preventing colon carcinogenesis. Bioactive components (curcuminoids) of turmeric oil extracted from Curcumin Recovered Turmeric Oleoresin (CRTO) with hexane were concentrated by employing Solvent Resistant Nanofiltration (SRNF) membranes. Hydrophobic NF membranes displayed a curcuminoid rejection of 97% with an average process flux of 2.25 LMH. Further studies in solvent phase with solvents namely, hexane, ethyl acetate, acetone and isopropyl alcohol revealed that the oil productivity could be improved four times, without compromising the curcuminoid rejection with ethyl acetate. These results showed that SRNF is a potential method and can be used to obtain any desired ratio of curcuminoids to turmeric oil offering value addition.

Concentration of bioactive rich juices using forward osmosis (FO): Forward osmosis (FO) is used for concentrating fruit juices at ambient temperature and pressure. The osmotic pressure difference between feed and draw solution acts as a driving force for transport of water. Pomegranate juice was concentrated using 6M NaCl draw solution and a concentration of 58.1°Brix (4-fold) was achieved while total phenolic content (TPC) and anthocyanin content were found to be concentrated to 4.5-fold and 4.3-fold, respectively. Qualitative and nutritive attributes were preserved in the concentrate.

#### **Self-cooling Can** (Matche RS)

Self-cooling having duel chambers, one surrounding the other was designed making it a self-cooling food package. An insulated container of 500 ml capacity was used as the outer chamber which holds the chemical reagents. The insulated container consists of two flasks placed one within the other and joined at the neck. The gap between the flasks was partially evacuated of air, creating a partial vacuum which reduces heat conduction or convection. Heat transfer by thermal radiation is minimized by silvering flask surfaces facing the gap. Flask is fabricated inside and outside in 18/8 quality stainless steel, which is rust proof. Also, there is an inner copper coating for better heat reduction and have their opening stopper with polyethylene plastic cap. Aluminium can of 350ml capacity was used as the inside chamber which carries the liquid product. In the outer compartment, the salt mixture was taken and the product (50 ml) was taken in the inner compartment. Initial temperature of the product was noted down. The water for reaction (15 ml) was added in the outer compartment and shaken for 3 minutes. The thermometer was inserted into the product to record the temperature drop. The temperature difference was calculated as  $\Delta T(^{\circ}C) = T_1 - T_2$ , where,  $T_1 =$ Initial temperature (°C),  $T_2$ = Final temperature (°C)

In the study on optimization of ratio of salt mixture for efficient self-cooling in self-cooling container, experimental design with 20 runs, 4 factors, three levels, D-optimal mixture was applied. The range of each factor was selected on the basis of preliminary trials. The amount of water required for the reaction, reaction time as well as product quantity were kept constant in each of the 20 formulations. Response surface methodology (RSM) with CCD (Central Composite Design) was used to observe the relationship between variables i.e., salt-mix concentration, water required for reaction, product quantity as well as reaction time and response (temperature difference), to determine the optimal condition for higher selfcooling efficiency. Different formulations were taken and experiments were performed accordingly. The results are being evaluated.

#### **Self-Cooling Pouch** (*Matche RS*)

The self-cooling pouch is a pouch-inside-pouch type having 3 chambers, 2 outer chambers and one inner chamber. In the 2 outer pouches, salts are added and a small water pouch (containing required amount of water for reaction) is placed inside each outer pouch and are sealed. The product is taken in the inner pouch and was sealed. The reaction is activated by pressing the water pouches placed inside the outer pouches. Application of pressure bursts the water pouches and water mixes with salts, setting off endothermic reaction. Urea, ammonium chloride, citric acid and sodium bicarbonate are used as the cooling agent because of its non-toxic and ecofriendly nature. In order to identify the amount of heat to be transferred, the temperature to which the product to be cooled is to be known. This will also decide the best molar ratio between chemical reagents and water which will produce maximum cooling for a long period of time experimentally. In the present work, selfcooling containers were developed which can cool liquid food from 25°C to 8°C in 3 minutes. Further, the process optimization is under progress.

### **Ready to cook vegetable biryani paste** (Sathish HS)

The objective of the project was to develop popular rice based shelf stable vegetable biryani with longer shelf-life. Drying of

vegetables was done in hot air oven and the paste was prepared with the standardized recipe having the required ingredients. Analytical tests like water activity and pH were determined to keep it to optimum levels. The prepared paste of biryani was mixed with the air dried raw basmati rice. The product was packed in PET/PP pouches and partial vacuum was applied and then pasteurized. Samples were stored at ambient temperature for 12 months for shelf-life analysis and microbial studies. These studies showed that tomato biryani packed in PET/CPP pouches can be stored under ambient conditions for a minimum of one year. The product offers great convenience since all the ingredients including rice is added into the product and requires only pressure cooking.

### Graphene oxide based nanocomposite films (Arunkumar P)

Graphene oxide (GO) and reduced graphene oxide (rGO) films were prepared by solvent casting technique in polyvinyl alcohol (PVA) matrix. Tensile strength (TS) of PVA/GO film improved by 18% whereas for PVA/rGO film TS increased by 27% compared to pure PVA film. The water vapour transmission rate (WVTR) of PVA/GO & PVA/rGO films reduced ~24 % compared to neat PVA film.



(a) Pure PVA, (b) PVA/GO and (c) PVA/rGO films

Zinc oxide nano-submicron particles were synthesised using phytoextract from two different zinc precursors (A) and (B). XRD pattern revealed crystalline nature of the product and all peaks could be indexed to hexagonal phase of ZnO. SEM images of ZnO revealed that the particles were highly agglomerated with irregular shape and size (~50 nm to ~500 nm). UV-Vis absorption spectra revealed only one broad peak, centered at 376 nm (A) or 369 nm (B) whereas photoluminescence spectra of ZnO obtained from (A) exhibited only blue emission at 428 nm whereas ZnO obtained from (B) showed blue (423 nm), blue-green (483 nm) and green (513 nm) emissions.



XRD pattern, SEM images, UV-Vis and PL spectra of ZnO NSM particles synthesized using leaf extract from (A) and (B)

### **Refractance window (RW) drying of fruits** (Umesh Hebbar H)

A laboratory-scale, batch-type RW drying system was developed in-house and used for the studies on dehydration of fruits such as apple and banana. Apple slices of thickness 2 mm were dried using the above unit and product qualities in terms of moisture content, water activity, colour and ascorbic acid content were compared with that of hot air dried (HAD), under similar processing conditions and also with freeze dried (FD). The time required to reach the final moisture content (5-6% wb) shortened in RW drying by nearly 25-37.5%, as compared to HAD. The lightness values of RW dried samples were close to freeze dried slices while HAD dried were darker. Retention of ascorbic acid in RW dried slices (~85%) was close to FD (~90%), and was higher as compared to that of HAD dried (~72%). Studies on banana puree drying to obtain leather showed that RW drying is quicker and also results in better quality product. In order to improve the product quality further and reduce processing time, a laboratory scale FIR assisted RW drying system was developed with a few modifications to the existing system. The preliminary trials indicated that nearly 50% reduction in drying time can be achieved with FIR assisted RW drying, as compared to RW drying alone. Banana puree was dried using RW and HA dryer in order to prepare dried banana leather. RW drying reduced the drying time by 68% compared to HA drying. Based on the studies carried out with batch system, conceptual drawings of continuous system have been prepared and fabrication work is in progress.

### Microencapsulation of blended oil into powder rich in PUFA (omeg-3 fatty acids) (Sukumar Debnath)

The microencapsulated spray dried powder

containing blended oil (based on linseed oil, sesame oil, rice bran oil and groundnut oil) rich in omega-3 fatty acids was prepared. The physicochemical and thermal analyses of the product are in progress.

### Table top fruits and vegetable washergadget (Nagaraju VD)

Conceptual design drawings for the unit was prepared and fabricated using the drawings. The unit has a concentric container which consists of stationary and rotary body. The rotary body has pores and rotates forward and



Conceptual prototype model of fruits and vegetable washer

reverse at 200 rpm using AC induction relay based bidirectional motor of capacity 150 W, 1.6 A. Solenoid control was provided for inlet and outlet valve. Embedded C program with microcontroller interface was incorporated with PCB for multiple versatility. The trials were conducted for select materials such as tomato, potato and grape, both with tap water and RO water. Common pesticides were checked in fruit and vegetable washer for both normal and RO water using High Resolution Mass Spectroscopy (HRMS). The pesticide levels were reduced by 30-40% and 60-70%, in tap water and RO water, respectively. Also, complete removal of foreign particles adhered to the outer surface were washed-off. Ozone kit was fitted to the washing unit and experimental trails are being conducted to achieve removal of pesticides from fruits.

# Machine for continuous cooking and discharging of ragi mudde/ ball making (Nagaraju VD)

The continuous cooking and discharging of ragi mudde/ball making machine was deployed for the supply of 1000 ragi mudde/day at Indira canteen on a trial basis at Bangalore. The product received a very good response from customers. Commercial ragi mudde making machine that was fabricated by CFTRI licensee, was demonstrated at Sri Siddaganga Matt, Tumkur. Based on the response received from Indira canteen and others, design drawings of the unit with capacity of 1000 ragi mudde/h were prepared. The fabrication work is in progress. The work on development of machine that produces balls of smaller size (100 g) was taken up and fabrication was completed. Nearly 3700 to 4000 ragi balls were

distributed to the public during open-day event of CSIR-CFTRI.

### Continuous jowar roti making machine (Nagaraju VD)

Traditional method of cooking and making of jower roti was studied and data was recorded. Data on various jowar varieties and cultivation practices were collected at Regional Agricultural Research Station, Vijayapura at UAS, Dharwad. Also, visited SLJAS Ukkali, SBBMMAS Vijayapura Woman's association (supported by Power Grid and ICRISAT), where jowar roti was prepared in large quantity and supplied to various places (an average of 1500 to 5000 rotis per day) to get first-hand information about large scale preparation and also data on various process parameters affecting quality of jowar roti. Commonly used jowar varieties such as M35, BJV 44 and CSV 29R were procured from Regional Agricultural Research Station in Vijayapura for analysis and trials. Studies on dough characteristics and rheology at different moisture ratios are in progress.

### Nutritious wheat based product using natural preservatives (*Prabhasankar P*)

*Millet based cookie cake:* Objective of the study was to develop low sugar and low-fat cookie cake. Replacement of wheat flour with



Millet based cookie cakes with natural preservatives

millets namely finger millet, pearl millet and little millet at various levels showed slight variations in physical and overall quality characteristics of cookie cake. The pasting characteristics of blends showed maximum viscosity between 827 and 426 BU, batter viscosity (9600 to 1600cP), specific volume (1.9 to 1.7 cc/g) and overall quality score (80 to 65 out of 90) showed acceptable quality characteristics. Various formulations were tried to optimize the quantities of ingredients for the cookie cake preparation. Batter rheological characterization and quality characteristics of the product were measured for the samples. Batter viscosity ranged between 1600 to 4800 cP, whereas the specific gravity was in the range of 1.01 to 1.12 cc/g. The volume and texture of the products ranged between 60 to 90 ml and 3014 to 7848 g force respectively. Further, the effect of ingredients on the guality characteristics of 100% millet blend was studied to optimize the formulation with desired characteristics. Effect

### Technology Development

of additives brought about significant improvement in the cookie cake with overall quality score of 75 out of 90 points. Storage stability of cookie cakes with the addition of different herbs individually and in combination was evaluated in comparison with synthetic preservative. Cookie cakes with herbs had comparable shelf life as compared to synthetic preservatives. The product showed no visible mould growth till 15 days of storage.

Low fat and sugar multigrain cookies: Developmentof high protein, high fiber, low fat, low sugar multigrain cookies using natural ingredients was the main aim of the project. Multigrain mix was prepared by combining peas, oats and fenugreek flour and blended with whole wheat flour. Further, the fat content



Low fat and sugar multigrain cookies

was replaced with oilseeds and sugar was replaced with dry fruits separately. The incorporation of multigrain mix to whole wheat flour increased the farinograph water absorption, amylograph pasting temperature, decreased the stability and final viscosity. The cookie dough became very soft with increase in the multigrain (1627 to 690 g-force) whereas on reduction in fat and sugar it increased (1656 to 4672 g-force). The diameter of the cookies increased and thickness decreased with the addition of multigrain. However, fat and sugar reduction decreased the diameter and increased the thickness of cookies. The breaking strength of cookies decreased, whereas by replacing fat and sugar the same increased indicating it to be harder. The use of emulsifiers helped to reduce the breaking strength (5725 to 3178 g-force). Sensory studies indicated that multigrain mix can be incorporated up to 75% and fat and sugar can be replaced up to 50 and 40% level respectively thereby increasing the protein and fibre by two-fold.

*Multigrain rusk:* Chemical composition of multigrain flours (Barley, Amaranthus and Fenugreek) determines that they are rich in protein and dietary fiber and could be incorporated as a source of fiber. Farinograph characteristics for the blends of wheat flour and multigrain flour showed that water absorption increased drastically. Dough development time decreased with the level of multigrain flour. Dough stability marginally decreased with



Multigrain Rusk

incorporation of multigrain flour. Amylograph characteristics for the blends of wheat flour and multigrain flour showed a decrease in gelatinization temperature with increase in the level of multigrain. There was significant change in peak viscosity due to incorporation of multigrain, showing that shear decreased, and

it became less viscous. Rusks were prepared using the multigrain flour at different level in the formulation and found that the spread ratio which gradually decreased with incorporation of the multigrain flour and breaking strength values decreased with increase in multigrain flour indicating that the rusk became crisp in nature. Hunter color values (L\*, a\*, b\* and  $\Delta E$ ) of rusks showed that as the level of multigrain increased in blend, the color of the crumb changed from creamy white to dull brown. Sensory scores gradually decreased with increasing level of multigrain. Based on physical and sensory parameters, incorporation of 15.75% multigrain in rusks were more acceptable. Addition of combination of additives (emulsifier and  $\alpha$ - amylase) was found to be acceptable with respect to texture, color, taste, flavor and overall acceptability. Multigrain rusk had higher protein and dietary fiber. In vitro studies showed that compared to control, multigrain samples had higher protein digestibility. Storage studies of rusk showed that multigrain rusk had similar characteristics to the wheat flour rusk.

Shelf stable thepla: Thepla is one of the traditional products consumed in North India, basically made from wheat flour which is devoid of some of the nutrition such as fiber, protein and minerals. The present study aims to develop millet based thepla using kodo and baira. The rheological characteristics of the multi-millet blends at different levels were carried out. Farinograph water absorption ranged between 72 and 73.7% and increase in dough development time (3.36 to 4.49 min) and stability (2.16 to 3.49 min) was observed with the increase in millet concentration. The optimization of the millet based thepla was done. The product has a shelf life of 15 days at ambient temperature.

High fiber bread: A commercial wheat flour (WF) having 0.51% ash, 10.29% dry gluten, 516 sec falling number, 21 ml Zeleny's sedimentation value and 4.05 dietary fiber content, white fiber flour (WFF) having 2.8% ash and 94.25% dietary fiber were selected for the studies. To increase dietary fiber content of bread, different blends were prepared by replacing wheat flour with WFF at 4, 8 and 12% levels. The blends were analysed for farinograph, extensograph and amylograph characteristics. The results showed that use of increasing amount of WFF in the blend from 0 to 8% increased farinograph water absorption, amylograph pasting temperature, decreased dough stability, extensograph resistance to extension, extensibility, energy and amylograph peak viscosity values. These results showed that addition of WFF increased water absorption capacity, decreased dough elasticity, extensibility and peak viscosity of WF indicating influence of WFF on the rheological characteristics of WF. Addition of WFF decreased volume, lightness value, increased moisture and crumb firmness value. The overall quality score of control bread was 65 for the maximum score of 70, 4% WFF (63) 8% WFF (61) and 12% WFF (56). Among different levels, WFF at 12% level showed adverse effect on the overall quality of bread. Nutritional evaluation of breads showed that the control bread and bread with 8% WFF had 3.2 and 9.9% dietary fiber respectively, indicating 3.1 times increase in the dietary fibre content when compared to control.

#### Multigrain semolina mixes

#### (Suresh D Sakhare)

Different multigrain semolina mixes were developed at the lab scale and further the operations were standardized for the large scale in pilot plant.

### Specialty flours for value addition of byproducts (*Aashitosh A Inamdar*)

Process interventions and their effect of different extraction rates on resultant atta quality was studied. The resultant atta obtained was analysed for physico-chemical, rheological and product making quality. It was observed that the colour of atta was becoming lighter with  $L^*$  values of 79 to 81. The ash content varied from 0.76% to 0.88% with the increase in extraction. The effect was also observed in the falling number and the sedimentation values of resultant atta. The dietary fibre was influenced with extraction and was found in the range of 4.5 to 7.9%. The *chapatis* from resultant atta were found to have better colour and overall quality score with increased extraction.

### Buckwheat in Indian Himalayan and North Eastern Regions (Crassina Kasar)

Buckwheat seeds from four different parts of India were milled into four fractions namely, fine flour, remaining flour, fine bran, coarse bran and husk. Grain characteristics of the buckwheat samples viz., density, colour and water activity were performed. Functional properties including water absorption, oil absorption capacity and colour of the milled fractions were carried out. The water absorption capacity was lowest in the fine flour fraction (180.10±12.05 -192.44±11.00%) and highest in the coarse bran fraction (233.78±19.28 - 308.59±12.74%) in all the samples. Bran fraction estimated the highest amount of protein. The protein content in the fine flour was in the range of 3.0% to 7.03%. High potassium content was observed in all the fractions (156.43±2.07 - 859.68±13.11 mg/100g). Phytate content in the fine flour, remaining flour, fine bran, coarse bran and husk were in the range of 0.585 ± 0.003-0.620 ± 0.014%; 1.121 ± 0.97 - 1.156 ± 1.00%; 3.000 ±

 $0.270 - 3.032 \pm 0.171\%$  and  $3.001 \pm 0.312$ - $3.256 \pm 0.202\%$  respectively.

Value-added products and by-products from papaya (*Carica papaya*) (*Vijayanand P*)

#### Papaya powder as a gelling agent

Papaya fruits of different stages viz., unripe, semi ripe and ripe were selected, peeled, sliced and pretreated. The pretreated papaya slices were dehydrated in a hot air drier. Papaya powder from unripe fruits were found to be a rich source of starch, dietary fiber, pectin, ascorbic acid. Papaya powder was evaluated for the water holding capacity, swelling capacity and gelling properties was found to be an excellent gelling agent in jams. It can also be used as a thickening agent in various food preparations.

