

## PERFORMANCE REPORT 2019-20



CSIR - Central Food Technological Research Institute Mysuru



## CSIR-CFTRI PERFORMANCE REPORT 2019-20

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

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Management Council / Research Council	117

### From Director's Desk......



It gives me immense pleasure to present the Performance report of the CSIR-Central Food Technological Research Institute for the year 2019-20. The report reflects the major measurable indicators of the research outcome as well as progress under major R&D activities.

The institute fared well in terms of publications in peer research journals, technology transfer, patents and HRD activities. Focused and intense efforts were made for reaching out to many academic Institutions, SHGs, Startups and Govt. agencies in furthering the impact of our knowledgebase beneficial to the society. It is gratifying to note that an External Cash Flow (ECF) peaked to more than double of the previous years and I can assure you all that with the partnerships, R & D capabilities and confidence of my colleagues would ensure a further smooth progress in the coming years. Outreach efforts got a thrust in terms of flood relief activities, science dissemination and JIGYASA efforts. Further, Skill development, Farmers-centric and Incubation Centre activities also advanced our efforts towards entrepreneurial activities.

Aligning with various National Missions, the Institute handled a large number of R&D projects in the current year which include the CSIR funded FOCUS and Breakfast Mission along with other FBR/NCP projects. The trust reposed by external agencies as our capabilities were immense as it has resulted in handling 89 Grant in Aid projects including the RashtriyaKrishiVikasYojana (RKVY) funded project for the establishment of Centre of Excellence (CoE) on Millets. Further efforts towards establishing a Global Rice Processing Centre also has been initiated with industrial funding. I am very happy to acknowledge the efforts of all S&T staff in getting associated with as many new CSIR projects under various categories.

I would like to express my sincere gratitude to DG-CSIR, Research Council and Management Council who have collectively guided and motivated our efforts for achieving the targets and milestones. It is my privilege to thank the funding agencies, Govt. departments and all other Stakeholders for their belief and confidence in us towards meeting the objectives under each of the schemes/projects.

Finally, it is my pleasure and pride to thank each and every one of my colleagues, importantly students and the entire '*Team CFTRI*' as the source of energy and strength in this journey.

I look forward to input from all our stakeholders in realising the mandates in the years to come.

Date : Aug 24, 2020

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

## Achievements at a Glance



Research Papers	118
Reviews	7
Book Chapters	19



Grant - in - aid	89
Consultancy	12
Sponsored	47



Industrial
Development

Patents Filed	5
Technologies Transferred	66
New Technologies Released	9



	M.Sc. Passed Out	30
Human Resource	ISMT Passed Out	30
Development	Ph.D. Awarded	42
	Skill Development Training	1233

# Achievements in Brief

#### 1. Research Publications

#### **SCI Publications**

- Achintya Kumar D., Latha M., Vijayaraj P., OsPLB gene expressed during seed germination encodes a phospholipase in rice, *3 Biotech*, 2020, **10(1)**, 30
- Aditi Goel, Prakash M. Halami, Jyoti Prakash Tamang, Genome analysis of *Lactobacillus plantarum* isolated from some Indian fermented foods for bacteriocin production and probiotic marker genes, *Frontiers in Microbiol.*, 2020, **11**, 40
- Akitha Devi M.K., Gyanendra Kumar, Giridhar P., Effect of biotic and abiotic elicitors on isoflavone biosynthesis during seed development and in suspension cultures of soybean (*Glycine max* L.), 3 *Biotech*, 2020, **10(3)**, 98
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- Amarjeet Kumar, Kudachikar V.B., Development, characterisation and efficacy evaluation of biochemical fungicidal formulations for postharvest control of anthracnose (*Colletotrichum gloeosporioides* Penz) disease in mango, *J. Microencapsulation*, 2019, **36(1)**, 83-95
- Amrutha Kala A.L., Karthik Kumara, Nanishankar V. Harohally, Lokanath N.K., Synthesis, characterization and hydrogen

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- Ankit Jain, Subramanian R., Manohar B., Radha C., Preparation, characterization and functional properties of *Moringa oleifera* seed protein isolate, *J. Food Sci. Technol.*, 2019, **56(4)**, 2093-2104
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- Apramita Devi, Anu Appaiah K.A., Andrew L. Waterhouse, Adsorption and biotransformation of anthocyanin glucosides and quercetin glycosides by *Oenococcus oeni* and *Lactobacillus plantarum* in model wine solution, *J. Sci. Food and Agriculture*, 2020, **100(5)**, 2110-2120
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isolate from pigeon pea (*Cajanus cajan*) milling waste by-product: Functional aspects and digestibility, *Food & Function*, 2019, **5**, 2710-2719

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- Aruna P., Praneeth J., Chetana R., Singh R.P., Development of ω-5 and antioxidant enriched bar with pomegranate seed powder, *J. Food Processing and Preservation*, 2020, 44(3), e14359
- Avinash Kumar, Simmi P., Sreedharan, Giridhar P., Combining bioinformatics and conventional PCR optimization strategy for one-time design of high-specificity primers for WRKY gene family using unigene database, *Mol. Biol. Rep.*, 2019, 46(3), 3461-3475
- Bhavya M.L., Chandu A.G.S., Sumithra Devi, Quirin K.W., Akmal Pasha, Vijayendra S.V.N., *In-vitro* evaluation of antimicrobial and insect repellent potential of supercritical-carbon dioxide (SCF-CO<sub>2</sub>) extracts of selected botanicals against stored product pests and pathogens, *J. Food Sci. Technol.*, 2020, **57(3)**, 1071-1079
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#### 2. Patents Filed / Granted in India

#### Filed

- A novel process for the preparation of green amla powder
- A machine and method for continuous grating and separation of seeds from fruits
- A composition of natural bioactive agents for extending the shelf life of perishable material
- A paper based time temperature indicator for monitoring the freshness/spoilage of the perishable products
- Antimicrobial peptide and its use thereof

#### Granted

- An improved process for induced ripening of bananas
- A device useful for continuous frying and discharging of deep fat fried Urad vada and other similar kind of products
- Insecticidal compounds from Nothapodites foetida and a process for the extraction thereof

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

The following sixty six processes were released to 125 parties.

- Atta with multi grains/ multi whole grains flour
- Barcake
- Bioactive molecule rich green coffee extraction
- Blends of coconut oil with other edible oils
- Bottling of sugarcane juice

- Canned (aluminium cans) mixed veg curry & rice based convenience foods
- Canning of pineapple slice
- Carbonated fruit beverages from selected fruits
- Chikki / nutra chikki
- Coffee concentrate
- Compounded asafoetida
- Convenience flour from ragi suitable for stiff porridge
- Deep fat fried egg cubes
- Dehydrated egg cubes
- Desiccated coconut
- Dhal based nutritional supplement for foods
- Eggless cake premix
- Energy food
- Fermented & dehydrated ready mixes for idli/dosa batter
- Fish wafer
- Flaking of foxtail millet
- Fortified sugarcane beverage in glass bottles
- Foods for diabetics
- Fruit jams & jellies
- Fruit syrups & squashes
- Fruits & vegetable dehydration: grapes, banana, onion, potato, peas, green chillies
- Gravy paste for different Indian cuisine
- Groundnut (peanut) butter
- Instant cake mix
- Instant gravy mixes (dehydrated) Fish fry masala, ginger chicken kabab & garlic kabab
- Instant products from moringa leaves

- Instant traditional foods: Rasam
- Jamun fruit products (squash, RTS beverage, syrup)
- Kokum RTS beverages & squash
- Layered parotta (South Indian)
- Mini dhal milling system
- Modified atmosphere packaging of minimally processed vegetables (carrot, beans, cabbage, bitter gourd & curry leaves)
- Multigrain instant semolina
- Mutton pickle
- Neera bottling
- Nutra chikki with added spirulina
- Online fortification of atta (whole wheat flour) / maida (refined wheat flour)
- Osmo-air dried fruit (pineapple)
- Pasta: Chocolate, multigrain, legume based
- Paushtik atta
- Pickles & chutney
- Plant growth promoter: Containing Ntriacontanol
- Preparation of ready to cook multi grain whole mix for drink / porridge
- Process for extension of shelf life of bread with natural preservatives
- Production of atta (whole wheat flour)
- Production of soya protein hydrolysate
- Ready mix: Jamun
- Preparation of ready to eat shelf stable egg crunchy bite
- Ready mix: Upma
- Roasted & flavoured cashew kernels

- RTS fruit juices & beverages
- Rural based biotechnological production of spirulina
- Shelf stable chapati
- Shelf stable muffins with natural preservatives
- Spice mix formulation: Rasam
- Sugar free cup cake
- Tamarind juice concentrate
- Tutti fruity (papaya/carrot)
- Value added products from coconut instant adjunct mix, instant filling mix, coconut rice mix, coconut bites
- Virgin coconut oil
- Wafers: Egg, chicken & mutton

## 4. New processes ready for commercial exploitation

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

- A process for the preparation of DOLYMIX, a ready to use mix for soft and enhanced number of idlys
- Process for production of multigrain gluten free semolina
- Multigrain gluten free instant upma mix



Ready to use Idli mix - "Dolymix"

- Multigrain gluten free instant rava idli mix
- Multigrain gluten free instant halwa mix
- Production of sorghum (jowar) semolina
- Production of pearl millet semolina (sooji/rava)
- Instant upma, halwa and rava idli mix from barley semolina
- Production of rice grits / sooji



Multigrain gluten free instant halwa

#### 5. Consultancy/Sponsored/Technical Service/Grant-in-Aid Projects

Type of project	No. of Projects as on 31.3.2020	No. of Projects completed during 2019-20	No. of New Projects initiated during 2019-20
<ul> <li>Sponsored</li> </ul>	47	24	23
Consultancy	12	3	9
Grant-in-Aid	89	25	32

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

Academic Programmes		Degree / Certificate Awarded
•	M.Sc. (Food Technology)	30
•	Certificate Course in Milling	30
•	Skill Development Programme	es 1233

#### 7. Symposia, conferences and events organised / sponsored by CSIR-CFTRI

• National Technology Day (May 11, 2019)

As part of the National Technology Day celebration, Shri Arvind Varchaswi, Managing Director, Sri Sri Tattva, Bengaluru delivered the Technology Day address. An MoU was signed between CSIR-CFTRI and Karnataka Health Promotion Trust (KHPT) on flour fortification technology as part of the function. Shri Prasanna DA, Chancellor, NIE University, Mysuru was the Chief Guest of the function and delivered Technology Day lecture. Dr. KSMS Raghavarao, Director presided over the function. Distribution of awards & certificates to licensees was held as part of the function. On this occasion, recognition for Excellence in Industrial Projects & Technology Transfer for the year 2018-19 were conferred to Fruit & Vegetable Technology Dept. and Flour Milling, Baking & Confectionery Technology Dept.



#### • Awards Day (Jul 10, 2019)

Prof. R.S. Sangwan, Director, AcSIR, New Delhi 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. KSMS Raghavarao, Director presided over the function.



## • Symposium on Science Communication and Journalism (Aug 13, 2019)

One-day symposium on Science Communication and Science Journalism sponsored by Vigyan Prasar, New Delhi, as part of outreach activities of India Science Wire was organized in which 120 delegates from Mysuru, Chamarajanagar, Bengaluru, Mangalore and Mandya participated. The symposium was inaugurated by noted Kannada Science Journalist Shri Nagesh Hegde. Talks on Science Journalism, Science Communication through new media, Science Writing in Indian languages and a panel discussion on the status of science writing in Kannada were held.



## Hindi Fortnight Celebration (Sep 12-26, 2019)

Hindi Fortnight was celebrated at CSIR-CFTRI from Sep 12-26, 2019. Variety of competitions



in Hindi were conducted for the employees and research students of the Institute. Prizes to the winners of competitions and employees for their official work in Hindi under the incentive scheme were awarded by the Chief Guest, Dr. Kota Harinarayan, Former Director, ADE, Bengaluru on CSIR Foundation Day.

#### State Level Conference on Science Communication, Popularization and Extension in Kannada: Road Ahead (Sep 21-22, 2019)

A two-day state level conference on 'Science Communication, Popularization and Extension in Kannada: Road Ahead' was organized in which 150 participants attended. The conference was a joint effort of Vigyan Prasar and Kutuhali, a science communication movement in Karnataka. The conference was inaugurated by Director, CSIR-CFTRI. Dr. TV Venkateswaran, Chief Scientist, Vigyan Prasar was the Guest of Honour.

Sessions on Science in Print medium, Science and New media, Science magazines in Kannada were held. 48 resource persons from various fields delivered lectures during the conference.



### • CSIR Foundation Day Celebrations (Sep 26, 2019)

CSIR Foundation Day was celebrated on Sep 26, 2019. Padma Shri Dr. Kota Harinarayana, Former Director, ADE, Bengaluru delivered the Foundation Day address. Dr. N.R. Parasuraman, Director, SDMIMD, Mysore was the Guest of Honour.



As a part of the celebrations, 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 prizes to winners of the various competitions held as part of Hindi Fortnight Celebrations.

• India International Science Festival (IISF) Curtain Raiser Event (Oct 12, 2019)



The Curtain raiser event of IISF was held on Oct. 12, 2019. Dr. Harsh Vardhan, Hon'ble Minister of S&T and Earth Sciences Health & Family Welfare released IISF brochure and addressed the media about the event. Hon'ble Minister also had a glimpse of CSIR-CFTRI products and visited incubation facility in the Institute.

## • CSIR-CFTRI Foundation Day (Oct 21, 2019)



Dr. S. Ayyappan, Former DG, ICAR, delivered Foundation Day address and distributed Annual Institute awards. An MoU was signed between CSIR and YES Bank on this occasion. Industry meet on food processing (CSIR-YES bank initiative) was held in which a total of 25 industries participated.

#### Vigilance Awareness Week (Oct 28 - Nov 2, 2019)

Chief Guest of the function, Shri J.B. Rangaswamy, Retd. Deputy Suptd. of Police,



Mysore addressed the gathering and distributed prizes to staff and school students.

#### • Kannada Rajyotsava Day (Nov 1, 2019)

Kannada Rajyotsava (Nov 1, 2019) and Kannada Habba (Nov 6, 2019) inaugural events were held in association with Kannada Sahrudaya Balaga. Prof. Krishne Gowda and Mr. Mohan Varnekar were the Chief Guests of the function. Dr. KSMS Raghavarao, Director, CSIR-CFTRI presided over the function.

• Workshop on Technology & Value Added Food for Farmers (Nov 25, 2019)

The workshop was organized by Kannada Sahrudaya Balaga on Nov. 25, 2019. The event was inaugurated by Dr. KSMS Raghavarao, Director, CSIR-CFTRI and Shri Nagaraj MH, Joint Director, Dept. of Horticulture, addressed the participants. Ahara Vignana magazine was launched on the occasion.

#### • Kannada Habba (Dec 10, 2019)

Kannada Sahrudaya Balaga organised the valedictory function of Kannada Habba on Dec. 10, 2019. Dr. KSMS Raghavarao, Director, CSIR-CFTRI presided over the function.



#### 7<sup>th</sup> Bioprocessing India Conference (Dec 14 - 16, 2019)

The conference was organised by CSIR-CFTRI in association with the Association of Food Scientists and Technologists (India) (AFSTI), Mysuru and DRDO-Defence Food Research Laboratory (DFRL), Mysuru. The focal theme of the conference was "Advances in bioprocessing of agri-food resources". There were three plenary talks by eminent scientists. Fifty one invited speakers from academia, research institutes and industry presented their work in fifteen technical sessions. The conference was attended by 245 delegates. In the poster sessions, 195 posters by young researchers, post graduate and Ph.D. students were presented. The exhibition organised during the event was well attended by industry participants.



• Republic Day Celebrations (Jan 26, 2020) Republic day was celebrated on Jan 26, 2020 in the Institute. Dr. KSMS Raghavarao, Director, CSIR-CFTRI hoisted the National flag and addressed the staff and students.

#### • Future India Talks Series (Jan & Mar 2020)

CSIR-CFTRI initiated and organized Future India Talks, a programme of public lectures by



Dr. Shekhar C. Mande, DG-CSIR, New Delhi addressing the gathering

eminent scientists and technologists. Three talks were held as listed below.

- How Indians Won the Silicon Valley by Dr. Sivanand Kanavi, Adjunct Professor, NIAS, Bengaluru, Jan 10, 2020
- Why Evolution Matters to Biology and Us by Dr. Amitabh Joshi, Professor, JNCASR, Bengaluru, Feb 12, 2020
- In Science We Trust by Dr. Shekhar C. Mande, DG-CSIR, New Delhi, Mar 9, 2020
- Seminar on Innovation & Sustainable Information Services in the Digital Era (Feb 3, 2020)

CSIR-CFTRI, Mysuru conducted one day seminar on "Innovation & Sustainable



Information Services in the Digital Era" on Feb 4, 2020 in association with ICSSR, New Delhi and support of AFST(I), Mysuru, American Chemical Society and Springer Nature. Prof. T.D. Kemparaju, Vice-Chancellor, Bangalore North University inaugurated the seminar and addressed the gathering. Dr. KSMS Raghavarao, Director, CSIR-CFTRI delivered the presidential address. Eminent speakers from National Institutes / Organisations delivered talks on open source information systems and state of art information services. Total of 85 library professionals and students attended the workshop.

#### • SRIFT 2020 Conference (Feb 15, 2020)

Innovation in Food-Tech, powered by Silicon Road Accelerator, Mysuru in partnership with CSIR-CFTRI was conducted on Feb 15, 2020 at Mysuru in which more than 250 participants from Industry/Academia participated.

#### Bhumi Pooja for a Global Centre of Rice Technology (GCRT) (Feb 22, 2020)

Bhumi pooja was held for setting up a Global Centre of Rice Technology (GCRT). Shri Sid Mukherjee, MD, Silicon Road Accelerator was the Chief Guest. The centre would establish a missing vital link between the rice milling sector and the academia. This facility will be established in collaboration with M/s APIT, Bengaluru and M/s Buhler India Private Limited.

## • National Science Day Celebrations (Feb 28, 2020)

CSIR-CFTRI JIGYASA team visited GHPS Siddaramanahundi and interacted with students & staff. Public lecture was arranged along with demonstrations on food adulteration on the occasion.

Three-day science theatre festival was organized in association with the Mysuru Science Theatre Festival Trust during the National Science Day. Three science dramas were held during the festival. The theatre was inaugurated by Dr. R. Balasubramaniam, Founder, Swami Vivekananda Youth Movement, Mysuru. In addition, half-a-day symposium on Science Fiction and Traditional Knowledge and Science and exhibition of portraits of eminent scientists drawn by Shri Anil Jagalur were also organized. Both the theatre festival and the symposium were open to the public.





#### 8. MoU(s) Signed

- Food Industries Capacity & Skill Initiative (FICSI), New Delhi
- Directorate of Food Processing, Govt. of Meghalaya
- Mar Athanasios College for Advanced Studies Tiruvalla (MACFAST), Kerala
- Extovate Venture LLP, Benguluru
- Karnataka Health Promotion Trust, Benguluru
- Confederation of Indian Industry (CII), Mysore Zone
- Asia Pulp & Papers Pvt. Ltd., Benguluru
- Buhler India Pvt. Ltd., Attibele
- Darshan Flexibles Private Limited, Mysuru
- Silicon RD Ideation Labs Pvt. Ltd., Mysuru
- SaReDh Enterprises, Bengaluru
- Delightful Gourmet Pvt Ltd., Bengaluru (LICIOUS)
- NutriPlanet Foods Pvt. Ltd., Bengaluru
- Tata Global Beverage Limited, Kolkata
- Associations of Lady Entrepreneurs of India (ALEAP), Hyderabad
- ICAR-Indian Institute of Millets Research (IIMR), Hyderabad
- People's University, Bhopal
- Society for Energy, Environment & Development (SEED), Hyderabad
- Banaras Hindu University, Centre of Food Science & Technology, Varanasi
- JSS College of Arts, Commerce & Science, Mysuru
- District Mineral Foundation, Keonjhar and Nabakrushna Choudhury Centre for Development Studies (NCDS), Bhubaneswar and WASSAN, Hyderabad
- AFSTI, Mysuru

• National Institute of Rural Development and Panchayati Raj (NIRDPR), Hyderabad



Signing of MoU between CFTRI and District Mineral Foundation, Keonjhar and Nabakrushna Choudhury Centre for Development Studies (NCDS), Bhubaneswar and WASSAN, Hyderabad



Signing of MoU between CFTRI and Spirulina Foundation, Tumkur

- Plataforma Ventures, Bengaluru
- NIE, Mysuru
- Food and Biotechnology Consultancy Services (FOBICS), Mysuru
- Tenon10, Hyderabad
- Maharashtra Centre for Entrepreneurship Development, Aurangabad
- Stonefield Flavours Pvt Ltd., Bangalore
- Food Karnataka Ltd., a Govt. of Karnataka undertaking, Bengaluru
- KIIT-Technology Business Incubator (KIIT-TBI), Bhubaneswar
- NBI Biosciences Pvt Ltd., New Delhi
- Agricultural and Processed Food Products Export Development Authority (APEDA), New Delhi

- Spirulina Foundation, Tumkur
- Deshpande Foundation, Hubli
- APIT, Bengaluru
- MGM University (IBT), Aurangabad

#### 9. Awards and Recognitions

#### Ph.D. Degree awarded

a) University of Mysore

Name of the Student		Title of the Thesis	Guide
•	Arun Tapal	Oil palm ( <i>Elaeis guineensis var, tenera</i> ) kernel globulin: Characterization and evaluation of its nutraceuticals property	Dr. Purnima Kaul Tiku
•	Govardhan Singh RS	Studies on the combined effect of Nt8U and soyasaponins in countering obesity	Dr. Uma V Manjappara
•	Kiranmai Ketha	Bioactive polysaccharide from green gram ( <i>Vigna radiate</i> ) – Structural and biological characterization	Dr. Muralikrishna G
•	Kirti Rani Saad	Molecular regulation of anthocyanin in static and submerged cultures of carrot	Dr. Nandini P Shetty
•	Mousami Shankar Addala	Major amylolytic enzyme derived from <i>Lactobacillus</i> grown on resistant starch: Biochemical characterization and genomic study	Dr. Muralikrishna G
•	Niharika Shanker	Utilization of omega -3 fatty acids and protein concentrate extracted from purslane ( <i>Portulaca oleracea L</i> .) for food product formulation	Dr. Sukumar Debnath
•	Pynam Hasitha	Modulation of inflammation mediated cancer by selected dietary components and their mechanism of action using <i>in vitro</i> and <i>in</i> <i>vivo</i> models	Dr. Shylaja M Dharmesh

- Davangere University, Davangere
- BAIF Development Research Foundation,
   Pune

Name of the Student	Title of the Thesis	Guide
Rateesh Krishnan	Influence of processing technologies on mineral composition of pearl millet and development of iron enriched beverage	Dr. Meera MS
Ranjini A	Genotoxicity of acrylamide and influence of resveratrol in toxicity protection	Dr. Manonmani HK
Roopesh S	Identification and characterization of novel protease from rice ( <i>Oryza sativa</i> L.) bran	Dr. Purnima Kaul Tiku
Shakuntala S	Pectic oligosaccharides derived from germinated chickpea ( <i>Cicer arietinum L.</i> ) structure-function relationship	Dr. Harish Prashanth KV
Swetha MP	Bioavailability and health benefits of defatted <i>Moringa oleifera</i> seed cake polyphenols	Dr. Muthukumar SP
<ul> <li>Siewe Fabrice Bruno</li> </ul>	Development of an efficient process for producing of seafood flavoring using fish byproduct	Dr. Bhaskar N
Simmi PS	Studies on transcription factor(s) interacting with the promoter of theobromine synthase gene of <i>Coffea canephora</i>	Dr. Giridhar P
Sindhu R	Evaluation of anticancer potential of	Dr. Manonmani HK
<ul> <li>Vishwanath SV</li> </ul>	Effect of arginine : lysine ratio of the plant storage proteins on hypercholesterolemia and hypertension	Dr. Purnima Kaul Tiku

#### b) AcSIR

Name of the Student	Title of the thesis	Guide
Anusha Jahagirdar	Obesity and thermogenesis: Molecules from dietary sources that convert white to brown adipose tissue	Dr. Malathi Srinivasan Prof. Ram Rajasekaran
Apramita Devi	Polyphenol transformations by malo-lactic bacteria during wine fermentation	Dr. Anu Appaiah KA
<ul> <li>Archana Gopalrao Lamdanda</li> </ul>	Wet processing for value added products from coconut ( <i>Cocos nucifera L</i> .)	Dr. Raghavarao KSMS

Name of Student	Title of the Thesis	Guide
Ashrafi Hossain	Effect of processing of maize on nutraceutical properties and development of functional foods	Dr. Jayadeep A
<ul> <li>Debika Ohja</li> </ul>	Molecular characterization of <i>Listeria</i> <i>monocytogenes</i> RecA, SSB and RecX proteins: Implications in homologous recombination and antibiotic resistance	Dr. Neelakanteshwar Patil K
Deepesh Panwar	Understanding the molecular basis of prebiosis of manno - oligosaccharides in probiotic <i>Lactobacillus</i> sp.	Dr. Mukesh Kapoor
Dhanashree	Understanding the pleomorphic nature of <i>Bifidobacteria</i>	Dr. Rajagopal K
Gaurav Singh Kaira	Understanding the molecular determinants of thermo -stability and substrate hydrolysis in ManB-1601: A GH26 endo -mannanase	Dr. Mukesh Kapoor
<ul> <li>Indhurathna</li> </ul>	Quality assessment and development of specialty foods from folk medicinal rice cultivars - <i>Kabirajsal</i> and <i>Kalabhatt</i>	Dr. Manisha Guha Dr. Purnima Kaul Tiku
<ul> <li>Kalaivani</li> </ul>	Metabolic engineering of Saccharomyces cerevisiae for overproduction of squalene	Dr. Sarma MVRK
Memthoi Devi	Enumeration of nutritional and bio-functional properties of <i>Rhus chinensis</i> mill (heimang) fruits and its products	Dr. Ng. Iboyaima Singh
Mohan Kumar B V	Immunoreactivity of Indian wheat varieties and their impact in low gluten food processing	Dr. Prabhasankar P
Murugesh CS	Athermal extraction and membrane clarification of green tea extracts	Dr. Subramanian R
<ul> <li>Musunuru Suneel Kumar Reddy</li> </ul>	Studies on the combined effect of obestatin and plant nutraceuticals in <i>in vitro</i> and <i>in</i> <i>vivo</i> obesity models	Dr. Uma V Manjappara
Pooja Acharya	Defining the roles of dietary omega - 3 fatty acids in the regulation of bile acid	Dr. Ramaprasad TR

