



Giving Food a Future

# PERFORMANCE REPORT | 2020-2021



CSIR-Central Food Technological Research Institute  
Mysuru

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Research Council

Director, CSIR-CFTRI

Management Council

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- Flour Milling, Baking & Confectionery Technology
- Food Engineering
- Food Protectants & Infestation Control
- Food Packaging Technology
- Food Safety & Analytical Quality Control Laboratory
- Fruit & Vegetable Technology
- Meat & Marine Science
- Grain Science Technology
- Lipid Science
- Microbiology & Fermentation Technology
- Molecular Nutrition
- Plant Cell Biotechnology
- Protein Chemistry & Technology
- Spices & Flavour Sciences
- Traditional Food & Sensory Science

### SUPPORT DEPARTMENTS

- Central Instruments Facility & Services
- IT Services & Computational Solutions
- Construction & Civil Maintenance
- Engineering & Mechanical Maintenance
- Human Resource Development
- Information & Publicity
- Library
- Planning, Monitoring & Coordination
- Technology Transfer & Business Development
- Resource Centres : Hyderabad, Lucknow & Mumbai

### ADMINISTRATION

- General Administration & Establishment
- Finance & Accounts
- Stores & Purchase





# CSIR - CFTRI | REPORT PERFORMANCE 2020-2021

**CSIR-Central Food Technological Research Institute**

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



It is my great privilege to present the Performance Report 2020-21 of CSIR-Central Food technological Research Institute (CSIR-CFTRI) as one of the constituent laboratory under CSIR Network for the benefit of all our stakeholders including the academia, Industry and Startups. The journey has been really enthralling, however as all of us are aware that Covid pandemic brought severe challenges to all of us. No doubt, new avenues have emerged for utilizing our knowledge base and expertise in resolving many more nation's pressing problems.

The Institute has been steady and successful in publishing in the peer-reviewed journals, technology transfer, human resource development activities while handling large number of externally funded grant-in-aid and Industry projects.

CSIR-CFTRI contributed immensely aligning with CSIR Strategic Group (CSG) steered by DG-CSIR under verticals such as Digital and Molecular Surveillance; Rapid and Economical Diagnostics; and Outreach activities. The Institute established a Covid Testing Laboratory in association with State Govt. for augmenting the testing capacity in the State. We also shared infrastructure resources for the Testing centres established in both Mysore and Mandya Medical colleges. The diagnostic tools

viz dipstick and aptamer based solutions for Covid testing are in the final phase of commercialization. Apart from it, an Ozone based disinfection unit and an array of Herbal Sanitizers are a few of the innovative outcomes of the deliberations held periodically by CSG. Further, almost 39 tonnes of RTE foods were mobilized through our licensee network for supplying to migrant workers, Covid warriors in the State and National Capital Region (NCR). The team from CSIR-CFTRI worked very closely with NGOs, State & Central Govt. departments at Ground Zero level during the pandemic.

CSIR continued to encourage all our R&D programmes and the Institute is well set with projects under Mission mode viz. Food Safety (ATLAS), Floriculture & Immunity, FTT/ FTC and FBR/ NCP categories.

The Institute got recognized as the State Level Technical Institution for the implementation of the PMFME Scheme in Karnataka. The Scheme is being implemented jointly by both the Central and State govt. during 2020-25 in order to bring almost 2.0 lakh unorganized food processing units into the organized sector. Under this, almost 300+ FPOs / Entrepreneurs were trained under One District One Product (ODOP) across the State. The Institute has been able to consolidate its position as a major

hub for innovation and nurturing startups as more incubation centres under PMFME, RKVY and BIRAC schemes are set to be operationalized soon.

Significant collaborations have been chalked out with leading academic Institutions in the country which include IITs (Guwahati & Tirupathi), ICT (Mumbai) and Universities. Our scientists have fared immensely during this period and three of our colleagues were figured in the 2% list of the Stanford University of World leaders in their respective domains is a matter of great joy and satisfaction.

We have been fortunate to have the wisdom and continued support of the Chairperson(s) & Members of both Research Council, Management Council and I would like to acknowledge each one of them for their priceless contributions.

I would like to thank DG-CSIR and CSIR HQ team for the support rendered in all our endeavors along with our Theme Director(s) and many esteemed academicians who were associated with various review and monitoring committees. It is also important to mention the support rendered by funding agencies viz. DST, SERB, DBT, MoFPI, FSSAI, CDB and many others which are the mainstay in pursuing our dream and mandate.