### Low sugar intermediate moisture (IM) papaya chunks

Optimized process conditions and developed low sugar ready-to-eat (RTE) restructured chunks (IM papaya product of two different formulations with sensorial acceptance by adopting 9-point hedonic scale) from ripe papaya puree. Low calorie IM papaya chunks F-2 (corn flour added+LMP) & F-5 (LMP) have 0.72 and 0.74 water activity respectively and both found to be stable at RT (29±1°C) for minimum of 3 months and more than 6 months at low temperature (6±1°C). The end products (F-2 & F-5) have good firm texture and can be cut into any desired shape. The end product have low calorific values (F-2 = 39.46 Kcal /100g, F-5= 86.24 Kcal /100g). F-2 was found to be good source of minerals (potassium, calcium & magnesium) in comparison to F-5.

### *Functional food based on fruits and vegetables for insomnia*

Insomnia or sleep disorder is becoming a common problem among all age groups. The



Preparation of Low Sugar Intermediate Moisture (IM) Papaya Chunks

causes are many. Food is known to influence the sleep pattern. Tryptophan, magnesium (cofactor), calcium, vitamin B6 are the precursors that stimulate production of serotonin (5-hydroxytryptamine) and melatonin (N-acetyl-5-methoxytryptamine), the neurotransmitters that regulate sleep wake cycle. Hence, an organoleptically acceptable product enriched with the precursors of these neurotransmitters is being developed. Beverage mix and functional yoghurt are the product formulations which include ingredients rich in tryptophan, melatonin, magnesium, calcium and vitamin B complex and these ingredients can regulate internal melatonin level and reduce anxiety, thereby improving sleep.

### Nutritionally rich biofunctional processed product from Kainth (*Pyrus pashia* Buch.ham ex.D. Don) fruit (*Kudachikar VB*)

Kainth fruits of two varieties from two different growing regions of Punjab and Uttarakhand during peak harvesting period were procured. Fruit pulp of both varieties were characterized for its nutritional composition, vitamins,

minerals, organic acids, phenolics and dietary fibres. The processed product, ready-to-serve beverage was developed from fine fruit pulp after several trails and the product was analysed for its stability and evaluated for its nutritional and antioxidant potential.

### Microbial and pesticide decontamination of freshly consumed vegetables (*Negi PS*)

Among the non-thermal and chemical treatments used for decontaminating microorganisms and pesticides from the surface of freshly consumed vegetables (tomato, cucumber, carrot, and lettuce), ozone  $(60 \text{ gm}^{-3} \text{ for } 10 \text{ min})$  caused reduction of 0.9-2.4 log CFU/g of native microbes, 1.2-2.1 log CFU/g of artificially inoculated E. coli, and 0.4-0.9 log CFU/g of artificially inoculated L. innocua, while lactic acid (0.25% for 10 min) resulted in lowering their count by 1.1-2.9, 1.2-2.3, and 0.1- 1.8 log CFU/g, respectively. Ozone was more effective as compared to the ultrasound treatment for pesticide reduction and lactic acid dip showed the higher reductions in pesticide residues as compared to sodium acetate, methyl eugenol, cinnamaldehyde and oregano oil. The combination treatment of lactic acid and ozone resulted in approximately 1.5-3.5 log reduction of native microflora along with 24-96% chlorpyrifos removal with minimal loss in carotenoids, and 11-26% reduction in ascorbic acid content of selected vegetables.

### **Development of functional ingredient rich** grain based products (Srinivas A)

#### Development of instant extruded sorghum

Instant extruded sorghum product which can be used as noodle/vermicelli/string hopper/instant breakfast string was developed through technological interventions like novel thermal treatment protocols, size reduction, hydration, extrusion, hydrothermal treatment. The product had good sensory acceptability and rich in fibre, protein, phenolics, gamma-tocopherol and alpha tocopherol.



Instant extruded sorghum and its reconstituted form

Using unpolished foxtail, little flakes were made and further flavoured millet flakes, khara and sweet pongal products were prepared which showed good consumer acceptability.





Foxtail millet and flakes

Little millet grain and flakes

Multi dhal *dhokla* mix was formulated which was found to be rich in potassium, calcium, sodium and magnesium and was rated better than the control *dhokla* product.





Multi dal dhokla Multi dal dhokla (Control) Studies on the fractionation of finger millet and characterization of the products of processing showed concentration of polyphenols, flavonoids and tannins in different mill fractions. The antioxidant activity and DPPH scavenging activity of the flour fractions were also studied.

### **Protein rich ingredients from plant seeds** (*Rajgopal K*)

Flaxseed is emerging as one of the important functional food because of its high linolenic acid oil, dietary fibre and high-quality proteins. Traditionally flaxseed is used for oil extraction without processing which results in deterioration of quality of oil due to extraction of mucilage. The cake obtained after extraction will be dark in color due to hull content. Development of efficient dehulling and demucilaging methods are essential for getting better quality oil and protein rich meal. The presence of mucilage which swells during extraction of proteins is one of the major hindering factors in the development of methods for preparation of protein isolate. An efficient method is developed for demucilaging of flaxseed. After demucilaging and dehulling the protein content of the meal was enriched from 24% to 48-52%. The demucilaged meal was evaluated for protein solubility. There was a remarkable increase in solubility (58%) after demucilaging. A 25 kg batch of flaxseed was demucilaged and defatted to get protein rich meal. There was 21% loss after demucilaging. The yield of protein rich meal obtained after demucilaging and dehulling was 8.3%. Protein isolate was prepared from the meal by micellar technique and isoelectric precipitation in order to compare the recovery and quality of protein. There was no difference in recovery of protein when isolate was prepared by both methods (30-35%). The gel filtration has shown that linin as the major protein fraction of the isolate prepared by both methods. The protein isolates had high purity of 94-96%. The micellar isolate had higher solubility and lower water binding

capacity compared to isoelectric protein isolate. Both isolates had solubility minimum in the pH range of 4.5 to 6.0. The isoelectric isolate had remarkably lower solubility in the pH range of 2-4.5 and 6-10 compared to micellar protein isolate. It is evident from the study that the extraction methods influence the overall functionality of flaxseed protein isolates. The protein isolate prepared by both methods was rich in branched chain amino acids (Val, Leu and Ileu) and low lysine to arginine ratio of 0.24 there by showing their possible utilization in infant formulations and special medicinal diets.

### **Specific enzyme blends for bakery products and cheese making** (*Sridevi A Singh*)

Microbial rennets, with activity similar to calf rennet, are in demand as the market for cheese has an annual growth rate of ~12-15%. After screening 16 fungal strains, three fungi were selected for their production of extracellular milk clotting activities. These were A. oryzae MTCC 5341, M. thermohyalospora MTCC 1384 and *R. azygosporus* MTCC 10195. Parameters for growth of M. thermohyalospora and R. azygosporus were standardized for medium, pH, temperature and moisture content. The fungi were grown on wheat bran by solid state fermentation and they produced 63,000–78,000 U/ dry bran. Both fungi showed optimum MCA activity at pH 6.5 at 55°C and 58°C respectively. Protease activity for MTCC 1384 was optimum at pH 4.5 at 58°C, and pH 5.6 at 63°C for MTCC 10195. Further, characterization of the activities is being carried out.

### Proteins/enzymes of probiotic lactobacilli involved in β-manno-oligosaccharides catabolism (Mukesh Kapoor)

 $\alpha$ -Galactosidase (LP- $\alpha$ -Gal) from *Lactobacillus* plantarum WCFS1 belonging to GH36 family

was cloned and expressed in *E. coli* Hi-control BL21 (DE3). LP- $\alpha$ -Gal was purified to homogeneity by Ni-NTA affinity chromatography and showed molecular weight of ~81 kDa on SDS-PAGE. Purified LP-α-Gal exhibited 3.4, 29.3% and 3077.3 U/mg of purification fold, yield and specific activity, respectively. LP-a-Gal exhibited tetrameric structure in its native form. The optimum pH and temperature of LP- $\alpha$ -Gal were 6 and 37°C, respectively. LP-a-Gal was capable of transglycosylating small molecules like galactose but had no transglycosylation ability for larger molecules like raffinose. Substrate depletion study showed that, L. plantarum WCFS1 can metabolize only short chain GMOS (degree of polymerization; DP 3). Global transcriptome microarray profiling of L. plantarum WCFS1 revealed differential expression, when GMOS or control sugars (glucose, galactose and mannose) were used as a sole carbohydrate source. Two genetic loci involved in cellobiose (~3.2kb) and oligosucrose (~7.3kb) utilization in L. plantarum WCFS1 were highly up-regulated up to 8.3 and up to 6.7-fold, respectively by GMOS utilization. gRT-PCR studies of the selected gene clusters showed correlation with microarray data. Upstream and downstream section of PTS23C was cloned in pNZ5319 vector and transformed in *L. plantarum* WCFS1 did not result in deletion of PTS23C. Internal segments from 6-Phospho-β-glucosidase and PTS23C were amplified and cloned in pRSETa and PET28a<sup>+</sup> the constructs were transformed in L. plantarum WCFS1 and did not result in any positive clone. From the microarray data, 6phospho  $\beta$ -glucosidase was found to be one of the prominent genes being upregulated in L. plantarum WCFS1 when grown in media supplemented with  $\beta$ -MOS. 6-phospho  $\beta$ glucosidase cloned and expressed in Hi-control E.coli BL21 (DE3). The expressed protein was purified by Ni-NTA affinity chromatography followed by size exclusion chromatography and showed a molecular weight of ~54 kDa.

In batch fermentation, DP2 GG- $\beta$ -MOS was preferred over DP3 by all *Lactobacillus* sp. except *Lactobacillus casei* var Rhamnosus. DP2/DP3 and GG- $\beta$ -MOS mixture inhibited the growth of enteropathogen *S. typhi* in co-culture fermentations. Fermentation of GG- $\beta$ -MOS mixture by *Lactobacillus* sp. produced short chain fatty acids. TGA and DTA analysis showed that the purified DP2 and DP3 are highly resistant to thermal degradation and thus can be incorporated into various food products. XRD analysis and FTIR analysis also confirmed the structure and amorphous nature of the oligosaccharides.

# Expression, purification and characterization of *Listeria monocytogenes* SSB1 (*Patil KN*)

Single-stranded DNA binding proteins play an important role in DNA metabolic processes including replication, recombination, and repair. The identification and biochemical characterization of the SSB1 protein from the foodborne pathogen Listeria monocytogenes has been done. The electrophoretic mobility shift assay revealed that the purified L. monocytogenes SSB1 protein binds to single stranded DNA, including the M13 circular single stranded DNA and oligonucleotide, with high affinity. The plasmid-based strand transfer activity showed that, in the absence of the SSB protein, L. monocytogenes RecA fails to catalyze the reaction whereas, the E. coli RecA protein has shown nicked DNA formation. Interestingly the addition of SSB1 protein stimulates both L. monocytogenes and E. coli RecA strand transfer activities however, it is sensitive to the order of addition of SSB1 protein. L. monocytogenes RecA fails to catalyze the reaction when SSB1 is added prior to RecA; nevertheless, it readily catalyzes the reaction when added after the RecA filament formation. The studies provide the first functional characterization of the *L. monocytogenes* SSB1 protein and gave insights into DNA repair and recombination processes in the gram-positive foodborne pathogen *L. monocytogenes*.

### **Novel anticancer protein from quinoa bran** (Sachin M Eligar)

Chenopodium quinoa is a pseudocereal cultivated since 3000 B.C. and is native to the Andean origin. The quinoa is gaining attention due to its nutritional facts. Quinoa bran is an agro waste being discarded due to high saponin (toxic) content in spite of high protein (18-24%). Protein from quinoa bran was isolated and partially purified using conventional chromatographic methods. These protein fractions show potential anticancer activity against liver and colon cancer cells. The observed effect is due to the induction of apoptosis as evidenced by caspase-3 activation and cell cycle analysis. The current study will help in utilizing an agro by-product, quinoa bran, as a cheap source of protein with important biological activities.



Effect of Quinoa protein on Liver and colon cancercells.
A. Dose dependent effect on different cells.
B. Time dependent effect at different concentration.
C. Caspase-3 activation.
D. Cell cycle analysis

### Millets arabinoxylan oligosaccharides (AXOS) induced anti-cancer effect (Sachin M Eligar)

Arabinoxylan is one of the important nonstarchy polysaccharide known to have many biological activities. The current study was aimed to isolate the arabinoxylan oligosaccharides from millet bran using different xylanase enzymes. These arabinoxylan oligosaccharides (AXOS) were fractionated and studied for their effect on the gastrointestinal cancer cells. The results show potent inhibition of cancer cell growth when studied in vitro in a time dose-dependent manner. The detailed signaling mechanism involved in the anticancer effect is being studied. Being natural molecules with high stability, these AXOS may find application in functional foods.



### Quantitative modelling of bacterial stress response (Sutapa Mukherjee)

The aim of the project is to understand some of the critical stress response mechanism of bacteria under different types of stress conditions through systems biology based approaches. The studies are aimed at potential food pathogens and bacterial species responsible for fruit and vegetable spoilage. As a response to the stress condition, bacterial cells switch to different gene regulation

programs that are necessary for the survival of bacteria. Using tools of mathematical and computational modelling, how the design of some of the crucial networks affects the synthesis of some key regulatory proteinsis being investigated.

#### Driven many particle systems in physics and biology (Sutapa Mukherjee)

This project is focused on transport processes inside the cell. A large amount of transport inside the cell happens through systematic hopping of motor proteins such as kinesins or dyneins on biopolymers. Various cellular organelle is transported from one location to another inside the cells in the form of "Cargoes" by these motor proteins. It is now well understood that such processes critically affect the overall fitness of our body. For example, a regulated secretion of lipid droplets by the lever is crucial for controlled amount of fat in the blood. It is understood that such lipid droplets are transported by the motor proteins inside the liver cell to a position from where these droplets are secreted out of the liver cells. It is believed that kinesin allows the liver to control how much fat has to be secreted out. The aim here is to develop mathematical and computational models that allow us to observe the collective behaviour of the transport processes involving many molecules under different cellular contexts.

### Antimicrobial proteins/peptide for food industry (Rajagopal K)

An antimicrobial protein/ bug-buster has been identified. Bug-buster kills most of the pathogenic microbes such as *Salmonella*, *Listeria*, *Vibrio cholera* and *Pseudomonas*. This may be introduced as an ingredient in the food material, so that extra sterilization is avoided. It is functional at harsh conditions such as high temperature and pH ranging 2-9. This may be used as an antimicrobial agent, therapeutic protein for food industries such as diary, meat, vegetables and fisheries.

### Ocins database for food industry (Rajagopal K)

The ocins are antimicrobial polypeptides produced by probiotic microbessuch as Lactobacillus, Enterococcus, Streptococcus, Leuconostoc and Bifidobacterium. They are produced in response to stress and for the selfdefense of the bacterium. It is indispensable to understand their mechanistic characteristics, structures, and functions, if the food industry is to reduce contamination levels and produce germfree foods. Databases of the ocins that are readily accessible to the food industry are scarce, but urgently required. Therefore, a very useful, uniqueand a simple ocin database was esatblised, which does not merely provide information about ocins, but also directs their utilization in the food industry. The database includes information about each ocin, its amino acid sequence, molecular weight and isoelectric point. The database also possess all the currently known ocin (probiotic origin only) sequences and structures, target organisms and relevant to food industries (aqua culture, dairy and meat industries) which is hard to obtain in other databases. The database is free for public and can be accessed at http://ocins. cftri.com/ocins/.

### **Rapid detection of bifidobacteria** (*Rajagopal K*)

The amplification of the xylulose-5-phosphate/ fructose-6-phosphate phosphoketolase (xfp) gene and the fructose-6-phosphate phosphoketolase (F6PPK) biochemical assay

has been extensively used to identify the Bifidobacterium spp. In the conventional assay, after isolation and harvesting, the stationary phase cultures are treated with different reagents sequentially finally leading to the formation of ferric hydroxamate (reddish violet colour) which is measured spectrophotometrically. The existing methods (F6PPK based) for identifying Bifidobacterium spp. were developed based on the availability of pure bacterial cultures, hence, not suited for mass screening. Therefore, the simultaneous isolation and identification of Bifidobacterium spp. directly from agar plates is needed. An onplate method for the rapid, simultaneous isolation and identification of Bifidobacterium spp. was developed from varied cultures, in which the isolating pure culture, harvesting and washing steps were bypassed. Mixed cultures of Escherichia coli, Lactobacillus, and Bifidobacterium spp. were used. No phosphoketolase activity was observed when plates contained disrupted E. coli, and Lactobacillus spp and activity was observed only with disrupted Bifidobacterium spp. The sensing of target bacteria by the on-plate F6PPK assay will lead to future studies of the composition and dynamics of intestinal microflora.

### Bioactives, technologies for selected spice, sugarcane product and analytical method for sugar (Borse BB)

## Enzyme assisted extraction of essential oil from Zingiber zerumbet (Bettadaiah BK)

Zingiber zerumbetis a perennial, aromatic and tuberose plant that grows in humid locations. A feasible method of extraction of essential oil from zerumbet, which has zerumbone, a sesquiterpene compound is developed. An enzyme-treated zerumbet was afforded higher percentage of oil compared to untreated sample. Enzymes like pectinase, viscozyme, hemicellulase, cellulase, amylase, and bioprotease and enzyme for herbal extract were At the temperature of 30°C and used. incubation of 1 h with different enzymes, the essential oil yield was measured. The result indicated that there is significant increase in the oil yield (25%, 4% overall oil yield) compared to the untreated sample (3.2% overall oil yield). Under the optimized conditions such as 2% enzyme treatment with incubation of 1 h at 30°C, the net oil recovery was accounted to be 2.5% to 25% with respect to different enzymes. Enzymes such as pectinase, viscozyme, amylase and hemi-cellulase afforded 25% more oil yield while cellulase afforded 19% more, enzyme for herbal extract afforded 12.5% more and bio-pectinase-N afforded 2.5% more oil. The GC profile of all the extracts were carried out and GCMS of the oil indicated the major compound as zerumbone.

### **Onion processing and drying using novel microwave method** (Nagarajan S)

Onion processing in terms of preservation and dehydration with the retention of characteristic components by employing suitable drying techniques was studied. The microwave in combination with hot air (combo) processing using conveyorised microwave drier results with a product with better retention of volatiles, pungent/ sulphur compounds, colour and overall quality. The dried onion under optimized conditions: moisture 6% (treated) and 4% (untreated). The rehydration studies by soaking in water and dipping in 1% potato starch solution resulted with the products comparable to that of fresh onion. The sample rehydrated with water was more acceptable.