Name of Student	Title of the Thesis	Guide
Prasad P	Exploring stearidonic acid rich triacylglycerol biosynthetic pathway in <i>Buglossoides</i> <i>arvensis</i> using transcriptomic and lipidomi c approaches	Dr. Sreedhar RV
<ul> <li>Priyanka BS</li> </ul>	Integrated approach for the downstream processing of enzymes involving liquid emulsion membrane	Dr. Navin K Rastogi
Rochak Mittal	Downstream processing of phycobiliproteins from macro-algae, <i>Gelidium pusillum</i>	Dr. Raghavarao KSMS
Sajan C Achi	Effect of bifidobacterial probiotics on alleviation of inflammation	Dr. Prakash M Halami
Sakthi Kumaran	Enrichment of millet foods for dietary bioactive molecules through fermentation	Dr. Vijayalakshmi G
<ul> <li>Saroj Yadav</li> </ul>	Neuroprotective effects of rice bran in experimental animal model	Dr. Jayadeep A
<ul> <li>Shamsiya Trichur Khabeer</li> </ul>	Molecules from <i>Punica granatum</i> (SHAMstat3pg), <i>Nigella sativa</i> (RAYstat4ns) as lipase inhibitors: An effective approach towards controlling obesity	Dr Manonmani HK
Shilja C	Antimicrobials and hybrid antimicrobials for food safety	Dr. Rajagopal K
Shrikanth CB	Effect of AMP-activated protein kinase modulators on sulfated glycosaminogly cans of tubular kidney cells under high glucose conditions	Dr. Nandini CD

#### c) Other Universities

Name of the Student	Title of the thesis	Name of the University
Amruthakala A.L.	Synthesis characterization and structural studies of Schiff base derivatives	University of Mysore, Mysore
<ul> <li>Devendra J. Haware</li> </ul>	Feasibility and health risk assessment of heavy metals in environment	RTM Nagpur University, Nagpur, Maharashtra

- d) CSIR-CFTRI Annual Awards 2018-19
- Best Contribution Award General Administration
   Bushra Masrur
- Best Contribution Award Finance and Accounts Vasantha UR
- Best Contribution Award Stores & Purchase Savitha MP
- Best Research Publication Award for Basic Sciences
  - Bhaskaragoud G., Geetha V., Sharanappa T., Mohan Kumar A.S., Hema Kumar C., Suresh Kumar G., Hypolipidemic and antioxidant properties of oryzanol concentrate in reducing diabetic nephropathy via SREBP1 downregulation rather than β-oxidation, *Mol. Nutr. Food Res.*, 2018, 62(8), e1700511
  - Ravi H., Nawneet Kurrey, Manabe Y., Sugawara T., Baskaran V., Polymeric chitosanglycolipid nanocarriers for an effective delivery of marine carotenoid fucoxanthin for induction of apoptosis in human colon cancer cells (Caco-2 cells), *Materials Sci. Eng.: C*, 2018, 91, 785-795
- Best Publication Award for Applied Research
  - Sijil P.V., Sarada R., Chauhan V.S., Enhanced accumulation of alpha-linolenic acid rich lipids in indigenous freshwater microalga *Desmodesmus* sp.: The effect of low-temperature on nutrient replete, UV treated and nutrient stressed cultures, *Bioresource Technol.*, 2019, 273, 404-415
- Best Student Award M.Sc. (Food Technology) Divya Choudhary
- Best Student Award ISMT
   Nuwarapaksha Gedara Sanjeewa Dharmarathana
- Best Research Fellow Award
   Pooja Acharya, Department of Biochemistry
- Best Technology Transfer Award
  - Dr. Sattur A.P., Microbiology & Fermentation Technology, "A-Hango"
  - Dr. Baskaran V & Team, Department of Biochemistry, Fortification of sugar with vitamin D & its variants, vitamin A and minerals (calcium & iron)
- Best R&D Department Award
   Grain Science & Technology

- Best Support Department Award
   Technology Transfer & Business Development
- Best Technical Support Staff (Gr. D(NT)) Murali Y.N., Department of Lipid Science
- Best Technical Support Staff (Gr. I) Mahesha I., Traditional Food & Sensory Science
- Best Technical Support Staff (Gr. II) Srirama R., Central Instruments Facility & Services
- Best Individual Award for Technical Contributions (Gr. III)
  - Ramesh G., Design & Fabrication Unit
  - Bavani Eswaran M., Central Instruments Facility & Services
- Best Individual Award for Scientific Contributions (Gr. III)
  - Krishnaiah H.E., Food Protectants and Infestation Control
  - Shri Punil Kumar H.N., Department of Technology Scale-up
- Best Individual Award for Scientific Contributions (Gr. IV)
  - Prakash M. Halami, Microbiology & Fermentation Technology
  - Ramaprasad T.R., Department of Biochemistry
- Best Individual Award for Technical Contributions (Gr. IV) Nagaraju V.D., Design & Fabrication Unit
- Individual Award for Maximum ECF generation
  - Asha Martin, Food Safety & Analytical Quality Control Laboratory
  - Keshava Murthy P.S., Food Packaging Technology
- Award for outstanding Institutional contribution
   Venkatesh Murthy K., Traditional Food & Sensory Science



Institute awardees along with dignitaries

#### e) Individual Awards

	Award Title	Instituted by	Awardee
•	Life time achievement award for 2019	International Society for Agriculture, Horticulture and Plant Sciences, New Delhi	Dr. Madhava Naidu M
•	Distinguished Researcher in Food Biotechnology	International Research awards Council, Trichy, Tamilnadu	Dr. Pushpa S Murthy
•	Scire Recognition Biotechnologist	Scire Conference Series, Goa	Dr. Pushpa S Murthy
•	Har Gobind Khorana Best Scientist	Bose Science Society, Pudukkottai, Tamil Nadu	Dr. Pushpa S Murthy
•	Distinguished Biotechnologist under Venus International Research Awards-VIRA 2019	Venus International Foundation, Chennai	Dr. Pushpa S Murthy
•	CSIR-Technology Award	CSIR, New Delhi	Dr. Rajagopal K
•	Senior Scientist Award	Asian Biological Research Foundation, Prayagraj, UP	Dr. Giridhar P
•	Outstanding Scientist Award	The Society of Tropical Agriculture, New Delhi	Dr. Giridhar P
•	Lifetime achievement award in the field of mechanical engineering	Venus international foundation, Chennai	Dr. Nagaraju VD
•	Life Time Achievement Award-2019	Andhra Pradesh Academy of Science, Amaravati	Dr. Raghavarao KSMS
•	Best Faculty Researcher Award	Indian Chitin and Chitosan Society, Erode, Tamil Nadu	Dr. Harish Prashanth KV
#### f) Recognitions by Academies

	Recognition	Instituted by	Awardee
•	Subhash Bhatnagar Memorial Award - 2018	AFSTI(I), Mysore	Mr. Mohd Shakeb
•	Korean Society for Scientific Research	Korean Government, Korea	Dr. Rajagopal K
•	Dr. GS Venkatraman Memorial NABS Best Scientist Award- 2019	National Academy of Biological Sciences, Chennai, Tamilnadu	Dr. Prakash M Halami
•	Prof. Gurcharan Singh Bains Award - 2018	AFSTI(I), Mysore	Mrs. Sudha ML

### g) Recognitions for Publications

### Best Paper as Editor's Choice

• Prakruthi Appaiah, Prasanna Vasu, Improvement, cloning and expression of an *in silico* designed protein enriched with large neutral amino acids in *Pichia pastoris* for possible application in phenylketonuria, *Journal of Food Biochemistry*, **44(3)**, e13151

### Top Cited Article (Jan 2018 - Dec 2019) in Journal of Food Process Engineering

 Nalawade S.A., Sinha A., Umesh Hebbar H., Infrared based dry blanching and hybrid drying of bitter gourd slices: Process efficiency evaluation, *Journal of Food Process Engineering*, 41(4), 2018, 1-11



Dr. Rajagopal K, Sr. Principal Scientist receiving the CSIR-Technology Award during CSIR Foundation day celebration at New Delhi



Dr. KSMS Raghavarao, Director, CSIR-CFTRI receiving the Life Time Achievement Award – 2019 from Sri Biswabhusan Harichandan, His Excellency Governor of Andhra Pradesh & Chancellor, Dr. BRAU, Srikakulam

### h) Other Recognitions

Awardee	Member / Panel Expert & Host Institution
Dr. Madhava Naidu M	Board Member, Coffee Board, Bangalore; Expert Committee Member, Spice Board Technical Expert Panel 2020
Dr. Sridevi A Singh	Task Force Member on Public Health and Nutrition, DBT; Member of Governing Board, NABI, Mohali; Member, BoS in Biochemistry and Molecular Biology, University of Mysore
Dr. Rajagopal K	Member, TNAU, Board of Studies in Biological Sciences; Member, Kerala Biote chnology Commission
<ul> <li>Dr. Alok Kumar Srivastava</li> </ul>	Chairman, Scientific Panel on Method of Sampling and Food Analysis, FSSAI; Chairman, Sectional Committee of Food and Agricultural Division FAD 28, BIS; Member, Sectional Committee of Food and Agricultural Division FAD 15, BIS; Member, Special Panel of DRDO on Food Science, Hill Agriculture, Biofuels and Bioresources
Dr. Asha Martin	Member, Scientific Panel on Sweets, confectionery, sweeteners, sugar and honey (FSSAI); Principal Member, Technical committee on Food Biotechnology Sectional Committee FAD- 23, BIS; Member, BoS for Food Sciences and Nutrition, University of Mysore; Expert Member, Project Review and Steering Group (PRSG) for Ministry of Electronics and Information Technology
Dr. Prasanna Vasu	Member, Technical Committee on Stimulant Foods FAD-6, BIS; Member, Test Methods for Food Products Sectional Committee FAD 28, BIS
Dr. Giridhar P	Member, Fragrance and Flavour Sectional Committee (PCD 18), BIS
Dr. Prakash M Halami	Member, Scientific Panel on Antibiotic Residues, FSSAI, New Delhi
• Dr. Anu Appaiah KA	Chairman, Scientific Committee on Water and Non-alcoholic Beverages, FSSAI, New Delhi; Member, Scientific Committee on Alcoholic Beverages, FSSAI, New Delhi; Chairman, FAD committee on alcoholic beverages, BIS; Member, FAD committee on water and non-alcoholic beverages, BIS

Awardee	Member / Panel Expert & Host Institution
Dr. Malathi Srinivasan	Member International Review committee of the Russian Science Foundation (RSF) to review, score and approve scientific proposals submitted to the RSF by the Russian Scientists
Dr. Ajay W Tumaney	Member FAD 13 BIS, FAD 15 BIS; Member Expert, Panel on Oils and Fats, FSSAI
• Dr. Jayadeep A	Member, Ministry of Human Resource Development (Department of School Education & Literacy) Committee for introduction of breakfast in Mid-Day Meal Scheme; Member, Board of Examiners, Univ. of Kannur; External Examiner, Ph.D. programme in Biochemistry, Univ. of Kannur; Member, Doctoral Advisory Committee of Kerala Agricultural University
• Dr. Negi PS	Member, APEDA Authority; Expert member, Technical Advisory Committee (TAC) of Technology Development and Utilization Programme for Women (TDUPW) of Department of Scientific and Industrial Research; Member, Scientific Panel for Fruits and Vegetables and their Products (includingdried fruits and nuts, salt, spices and condiments) of FSSAI; Member, Scientific Panel for Methods of Sampling and Analysis of FSSAI; Member, BoS Department of Agribusiness Management and Food Technology, North-Eastern Hill University, Tura Campus, Chasingre (Meghalaya)
Dr. Gothwal PP	Technical Member, State Level Empowered Committee for appraisal of food processing industry, Govt. of UP
Dr. KSMS Raghavarao	Member, Sectional Committees and INAE Forums of the Academy
Dr. Muthukumar SP	Member, Apiary Industry Technical Committee FAD-3, BIS; BoS in Biomedical Sciences, JSS Academy for Higher Education & Research (JSSAHER), Mysuru
• Dr. Harish Prashanth KV	Member, Research Advisory Committee, Adichunchangiri University, Mandya
Dr. Madan Kumar P	Advisory Committee Member, Diploma course in Food Safety Management, Sri Sankara Arts and Science College, Kanchipuram

	Awardee	Member / Panel Expert & Host Institution
•	Dr. Usharani D	Member, NetScoFAN, New Delhi
•	Dr. Umesh Hebbar H	Chairman, Project Review Committee, TDUPW Scheme of DSIR; Advisory Committee Member, UGC project for Centre for Advanced Studies-II (CAS-II) at ICT, Mumbai; Member, Pradhan Mantri Kisan Sampada Yojana (PMKSY), MoFPI; Member, BoS in Food Science and Technology, University of Mysore; Member, BoS in Food Technology of JNTU, Ananthapur Campus, AP; Member, BoS in Food Technology, Kongu Engineering College, Erode, TN
•	Dr. Ng. Iboyaima Singh	Member, Advisory Committee, UGC-DDU Kaushal Kendra, JSS College of Arts, Commerce and Science, Mysuru; Member, BoS in Food Science & Technology, The Karnataka State Rural Development and Panchayat Raj University, Gadag, Karnataka
•	Dr. Arun Kumar P	Member, Plastics Packaging Sectional Committee (PCD 21), BIS; Member, Method of Sampling and Test for Plastics Sectional Committee (PCD 27), BIS

### i) Other Awards

	Award Title	Instituted by	Awardee
•	AWSAR Award (3 <sup>rd</sup> Place)	DST, New Delhi	Ms. Bhavya ML
•	AWSAR Award under Top 100 Essays	DST, New Delhi	Ms. Sapna L Ms. Sandhya Shewale Ms. Debika Ojha
•	Dr. V.S. Korikanthimath award for Best Ph.D. thesis	Indian Society for Spices, IISR, Kozhikode, Kerala	Dr. Siddharth Priyadarshi
•	Best Young Scientist Award	International Society for Agriculture, Horticulture and Plant Sciences, New Delhi	Dr. Siddharth Priyadarshi
•	Student of the Year Award	International Society for Agriculture, Horticulture and Plant Sciences, New Delhi	Dr. Siddharth Priyadarshi

### i) Other Awards

	Award Title	Instituted by	Awardee
•	Young Scientist	Scire Conference Series, Goa	Ms. Vedhashree M
•	Indo-Australian Career Boosting Gold Fellowship	DBT, New Delhi	Dr. Ajam Shekh
•	Best Student Award under M.Sc. (Nutrition Biology)	AFSTI(I), Mysore	Ms. Meena Kumari P
•	Young Scientist (Junior) Award	Nutrition Society of India, Thiruvananthapuram, Kerala	Ms. Meena Kumari P



Ms. Bhavya M.L., AWSAR Award winner from CSIR-CFTRI along with President of India and other dignitaries

### j) Best Research Papers / Posters Awards

7<sup>th</sup> Bioprocessing India Conference on Advances in Bioprocessing of Agri-Food Resources, Dec 14-16, 2019, CSIR-CFTRI, Mysuru

- Ajana P., Neenu Ravikumar, Madhubalaji C.K., Puthusseri B., Sarada R., Vikas S. Chauhan, Bioaccessibility and bioavailability of folate from spirulina
- Cathrine M.S.B., Gowthami J.P., Muthukumar S.P., Tanaji G. Kudre, Evaluation of *Lactobacillus* fermented slaughterhouse wastewater protein as an alternative protein source for the poultry growth performance and its impact on the meat quality
- Dhanamjai Penta, Syed Musthapa M., Dietary bioactive of cruciferous vegetables to overcome breast cancer stemness and chemosresistance
- Hamsavi G.K., Archana G. Lamdande, Suresh Kumar G., Raghavarao K.S.M.S., Stabilization and characterization of coconut milk employing additives and homogenization
- Jethani H., Nair S., Radha C., Chauhan V.S., Sarada R., Umesh Hebbar H., Plant based cationic bio-flocculant assisted downstream processing of *Arthrospira* (*Spirulina platensis*) biomass
- Ravindra P.V., Janhavi P., A dietary supplement to improve VO2max in endurance athletes
- Sapna I., Jayadeep A., Enzymatic bioprocessing enhances nutraceutical components of red rice bran
- Sarma M.V.R.K., Kalaivani Paramasivan, Metaheuristic algorithm- based knockout

prediction and *in-vitro* validation for improved squalene in *Saccharomyces cerevisiae* 

ICFoST 2019 - 27<sup>th</sup> Indian Convention of Food Scientists and Technologists, Jan 30, 2020 - Feb 1, 2020, Tezpur University, Tezpur, Assam

- Divya P.M., Ashwin Kumar M.S., Suresh D. Sakhare, Sreerama Y.N, Roopa B.S, Development of cereal and non-cereal based composite flour to enhance nutritional status
- Shaba Noore, Mohd. Shakeb, Srinivas A., Development of masala vada using buckwheat

### 8<sup>th</sup> International Translational Cancer Research Conference, Feb 13-16, 2020, Banaras Hindu University, Varanasi

- Kaumudi Pande, Sridevi A. Singh, Anbarasu K., Myricetin delivery by virtue of exosomes to restraint immunomodulatory molecules in defiance of ovarian cancer
- Rajalakshmi P., Anbarasu K., MORC2, an oncogenic protein with immunomodulatory potential in human breast cancer

### 11<sup>th</sup> NABS National Conference, Pondicherry University, Puducherry, Sep 25-27, 2019

- Arwind S, Halami P.M., Genome mining of Bifodbacterium longum NCIM 5672 for probiotic functionalities and its application using CRISPR CAS system
- Steji Raphael, Halami P.M., Genomics view of *Bacillus licheniformis* MCC 2514: A probiotic culture with new antibiotic producing ability

FOODS-2019-ITAF : International Conference on Innovations and Technological Advances in Food, M.O.P. Vaishnav College for Women, Chennai, Aug 5-6, 2019

- Bharath A.P., Ashwath Kumar, Soumya C., Prabhasankar P., Effect of dicoccum wheat, barley flour and soya flour on pizza making quality and its starch digestibility
- Sidiqat Adamson Shodehinde, Indrani D., Prabhasankar P., African yam bean flour: product quality, biofunctional activities and immunochemical validation of gluten free biscuits

### Silicon Road Innovation in Food-Tech (SRIFT) Conference 2020, Mysore, Feb 15, 2020

- Ramesh G., Jaganantha, Sriram R., Nagaraju V.D., Table top fruits and vegetable washer domestic gadget
- Soumya C., Sudha M.L., Indrani D., Prabhasankar P., Natural preservatives in bakery products
- Matche R.S., Subhash Pawde, Freshness keeper for extension of shelf life of fresh produce

National Conference on Health and Wellness through Nutrition and Nutraceuticals, Ramaiah University of Applied Sciences, Bangalore, Jan 22-24, 2020

 Arpitha H.S., Sowmya Shree G., Kunal Sharan, Ganesan P., Lutein prevents hyperglycemia-mediated blockage of endogenous antioxidant machinery in retinal pigment epithelial (ARPE-19) cells  Yogendra Prasad K., Sowmya Shree G., Tehreem M., Poornima Priyadarshini C.G., Ganesan P., Luminal breast cancer (MCF-7) cells are more susceptible to lutein treatment than triple-negative cancer (MDA-MB-231) cells

### 8<sup>th</sup> Indian Chitin and Chitosan Society Symposium, ICT-Mumbai, Sep 19-20, 2019

- Pramod Kumar P., Harish Prashanth K.V., Chitosan derivatives protect oxidative stress and mitochondrial dysfunction in Drosophila against the neurotoxicity induced by a mitochondrial complex I inhibitor, rotenone
- Punarvasu T.P., Harish Prashanth K.V., A self-assembled microparticle of chitosan derivatives (SAM) inhibit tumor angiogenesis and induce apoptosis in *Ehrlich ascites* tumor bearing mice

# Research Papers / Poster Awards in other Seminars

- Kalaivani P., Sarma Mutturi, Systems based metabolic engineering of Saccharomyces cerevisiae for squalene synthesis, 7<sup>th</sup> Conference on Physiology of Yeasts & Filamentous Fungi, Milan, Italy, Jun 24-27, 2019
- Raghavendra S.V., Role of CSIR-CFTRI in rural development through free technologies with special reference to rice milk mix, National Conference on Science & Technology for Rural Development, University of Mysore, Mysore, Oct 17-18, 2019
- Vedashree M., Nanishankar H.V., Madhava Naidu M., Enhanced stability and

characterization of 6-gingerols encapsulated by gama cyclodextrin metal organic frame works, 3<sup>rd</sup> International Conference on In Sync-With Next Generation Biosciences (INGB 2019), Goa, Nov 6-8, 2019

- Narsing Rao G., Sulochanamma G., Madhusudhan Rao D., Prabhakara Rao P.G., Sathiya Mala K., Antioxidant and antimicrobial activity of amla (*Emblica* officinalis L.) seed methanolic extract, NSI Annual National Conference on Nutrition Security, Thiruvanantapuram, Nov 8-9, 2019
- Urvashi Sahu, Liza George, Manivannan S., Ezhil Vendan S., Penetration potential of phytochemical fumigants in rice weevil, *Sitophilus oryzae*, 1<sup>st</sup> National Agrochemicals Congress: Country's status on various fronts of Agrochemicals, New Delhi, Nov 13-16, 2019
- Giridhar P., Tubers of swallowroot A treasure trove of economically important metabolites, 10<sup>th</sup> International Conference on Agriculture, Horticulture and Food Sciences, New Delhi, Dec 21-22, 2019
- Amrita Ray, Suresh D. Sakhare, Alok K. Srivastava, Development of roller milling process to obtain quinoa fractions with enhanced nutritional quality, International Conference on Bioresource Technology for Food, Energy and Environmental Sustainability (ICBTFEES-2020), Gandhigram Rural University, Dindigul, Tamilnadu, Jan 8-10, 2020
- Sravan Kumar S., Monisha Arya, Paramesha M., Giridhar P., Micropropagation of *Basella rubra L*. and

effect of photoperiod on callus growth, bioactive compounds and antioxidant activity, National Conference-Advances in Plant Biotechnology-2020, Dayananda Sagar University, Bangalore, Jan 28, 2020

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

- Journal of Food Science and Technology, Springer (Prakash M Halami)
- Journal of Food Science and Technology, Springer (Vijayendra SVN)
- Indian Food Industry, AFST(I), Mysore (Negi PS)
- BMC Complementary Medicine and Therapies, BMC, Part of Springer Nature, New York, USA (Negi PS)
- 3 Biotech, Springer (Giridhar P)
- International Journal of Genuine Traditional Medicine, Association of Humanitas Medicine, Republic of Korea (Negi PS)
- Journal of Food Measurement and Characterization, Springer (Prabhasankar P)
- Journal of Food Process Engineering, John Wiley, USA. (Navin K Rastogi)
- International Journal Membrane Sci. Technol., Cosmos, (Navin K Rastogi)
- Journal Food Biology, Scholar journals, Elsevier (Raghavarao KSMS)
- Non-coding RNA Research, KeAi (Syed Musthapa M)
- International Journal of Food Science and Nutrition, Gupta Publications, New Delhi (Sudheer Kumar Y)
- Journal of Food Science and Technology, Springer (Inamdar AA)

### I) Editorial and Advisory Boards

- Research & Reviews: Journal of Food Science and Technology, STM Journals (Harish Prashanth KV)
- Frontiers in Cellular and Infection Biology, Frontiers, UK (Rajagopal K)
- Frontiers in Microbiology, Frontiers, UK (Rajagopal K)
- Biotechnology Letters, UK (Rajagopal K)
- EC Nutrition, Ecronicon (Sudheer Kumar Y)
- Blue Biotechnology, Nova Publishers, USA (Prabhasankar P)
- Research and Reviews: Journal of Food Science and Technology (Prabhasankar P)
- International Journal of Immunology (Prabhasankar P)
- Journal of Food Science and Technology, Springer (InamdarAA)
- Journal of Food Science, IFT, Chicago, USA(Negi PS)
- Signpost Open Access Journal of Organic and Biomolecular Chemistry, Research Signpost, Thiruvananthapuram,India (Negi PS)
- Journal of Engineering, Hindawi (Navin K Rastogi)
- The Scientific World Journal, Hindawi (Navin K Rastogi)
- Research & Reviews: Journal of Food Science & Technology, STM (Navin K Rastogi)
- Journal of Membrane Science & Technology, Omics (Navin K Rastogi)

- Journal of Food Research and Technology, Jakraya (Navin K Rastogi)
- The Indian Journal of Nutrition and Dietetics (Raghavarao KSMS)
- Journal of Laboratory Animal Science, Laboratory Animal Scientists' Association, India (Muthukumar SP)

### **10.** Participation in Exhibitions

- CSIR Technology Showcase: Organised by CSIR-IITR, Lucknow at CSIR-IITR, Lucknow, Apr 18, 2019
- CSIR-CFTRI Industry Conclave: Organised by CSIR-CFTRI at CSIR-CFTRI, Mysore, Jun 4, 2019
- U.P. Mango Exhibition: Organized by Department of Horticulture & Food Processing, Govt of UP at Indira Gandhi Prathisthan, Lucknow, Jun 22-23, 2019
- Farmers Workshop: Organised by Univ. of Horticultural Sciences, Bagalkot at Bagalkot, Karnataka, Sep 20, 2019



Inauguration of CSIR-CFTRI Industry Conclave by Director, CSIR-CFTRI along with other dignitaries

- Udyama Samagam Two days National Seminar, Industrial Fair and Expo: Organized by MSME Development Institute, Mangalore, Udupi, Sep 27-28, 2019
- 8<sup>th</sup> International Mookambika Rice & Food Grains Tech Expo 2019: Organised by Mookambika Exhibitons and Karnataka State Rice Millers Association at Hassan, Oct 12-13, 2019
- National Workshop on Nutricereals: Organised by Odisha Millet Mission, Bhubaneshwar, at Bhubaneshwar, Odisha, Oct 16, 2019
- **IISF Outreach Programme:** Organised by CSIR IITR, Lucknow at CSIR IITR, Lucknow, Oct 15-16, 2019
- International Science Festival, 2019 (IISF-2019) & EXPO: Organized by Ministry of Science and Technology Govt. of India at Biswa Bengla Convention Centre & Science City, Kolkatta, Nov 4-8, 2019
- Workshop cum Exhibition of "CSIR Food sector and food processing developed by CSIR": Organized by CSIR, at New Delhi, Nov 13, 2019
- 11<sup>th</sup> Agrovision-2019: Organised by MSME, Govt. of India and Govt. of Maharashtra, at Nagpur, Maharashtra, Nov 22-25, 2019
- North East Food Show 2019: Organised by Food Processing Department, Govt. of Meghalaya, at Polo Ground, Shillong, Dec 4-6, 2019
- Mondei Festival: Organised by District Administration at Nabarangpur, Odisha, Dec 13-15, 2019

- 107<sup>th</sup> Indian Science Congress: Organised by ISCA and UAS Bengaluru at University of Agricultural Sciences, GKVK Campus, Bangalore, Jan 3-7, 2020
- Consultative Meeting on Food Processing - cum - Techno Exhibition: Organised by CSIR and Manipur State Govt., at Lamphelpat, Imphal, Jan 24, 2020
- Kisan Mela: Organized by CSIR-CIMAP at CSIR-CIMAP Lucknow, Jan 31, 2020
- 27<sup>th</sup> Indian Convention of Food Scientists and Technologists (ICFoST): Organised by AFST(I) Tezpur University, CSIR-CFTRI and DFRL at Tezpur, Assam, Jan 30 - Feb 1, 2020
- North East Food Processing & Machinery Expo 2020: Organised by CSIR at Guwahati, Assam, Feb 17-19, 2020



North East Food Processing & Machinery Expo 2020 at Guwahati, Assam

 National Organic Festival of Women Entrepreneurs: Organised by Ministry of Food Processing Industries (MoFPI), Government of India, and Ministry of Women and Child Development (MoWCD), Government of India, at New Delhi, Feb 21 -23, 2020

- Farmers's Forum "Nammaura Kala Jatre": Organised by Namma Kaveri News Channel at Mandya, Feb 28 - Mar 1, 2020
- Rice & Food Grains Tech Expo 2019: Organised by Mookambika Exhibitons and Karnataka State Rice Millers Association at Hyderabad, Feb 29 - Mar 1, 2020
- NUTRI EXPO 2020-Food Safety & Food Adulteration: Organised by JSS - AHER & JSS hospital in association with CSIR-CFTRI and DFRL at JSS, Mysuru, Mar 3, 2020



CSIR-CFTRI stall during 11<sup>th</sup> Agrovision-2019 at Nagpur, Maharashtra

### 11. Entrepreneur Development Programmes (EDPs):

 Capacity building training programme on Food Processing for SC-ST aspiring and existing entrepreneurs under NSSH, MoMSME, Govt. of India (Jan.6, 2020)

Key focus of this programme was capacity building of SC/ST entrepreneurs in the area of Food Processing. The following three programmes were held.