Finally, I would like to thank each and every staff and students who have put their sincere effort towards fulfilling our mandate year after year.

It will be our joy to hear from all our stakeholders and well wishers as well in taking forward the agenda of food and nutrition security of the Nation.

**Nov 23, 2021**

(Sd/-)  
**Sridevi Annapurna Singh**



# Achievements at a Glance



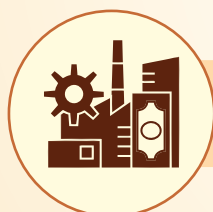
## Publications

Research Papers	107
Reviews	14
Book Chapters	7



## Projects

Grant-in-aid	84
Consultancy	15
Sponsored	39



## Industrial Development

Patents Filed	2
Patents Granted	18
Technologies Transferred	66
New Technologies Developed	34



## Human Resource Development

M.Sc. (Food Technology)	30
Certificate Course in Flour Milling	29
Ph.Ds Awarded	29
Skill Development Programmes	929





# *Achievements in Brief*



## 1. Research Publications

### SCI Publications

1. Achintya Kumar D., Arun Kumar V., Ram Rajasekharan, Vijayaraj P., Activity-based protein profiling of rice (*Oryza sativa* L.) bran serine hydrolases, *Scientific Reports*, 2020, **10**, 15191
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  15. Chua E.T., Ajam Shekh Y., Eltanahy E., Thomas-Hall S.R., Schenk P.M., Effective harvesting of *Nannochloropsis* microalgae using mushroom chitosan: A pilot-scale study, *Frontiers in Bioeng. and Biotechnol.*, 2020, **8**, 771
  16. Darshan C.M., Bharadwaj K.R., Tejash S.M., Negi P.S., Devendra Haware J., Radha C., *Moringa oleifera* seed protein isolate as an alternative for purifying turbid water, *Desalination and Water Treatment*, 2020, **203**, 129-136
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## 2. Patents Filed / Granted in India

### Filed

- Micro-perforation based time temperature indicator (TTI) for detecting freshness of the perishable products
- Nutritional composition for endurance performance enhancement of athletes

### Granted

- A process for the preparation of photo-stable, water-soluble curcumin from turmeric (*Curcuma longa*)
- A process for preparation of slow carbohydrate digestibility rice suitable for diabetics
- An improved process for the preparation of vanilla extract
- A process for the preparation of a low-fat multigrain ready-to-eat snack
- An improved medium composition and a process for enhanced lutein production from microalgae
- An automatic device for pneumatic extrusion of dough
- A process for the preparation of semisolid palm fat containing high amount of partial glycerides and having emulsifier property
- A process for the preparation of low sour pulp from highly acidic fruits useful for preparation of food products
- A device for making twisted snack product

- A device for cutting spherical shaped fruits and/or vegetables into multiple number of pieces
- A process for expansion of brown rice
- An improved process for the preparation of bland turmeric powder with enhanced curcuminoids
- A process for faster curing vanilla beans and production of vanilla concentrate thereby
- A process for successive preparation of pungent aromatic powder and pungency free colourant from chilli
- A process for the production of milk clotting enzyme from *Aspergillus oryzae* MTCC 5341
- A process for the production of ready-to-eat low fat potato snack
- Radical scavenging water soluble yellow colourant turmeric formulation
- An improved magnetic separator suitable for processing food grain

## 3. Processes / Technologies transferred for commercial exploitation

The following sixty six processes were released to 124 parties.

- Banana pseudostem juice
- Bland soy protein concentrate
- Bottling of sugarcane juice
- Cereal flakes - Jowar
- Chestnut based gluten free cookies
- Chikki/nutra chikki
- Coffee concentrate
- Compounded asafoetida