### <sup>1</sup>*H NMR based quantification method for sugars* (Nanishankar V Harohally)

Jaggery is made from sugar cane/palm sap. It is a traditional sweetener consumed across the country. Conventional method of analysis of sugar is time consuming and laborious. In this context a simple <sup>1</sup>H NMR based method development for analysis of sugar content was envisaged. Jaggery usually contains about 65-85% of sucrose and about 10-15% of reducing sugars. NMR quantification method development involved the first and foremost selection of NMR solvent D<sub>2</sub>O as jaggery contents are entirely soluble in water. Subsequently, a standard was chosen which has chemical shift way different from contents of jaggery that is sugars. This is important to avoid interferences during the integration of peaks of analyte. Further, a measured amount of jaggery (at least triplicate trial is essential) is transferred to NMR tube along with known quantity of standard. Then spectra were acquired and further analysis involved integration of peaks due to sucrose, reducing sugars and standard. Subsequently, via comparison of integration and using the NMR quantification formula, the sugar contents were evaluated.

#### *Nano-encapsulated beetroot colorant* (*Pooja J Rao and Sowbhagya HB*)

Beetroot concentrate with 50° Brix was prepared by evaporating the autocloved beetroot juice. The beetroot concentrate, a major source of betalains, contained 0.0456% betacyanin and 0.0480% betavulgaxanthin. The concentrate was nanoencapsulated using water-oil-water multilayer method. The particle size, zeta potential and encapsulation efficiency of the nanoemulsions were ranged from 145-300 nm, -42 to -16 mV and 33 to 99%, respectively, depending on core (beet colour concentrate) to carrier (proteinpolysachharide) ratio along with concentration of surfactant. The UV-visible spectroscopy absorbance at 540 nm and 480 nm for betacyanin and betavulgaxanthin, respectively, confirmed the presence of betalains. The stability study of betalains before and after nanoencapsulation at pH 3 showed that nanoencapsulated beet colorant was more stable than unencapsulated beet colour. The nanoemulsion was spray dried and the nanoencapsulated beet colorant powder was added in tomato soup mix powder and hard boiled candy to show its applications in food products.





Beetroot nanoemulsion

Hard boiled candy incorporated with nanoencapsulated beetroot concentrate

### Nutraceutical food products by incorporating nanoencapsulated curcumin (Pooja J Rao)

Solubility of curcumin in lipids such as milk fat and virgin coconut oil was evaluated using UVvisible spectroscopy technique wherein acetone was used as blank. The particle size of curcumin in milk fat and virgin coconut oil is 395.1 nm and 1.8 µm, respectively. The use of mixture of lipid and curcumin to prepare curcumin nanoemulsion is under progress.

### Value added products from green coffee (Pushpa S Murthy)

Green coffee is a prime source of antioxidants to functional food and nutraceuticals. *Arabica* 

and Robusta varieties were screened and decaffeinated using ethyl lactate and extracted with a polar solvent to obtain Chlorogenic acid (CGA) enriched green coffee extract (GCE). The physicochemical qualities (moisture, pH, particle size and colour) and bioactive compounds (total phenolics, chlorogenic acid and caffeine) of GCE was assessed. The GCE had  $12.78\pm2.1$  mg GAE g<sup>-1</sup> phenolics and 10.98mg g<sup>-1</sup> chlorogenic acid (CGA). To improve the stability of CGA, the GCE encapsulated by spray drying using maltodextrin (MD) and skim milk (SM) as coating agent individually and in combination. Physicochemical, antioxidant properties and biofunctionalities of microparticles were evaluated. Highest encapsulation efficiency of GCE with maltodextrin (1:1) was 86%±3 with the smaller particle size (2.3±0.1µm). Under the simulated gastric juice and bile salts solution, microencapsulation provided significantly better protection compared to nonencapsulated GCE.

### Starter culture technology for coffee processing (Pushpa S Murthy)

*Arabica* coffee is fermented to obtain intense flavor profile and finds elusive prospects in the coffee industry. The *Arabica* mucilage represented 2-5% dw of the fruit with 94% moisture, 4% sugars, 0.7% protein and 3-1% pectin. Inductive isolation and screening of functional attributes of microbial strains in varied ratio responsible for mucilage elimination were conceded in coffee pulp simulation media. Fermentative vigor along with the enzymatic progression of the microbes was streamlined and the prospective isolates of mixed culture were optimized. The *in-silico* docking on the fermentation mechanism using starter displayed interaction between the pectin and pectinase at its minimal energy state. The 1CZF disclose the best interaction binding energy (-3.92) with rapid enzymatic and desired fermentation. A central composite rotatable design was employed to study the effect of inoculum of empirically selected consortia (10%) Saccharomyces cerevisiae, Lactobacillus plantarum and Bacillus sphaericus (1:1:1) on the coffee fermentation with prime factor alcohol, pectin and sugar as with response variables. The fermentation at the 40°C temperature with pH 5.6 reveals primary and secondary metabolites of starter culture was indicative of alcohol (70.26 mg/ml), sugar (5.5 mg/ml) and pectinase enzyme (11.66 U/ml) compared to natural fermentation. The sensory profile with green beans produced by starter scored 7.0 on a hedonic scale. The effect of integrating mixed starter which is metabolically synergistic gives systematic quantitative insights of Arabica coffee fermentation with consistent guality compared to natural fermentation.

## Value added products from underutilized rhizomes (Madhava Naidu M)

*Curcuma angustifolia* L. rhizomes were obtained from Chhattisgarh State and *Zenzuber zerumbet* rhizomes obtained from Indian Institute of Spices Research (IISR) Calicut, Kerala State were washed, air-died and stored in cold room at 4°C. Rhizomes (200 g), which contained ~ 60% moisture were taken in each experiment. Peels (50 g) were removed by de-skinning of the rhizomes. The de-skinned rhizome was sliced and made into a paste using a laboratory grinder. Water (1 I) was added to paste and passed through a muslin cloth. The fibrous residue (6 g) was discarded. The filtrate in each trial was subjected to pretreatments with different reagents viz., hydrochloric acid

(0.1, 0.2, 0.5%), acetic acid (1, 2, 4%), salt (2, 4, 6, 8%), acidified methanol (0.1%), gelatin (0.1, 0.5, 1%), sodium bicarbonate (1, 5%), magnesium carbonate (1%), potassium carbonate (1%), calcium carbonate (1%), calcium oxide (1%), potassium metabisulphite (2%) and sodium hydroxide (0.05, 0.1, 0.25, 0.5%). The treated mixture in each case was centrifuged at 5000 rpm for 30 minutes supernatant discarded, and residue was redissolved in water. This was neutralized to pH 7 and centrifuged. The resulting flour sediment was washed with water to afford a clean white product. The concentrations of 0.25% gelatin, NaOH (0.1%) and  $K_2S_2O_5$  (2%) were found to be optimum for the removal of bitterness from Curcuma angustifolia and Zenzuber zerumbet with little effect on physico-chemical characteristics of flour. The product, obtained after sun drying, was subjected to sensory studies for its colour and taste attributes and the prepared flour was evaluated for its chemical composition, mineral profile, and functional properties. The product deteriorative characteristics were studied and functional and







Starch granules



Curcuma angustifolia



Starch powder

economic package was designed to get shelf life of more than a year for the product. The study, thus, provides a simple solution for effectively removing the bitterness of Curcuma

angustifolia L. and Zenzuber zerumbet rhizomes and obtaining quality shelf-stable flour. The new process obviates tedious and time-consuming process steps of the traditional process. Further, sensory studies on the flour from the present process showed it to be comparable to the control sample from the traditional process.

#### Texturized fish products and shelf-life studies (Rathina Raj K)

Process for the preparation of surimi powder (500 g, small/lab scale) from pangasius fish (Pangasius bocourti) was optimized using vacuum/spray drying in the presence of 1% xanthan gum, 5% trehalose and 2% sorbitol. Optimized the formulation for the high protein mayonnaise (HPMPSP) preparation from surimi powder. Storage stability of HPMPSP in terms of oxidative and microbiological quality was studied for five months. The storage stability of mayonnaise (pasteurized and unpasteurized) were studied for 5-month



Pangasius fish

Fish surimi mayonnaise

duration at cold storage (4-6°C) and room temperature (28± 1°C). The peroxide and TBARS values of unpasteurized and pasteurized mayonnaise were significantly increased as storage period increased. Microbiological evaluation showed that surimi mayonnaise was stable and resistant to microbial spoilage during storage which was due to a decrease in pH vaules. Further, continuous (till one year) storage stability of HPMPSP is in progress. Scale up (10 kg) of surimi powder and high protein mayonnaise

production from pangasius fish are in pipeline. Scale up studies of up to 5 kg fish cubes was carried out. Also, quality of frozen fish cubes during storage was studied up to 3 months with respect to microbiological quality, fat oxidation, texture profile and sensory properties. All the quality parameters studied indicates a stable fish cubes up to 3 months of study.

### Alternatives for meat – plant based meat analogs/mock meat (Sachindra NM)

Studies were carried out to evaluate the solubility of protein from three different pulses, namely, chickpea, green gram and horse gram at different pH. The solubility of chickpea protein was highest at pH 4.0 followed by pH 6.0 and was lowest at pH 3.0. The solubility of protein from horse gram was highest at pH 3.0 and was lowest at pH 5.0. With respect to green gram, the protein solubility was highest at pH 6.0 and was lowest at pH 4.0. A defatted chickpea flour was prepared by solvent extraction process, wherein the fat content was reduced by 92%. Studies are being carried out to standardize the conditions for preparation of protein isolate by isoelectric precipitation and to evaluate its functional properties. Studies were also carried out to prepare mock chicken meat using gluten and defatted soy flour. A prototype mock chicken meat chunks was prepared, which was found to be sensorially acceptable and resembling the chicken meat to the extent of 60%.



Mock meat samples

### Proteinaceous material from waste water streams of fish/ meat processing (Tanaji Kudre)

Proteins from surimi wash water, wastewaters from beef, mutton, chicken, and fish slaughter houses were recovered using the pH shifting method and mixed in equal amounts to obtain blended protein (BP). To enhance the economic feasibility of the blend proteins hydrolysate preparation, the wet pellet of blended proteins (WBP) was used for both enzymatic and fermentative hydrolysis. Flavourzyme was selected to optimize the enzymatic hydrolysis of WBP using RSM in the central composite design at 55°C considering degree of hydrolysis, antioxidant activities and ACEinhibition activity as the major response factors. Optimum conditions for highest DH, TEAC, DPPH, FRAP and metal chelating activity (predicted response values) using quadratic model were achieved at L/S ratio of 70 (v/w) E/S ratio of 35 U/g protein and hydrolysis time of 80 min. Under this optimized condition, DH, TEAC, DPPH, FRAP and metal chelating activity was found to be 13.06%, 163.41 µmol TE/g, 166.78 µmol TE/g, 157.74 µmol TE/g and 187.76 µmol EDTA/g respectively. For maximium DH, iron binding capacity and ACE-inhibition activity, the optimum hydrolysis conditions (predicted response values) using quadratic model were found to be at L/S ratio of 95.2 (v/w), E/S ratio of 60.20 U/g protein and hydrolysis time of 113.64 min. Under these conditions, the predicted response values using the quadratic model were 36.61% for DH, 58.03% for iron binding capacity and 27.20% for ACE-inhibition activity. Both optimized hydrolysates presented the negligible antagonistic activity against the E. coli, L. monocytogenes and S. aureus. For fermentative hydrolysis of WBP, three Lactobacillus species (Lactobacillus plantarum, Lactobacillus plantarum subspecies

plantarum and Pediococci Iolii) were used to select the best one for producing hydrolysates with antioxidants (TEAC, DPPH, FRAP and metal chelating activity), iron binding and ACEinhibition property. P. Iolii showed the higher DH, TEAC, DPPH, FRAP and metal chelating activity at 15% protein concentration compared to other Lactobacillus culture. Therefore, P. Iolii was selected for further optimization using RSM in CCD employing hydrolysis time (36-60 h), carbohydrate concentration (0.5-1.5%, w/v) and WBP concentration (5-15%, w/v) as independent variables. Optimum conditions for highest DH, TEAC, DPPH, FRAP and metal chelating activity were achieved at protein (WBP) concentration of 18.4%, carbohydrate concentration of 1.4% and hydrolysis time of 56.18 h. Under the optimized conditions, DH, TEAC, DPPH, FRAP, and metal chelating activity was found to be 43.5%, 574.34 µmol TE/g, 420.17 µmol TE/g, 407.86 µmol TE/g and 509.77 µmol EDTA/g, respectively. Similarly, RSM generated optimum fermentative hydrolysis conditions were 18.4% WBP concentration, 1.8% carbohydrate concentration and 56.18 h hydrolysis time for



slaughter

water





Wastewater protein pellets house waste

Fermentative **Bio-functional** hydrolysis by P. Iolii

protein hvdrolvsate

the maximum DH (40.5%), iron binding capacity (90.2%) and ACE-inhibition ability (66.3%).WBP hydrolysate prepared by P. Iolii (FWBPH) using 1.8% carbohydrate concentration, 18.4% WBP concentration and 56.18 hrs hydrolysis time displayed higher antimicrobial activity against E. coli, L. monocytogenes, and S. aureus than that

ofhydrolysate prepared using 1.4% carbohydrate concentration, 18.4% WBP concentration and 56.18 hhydrolysis time. Overall, from the results, it can be concluded that fermentative hydrolysis was most suitable for producing an antioxidant, iron binding, ACEinhibitory and antimicrobial potential peptides.

#### Ready-to-reconstitute Gulab Jamun (Venkatesh Murthy K)

Cold syrup absorption study of jamun: Different sugar syrup concentration namely 35, 45, 55 and 60°Brix were prepared and fried jamun under cold condition (ambient temperature) were added and reconstitution behaviour was studied. Results showed that at lower Brix such as 35 and 45 the absorption was found to be faster than that of higher Brix syrup, but the consistency was not acceptable, and the results were not encouraging. Hence, the experiment was planned to have hot syrup reconstitution with a shorter time duration. After conducting many trials, based on the results obtained it is planned to have ready to-reconstitute jamun.

Preparation of ready-to-reconstitute jamun: Jamun were fried at 140°C and packed in microwavable pouch and impact sterilization was done. Syrups with 55 and 65 Brix were boiled and packed in microwavable pouch and sterilized. Both the syrup and jamun were kept for storage study under refrigerator, ambient and accelerated conditions for 30 days. Samples were periodically withdrawn at the intervals of 10 days and its physico-chemical, microbiological and sensory evaluation were carried out. Jamun and syrup pouches were opened simultaneously and transferred to the glass bowl and heated in the microwave for 3 mins to get ready-to-eat jamun. The results showed that under ambient and refrigerated conditions, samples were found to be safe and having acceptable taste with respect to all

sensory parameters comparable with control samples. Samples stored at accelerated condition showed change in texture and colour of the jamun but having acceptable taste.

Shelf life extension of milk based Indian traditional sweet meat Basundi: Basundi is easily perishable within 48 h. Hence an attempt has been made to extend the shelf life of basundi with desirable sensory quality. Preliminary studies were carried out to extend the shelf life of milk based Indian traditional sweet basundi. Five natural biopreservatives having antimicrobial activity viz., ghee from cow's milk, cardamom, honey, clove and saffron were used in the preparation of basundi. The basundi was prepared using traditional method. Based on the microbiological data the results revealed that basundi prepared using ghee from cow's milk as a preservative was safe for consumption with acceptable sensory qualities for 2 days and 5 days at ambient and refrigerated conditions respectively.

### **Coconut based products for sustenance in sports** (*Chetana R*)

Sports nutrition products are consumed by both professional athletes and mainstream consumers from all walks of life seeking to boost their energy levels and promote general health. Sports energy drinks and foods, in particular, have penetrated a wide range of consumer profiles from very active to occasionally active. The proposed project is aimed at development of value-added coconutbased products for sustenance of energy levels in sports personnel during sporting events.

### Multipurpose spiced paste, gravy paste extruded hyacinth beans product (Shailaja R)

Storage studies and nutritional labelling for tomato based multipurpose spiced paste,

tomato based gravy paste with sesame seeds, groundnut, cashewnut are under progress. Bulk preparation using planetary mixer for the production of hyacinth beans and rice based extruded products are also under progress. Additional products such as mixed vegetable jam and mixed vegetable bar were standardized using cardamom, cinnamon and nutmeg flavours.

### Diversified products for commercial mango varieties Chausa and Amarpali (Gothwal PP)

Selected Amarpali and Chausa mango trees were sprayed with formulation consisting of curacrol 25 ml/10 l, antracol 25 g/10 l and surfactant (Imidacloprid 40 ml/10 l), bavistin 20 g/l, planofix 3 ml/10 l) mixed properly using acetone in paste/slurry form and diluted with water at the ratio of (0.15%) for final spraying. Healthy fruits at 80% maturity along with the stalk (1 cm length) were harvested from the trees and different post-harvest treatments were provided to the fruits in 6 lots. Data revealed that the PLW of fruits increased with progress in storage period. PLW of control fruits have shown maximum weight loss while treated fruits recorded lower PLW. This could be due to increased transpiration losses and enhanced respiratory activities in fruits. TSS of treated fruits increased gradually during ripening and attained maximum 18.4°Brix in Amarpali mangoes and 19.2°Brix in Chausa mangoes. The decrease in titratable acidity during ripening in treated mangoes was slow whereas the acidity decreased at faster rates in control fruits exhibiting accelerated ripening of control fruits over treated. Total sugars showed a continuous increase during ripening, however the decrease in reducing sugar was faster in control fruits as compared to treated fruits. Results indicate that Amarpali mangoes stored at a temperature of 12-13°C were good up to 28

days of storage period and the mangoes kept at room temperature were better up to 15 days of storage. *Chausa* mangoes stored at a temperature of 12-13°C were good up to 26 days of storage. However, the mangoes kept at room temperature were better up to 14 days of storage. The physiochemical parameters were studied and found within the limits. Products prepared from ripened mangoes were found to be good.