- Fruit and vegetable technologies for value addition
- Spice processing: Business opportunities & future prospective
- Wheat milling and baking technology

A total of 71 candidates participated in these three programs. The session was inaugurated by Ms. Kokila A, Branch Head, NSSH Office, Bangalore. Dr. KSMS Raghavarao, Director, CSIR-CFTRI, presided over the function.

• 10 more EDPs were held in which overall 531 participated.

### 12. Visit of International Delegation & Training

- French delegation from Embassy of France consisting of Prof. Srini V. Kaveri, Director of Research, INSERM, Paris, Director, CNRS Bureau in India and Dr. Jerome Bove, Scientific Director, Embassy of France visited the Institute and interacted with scientists (May 30, 2019)
- A team of 15 graduate students from Kennesaw State University, Atlanta, USA visited the Institute (Aug 13, 2019)
- Dr. Zierfels Gabriele Gertrud, Metrohm International, Germany visited the Institute and had interaction with scientists on Ion chromatography technique and its application on food samples (Nov 13, 2019)
- A team of 4 Mauritius industry delegates visited the Institute and had interaction with CSIR-CFTRI scientists pertaining to technologies related matters (Nov 28, 2019)

- Prof. Ram H. Nagaraj, University of Colorado School of Medicine, Aurora, Colorado, USA visited the Institute and delivered the invited talk organised by SBC (I), Mysore Chapter (Dec 27, 2020)
- A team of 14 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 (Jan 11 - 17, 2020)
- Denmark team consisting of Dr. Jakob Williams Orberg, Counsellor, Embassy of Denmark and consulate staff visited the Institute pertaining to collaborative activities between both the Institutions in the area of Food Science & Technology (Feb 7, 2020)
- A team of 25 International delegates from Afro-Asian countries participated in International training programme organised by CSIR-CFTRI on "Food processing and value addition technologies for agripreneurship" under "Feed The Future India Triangular Training Programme-FTFITT" sponsored by MANAGE, Hyderabad (Mar 4-18, 2020)
- French delegation from Embassy of France consisting of Prof. Srini V. Kaveri, Director, CNRS office in India, Embassy of France, Dr. Ameye Paul Francois visited the Institute and had interaction with scientists (Mar 11, 2020)



Denmark team in discussion with CSIR-CFTRI team

### **13.** Support Department Activities

Wide range of information services such as Current Awareness Service through blog announcements, database search and document delivery services were provided by the library in addition to providing access to around 4183 e-journals through CSIR consortium. Books corner on specialized areas such as Indian cuisine and food regulatory was created. User awareness training program on Web of Science and EndNote was organized. The program was aimed at encouraging the optimal use of e-resources and enabling users to use the analytical tool in their research workflow in a more effective manner.

Students of various institutes across the country were showcased the facilities of the Institute. A total of 2890 students in about 45 groups visited the Institute.

Central Instruments Facility and Services Department provided services to the researchers and incubatees of the Institute through SAIF portal.

An online portal for the development of unified recruitment platform across CSIR laboratories was developed by CSIR-CFTRI using open source platform and tools. The modules include: Registration, Filling up the basic information, Validation, Uploading and Instant communications. The Management interface comprises Posting position-wise details, Criteria settings, Customizable filters, Generation of synopsis; Proceedings, Call letters, Consolidated score card and Offer letters. The software has been successfully implemented in the recent recruitment process of the Institute.

Water proofing treatment for various blocks of the Institute, re-laying and re-surfacing of roads and maintenance of the main mansion was carried out.

# Societal Programmes

# Cyclone Relief Operation in Odisha State

CSIR-CFTRI despatched cyclone relief food material to Odisha State during May 2019 in association with its sister lab, CSIR-IMMT, Bhubaneswar. Altogether, 18 tonnes of RTE food items were sent both by air and road. The items comprised of shelf-stable chapathis, high protein rusks, instant upma, drinking water etc.

### • Flood Relief Food for North Karnataka and Hassan

In the first week of Aug 2019, the nature's fury continued with floods and heavy rains in Belagavi and Hassan districts of Karnataka. During this period, CSIR-CFTRI supplied food materials for Belagavi and Hassan districts.

As per the request by DC, Hassan, CSIR-CFTRI sent around 5000 meals on Aug 10, 2019. The meal packets contained a total of 4,000 chapattis (2,500 meals), 3000 packets (100 gms) of tomato chutney, 100 kg of rusk (1,000 meals), 6,000 bottles of drinking water and about 300 kg (3,000 meals) of ready to constitute avalakki mix.

The consignment of around 5 tonnes of food items was sent through vehicle to the District Administration, Belagavi on Aug 17, 2019. The consignment comprised of RTE foods & grocery materials.

### NSDC Aligned Skill Development Programmes

1. Microbial Food Safety and Fermentation (Jul 01-26, 2019)

CSIR-CFTRI conducted a NSDC - aligned 4 week programme on "Microbial food safety and

fermentation". The program focused mainly on microbial food safety and microbial on fermentations. It was targeted to those interested in working on microbial food safety, hygiene and quality assurance in food related industries and entrepreneurs for the production of value added products. Certificates in Qualification pack, FIC/Q7603- Food Microbiologist (NSQF level 6) was awarded to 19 successful candidates.



### 2. Post-Harvest Technologies for Fruits and Vegetables (Nov 4 - 29, 2019)

The NSDC course covered processing, production and quality aspects of various fruit and vegetable products. The course was meant for persons intending a career in the fruit and vegetable industry, horticulture, students, entrepreneurs, self-help groups, FPOs, CFCs, quality control managers and lab technicians/assistants. Twenty one candidates were awarded NSDC certificates in Qualification pack: Supervisor - Fruits & Vegetables Processing (FIC/Q0109; NSQF level 5).

### 3. Baking Technician (Jan 20 - Feb 14, 2020)

A 4-week NSDC aligned programme on "Baking Technician" under the aegis of

National School of Baking Technology & CSIR-CFTRI was conducted. Participants were trained on choice of quality ingredients, product development, quality criteria, packaging aspects, FSSAI guidelines, nutritional profiling, health and hygiene. NSDC certificates in Qualification pack: Baking Technician / Operative (FIC/Q5005; NSQF level 4) was awarded to 23 candidates. The course provides job opportunities for persons intending to have a career in baking industry, SHGs, un-organized bakery personnel, quality control managers, lab technicians/assistants etc.

### Workshops conducted for Farmer Producer Organizations and Entrepreneurs

- Workshop on CSIR-CFTRI Technologies: CSIR-CFTRI in association with Food Karnataka organized one day workshop on CSIR-CFTRI technologies on Nov. 29, 2019 at Bengaluru. The programme was inaugurated by Shri Rajendra Kumar Kataria, Secretary, Dept. of Agriculture, Govt. of Karnataka in which Shri Manoj Ranjan, Special Secretary, Food Processing was also present. An MoU was signed on the occasion between CSIR-CFTRI and KAPPEC. In the workshop, almost 200 participants representing FPOs, startups, and entrepreneurs attended.
- One day workshop on "Cashew processing and value addition" in association with CII, Mangalore Chapter was organized on 3<sup>rd</sup> Dec 2019 at Mangalore. The objective of the workshop was to impart awareness amongst cashew processors on machineries, preservation, packaging and FSSAI regulations. A total of 40 processors participated in this programme.

- An Interactive meet on Food Cluster development in Mysore district on Jan 13, 2020 was held in which over 40 representatives from food industry, startups and entrepreneurs attended. The meeting was inaugurated by Shri Jagadeesh S, Additional Director & CEO, TECSOK, Govt. of Karnataka and officials from DIC & TECSOK were present.
- The third edition of CFTRI-KEMI program was organised in the Institute during Jan 20-25, 2020 in which 13 startups participated. Faculty from both the institutions delivered lectures and presented case studies in the program.



Interactive Meet on Food Cluster Development with stakeholders

### CSIR - KSTePS Skill Meet (Sep 18, 2019)

A session on "Skill development opportunities" for CSIR with Govt. of Karnataka was conducted in which representatives from various CSIR labs such as IICT, IHBT, CCMB, NCL, IICB, CSMCRI, CIMAP and IMTECH participated along with Govt. officials from Karnataka Science & Technology Promotion Society (KSTePS).

### Processing of Fruits & Vegetables (Feb 10-13, 2020 & Feb 24-27, 2020)

This programme on the processing of fruits and vegetables for 3 days was conducted for B.Voc/M.Voc (Food Processing) students at JSS Arts & Science college, Mysore.

### CSIR-800 Activities

Food Micro-Entrepreneurs Network (Jan 27, 2020): CSIR-CFTRI created a microentrepreneurs network for promoting the cottage food industries to enhance their skillsets and capabilities. One-day workshop on 'Value Chain Network for Food Micro-Entrepreneurs in Mysuru' in the area of agrifood processing was conducted in which panel discussion with experts and demonstration was held. A portal has been launched at URL, https://ment.cftri.res.in in which more than 218 have registered so far.



Demonstration of papad making and leg operated papad press to Micro-Entrepreneurs

### Incubation Centre Activities

The incubation centre, Nutra-Phyto Incubation Centre & Common Instrumentation Facility (NPIC-CIF) is fully operational in the campus. At present, 8 startups are functioning and six have exited so far. During this year major events organized for networking with industry and other stakeholders include: Startup window for FoodTech, Bio-Mysuru Summit, Bio-entrepreneurs Meet and Coffee Meet & Interaction with startups. Dignitaries such as Dr. Harsh Vardhan, Hon'ble Minister for Science & Technology, Dr. EV Ramana Reddy, Additional Chief Secretary, Govt. of Karnataka, DG-CSIR and many others visited the centre.



Visit of Dr. Harsh Vardhan, Hon'ble Minister for Science & Technology to NPIC-CIF

### Farmer Centric Activities

CSIR-CFTRI conducted a total of 23 custommade training programmes on post-harvest handling and value additions of produces for the benefit of farmers/FPOs. 380 farmers including 159 women farmers from Karnataka, Kerala, Maharashtra, Andhra Pradesh, Tamil Nadu, West Bengal, Meghalaya & Mizoram, FPOs, SHGs attended these training programs.





The topic covered include basic food processing and preservation, value addition to agri-horticultural produces such as millets, jaggery, turmeric, ginger, fruits and vegetables - custard apple, jack fruit, pineapple, banana, vegetables and many more; value addition to bakery products and spirulina cultivation. Further, participants were given exposure to plant and machinery, specific processing technologies and common processing facility.

#### JIGYASA

As part of the JIGYASA activities, the following programmes were held.

- Student-Scientist connect programme for students of Jawahar Navodaya Vidyalayas of Mysore, Chamarajanagar, Mandya and Mysore on Aug 26-27, 2019
- IISF half-a-day event for students of KVS (Mysore), CFTRI school and Maharani PU college on Oct 10, 2019
- Two days programme for Govt. schools in Mysore on Nov 27-28, 2019
- Student-Scientist interaction at respective KVS (Mysore, Chamarajanagar, Mandya) during Feb 2020
- GHP School, Siddaramanahundi, Mysore as part of the National Science Day celebrations on Feb 28, 2020

Overall, 806 students and 53 teachers participated in these programmes.





Progress Under R&D Projects

**ENGINEERING** 

**SCIENCES** 

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

The effect of FIR assisted RW drying (FIR+RW) on drying behaviour, retention of nutrition, microstructures and flavour compounds in apple slices of different thickness was studied and compared with RW and Heat Assisted (HA) drying alone. Laboratory scale FIR+RW drying system developed was used for the study. Study revealed that drying time increased as slice thickness increased from 2 to 5 mm irrespective of drying methods. Drying time was lowest in case of FIR 60°C+RW (25 min for 2 mm; 65 min for 5 mm thickness) and was ~50% less compared to that of RW alone in and ~66-69% less with HA for 2 and 5 mm slice thickness, respectively. Maximum retention of ascorbic acid was observed in FIR 60°C+RW (79.2%) for 2 mm thick slice. Retention of antioxidant activity was higher in FIR+RW drying at both the temperatures (50 and 60°C). Also, higher amount of TPC, TFC, flavour retention and minimal changes in colour and microstructure were observed in this combination, as compared to HA drying. RW drying alone reduced energy consumption by

nearly 18-20%, while FIR + RW reduced it by 37-46%, as compared to HA drying. Also, studies on the effect of water temperature (70, 80 and 90°C) and puree thickness (2, 3 and 4 mm) on RW drying of banana pulp were carried out. Increase in puree thickness and decrease in water temperature increased the drying time to achieve desired moisture content in product (12-13% wb). Pulp of 2 mm thick dried at 90°C required ~50 and 63% less drying time than that for 3 and 4 mm, respectively. Studies showed that combination of FIR and RW drying requires lesser time for drying and also results

### Microencapsulation of blended oil into powder rich in PUFA (Sukumar Debnath)

in better quality product, as compared to RW or

HAdrying alone.

Microencapsulation of oil samples rich in omega 3, omega 6 fatty acid such as flaxseed oil, sesame oil, rice bran oil or their blends was carried out. Main aim of this work was to develop PUFA enriched microencapsulated oil powder. Spray drying was carried out at 140°C and about 8% of oil was encapsulated using maltodextrin as wall material and tween-20 as



Laboratory scale FIR assisted RW dryer

emulsifier. The encapsulation efficiency was found to be 90-94% and PUFA content of the powder was found to be about 39%. Morphology and particle size of the microencapsulated oil powder was evaluated using SEM and particle size analyzer, respectively. Flow properties were calculated based on the observations of bulk density, tap density, cohesiveness. Analyses were performed for various oil samples and emulsion was checked for its viscosity and stability. Powders obtained were free flowing and were evaluated based on their flow properties, encapsulation efficiency, oxidation properties and powder yield. Sensory evaluation of the powder (in warm/cold water) was found acceptable. Microbiological examination of the products showed that flax-rice bran oil based powder was stable for 21 days in simple polythene pouches at room temperature. The stability can be improved/increased to 3-6 months by selecting the proper packaging material such as tin container.

# Membrane augmented vegetable oil extraction-refining (Subramanian R)

The membrane desolventising performance of indigenously prepared CSMCRI-SRNF membranes was assessed and conceived a membrane-augmented extraction-refining process to exploit the untapped potential of membrane technology in the vegetable oil industry. The pre-treatment of the miscella is being examined employing micelle-enhancedultrafiltration and acid/alkali treatment followed by centrifugal separation to meet the requirements of SRNF. Besides, the step would partially degum, decolourise and dewax the crude miscella, thereby reducing the chemicals and other utilities required in the post-membrane refining steps. Further, a transport model was developed to predict the permeability of solvents in the hydrophobic SRNF membrane for its induction in the simultaneous desolventising and deacidifying steps. The proposed augmentation of membrane desolventising plant in the vegetable oil extraction-refining would save 65% of the distillation energy which typically accounts to ~1750 MJ/h in a 300 TPD soybean extraction plant.



Membrane augmented vegetable oil extraction-refining

# **Processing of turmeric oil by nanofiltration** (*Rastogi NK*)

Curcumin-removed-turmeric-oleoresin (CRTO) consists of volatile and fixed oils, resin and leftover curcuminoids, but remains as an underutilised by-product. Hexane-extracted turmeric oil from CRTO (CTO) contains the bioactive sesquiterpenoids, namely, arturmerone, turmerone and  $\beta$ -turmerone. Although, bioactive constituents are susceptible to thermal degradation, the distillation method was followed to recover the turmeric oil, as there is no alternative milder processing technology. Nano filtration (NF)

technology was employed for the separation of volatile oil and the concentration of turmerones in the CTO. During membrane processing of CTO, the volatile oil content increased from 75 to 97.8% while increasing the ar-turmerone content from 16.4 to 19.4%. The storage studies revealed that the membrane-processed turmeric oil (MTO) possessed higher stability of turmerones than hydro-distilled turmeric oil (HTO). The study demonstrated a non-thermal route to produce turmeric oil with higher turmerone stability and bioactivity, thus offering scope for value-addition to CRTO.



Membrane processing of CRTO turmeric oil

### Solvent extraction of green coffee beans for chlorogenic acids (Manohar B)

Chlorogenic acid (CGA), a constituent of coffee, has several beneficial effects, in particular improved glucose and lipid metabolism, as well as anti-oxidant and antiinflammatory activity. The main objective of this work was to extract a bioactive component CGA from green coffee using different solvents water, methanol, isoproponal and hexane. Water extraction has been found to be the best for extraction of CGA and polyphenol followed by methanol. Box-Behnken design of experiment was carried out to study the optimization of extraction of CGA with water involving 3 independent variables namely, particle size (up to 2100 um), solvent-material ratio (up to 40:1) and time of extraction (up to 3 h). The maximum CGA of 5.17% was predicted by response surface model at a particle size 2100 um, solvent-material ratio of 40:1 and time of 3 h. In the process of preparing (grinding) samples from green coffee beans, physical characteristics of beans, grinding energy and particle size distribution studies which are important parameters in extraction were also carried out. Supercritical CO<sub>2</sub> extraction at pressure (300 bar and 50°C) did not extract any CGA.

### Continuous rice cooking machine (Nagaraju VD)

Large-scale production of cooked rice carried out in batch mode using manual operations is facing major constraints in terms of quality variations between batches, generation of effluents, labor requirements, safety and hygiene related issues. In order to overcome the above problems associated with current process, design and development of a rice cooking machine to be operated in continuous mode, with very less/no generation of waste water was taken up. Initial trials were carried out in the existing steam box conveyor with the supply of steam from boiler and by maintaining a conveyor speed to have a residence time of about 10-12 minutes. Further, a continuous cooking machine was designed and developed for the study. Rectangular shaped troughs of 300x100x25 mm dimension were assembled in series in the form of endless conveyor with the

help of 'K1' attachment chain link. The troughs were fed with known quantity of rice and water and further, with the help of variable drive mechanism, it was moved through the steam box for 10-12 min. Required cooking temperature of around 95°C was maintained in the steam box throughout. The cooked rice was collected at the exit and used for the preparation of rice based products. The quality characteristics of cooked rice were determined.



Continuous rice cooking machine

### Virgin coconut oil by wet milling (Venkatesh Murthy K)

Virgin Coconut Oil (VCO) by wet milling is a novel and high value coconut product known for its nutraceutical benefits and as a functional food. Demand for VCO is rapidly increasing and VCO manufactured in, micro or medium scale levels, has excellent potential for improving coconut farm incomes by five to eight fold over traditional copra production or sale of fresh nuts. Presently, dedicated pilot plant that can process coconut at a reasonably higher scale for the production of VCO is not available. Hence, this project has a major objective of establishing a dedicated pilot plant for large scale processing of VCO. Based on VCO technology developed earlier by CFTRI, in collaboration with Coconut Development Board, the necessary machinery for a dedicated pilot plant (~500 coconuts per hour) were identified and the work is in progress.

# Graphene oxide based nanocomposite films (Arunkumar P)

An eco-friendly method using phytoextract was employed for the synthesis of zinc oxide (ZnO) nanoparticles without any capping agents. Different concentrations of ZnO nanoparticles were loaded into methyl cellulose (MC) to develop MC-ZnO films by solution casting technique. As-obtained MC/ZnO bionanocomposite films showed improved mechanical (by 32%) and antimicrobial properties compared to MC film because of the formation of torturous pathway due to uniform dispersion of ZnO into MC matrix.



(a, b) Pure MC film and (c,d) MC/ZnO film

### **Safety of food in parcel wrap** (Jeevan Prasad Reddy)

Recently, several concerns have been raised on safety of food packed in parcel wrap cooking applications. The hotels and roadside stalls are widely using plastics and recycled plastics to pack hot foods (Idly, curries etc.) and also to cover the serving plate. Unfortunately, there are no regulatory standards on migration for these plastic packaging intended to be in contact with food. Hence, it is essential to know the harmful impact of plastic coming into contact with humans. Therefore, the present study is aimed to estimate the specific migration additives from PP/P/PS packaging materials at different time and temperatures from the commercial samples locally collected. Styrene monomer was used to prepare Polystyrene (PS) disposable foam plates which are extensively used to serve hot foods. Styrene has several adverse health effects upon human exposure to vapours such as irritation of eyes, nose, throat, and skin. Therefore, styrene monomer migrating from the disposable styro foam plates into hot foods was estimated using HPLC method. Experiments on migration analysis were carried out according to Regulation (EU) No. 10/2011. Food simulants such as distilled water, 10, 20 50% ethanol, 3% acetic acid (room temperature/40/60°C for 10 days) and nheptane (38°C for ½ h, 66°C for 2 h) were used in this study. Two samples were collected from the market from different vendors. The values were found below 0.001 mg/kg for all the stimulants tested at different temperatures. There was no prescribed specified migration limits for styrene monomer as per the EU

standards. However, for drinking water, the Environmental Protection Agency (EPA) has determined that exposure to styrene in drinking water at concentrations of 20 mg/L for 1 day or 2 mg/L for 10 days is not expected to cause any adverse effects in children. Also the EPA has indicated that lifetime exposure to 0.1 mg/L styrene in drinking water is not expected to cause any adverse effects.

### **Global migration studies on plastics** (Sathish HS)

Plastics are widely used for food packaging because they have several advantages to offer to consumers such as they are safe, lightweight, strong, easily processable, storable and economical. However, plastics are manufactured using low-molecular-weight materials, such as residual monomer(s), oligomers or additives (plasticizers, antioxidants etc.), which can migrate into the food and they are potential contaminants. Therefore, it is necessary to determine the amount of additives migrating from plastic materials, which are intended to be used for food packaging applications. Overall migration test was conducted for food contact materials like laminates, coated materials, rubber, PVC pipes, PET bottles and other plastic materials intended to be used for food packaging applications. The overall migration to be carried for the food contact materials as per the BIS and USFDA regulations. The migration limits have been set for many additives as per the toxicological risk assessment of these substances within the area of food contact materials.

### Packaging and shelf life extension of paneer (Sathish HS)

The objective of this work was to study the shelf-life of ready to use paneer using sterilization process and Refrigerated Foods with Extended Durability (REPFED) technology. Paneer was cut into pieces and initial water activity was adjusted according to the process. Two variations were done, one being the partially vacuumed paneer and the other being the paneer dipped in brine solution and both were packed in PET/PP pouches. Hermetically sealed pouches were then subjected to pasteurization and sterilization. The pasteurized and sterilized pouches were kept under refrigerated and ambient conditions. The stored samples were withdrawn periodically up to 10 weeks and were subjected to microbial and sensory analyses. The study showed that paneer stored under refrigeration was sensorily superior compared to that stored under ambient condition.