- Convenience flour from ragi suitable for stiff porridge
- Dehydrated drumstick powder
- Desiccated coconut
- Dolly mix
- Dry dehulling of sesame seed
- Fermented and dehydrated ready mixes for idly and dosa batter
- Finger millet based multigrain semolina for preparation of upma, kesari bath, porridge & others
- Flaking of foxtail millet
- Fruit syrups and squashes
- Canning of fruits & vegetables
- Preparation of fruits jam & jellies
- Edible full fat soya flour
- Ginger & garlic paste
- Groundnut (peanut) butter
- Instant cake mix
- Instant coffee cubes
- Instant gravy mixes (dehydrated)
- Instant halva mix from millets and multimillets semolina
- Instant moringa leaves soup mix
- Instant rava idli mix from millets and multimillets semolina
- Instant upma mix from millets and multimillets semolina
- Low glycemic index noodles
- Maize chips
- Malted weaning food
- Marigold oleoresin
- Microbial inoculums for the management of coffee pulp effluent
- Modified atmosphere packaging of minimally processed vegetables
- Mutton pickle
- Nutra chikki with added spirulina
- Nutri fruit bars with immune boosters
- Online fortification of atta or maida
- Osmo air dried fruits amla, jack fruits, pineapple, mango
- Ozone based disinfection system
- Paan flavoured water
- Pickles and chutney
- Potato wafers/chips
- Preparation of beverage mix from malted ragi
- Preparation of ready to cook multigrain whole mix for drink/porridge
- Preparation of shelf stable biriyani paste
- Preparation of shelf stable roti from non wheat cereal and millet
- Protein rich ragi vermicelli
- Raw banana powder
- Roller milling process for semolina (sooji/rava) from millets and preparation of multimillets semolina
- RTE low fat flaked spicy maize /corn snack
- RTS fruit juices and beverages
- Shelf stable jowar flour



Paan flavoured water



- Shelf-stable varieties of curry pastes for vegetarian & non-vegetarian traditional cuisines
- Spirulina choco bar & cereal bar
- Tamarind candy
- Tamarind juice concentrate & powder
- Tomato product preparation
- Turmeric powder technology from fresh rhizomes
- Tutty fruity
- Upma ready mix
- Value added products from coconut-instant adjunct mix, instant filling mix, coconut rice mix, coconut bites
- Virgin coconut oil
- Wafers: Egg, chicken and fish
- Whole wheat flour vermicelli

#### 4. New processes ready for commercial exploitation

Thirty four processes were newly developed for commercial exploitation as detailed below:

- A process for flavour essence from *Decalepis*
- Antidiabetic barley-herb based beverage mix: DiaLow GI-47



Flavour essence from Decalepis

- Antidiabetic wheat-herb based beverage mix: DiaLow GI-49
- Baked savoury snacks
- CGA enriched coffee cubes
- Polyphenols rich chocolate
- Herbal bulk sanitizer product
- Herbal fogging disinfectants for mist sanitizer system
- Herbal hand sanitizer (Gel form)
- Herbal hand sanitizer (Liquid form)
- Herbal spray sanitizer
- Instant coffee cubes
- Know-how on ozone based air disinfection system
- Minimally processed pomegranate arils
- Nutrient and micronutrient rich Ready to Eat (RTE) salad
- Nutritious high fibre soup sticks
- Paan flavoured water
- Preparation, characterization and evaluation of beverage concentrate / mango paste in collapsible tube
- Preparation, characterization and evaluation of beverage concentrate / guava paste in collapsible tube
- Preparation, characterization and evaluation



CGA enriched coffee cubes



of beverage concentrate / pineapple paste in collapsible tube

- Preparation, characterization and evaluation of beverage concentrate / mixed fruit and vegetable paste in collapsible tube
- Process for instant tomato crush, tomato rasam mix and tomato rice bath mix
- Process for production of banana alcohol
- Process for production of banana wine
- Process for the preparation of raw banana powder (unripe)
- Process for the preparation of whey protein hydrolysate
- Process knowhow for dehydration of coriander foliage
- Process knowhow for preparation of zerumbone crystals from fresh zerumbet rhizomes
- Process knowhow for the preparation of chestnut based gluten free cookies
- Ragi based biscuit
- Ready to eat weaning food based on malted multi-cereals
- Ready to eat weaning food based on malted rice
- Ready to eat weaning food based on malted wheat
- Sweet potato soup mix



Herbal sanitizers & disinfectants

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

Sl. No.	Type of project	No. of projects as on 31.3.2021	No. of projects completed during 2020-21	No. of new projects initiated during 2020-21
1.	Sponsored	35	4	17
2.	Consultancy	9	6	7
3.	Grant-in-Aid	65	19	25

## 6. M.Sc. / ISMT / Skill Development Programmes

Sl. No.	Type of project	Degree / Certificate Awarded
1.	M.Sc. (Food Technology)	30
2.	Certificate Course in Milling	29
3.	Skill Development Programmes	929

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

- **National Technology Day (May 11, 2020)**

CSIR-CFTRI celebrated National Technology Day on May 11, 2020 in association with Swamy Vivekananda Youth Movement (SVYM), Mysore. On this occasion, Dr. R. Balasubramaniam, Founder, SVYM delivered the talk on "What do villages expect from food scientists?"