## Value addition to exotic vegetables and disinfestations of millets by a novel method (*Jyothirmayi T*)

Spice formulations were prepared by incorporating dehydrated tomato, onion, ginger along with other spices viz., salt, black salt, chilli powder, turmeric powder, cumin, coriander etc. and extruded millet based products were coated with spice formulations and carried out sensory acceptability and storage studies. Gluten free extruded products were developed using multigrain (consisting millets, corn grits, pulses and defatted soya flour) incorporating vegetables lettuce and carrot and the products were shelf stable and good even after 4 months of storage in nitrogen filled MPE pouches. Ridge gourd (Luffa actangula) peel was separated and dried in a tray drier at 55-60°C for 8-10 h. The powdered peel was analysed for dietary fibre. A method was standardized for enhancement of dietary fibre using acetate and HCI-KCI buffers. An enhancement of dietary fibre to an extent 67% from 45% was achieved. The dietary fibre rich peel powder was incorporated at 5, 10 and 15% levels in millet incorporated extruded snacks and studied their acceptability. It was observed that 10% incorporation of peel powder was acceptable. The cereals/millets such as sorghum (Sorghum bicolour L.), pearl millet (Pennisetum *typhoideum* L.) and foxtail millet (Setaria italica) were exposed to microwave radiation to check its effect for insect infestation such as Cryptolestes ferrugineus, Sitophilus zeamais, Tribolium castaneum and Plodia interpunctella as well as microbial guality. The study included the optimization parameters for disinfestation of millet grains. Microwave disinfestation at 4 w/g is considered safe and competitive alternative method to fumigation as it avoids environmental pollution.

### **Cereal and spice based formulation in management of diabetes** (Baskaran V)

In order to develop functional foods based on cereals and spices/herbs and to elucidate their anti-diabetic regulatory mechanism barley (Yava, Hordeum vulgare) or wheat (Godhuma, Triticum aestivum) flours (base material) were blended separately with spices/herbs triphala [(Ayurvedic herb mix -Haritaki(Terminalia chebula), bibhitaki (Terminalia bellirica) and Amalaki (Emblica officinalis], sesame oil, ghee, turmeric, and black salt (for taste). The mixture was homogenized to slurry and processed by drum drying or hot air flow drying. These products were evaluated for nutrient, bioactive components, and  $\alpha$ -amylase and  $\alpha$ glucosidase inhibition and bile acid sequestration. Barley based product (Bbp) contained (dry weight basis/g) phenolic 18.37 mg, flavonoids 12.6 mg and tannins 18.48 mg respectively. Wheat based product (Wbp) contained 19.079 mg, 13.486 mg and 36.43 mg of phenolic, flavonoids and tannins, respectively. The total protein (%), lipid (%) and carbohydrate (%) content of Bbp and Wbp was 12.5, 5.7 and 64.3 and 12.8, 5.8 and 68.5 respectively. The energy value (Kcal) for Bbp and Wbp was 428 and 440. The sensory values for both the products were found to be acceptable. In traditional Indian food, plant based food formulation have been used for medicinal purpose. The developed products are highly nutritive with  $\alpha$ -amylase,  $\alpha$ glucosidase inhibition and bile acid binding property and can be therapeutic food for management of diabetes.

### Translational Research

### Plant derived food molecules as viable therapeutic agents to down regulate hyperglycemia (Baskaran V)

Lactucaxanthin, an antioxidant carotenoid found in lettuce (Lactuca sativa) is gaining importance owing to its antidiabetic property. However, currently no clear purification techniques are available due to difficulty in separation from lutein complex. Hence, the present study focused on establishing a simplified method to purify lactucaxanthin and to examine its antioxidant potential. Among the lettuce species, green lettuce contained higher concentration (mg/100 g dry weight) of lactucaxanthin  $(3.05 \pm 0.12)$  followed by Romania (0.42  $\pm$  0.05) and Iceberg (0.36  $\pm$ 0.06) respectively. Purification by TLC followed by preparatory and analytical HPLC resulted in 99-100% purity of lactucaxanthin ( $\lambda_{max}$ -439 nm). FTIR, LC-MS (M+H<sup>+</sup>-H<sub>2</sub>O = 551) and NMR analysis further revealed the characteristic chemical structure and purity. The radical scavenging activity (DPPH-35.65±0.85 µg/ml and ABTS-4.92±0.81 µg/ml), total antioxidant (5 µg equivalent 23.71±1.88 µg of ascorbic acid) activity and reductive capability (20 µg equivalent 26.14 µg of quercetin) of the lactucaxanthin prove its antioxidant potential. Purification of lactucaxanthin from green lettuce was established for its effective use in food and pharma application as antidiabetic and eye protective nutraceutical like lutein.

### Amelioration of diet induced diabetes (Baskaran V)

The stimulation of adenosine monophosphate -activated protein kinase (AMPK) is a prime target to decrease the hyperglycemic condition.
Hence, lutein (L) and oxidised lutein (OXL) were studied against this target molecule for the treatment of type II diabetes. In the current study, a plausible interaction of L and OXL with AMPK was investigated by molecular docking. In addition, the effect of L and OXL for the activation of AMPK that triggers the downstream regulator peroxisome proliferator-activated receptor v coactivator 1a (PGC-1a), TFAM expression, mitochondrial DNA (mtDNA), mitochondrial biogenesis and superoxide dismutase 2 (SOD2) in high glucose treated HepG2 cells were investigated by quantitative polymerase chain reaction and Western blot analysis. Molecular docking reveals higher binding affinity of L ( $\Delta G$ =-6.3 kcal/mol) and OXL ( $\Delta G$ =-15.5 kcal/mol) with AMPK, compared with metformin ( $\Delta G$ =-5.0 kcal/mol). The phosphorylation of AMPK increased by 1.3- and 1.5-fold with L and OXL treatment, respectively, in high glucose induced HepG2 cells. The activation of PGC-1a is significant (P<0.05) in OXL group than L. Similarly, TFAM expression is increased with L and OXL compared to the high glucose group. Further increase in SOD2 and mtDNA, confirms the efficacy of L and OXL in restoring the mitochondrial biogenesis in high glucose induced cells through AMPK, PGC-1a, and TFAM.

Lutein has a potential antioxidant, antidiabetic and anticancerous activity, however lutein has limitations like being sensitive to heat, pH, light. Also, lutein is hydrophobic in nature, which limits its bioavailability. Hence, in order to enhance the physicochemical properties, solubility, stability and bioavailability, the focus was on the nanoencapsulation of lutein using natural polymers (chitosan and sodium alginate). Lutein nanocarrier (LNC) system was optimized by the application of Plackett-Burman factorial design and the LNC were optimized for the particle size, polydisperability index (PDI) and zeta potential. The dynamic light scattering and the scanning electron microscopy examination revealed that the optimized LNCs surface morphology was smooth and spherical and the particle size ranged from 40 to 160 nm (mean 125 nm). The zeta potential and PDI were found out to be 45 ± 5 mv and 0.174 ± 0.02 respectively. In vitro release profile of lutein from LNCs showed the control and sustainable release (upto 71%) upto 72 h. Aqueous solubility of LNCs (230  $\mu$ g/ml) were much higher upto  $\approx$  1000 fold than the free lutein (230 ng/ml). Fourier transform infrared spectroscopy analysis showed no chemical interaction among CS, SA and lutein, indicating the possible weak intramolecular force (hydrogen bonding). Differential scanning calrometry and X-ray diffraction analysis revealed that the lutein is distributed in a



Characterization of lutein-loaded Ncs. (A) Particle size distribution, (B) zeta potential, (C) SEM and AFM micrograph along with morphological structures of the free and nanoencapsulated lutein, phase contrast microscopy images, magnification 40X (D) and 100X (E).

disordered amorphous state in LNC. The bioavalability studies using Caco-2 cell lines showed the total transport of lutein from LNCs was 40% more than the mixed micelles. Results suggest that LNCs is an efficient carrier for enhancing stability, solubility, hydrophilicity and bioavalability of lipophilic carotenoid molecule lutein, which helps in its application as nutraceutical in food and pharmaceutical industries.

### Indian brown algae nutraceuticals on obesity prevention (Baskaran V)

Effects of FUCO (Fx), Polysaccharides (P), lipid (L) and drug (orlistat) on oxidative stress and thermogenesis in obesity were assessed. Obesity was induced in male C57BL6 mice (23 days old) by giving lard (60% kCal) in diet (HFD). FUCO (Fx) (200 uM/kg body weight), Polysaccharides (P) (2%/kg body weight), lipid (L) (2%/kg body weight) and drug (orlistat) (20 g/kg body weight) was given for 1 month after induction of obesity as a micelle with 2.5 mMmonoacyl glycerol, 7.5 m Moleic acid and 12 mM taurocholate. Plasma and liver oxidative stress and thermogenic parameters (in adipose) were assessed. Plasma and liver nitric oxide, MDA and protein carbonyls were significantly (p < 0.05) increased in HFD group compared to control and treatment groups which showed recovery to normal levels. Catalase, SOD, glutathione peroxidase and glutathione transferase activity and glutathione level in plasma and liver of HFD group were significantly (p < 0.05) decreased. Plasma HDL, LDL, cholesterol, and phospholipids were significantly (p < 0.05) increased in HFD group that was reverted to normal in treatment groups. The expression of PPAR-y, Akt, P-38 was higher in HFD group adipose (p < 0.05) compared to treatment groups, indicating

inhibition of adipogenesis. UCP-1 and p-Akt expression were higher (p < 0.05) in treatment groups compared to HFD group suggesting thermogenic activity of brown algae nutraceuticals. Histopathology of liver and adipose tissue indicated that the triglyceride content in the liver and adipose tissue of HFD groups was highest, which was comparable to control in the treatment groups. The groups administered with Fx, and lipids exhibited highest obesity prevention compared to polysaccharide and were at par with the drug.

### Anti-cataract potential of lutein in presence of EPA-DHA (Baskaran V)

Lutein is a major antioxidant and blue light filter present in the lens and retina. Increased oxidative stress and inflammation precedes lens opacification. Lutein in combination with n-3 fatty acid down regulated oxidative stress markers, proinflammatory cytokines and eicosanoids and restored the antioxidant potential in cataract induced mice model.Serum and lens nitric oxide, MDA and protein carbonyls were significantly (p < 0.05) increased in cataract compared to control and experimental groups. Catalase, SOD, glutathione peroxidase and glutathione transferase activity and glutathione level in serum and lens of cataract group were significantly (p < 0.05) decreased. Serum eicosanoids (PGE2, LTB4, and LTC4) and cytokines (CRP, TNF-a, IL1-b, and MCP-1) were significantly (p < 0.05) increased in cataract. The activity of cPLA2 and Cox-2 in cataract lens was higher (p < 0.05) compared to other groups. Inflammatory markers EP-1, NOS-2 and NF-kb expression were higher (p < 0.05) in cataract. The ratio of water insoluble to water soluble protein was increased in cataract lens. Group administered with lutein (L) + unsaturated fatty acids (EPA-DHA) exhibited

highest cataract prevention compared to lutein + fatty acids linoleic acid (LA) and oleic acid (OA). Percent of cataract was calculated by measuring the opaque area/clear area X 100 using Image J Software.



### Food for high altitude induced loss of appetite (Gopinath M)

One of the key physiological challenges faced with living at high altitudes (HA) (3500 m to 6100 m), is loss of appetite (known as anorexia). This, coupled with the increased energy demand (5000 cal at HA versus 2500 Cal at normal altitude) leads to muscle atrophy and weight loss at HA. In mammals, hunger is regulated by a hormone ghrelin. Reduced ghrelin level is one of the causal factors in anorexia. Hence, restoration of ghrelin levels either by triggering its endogenous secretion by stomach cells via phytochemicals or delivering mature ghrelin peptide via nanocarriers in human GI tract holds the key for solving this issue. Phytochemicals often exhibit poor bioavailability in GI tract. Screening phytochemicals from edible plants, isolated as nanovesicles for ghrelin inducing capacity in stomach adenocarcinoma cells is the main aim of the project. In addition, the efficacy of mature ghrelin peptide packaged into edible nanovesicles for its delivery potential and hunger inducibilityis also investigated. Both aims are at their early stages of discovery.

### Exploring the effect of diabetes on pathology of the lung (*Ravindra PV*)

In the long term, diabetes profoundly affects multiple organs, such as the kidney, heart, brain, liver, and eyes. The gradual loss of function in these vital organs contributes to mortality. Nonetheless, the effects of diabetes on the lung tissue are not well understood. Clinical and experimental data from our studies revealed that diabetes induces inflammatory and fibrotic changes in the lung. These changes were mediated by TGF-β-activated epithelial-to-mesenchymal transition (EMT) signaling pathways. The studies also found that glucose restriction promoted mesenchymal-toepithelial transition (MET) and substantially reversed inflammatory and fibrotic changes, suggesting that diabetes-induced EMT was mediated in part by the effects of hyperglycemia. Additionally, the persistent exposure of diabetic cells to high glucose concentrations (25 mM) promoted the upregulation of caveolin-1, N-cadherin, SIRT3, SIRT7 and lactate levels, suggesting that longterm diabetes may promote cell proliferation. Taken together, the results demonstrate for the first time that diabetes induces fibrotic changes in the lung via TGF-B1-activated EMT pathways and that elevated SMAD7 partially protects the lung during the initial stages of diabetes. These findings have implications for the management of patients with diabetes.

### Nutritionally and nutraceutically enriched gel-based products for endurance exercises (*Ravindra PV*)

The strain tissues in the body undergo structural, functional and metabolic changes in response to the endurance stimuli. The nutritional requirements for the strain tissues during the preparatory and recovery phase of the endurance training varies. Traditionally, during endurance exercises, salted peanuts, banana, oranges, glucose biscuits, etc., are provided to meet the nutrition demands of the tissues. However, commercially there are no products in the market that can provide all-inone (the energy demand, attenuate the oxidative stress and tissue inflammation, as well as repair muscle fibres and promote a quick recovery) needs and that is made of all natural products that is tailor-made to specific phase of endurance exercise. Therefore, gel-based edible products (V2Max Endure) that can encompass the endurance requirements of tissues was developed. The results in cell culture and animal model of endurance show that endurance products improve the endurance by increasing the mitochondrial biogenesis and activation of lipid breakdown. Currently, products are being produced on a larger scale in the pilot plant and are being validated in human athletes by conducting trials.

### Molecular link between diabetes and its role in the development of non-alcoholic fatty liver disease (NAFLD) (*Ravindra PV*)

The project aims at the investigation of the molecular association between diabetes anddevelopment of non-alcoholic fatty liver disease (NAFLD). Furthermore, it also aims at elucidation of the role of epigenetic factors such as non-coding RNAs in diabetes-induced NAFLD. Additionally, the project is also designed for screening of bioactives that have a potential to prevent or attenuate diabetes-induced NAFLD. Type 2 diabetic *in vitro* cell line model as well as *in vivo* mouse models were developed and characterized by diabetic-specific assays. Diabetic cells showed resistance to glucose uptake by 3 fold compared to the control, while diabetic animals

exhibited elevated blood glucose, HBA1c, liver enzymes, lipid profile etc. Further results indicated increased cellular infiltration in the liver tissue, elevated NF- $\kappa$ B, collagen 1, fibronectin, and  $\alpha$ -SMA levels suggesting that diabetes induces both inflammatory and fibrotic changes in the liver tissue. Currently, studies are being done to investigate the mechanism of diabetes induced fibrotic changes in the liver.

### Microbes and their metabolites for food and health (Venkateswaran G)

Production of natural vinegar through fermentation using banana fruits as a substrate was optimized and the concentration of acetic acid ranged between 3.35-4.97 µg/ml. Major polyphenols noticed were gallic acid, methyl catechol, ferulic acid, caffeic acid and myristic acid. Total sugar content was found to be 0.302-0.674 mg/ml and reducing sugar was 0.25-0.43 mg/ml. Two Saccharomyces cerevisiae strains viz. commercial strain and NCIM 3176 were evaluated for biomass production in both batch and fed-batch cultivations. The strain NCIM 3176 achieved a maximum biomass concentration of 10.95 g and 45.26 g DW/L in batch and fed-batch cultivations, respectively. The yields corresponded to 0.43 and 0.46 g DW/g glucose in batch and fed-batch cultivations, respectively. The process has been standardized for 100 L using 40 L working volume. The production costs were calculated, and it was found that 1 kg of wet cake would cost approximately 85-90 INR.

### Metabolic engineering of Saccharomyces cerevisiae for overproduction of squalene (Sarma MVRK)

Genome scale model for *S. cerevisiae*, iMM904, was used to find gene deletion and

overexpression targets in order to improve squalene flux. Based on this in-silico study, a double mutant strain SK21 (*lys1\Deltaadk1\Delta*) was developed and validated in-vitro for squalene improvement. Pathway engineering strategies, modified medium conditions, and fed-batch cultivation have synergistically improved the squalene synthesis to a titer of 1937 mg/L. This is 121-folds higher than the original laboratory strain BY4741. Finally, the metabolically engineered strain SK22 was adaptively evolved in the presence of Erg1p inhibitor, terbinafine, for enhanced squalene accumulation. The squalene accumulation in shake-flask experiments of evolved strain SK22 reached to a maximum of 400 mg/L and 193 mg/L in the presence and absence of terbinafine, respectively. It was observed that neutral lipid content and clustering of lipid droplets increased with increase in squalene accumulation. Overall, the present study provides insights into genetic perturbations, adaptive evolution and process development for improved squalene synthesis using S. cerevisiae.



Fed-Batch cultivation of engineered *S. cerevisiae*. Time course profiles of squalene and ergosterol with (A) glucose as the carbon source under high aerobic conditions, (B) glucose and ethanol as a carbon source under low aerobic conditions

### Characterization of anti-microbial compound produced by food-fermenting bacteria (Prakash M Halami)

To evaluate the diversity among nisin-like lantibiotics, 10-LAB cultures that showed

positive response to nisin specific reporter (AUT1) were characterized. Three nisin producing cultivars were characterized by whole genome sequencing. Twelve Bacillus spp producing subtilin-like antibiotic was also charactezed in addition to Bacillus licheniformis MCC 2512<sup>™</sup> that is known to produce sublichenin. Taxonomical identification of B. tequilensis and B. velezensis (known to produce subtilin like bacteriocin) by 16S RNA gene sequencing was carried out. Nisin producing LAB cultures (C2d, SP2C4 and FS2) by whole genome sequencing showed high similarity with Lactococcus lactis ssp. lactis. C2d and SP2C4 harbornis A gene and FS2 harbornis Q gene. Whole genome sequencing of plantaricin producing two Lactobacillus plantarum cultures - DHCU70, Dkp1 was done. Through BLAST analysis, bacteriocin encoding operon was identified and found to show similarity with NC8 type of plantaricin, whose mode of action was other than inhibiting cell wall or DNA biosynthesis.