### Shelf-life extension of soaked almonds using hurdle technology (Sathish HS)

The study aims at the extension of soaked almonds for up to 3 months by using hurdle technology. Raw almonds were soaked in water and peeled. The initial water activity and pH of soaked almonds were adjusted. Two variations were tried out, one being the partial vacuumed soaked almonds and other being soaked almonds dipped in honey, both packed in the PET/PP pouches. Hermetically sealed pouches were subjected to pasteurization and stored at three different conditions (37°C, 27°C and refrigeration (6-8°C)). The stored samples were withdrawn periodically (every month) up to 6 months and these samples were analyzed for microbial content, sensory attributes, physico-chemical properties, proximate analysis and colour measurement. The study showed that among all the variations, soaked almonds dipped in honey and stored at refrigeration condition was acceptable after 6 months.

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

The phenolic contents (free, esterified, and bound form) of fractionated Kainth fruits was evaluated (178.33±6.90, 151.33±7.73, 707.16±19.77 mg GAE/100g) along with individual phenolic profile. For geographical variation in phenolics, the fruits were procured from PAU, Punjab and from Tehri district, Uttarakhand. But there was no geographical variation found in terms of presence of individual phenolics, but their quantity was slightly varied. The fruits were also checked for its nutritional compositions (vitamins, minerals, organic acids, phenolic compounds and dietary fibre). Based on LOX Inhibition assay for fractionates of phenolic compounds from the fruit pulp, the processed product (RTS, IMF) was developed from fruit fine pulp and fruit waste (after several trails) and these products were analysed for its stability and also evaluated for its nutritional and antioxidant potential. The studies on in vitro antiinflammatory activities of the crude fruit extracts or processed products were carried out on cell line culture. The viability test was carried out for all the three extracts. The IC<sub>50</sub> value was calculated and found to be 1000 ug/mL. No significant viability changes were observed upto 250 ug/mL for all the three extracts. The extracts were further checked for inflammatory markers IL-6, TNF- and IL-10. The partially purified Kainth extracts B, E and F showed prominent anti-inflammatory effect by

### TECHNOLOGY DEVELOPMENT

suppressing LPS induced IL-6, TNF-a upregulation at concentration of 100 µg/mL. While three fractions were also able to rescue IL-10 cytokine levels that are inhibited by LPS. All the three fractions were compared with commercial drugs/polyphenols. Further validation of study was carried out by using in vivo carrageenan induced paw edema model to anti-inflammation property of extracts. The study was carried out on Swiss albino mice at three concentrations (30, 100 and 300 mg/kg body weight). The study showed that at a concentration of 100 and 300 mg/kg body weight were able to rescue the carrageenan induced inflammation in paw volume (cm<sup>3</sup>). Further, the cytokines levels were checked by ELISA method for paw edema proteins. The study showed that at highest concentration (300 mg/kg body weight) it was equally effective as commercial drug (positive control diclofenac sodium) against carrageenan induced inflammation. There was no significant difference between control, positive control (diclofenac sodium) and B, F extracts for IL-6 and TNF- levels. In histopathology, H and E staining was carried out for paw samples and results revealed that extracts B, F were effective and less accumulation of nucleus than carrageenan induced samples. The bioavailability and bioaccessibility were also carried out for extracts B, F. The study confirms that Kainth extracts and its products could be useful for anti-inflammation effect that can address and overcome the life style physiological disorders such as diabetes and obesity.

### Food products from various fractions of Kainth fruit (Chauhan AS)

The process conditions were optimized based on various combinations (low methoxyl pectin and thickening agent) to prepare low sugar restructured high moisture food products (gel like product) from various fractions of Kainth (Pyrus pashia Buch.-ham ex. D. Don) fruit i.e. enzyme clarified pulp juice (CPPP-20%, CPPP-40% and CPPP-100%) and leftover pomace after enzyme liquefaction (PPW-5, PPW-10 & PPW-20) (waste). The sensorial accepted products were subjected to physicochemical analysis. All the products prepared based on Kainth pomace (waste) were rich in crude fibre in comparison to its enzyme clarified pulp juice-based products irrespective of even 100% concentration of the fraction. The sensorial accepted products packed in HDPE container were stored at low temperature  $(4\pm1^{\circ}C)$  and found microbiologically safe and stable during prolonged storage (beyond six months).



Low sugar restructured high moisture food products from Kainth fruit

# High moisture food product (HMFP) from bael (Aegle marmelos) puree (Chauhan AS)

The low sugar and high moisture gel like readyto-eat product from bael (*Aegle marmelos*)

puree was developed. Total 16 formulations were formulated by varying the sugar percentage, types of hydrocolloids, and pulp to water ratio in order to get end product with desired consistency (gel like texture) which is appealing to the consumer in flavor and taste. Based on the sensory scores, the best formulation (F-16) having pulp to water ratio being 1:1, sugar content 28%, hydrocolloids used being low methoxyl pectin and other thickening agent and preservative (sodium benzoate). The optimized bael HMFP was stored at low temperature (6°C±1) for evaluation of physiochemical and sensory properties. The storage studies revealed that the bael HMFP was found stable, microbiologically safe, firm textured (gel like consistency) and palatable even after 90 days of storage. There were marginal changes (except vitamin C) in the physicochemical properties of the bael HMFP stored at low temperature for 90 days. The total retention in phenolic content was found to be 89.48% and total retention in vitamin-A value was found to be 85.42% over a storage period of 90 days. The end product possesses a great potential for commercialization owing to its vitamin-C, vitamin-A and total phenolic content as well as its peculiar exotic flavor and taste.



High moisture food product (HMFP) from bael fruit puree

### Ready to eat (RTE) intermediate moisture (IM) product from blended juice of watermelon and pineapple (Chauhan AS)

Studies on ready to eat gel like IMF product (~50°brix) from juice blend of pineapple and watermelon, which is shelf stable, less sugary and delay in flavor and color changes during storage was carried out. Fourteen formulations with varying ingredients were prepared in order to get the product which is appealing to the consumer. All the formulations were analyzed for various parameters like moisture, pH, TSS, TPA, color and sensory properties. Based on the sensory score, F-14 formulation for IM product was chosen the best, which was prepared from 70% pineapple and 30% watermelon juice, 18% added sugar, hydrocolloids used being low methoxyl pectin and other thickening agent and preservative as sodium benzoate (220 ppm). The chosen formulation was further analyzed for physiochemical and sensory properties upon storage of 90 days at low temperature (6°C±1). Total retention of 91.9% of vitamin-A and 78.23% of total phenolic was found while ascorbic acid was reduced by 49.6%. Even after storage for 90 days at LT, the product was found stable, microbiologically safe, firm textured and retained in organoleptic properties. The IM product F-14 formulation was found highly acceptable by the consumers and have good retention quality in physiochemical and organoleptic properties. This product possesses a great potential in Indian market as well as in international market owing to its nutraceutical properties and its exotic flavour.



Intermediate Moisture (IM) product blended juice of watermelon and pineapple

### **Processed products from beetroot** (*Vijayanand P*)

Beetroots were processed into beetroot pulp, beetroot powder, instant beetroot beverage mix and beetroot sauce.

*Beetroot Sauce:* Beetroot of firm mature quality were washed, peeled and pretreated for pulp extraction. Beetroot pulp has a total soluble solids 7°Brix, pH 6.09, betalins 0.32 mg/l and nitrates 4.030 mg/g. Beetroot pulp was blended with sugar, salt, food acidulant, spices, red chiliies, green chillies and ginger. The beetroot pulp was concentrated, pasteurized and filled into glass bottles. The sauce contained total soluble solids 21°Brix, acidity 1.19%, betalins 0.179 mg/l and nitrates 1.293 mg/g. The beetroot sauce was highly acceptable with deep red color, flavour and overall quality. The product was stable for 3 months storage at room temperature.

*Beetroot powder:* Beetroot powder with very good colour and flavor was obtained by dehydration of beetroot under controlled conditions. Beetroot powder was found to be a rich source of betalins (5.68 mg/l) and nitrates (55.7 mg/g). The powder was packed in food grade flexible packaging material and stored at room temperature. Beetroot powder can be used as a functional component in different food products.

Instant beetroot beverage mix: Beetroot powder was formulated with ginger powder, food acidulant and stevia powder to obtain instant beetroot beverage mix. The beverage mix reconstituted in water resulted in highly acceptable beverage with deep red colour, flavor and overall quality. The beverage mix had a moisture content of 4.53%, betalins 4.87 mg/l, and nitrates 47.5 mg/g. The product packed in polyester polyethylene pouches was found to be highly acceptable for 3 months storage at room temperature.



Reconstituted beetroot beverage

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

The non-thermal treatment with ozone was more effective than ultrasonication in reducing microbial load for lettuce, cucumber and carrots. Lactic acid treatment resulted in the highest microbial reduction in tomato, and considerable reductions of microbial load in cucumber, carrot and lettuce among various chemicals used. Ozone and lactic acid treatments also showed the highest reductions in pesticide residues as compared to other treatments. Although reduction in nutrient content was observed by various non-thermal and chemical decontamination techniques, the losses were least in ozone and lactic acid treated vegetables. The combined treatment of ozone and lactic acid showed promising results in reducing the level of microbial and pesticide contaminants. The combined treatment also showed reduced contamination and rotting of vegetables during storage and there was a slight increase in the shelf life of treated vegetables as compared to untreated vegetables.

### Foxtail millet milled fractions as ingredients for snack foods (Sreerama YN)

Sequential dehulling and pearling of foxtail millet (Setaria italica; PS4 cultivar) fractionated the seed caryopsis into four milled fractions; dehulled grain, hull, pearled grain and bran. The hull is the outermost layer of the millet representing about 18.62% of the whole grain kernel weight. Subsequent pearling of dehulled grains yielded 25% bran and would likely contain segments of aleurone layers, testa and germ. The pearled grain fraction (mostly endosperm) represented the remaining 75% of the dehulled grain weight. The moisture content of whole and milled fractions of foxtail millet ranged from 7.2 to 10.6%. The protein content of whole grain was 10.2%. Bran fraction exhibited the highest protein content (15.3%) followed by dehulled and pearled grain fractions. Fat content among the milled fractions ranged from 0.48 to 25.3% with highest in bran. Ash content was higher in hull and pearled fractions. The carbohydrates in whole and milled fractions ranged from 37.6 to 78.4%. The millet fractions were found to be rich sources of both soluble and insoluble dietary fibre. Quantification of antinutritional factors such as saponins, phenolic compounds, phytic acid and trypsin inhibitory activity indicated variation in their distribution among milled fractions. The protein solubility index of millet fractions was in the range of 3.217.8 mg/g in water. The dehulled grain flours had the highest water and oil absorption capacity, emulsion activity, stability and foaming capacity. Results suggest that appropriate milled fractions can be chosen to develop a desired product based on technological or nutritional demands.

# Utilization of by-products from black gram milling industry (Meera MS)

There is a tremendous scope for grain processors to convert underutilized byproducts of pulse processing into useful products. In this respect, the effect of extrusion on functional characteristics and anti-nutrients of black gram by-product was studied. The sample before extrusion exhibited 2.85 and 1.64 g/g for Water Absorption Capacity (WAC) and Oil Absorption Capacity (OAC), respectively. After the extrusion process, WAC significantly increased to 3.61 g/g, while no change was observed for OAC. The EC before extrusion was found to be 51.5% which reduced significantly to 36% as a result of extrusion. The sample before extrusion produced a fairly stable emulsion with ES of 44.25%, however, after extrusion it had a lower stability value (13.75%). The phytic acid content before and after extrusion showed the value of 0.7 g/100 g, revealing that it remained unchanged while there was marked decrease in the flavonoid and saponin contents.

### **Cereal based fermented beverage** (*Shruti Pandey*)

Cereal based fermented beverage was formulated using rice flour, germinated barley and other food adjuncts. The beverage formulated had an acidity of 0.03-0.29 with a pH of 3.22-3.33. Sensorially the beverage was found acceptable. The shelf life of the product was 7 days under refrigerated condition.

## **Development of gadgets for grains** (*Srinivas A*)

Gadgets to measure certain physical and engineering properties like paddy crack detector and coefficient of friction of grains are of great use in the domain of grain processing. A prototype of the Paddy Crack Detector (PCD) for 25 grains were developed. The electronic circuitry was designed and components were housed in a cabinet. The 3D drawings of the same were prepared to check its suitability. The unit was tested for performance and was found working satisfactorily. The number of grains to be tested were increased from 25 to 50. Accordingly, the design of electronic components and cabinet were changed. Work on 3D printing and assembly of electronic components is under progress.



3D drawing 25LED PCD

### Iron fortified rice (Jayadeep A)

Fortification of raw rice at different concentrations of iron was carried out in a suitable solvent and incorporation into grain without any electrical equipment. In the fortified rice, the iron content ranged from 11-38 mg/100 g, which corresponds to 64-220% of the RDA. But the colour values of rice for brightness and yellowness were not altered and starch microstructure was also not affected. Quality of cooked rice showed that in fortified rice, insignificant decrease in

brightness and increase in yellowness was found with no alteration in textural properties like cohesiveness, springiness and gumminess, except for increase in hardness. However, sensory quality attributes of cooked rice were at par with the control. In the cooked samples, iron retention was 55-90% and 100 g of cooked rice could provide 18-30% of the RDA. The low cost, non-thermal, fortification technique (without application of any heating equipment) resulted in iron fortified rice with acceptable textural, cooking and sensorial properties.



(A) Control raw rice, (B) Sample 1- Iron fortified raw rice
 (13 mg/100g), (C) Sample 2- (24 mg/100g), (D) Sample
 3- Iron fortified raw rice (48 mg/100g)

#### Ragi based nutritious foods

#### (Usha Dharmaraj)

Ragi sample obtained from the Keonjhar region (Odisha) were analysed for the content of moisture, protein, fat, carbohydrate, zinc, soluble and insoluble fibre. Extrusion cooking works with the principle of combined efforts of shear force along with high pressure and temperature which is responsible to modify starch properties. Generally, extrusion cooking converts the flour into ready-to-eat form. About 2 kg of ragi was powdered and extrusion cooked and the effect of extrusion cooking on the quality characteristics of the flour was evaluated. The studies showed that compared to the raw flour, extruded flour contained lower moisture content. Particle size distribution studies indicated low percentage of very fine particles and the sedimentation value was high. Pasting profile studies also showed that extrusion cooking resulted in decrease in gelatinization temperature (57%), peak viscosity (67%), hot paste viscosity (90%), cold paste viscosity (91%) and setback value (92%) and increase in break down (15%). These indicates that starch gelatinization and consequent changes in properties may be of use for instant beverage and porridge. The extruded ragi flour was used as a base to formulate a ready-to-eat chhatua like product, suitable for children. The nutrient composition of the formulation was found as 12.5 g protein, 5.2 g fat, 1.29 g soluble and 13.1 g insoluble fibre, and zinc 2.3 g per 100 g.

### **Centre of excellence in millet processing** (Meera MS)

Although efforts are being made to promote millets, dedicated machinery for primary and secondary processing is needed to bring millets on par with the major grains. An integrated approach to tackle and solve the various issues like milling methods, poor shelflife of milled products, technologies for the production of convenient/products, is required to promote millets. In order to overcome the drawbacks in millet processing, establishment of a centre with processing lines for millet was initiated. About three complete milling lines are being created depending on the nature of grains and end product. These milling lines will enhance the quality of the milled product and help in developing novel millet products. Complete baking lines for millet biscuits, cookies etc will also be part of the millet centre. Extrusion line for ready-to-eat products,

machinery for ready-to-cook traditional products is also being set up. Roller milling and fortification facility that has been standardized to process millets for semolina production is also part of the centre. Apart from the processing lines, analytical quality control and packaging facilities will be part of the centre. Establishment of the CoE on millets will not only be beneficial for farmers, SHGs, FPOs, startups and all other stakeholders involved in the production/ processing/trading of millets and millet products but also the consumers at large.

# **Spice bioactive / oil and natural colours** *(Madhava Naidu M)*

Green technology and selective extraction of fenugreek seed husk: Fenugreek (Trigonella foenum graecum L.,) seeds host a wide variety of bioactive compounds. Polysaccharides being an important constituent of fenugreek seeds have galactomannan as a major soluble fibre that has shown to enhance glycemic control. The study was aimed at improvising the yield recovery of galactomannan from fenugreek seeds through selective extraction of husk containing endosperm by separating the cotyledons through technological intervention. Comparative studies were done to evaluate the yield obtained between different groups. Structural elucidation and characterization were compiled to confirm the compound. Crude GM yielded twice, and pure GM yielded 3.25 times more the yield that can be obtained through whole seed samples. The extracted galactomannan also inhibited αamylase and a-glucosidase enzymes in vitro with  $IC_{50}$  values of 42.15 ± 0.17 ppm and 134.34 ± 10.3 ppm respectively. Owing to the minimal fat content of husk, defatting procedure were omitted without altering the consecutive steps

to overcome usage of solvents. This kind of selective extraction helps higher recovery of the bioactive compound, minimal use of the resources, and promotes industrial viability as well as green technology.

6-gingerol from fresh ginger: 6-gingerol is one of the prominent bioactive components of ginger. The varietal variation and the time of maturity on 6-gingerol content were studied. Ten authentic cultivars of ginger were collected and analysed for oleoresin, 6-gingerol, polyphenol and its antioxidant activity. Results showed that, among all ten varieties, ING 5 variety showed the maximum yield of oleoresin (11.05%) followed by ING 6 (10.5%). Maximum 6-gingerol content (7.59%), total polyphenol content (TPC) (34-36 mg/g) and antioxidant activity (85±0.5%) at 200 ppm in comparison with BHA (91%) were observed in ING 6. Among ten cultivars analysed, ING 6 was chosen for maturity studies. ING 6 was cultivated in Mysore and after 150 d of sowing fresh ginger rhizomes were harvested and analysed for ginger oil, oleoresin, 6-gingerol and its antioxidant activity. The oleoresin (6-10%) and 6-gingerol concentration (2.26-7.28%) were found to increase with maturity (150 to 270 d). However, no significant changes were observed in volatile oil (1.03±0.2%) content. As maturity increased TPC also increased (14.4 to 34.7 mg/g) and antioxidant activity also showed an increase from 60 to 90% when compared with BHA (91%) at 200 ppm.

# Onion processing using conveyorized microwave dryer (Nagarajan S)

Onion processing is important in terms of preservation by employing suitable drying and reconstitution techniques. Microwave processing and drying results in better retention of volatile/ pungent sulphur compounds and color along with overall quality. Under optimized conditions the dried onion has shown the product with moisture content of 6% in acetic acid treated sample and 4% in untreated samples. The preliminary color and appearance of the dried onion samples was appealing, and bright red color was observed with acetic acid treated sample and moderate red color with untreated sample. Whereas the market sample had pale red color with wheatish-white color predominately. The preliminary GC and GC-MS analysis of microwave dried samples showed the retention of character impact volatile compounds i.e. nonanal (untreated 8.458% and treated 6.485%) and allyl methyl sulfide (untreated 25.9% and treated 20.5%) and 3,5-diethyl 1,2,4-trithiolane (treated 28.3% and untreated 23.6%) respectively. Whereas in the market sample (dried sample of onion) on Clevenger /Likens-Nickerson extraction gave traces of the volatiles with the retention of 5.04% of allyl methyl sulfide and trace quantities of 3,5diethyl, 1,2,4-trithiolane, respectively. The study proved that microwave drying of onion provides scope for large scale processing with less time and energy. In addition, microwave dried onion had better appearance in terms of texture, colour and appeal.

# Health-cola beverage using natural sweeteners (Nagarajan S)

The preparation of cola beverage using natural sweeteners with low GI and preliminary sensory evaluation was carried out by standardizing the acidulants in cola beverage. Accordingly, the cola flavour blend was formulated using caramel color and palm sugar. The pH was adjusted to 3 - 3.5 and stored at room temperature (26-28°C) and at refrigerated conditions (12-15°C). Preliminary microbial analysis of the product showed the presence of food borne pathogen originated from commercially procured palm sugar. Hence sugar was purified/recrystallized and used for preparing the cola beverages. The sensory analysis of the product was found acceptable and comparable to that of commercial cola beverage.

### NMR for qualitative and quantitative analysis of curcuminoids (Sachin R Chaudhari)

Curcumin along with demethoxycurcumin and bisdemethoxycurcumin as a whole called curcuminoids is an active phytochemical constituent in turmeric. Turmeric from different origins were profiled by NMR spectroscopy for the determination of curcuminoid percentage. This is first report by NMR for analysis of all the three curcuminoids simultaneously apart from structure analysis bringing out the novelty of the work. Existing HPLC method is time consuming, needs large volume of solvents and needs authenticate standards. On the other hand, protocol proposed here is a straightforward, easy sample preparation procedure and can be performed in 10 minutes without the need of any reference compound. The proposed methods are useful to pharmaceutical/ food industries for selecting the good source of turmeric and to understand turmeric geographical origin.

# Anti-carcinogenic potential and mechanism of zerumbone (Bettadaiah BK)

Zingiber zerumbet displays various

pharmacological activities due to presence of zerumbone, a sesquiterpene molecule. Among numerous procedures proposed for the extraction of bioactive compounds from the rhizome of zerumbet, hydro-distillation method affords essential oil yield of 3.2%. The feasibility of extraction of essential oil and oleoresin from Zingiber zerumbet rhizome by enzyme assisted hydro distillation and enzyme assisted solvent extraction was studied. Pretreatment of zerumbet rhizome powder with enzymes (α-amylase, bio-protease, cellulase, enzymes from herbal extract, hemicellulose, pectinase and viscozyme) prior to hydro distillation and various solvent extraction (ethanol, methanol, isopropanol, acetone, dichloromethane, ethyl acetate and chloroform) were optimised under different treatment conditions of varying temperature (30°C, 40°C and 50°C) with incubation time (60, 90 and 120 min) at different concentration of enzyme (1 to 5%). It was found that, in enzyme assisted hydro distillation method there is a higher percentage recovery of volatile oil of zerumbet than the control. The recovery of oil varies between 3.28 to 4% in comparison to control sample where enzyme treatment is absent (3.2%). The highest recovery (4.0%) was found in pectinase, hemicellulose, viscozyme and amylase enzyme with optimised condition of incubation for 1 h at 30°C. Under similar conditions, the yield of oil in the case of cellulose, herbal extract and bio protease treated sample was 3.8%, 3.6% and 3.28% respectively. In general, the oil yield was improved by 25% in case of pectinase, hemicellulose, viscozyme and amylase and 18.75%, 12.5% and 2.5% increase in the case of cellulose, herbal extract and bio protease

enzyme treatment respectively. GC profile of all the extracts was carried out. In the case of oleoresin extraction, enzyme treatment was carried out before solvent maceration. Increase in percentage recovery of oleoresin in ethanol, methanol, isopropanol, acetone compared with untreated samples was observed. The range was 6 to 8.8%, 5.3 to 7%, 4.3 to 6.2%, 4.1 to 5.7% respectively. The maximum yield gain accounting to 47% was with ethanol.

### Nano-encapsulated medicated ghee (Pooja J Rao)

Medicated ghee was nano encapsulated using oil-in-water emulsion method and spray dried. The core to carrier ratio, influence of salt and surfactant were studied and stabilized. The yield of samples with varied physico-chemical parameters ranged from 4.17 to 8.59 g/100 ml of emulsion. The spray dried powders were then reconstituted at 1 mg/mL to measure particle size and PDI on 0th, 8th and 16th day.



The study further aims at analysing encapsulation efficiency of prepared formulations and studying their surface morphology using SEM followed by development of a food product to increase the palatability of bitter medicated ghee thereby augmenting acceptability of the formulation.

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

The solubility of curcumin in two different lipids, milk fat (MF) and virgin coconut oil (VCO) was assessed. The solubility of curcumin was found more in VCO than MF. The curcumin dissolved in lipids is used in the preparation of nanoencapsulated curcumin. The oil-in-water method was employed to prepare curcumin nanoemulsion. The water soluble milk protein/protein-polysaccharide combination was used as carrier material. The influence of the amount of curcumin, MF/VCO, surfactant and pH of the emulsion on the particle size (PS), polydispersity index (PDI) and zeta potential ( $\zeta$ ) of the nanoemulsion has been studied. The samples prepared with MF/VCO, sodium caseinate and Tween 80 at pH showed higher particle size (200 nm - 5 µm) and higher zeta potential (between -15 to -30 mV). Further, an autotitration using zeta potential analyzer (Malvarn) showed a small particle size (<100 nm) and low  $\zeta$  (< -30 mV) at pH 8.5. The stability (with respect to change in particle size and zeta potential) of curcumin nanoemulsions was also studied for 45 days.

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

Green coffee beans (GCB) are rich in phenolic acids, especially in chlorogenic acid (CGA), and its related compounds with potential health benefits for consumers. Currently market trends include not only the protection of food components, but also for products with prohealth properties through the incoporation of antioxidants. The work was aimed to valorize green coffee spent (GCS) as a food ingredient and its application in bakery products. About 70% GCS was obtained after processing green coffee for chlorogenic acid. The cookies fortified with GCS (roasted and unroasted) were evaluated for physicochemical properties and food safety. The roasted and unroasted GCS flour had dietary fibre ranging from 3.3±1.08 and 2.6±0.21%, total polysaccharides with 8.29±0.05 and 16.34 µg/mg along with fair amount of ash, protein, and soluble dietary fiber. The acrylamide content in UGCS flour cookies recorded in the range of  $23.429 \pm 0.4$  lg ACR/kg d.m. and in RGCS flour ranged from 32.6-37.8 ± 0.3 to Ig ACR/kg d.m. The sensory attributes such as color and aroma formulations made with RGCS flour cookies received the highest points. Thus, prebiotic oligosaccharide rich RGCS flour represents as a novel alternative food ingredients, which can be used to develop various functional foods.

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

The consortia of *Saccharomyces cerevisiae*, *Lactobacillus plantarum* and *Bacillus sphaericus* (1:1:1) at 10% inoculum concentration was found significant in demucilizatin of Arabica coffee beans with noticeable improvement in quality compared to natural fermentation. The sensory profile of starter fermentation scored 7.0 on 1–10 scale. Prospective insights on application of starter consortia on Arabica coffee fermentation indicates prime requisite for coffee industry. The work elaborates the volatile profile development in defined starter consortia treated and naturally fermented Arabica coffee. The effect of isolated potential microbes on Robusta coffee fermentation was examined. Also, the individual yeast isolate resulted mucilage degradation, on Robusta coffee fermented using 10% yeast inoculums compared with natural fermentation. The studies on metabolites impact on flavor development, organoleptic analysis and volatile profiling of respective treatment is under progress.