- **Half Day Virtual Colloquium on Recent Advances in Microalgal Biotechnology (July 27, 2020)**

The colloquium arranged in the virtual mode focused on the microalgal biotechnology, its



prospects and challenges. There were six oral lectures from researchers working on microalgal biotechnology.

- **Future India Series (Aug 6, 2020)**

As part of this series, a lecture on 'Energy and Cooking' was delivered by Prof A B Pandit, Vice Chancellor, ICT, Mumbai on Aug 6, 2020. In the function presided by Director, CSIR-CFTRI, Prof. Pandit discussed the efforts at ICT over the past few years about cooking process and energy transfer especially at a household level.

- **Independence Day Celebrations (Aug 15, 2020)**

74th Independence Day of the nation was celebrated in the Institute in which Director, CSIR-CFTRI addressed staff in a virtual mode.



- **CSIR Foundation Day (Sep 26, 2020)**

On CSIR Foundation Day celebration, Dr. R. Subramanian, Advisor (M&A), in his opening remarks summarized the contribution of CSIR laboratories since its inception. Shri. Jitendra J Jadhav, Director, CSIR-CFTRI & NAL delivered the Foundation day address. In his address, the efforts of the Scientists in development of technologies under FTTs, Sugar fortification, development of Ozone Disinfection unit and

supply of RTE foods and food supplements to migrant labourers during calamities were lauded. As part of the celebrations, awards to meritorious students, felicitation of retirees, staff who have completed 25 years of service, Covid warriors and awards under Hindi incentive scheme were distributed.



- **VAIBHAV Summit (Oct 12-19, 2020)**

'Agro Economy & Food Security' was one of the 18 verticals planned under Vaibhav Summit 2020, in which there were six horizontals such as Precision agriculture, Sustainable and climate smart agriculture, Food safety and nutritional security, Climate resilient livestock, Veterinary therapeutics, Immuno-biologics and zoonoses control, Nanotechnology in food/feed processing and metabolic biology of food and Modern fisheries, aquaculture and seed production. Under Food & Security horizontal,







five sub-horizontal namely Processing of agriculture produce, Food fortification and biomolecules, Food safety and quality, Smart and Biodegradable packaging and Storage and Handling Strategy were covered. Total of 336 participants including 104 panellists of which 45 Non-Resident Indian Scientists from 19 countries participated.

- **World Food Day 2020 (Oct 16, 2020)**

World Food Day 2020 was celebrated at Resource Centre, Hyderabad in which Dr. Rajan Sankar, Tata Trusts, delivered the key note address. Prof. KSMS Raghavarao, IIT-Tirupati delivered Sri. P.V. Suryaprakasa Rao Memorial Lecture, 2020 on this occasion.

- **CSIR-CFTRI Foundation Day (Oct 21, 2020)**

The Foundation Day Lecture on "Workspace Wellness and Profile of Heart Diseases in India" delivered by Chief Guest, Dr. C.N. Manjunath was Director, Sri. Jayadeva Institute of Cardiovascular Sciences & Research, Bangalore. The Guest of Honour, Sri. Harsha Kikkeri, CEO, HoloSuit, Mysore and Sri. Jitendra J Jadhav, Director, CSIR-CFTRI were present. The Annual Institute Awards were announced on the occasion.



- **Vigilance Awareness Week (Oct 27 - Nov 2, 2020)**

Dr.(Smt.) Suman D. Pennekar, IPS, Superintendent of Police, A.C.B. & Deputy Director, Karnataka Police Academy, Mysore, delivered the Vigilance Day message on Oct 28, 2020. Prizes were distributed to the winners of various competitions conducted as part of the celebrations. Vigilance activities report was presented by Shri. DJN Prasad, Vigilance Officer & Administrative Officer of the Institute.



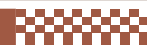
- **Kannada Rajyotsava Day (Nov 1, 2020)**

Kannada Rajyotsava was celebrated on Nov. 1, 2020 organised in association with Kannada Sahrudaya Balaga. The Rajyotsava message was given by Dr. B. Manohar, Chief Scientist & Advisor (M&A) on the occasion.

- **IISF 2020 (Dec 3, 2020)**

Curtain Raiser event of IISF 2020 was conducted on the theme "Science for Self Reliant India and Global Welfare" wherein Opening Remarks was given by Shri Jitendra J. Jadhav Director, CSIR-CFTRI. Dr. B. Manohar, Chief Scientist & Advisor (M&A) was present. Successful Women entrepreneurs, Smt. Chaya Nanjappa, Managing Partner, Nectar Fresh Pvt Ltd.; Sree Lakshmi Desiraju, CEO & Co-Founder, Triphase





Pharmaceuticals Pvt Ltd.; Smt. Revathi Jagadeesh, Founder CEO, SaRedh Enterprises; Dr. Sushma Appaiah, CEO & Founder, Golz Nutrition, delivered lectures in the technical session.