#### Novel RNA biosynthesis inhibiting peptide antibiotics of probiotic bacteria (*Prakash M Halami*)

Work on characterization of antimicrobial peptide of *Bacillus licheniformis* MCC 2514 known to inhibit RNA biosynthesis was undertaken. Antimicrobial peptide was found to be inactivated by proteinase K and was of low mol.wt. (~3 kDa). Besides nanopore technology, whole genome sequencing was carried out to ascertain the genes responsible

for peptide antibiotic production. The whole genome sequencing of the bacterium B. licheniformis MCC2514 was performed using long-read generating PacBio SMRT sequencing. The genome consists of a single contig yielding a total length of 4,230,480 bp with an average GC content of 46.2%. The genome annotation was completed using RAST server and resulted in 4647 coding sequences and 4836 genes. PHASTER analysis of the genome identified 4 intact prophage regions comprising a total of 173.3 Kb length and consists of 196 coding regions. Genome analysis using Bagel4 software identified two unique antibacterial lassopeptides namely, Microcin J25 and Capistruin which are inhibitors of bacterial RNA polymerase, which is under focus for further characterization.



Butanol extraction and MOA of AMP produced by *B licheniformis* 

### High value bio-based product for healthcare and cosmetic applications (Praveena B Mudliar)

Decaffeination of caffeine containing waste produced by tea and coffee processing industries and its value addition by microbial biotransformation to methylxanthines (MX) was investigated. Strategies to increase caffeine yield by modification of the conventional method of solvent extraction indicated that steam injection improved extraction yield of

caffeine (2 fold) from coffee husk (0.3g/100 g), coffee bits and black (1.9g/100 g), tea dust (2.4 g/100 g) and dry tea leaves (1.9 g/100 g) which were used as the source of caffeine containing by-products. A process was designed for the production of valuable methylxanthines (MX) by using a fungal culture previously isolated in the laboratory. Further studies indicated that alvcerol could be used as a cost-effective carbon substrate for caffeine biotransformation to MX. The optimized parameters for production of MX was found to be caffeine 1 g/L, glycerol 6 g/L, temperature 30°C, inoculum size 10<sup>5</sup> spores/ml with an agitation speed of 150-250 rpm. Initial fermenter studies (1.5 L) showed that the shake flask experiments could be scaled up with no loss in product yield (0.4 g MX/g caffeine).

### Utilisation of banana bunch stem from municipal waste (Anu Appaiah KA)

Banana is one of the largest herb groups in the world. Banana farming generates huge quantities of biomass, all of which go as waste due to the non-availability of suitable technology for its commercial utilization. Even though the leaves are used to a restricted quantity as animal fodder, the part of banana bunch stem biomass is not used as animal fodder directly, because of its high polyphenols content. Hence, the study was focused to resolve this problem. Batch fermentation experiments were carried out for seven days using KTP strain of Saccharomyces cerevisaeand viable count of the fermented samples was estimated on every 0<sup>th</sup>, 1<sup>st</sup> and 7<sup>th</sup> days of incubation. Nutritional analysis and spectrophotometric mediated analysis of total sugar, total reducing sugar, total polyphenols and total flavonoids of fresh banana bunch stem and fermented stem samples was performed. The moisture content of banana bunch stem was 89.5%, pH 6.5, proteins7.567 g, fat-0.0958 g and ash content of 0.3294 g. The total soluble solids increased with decrease in polyphenols content. It can be concluded that banana bunch stem polyphenols can be reduced through a fermentation process and can produce value-added product for society.

### **Fixed oils from the Indian spices** (Ajay W Tumaney)

In addition to the 14 spices reported last year, extraction of fixed oil were successful from 9 more Indian spices namely asafoetida, mace, aniseed, pomegranate seed, marjoram, parsley, Pepper longum, dill and turmeric. Colour and refractive index analysis of the fixed oil were done. Fatty acid profiling of the fixed oil through GC-MS was performed. Antioxidant assays namely FRAP, TEAC and DPPH were done to estimate the antioxidant potential of the fixed oils. For nutraceutical estimation, total phenolic and phytosterol content of the fixed oils were quantified using spectrophotometer based analysis. Total phenolic, tocopherol and phytosterol content were also estimated by HPLC.

Mustard seed (33.83%) recorded the highest amount of fixed oil whereas turmeric (0.16%) parsley (0.96%) showed the least fixed oil content. Palmitic, oleic and linoleic acid were the predominant fatty acids while presence of very long chain fatty acids ranging from C22:0 to C28:0 were also detected in asafoetida, parsley, marjoram and mustard fixed oil. Apart from mustard fixed oil, an alternative source of erucic acid was found in asafoetida fixed oil. Among all spices, mace and pomegranate seed fixed oil showed highest antioxidant property owing to their high phenolic content. Phenolic analysis by HPLC showed that cinnamon fixed oil had the highest amount of cinnamic acid, gallic acid and quercitin. Phytosterol levels were recorded to be highest in tejpat and chilli fixed oil. All isomers of tocopherols were found to be highest in tejpat fixed oil.

### Polyunsaturated fatty acid accumulation in chia (Salvia hispanica) seeds (Ajay W Tumaney)

Salvia hispanica (Chia) is the highest reported terrestrial plant source of heart healthy omega-3 fatty acid, alpha-linolenic acid (ALA). Mature seeds contain around 62-65% of ALA, as determined by GC-MS, and an oil content of 26-30%. Amino acid sequences of corresponding acyltransferases taken from Arabidopsis (TAIR) served as a query for a TBLASTN search against assembled transcripts of S. hispanica. Putative PDATs (phospholipid : diacyglycerol acyltransferase) & DGATs (diacylglycerol acyltransferase) identified were cloned into S. cerevisiae for their functional and biochemical characterisation. The quadruple mutant strain (H1246) of S. cerevisiae that lacks TAG was used for functional characterization. Transformation of H1246 with acyltransferases showed functional DGAT1 & PDAT1 enzymes that were able to restore TAG biosynthesis in mutant. BODIPY staining further confirmed lipid droplet formation upon acyltransferase activities. PDAT2 protein expression was observed. However, it was not able to form TAG in mutant. Substrate feeding assays with linoleic acid (18:2) and linolenic acid (18:3) showed that PDAT1 was able to incorporate these PUFA's in a concentration dependent manner when compared with DGAT1, indicating a more predominant role in channelling polyunsaturated fatty acids into TAG.

### Profiling and functional characterization of rice bran lipases (*Vijayaraj P*)

The present study was aimed to identify acyl-

hydrolases from rice bran by activity-based proteome profiling (ABPP) and genome sequence analysis. The interference of lipids in the form of an endogenous substrate is a potential challenge in ABPP assay due to the competitiveness between the serine hydrolase probes and endogenous lipids. The analysis of particular class of proteins, especially enzymes require an active state during isolation. Lipid removal is an essential step in protein extraction for the downstream applications. Organic solvents were extensively used as delipidation agents, but they render the proteins denatured and biologically inactive. Hence, it was aimed to address the major challenge and limitations in the removal of endogenous lipids from lipid-rich biological samples for functional proteomics. The delipidation protocol was revisited and a rapid, solvent-free delipidation method was developed using activated silica. The functional integrity of the proteins in the delipidated samples was validated by enzyme assay and ABPP approach. The delipidated protein samples showed improved clarity and a significant reduction of endogenous lipids. Detection of serine hydrolases using ABPP labeling was enhanced upon delipidation. Further, the total polyphenol content was reduced significantly, which helps to enhance the protein enrichment and small molecule screening by ABPP. Collectively, these results suggest that the present solvent-free delipidation approach is efficient and highly compatible with functional proteomic applications.

# Inhibition of monoacylglycerol lipase for the management of obesity and prevention of diabetes (*Vijayaraj P*)

The study aims to create an integrated platform for the functional characterization of lipid metabolizing enzyme and its therapeutic potentials. The human monoacylglycerol lipase gene was cloned and overexpressed. The purified recombinant protein was used as enzyme source to screen inhibitors from food



sources based on traditional knowledge as well as human consumption. Based on the in vitro enzyme assay and ABPP using recombinant hMAG lipase, a set of extracts were shortlisted for further study. The 3T3-L1 cells were used for in vitro validations since the cells have higher expression of MAG lipases and activity. First, the expression of MAG lipase was examined in 3T3-L1 cells by immunoblot analysis using monoclonal anti-MAGL antibody. There was a significant level of MAG lipases expression in the cell-free lysate, and it was reduced by the JZL184 inhibitor. The cells were cultured in the presence of various extracts, and the level of MAG lipase expression was monitored. The result depicted that the expression was reduced significantly with few extracts, particularly millet bran extracts. The rice bran extract (B-rb) was used as one of the controls. The inhibition observed with rice bran extract could be due to the oryzanol. The *in vitro* inhibition of pancreatic lipase by oryzanol was reported, however, this is the first report on inhibition of MAG lipase by oryzanol. The MAG lipase activity was monitored in cell-free lysates (control and extract treated cells). Interestingly, there was a significant inhibition observed with the B-Ex1, B-rb, and LS1 extracts and it was 85-90% inhibition as compared with control. The number of lipid droplets was also significantly

low in B-Ex1, B-rb and LS1. Further, biochemical and mRNA analysis needs to be done. The deliverable will be the potent monoacylglycerol inhibitor molecules from food sources for the management as well as the prevention of obesity and diabetes.

### Inhibition of pancreatic lipase enzyme for the management of obesity and diabetes (*Vijayaraj P*)

The goal of the proposed study is the inhibition of pancreatic lipase enzyme by dietary supplementation for the management and prevention of obesity and diabetes. The reduction of lipid absorption could control the circulatory FFA-mediated insulin resistance and the prevalence of diabetes. Hence, the restriction of dietary lipids is a promising target to control obesity mediated complications. The consumption of legumes positively correlated with the reduction of body weight. Lipase inhibitors using porcine and human pancreatic lipases were identified and evaluated in the present study. The highly sensitive fluorometric method was adopted to access the pancreatic lipase activity with anthocyanin. Based on the preliminary results, the mode of inhibition was studied for cyanidin and cyanidin-3-glucoside. The IC<sub>50</sub> value of cyanidin was 28.29  $\mu$ M which was 6.5-fold higher than the cyanidin-3glucoside (188.28 µM). An apparent Ki of 27.28 µM was determined for cyanidin and cyanidin-3-glucoside (88.97 µM) with noncompetitive inhibition. Collectively, these results suggest that the glycosylation of the anthocyanidins significantly reduces lipase inhibition. The noncompetitive inhibition of pancreatic lipase may exert significant pharmacological activities toward obesity complications by calorie restriction. Similar experiments were performed with human recombinant pancreatic lipase.

### **Probiotic drink using natural media** *(Muniasamy N)*

Lactobacillus plantarum, a widely used probiotic organism is grown on MRS agar or broth which consists of beef extract and other synthetic components for inducing the growth. Utilizing the naturally available green media like tender coconut water (TCW) will mainly reduce the cost when compared to the conventional media. Using this green media may increase the biomass, normalized growth media and it is a green alternative to animal based protein products and other standard media.TCW media with supplements for the growth of probiotic bacteria L. plantarum was developed and the study shows that *L. plantarum* grown in MRS broth and TCW have the same morphology. TCW based probiotic drink was developed as a non-dairy based alternative for people with lactose intolerance and strict vegan diet consumers.



Scanning electron microscope images of *L. plantarum* grown in (a) MRS broth and (b) Tender Coconut Water (TCW) show same morphology

#### Ketogenic food products (Ajay W Tumaney)

Ketogenic diets are characterized by a reduction in carbohydrates (usually to less than 50 g/day) and a relative increase in the proportions of good quality fat and protein. Recent advances have shown that these diets and recipes can be implemented as an independent or adjuvant therapy for various

lifestyle related metabolic disorders. The currently available ketogenic recipes and products are mostly from western origin and there is a need for Indian ketogenic food products in different formats. In this project, various Ketogenic Product (KP) for Indian palate are being formulated and developed. Three KP such as keto-shake, keto-patty and keto-appetiser have been developed with low carbohydrate and high fat composition. Formulation optimization studies have been performed on these products to get desirable composition and acceptable sensory profiles. The sensory analysis has shown that products are acceptable. The in vivo study in mice to substantiate the ketogenic claim on these products is under progress.



Keto Shake

Keto Patty Keto Appetiser

### **Instant natural nutraceutical mix** (Vikas Singh Chauhan)

The fresh fruit extract of *Morus alba* (mulberry) was dried using maltodextrin as a carrier material to obtain a readily dispersible nutraceutical rich powder. A readily dispersible algal base was prepared by drying the fresh biomass of Spirulina platensis using starch as a carrier material. Both the mulberry and spirulina powders were characterized for antioxidant activity and bioactive compounds. Beverage bases were developed from a combination of spirulina and mulberry fruit extract and nutritionally characterized to explore the effect of interaction among the various phytonutrients and bioactive compounds. The spirulina and mulberry based ready-to-dilute instant dry mix using different natural flavours

was formulated. Natural amla and lime based dry mix were given to panelists for sensory analysis and based on the response, natural amla flavor was selected for product development. The final formulations of instant natural nutraceutical mix developed are comprised of dispersible spirulina base, with sweetened natural amla flavour and dispersible spirulina base and mulberry fruit extract with sweetened natural amla flavour.

### Bioactive metabolites from the fruits of under-utilized plants: *Malphigia glabra* and *Ixora coccinea* (*Giridhar P*)

The phtyoconstituents analysis, antioxidant potential, major bioactives characaterization from fruits of M. glabra and I. coccinia were accomplished in the earlier studies. Also, 3 food formulations based on Acerola and Ixora fruit extracts were attempted. The formulations based on Acerola fruit extracts appears to be good in terms of sensory score. The mineral content of the fruits of both Acerola and Ixora were studied. In I. coccinea fruits, potassium was present in highest concentration with 128 mg and the least amount of mineral was copper with 2.78 mg. Other minerals like, iron (6.95 mg), calcium (12.98 mg), magnesium (9.27 mg) and sodium (6.49 mg) were also present whereas zinc was absent in the 100 g of fruits. In fruit pulp of Malpighia glabra too, calcium (10 mg), iron (0.3 mg), Mg (15 mg), potassium (135 mg), Zn (0.05 mg) were recorded per 100 g fruits. Once again the acerola fruit extract based food formulation- Marzipan was prepared to verify its suitability for a process.

### Root specific flavour metabolite 2-hydroxy-4-methoxy benzaldehyde in Decalepis hamiltonii (Giridhar P)

The precursor ferulic acid feeding to D.

hamiltonii callus suspension culture medium for the accumulation of vanilla flavour metabolites i.e., 2H4MB, vanillic acid, vanillin gave a good response with substantial increase in the levels of these metabolites. This would be having implications in biosynthesis of respective vanilla flavour attributing metabolites at very high levels for their large scale production. Expression pattern of various genes involved in 2H4MB production during tuber development in D. hamiltonii was studied and the results indicate that the flavour compounds vanillin and 2H4MB increases with maturation of tuber. But this increase was limited to 3 years of maturation and later, much increase in flavour content was not observed. The expression of key PPP genes like DhPAL, DhC4H, DhCOMT and DhVAN increases with flavour content and maturation until the tuber reaches the second stage, DhC4H maintained constant expression even in third stage of maturation. Only DhPAL showed parallel increase in gene expression with flavour content throughout the three stages. DhVAN and DhCOMT genes showed a decrease in their expression from second to third stage of tuber maturation. All the key phenyl propanoid genes are directly or indirectly involved in flavour biosynthesis along with maturation of tubers in D. hamiltonii. Second stage of tubers is transcriptionally more active compared with first and third stage of tubers.

### Metabolite profile and betalain biosynthesis in Basella spp. (Giridhar P)

Basella rubra L. (Basellaceae) in vitro callus culturing for pigment production was continued. Callus growth curve studies with optimized medium NAA (0.1 mg/L) and BAP (6 mg/L) to assay the biomass production for 6 weeks on weekly harvest. A progressive increase in callus biomass was noticed till 5th week of culturing with an yield of 12.42 g which later on reduced to 7.64 g. Photoperiods play a crucial role for obtaining the maximum biomass wherein continuous light > photoperiod 16L:8D > continuous dark. A three fold increase in the chlorophyll content in continuous light callus cultures was noticed compared to initial weeks. The total phenolics and flavonoids were maximum during the 1st week of growth in 80% aqueous ethanol and water extracts, respectively. The continuous light maintained callus cultures showed good antioxidant activity in methanol extract at 1st week of culturing. Optimization of culture conditions for the production of pigment in suspension cultures was successful up to 1 L capacity. LC HRMS characterization of the obtained pigmented suspension cultures was successful. A positive influence of addition of 10% coconut water into the culture medium showed three folds increase in biomass with green colouration.

### Bioengineering of 4-hydroxy isoleucine diosgenic production in fenugreek (Nandini P Shetty)

Enhanced metabolite production using elicitors will be of great interest to the food industry because it will be cost effective and improve the overall nutrient value of the leaves. The knowledge generated in the project on plant metabolic gene networks in response to external stimuli can be applied by industrial end-users for enhancement of secondary metabolites. These compounds were detected by screening different varieties and stages of seeds, leaves and seedling and the germplasm with high amount of these compounds were used to establish in vitro culture systems. The scaling up of these high-value metabolites would enhance the production of the metabolites which could be used in food products.

### Microalgae as an alternate source of bioavailable vitamin $B_{12}$ (Sarada R)

Spirulina and Chlorella biomass were used as a source of bioavailable vitamin B<sub>12</sub> in Wistar rats. Results clearly indicated that vitamin B<sub>12</sub> from the Spirulina and Chlorella biomass is bioavailable in the Wistar rats and it can be one of the alternative sources of bioavailable vitamin B<sub>12</sub> Further, the animal fecal, cecal matter were evaluated for microflora. Nutrition has a major influence on the composition of the gut microbiota affecting the health. Feeding of Chlorella and Spirulina biomass to Wistar rats facilitated the increase of the favourable gut bacteria viz. 4-log increase in Bifidobacterium, 2-log increase in Lactobacillus and total bacteria of fecal matter and 2-log increase in Bifidobacterium and total bacteria in cecum. The cecum performance of the rats was also improved in the algal biomass fed group as indicated by the increased cecum weight (70% in Chlorella and 50% in Spirulina biomass fed rats). Fecal matter bacterial flora viz Bifidobacterium, Clostridium, total bacteria, lactose fermenting bacteria, non-lactose fermenting bacteria, Lactobacillus were investigated.