### **Diversified egg products** (Sachindra NM)

An egg beverage mix was formulated by blending egg albumin powder with sugar powder, skim milk powder, defatted soy flour, salt, citric acid and flavor. The protein content in the beverage mix was in the range of 31-39% and fat content in the range of 2.5-3.5%. The beverage mix had improved water solubility, water absorption capability and lower foaming properties compared to egg albumin powder.

Studies were carried out to prepare egg white protein hydrolysate using bromelain. In this study hydrolysis of egg white using the bromelain under the predicted operating conditions derived from the response equation of design experiment produced improved effects on the antioxidant capacity of the hydrolysate. The optimized conditions of bromelain hydrolysis of egg white by means of time (25 h), pH (9) and E/S ratio (1:100) was established for highest response of antioxidant peptide formation (measured as % DPPH) scavenging activity by using the Box-Behnken design.

Egg yolk fractionation processes to obtain granules and plasma was optimized. Centrifugation at 8000 rpm at 4°C for 45 minutes resulted in better separation of granules and plasma. Protein content of egg yolk granules ranged from 63.93% to 68.3% (dry matter basis) and the lipid content ranged from 26.86% to 31.41% (dry matter basis) depending upon the type of treatment employed. Protein content of egg yolk plasma ranged from 24.43% to 26.62% (dry matter basis) and the lipid content ranged from 68.79% to 71.79% (dry matter basis). One third of total lipids and cholesterol of egg yolk fractionated into the granules and two-third lipids and cholesterol fractionated into the plasma. Inversely two-third protein was present in the granules. These types of fractionations can be used for speciality products. New products (egg stick, snack food) was developed consisting of egg yolk granules, freeze dried egg white powder, skim milk powder PUFA rich oils such as olive oil and soy lecithin. The consistency of the product was found similar to that of fresh egg yolk.

### Proteinaceous material from wastewater streams of fish/ meat processing (Tanaji G Kudre)

Protein hydrolysate (FWBPH) having antioxidant, antibacterial and anti-ACE potentials was prepared from the wet blend proteins (WBP) recovered from the different meat/fish processing wastewater streams (surimi wash water and slaughterhouse wastewaters namely fish, cattle, poultry, and goat) using *P. lolii* at 1.8% carbohydrate, 18.4% WBP concentration, and 56.18 h hydrolysis time. FWBPH was evaluated for the functional protein feed ingredient for poultry (broiler) growth performance. To examine the quality of FWBPH, rat bioassay was performed by replacing casein (standard protein) with
different levels of FWBPH (0, 50, 75, and 100%, w/w). Rat group fed with 50% FWBPH (F50) showed better FCR, FER, PER, weight gain, liver, hematological, serum biochemical parameters, relative organ weight, histopathology, and antioxidant activities when compared to all studied groups in male albino Wistar rats. The SGOT and SGPT levels increased linearly with the increase in levels of FWBPH. However, F50 showed slightly higher antioxidant activities (catalase and superoxide dismutase) in the liver as compared to the control group. Therefore, in the rat bioassay, 50% FWBPH substitution as a protein source in standard (AIN93G) feed can be regarded as an ideal replacement for superior nutritional quality and enhanced growth performance of rats. To evaluate the growth performance of poultry birds, soya protein was replaced with different levels of FWBPH (0, 25, 50, 75, and 100%, w/w) in the diet. The bird group (F75) fed with diet containing 75% FWBPH presented the highest weekly body weight gain and PER suggested that the feed quality of the F75 group was better when compared to other feed diets counterparts. Incorporation of FWBPH in the diet at all levels did not affect the relative organ weight, histology, hematological, and serum biochemical parameters of broiler chicks. Furthermore, F75 exhibited slightly higher liver catalase and SOD activity (antioxidant activities) as compared to other FWBPH fed groups. Overall, the result suggested that the incorporation of FWBPH at

all levels did not show any morphological, physiological, pathological, and clinical defects except a higher level (F100). Furthermore, the impacts of FWBPH on the meat quality of chicken broiler birds were examined. The results of meat analysis revealed that the chicken meat of the F75 group had better meat quality and sensory scores among all groups. The meat of all FWBPH fed broiler birds showed slightly higher iron content and increased with an increase in FWBPH levels. Therefore, 75% replacement of soy protein concentrate with FWBPH could be a better alternative protein source for the growth improvement and overall performance in the poultry chicken broilers. The formulation of poultry feed with an appropriate amount of FWBPH could boost the alternatives for the replacement of antibiotic growth promoters in animal/poultry feed.

#### Millet based gluten-free bread

#### (Prabhasankar P)

Celiac disease (CD) is an auto-immune disorder which causes chronic inflammation in small intestine triggered by ingestion of wheat gluten and related proteins from rye, barley and triticale. In India, 6 to 8 million people are suffering from CD. The only safe diet for them is gluten free products. Gluten free foxtail millet (100%) based bread was optimized using addition of enzymes which helps in increasing the gas holding capacity in batter and also helps in network formation. Foxtail millet bread without enzyme addition was used as control.



slaughter house waste water

Bio-functional protein hydrolysates (FWBPH)



Rat fed with FWBPH



FWBPH

Optimized bread had higher volume (345 cc) and specific volume (2.09 cm<sup>3</sup>/g) than control bread (308 cc, 1.69 cm<sup>3</sup>/g). Textural studies showed that optimized bread had lower hardness (50.53 N) than control bread (87.01 N). Microstructure studies revealed that enzyme addition causes uniform distribution of protein and starch similar to wheat bread. Sensory studies showed that optimized foxtail bread was acceptable with good colour, shape and uniform cell distribution than foxtail control.

### Value addition to buckwheat of Indian Himalayan and North Eastern regions (Crassina Kasar)

The noodle-making characteristics of Indian buckwheat was studied. The effect of milling method and improvers on the quality characteristics of buckwheat noodles were carried out. Noodles were produced from rollermilled buckwheat flour (RBN) and hammermilled buckwheat flour (HBN). The effect of different levels of improvers namely gluten, emulsifiers and hydrocolloids on the quality of these noodles were evaluated for cooking properties, quality characteristics and sensory attributes. Addition of gluten powder at different levels showed a gradual decrease in the cooking loss in both the RBN and HBN noodles. Gluten improved the texture of the noodles measured in terms of breaking strength. Xanthan gum has the best effect on the texture in both the RBN and HBN noodles. Further, the effect of milling method on the nutritional composition of buckwheat noodles was evaluated. The protein content of RBN is 8.37% whereas it is 13.97% in HBN. The total dietary fiber of HBN (9.02%) is two times higher than that of RBN (4.85%). The amino acid and minerals profile of noodles produced from HBN

is better than that of the noodles produced from RBN. The bioactive components namely total polyphenol content and total flavonoids content are higher in HBN than in RBN. The nutritional profile of HBN is superior to RBN. However, phytates and tannins content in HBN and RBN are 2.3% and 0.67% and 0.057% and 0.011% respectively.

### Chemical free and natural colour/ flavour based bakery products (*Prabhasankar P*)

Natural plant pigments in steamed bread: Study on use of plant pigments as natural food colour in bakery products was explored. The beetroot juice concentrate having 0.716% betalain content was used in muffin preparation and after baking only small quality of belatin was present. The beetroot juice concentrate was encapsulated to 150-200 nm to enhance its stability and the betalin content was at 0.214%. The concentration of betalin present in the muffin marginally increased. Using the oil soluble beet the stability of betalin in the muffin further increased. The muffins prepared with oil based beet was acceptable with respect to the sensory characteristics. Use of some commercial bioflavonoids and laboratory anthocyanins-rich extracts in steamed bread did not have effect on the colour of the product.

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

Resultant atta, bran and germ are by-products of the roller flour milling industry and together account for 30-35% of the total milled products. The objective of this study was to utilize wheat bran and resultant atta for their value addition to produce biodegradable-edible disposable plates. The formulation of flour/ base using

100% wheat bran, and replacing wheat bran with resultant atta in different ratios were studied. Edible plates were prepared from these combinations with addition of salt, additives, oil and water.



Biodegradable-edible disposable plates

### Protein enriched foods with improved digestibility (Sashikala VB)

Various products such as roasted soy bean and soy flakes that could be consumed as used as snacks were prepared after suitable processing. Soy bean was subjected to roasting under controlled conditions to prepare roasted soy and suitable spicy coating to get a crunchy soy namkeen. The hardness (N) value of roasted soy namkeen was ~162.52 N and had a protein content of 40.89% and fat content of 18.99%.



Roasted soy namkeen

The soya dhal was flaked after suitable hydrothermal treatments to obtain soya dhal flake which was then coated with chocolate. The soy flakes had a protein content of 42.61%, fat content 41.61% and ash content of 0.95%. The sensory evaluation conducted indicated that the coating of chocolate on the soya-flakes resulted in increase in scores of taste, flavour, crispiness and overall acceptability. Among the soya flakes and chocolate coated soya flakes, the latter had scored 7.8 than plain one (7.4) in texture attribute.



Soya dhal flakes before and after coating

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

Fungal milk clotting enzymes are being studied extensively as substitutes for animal rennet to clot or curdle milk. Aspergillus oryzae MTCC 5341 was grown by solid state fermentation on wheat bran containing defatted soy flour and moisture at specific. After its optimum growth, the mouldy bran was dried and enzyme was extracted. Milk clotting activity from A. oryzae was compared with commercial Mucor miehei rennet. Initial studies from A. oryzae extract exhibited protease and milk clotting activity of 0.170 ± 0.010 U/ml/min and 4,000 ± 36 SU at 40°C respectively. Whereas, Mucor miehei rennet had protease and milk clotting activity of 0.097 ± 0.008 U/ml/min and 76,400 ± 136 SU at 40°C respectively. However, yield of curd from A. oryzae was highest at 60°C at 5.32 g and yield of curd from Mucor miehei rennet was highest at 55°C at 7.95 g.

### Quantitative modeling of regulatory processes associated with bacterial stress response (Sutapa Mukherjee)

Using mathematical and computational tools, it was attempted to understand some of the regulation processes behind the functioning of the major regulators of bacterial stress response. In this connection, a particular feedforward loop (FFL) was studied that regulates horizontal gene transfer in Salmonella enterica when the bacteria is subjected to stress due to bile salt. Interestingly, unlike conventional transcription factor driven FFLs, this particular FFL is driven by small regulatory RNAs (sRNAs). It was shown that this FFL leads to a speedy response through fast target protein synthesis in comparison with other commonly found FFLs. Further, depending on the concentration of sRNA, the FFL can lead to maximal noise filtration in the target protein concentration.

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

A GH36 α-galactosidase from *Lactobacillus plantarum* WCFS1 was cloned and over expressed in Hi-control *E. coli* BL21(DE3). Ni-NTA affinity gel chromatography resulted in purified protein (*Lp*αG; specific activity 3077.35 U mg<sup>-1</sup>, Mw80 kDa, 29.3% yield). *Lp*αG displayed optimum activity at pH 6 and 37°C. The  $K_m$ ,  $V_{max}$  and  $k_{cat}$  / $K_m$  of *Lp*αG towards *p*NPαGal were found to be 0.93 mM and 714.3 µmol ml<sup>-1</sup> min<sup>-1</sup> and 12075 s<sup>-1</sup> mM<sup>-1</sup>, respectively. *Lp*αG displayed maximum transglycosylation activity towards melibiose and synthesized majorly a trisaccharide (yield 20.37%). NMR characterization revealed that trisaccharide consists of only single species of α- linked galactooligosaccharide (αGOS; α-D-Galp-(1  $\rightarrow$  6)- $\alpha$ -D-Galp-(1  $\rightarrow$  6)-D-Glcp) with  $\alpha$ - $(1 \rightarrow 6)$  regioselectivity.  $\alpha GOS$  displayed prebiotic property by supporting the growth of probiotic L. plantarum WCFS1 and Bifidobacteria adolescentis DSM 20083. A GH13 raffinose-6-phosphate hydrolase (lp\_0189; agl2, 1.67 kb) gene was cloned in pET-28a(+) and expressed in HI-Control E.coli BL21 (DE3). The expressed protein displayed monomeric molecular weight of ~64 kDa on SDS-PAGE. However, expressed agl2 formed inclusion bodies and could not be recovered in soluble form for further characterization. To investigate the involvement of pts23C membrane transporter (lp 3010) in cellobiose operon, deletion of the mutant of pts23C was attempted. 1 kb upstream and 1 kb downstream fragments of 1.47 kb pts23C were cloned sequentially in pNZ5319 mutagenesis vector. The resultant pts23C-KO plasmid was transformed in L. plantarum WCFS1. The colonies obtained were screened but none of them were found positive. DP2 and DP3 guar gum oligosaccharides (GG-β-MOS) were structurally characterized by NMR, FTIR and XRD. DP2 was composed of two species (A) mannopyranose  $\beta$ -1,4 mannopyranose and (B)  $\alpha$ -1,6-galactosyl-mannopyranose while, DP3 oligosaccharide showed presence of three species i.e. (A)  $\alpha$ -D-galactosyl- $\beta$ -Dmannobiose (galactosyl residue at reducing end), (B)  $\alpha$ -D-galactosyl- $\beta$ -D-mannobiose (galactosyl residue at non-reducing end) and (C) mannopyranose  $\beta$ -1,4 mannose  $\beta$ -1,4 mannopyranose. In batch fermentation, DP2 GG-β-MOS was preferred over DP3. DP2/ DP3 and GG-β-MOS mixture inhibited the growth of enteropathogens. The studies on low-fat, synbiotic ice creams demonstrated the

effectiveness of  $\beta$ -manno-oligosaccharides in improving the survival of *Lactobacillus* sp. and also enhancement of the functional properties.

#### Molecular and functional characterisation of *Listeria monocytogenes* RecA protein (*Patil KN*)

The studies showed that L. monocytogenes expresses recA more than 2 fold in vivo upon exposure to the DNA damaging agents, MMS and UV. The purified L. monocytogenes RecA protein showed robust binding to single stranded DNA. The RecA is capable of forming displacement loop and hydrolyzes ATP, whereas mutant LmRecA<sup>K70A</sup> fails to hydrolyze ATP, showing the conserved walker A and B motifs. Interestingly, L. monocytogenes RecA and LmRecA<sup>K70A</sup> perform the DNA strand transfer activity, the hallmark features of RecA protein with an oligonucleotide based substrate. Notably, L. monocytogenes RecA readily cleaves L. monocytogenes LexA, the SOS regulon and protects the presynaptic filament from exonuclease I activity. Altogether, these studies provide the first detailed characterization of L. monocytogenes RecA and also presents important insights into the process of homologous recombination in a gram positive foodborne bacteria L. monocytogenes.

*p-Coumaric acid inhibits the Listeria monocytogenes RecA protein functions and SOS response: An antimicrobial target:* Bacterial RecA plays an important role in the evaluation of antibiotic resistance via stressinduced DNA repair mechanism, SOS response. Accordingly, RecA became an important therapeutic target against antimicrobial resistance. Small molecule inhibitors of RecA may prevent adaptation of antibiotic resistance mutations and the emergence of antimicrobial resistance. Phenolic compound p-Coumaric acid as potent RecA inhibitor was observed in the study. It inhibited RecA driven biochemical activities in vitro such as ssDNA binding, strand exchange, ATP hydrolysis and RecA coprotease activity of E. coli and L. monocytogenes RecA proteins. The mechanism underlying such inhibitory action of p-Coumaric acid involves its ability to interfere with the DNA binding domain of RecA protein. p-Coumaric acid also potentiates the activity of ciprofloxacin by inhibiting drastic cell survival of L. monocytogenes as well as filamentation process; the bacteria defensive mechanism in response to DNA damage. Additionally, it also blocked the ciprofloxacin induced RecA expression leading to suppression of SOS response in L. monocytogenes. These findings revealed that p-Coumaric acid is a potent RecA inhibitor, and can be used as an adjuvant to the existing antibiotics which not only enhance the shelf-life but also slow down the emergence of antibiotic resistance in bacteria.



X - Denotes inhibition by p-Cournaric acid

A model depicting the RecA function and inhibition by p-Coumaric acid

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

Quinoa bran proteins were isolated and their anti-cancer property were tested against liver and colon cancer cells. Few selected fractions showed interesting growth inhibitory properties. The observed effect was due to the induction of apoptosis, as evidenced by the activation of caspase-3, Annexin V binding and cell cycle analysis. These proteins were characterized by in-gel trypsin digestion, followed by LC-MS/MS using HRMS. Four proteins viz., antiviral-MAP, superoxide dismutase, trypsin inhibitor DE3, and ribosome-inactivating protein, which are known for anti-cancer properties were found.

Inhibition of Advanced Glycation End products (AGE) by natural oligosaccharides to combat diabetes: Glycation is a non-enzymatic reaction between reducing sugars and proteins. Formation of AGEs is a complex process, and they have received attention during recent days. AGEs are known to interact with many cellular proteins and modify them irreversibly. They also induce an inflammatory response and worsens the condition in diabetic patients. Inhibition of the AGE formation is one of the important targets to reduce the secondary complications in diabetic patients. Arabinoxylan oligosaccharides (AXOS) were isolated and characterized from millet bran, which showed the inhibition of AGE formation in the BSA-glucose model. Fluorescence spectroscopy, SDS-PAGE and colorimetric estimation of different AGE intermediates showed potent inhibition of AGE formation by AXOS.

### Mitochondrial fusion associated with mitophagy and exosomes (Anbarasu K)

Mitophagy is a process of selective degradation of damaged or dysfunctional mitochondria(mt) at the autophagolysosomes. Through mitophagy, cancer cells escape apoptotic or necrotic cell death. On the other hand, mt fusion is the process of fusion of damaged mt to the healthy ones. Studies suggest that production in tumors of normal mt could be tumor suppressive by promoting oxidative metabolism and enhanced reactive oxygen species(ROS) production. SH3GL2, a vesicular endocytosis associated protein translocated to mt was identified and activated when overexpressed in human breast cancer cells. This was accompanied with enhanced mt fusion, decreased mitophagy and enhanced expression of key mt fusion and mitophagy associated protein ATG5. Exosomes are 50-200 nm, small-secreted endocytic vesicles from all cell types and present in body fluids. They carry nucleic acid and proteins, act as cell-cell communicator and implicated in biomarker development.SH3GL2 was overexpressed in three breast cancer cell lines which induced MFN2 expression. To determine whether this information is carried by their exosomes, western blotting was performed in culture supernatant derived exosomes from cells and low level of SH3GL2 and MFN2 was detected in control culture derived exosomes and enhanced expression was detectable in exosomes derived from the SH3GL2 overexpressing culture supernatant. Thus, breast cancer cell derived exosomes carry SH3GL2 and MFN2 proteins and altered SH3GL2 and MFN2 expression is detectable in the exosomes that could be a cue for biomarker development.

### Scoping study in Odisha for THR and menu diversification (Alok K Srivastava & Sridevi A Singh)

Studies for menu diversification and modification of take home rations provided through anganwadis by Government of Odisha was taken up. Teams from CSIR-CFTRI visited Odisha to visit several self-help groups, federations and anganwadis to evaluate the quality of raw materials, processing steps, product quality and other factors. The storage conditions for raw materials and products, processing steps including standardization of roasting conditions to be studied. Quality of the raw materials and products were studied. The menu diversification possibilities without affecting the calories or protein content, using cost-effective, locally available raw materials, as well as micronutrient fortification were recommended.

#### Ready-to-reconstitute idlis (Babylatha R)

Ready-to-reconstitute (RTR) idlis (5 min) were prepared from the optimized ground batter of black gram and idli rice. These steamed idlis were dehydrated under optimal condition in order to obtain quick reconstitution with instant sambar. Both dehydrated and instant sambar were packed in metalized polyester and further it was packed in pp container and shelf life studies were carried out. Initial water activity of idli and sambar was 0.36, 0.34, fat content was 1.35, 11.12 g/100 g, free fatty acids (FFA) was 0.3, 0.5 g/100 g, and colour values were- L 62.3, 51.6; a 1.7, 18.3; and b 6.8, 39.2 respectively. Sensory analysis of the fresh and stored products were compared with market samples with respect to sponginess, hardness, chemical odour, idli flavor, metallic taste, and overall quality. The prepared products were compared with market samples and the above parameters were analyzed. Three formulations were also made using bajra, ragi and foxtail. These millet based idlis also had 5 min reconstitution with instant sambar and all the dehydrated idlis had six month shelf life due to lower water activity.

### Sensory Lexicon for selected coconut based products (Asha MR)

Commercial samples comprising selected coconut based products were procured from local supermarkets. In the first batch, 26 samples were procured which were categorized under several classes. A trained sensory panel generated about 380 sensory descriptors for 15 categories of coconut based samples, namely cookies, fried snack etc, using "Free Choice Profiling" method (Descriptive Analysis). This is a significant part of the sensory lexicon on coconut based products.

#### Coconut based beverages processing with UV-C irradiation (Sudheer Kumar Y)

This study investigated the effect of ultraviolet-C irradiation on the inactivation of microorganisms in coconut water, a highly opaque liquid food  $(1.01 \pm 0.018$  absorption coefficient). Ultraviolet-C inactivation kinetics of *Escherichia coli*, *Salmonella enterica* and *Listeria monocytogenes* in coconut water were investigated. Ultraviolet-C irradiation at 254 nm was applied to stirred samples, using a collimated beam device. A series of known ultraviolet-C doses (0-28 mJ. cm<sup>-2</sup>) were applied for ultraviolet-C. Inactivation levels of all organisms were proportional to ultraviolet-C

dose. At the highest dose of 21 mJ. cm<sup>2</sup>, two pathogenic bacteria (E. coli and S. enterica) were inactivated by  $5-\log_{10} (p < 0.05)$  in coconut water. For, L. monocytogenes the UV-C dose required for 5-log<sub>10</sub> is 14 mJ. Cm<sup>-2</sup>. Results showed that ultraviolet-C irradiation effectively inactivated bacteria in highly opague coconut water. The log reduction kinetics of microorganisms followed log-linear and exponential models with higher  $R^2$  (>0.90) and low root mean square error values. Fluid optics were the key controlling parameters for efficient microbial inactivation. Therefore, the ultraviolet-C dose must be calculated not only from the incident ultraviolet-C intensity but must also consider the attenuation in the samples. The physico-chemical properties of the coconut water treated with collimated beam system at a dose of 21 mJ. cm<sup>-2</sup>, showed no significant differences in terms of pH, Brix (TSS), Titratable acidity and L\*, a\*, b\* values.

A significant decrease in aflatoxin (G1, B2, and B1) reduction percentages was observed. A maximum of 91.2% of overall reduction of aflatoxin content was observed in sample solution supplemented with 0.15% hydrogen peroxide for a dose of 1528 mJ. cm<sup>-2</sup>. A dosedependent degradation of aflatoxin G1 with an  $R^2$  = 0.95. The variation in sensitivities of the aflatoxins resulted in high reduction values at the initial dose of 382 mJ. cm<sup>-2</sup>. The dose range selection was well suited with degradation rate constant for aflatoxin G1 where a gradual relation between the dose and reduction of aflatoxin G1 can be clearly observed. The results imply that adequate log reduction of vegetative cells and model viruses is achievable in coconut water and suggested significant potential for ultraviolet-C treatment of other liquid foods.

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

A spicy spread was prepared, using dhals, spices, natural acidulants, sugar, salt, trans free fat (TFF), VCO, coconut fibre and emulsifiers. The effect of variations of TFF: VCO on quality of the spicy spread was studied. Blends of TFF and a liquid VCO were used for preparation of fat based spicy spreads. The effects of fat: oil ratios, on spread ability and phase separation were studied. Results showed that the moisture ranged between 1.59 to 1.72%, fat between 49-50%, protein 18-20% and ash content was 0.21-0.22%. The prepared products did not show any oil separation at 25 or 37°C.The consistency or hardness showed an increase with increase in the quantity of TFF. Similar trends were observed with the viscosity, yield stress and consistency index of the spicy spreads. The formulated spreads showed good spread ability, stability and were found highly acceptable.

### **Composite flour from wheat and coconut flour** (*Roopa BS*)

Composite flour was developed from whole wheat flour (WWF) and coconut flour, a byproduct from coconut oil industries. WWF was substituted with coconut flour in various ratios. The developed composite flour showed improved fat (2.3 to 4.4%), protein (10.4 to 12.7%) and dietary fibre (13.9 to 22.2%). The values of sedimentation, gluten yield and falling number showed significant decrease as the substitution of coconut flour increased. There was an increase in water absorption (2.0-2.3 g/g) as well as swelling capacity (33-39 ml) and decreasing trend for oil absorption capacity of the composite flour. A strong effect of noncereal flour on wheat flour characteristics is observed due to its particle size, dietary fiber and protein content. Hence, coconut flour being a by-product, it could play a better role in the development of cost effective composite flour with enhanced nutritional properties and desired functional role in dough rheology.

#### Value addition of aromatic black rice of North East regions (Iboyaima Singh)

Preparation of ready to-reconstitute black rice jamun: Gulab jamun is one of the most consumed sweet in India basically prepared with maida. In this study, maida was replaced with black rice which is rich in anthocyanin and has many beneficial effects. Gulab jamun was formulated with black rice powder, ghee and milk powder. As the black rice has good binding property there is no need of adding any extra food additives. Jamun were fried at 140°C and packed in microwavable pouch and impact sterilization was done. Similarly, syrup (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 the samples were found to be safe and having acceptable taste compared to control. Jamun samples stored at accelerated condition

showed change in texture and colour but had acceptable taste.

Popped black rice chikki: Nutra enriched chikki was prepared by incorporating popped black rice, which is rich in nutraceuticals. The product was evaluated for their physicochemical characteristics. The formulation and processing parameters for preparation of popped black rice chikki, were standardized. Popping black rice imparted a crunchy and crispy texture to the rice which was suitable to be used in chikki. Popped black rice and popped black rice with groundnut were the two variants of chikki that were tried. Results showed that moisture ranged from 4.02 -12.24%, fat ranging from 1.77-2.58%, protein was about 6.25-18.12%, texture or hardness was between 13-17.96 N, no colour difference was observed. Anthocyanin, a group of flavonoids, which are the main bioactive principle in black rice, ranged from 53.26-81.71 mg/100 g in the prepared chikki. Black rice as such had 223.52 mg/100 g. The peroxide value which indicates storage stability of the products ranged between 0.48-1.98 meq/100 g, free fatty acid composition was 1.02-1.08 meg/100 g. Water activity ranged between 0.27-0.29, minimal or no microbial growth. The storage stability and quality parameters of black rice chikki and black rice plus groundnut chikki were studied for 30 days at ambient temperature wherein they were microbiologically safe and were sensorily acceptable. The antioxidant content of the chikki showed the presence of good amounts of antioxidants and polyphenols, essential for the human health. Hence, popped black rice was incorporated into the Indian traditional sweet chikki with enhanced nutraceutical value.

# Value addition to fruit pulps/ peels and vegetable based snack bars (*Jyothirmayi T*)

Banana powder: A process for foam mat dehydration of banana pulp for free flowing banana powder was optimized by incorporating different foaming agents (CMC, egg white and soy lecithin), foam stabilizer (0.1% TWEEN 80) and water (1:0.5, 1:1, 1:1.5), and the products were ground into powder using anti-caking agent (2% tricalcium phosphate). Moisture, colour, sugars, fibre, vitamin C of the product were analysed. The sensory evaluation of the reconstituted samples were found to be acceptable. The applications of the dehydrated powder in custards or flan and storage studies are under progress.

*Vegetable snack bar:* A process for preparation of vegetable snack bar consisting of dehydrated carrot and beetroot (25-40%), jaggery (50-60%), peanuts and puffed amaranth with vanilla flavor (1-2%) and bar setting temperature (100°-115°C) was optimized. The product was found to be acceptable.

Utilization of pomegranate peels: The pomegranate peel was separated, cleaned and dried in a tray dryer at 55-60°C for 8-10 h and grounded to powder. The powdered peel was analysed and found to be rich in bioactive principles such as ascorbic acid, polyphenols, beta-carotene, lycopene, chlorophyll and dietary fibre. A method was also standardized for enhancement of dietary fibre using HCI-KCI and acetate buffers followed by precipitation with alcohol. The dietary fibre enriched sample was incorporated into bakery biscuits at 1, 5, and 6% levels. Biscuits with 5% levels were found to be acceptable. *Extraction of natural colourants:* The seeds of ripened bitter gourd and snake gourd were used for extraction of red coloured pigments. The results of the HPLC analysis of the extract showed that lycopene was the major pigment on the seed coats of these materials. Further work is under progress.

### Farm based S & T interventions for socioeconomic development in the aspirational district of Nabarangpur, Odisha (Jyothirmayi T)

Number of awareness programmes on food processing and preservation were organized at Umerkote, Nabarangpur and Papppadahandi in Odisha. Further, training programme on food processing and preservation was also conducted at Hyderabad and Nabarangpur. The main objective of these programmes was to generate and encourage first generation entrepreneurs to start food processing units at Nabarangpur district, Odisha. During the hands on training programmes, processes such as dehydrated potato wafers, mango bar, lime pickle, tomato pickles, mixed fruit jam, mango RTS beverages, orange squash, biscuits, millet based extruded RTE snacks and home-made chocolates were demonstrated.

### Plant-based phenylalanine-free protein supplement for phenylketonuria (PKU) (Arun Kumar V)

The objective was to produce a cost-effective protein supplement devoid of phenylalanine (Phe) for nutritional management of Phenylketonuria (PKU). PKU is an inborn error of amino acid (AA) metabolism due to deficient activity of phenylalanine hydroxylase (PAH), which converts Phe to tyrosine. The plant-

based protein was hydrolyzed using chemical and enzymatic methods and Phe was removed from the protein hydrolysate using suitable chromatography techniques. The content of Phe in the sample before and after treatment were analyzed using TLC, HPLC and amino acid analysis. Activated carbon removed 85.73% of Phe from plant-based protein hydrolysate, whereas the currently developed hybrid filtration method achieved 100% of Phe removal from hydrolysates. Further, amino acid analysis of the protein hydrolysates were carried out, and the protein score was adjusted according to WHO amino acid requirement. The resultant protein supplement is under evaluation for its efficacy to achieve metabolic control of Phe levels in PKU induced animal model.

# Value added products from *Diospyros melanoxylon* fruit (*Shailaja R*)

*Diospyros melanoxylon* fruit (*Temburni* in Marathi) is one of the most underutilised fruits grown in the forest areas of Maharashtra. The fruit and its seeds have potential to convert into value added products on commercial scale. Fruits were procured from the Kosbad village. Method of extraction of pulp from the ripe fruit has been standardized. The chemically preserved and frozen pulp of the fruit can be used for the preparation of value added products like fruit bar, jam and fruit juice beverages – RTS, squash and health drink powder.

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### Low phenylalanine food for phenylketonu rics (PKU) patients (*Singh RP*)

The multipurpose flour was prepared by mixing corn starch, potato starch and gelatin in the proportion of 7:2:1. Gelatin is a good source of protein which is required for the growth of the PKU patient, and importantly, it is less in Phenylalanine (PA) which is an added advantage. The other ingredients viz. starch was selected as a source of carbohydrate that does not contain protein. The formulated flour was further evaluated for its quality attributes and was used for product development.

### Morin-enriched fraction from guava leaves for gastritis (Madan Kumar P)

The aim is to prepare morin-enriched extracts from guava leaves for functional foods for gastritis. Three different extraction methods were employed (infusion, ultrasound aqueous and ultrasound methanol) to collect the extracts from guava leaves. These extracts were checked for the presence of morin and quantitated using HPLC method. Further, the mass of the morin in the extracts were determined by LC-MS/MS. Of the three methods, ultrasound methanol (48 h) showed 5.38-fold increase in morin enrichment compared to infusion (48 h) and ultrasound aqueous (48 h) as determined by HPLC method. The ultrasound methanol (48 h) extract showed the spectra and retention time similar to that of standard morin (Sigma – 99%) and the presence of morin was confirmed by the molecular mass of 302.2 g/mol by LC-MS/MS analysis. Morin-enriched ultrasound methanol extract from guava leaves will be employed for studies against gastritis.

# Bioactive food formulation to overcome chemoresistance and tumor recurrence (Syed Musthapa M)

Diindolylmethane (DIM), a key bioactive from the cruciferous vegetable, in combinations with centchroman (CC), a selective estrogen receptor modulator, have shown to synergistically inhibit the cell proliferation, stemness and induce cellular apoptosis in human breast cancer MCF-7 and MDA-MB-



The combinations of DIM and CC inhibit the stemness potential of human breast cancer cells

231 cells. The inhibition of cellular proliferation was accompanied by G<sub>0</sub>/G<sub>1</sub> phase cell-cycle arrest and induction of cellular apoptosis in human breast cancer cells. Remarkably, DIM has also decreased the efflux of CC and thereby enhancing the intracellular CC concentration by impeding the chemoresistance of breast cancer. Intriguingly, the combination of DIM and CC considerably inhibited the stemness and tumorigenic potential of human breast cancer cells by altering the key epigenetic modulators. Collectively, it was found that DIM, a dietary bioactive, have the potential to overcome the chemoresistance and tumor reoccurrences. Further, the development of DIM-based phytonutraceuticals advances the medicinal value of the cruciferous vegetables, in addition to its commercial value.

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

High altitudes (HA) causes significant changes in both human physiology and psychology. One of the key physiological challenge faced by soldiers deployed at HA, is loss of appetite (known as anorexia). This, coupled with the increased energy demand and basal metabolic rates required at HA, leads to muscle atrophy and weight loss. In the absence of hunger, a high caloric diet does not solve this problem. Hence, dietary bioactives with appetite induction capabilities is expected to ameliorate HA-induced anorexia. Edible nanoparticles (ENPs) are loaded with plant-derived microRNAs, protein, lipids and phytochemicals. Plant bioactives isolated in the form of ENPs is reported to exhibit better bioavailability and ADME properties compared to other extraction procedures. ENPs were purified from some of the edible plants known to induce hunger and characterized them. Keeping the therapeutic value of ENPs and scalability requirement in mind, a cost-effective process to purify these ENPs were developed using edible polyethylene glycol. However, developing a high calorie diet will not be a solution to meet the increased energy demand at HA (5000 Cal at HA vs 2500 Cal at normal altitude), unless the underlying loss of appetite is eliminated. Human appetite is tightly regulated by Ghrelin (GHRL), a 28aa peptide hormone, which acts on hypothalamus, to stimulate appetite and food intake. ENPs were purified from various plant sources that can induce appetite using the cost-effective PEG method. The biophysical/biochemical characterization of these ENPs and their ability to induce GHRL secretion is currently underway.

## Dietary products to downregulate obesity risk factors (Suresh Kumar G)

Food bioactives can be used to treat obesity and other related disease which needs to be critically explored. Glycosaminoglycan (GAG), a nutraceutical component was isolated from Mackerel fish waste. *In-silico* docking showed good interaction of GAGs with lipase and was able to inhibit intestinal lipase activity. It also showed bile acid binding property pointing to its putative lipid lowering effect. Ergosterolenriched fractions of mushrooms and phenolic concentrate from *Cyperus rotundus* had potent antioxidants and showed lipase inhibition properties and also reduced lipid accumulations in the 3T3L1 cells.



Effect of phenolic concentrate on lipid droplets

#### Brown algae nutraceuticals attenuates oxidative stress and adipogenesis (Baskaran V)

The nutraceuticals (FUCO, polysaccharides and total lipid) potential of Indian brown algae Padina tetrastromatica on obesity was investigated through adipogenesis and thermogenesis regulated by Akt, p-Akt, p38, PPARy and UCP1 signalling pathway. Biochemical markers were compared in a highfat diet (HFD) fed mice and the potential mechanism of action of nutraceuticals was studied. Nutraceuticals exhibited good antiobese effect by reducing body weight and reverted the triglycerides and cholesterol levels to normal. The molecular docking studies showed the greater binding potential of FUCO towards the thermogenic markers PPARy, IGF-1, p38, PGC1-α and PPARγ-PGC1-α (-7.26, -6.94, -6.43, -4.87 and -5.77 kcal mol<sup>-1</sup>) in comparison with orlistat (-4.6, -2.26, -3.36, 1.96 and -1.99 kcal mol<sup>-1</sup>). In addition, the protein expression of Akt was increased by 15.5, 12.25, 17.43, 15.05 folds, respectively, on treatment with Orlistat (drug), FUCO, total lipid and polysaccharide groups, respectively and UCP-1 expression was higher (11.3 and 9.9 folds) in FUCO and drug group compared to HFD. Findings demonstrate that nutraceuticals of P. tetrastromatica could be a potential candidate for managing obesity and associated metabolic disorders.

# Angioprotecive property of lactucaxanthin in diabetes (Baskaran V)

Hyperglycaemia mediated perturbations in biochemical pathways and induction of oxidative- endoplasmic reticulum (ER) stress, hypoxia and angiogenesis contribute to the pathogenesis of diabetic retinopathy (DR). The aim was to investigate the protective effects of lactucaxanthin (Lxn), a predominant carotenoid found in lettuce and an isomer of lutein, on hyperglycemia-induced oxidative stress in a DR model of ARPE-19 cells. Lxn mitigated stress condition by reducing intracellular reactive oxygen species (ROS) and lipid peroxidation besides upregulating cellular antioxidant enzymes SOD, CAT and GR. Expression of HIF-1a, ER stress and VEGF, the prime mediators of angiogenesis, augmented in hyperglycemic insult and were suppressed upon treatment with Lxn and lutein. Similarly, ER stress markers XBP1, ATF4, ATF6 and ER stress induced inflammation marker NF-kB were also downregulated upon Lxn treatment. Lxn strongly inhibited HG induced migration of ARPE-19 cells and attenuated the decrease in the expression of occludin and ZO-1 as compared to their levels in normal control. Lxn potentiality aid ARPE-19 cells to overcome the hyperglycemia-induced oxidative and ER stress compared to its isomer lutein. Taken together, the results demonstrate that, Lxn exhibit robust anti-angiogenic activity and would therefore be useful as an alternative therapy to prevent and/or delay DR progression.



Effects of Lxn and lutein on the protein expressions of HIF-1 $\!\alpha$ 

#### Antidiabetic property of cereal and herbbased functional food (Baskaran V)

Traditional therapeutic food is gaining renewed attention owing to health benefits. However, there is a lacuna when it comes to scientific validation. Traditionally practiced food was formulated using cereals and a blend of herbs and validated scientifically for antidiabetic property. Protein (7.4-13%), total fat (15.5-

17.7%), carbohydrate (45-50.8%) and total dietary fiber (15.4-18.28%) of products were within the range for functional foods. Phenolic compounds were characterized by UHPLC-HRMS based on MS and MS/MS fragmentation. The starch digestibility of products ranged between 61-65% with low estimated glycemic index of 47.3-53.8. Methanolic extract of products showed antioxidant activity in dose dependent manner and inhibited  $\alpha$ -amylase,  $\alpha$ -glucosidase and DPP4. Bile acid binding capacity was higher for aqueous extracts. The formulated product was efficient in inhibiting glycolytic enzymes and DPP4, which helps in attenuation of hyperglycemia.

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

A ready-to-eat, all-natural nutritionally rich nutraceutical for improving endurance performance was developed. It is chewable and tastes like sweet and sour. It does not contain added preservatives, additives, or colouring agents. It is stable at room temperature and with an extended shelf life of up to 1 year. The product provides 100 Kcal/30g serving size and is non-toxic to tissues, enhances the swimming ability as well as grip strength in mice. The product promotes glycogen accumulation and fat degradation in adipose tissue. At the cellular level, it activates AMPK- $\alpha$ -PGC-1 $\alpha$  signalling and also increases the levels of MnSOD. In athletes, it significantly increases VO2max and haemoglobin concentrations and decreases serum CPK and CRP in both male and female athletes. Thus, the formulated product improves endurance performance by promoting fat degradation and by its antiinflammatory and anti-oxidative stress effects.

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

The project aims to understand the interplay of molecular events leading to diabetesassociated NAFLD. The transcriptome analysis of the type 2 diabetic model (HepG2) by the Illumina HiSeq method was examined. Differential expression, followed by gene ontology and pathway enrichment analysis, was performed between control and diabetic cells. Transcriptome analyses revealed 31 genes including those coding for IncRNAs (28), miscellaneous (misc.) RNA (1), and to be experimentally confirmed (TEC)RNA (2) were significantly (p<0.05) up-regulated in diabetic cells. While 19 genes coding for IncRNA (13), small nucleolar (sno)RNA) (1), misc RNA (2), and TEC (3) were significantly (p<0.05) downregulated in diabetic cells. Further, 105 proteincoding genes, of which 57 genes were significantly (p<0.05) up-regulated, while 48 genes were significantly (p<0.05) downregulated in diabetic cells. The data further suggests that genes that positively regulate the steroid biosynthesis pathway and intrinsic apoptotic pathway were significantly (p<0.05) up-regulated, indicating that diabetes may induce NAFLD through the activation of steroid biosynthesis and apoptotic pathways. Studies are underway to validate the transcriptome findings in both in-vitro and in-vivo diabetic models.



Volcano plot showing the differential upregulation of genes in type 2 diabetic HepG2 model

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

The project aims to explore the pathological changes in the lung in diabetes. It was shown that diabetes induces fibrotic changes in the lung via TGF- $\beta$ 1-activated EMT pathways and that elevated SMAD7 partially protects the lung during the initial stages of diabetes. The TGF- $\beta$ 1/SMAD7 ratio in lung and kidney tissues was compared, which were harvested at the same time from the same animal. It was observed that in the lung, the ratio was not significantly different from that of the control until 8 wk. However, the ratio increased significantly (by 4-fold) at 12 wk compared to the ratio in control.

To determine if the delayed response of the lung was due to the presence of higher SMAD7 levels or lower TGF-B1 levels in the lung than in the kidney, the TGF-β1 levels in the diabetic lung, kidney and liver was compared with those in the respective controls after 8 weeks of diabetes induction. It was found that the diabetic kidney expressed significantly higher levels of TGF- $\beta$ 1, followed by the liver and the lung. These data suggests that TGF-β1induced fibrosis affects the kidney more prominently than the lung and the liver. The above results suggests that the presence of higher levels of SMAD7 and lower levels of TGF- $\beta$ 1 in the diabetic lung than in the diabetic kidney contributes to the delayed response of the lung to the effects of diabetes compared to that of the kidney. These findings have implications for the management of patients with diabetes.

### Novel RNA biosynthesis inhibiting peptide antibiotics of probiotic bacteria

(Prakash M Halami)

Expression studies of the 4 different bacteriocin genes namely LA1 (Lichenicidin A1), LA2

(Lichenicidin A2), Sono (Sonorensin) and Lasso (Lassopeptide) found in Bacillus licheniformis MCC 2514 was analysed by the Real Time PCR. Expression level of the lassopeptide gene was focused on because the bacteriocin of the current study is found to have its inhibitory action on RNA biosynthesis, similar in mode of action of lassopeptides. Maximum expression of lassopeptide was found at 24 h of growth. Lassopeptide expression was diminished in the mutant defective in inhbiting the growth of Koccuria rhrizophila. In addition, adherence ability of the B. licheniformis was evaluated in an in vitro cell model using CaCo2 cell line. Bacillus licheniformis (BL) adhered very strongly and Bifidobacterium breve (BB) adhered moderately. Co-incubation of both culture in combination didn't show much difference in adherence. With reference to adhesion %, it was found to be 79.86% in BL and adhesion of BB was moderate with 34.22%. This clearly indicates that BL had better adhesion when compared to BB.

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

In order to evaluate the diversity among nisinlike lantibiotics, 10-LAB cultures that showed positive response to nisin specific reporter (AUT1) were characterized. Among them, three nisin producers were studied by whole genome sequencing. Nisin producing LAB cultures (C2d, SP2C4 and FS2) by whole genome sequencing showed high similarity with *Lactococcus lactis* ssp. *lactis.* C2d and SP2C4 harbor *nis*A gene and FS2 harbor *nis*Q gene. In addition, 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 inhibiting cell wall biosynthesis. In parallal, twelve Bacillus spp producing subtilin-like antibiotic was also characterized. Bacillus licheniformis MCC 2512<sup>T</sup> that is known to produce sublichenin was studied in detail for its activity against drug resistant bacteria. Taxonomical identification of B. tequilensis and B. velezensis (known to produce subtilin like bacteriocin) was characterized and their gene sequences are being studied.

# Thermotolerant *Streptomyces* sp. for chitinase production using rice straw (*Sarma MVRK*)

Thermotolerant Streptomyces sp. K5 strain was used for chitinase synthesis. The culture supernatant was subjected to MS/MS analysis using in solution trypsin digestion method. Here, the objective is to ascertain the presence of chitin and cellulose degrading peptides present in the digested extracellular fraction. It can be observed that 3 chitinases and 5 chitin binding proteins have been mapped from NCBI database. The strain K5 seems to synthesize chitinase which is similar to Chi40 and Chi25 from Streptomyces thermoviolaceus. Apart from above three chitinases, there were several peptides that matched to multispecies chitin binding protein present in Streptomyces genus. In case of cellulose/hemicellulose degrading enzymes, the peptides from the supernatant matched to cellulases/glucanases belonging to both GH5 and GH6 families.

GPIQLSWNFNYK AAGDAIGVDLLNNPWLVENDPAIAWK NPFYTYQGLVDALSAFPGFANTGDDTTK GPIQLSWNFNYKAAGDALGIDLLNNPWLVQNNSAVAWK NPAQVQSR FAVLDSNAGGRGAGYVPDG TLCSAGDRSPYDFSAYNAAR SGDALMFIQWVR THLTSGAGIQLQYSNWAAHPGDFR TYLCYLDAR FAVLDSNAGGR SPYNFTGYNAAR SGDALMFIQWVR

Identified key peptides list from K5 strain belonging to chitinase/chitin binding proteins

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

Studies were conducted in bench scale bioreactor (5L) for the production of methylxanthines. In batch mode of operation, the effect of different agitation and aeration rates on product formation was determined. Results indicated that at an agitation speed of 300 rpm and aeration of 5 lpm, there was separation of biomass from media, excessive foaming and shear stress which resulted in poor product formation. Under conditions of low agitation (120 rpm) and aeration of 5 lpm, although, there was profuse growth of biomass, it did not result in increase in product formation. A significant improvement in product yield was observed when agitation speed and aeration rate of 250 rpm and 3 lpm, respectively, was maintained. Repeated trials showed consistency in product formation and nearly 1.25-fold increase in productivity at 5L scale (0.1 g/l/day) in comparison to flask experiments (0.08 g/l/day). Forward osmosis membrane studies (feed rate: 80 lph with water removal rate of 20 lph), resulted in near 4-fold increase in product concentration and downstream recovery.

#### Deciphering the mode of action of a sleep inducing seed oil (Malathi Srinivasan)

This project aims at finding a safe, nonaddictive alternate to sleeping pills, in an edible seed oil. The seeds were procured and the oil was extracted using a Buchi extractor. The extracted lipid was converted to fatty acid methyl esters using BF<sub>3</sub>/MeOH and the FAMEs were profiled for fatty acid composition using an Agilent GC-MS, and for other metabolites using HPLC. The oil has a profile very similar to that of sunflower. HPLC profile of the oil showed the presence of melatonin. Melatonin is known to be a key regulator of the circadian rhythm and is both water and oil soluble. Future studies will identify other sleep-inducing compounds and their mode of action using animal experiments.



Oil seed plant and seeds

#### Fixed oils from the Indian spices

#### (Ajay W Tumaney)

Fixed oil was extracted from 39 Indian spices which are under the purview of Spice Board of India. A wide array of fixed oil percentage was found ranging from as low as 0.25% in tamarind to as high as 47.09% in poppy seed. Some of the spices such as chilli, kokum, parsley, marjoram, fenugreek and pomegranate seed showed no presence of volatile oil components but had a significantly higher percentage of fixed oil. GC-MS analysis showed palmitic, stearic, oleic and linoleic acid to be the predominant fatty acids in most of the spice fixed oil. Interestingly, presence of alphalinolenic acid which is not abundantly found in plant sources were also detected in kokum, tejpat, asafoetida, marjoram and parsley fixed oil. In general, all the spices fixed oils had a higher ratio of unsaturated fatty acids thereby rendering major health benefits. Presence of some 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 an alternative source of erucic acid was found in asafoetida fixed oil. Presence of some unusual fatty acids like C15:0, C16:1 (cis 7), C16:1 (cis 9), C16:2, C16:3, C17:1 and C18:1 (cis 13) were also detected in some of the spice fixed oil.

Antioxidant assays namely DPPH, TEAC, and FRAP were performed and highest radical scavenging activity was shown by ginger and mace fixed oil. Highest FRAP activity was seen in turmeric, ginger, nutmeg and mace fixed oil. Significant TEAC activity was also observed in turmeric, ginger, nutmeg and mace fixed oil. For both FRAP and TEAC trolox was used as standard. In addition, it was found that turmeric, ginger, rosemary, mace and chilli fixed oil had the highest phenolic content. Upon comparison among different antioxidant assays, turmeric, mace, black pepper, pepper longum and cambodge fixed oil showed highest antioxidant property owing to their high phenolic content. Gallic acid, 4, hydroxybenzoic acid, vanillin, transcinnamic acid, caffeic acid, p-coumaric and kaempferol were the common polyphenols present in most of the sample. The data generated from this project was assembled in a form of a database named as 'Spiceoilveda'.

# Polyunsaturated fatty acid accumulation in chia (*Salvia hispanica*) seeds

(Ajay W Tumaney)

In Chia, the key lipid genes involved in channelling PUFA from phosphatidylcholine (PC) into TAG have been identified from transcriptome data. The isolated nucleotide sequences showed strong identity with Arabidopsis homologs. Analysing the expression levels of genes during seed development gives us a direct insight into the roles they play. There are no reports of stable internal reference genes for normalization in chia. Three distinct tissue sets - vegetative tissues, abiotic stress treatments on plant and reproductive tissues were taken for study and the stably expressed genes in chia were identified through two softwares, geNORM and Normfinder. The results obtained were used to assess the expression profile of key lipid genes involved in TAG formation. ShDGAT1 showed high expression at 7 DAF (Days after flowering) and at the final stage of seed maturation (28 DAF), indicating its prominent role in oil accumulation. ShPDCT enzyme showed high expression at 7 and 14 DAF, suggesting a prominent role for movement of PUFA generated on PC to DAG, and eventually TAG. Substrate specificity studies were carried out with LA and ALA. ShLPCAT showed strong preference towards PUFA-CoAs over

saturated fatty acyl-CoAs. Both ShDGAT2 and ShPDAT1 enzymes preferred ALA, and showed a concentration dependent increase in ALA incorporation into TAG. HRMS and TLC analysis of neutral lipid fraction also confirmed the formation of trilinolenin ( $\alpha$ Ln $\alpha$ Ln $\alpha$ Ln) in cells expressing ShDGAT2 and ShPDAT1. Only ShPDAT1 enzyme preferred LA, and it exhibited a concentration dependent increase in LA content of TAG. It can be concluded that ShPDAT1 and ShDGAT2 can be good candidates to metabolically engineer oilseed crops to produce PUFA rich oils.