#### **Biodiesel production using indigenous microalgae of North-East India** (Sarada R)

Microalgae strains were obtained from Assam Central University (ACU), Assam collected from different areas of North-East India. The microalgal cultures were maintained in BG-11 and BBM media. Microalgae were characterized for their growth profiles, proximate composition and pigment content. Biomass yield varied among microalgae in the range of 1.18 to 0.81 g L<sup>-1</sup>. All the strains showed protein content of 41-53%. The phycocyanin content was in the range of 5-7% (w/w). Among

the Cyanophycean species, Oscillatoria contained 25.8% lipid, Westiellopsis (an edible cyanobacteria) 21.4% and Lyngbya sp. 16.4%. In Oscillatoria and Westiellopsis saturated fatty acids (SFA) formed the major proportion (61-66%) followed by 27-29% of monounsaturated fatty acids (MUFA) and 7% polyunsaturated fatty acids (PUFA). In Lyngbya, PUFA constituted 29% of total fatty acids with GLA and ALA as major and with 3% EPA. The Chlorophycean microalgae Tribouxia and Chlamydomonas contained 17% and 23% lipid with SFA as major followed by PUFA and MUFA. Both the strains showed variations in their fatty acid profiles and Chlamydomonas showed 8% EPA while *Trebouxia* showed 2% DHA and 10% ALA. In all the algal species, palmitic or myristic acids were predominant among SFA while palmitoleic or oleic acids were major fatty acid among MUFA.

Scale-up studies in indigenous designed airlift photobioreactor were initiated. *Tribouxia* sp. was cultivated on trial basis. Productivity of biomass was 4 times more compared to flask experiment. Algal density (~1 OD) was achieved in 8 days in photobioreactor as compared to 20 days in flask culture. Lipid and other biochemical analysis is in progress. All hydrodynamic and mass transfer properties such as mixing time, liquid recirculation velocity, gas holdup required for scale up were worked out. Optimization of various parameters such as  $CO_2$  conc., light and pH are under progress.

### Plant cell wall deconstruction of cropresidues and biotransformation to valueadded products (Sandeep N Mudliar)

The dilute acid, steam explosion, 2-step: steam explosion followed by alkali were evaluated for pre-treatment of rice husk (RH) and wheat

straw (WS). The maximum hemicellulose and lignin removal via degradation and dissolution was observed for SEA pre-treatment of WS, enabling higher cellulose enrichment (up to 57% w/w) and recovery (up to 87%). In both the substrates, the hemicellulose solubilization was >90% for all the pre-treatments, while maximum lignin removal (up to 67%) was observed for SEA pre-treatment for WS. The biomass particle size in the range of 0.3-0.6 mm enabled higher pre-treatment efficiencies in terms of cellulose enrichment. The liquid fraction obtained after DA pre-treatment indicated higher COD values (16120-28080 mg/L) as compared to SEA (10920-13520 mg/L) due to lower cellulose recoveries in DAP (65-72%). SEM analysis of the biomass indicated disrupted regions with multiple pores. FTIR analysis revealed cleavage of lignin side chains, and XRD analysis confirmed increase in cellulose crystallinity post pre-treatment.

#### Anaerobic co-digestion of FOG (Fats, Oils and Grease) containing sludge from dairy industry (Sandeep N Mudliar)

The characterization of FOG (fats, oils and grease) and waste activated sludge (WAS) were carried out from a local dairy industry near Mysore for various physico-chemical parameters such as COD, total solids, lipid content, proteins, carbohydrates along with fatty acid content and profile. The characterization for the second dairy industry near Nagpur has been initiated to understand the variations in characteristic parameters across different dairy industries. The COD was in the range of 90000-120000 mg/L, while the lipid content was in the range of 40–60%. The fatty acid profile indicated predominance of saturated fatty acids.

The low-thermal pre-treatment system along

with anaerobic digestion has been optimized which enhanced methane production up to 52% along with enhanced COD reduction up to 60%. Anaerobic bioreactor has been indigenously designed with energy efficient impeller induced mixing in a draft tube and scaled up to 10L. The pilot scale anaerobic digester for FOG sludge with improved mixing via draft tube was designed, fabricated and installed. The prototype membrane bioreactor system (20L) has been indigenously developed; and is integrated with the anaerobic digestion system to facilitate 'zero' discharge. Studies were also conducted to understand the types of fouling, chemical and AOP based protocols for membrane cleaning is being studied.

### High performance hybrid process development for CO<sub>2</sub> sequestration into hydrogen and high value metabolites (Ajam Shekh)

Isolation and identification of 7 microalgal isolates from various lakes and ponds in the vicinity of Nagpur from Central India has been done. These microalgal isolates were screened for biomass, lipids and other high value metabolites like pigments, PUFAs and other speciality fatty acids. Detail characterization of these isolates was completed for lipid storage potential, quality of lipid with respect to FAME analysis and phenolic content. The performance of these isolates was also tested under nutrient and oxidative stress. Studies were carried outto establish a relationship between stress, ROS production and lipid enhancement in the cells. Interim results corroborate the elevated PUFA containing lipid content under stress with positive correlation to ROS in the cells. One of the isolates is also characterized for stearidonic acid which has significant nutraceutical applications.

#### **Dietary modulators on key targets in diabetes** (*Nandini CD*)

One of the metabolites produced by Hexosamine Biosynthetic Pathway (HBP), UDP-GlcNAc plays an important role in regulating function of proteins by O-GlcNAcylation. Till date the role of AMPK modulation on O-GlcNAcylation is not evaluated. The role of AMPK on GlcNAcylation in NRK-52E cells (proximal renal tubular cells of epithelial origin) was determined. siRNA was used to knockdown AMPK which resulted in decreased global O-GlcNAcylation indicating that HBP pathway is affected. Further, global O-GlcNAcylation levels of protein in cell lysates were significantly higher in cells grown in high glucose condition. Interestingly, pharmacological AMPK activator, A76 did not attenuate the increased O-GlcNAcylation levels alluding to the fact that it does not act on HBP pathway. Further work to determine the role of AMPK modulators is underway.





#### Glucose-stimulated insulin release (Ravi Kumar)

The effect of vanillic acid (VA) on potentiation of GSIS was tested using the INS-1 pancreatic  $\beta$ -cells. Dose-response studies demonstrated

that VA could potentiate glucose-stimulated insulin secretion at 10 µM concentration while maximum potentiation was observed at 50 µM in the presence of 8.3 mM of glucose. VA exhibited glucose lowering property in rats with high glycemia treated at 30 and 60 mg/kg, compared to control group. In both, VA 30 mg/kg group and VA 60 mg/kg groups a significant reduction in the blood glucose level were observed suggesting the hypoglycemic effect of VA in rats with high glycemia. In addition to reduced glucose levels, VA significantly increased the insulin levels in these rats. The maximum amount of secreted insulin estimated in VA 30 mg/kg and VA 60 mg/kg groups was 1.34, 1.82, µg/L respectively. The data suggest that VA reduces the glucose level by increasing the insulin in VA treated rats. These results also support the results of VA mediated GSIS in INS-1 cells and isolated islets of Langerhans.

#### **Bioactive compounds in ameliorating the NAFLD** (*Pulla Reddy B*)

Non-alcoholic fatty liver disease (NAFLD) is characterized by abnormal accumulation of fatty acids and triglycerides in the hepatocytes. Effect of policosanol (60-70% 1-octacosanol extracted from sugarcane wax) inNAFLDinduced C57BL6 mice was determined. Policosanol (100 mg/kg/body weight) treatment by oral gavage resulted in significant improvement in liver enzymes and lipid profiles (p < 0.05). Further, fat content in liver was decreased as a result of treatment. mRNA levels of key molecular targets Steroid Regulatory Binding Protein 1c (SREBP1c), Fatty Acid Synthase (FAS) and Perilipin-2 (PLPN 2) levels were also decreased as compared to untreated mice. Based on the results it can be concluded that policosanol will be useful in the prevention of NAFLD.

#### Maternal hypercholesterolemic diet on liver glycosaminoglycan metabolism of pre- and post-natal rats (Nandini CD)

The isolated and purified glycosaminoglycans (GAG) was tested for binding to lipoprotein lipase (LPL). LPL, is an enzyme which obligatorily requires the presence of GAG, especially of heparan sulfate class for its activity. LPL in endothelial cells is found tethered to heparan sulphate (HS). Loss of HS leads to loss of its activity. A simple methodology was developed based on the principle of metachromasy with the dye dimethyl methylene blue (DMMB).



Principle of Glycosaminoglycan-Lipoprotein binding assay

Using the protocol, GAGs isolated from liver of animals from various developmental stages were tested for binding with LPL. Results revealed that in early developmental stages, GAGs from E-19H and P7H showed decreased metachromasy which correlates to increased binding of GAGs to LPL. However, they were found not significant to their respective controls. On the other hand, GAGs from P21, 8W and ML showed increased metachromasy because of decrease in LPL binding. This shows that there are modifications in the GAG chains which cannot be figured out by carrying out global disaccharide composition analysis.

#### Structural basis of promiscuity in sugar nucleotidylyl transferases family of enzymes (Balaji Prakash)

Extensive study on a sugar nucleotidylyl transferase (SNT) – GImU, led to the classification of members of SNTs family into five distinct groups. The aim was to biochemically validate the predictions made from the structural bioinformatics work. The absence of 3D structures for many SNTs precludes the understanding of substrate promiscuity exhibited by many SNTs. It was also aimed to crystallize and determine the structure of the representative enzymes from several subgroups of SNTs.

Mg<sup>2+</sup> dependence of nucleotidylyl transferase activity: All SNTs catalyze the transfer of a nucleotide monophosphate moiety from nucleotide triphosphate to the phosphate group of a sugar, to form an activated sugarnucleotide. The two-metal ion bound crystal structure of GImU had uncovered the roles of these metal ions in the catalysis of nucleotidylyl transferase reaction. Earlier, it was shown that for GImU (class 1A) and CaUAP1 (class IIA), Mg<sup>2+</sup> was absolutely required for activity. The conservation of characteristic 'Mg<sup>2+</sup><sub>4</sub>-stabilizing/ substituting motifs' in uncharacterized SNTs may indicate a similar dependence on metal ions for catalysis. To test if this was indeed the case -- two putative, uncharacterized SNTs a) NG<sup>GT</sup> (glucose-1-phosphatethymidylyl transferase from Neisseria gonorrhoeae and b) TT<sup>EC</sup> (2-C-methyl-D-Erythritol-4-phosphatecytidylyltransferase from Thermus thermophilus) were chosen. For these two SNTs, the activity was measured at increasing concentrations of Mg<sup>2+</sup>. Further experiments employing mutants with abolished  $Mg^{2+}$  stabilizing activity indicate that  $Mg^{2+}$  is indispensable for catalysis by SNTs. The importance of  $Mg^{2+}$  ions for catalysis in both  $NG^{GT}$  and  $TT^{EC}$  are demonstrated.



Metal ion dependency on the nucleotidylyl transferase activity of SNTs: (A) Nucleotidylyl transferase activity of SNTs against increasing concentration of Mg<sup>2+</sup> ions with uridyltransferase activity expressed as percentages of maximal activity. (B) Nucleotidylyl transferase activity was assayed for wild-type SNTs and corresponding mutants and the product formed by wild type protein considered as 100%.

### Novel antimicrobial peptides for diverse applications (Balaji Prakash)

Advances in computational biology have aided the identification of novel drug targets and opened avenues for therapies based on inhibition of specific proteins or their interactions. Concurrently, unlike small molecule drugs, peptides are considered better for targeting protein-protein interfaces due to the larger surface area and multiple interactions they offer. A range of naturally occurring peptides act as inhibitors, toxins and modulators of biological functions. The latest computational methods lend confidence to denovo design new functions to biomolecules. Exploiting these, the aim of this project is to redesign such peptides as anti-microbial against specific target(s), via suitable modifications. Preliminary work affirms feasibility of such an approach.

### Anti-angiogenic potentials of marine algal carotenoids (*Ganesan P*)

In continuation to the previous findings, the effect of lutein isolated from marine alga Chaetomorpha sp. on the expression of TSP-1, MMP-2, MMP-9 and IL-8 was analysed. The results indicate that lutein significantly upregulated those migration signalling markers. Together these data show that lutein promotes endothelial cell tube formation (angiogenesis) by activating cell migration but, not through activation of cell proliferation. On the other hand, neoxanthin exhibited anti-angiogenic effect with significantly reduced tube formation on the in vitromatrigel model. Collectively, these data emphasize that carotenoids possess differential effect on angiogenesis, which may be due to variation in the functional group(s) present in their structure.

#### MksB protein on chromosome condensation and segregation (*Ravi Kumar*)

DNA molecules carrying genetic information are inordinately long in size and therefore cannot be accommodated in the cells as such. These molecules need to be condensedin size by several folds. SMC/MukB proteins belong to a large family of ATPases with a five-domain structure. The N and C terminal globular domains are connected to a flexible domain called hinge by two coiled-coil arms. The N and C-terminal globular domain consist of a conserved Walker A and Walker B motifs

respectively and together they constitute the head domain. MksB proteins have a MukB like structure, but with a significantly shorter coiledcoil region.

*M. smegmatis* MksB (MsMksB) exhibited binding towards larger DNA substrates. Therefore, in the subsequent studies, the dimer fraction of MsMksB was characterised. To further assess the DNA binding properties of MsMksB dimer and its variants with larger DNA substrates, EMSA on agarose was performed.



EMSA showing binding properties of MsMksB with larger DNA molecules

The DNA-protein complexes were resolved on 1.2% agarose followed by gel electrophoresis. Similar to EcMukB, MsMksB also showed binding with different forms of DNA but with a lower affinity. A similar phenomenon of reduction in the DNA binding affinity was observed in case of PaMksB. Incubation of negatively supercoiled plasmid with increasing concentration of MsMksB led to the formation of h i g h a p p a r e n t molecular weight complexes. The binding of MsMksB to DNA was also found to be independent of either ATP or a divalent cation, MgCl<sub>2</sub>.

### Characterization of FADS from food pathogens (Ravi Kumar)

Flavoproteins are an important constituent of living system where they perform a number of vital functions. The cofactor required for the proper functioning of this enzyme are Flavin Mono Nucleotide (FMN) and Flavin Adenine Dinucleotide (FAD). The biosynthesis of these cofactor in prokaryotes is carried out by FAD synthase (FADS), a bifunctional metalloenzyme. The riboflavin kinase (RFK) activity of *S. aureus* FADS was characterised. It was showed that RFK domain had a preference for Mg<sup>2+</sup> as a divalent cation and it is necessary for the kinase activity. Also, the helix deletion construct of FADS showed an impaired RFK activity whereas FMN adenylyl transferase activity was unaffected. This implicates the role of helix domain present as a hinge in RFK activity of FADS.

### Bioactive peptides mediated protection of prediabetes/ diabetes associated cardiomyopathy (Poornima Priyadarshini CG)

Prediabetes is defined as impaired fasting glucose and impaired glucose tolerance occurs before the development of *Diabetes mellitus*, and increases all the risk factors associated with diabetes including diabetic cardiomyopathy (DCM). The transition from prediabetes to diabetes varies and may take many years depending on the individual. However, the current estimate indicates that the individuals with the pre-diabetes eventually develop *Diabetes mellitus*. Further, the microvascular and macrovascular



complications typically associated with diabetes are detected even before the development of the diabetes. Hence, determining the cardiovascular risk and cardiac dysfunction at prediabetic condition gain utmost importance in order to reduce the morbidity and mortality associated with diabetes. Dipeptidyl peptidase 4 (DPP4) is identified as one of the important clinical marker of prediabetes and known to play an important role in the progression of DCM. However, the relevant therapeutic strategies towards the management of prediabetes is still unclear. Thus, by inhibiting DPP4 right at prediabetic state, it is presumed to be a better strategy to manage/prevent the evolution to most serious stages of the disease. Towards this project, potential bioactive peptide inhibitors are identified, characterized using activity studies in vitro, cell based assaysand by in silico binding studies. Animal experiments in prediabetes model are in progress.

### Dipeptidyl Peptidase 4 (DPP4) inhibition by polysaccharides of plant/animal origin and their potential role in diet induced obesity (Poornima Priyadarshini CG)

One of the recently approved therapy for both type 2 diabetes and obesity is the incretin therapy. Glucogon like peptide1 (GLP1) and gastric inhibitory peptide are the incretins involved in glucose homeostasis. In obese condition, GLP1 action is impaired when compared to normal condition. GLP1 exerts a

potent insulinotropic activity. It also reduces appetite, suppresses glucagon secretion, slows gastric emptying and stimulates β-cell regeneration. Epidemiological studies conducted on obese patients by intervening with food molecules have reported to give positive results. Carbohydrates and polysaccharides comprise a major portion of our daily diet. Dietary fiber and some other complex polysaccharides transit the gastrointestinal tract and reach the distal portion of the gut wherein they undergo fermentation and act as a food for gut microbiota. Polysaccharides from different sources have shown to bring down obesity by increasing GLP1 levels. Another mechanism through which GLP1 levels can increase is by inhibiting DPP4 enzyme. DPP4 is an exopeptidase enzyme that cleaves GLP1 at Nterminal and reduces its activity. DPP4 level is found to be higher in obese condition. Based on this background, among the polysaccharides, Glycosaminoglycans (GAGs) was chosenand it was extracted from bovine milk. GAGs have shown anti-obesity effect in animal models. Extraction process of GAGs from milk was standardized. The GAGs composition in the bovine milk was identified and their role in adipocyte differentiation is in progress using cell culture models.

### Detection and quantification of food adulterants and contaminants

(Prasanna Vasu)

A new LC-MS/MS method was developed for aflatoxin (B1, B2, G1 & G2) and patulin analysis, which showed good linearity  $(r^2 > r^2)$ 0.98), with good recovery and repeatability/reproducibility (RSD, <20%). HPLC methods were optimised and validated for deoxynivalenol (DON), and ochratoxin A (OTA). The sensitive and specific LC-MS/SRM method for formaldehyde analysis showed good linearity ( $r^2 > 0.999$ ) for Girard P derivatized stable isotope labelled. Addition of vegetable fat can be detected by presence of lauric acid in chocolate by GC method, which is allowed only upto 5%. To understand the comprehensive lipid profiling and discriminate the ghee samples, rapid and non-invasive Fourier Transform Infrared Spectroscopy (FTIR) was used. Analysis of 90 ghee samples collected from different origin (cow, buffalo) and regions of India indicated a finger print region (1350-1200 cm<sup>-1</sup>) to discriminate the origin of the ghee samples. Characteristic changes assists to identify the geographical origin of the samples.