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

The unique phytochemicals and fatty acid compositions of rice bran were targeted for nutraceutical development. The endogenous lipases and hydrolases are responsible for the rapid deterioration of rice bran. Hence, it was attempted to provide the first comprehensive profiling of active serine hydrolases (SHs) present in rice bran proteome by activity-based protein profiling (ABPP) strategy. The active site-directed fluorophosphonate probe (rhodamine and biotin-conjugated) was used for the detection and identification of active SHs. ABPP revealed 55 uncharacterized active-SHs and are representing five different known enzyme families. Based on motif and domain analyses, one of the uncharacterized



SHs (Os12Ssp, storage protein) was selected for functional characterization by overexpressing in yeast. Schematic representation of domains and motifs of the identified Os12Ssp protein. Os12Ssp was expressed during the initial stage of germination. The purified recombinant protein was confirmed by mass spectrometry. Os12Ssp showed the presence of protease activity, and it was inhibited by the covalent serine protease inhibitors. Collectively, the comprehensive knowledge generated from the study would be useful in expanding the current understanding of rice bran SHs and paves the way for better utilization/stabilization of rice bran.

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

The study was aimed 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 the purified recombinant protein was used as an enzyme source to screen inhibitors from food sources based on traditional knowledge and as well as human consumption. The in vitro validation of the shortlisted inhibitor molecules was performed in 3T3-L1 cells. B-Ex1, B-rb, and LS1 extracts showed significant inhibition with hMAGL along with reduced lipid accumulation. Further, the in vivo validation was performed with B-Ex1 and LS1 in the diet-induced insulin resistance mice model. The level of MAGL activity and expression was measured in adipocytes. The circulatory free fatty content was reduced significantly in the treated group, along with the controlled glucose homeostasis.

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

The main objective was to find potential pancreatic lipase enzyme inhibitors from natural sources to combat obesity and diabetes. The initial study was conducted at the National Food Research Institute, Japan, and many food sources were screened for the inhibitor by fluorometric enzyme assay. A set of natural inhibitors were shortlisted based on the inhibitory potency. Further, the functional validation of selected inhibitors were performed by activity-based protein profiling (ABPP) and its mechanistic studies on the human pancreatic lipase enzyme. The human pancreatic lipase (hPL) was cloned into bacterial and yeast expression vector. The purified recombinant hPL was used as an enzyme source for enzyme assay and ABPP for inhibitor screening. The identification of the potent inhibitor molecule from millets revealed that a mixture of ferulic acid esters of sterol and triterpene alcohols are responsible for inhibition. Based on the ABPP and enzyme assay, the extracts were fractionated and analyzed. Besides, the level of oil content, lipid and fatty acid compositions were profiled.

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

Various Ketogenic Products (KP) for Indian palate were formulated and developed. Three KP such as keto-shake, keto-patty and ketoappetizer were developed with low carbohydrate and high fat composition. The *in vivo* study to substantiate the ketogenic claim was performed in high fat diet (HFD)- induced obese mice model system. As expected, feeding of HFD increased plasma glucose, triglyceride, total cholesterol levels in mice. It

concomitantly also increased HDL-C levels. The keto-shake decreased glucose levels by 54%, triglyceride by 61%, total cholesterol by 79% and HDL-C by 63%. Whereas, the ketopatty and keto-appetizer reduced glucose levels and retained HDL-C levels compared to HFD group. All the keto products increased ketone bodies compared to the HFD and chowfed controls. The size and morphology of the vital organs were not affected upon treatment. SGPT, SGOT and lactate dehydrogenase levels were unaffected upon treatment. Alkaline phosphatase levels though showed variation were in the permissible range indicating that keto-products did not have any deleterious effect on the vital organs.

### Stearidonic acid biosynthesis in Buglossoides arvensis and production of stearidonic acid in chia (Salvia hispanica) (Sreedhar RV)

Buglossoides arvensis seed oil is the richest natural source of ω-3 fatty acid - stearidonic acid (SDA) which is nutraceutically superior than  $\alpha$ -linolenic acid (ALA). However, molecular basis of polyunsaturated fatty acid synthesis in it is unknown. B. arvensis fatty acid desaturase2 (BaFAD2), fatty acid desaturase3 (BaFAD3) and delta-6-desaturase (BaD6D-1 and BaD6D-2) genes were identified by mining the transcriptome of developing seeds and functionally characterization them through heterologous expression in Saccharomyces cerevisiae. In silico analysis of their encoded protein sequences led to identification of conserved histidine-boxes and signature motifs essential for desaturase activity. Expression profiling of the genes showed higher transcript abundance in reproductive tissues than in vegetative tissues. Their expression varied with temperature stress

treatments. Yeast expressing *BaFAD2* could desaturate both oleic acid and palmitoleic acid into linoleic acid (LA) and hexadecadienoic acid, respectively. Fatty acid supplementation studies in yeast expressing *BaFAD3* and *BaD6D-1* genes revealed that the encoded enzyme activities of *BaFAD3* efficiently converted LA to ALA, and *BaD6D-1* converted LA to  $\gamma$ -linolenic acid and ALA to SDA, but with preference to LA. *BaD6D-2* did not show the encoded enzyme activity. The results help in understanding SDA biosynthesis in *B. arvensis.* It also adds to the repository of fatty acid desaturase for biotechnological production of SDA in common oilseed crops.





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

Comprehensive bioprospecting of newly isolated indigenous microalgal species has been done for biomass, protein, carbohydrates, lipids and pigments. A study on establishing a correlation between various stress, reactive oxygen species, and lipid accumulation has been attempted along with detail FAME profiling under various stress inducing conditions. Freshwater and marine microalgal strains are identified for high value PUFA viz stearidonic acid (4-8% of total FAME) and eicosapentanoic acid (30-40% of Total FAME) known for nutraceutical applications. Studies on the effect of stress on enhancement of stearidonic acid and EPA have indicated no major change. EPA containing oil from Nannochloropsis oceanica with 30-40% EPA has been produced and the shelf life studies are under progress. Implications of oxidative stress on initiation of autophagy and global trascriptome analysis of microalgae have been initiated.

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

The focus of this project is to identify potential North-East region microalgae for nutraceutical and biodiesel applications through evaluation of biochemical constituents. Microalgae strains were obtained from Assam Central University, Assam collected from different areas of North-East India. Based on the growth and lipid profile, Trebouxia was selected for further studies. Sodium nitrate was determined as best nitrogen source as it doubled the growth rate and increased the lipid content by 40% compared to the ammonium carbonate. Maximum biomass concentration and productivity was obtained at room temperature of 30°C in photobioreactor. The results suggested that cold temperature (15°C) enhanced the lipid (40%) and protein (50%) contents in the biomass. Low temperature enhanced the accumulation of docosahexaenoic acid (DHA, C22:6) from 1-3% to 10-11%. Under normal culture conditions stearidonic acid (C18:4) is absent but under

15°C temperature it is accumulating. Alpha linolenic acid (C18:3) also increased at low temperature. The effect of CO, supplementation at 5, 10 and 20% levels on Trebouxia was studied in an air-lift photobioreactor. Maximum productivity was obtained in 10% CO<sub>2</sub>. Higher CO<sub>2</sub> concentration promoted the accumulation of chlorophyll, carotenoids, lipid and protein content. The fatty acid composition showed significant variation with the level of CO<sub>2</sub> supplementation. There is significant increase (4-folds) in the accumulation of docosahexaenoic acid (12% DHA, C22:6) under 20% CO<sub>2</sub> condition. The present results suggested that this microalga is appropriate for mitigating CO<sub>2</sub> in the flue gases, biodiesel production and as a source of nutritionally important lipids.

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

Characterization of metabolite profiling of Basella rubra green callus, growth curve of callus biomass with optimized betacyanin induction on culture media for 6 weeks was investigated. Maximum retention of pigment in callus was extended by 4 - 7 days and further studies are in progress. Efforts are being made to extend the pigment stability up to15 days so that it is expected to generate more pigmented callus biomass. One of the major observations noticed is that; the callus biomass which is in contact with medium surface was only producing pigmented callus and it is also observed to be polarity-based response. In order to demonstrate this polarity-based response, studies were carried out by sandwiching the callus cultures in between the solid medium wherein the cells are in touch with the medium both in upper and lower sides to the medium. However, upper side remained green

or turned brown without any pigmentation. Only the callus surface touching to the lower side produced pigmentation. Being the precursor of betalains, addition of DOPA and tyrosine into the culture medium did not induce pigmentation. In greenhouse and garden grown plants, stress is the major factor that could be crucial factor for intense pink color of fruits, also in tender petioles, veins and to some extent complete plant under nitrate or drought stress and photoperiods. However, the photoperiods did not show much influence of the retention of pigments *in vitro*.

### Root specific flavour metabolite 2-hydroxy-4-methoxy benzaldehyde (2H4MB) in Decalepis hamiltonii (Giridhar P)

To identify the candidate genes involved in 2H4MB biosynthesis, transcriptomic approach was initiated with an initial focus on candidates representing the six major enzyme families to play a possible role in 2H4MB biosynthesis. De novo transcriptome assembly, functional annotation and pathway analysis was done. Then full-length sequences of PPP genes identified were obtained. Simple sequence repeat (SSR) regions were predicted from clustered transcripts using the MIcroSAtellite (MISA) tool. Transcripts encoding SSR were mapped to KEGG pathways. Putative Vanillin synthase (VAL) full length gene sequence was identified in the transcriptomic data. The identified sequence has 100% similarity with previously reported partial sequence GenBank. In clustal omega the full-length vanillin synthase protein has showed 76% Glechoma hederacea and 70% Vanilla planifolia similarity, respectively. Apart from this, cloning of putative vanillin synthase into pET28a expression vector was done.

### Edible coating containing bioactives from mulberry leaves for management of bell pepper anthracnose (Nandini P Shetty)

Coating mulberry crude extract could extend the shelf life and prevent infestation by *Colletotrichum capsici* of capsicum by 15 days when compared to control. The screening for the bioactive compounds from mulberry leaves was carried out. Two compounds were identified as a potential bioactive which could inhibit *C. capsici*. The extract could inhibit the activity of N-glycan processing enzymes and other cell wall degrading enzymes. Furthermore, the capsicum treated with extract showed a lower activity of absicic acid.

# Stable anthocyanin in Saccharomyces cerevisiae by synthetic biology approach (Nandini P Shetty)

The three anthocyanin pathway genes flavanone-3-hydroxylase (F3H), dihydroflavonol-4-reductase (DFR) and anthocyanidin synthase (ANS) were selected. *Arabidopsis thaliana* (F3H and ANS) and *Gerbera* hybrid (DFR) from NCBI was used for construction and cloning of ACN genes in yeast. The amino acid sequences of three proteins were reverse translated into DNA sequence. Codons were optimized for *Saccharomyces cerevisiae* and synthesized. The resulting cloned plasmids (pYES2.1V5-His-TOPO-F3H, pYES2.1V5-His-TOPO-DFR and pYES2.1V5-His-TOPO-ANS) was used for transformation into *E. coli* cells.

# Enhanced production of flavour metabolites (*Giridhar P*)

Establishment of *in vitro* cultures (callus) of *D. hamiltonii* in bench scale on nutrient medium was accomplished. The calli were subjected to

establish suspension culture for enhancement of flavour metabolite (2H4MB). After two subcultures the suspension cultures were grown for 4 weeks for recording biomass and flavour content. The influence of cultures flask capacity (from 150 ml to 1 L) on flavour content and biomass was studied. Low concentration of inoculum in shake flask supported significant increase in biomass yield of 110 g/l and 180 g/l respectively. However, the flavour content remains constant at both scale 0.15 mg/g FW, and 0.14 mg/g FW, respectively. Further the calluses from suspension culture were optimised in stirred tank bioreactor. The culture conditions were optimised with respect to inoculum, pH, for both 1L and 3L reactors. The optimised conditions like rpm, aeration and temperature for the culture in the bioreactor stabilises for 7 days without contamination. However, 5% increase in biomass and very minute increase in flavour content was observed. Further, effect of light illumination, precursor feeding and elicitor mediated stress studies are in pipeline for the enhancement of biomass and flavour metabolite at these optimised conditions.

### Plant Cell wall deconstructions of cropresidues and biotransformation to value added products (Sandeep N Mudliar)

Wheat straw and rice husk pre-treatment at various particle size was assessed via steam explosion, dilute acid pre-treatment and wet air oxidation. The results indicated cellulose enrichment up to maximum of 53% along with cellulose recovery of up to 75%. Hemicellulose solubilization was in the range of 50-75% and lignin removal was in the range of 75-90%. The inhibitors such as furan aldehydes, organic a cids, phenolic compounds were

characterized. Wastewater characteristics were analyzed for various parameters like COD, BOD, TS, TSS, TDS, VS, FS and VFA. The results indicated that COD was in the range of 12000-15000 ppm for wet oxidation pre-treatment, 20000-24000 ppm for steam explosion followed by alkali pre-treatment and 7000-11000 ppm for dilute acid pre-treatment.

The pre-treated biomass obtained by various pre-treatment was subjected to enzymatic hydrolysis. The efficiency of enzymatic hydrolysis was in the order: wet oxidation (80%) > steam explosion followed by alkali pretreatment (65%)>steam explosion (58%)> dilute acid pre-treatment (47%). Relative hydrolysis efficiency was observed to be in the range of 70-80% as compared to pure cellulose as control. Xylitol production from pure xylose was standardized with Pichia stipitis in presence of various inhibitors such as furfural, HMF and acetic acid individually and in combination. Yield and productivity were found to be 0.48 g xylitol/g xylose and 0.13 g/L/h, respectively.



Wet oxidation reactor

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

Sustainable pre-treatment system followed by anaerobic digestion was scaled up to 10 L scale

in an indigenously designed bioreactor with energy efficient impeller induced mixing in a draft tube. The pilot plant of the same (50 m3) was installed at a model dairy and commissioned. The inoculum from existing UASB reactor in the industry was used as a starter seed. The CNP ratio was adjusted and the reactor was acclimatized with 0.5 - 3% FOG. The gas evaluation was assessed, and it was observed that initial methane formation took 3 months and biogas with CH4 >55% was observed. The COD reduction initially was less than 10%, which gradually increased to 33% after 4 months.

The samples from pilot scale anaerobic digester located at a model dairy was collected for a period of 3 months. The inlet and outlet FOG sludge samples were carried for various physico-chemical parameters. The COD of the inlet was in the range of 60000-180000 mg/L, while the outlet COD was in the range of 4000 – 40000 mg/L. The COD reduction initially was less than 10%, which gradually increased to 80%. About 85-90% of total solids and 83-85% of volatile solids were removed efficiently. Further, investigations are in progress to assess the effect of temperature, FOG concentration and loading on biogas formation kinetics and yield. Also, the membrane



Indigenous prototype bioreactor with impeller induced mixing in a draft tube

bioreactor has been developed at 20 L scale in the laboratory, which will be scaled up to pilot scale at model dairy.

#### Health food formulations (Nandini CD)

Efforts are being made to develop diabetic friendly food formulation. An array of bioactives were screened for AMPK modulation and one bioactive showed to be a potent activator. Initially its stability to heat treatment was determined by GC and results revealed that the bioactive molecule is destroyed in pure form but when in native source, the loss of activity is 50% depending on the heat treatment. Its ability to activate AMPK when in formulated form was also determined.

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

Changes in protein expression of receptors working in tandem with glycosaminoglycans in liver of pre-and post-natal rats from high cholesterol-fed mothers were determined. Significant changes in expression of LRP1 and LDLr was observed across the developmental changes in offsrings from HC-fed mothers. Further, changing diet from HC to control diet (8W H-C) did not completely mitigate the changes in LDLr levels hinting at irreversible changes as a result of faulty diet. Histopathology of the liver revealed the presence of fatty liver to some extent.



Protein expression studies of LDLR across various developmental stages

# Bioactive peptides-mediated protection of prediabetes/ diabetes associated cardiomyopathy

(Poornima Priyadarshini CG)

Prediabetes is distinguished by having impaired fasting glucose (IFG) (100–125 mg/dL glucose), IGT (140–199 mg/dL glucose 2 h after a 75-g oral glucose tolerance test). In addition, early degradation of incretins, increase in the level of triglycerides, macrovesicular fatty degeneration, fibrosis surrounding coronary artery and fat deposition in the tissues were observed during prediabetes. Both serum and tissue specific markers in a prediabetes animal model was also studied. The prediabetes condition was induced by a high-sucrose (HSu) diet.

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

Bovine milk (bm) contains a multitude of bioactives such as macromolecules, ions, minerals and vitamins essential for human health including glycosaminoglycans (GAGs). An attempt was made to isolate and characterize GAGs, as a first step, from bovine milk with an aim to determine its bioactivity. Isolated GAGs were of predominately chondroitin sulphate (CS)/Dermatan sulphate (DS) class along with hyaluronic acid and heparan sulphate (HS). The disaccharide analysis revealed that 4-sulphation was predominantly present in CS/DS. The hybrid structure of CS/DS was identified based on the amount of iduronic and glucuronic acid content.



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

Vanillic acid (VA), a dietary phenolic compound is generally studied for its anti-oxidative and anti-inflammatory effects. However, the effect of VA on insulin secretion and its mechanism of action has never been explored. In this study, it is reported that VA augments glucosestimulated insulin secretion (GSIS) in both insulin-secreting cell line INS-1 and isolated rat pancreatic islets. Potentiation of GSIS is accompanied by a concurrent increase in 3',5'cyclic adenosine monophosphate (cAMP) and activation of protein kinase A (PKA) in INS-1 and rat islets. The activated cAMP-PKA pathway, in turn, phosphorylates extracellular signal-regulated kinases 1/2 (ERK1/2) in INS-1 cells. Pharmacological intervention with PKA and ERK1/2 inhibitors revealed that VA potentiated GSIS is primarily dependent on PKA mediated ERK1/2 activity. These findings demonstrated that VA directly acts on insulinsecreting pancreatic  $\beta$ -cells to exert its insulinotropic effect thereby providing a novel role of VA in the regulation of insulin secretion.

### Excess protein exposure to the pregnant and lactating mice results in low bone mass disorder in the offspring (Kunal Sharan)

Maternal nutrition appears to be an important factor for the offspring's skeleton development and the onset of osteoporosis later in life. Reports suggest that maternal low protein diet regulate bone mass negatively. However, the effect of a high protein diet (HPD) is not known. The study shows that C57BL6 mice when fed with HPD during pregnancy and lactation gave birth to offspring with reduced skeletal growth at birth and diminished bone micro-architecture throughout their life. This effect was due to a decreased osteoblast maturation. The miRNA sequencing results demonstrated that miR-24-1-5p was highly expressed in HPD group osteoblast cells. Target prediction and validation studies identified SMAD-5 as a direct target of miR-24-1-5p. Further, mimic and inhibitor studies showed a negative correlation between miR-24-1-5p expression and osteoblast function. Moreover, ex-vivo inhibition of miR-24-1-5p reversed the reduced maturation and SMAD-5 expression in the HP group osteoblasts. Together, the study showed that maternal HPD programs reduced bone mass of the offspring through the targeting of SMAD-5 by miR-24-1-5p in the offspring's skeletal osteoblasts.

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

The carotenoids profile of three Indian marine algae was identified for the first time. Lutein and zeaxanthin were identified as a major carotenoid in *Gracillaria* sp. and

Chaetomorpha sp., respectively. Since the effect of lutein on angiogenesis is not well understood, the effect of purified lutein was evaluated on human umbilical vein endothelial cell (HUVEC) proliferation, tube formation and migration as in vitro model assay of angiogenesis. The results showed that lutein promotes endothelial cell migration and tube formation, but not the proliferation. Further, the gene expression study demonstrates that the angiogenesis promoting activity of lutein is associated with upregulated expression of matrix metalloproteinase 2 (MMP-2), thrombospondin 1 (TSP-1) and interleukin 8 (IL-8) genes. However, it did not affect the expression of endothelial specific growth factors, VEGF and FGF, and their specific receptors. Further, lutein up-regulated protein expression of pAkt, whereas no change was observed in the expression of pERK1/2. The findings for the first time demonstrate the proangiogenic property of lutein and the underlying possible molecular mechanism for this effect. Further, the phenolic extract of seagrass, Halophila ovalis activates the intrinsic pathway of apoptosis in MCF-7 cells. This growth inhibitory effect of the phenolic extract was evidenced by the alteration in the protein expression of intracellular cell death, survival and antioxidant markers. It is evidenced from the study that this plant possesses active principles such as luteolin, syringic acid, p-hydroxy benzoic acid, tcinnamic acid, catechin and kaempferol in considerable amount that might be responsible for these anti-cancer effects, which provide a platform for future studies with isolated active molecules against breast cancer cells.

# Structure based novel antimicrobial peptides (Balaji Prakash)

A series of peptides were designed earlier and their antibacterial potential against few food spoilage bacteria and food borne pathogens were determined. Among these one of the peptides was found very effective with a very low MIC value. It was determined that the peptide act by destabilizing the cell membrane. Hemolytic and cytotoxicity assays performed using this peptide inferred that the peptide is safe for food preservative applications. The peptide effectively inhibited the growth of the bacteria in a model food system (cooked rice). Further, the peptides were designed with an objective to simultaneously act against two or more targets. Ability to inhibit serine proteases and a membrane disrupting function were the two activities that were incorporated into these and the aim was to study the mechanism by which these peptides act.

# Detection and quantification of food adulterants and contaminants

#### (Prasanna Vasu)

A sensitive stable isotope dilution LC-MS/MS method was developed for aflatoxin quantification, which showed good linearity (r<sup>2</sup>>0.993), recovery (90.16-98.88%), repeatability and reproducibility (% RSD, <6.2%). A simple Girard P reagent mediated derivatization method to quantify formaldehyde in milk using labelled isotope was developed. The derivatization with GP for formaldehyde leads to two isomer peaks (2.05 and 2.33 min) in both STD and ISTD transitions. The endogenous level of formaldehyde in pooled cow milk sample showed ~1.2 to 1.4 ng/mL (ppm).

### **FT-IR spectroscopy for edible oils** (Usharani D)

Adulteration of edible oils and fats has attracted more attention among researchers and consumers in recent years for obtaining high quality and nutritious value to edible oil. Compositions of fats are modified during adulteration in most of the marketed ghee samples. Identifying this composition is challenging due to the complex fatty acid profile in animal fats and it is also difficult to obtain the standards for quantification. Understanding the comprehensive lipid profiling and discriminating the ghee samples was investigated using rapid and non-invasive Fourier Transform Infrared Spectroscopy (FT- FOOD PROTECTION AND SAFETY

IR) method. Various samples of ghee of different origin (cow, buffalo) and regions of India were collected. The results of 150 samples of ghee provided a finger print region to discriminate the geographical origin of the ghee samples.

# Identification of vegetable fat in the chocolates (Usharani D)

An in-house UPLC method for identification of triacylglycerols and quantification of cocoa butter equivalents (vegetable fat) present in the imitation chocolates was developed. A variety of dark chocolates and milk chocolates, along with the samples provided by FSSAI were tested for the identification of vegetable fat. The mathematical equations for the estimation of vegetable fat was obtained from AOAC (20th Edition 2016, Ce 11-05). Results indicate that total fat, fat composition of the test samples of branded companies were in accordance with label declaration. The cocoa butter equivalent percentage in chocolate was below 5%. Through this method, the vegetable fat that is categorised as cocoa butter could be successfully identified.

# Quantitative determination of creatine in nutritional supplements (Asha Martin)

A simple and rapid reverse phase High Performance Liquid Chromatography method was developed for the quantitation of creatine in nutrition supplements. The creatine was well resolved with a retention time of 4.0 min under standardized conditions. Analysis of dilutions of taurine from 5 - 50  $\mu$ g/mL showed a linear response with a regression close to unity (R<sup>2</sup> = 0.999). Applicability of the method was assessed by analysing commercially available sports supplements and body building supplements. The levels of creatine were in accordance with that reported in the labels of the analyzed samples. The sensitivity and simplicity of the method render it suitable for use in quality control laboratories.

# Bio-fumigation system for safe storage of pulses (*Ezil Vendan S*)

An eco-friendly pulse storage bio-fumigation system was developed with 200 kg of grain storage capacity by using bio-fumigant insecticide against the infestation of Callosobruchus maculatus adults in green gram. It was found that the phytochemical volatiles diffusion in stored grains was directly proportional to the dimensions of fumigation chamber, quantities of food grains and concentration of bioactive ingredients. In the bio-fumigation system with 100 kg of green gram, 100% insect disinfestation was achieved within 5 days of exposure. Sedimentation of phytochemical fumigant residues were directly correlated with the physico-chemical characteristics of food grains. Among the tested pulses, maximum level of residues were observed in the green gram than chickpea and green peas. In addition to food grains, phytochemical fumigant residues were detected in the body surface and total body of the insect pests. The results suggest that phytochemical fumigants penetrate into the body tissue through cuticular surface. More than 5 ppm of bioactives were ingested into the body of C. maculatus adults during biofumigation process.

### **Disinfestation of insect pests in grain storage bags** (*Ezil Vendan S*)

Essential oils of edible plants were used as biofumigants against the stored product insect pests. Among the tested seven different essential oils, onion oil showed potential fumigant toxicities against the grain beetle (Sitophilus oryzae) and pulse beetle (Callosobruchus maculatus). Synergistic activities of the selected insecticidal essential oils have been examined against the targeted pests at different proportions. Fumigant toxicity results indicate that pulse beetles are highly susceptible to insecticidal essential oils than the grain beetle pests. In the present study, a model of bio-fume generator was developed for disinfestation of insect pests in the grain storage bags. With the use of bio-fume generator, phytochemical volatiles were generated from the selected essential oils and fumigated the grains in storage bags. Ovicidal, oviposition deterrent and adulticidal activities of the generated volatiles were evaluated by fumigation effects. Insecticidal activities of the generated volatiles were positively correlated with the fumigation exposure duration and grain quantities. After 72 h of fumigation exposure, 94% adulticidal, 91% oviposition deterrence and 100% ovicidal activities were observed in the pulse beetles with the significance of P<0.05. Investigation of disinfestation of insect pest species on different food grains is under progress.

### Insecticidal activity of *Ocimum tenuiflorum* oil and eugenol against stored product insects (*Sumithra Devi S*)

Fumigant action against *Tribolium castaneum* adults and larvae: The insecticidal activity of *O*.

*tenuiflorum* and its major constituent eugenol oil, against *Tribolium castaneum* in wheat flour, maida, rice flour, gram flour and sooji were determined at concentrations of 250, 500 and 1000 ppm. About 40 to 60% kill was achieved at 250 ppm while 100% mortality was recorded at highest test concentration of 1000 ppm. Similar studies with *T. castaneum* larvae were made to evaluate their effect on development into adults. The mortality followed a concentration and time dependent response. Further responses varied the milled products.

Bioassay for insecticidal activity against *C. maculatus* with different pulses viz., green gram (*Vigna radiata*), Bengal gram (*Cicer arietinum L*), cowpea (*Vigna unguiculata*) and flat bean (*Phaseolus vulgaris*). The effect of *O. tenuiflorum* oil and eugenol on *C. maculatus* with different pulses showed a linear increase

in mortality with increase in the test dosage from 50, 100, 150, 200 and 250 ppm as well as with time. Mortality of insects ranged from 25 to 73.7% and 71.6% mortality by 24 h for O. tenuiflorum oil and eugenol, respectively. A 100% mortality was observed by 48 h in all the cases. The response of C. maculatus to both O. tenuiflorum oil and eugenol in fumigant toxicity assay showed significant (p<0.05) lethality, leading to 93.33% and 96.67% mortality at 500 µL/L air, respectively, for 1 h exposure period. It was found that LC50 of O. tenuiflorum oil and eugenol were 279 and 256 µL/L air. Further, in vivo AChE inhibition studies revealed that pulse beetle exposed to essential oil and eugenol at LC25, LC50 and LC75 caused ~10, 19 and 48% AChE inhibition, respectively, compared to the control.

**CSIR** 

**PROJECTS** 

### Fast Track Translational Projects

# Isolation of arabinoxylans from defatted cereal brans (Baskaran V)

Arabinoxylan (AX) was isolated from both wheat and rice brans by saturated calcium hydroxide and Sodium hydroxide initially at lab scale and later at pilot scale. Results showed varying yields in different fractions. Detailed physicochemical characteristics of AX rich polysaccharides were carried out. Total carbohydrate, xylose to arabinose ratio, glucuronic acid, glucose and protein levels were measured. Viscosity studies were completed and Fraction B shows good viscosity property. Antioxidant properties were measured for three fractions at 0.1 % of AX, and IC50 value found to be 470, 620 and 860 µg for Fraction A, B and C respectively. Further, bulk isolation of AX was carried out only with wheat bran. Initially 1 kg level extraction was carried out and found to be reproducible. Similarly, 5 kg level extraction was completed and the results were found significant. Prebiotic potential of AX from wheat bran was carried out at 0.25, 0.5 and 1 % oncentration using lactobacillus sps. i.e., Lactobacillus fermentum and Lactobacillus plantrum in comparison with inulin. Results indicate that at 0.25% AX pre-biotic potential is more than inulin. Incorporation of AX at different concentration into 'Soup Crackers,' a wheatbased product was carried out. Texture analysis, sensory analysis and nutritional parameters were found in acceptable range. Incorporation of AX into pasta was carried at 0.1, 0.2 and 0.4 %. The products have similar texture in comparison to control. The overall acceptability score was 6.5. Wheat arabinoxylan has received GRAS status up to 5% consumption in the food products. The current process involves the use of calcium chloride hence safety studies need to be carried out. Process for the preparation of wheatAX is under progress.



Mission Projects

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

#### Milk spoilage indicator (Matche RS)

The present innovation relates to the time temperature indicator/integrator for real time monitoring of the freshness/spoilage of the pasteurized milk. An indicator was designed by understanding the spoilage kinetics of pasteurized milk. It comprised of activation liquid which have ability to diffuse the vapours with correlation of the time and temperature, irrespective to the storage conditions. Indicator provides visually observable colour change while monitoring the product freshness/ spoilage of milk. Raw materials used are

relatively cheaper and it does not require specific storage conditions. The device is attached with the milk packet after packaging of the milk, which ultimately starts the real time monitoring of the freshness/spoilage of the milk as the activation liquid diffuses with increase in time and temperature irrespective to the storage condition. The device does not have direct contact with the food product so there is no chance of affecting the product quality or safety. Factory trials were conducted successfully. Commercialization of the proposed technology is under progress.



### Monitoring of the freshness/ spoilage of the juice (*Matche RS*)

The juice available in the market are usually packed in the tetra packs which is sterilized and have shelf life of minimum 6 months. But after opening of the pack, the juice gets contacted with the external environment and spoilage chances get increased. At present the only option for the spoilage testing is sensory characteristics of the juice only. Hence, the present invention can help to monitor the freshness of the juice. The institute has developed a smart cap replacing the normal cap of the tetrapack. One gentle flip of the tetra



Juice freshness/spoilage indicator

pack allows the juice to be in contact with the smart cap for monitoring the freshness of the juice. App based monitoring of freshness of the juice by NFC enabled device was developed and the smart cap does not require specific storage conditions.

### Freshness / spoilage indicator of chicken meat (*Matche RS*)

The present innovation relates to the time temperature indicator/integrator for real time monitoring of the freshness/spoilage of the chicken meat. At present, chilled meat suppliers are entering into the market of the fresh meat, where they are claiming to transfer fresh meat through cold chain at 4°C but more or less the cold chain breakage may happen due to several factors like improper handling or load shedding etc. So present invention can monitor the freshness or spoilage of the chicken meat during the cold chain supply and communicate the status of the chicken freshness to the consumers instantly. An indicator was designed using the spoilage kinetics of the chicken meat. This invention is simple, compact, inexpensive, and easy to operate. The device is reliable and reproducibility can be achieved by utilization of reproducible quantity of activation liquid, selective barrier material as well as by using proper activation mean. The device will be attached with the chicken packet, which does the real time monitoring of the freshness/spoilage of the chicken meat as the activation liquid diffuses with increase in time and temperature irrespective to the storage condition. The device does not have direct contact with the food product so that there is no chance of hampering the product quality or





EXPIRED

Still Fresh

## Freshness keeper for shelf life of perishable material (Matche RS)

The freshness keeper to extends the shelf life and freshness of fruits, vegetables and other perishable edible or non-edible product by using the botanical extracted bioactive agents. It has the anti-microbial, anti-oxidation, insecticidal properties for extending the shelf life and freshness.

There are wide ranges of chemical, gaseous and physical treatment to reduce the postharvest losses. Here both efficacy of technique as well as safety issues are important. There is a need to develop natural, nontoxic component that are effective to hold the freshness and prevent the spoilage of perishable products that have anti-microbial, anti-oxidation, and insecticidal and ethylene scavenging properties.

In the present invention, properties were immobilized in food packaging material including the antimicrobial, anti-oxidation, insecticidal and ethylene scavenging. Novelty of the material extends the freshness and shelf life and prevents insect, bacterial, fungal viral infection, combinations thereof, on perishable substance.

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

Aptamer based colorimetric assay kit for detection of Aflatoxin B1: An aptamer based colorimetric assay kit was developed for the detection of AFB1. The assay kit developed contains aptamer (specific to AFB1) immobilized paper strips and reagents for development of colour on the strips. Prepared samples were added to the sample slots marked on the strips. The reagents are added and the colour formed after the analysis can be read using a mobile app (in progress). This kit enables preliminary screening for presence of aflatoxin B1 in food samples. Standard Operating Procedure (SOP) including sample preparation protocols was developed for conducting the assay.

Colorimetric kit for detection of formaldehyde: A colorimetric kit for detection of formaldehyde adulteration in food products was developed. The design of the assay is to give a qualitative "yes" or "no" indication as well as a semiquantitative determination of formaldehyde. The assay is conducted by addition of two reagents to develop the colour. Semiquantitative determinations can be made by comparing the colour to a colour chart which would be provided with the kit. A Standard Operating Procedure (SOP) has been prepared for conducting the test for both qualitative and semi-quantitative determination.

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

Stable isotope dilution method using internal standard was developed for specific and sensitive quantification of acrylamide. 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 – 3.5 % for LOQ and QC samples, and thus qualifies all bio-analytical parameters. The acrylamide contents in various food samples (numbering ~180) range from 6 to 51 ppb in dhals and peas, 145 to 254 ppb in muruku, 41 to 519 ppb in chips, 70 to 620 in french fries, 42 – 146 in pizza, bun, garlic breads, 68 to 315 in vadas,

137 to 1420 in sweets, and 22 to 861 in different other fried snacks like cutlet, samosa, masala cashews, kara bondi, chapati, pakoda, bhajji, bonda. A survey format has been devised to obtain the average 'probable acrylamide intake' data nation-wide, which will be helpful in acrylamide exposure assessment. Mitigation protocols using amino acids (leucine, glutamine, isoleucine, and L-citrulline), salts such as calcium lactate, magnesium lactate, calcium chloride, magnesium chloride, and calcium carbonate, and vitamins like Lascorbic acid, calcium pantothenate, pyridoxal hydrochloride, nicotinamide, were performed. In Maddur vada, a significant reduction of acrylamide was observed with 0.2% glutamic acid (64% reduction), 0.5% of magnesium lactate (54 % reduction), CaCl<sub>2</sub> (69% reduction) and MgCl<sub>2</sub> (80% reduction). In potato chips, acrylamide reduction observed was 87% and 71% with 0.5% and 0.25% glutamic acid, respectively, and 80% isoleucine. Combined approach involving sacrificial additives in mitigating acrylamide content also showed promising result. In potato chips, amino acids and salt combination like magnesium lactate and glutamic acid at 0.25%, showed 72% reduction. Use of asperginase enzyme in the formulation mitigated the acrylamide to the high extent of around 95%. These approaches can be utilized in large scale mitigation of acrylamide content in deep fried foods.

#### *ii)* Nutraceuticals and Nutritionals

# Bioaccesibility and bioavailibity of vitamin B<sub>12</sub> (Sarada R)

Bioaccesibility studies by *in vitro* digestion method was carried out in three different ratios

of vitamin B<sub>12</sub> and G. glabra ethanolic extract (1:50, 1:100, 1:200). Samples were analysed by HPLC method and results showed 40% bioaccesibility compared to the standard vitamin B<sub>12</sub>. MTT assay of 24 h and 48 h for G. glabra (ethanol extract) was carried out by treating CaCo2 cells with different concentrations 5-450 mg. cytotoxicity was not observed at the tested concentration of G. glabra extract. Bioavailability of vitamin B<sub>12</sub> has been carried out in CaCo2 cells for 21 days by TEER method at 10, 50 and 100µg conc. of G. glabra ethanol extract along with 200 µg of vitamin B12 in Transwell membrane plates. The results indicated three-fold increase in absorption of vitamin  $B_{12}$  at 100 µg of *G. glabra*. Wistar weanling rats of 2 wks old weighing 35-40g were choosen and based on their average body weight (38.3  $\pm$  1.5g) grouped into six groups 6(n). vitamin B<sub>12</sub> deficiency was induced till 80 days by providing a diet devoid vitamin B<sub>12</sub>. After confirming the vitamin B<sub>12</sub> deficiency in rats, experiment with oral gavage of G. glabra (ethanolic extract) for 4 wks was carried out. Average initial and final food intake and body weight of rats were monitored and hematological parameters and organs weight of the experimental rats have been recorded. No significant differences were observed in body weight, food intake or haematological parameters among the control and extract fed rats. Serum analysis of vitamin B<sub>12</sub> and homocysteine levels are to be analysed for envisaging the vitamin B<sub>12</sub> enhancement effect of G. glabra extract.

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

Lentinula edodes on treating with UVB was

enriched with vitamin  $D_2$ , it had increased from as on cooking minir negligible value to 75.5  $\mu$ g/g oven dried sample provides RDA of iron a (provided by CSIR-IHBT). The bioaccessibility folic-14%: Vit C-20% as

negligible value to 75.5 µg/g oven dried sample (provided by CSIR-IHBT). The bioaccessibility of vitamin D<sub>2</sub> determined by ATCC cells ranges between 60-85% in different parts of Lentinula edodes. The bioavailability of vitamin  $D_2$ enriched Lentinula edodes was determined in rat model by providing 100, 125 and 150% of RDA of Vitamin D<sub>2</sub> equivalent Lentinula edodes in vitamin D deficiency induced rats. The efficacy of Lentinula edodes in alleviating the deficiency was compared with the vitamin D deficient rats provided with standard vitamin D. Weanling male Wistar rats, initially were divided into two groups of six in control group (that received normal AIN93M diet) and other group of 36 rats received AIN93 diet devoid of vitamin D and placed in dark room for 45 days which were made vitamin D deficient. The deficient rats were replenished with different sources of vitamin D for 45 days through oral gavaging.

### Nutrifoods for breakfast (Jayadeep A)

Instant nutritious spicy and sweet mixes of traditional Indian foods which can be readily constituted in hot/boiling water, and used for breakfast in school were developed. Nutri-Breakfast/Tiffin mixes were upma (spicy, sweet), poha (spicy) and khichdi (spicy), pongal (sweet). Mixes were fortified with 25% RDA of iron, zinc, folic acid, vitamin B12, vitamin A and vitamin C. As a part of development of DPR, process trials of ready mixes were carried out and evaluated for their quality. Reconstituted mixes were sensory acceptable, convenient to prepare and has good storage characteristics. Micronutritional studies showed that in spite of storage as well as on cooking minimum quantity of food provides RDA of iron & zinc- 17%; Vit B12 & folic-14%; Vit C-20% and Vit A- 6%. In addition to major products, trial of novel instant products like Nutri-bun, Nutri-bar, chutney, rice noodle, etc., were also carried out.



Nutri-Breakfast/Tiffin products processing line with machineries for grain polishing, roasting, pulverizing, blending, sifting, seasoning, packing put up which can be used to demonstrate batch processing at 500 kg/day for training to SHG/NGOs.

DPR and blueprint of an Integrated Instant Nutri-Breakfast/Tiffin Mixes production line with raw material specifications, process steps, machineries, plant layout, quality control, economics and carbon footprint were prepared for introducing breakfast in schools. These integrated plant can cater to the production of 10 pan India spicy and sweet forms of upma, poha, khichdi, kumol, sattu and dahlia. Entrepreneurs/ State governments can set up production units for low cost, instant nutritious breakfast/tiffin mixes across India for schools, community or emergency feeding once policy guidelines are put in place.

# Shelf-life studies of breakfast products (Sathish HS)

Shelf-life studies were carried out with different packaging materials under normal (27°C and 60-65% RH) and accelerated storage
conditions (i.e. 38°C and 90% RH) for the below mentioned products.

Two samples of sweet poha (NIIST Trivandrum), T5 (sweet poha coated with jaggery and milk powder) and T6 (sweet poha blended with jaggery and milk powder) were received from NIIST, Trivandrum. The samples were packed in PET/PE pouches and were stored under accelerated conditions. The physicochemical, microbial and sensory analysis showed that both the products are acceptable up to 45 days. The shelf life of the sweet poha under accelerated conditions was found stable up to 45 days which indicates that under ambient conditions, the product might be safe for consumption up to 90 days.

Based on the physicochemical and microbial analysis, spicy poha stored under accelerated conditions in the selected packaging materials (PP, PET/PP and HDPE) was found to be acceptable up to 30 days. In ambient conditions, the product packed in all 3 packaging materials was observed to be acceptable up to 45 days. These results should be correlated with sensory analysis to determine the shelf life of the product.

The results of fortified spicy poha stored under accelerated condition in Met.PET/PE was found to be acceptable up to 45 days based on physicochemical & microbiology analysis. These results should be correlated with sensory analysis to determine the exact shelf life of the product.

The vitamin A fortified buns were stored in the PET/PE, HDPE, PP packaging materials and stored under ambient conditions were safe for consumption up to 5 days.

The physicochemical and microbial analysis showed that fortified upma mix are safe for consumption up to 60 days under accelerated storage conditions. These results should be correlated with sensory analysis to determine the exact shelf life of the product.

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

An intervention study in older animals was attempted. Fifteen months old balb/c mice were used in the study, assuming that such aged animals would have started to experience neurodegeneration and diminishing cognitive abilities. The effect of supplementing an ALA rich oil, namely chia oil and/ virgin coconut oil in such conditions was assessed.

Five sets of 15 months old balb/c mice (6 each) were used in the study. Chia oil or VCO or chia:VCO (1:1) was supplemented by oral gavaging. Saline was given as control and Donepezil was given to serve as positive control. Uptake of the fatty acid was confirmed by checking for excretion of the oil in faecal matter at 3 different time intervals and by checking the fatty acid profile of the blood plasma at the end of the study period which lasted for 4 wks. Other biochemical parameters were also studied.

Prior to sacrifice, the animals were assessed for their memory skills using the well reported behavioural methods like step down latency and elevated plus maze, that are indicative of hippocampal memory. Upon culling the mice, the brain tissues were separated and frozen to conduct biochemical and molecular studies. The hippocampal and cortex regions were separated and the hippocampal tissues were used to study the expression of several protein biomarkers by immunoblot methods.



C+V Expression levels of beta amyloid and Tau proteins in the treated brain tissues - C-Chia oil; V-VCO; D-Donepezil

V

Ctrl

C

D

Accordingly, Chia, VCO and the combination were found effective in improving cognition in aged mice (memory and neural plasticity), but may not abrogate AD like conditions (neurodegeneration). Further clinical studies with NIMHANS is under progress.

### Microalgae as a source of Alpha Linolenic Acid (ALA) (Chauhan VS)

A two-stage cultivation strategy for production of biomass with enhanced content of ALA rich lipids was standardised. First stage cultivation at 25°C to obtain the biomass followed by second stage incubation at 5°C for accumulation of ALA rich lipids. The lipid content and ALA fraction of total fatty acids of two stage cultivated cultures enhanced by 1.8 fold and 1.3 fold respectively compared to the single stage control cultures without any

significant loss of biomass content. The outdoor cultivation of the microalga was carried out for 10 months at 800-1000 L scale in outdoor open raceway pond in semi continuous mode with periodic harvesting through centrifugation. The aerial biomass productivity has been in the range of 8 to 10 gm<sup>-2</sup>d<sup>-1</sup>. Drying of biomass through spray drying has been optimized. In vivo acute sub-acute toxicity studies with algal biomass in rat model has not shown any toxicity.

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

Authentic spice samples were procured, specimen vouchers deposited, authenticated, extracted, evaluations on samples / extracts / oleoresins (OR) was carried out. Efficacy studies on spices and their extracts were carried out employing the well-established three-tier-screening strategy, wherein in vitro systems, C. elegans based studies and in vivo rodent models were employed for testing the spices against various factors of NDs. Blood brain barrier related studies was carried out employing PAMPA assay. The present study is consistent with previous studies, the GSH and GPx level decreased in scopolamine administration further it was slightly increased when co-administration of spice oleoresins. The AChE activity was reduced 5-15% in pepper, turmeric oleoresin and drug administered rats. The increase in SOD and catalase activity in turmeric and pepper OR group may be due to strong antioxidant potential of turmeric and pepper against protein oxidation, glycoxidation, glycation etc. Formulation of most effective combination prepared and pre-clinical safety studies will be conducted as per DCG(I) Schedule Y guidelines.

# Focused Basic Research / Niche Creation Projects

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

Big data Analytics platform was configured with Hadoop 2.7.3, R Studio Server 1.1.442 on a linux (Ubuntu 18.04) platform. The datasets such as WHO standards with respect to height and weight, RDA, clinical symptoms of nutritional deficiency from NIN; nutritional information of MDM/ ICDS food menus served in the aspirational districts and nutritional profile of CFTRI products were loaded into the HDFS (storage platform). An android application was developed to capture the survey data. In the first phase of survey, the data was collected from anganwadies/schools in the Wayanad district with the help of local ICDS/MDM functionaries. Preparation of various analytics are underway.

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

LC-MS/MS methods were optimized and validated to quantify water soluble B-vitamins (B1, B2, B3, B5, B6, B8, B9 and B12), antibiotics and mycotoxins in nutraceutical products (Spirulina powder and honey), and authenticate the honey using isotope ratio

mass spectrometer (IRMS). The linearity, linear range, recovery and reproducibility in the spiking of LOQ and QC levels were in permissible limits. The level of vitamin B3 (613 µg/10 g) was highest in all the Spirulina samples tested followed by Vitamin B1 (192 µg/10 g). IRMS was used to authenticate honey, and to perceive the level of sugar adulteration. EA-IRMS and LC-IRMS methods have been optimized and validated to detect the C4 and C3 sugar adulteration in different honey samples based on their  $\Delta^{13}$ C value  $(=^{13}C/^{12}C)$  isotope ratio). The samples which conforms in C4 sugar adulteration was found to be non-conforming in C3 adulteration test, indicating addition of rice or other syrup in honey. For antibiotic analysis, a simultaneous multianalyte LC-MS/MS method was developed and validated using wide range of antibiotics (like tetracyclines, sulfonamides, lincosamides, macrolides, nitrimidazoles and β-lactams). The optimum pH for simultaneous extraction of antibiotics was found to be pH 7.0. The validation parameters gave good linearity, linear range, recovery (80 - 110%) and reproducibility (%CV < 20), as per SANCO guidelines (EU guidelines). A new, novel ionic liquid aqueous two-phase system (IL-ATPS) mediated LC-MS/MS method for quantification of patulin and aflatoxins in different food and nutraceutical product was developed. The validation parameters were found within the permissible range.



pH for the simultaneous extraction of different antibiotics in honey

# Screening pesticides and elucidation of robust UPLC MS/MS method

Insecticide/pesticides are contaminants present in fruits, vegetable, cereals, pulses, meat and marine samples. Based on the structural moieties present in the organic synthetic pesticides it can be classified as organochlorines, organophosphates, carbmates and pyrethroids. Analysis of organopesticides through gas phase chromatography has a few challenges including volatility of compounds and high signal/noise ratios. Hence, an in-house UPLC/MS-MS protocol was adapted and optimized for organopesticides of about 204. By this the total run time could be reduced and was also able to screen 204 pesticides through multiple reaction monitoring. Further, a mix of five organopesticide such as acephate, monocrotophos, phosphoamidon, diaznion and malathionin were also validated in cereal and wheat samples whose LOD is 0.5 ppb and LOQ is 1 ppb.



UPLC MS/MS method for pesticides that are less volatile or unstable to analyse in GC-MS/MS

 iii) Translation of pre-clinically tested probiotic formulation to human population with special emphasis on cytokines modulation and gut microflora (Prakash M Halami)

Process for the production of shelf-stable probiotic curd up to 2 litres was standardized

and sensory evaluation of the product by the volunteers was accomplished. In addition, metabolite analysis by NMR spectroscopy and FTIR was undertaken. Further, freeze drying of probiotic and starter culture for higher viability, storage up to one month duration has been accomplished. Whole genome sequencing of the Lb. fermentum probiotic culture to identify novel genes and preclinical trials of the product in mice model with high fat diet has been accomplished and it was found that the normalization of Firmicutes to bacteroidetes ratio upon probiotic intervention. Clinical trials were undertaken among healthy individuals (n=37) by feeding probiotic curd. Results indicated that there was no notable difference in the anthropometrical measurements, blood pressure and hematology. The biochemical tests, cytokines profiling, metabolites profiling is being done in the serum samples. The microbiome and metabolites profiling will be carried out in the stool samples.

#### 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 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, identifying such unique catalytic and regulatory sites in these enzymes was envisioned. Besides bringing a wealth of knowledge about the bacterial world, the sites identified here can be targeted subsequently to design inhibitors specific to food pathogens.

Rel from few foodborne pathogens Pseudomonas aeruginosa (Rel<sub>Pae</sub>), Micrococcus luteus (Rel<sub>Miu</sub>), Salmonella enterica (Rel<sub>sen</sub>), Shigella flexneri (Rel<sub>sen</sub>), Klebsiella pneumonia (Rel<sub>Kon</sub>) and gut bacteria Bifidobacterium longum (Rel<sub>RID</sub>) were cloned into pet28a expression vector with a C-terminal 6-histidine tag. These proteins were over expressed in E. coli and tested for their solubility. Of these, Rel<sub>Mu</sub>, Rel<sub>sen</sub> and Rel<sub>sen</sub> showed a very low expression. Further mutant strains were constructed which includes only the N-terminal catalytic domains (hydrolase and synthetase) (N-Rel<sub>Lmo</sub>, N-Rel<sub>Sfl</sub>, N-Rel<sub>Sen</sub>, N-Rel<sub>Knn</sub>, N-Rel<sub>Pae</sub>). The proteins were optimized for their expression and purified and their activities were tested.

- Harnessing Appropriate Rural Interventions & Technologies (HARIT)
- i) Empowerment of rural woman in food processing sector with select technologies (*Giriyappa K*)

The objective of the project is to catalyze employment generation and skill development under food sector for the women from backward Districts of Karnataka viz. Raichur and Yadgiri. During this period, nearly 350 women belonging to various Women Self Help Groups from Raichur and Yadgiri Districts of Karnataka State were trained as a part of Women Empowerment programme by skilling them in food related technologies.

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

A podcast entitled Thali Tales (English), Thali Tales (Hindi) and Oota Paata (Kannada) was launched. A total of 56 episodes were produced and disseminated through WhatsApp group of around 1800 registered users. In addition, the podcast content was broadcasted through two community radio stations, Janadhwani (Sargur) reaching an estimated 90,000 audience in rural areas and Jnanadwani (Mysuru) reaching an audience of 8,000 school/ college students/ teachers in Mysuru city.

# iii) Establishment of Common Facility Centre for Spice processing (Umesh Hebbar H)

The major objective of this project was the establishment of a Common Facility centre (CFC) for spice processing in association with Wasuki Farmers Society in Wynad, Kerala, which is an aspirational district as per NITI Aayog. Under an MoU, technical dossier for 5 technologies (green cardamom color fixation, white pepper and pepper in brine, ginger candy and ginger beverage) were transferred to the Society and demonstrated at a scale of ~15 kg to the representatives of Society. This is in addition to 3 of the technologies transferred in the previous year. The key aspects of the technology were explained during demonstrations and inputs on adopting the same at the plant were provided.



Technology demonstration on green colour fixation in cardamom

Staff as on 31.03.2020

# Raghavarao KSMS . ... . DIRECTOR

# Director's Office

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Mahesh S Palakshan B Veeranna 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 Anil Kumar K (In-charge)** Ganesh Prasad PS Vittal Rao

Security Chandra Shekar (Sr. Security Officer)

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