### Structural characterization of porphyrin analogs (Usharani D)

Porphyrin analogs have huge applications in biological and opto-electronical fields as photodynamic therapy agents, materials for solar energy conversion materials for nanomolecular devices, and nonlinear optical applications. Fine tuning the porphyrin analogs for NIR absorption enables them to use in biomedical applications such as tissue diagnostics, photodynamic therapy dyes and microscopic imaging agents. Conformationally rigid Hückel aromatic ethynylene-cumulene conjugated heteroannulenes have been synthesized, characterized and observed with NIR absorption. The work was carried out in collaboration with IACS, Kolkata.



NIR absorption of ethynylene-cumulene porphyrin analog

### Maternal nutrition and lactation performance (Kannan R)

High-end UHPLC-MS/SRM methods were developed to quantify micronutrients (B-vitamins and fat-soluble vitamins) and



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macronutrients (protein and lactose) from human milk and sera. The B-vitamin analysis showed vitamin B5 is the highest and B8 is the lowest in human milk samples. The trend of Bvitamins based on the concentration showed B5>TC>B2>B1>B3>B6>B9>B8.

B-vitamins analysis in human milk are B1 (thiamine, TMP, TPP), B2 (riboflavin, FAD, FMN), B3 (niacin, nicotinamide), B6 (pyridoxine, pyridoxamine, pyridoxal, PLP, pyridoxic acid), B9 (folic acid, 5-MTHF), TC (betaine, choline, acetylcholine).

### **Mycotox in inbreast milk samples** *(Kannan R)*

UHPLC-MS/SRM method was developed to quantify 6 aflatoxins (aflatoxin  $B_1$ ,  $B_2$ ,  $G_1$ ,  $G_2$ ,  $M_1$ and  $M_2$ ) and 2 ochratoxins (OTA and OTB) from milk samples (cow, goat, buffalo and pasteurized milk samples) collected in local. Sodiated OTA seems to be present in all milk samples.  $M_1$  and  $M_2$  were present only in cow, goat and pasteurized milk samples. This method was applied to analyse mycotoxin content in human milk samples, which showed only the sodiated OTA in trace amount.

### Food based molecules as inhibitors of PCSK9 (Asha Martin)

Proprotein convertase subtilisin/kexin type 9 (PCSK9) has been identified as a novel target for the treatment of hypercholesterolemia. Selected molecules of dietary origin were screened for their ability to modulate PCSK9 and low-density lipoprotein receptor (LDLR) expression. One of the lead molecule designated as C1 validated by *in vitro* cell based assays for its inhibitory activity of the PCSK9/LDLR interaction and capability of increasing LDL uptake. The effect of C1 on cell surface expression of LDLR and LDL uptake was confirmed by immunofluorescent staining of LDL receptor. Furthermore, expression of protein level of PCSK9 and LDLR was confirmed by Western Blot. *Invitro* cell based results revealed that C1 is a promising candidate for designing a novel potent inhibitor of PCSK9. To ascertain the potency of the lead molecule, C1 compound was synthesized andits purity was confirmed by NMR and HRMS.



Control C1(1µM) C1(5µM) Bodipystaining in HepG2 cells (control and treated cells)

### Garlic essential oil as potent biofumigant against pulse beetle (*Ezil Vendan S*)

Four edible essential oils were investigated for the control of stored product insects. Among the tested essential oils, garlic oil was identified as most potent biofumigant against the tested stored product insect pests. Initially, effective dose of garlic essential oil to achieve 100% mortalities in Sitophilus oryzae, Oryzaephilus surinamensis and Callosobruchus maculatus with 25 and 500 g of respective food commodities was determined. A new model of grain storage bin was designed and developed with the capacity to hold 25 kg of grains and pulses. Nearly 100% insect control was achieved in C. maculatus at an appropriate dose of garlic essential oil fumigation for 72 h exposure containing 20 kg of either green gram, chickpea or green pea commodities. For S. oryzae and O. surinamensis, <50% insect

control was observed with garlic essential oil for 72 h exposure containing 20 kg of wheat grain. Sedimentation analysis results revealed that wheat and rice grains had more absorption affinity to phyto-volatiles than green gram which was confirmed by the GC-MS analysis. Phytochemical residue removal methods were studied and it was observed that 98% of residue could be removed by aqueous method.

### Bioactives from *Piper betle* ad its efficacy against stored grain fungi and *Sitophilus oryzae* (*Sumithra Devi S*)

The less explored plant material Piper betle which is edible and has therapeutic values was evaluated against stored grain insect pest Sitophilus oryzae and selected fungi. Insecticidal activity of Piper betle leaf powder was evaluated at different concentrations i.e. 1%, 3% and 5% concentration on rice weevil in grain (wheat). A dose and time dependent mortality was observed. Powder at 5% concentration resulted in 95% mortality by 14 days, whereas, at 1% and 3% levels 95% and 98.3% mortality was observed by 21 days. EA extract of P. betle leaves against S. oryzae, at 1000 ppm recorded 93.33% mortality by 21 days. 100% reduction in F<sub>1</sub> progeny emergence was observed with betle leaf powder treatment whereas the EA extract exhibited >80%reduction in F1 number. Acetyl cholinesterase activity both in vivo and in vitro studies were carried out to evaluate the effect of P. betle leaves extract on S. oryzae. In in vivo studies, 30% inhibition in AChEase activity was observed, whereas, in vitro studies revealed 60% inhibition of AChEase activity. The potential of P. betle extract to inhibit growth of mold growth especially the storage fungi were determined. Considerable morphological alterations in hyphae and spores were observed. Shrivelled hyphal aggregates were



Scanning electron pictures showing effect of *P. betle* extract on *A. flavus* mycelia. a- normal, b- treated and *P. thomii* spores- c- normal, d- treated.

commonly observed in the treated mycelia, compared with the regular, homogenous, normal hyphae in control.

### Phytocompounds and adjuvants on the stored product insects (Manivannan S)

The effect of selected phytocompounds for their insecticidal activity on rice weevil, Sitophilus oryzae was evaluated. The response of adults was carried out following treatment with individual phytocompounds viz., alpha-pinene, beta-pinene, thymol and myrcene and as binary mixtures. The adults of S. oryzae were exposed to various concentrations of phytocompounds *viz.*, 5, to 125  $\mu$ IL<sup>-1</sup> air for 24, 48 and 72 h, while the binary mixtures involved test concentrations at 25 and 80 µl levels with and without the presence of carbon dioxide as a carrier gas. The results indicated that the order of susceptibility of adults of S. oryzae to phytocompounds was beta-pinene>alphapinene>myrcene>thymol. The mortality of the adults of S. oryzae followed a concentration and time dependent response. It was observed that the least test concentration of beta-pinene i.e. 5 µl/L air, could result in 98% mortality of the adults over 72 h exposure. On the other hand,

the lowest mortality was obtained in 5  $\mu$ l/L air test concentration (4.4%) over 48 h exposure in alpha-pinene treatments. It was also observed that, complete mortality of the adults can be achieved at a test concentration of 100  $\mu$ l/L air even at 24 h exposure in myrcene treatments. Further, it was observed that a test concentration of 25  $\mu$ l/L air of beta pinene could induce complete mortality in *S. oryzae*, as against 100 $\mu$ l/L concentration recorded for alpha-pinene experiments. In the binary mixture studies, 80  $\mu$ l beta pinene + 80  $\mu$ l myrcene showed increasing mortality with 63.1%, while, the addition of CO<sub>2</sub> to this combination increased the mortality to 86.04%.

# Microstructural characteristics on the cuticular surface of stored product insect pests (*Ezil Vendan S*)

Cuticular surface in stored product insects (SPI) plays vital role in protection against physical and chemical stresses encountered during infestation activities. In order to understand the microstructural adaptability and functional potential of integuments, the cuticular surface in nine different species of SPIs was examined. Insect antenna, hindwing, forewing and legs were ablated from the active individuals and were observed under Foldscope. The observed images were recorded with the aid of smart phone device by fixing with Foldscope. Antennal apex system and characteristics of other antennal segments in SPIs are described. Remarkably, the dispersal of sensilla on the surface of integument in antennal segment was less in Sitophilus oryzae compared to other SPIs. Integument surface structure highly varied in forewings than in hindwings for all the observed beetle species. Fascinatingly, plain-circular, blob-circular and plain-rectangular chain markings were found in the forewings of *Callosobruchus maculatus, S. oryzae* and *Tribolium castaneum*, respectively. Further, tarsal claw system and their surface characteristics in SPIs are also described.



Foldscopic view of microstructures in the surface of forewing and hindwing of stored product insect pests. A-F: Forewing; G-L: Hindwing; A & G - Callosobruchus maculatus; B & H - Oryzaephilus surinamensis; C& I -Sitophilus oryzae; D&J - Lasioderma serricorne; E & K -Tribolium castaneum; F & L - Rhyzopertha dominica

### Bio-fumigation system for safe storage of food commodities against stored product insect pests (Ezil Vendan S)

Plant essential oils and phytocompounds are potential alternative to phosphine fumigant against the stored product insect pests. In the present investigation, five edible plant essential oils and three phytocompounds were evaluated against Sitophilus oryzae and Callosobruchus maculatus under with food condition. Synergistic action of essential oils with phytocompounds were evaluated at different combinations against the test insect species. Based on the screening study results, a formulation was prepared in the combination of peppermint oil, garlic oil and allyl disulfide in the ratio of 1:1:0.5. About 100% mortality of S. oryzae was achieved at 500 g of wheat grain. Designing and development of fumigation system and formulation based further studies are in progress.

### Quantitative determination of taurine in infant formulas, dietary supplements and energy drink (Asha Martin)

A liquid chromatography method involving post-column derivatization with ninhydrin was optimized and comprehensively validated with the aim of quantifying taurine in food supplements. Validation tests were performed for selectivity, accuracy, precision, linearity range, limit of detection, recovery and measurement of uncertainty. Excellent sensitivity, reproducibility and selectivity were achieved. Analysis of dilutions of taurine showed a linear response with a regression close to unity ( $R^2 = 0.9993$ ). The limit of detection and limit of quantification for the method was 1.8  $\mu$ g/L and 6.2  $\mu$ g/L, respectively. The overall percentage recoveries for these methods ranged from 95-98%. The validated method was applied successfully for the quantification of taurine in diverse food matrices rendering it suitable for use in enforcement laboratories.



Representative chromatogram of (a) taurine standard (10 µg/mL) (b) a mixture of H-G standard and taurine by post column derivatization at 570 nm

### CSIR Projects

### Fast Track Translational Projects

### i) Isolation of arabinoxylans from defatted cereal bran (Baskaran V)

Arabinoxylans (AX) were isolated both from defatted wheat and rice bran using 2% calcium hydroxide and 10% alkali in pilot plant at 1 kg level with varying yields. The methodology was modified by replacing dialysis step with ultrafiltration step. Moisture, ash, silica, fat, protein, crude fibre were determined in arabinoxylans isolated from wheat and rice bran. Calcium hydroxide extracted samples consisted of high amount of carbohydrate when compared to hemicellulose A and B. Protein, crude fibre (lignin and cellulose) and fat contents are negligible. Hemicellulose A extracted from rice bran consisted of relatively high amounts of silica followed by calcium hydroxide extract. GC analysis showed arabinose and xylose with highest peaks along with the presence of small amounts of glucose. Extraction of arabinoxylan using calcium hydroxide was scaled up with 5 kg as starting material successfully to obtain similar level of vield.

### ii) Non-thermal processing of liquid foods (*Rastogi NK*)

High-pressure processing facility (2.0 L) designed and developed at CFTRI was successfully commissioned. Experiments were conducted with sugarcane juice and tender coconut water (TCW). High pressure treatment (600 MPa, 50°C, 5 min) of sugarcane juice along with moderate amount of preservative

(SO<sub>2</sub> at 70 ppm) resulted in reduction of microbial count to safe level prescribed by FSSAI without affecting its ascorbic acid content. The non-thermally treated juice was safe during two-week storage at refrigerated temperature, and further storage study is under progress.

High-pressure treatments of TCW (500 MPa, 25°C for 5 min and 300 MPa, 45°C for 5 min) were able to reduce microbial count to safe levels as specified by FSSAI and samples remained safe during 4-week storage at 4°C. Ascorbic acid content was close to fresh TCW (80-100% retention) immediately after the treatment, while phenolic content of samples decreased drastically (78-83%), but remained unchanged during further storage. The high-pressure treated samples were sensorily acceptable. Further storage study is under progress.

### iii) Carbonated fruit juice beverage from selected fruit crops (*Vijayanand P*)

Technology for the carbonated fruit juice beverages from fruits viz., mango, guava, grape, lime, pomegranate, apple, orange was developed. Fruit pulp/juice extraction, pretreatment, concentration for different fruits were standardized. The fruit pulp/juice was pre-treated, blended and processed to achieve the desired quality. The fruit juice base was homogenized, carbonated and bottled under controlled conditions. Carbonated fruit juice beverages from these fruits were analysed for the nutritional, microbiological and sensory quality. Sensory evaluation indicated that the products were highly acceptable with respect

to colour, flavour, taste and overall quality. Technology for carbonated fruit juice beverages containing fruit juice/pulp will be advantageous to the consumers and farmers by increasing the consumption of fruits. Manufacture of fruit juice based carbonated RTS beverages is considered beneficial as it contains fruit pulp/juice. Technology for the carbonated fruit juice beverages was released for the entrepreneurs.

### Mission Projects

### *i)* Food and Consumer Safety Solutions (FOCUS)

#### Milk Spoilage Indicator (Matche RS)

Milk spoilage quality analysis was conducted in three different temperature conditions (38, 27, and 4°C) for pH of the milk, lactose content, COB test, alcohol test and acidity. TTI kinetics was performed to correlate the spoilage parameters. Activation energy of the pH and acidity during the spoilage of milk was correlated with the activation energy of colour changing TTI. Based on activation energy of milk spoilage parameters and indicator, the TTI was optimized and lab trials were conducted.

### Packaging-integrated biosensors for fruit juices (Matche RS)

Aseptically packed orange juice was taken for the study. Quality analysis and shelf life study of the orange juice was conducted at three different temperatures (40, 27, 10°C) and different time intervals. Quality parameters were assessed for colour, non-enzymatic browning, pH, Total Soluble Solids (TSS) and ascorbic acid. Aseptically packed orange juice was selected to identify the quality deteriorating metabolites such as ascorbic acid, acetic acid, ethanol, di-acetyl, furan derivatives, guaiacol

and furanoneswhich are responsible for the offflavour and off-odour of the juice. According to production of metabolites, sensory analysis and microbiological study (bacteria, yeast and mould) the spoilage period of the orange juice was selected as well as TTI was designed which changes colour according to quality deterioration of juice.TTI kinetics was obtained by keeping the opened juice pack (200 ml) at different temperature conditions (40, 27, 10°C and the spoilage analysis was done at different time intervals.TTI indicator/sensor have the correlation of colour change with the spoilage of the juice. Real time monitoring of the freshness of juice can be done by the TTI indicator/sensor developed.

### Smart packaging- Spoilage indicator for meat (*Matche RS*)

Processed and packed chicken sample was procured and stored under three different temperatures (4, 27, 37°C) as well as quality parameters such as colour, texture, pH, TVBN analysis and microbiological study were observed at different time intervals.TVBN analysis and total viable count (TVB) for the raw chicken were observed at three different temperatures (4, 27, 37°C) and accordingly spoilage limit was decided.Indicator strips were designed according to spoilage limit of chicken, which changes the colour with the increase in TVBN content. Indicator strips which shows the visual colour change with the spoilage of the chicken was designed where, the colorimetric pH sensitive synthetic as well as natural dyes were used and immobilized on paper. Hence the paper strip can be used as an indicator for the chicken spoilage. Laboratory trials were conducted and validation of indicator is being carried out by industry partner.

### Methods for the detection of food toxins and contaminants (Praveena B Mudliar)

A paper based format using aflatoxin B<sub>1</sub>(AFB<sub>1</sub>) specific aptamer was developed for the detection of the mycotoxin. The aptablot assay was based on aptamer as the capture agent followed by the addition of detecting agents namely anti-AFB<sub>1</sub> primary and secondary antibodies. The developed aptablot assay showed linearity over a wide range (1 pg/mL to  $1 \mu g/mL$ ) with a regression coefficient of 0.994. This method was also validated in food samples namely dried red chilli, whole black pepper and groundnut. The performance and sensitivity of the developed aptablot was compared to the conventional well based assay (competitive ELISA) and was found to have a broader linear range and higher sensitivity.

A colorimetric nanoprobe was developed for the detection of formaldehyde. The principle was based on enzyme-nanoparticle chemistry which led to a concentration dependent color change in the presence of formaldehyde. A qualitative test for formaldehyde adulteration in fish was developed using the designed biosensing principle. Semi-quantitative detection of HCHO ranging from 1 – 1000 ppm was also evaluated. Further validation of the assay is being carried out.

#### **Risk assessment and mitigation of acrylamide** (*Alok K Srivastava*)

Acrylamide is an important contaminant produced in the fried foods, which is receiving increasing attention because of its potential toxicity (neurotoxic and genotoxic). LC-MS/SRM method was developed and validated for acrylamide using labelled acrylamide as internal standard. The dynamic range is from 0.016 to 1  $\mu$ g/mL with R<sup>2</sup> of 0.999. The intraday validation showed accuracy of 82 - 101% with

CV 0.6-10% for LOQ and QC samples. Mitigation studies of acrylamide in foodsis also carried out. The preliminary studies gave promising results with organic acid salts of calcium.

### ii) Nutraceuticals and Nutritionals

### Nutraceutical formulation for the increased bioavailability of vitamin $B_{12}$ (Sarada R)

The project focused on evaluation of enhancement in the bioavailability and bioaccessibility of Vitamin B<sub>12</sub> in the nutraceutical formulation proposed by CIMAP. In view of this CFTRI animal ethical committee clearance has been obtained for carrying out the bioavailability studies of vitamin B<sub>12</sub> in rat model. Standardized the protocol for bioaccessibility of vitamin B<sub>12</sub> in *in vitro* model using standard B<sub>12</sub> and B<sub>12</sub> fortified AIN-93 diet. With Standard B<sub>12</sub>, 28% bioaccessibility was obtained and with Vit.B<sub>12</sub> fortified AIN-93 diet 22% was obtained. The cell viability by MTT assay was analysed in CaCo-2 cell line. Tested concentration (10-400µg/ml) of Glycyrrhiza glabra and Moringa oleifera extracts had no inhibitory effect on cell viability even after 48 h.

### Selenium and vitamin D<sub>2</sub> enriched formulation from Lentinula edodes (Shiitake) (Jyothilakshmi A)

The objective of the project was to determine the bioaccessibility and bioavailability of selenium and vitamin  $D_2$  from Shiitake mushrooms sent by IHBT. The mushroom samples were fortified with selenium and vitamin  $D_2$ . The total and bioaccessible selenium was determined.

Selenium content of the fortified mushrooms increased by threefold. Selenium bioaccessibility was determined by simulated

gastro-intestinal digestion method and selenium was determined by ICP. Bioaccessible selenium was also higher by three fold in fortified mushrooms but percent bioaccessibility of native and fortified mushrooms was similar. The table presents the vitamin D content of native and fortified mushrooms. Vitamin  $D_2$  content increased in a dose dependant manner irrespective of the mushroom part. Among the mushroom components, gills showed the highest vitamin D content followed by stipes. The studies on bioaccessibility of vitamin  $D_2$  bioavailability in the caco2 cell model is under progress.

Mushrooms	Total selenium	Bioaccessible selenium	Percent bioaccessibility
Native	2.61 ± 0.12	0.25 ± 0.03	9.6
Selenium fortified	8.03 ± 0.04	0.76 ± 0.05	9.4

Selenium content of native and selenium fortified mushrooms  $\ - \ \mu g/g$  sample

Sample description	Vitamin D₂ content (µg/g)	
Gills 20	42.9 ± 1.1	
Gills 25	44.3 ± 0.9	
Gills 30	85.6 ± 2.4	
Caps20	26.3 ± 1.1	
Caps30	62.4 ± 1.5	
Stipes 20	25.7 ± 0.5	
Stipes 25	26.6 ± 2.7	
Stipes 30	77.4 ± 0.9	

Vitamin D<sub>2</sub> content of native and irradiated *Lentinula edoedes* mushroom components with different doses

#### Nutrifoods for breakfast (Jayadeep A)

Development of safe, hygienic, nutritious and convenient breakfast foods for school children in 6 centres of 5 zones in the country, evaluation of product delivery, acceptability and nutritional improvement and preparation of blue print for setting up of model breakfast products processing line are the objectives of the project. Out of CFTRI technologies, the breakfast product mixes were identified based on types such as main course, adjuvant, sweet, beverage, snack and also based on convenience like RTE (ready-to-eat), RTR (ready-to-reconstitute) and RTC (ready-tocook) the products were selected. The products shortlisted includes 12 main course products, which includes 4 RTE products, 2 RTR products and 6 RTC products; 6 adjuvant products which are RTE; 3 sweets which includes 2 RTE and 1 RTC products; 3 beverages which include 2 RTR and 1 RTC products; 3 RTE snack products, which include 1 non-vegetarian item also.

Pan India breakfast items such as upma (spicy, sweet), poha soft (spicy) and khichdi (spicy, sweet) which are traditional, wholesome, acceptable and can be prepared in school level were identified from the list of technologies available in CFTRI. Nutritional and micronutritional quality were evaluated and it was found that there was a need to improve the quality with respect to iron, folic acid, B<sub>12</sub>, vitamin A, etc. As a part of development of SOP, large scale process trials of ready mixes of identified breakfast items were carried out and evaluated for their quality with respect to sensory, convenience of use and storage characteristics. Engineering aspects of few of the food mixes was done by looking into the raw material used, processing steps, material balance, machineries, scalability and costing.

Laboratory trials to improve the convenience of preparation and enhance the quality of breakfast items were carried out with different raw materials with the application of thermal, hydrothermal and drying technologies. This resulted in improved poha, upma, khichdi and development of a new product- instant brown rice noodle (masala/milky).



Uppma (spicy)

Sooji halwa



Poha spicy varients



Instant brown rice noodle



Khichdi (spicy)

### Alpha linolenic acid based nutraceuticals for cognition - chia component (Malathi Srinivasan)

The project aims at identifying nutraceuticals for various health conditions. Alpha linolenic acid (ALA) is an essential omega 3 fatty acid that gets converted to the LCPUFAs (Long Chain Polyunsaturated Fatty Acids), Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA), of which DHA is the brain lipid. Hence, it was proposed to study the effect of the precursor molecule ALA as a nutraceutical in cognition. Virgin coconut oil

(VCO) was also evaluated for cognition to see possible synergistic effects. *Salvia hispanica* (chia) seed is a very rich source of ALA and is being studied for its cognition enhancing properties. Optimization of extraction methods and encapsulation of chia seed oil as soft gels have been completed. Shelf life studies for chia oil is being done at monthly intervals. Effect of ALA in cognition was studied in mice models, by oral gavaging saline/ chia oil/ VCO to 2 months old normal mice. Uptake of the fatty acid was confirmed by checking for excretion in faecal matter, and by checking the fatty acid profile of the blood plasma.







A) GC profile of chia oil with ALA peak at RT 20.287 min. B) Fatty acid profile of chia oil extracted by ghani and solvent methods, alongside a 2 year old chia oil sample. The profiles are comparable. C) Softgel capsules of chia oil



[96]

Further, it was observed that chia oil intake resulted in decreased activity of acetylcholine esterase and beta secretase, although not statistically significant, as the experiments were carried out in normal mice. Future experiments will focus on cognition impaired mice and in humans (in collaboration with NIMHANS, Bangalore).

### ALA based nutraceuticals for cognition and depression management (Chauhan VS)

Four microalgae were selected for comparative study based on their lipid content and ALA profile. The microalgae were subjected to low temperature stress (5 and 15°C) and nutrient stress. Desmodesmus sp., an indigenous microalga showed an enhanced accumulation of ALA rich lipids. Low temperature stress (5°C) enhanced the lipid content by 1.5 fold to 34% and ALA fraction of total fatty acids to 44%. Nitrogen depletion enhanced the lipid content to 39%. However, the ALA fraction of total fatty acids reduced to 18%. Treatment with phytoharmones (0.5 ppm DAH and cytokinin) enhanced the specific growth rate by about 40%. The lipid content of phytoharmone treated cultures increased to 31% with no significant change in fatty acid profile. Mixotrophic cultivation with glucose showed higher growth profile. Sodium acetate (0.1M) and glucose (0.5M) enhanced the lipid content of the microalga to 43% (w/w), an increase of 1.8 fold compared to control. However, mixotrophic cultures exhibited a decrease in ALA fraction of total fatty acids. The culture of selected microalga, Desmodesmus sp., has been successfully scaled up to 200 L in outdoor open raceway ponds.

### Screening of spices for activity against neurodegenerative diseases (Borse BB)

Authentic varieties of spices viz., pepper,

turmeric, ginger and chilli were procured from Kannur, (Kerala), Mysore and Bydagi respectively. Samples were deposited in Botany department, University of Mysore and Herbarium voucher was obtained for the spice samples. Pepper oleoresin from three varieties of pepper viz., Panniyur, Panniyur 1, Kalluvally were prepared using ethanol and aqueous ethanol as extraction solvent. Turmeric oleoresin from Salem variety was prepared using ethanol, aqueous ethanol and water as extraction solvent. Ginger oleoresin from Mysore variety was extracted using ethanol and aqueous ethanol. Chilli oleoresin samples from Bydagi variety (8 samples) were prepared with ethanol and aqueous ethanol as extraction solvents. Oleoresin samples of pepper, turmeric, ginger and chilli were sent to CSIR-CDRI for efficacy studies for neurodegenerative diseases in C. elegans model system. Based on the results of the efficacy studies formulations will be prepared.

### Focused Basic Research / Niche Creation Projects

i) Data analytics based on diet diversity, food consumption and nutritional deficiency (Manilal P)

Baseline survey proforma for the collection of nutritional status data were made ready. Common food items from Raichur and Wayanad districts were standardized for different measures. Nutritive values such as protein, fat, CHO, energy, iron, calcium, zinc, vitamin A were calculated for each of these food items (100 g) by using Indian food composition tables (NIN). Nineteen CFTRI food products rich in protein, energy, vitamins and minerals with nutritional information were compiled, which are useful for affordable product recommendations to children. The datasets such as WHO, RDA and NFHS-4 were

normalised for data analytics application. Mid day meal and ICDS food scheme charts of both Karnataka and Kerala State were collected and nutritional information was calculated. The necessary permission from respective State Govt. departments for carrying out MDM/ICDS survey were obtained.

ii) Estabilishment of `National Analytical Facility' for analysis of nutraceuticals and chemical markers in food products (NAFANC) (Alok K Srivastava)

FSSAI regulations on supplements, nutraceuticals and special foods covers broad categories and carry detailed requirements about their claims, composition, labels, etc. The aim is to develop method to analyze simultaneously all the vitamins in food samples. Initially, HPLC method for vitamin ( $B_9$  and  $B_{12}$ ) analysis has been optimised. The HPLC method gave good recovery (95.5%) of vitamin  $B_{12}$  from fortified wheat samples.

iii) Translation of pre-clinically tested probiotic formulation to human population with emphasis on immunomodulation and gut microflora (Prakash MHalami)

Protocol was standardized with reference to inoculum size, duration of fermentation and carbon source requirements for the preparation of probiotic shelf-stable *dahi*. At the end of fermentation, the count of nisin producing

starter culture (Lactococcus lactis) and probiotic culture (Lactobacillus fermentum MCC 2760 was found to be 9.73 and 9.25 log cfu/ml, respectively. The product was served to volunteers for sensory and acceptability. The condition for freeze drying with suitable cryoprotectant was optimized and it was found that bacterial cells of L. fermentum MCC 2760 freeze dried with 5% DSM along with 4% sorbitol and 5% sucrose in sodium phosphate buffer showed maximum viability of 98.5%. Similarly, Lactococcus lactis freeze dried with 5% DSM and 5% each of sucrose and mannitol in a sodium phosphate buffer showed viability of 97%. Probiotic curd will be served to healthy individual to study immune-modulation and gut microflora. Effect of probiotic L. fermentum MCC2760on inflammatory markers and gut microflora in normal and high fat fed Mus domesticus (C57BL6 mice) was undertaken. Influence of probiotics curd that contains L. fermentum MCC2760 culture on change in gut microflora and inflammatory markers between high fat diet (HFD) and normal diet fed animals has been initiated.

iv) Structure-function relationships in enzymes critical for the survival of bacterial food pathogens (Balaji Prakash)

The goal of the project is to study some important bacterial enzymes using clearly defined strategies and obtain mechanistic details underlying their biological function. This is an important step in understanding how



SEM (a) and phase contrast microscopy (b, positive; c, negative) of probiotic Lactobacillus fermentum MCC 2760; d, SEM of Lactococcus lactis L-11

enzymatic actions are fine-tuned for the bacterial world. Variations across homologs manifest as species-specific tailoring of enzyme function. Using a multitude of techniques, such unique catalytic and regulatory sites in these enzymes are identified. Besides bringing a wealth of knowledge about the bacterial world, the sites identified can be targeted subsequently to design inhibitors, specific to food pathogens.

### Harnessing Appropriate Rural Interventions & Technologies (HARIT)

i) Empowerment of rural women in food processing sector with select technologies (Giriyappa K)

Under the project, relevant secondary data were collected on various socio-economic aspects and food crops grown at proposed aspirational districts of Karnataka (Raichur and Yadgiri). Few suitable technologies from the list of technologies from CFTRI were identified for implementation of training to women. Subsequently, a three member team from CSIR-CFTRI visited Raichur and Yadgiri districts and held discussions with stake holding officials including Deputy Collectors of both the districts and apprised them on the proposed project plan, methodology, sample women selection to empower them in food sector through CSIR-CFTRI technologies. During the meeting, a few clarifications were provided on the modalities and resources for training. It was suggested that, effective utilisation of trained women to empower them as entrepreneurs by linking available various State sponsored schemes existing is essential to empower women to make them selfemployed. Based on the inputs provided by the

participants, it was decided to organise two days orientation programme for local select officials on CSIR-CFTRI technologies and training facilities available for training the women group. This orientation programme was required to involve local officials in enrolling and identifying the right kind of enthusiastic women (100 beneficiaries each from District) for training at CSIR-CFTRI, Mysuru.

ii) Dissemination of nutrition, food safety, food research and hygiene practices to general public through social media (Sharma ASKVS)

A podcast on food nutrition, food science and food safety in Kannada titled `Oota Paata', in Hindi and English titled `Thali Tales' was started and 2 episodes were broadcast during the period.

### iii) Common facility centre for spice processing (Sowbhagya HB)

Wayanad district which is an aspirational district under Neethi Aayog was selected for the establishment of a Commom Facility centre (CFC) for spice processing. An FPO "Wasuki Farmers Society", Wayanad with 1500 farmers as members of the society was identified as the beneficiary in the Harit Project which is also justified as significant amount of spices viz., pepper, ginger and turmeric are grown in the district. In the first stage, a detailed discussion was held with the Society members and scientists from CFTRI on feasibility of setting up of a CFC for spice processing at their premises for the benefit of the farmers of Wayanad. Eight technologies of CSIR-CFTRI on value addition and processing of spices were identified mutually based on the raw material available in Wayanad and the marketing feasibilities. On mutual agreement, an MoU was signed by

CFTRI with the FPO "Wasuki Farmers Society" on 8<sup>th</sup> March 2019. A visit to the society was made by scientists from CFTRI to evaluate the land and existing facilities at the society premises and to decide upon the equipments required for processing of the spices. The land at the society premises was found to be sufficient and some of the equipments which were are already installed were found to be useful for the spice processing. Equipments which are required to be procured for spice

processing were identified. As a part of the objective of the project, a training programme on "Opportunities in Spice Processing" was conducted for the farmers of the society for two days on 19<sup>th</sup> and 20<sup>th</sup> March. Demonstration of the process of ginger dehydration, turmeric curing and ginger paste preparation was carried out for the farmers with lecture classes on processing of spices, powder preparation, value addition and packaging of spices and spice products.

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Ravendra Pratap Singh (Head) Co-ordinators Giridhar P (Ph.D. - AcSIR) Nandini P Shetty (Ph.D. - Universities) Ajay W Tumaney (Short Term Courses) Mukesh Kapoor (Integrated M.Sc. - Ph.D. on Nutrition Biology) Manjunatha JR (M.Sc. Food Technology) Asha Dinakar Hanumantha Jyotsna Rajiv Lakshmi K Rekha MN

# Library

# Manilal P (Head) Padmavathi T (Coordinator) Anseem Ahmed Bharathi Murthy P Mahadevi Shivappa S Somashekar KS Suneetha R Bhandarkar

# **Information & Publicity**

Sathyendra Rao BV (Head) Sharma KVSAS (Coordinator) Radha Ravishankar AC Renuka S

# **Planning, Monitoring & Coordination Manilal P (Head)** Anita CS Chaya Devi R Kumar B

Kusuma K Parigi Ramesh Kumar Udaya Kumara H

# Technology Transfer & Business Development Sathyendra Rao BV *(Head)*

Giriyappa Kollannavar Iboyaima Singh Ng. Kalpana SG Mahadev S Khanapuri Pattekhan HH Raghavendra SV

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## **Traditional Food & Sensory Science**

Venkatesh Murthy K (Head) Amudha Senthil Asha MR Babylatha R Chethana R Jeyarani T Mahesha I Manjula TC Roopa BS Sudheer Kumar Yannam

# Administration

Office of the Administrative Officer Prasad DJN (AO) Rao PVR

**Establishment - I Padmavathi HR(SO)** Sudhakar S Vijayalakshmi J Rao

**Establishment - II Padmavathi HR(SO)** Malini TS Nataraja C

Establishment - III/IV Anupama R (SO) Basavaraju C Niveditha D Preetha K Rajashekara M Rajdeep Singh Rathour

**Establishment - V Sujatha Ravikumar(SO)** Balarama CS Jyothi S Nagamani S Padmini M Ramesh S Usha Kiran KA **Establishment - VI Shobha S (SO)** Chanchala Kumari N Nagaraju M Santhosh G Savitha K Venkatesha P

Establishment - VII Rajashekar KL (SO) Maheswara Murthy M Shivanna K

Establishment - VIII Geetha S(SO) Bushra Masrur

**Hindi Implementation Unit Anitha S (***Hindi Officer***)** Abhilasha Singh Kashyap

# Finance & Accounts

Suman Kanti Roy (FAO) Rajesh V (SO) Basavanna K Bhuvaneshwar P Divya MV Manikanta Swamy SN Masthamma M Naushad Basha MR Pradeep R Prashanthi P Raghavendra TK Rajamallu M Ravi VK Shashikumar P Vasantha UR

**Transport Shobha S (SO)** Gangadharappa KC Hemantha Krishna M

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Mohammed Shauib Nanjunda R Rangaswamy SK Suresha S Venkatesh K

# **Stores & Purchase**

## Sundar HV (COSP) Shenbaganathan A (SO)

Abhijna Anil Govind Revankar Katanna Kavyashree L Lakshmi Nath Thakur Lawrence A Prasad T Ravikumar C Raviswamy HC Reshma Rajagopalan Savitha MP Shiva Kumar CR Somaiah PT Tembhekar Nitin Baburao Vijaya Kumar BV

## Canteen

Mahesh S Palakshan B Veeranna Ramakrishna Velu M

IFTTC Guest House Satheesh P (In-charge) Chikkabasave Gowda

Health Centre Kala R Swamy (Chief Medical Officer) Avilash S Rani (Lady Medical Officer) Devaraju P Gangamma Jayalakshmi MB Naveen Kumar AV Poornima N Sangeetha Lal EP Shivamallappa VM

#### Agri-horticulture

**Sreedhar RV (In-charge)** Ganesh Prasad PS Vittal Rao

Security Chandra Shekar (Sr. Security Officer)

# **CSIR-CFTRI Resource Centres**

RC Hyderabad Jyothirmayi T (Head) Balaswamy K Madhusudhan Rao D Nagender A Narasing Rao G Prabhakara Rao PG Rudrayya G Math Sathiya Mala B Sridhar Rachakonda Srinivasulu Korra Sulochanamma G Yadaiah M

RC Lucknow Gothwal PP (Head) Mahejibin Khan Rahul Singh

RC Mumbai Walde SG (Head) Ahuja DK Khadka Deo Bahadur Sher Singh Nandkishor Santhanam PSPM Shailaja R Sheetal Gupta



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