- **Virtual Colloquium on Revisiting the Development of Infestation Control and Protectants Research (Dec 28, 2020)**

Virtual colloquium on "Revisiting the Development of Infestation Control and Protectants Research" was held on Dec. 28, 2020 organised by Pesticide Science Study Group at CSIR-CFTRI. Dr. B. Manohar, Chief Scientist & Advisor (M&A) presided over the function.



- **Virtual Colloquium on Translating Academic Research to Entrepreneurship (Jan 20, 2021)**

A virtual colloquium on "Translating Academic Research to Entrepreneurship" was held on

Jan 20, 2021 at CSIR-CFTRI and Dr. Sridevi Annapurna Singh, Director, CSIR-CFTRI presided over the function.



- **Covid Warriors Felicitation (Jan 29, 2021)**

Covid warriors working in the Covid Testing Centre was felicitated on January 29, 2021. Smt. Rohini Sindhuri, IAS, District Commissioner, Mysore and Dr. Sridevi Annapurna Singh, Director, CSIR-CFTRI was present on the occasion.



- **International Virtual Conference on Emerging Trends In Food Protectants and Infestation Control (Feb 24-25, 2021)**

Pesticide Science Study Group at CSIR-CFTRI hosted an International virtual conference on "Emerging Trends in Food Protectants and



Infestation Control on Feb 24, 2021. Dr. Prakash M Halami, Chief Scientist & Head, Microbiology & Fermentation Technology welcomed the participants and Dr. Sridevi Annapurna Singh, Director, CSIR-CFTRI, delivered the inaugural address. Eminent scientists in the field presented their findings in various technical sessions.



#### ● **National Science Day (Mar 1, 2021)**

National Science Day celebration was held in the Institute in which Dr. G. R. Chandak, Chief Scientist & Group Leader, CSIR-CCMB, Hyderabad delivered the lecture "A Journey from simple to complex genetic disorders: The Silver Jubilee". Dr. Sridevi Annapurna Singh, Director, CSIR-CFTRI, presided.



## 8. MoU(s) Signed

Twenty four MoU(s) were signed with twenty seven organisations as listed below.

- Central Silk Board - Central Sericultural Research and Training Institute (CSB-CSRTI), Mysuru
- Central Silk Board - Central Silk Technological Research Institute (CSB-CSTRI), Bengaluru
- Clevergene Biocorp Pvt. Ltd., Bengaluru
- Denovo BioLabs Pvt. Ltd., Bengaluru
- Department of Women & Child Development and Mission Shakti, Govt. of Odisha
- Directorate of Agri & Food Production, Govt. of Odisha, Bhubaneswar
- Nabakrushna Choudhury Centre for Development Studies & WASSAN, Bhubaneswar
- Econut Coconut Producer Company Ltd., Mysuru
- Grassroots Research and Advocacy Movement (GRAAM), Mysuru
- Indian Association for the Cultivation of Science (IACS), Kolkata
- Indian Institute of Technology (IIT), Guwahati
- Indian Institute of Technology (IIT), Tirupati
- Institute of Bioresources and Sustainable Development (IBSD), Imphal, Manipur
- Institute of Chemical Technology, ICT, Mumbai
- JSS Science & Technology Univ., Mysuru



- JSS Academy of Higher Education & Research, Mysuru
- Karnataka Science and Technology Academy (KSTA), Bengaluru
- Kerry Ingredients India Pvt. Ltd., Bangalore
- Marico Ltd., Mumbai
- Saredh Superfoods Pvt Ltd., Bengaluru
- Schevaran Laboratories Pvt Ltd., Mysuru
- Shivaji University, Kholapur
- Shreedhareeyam Farmherbs India Private Limited, Kerala
- St. John's Research Institute, Bengaluru
- University of Agricultural Sciences, Raichur
- Azooka Pvt Ltd., Bengaluru
- Xavier Institute of Management & Entrepreneurship (XIME), Bangalore



Signing of MoU between CSIR-CFTRI and CSB - CSRTI, Mysuru



Signing of MoU between CSIR-CFTRI and Kerry Ingredients India Pvt. Ltd., Bangalore

## 9. Awards and Recognitions

### Ph.D. Degree awarded

#### a) *University of Mysore*

Name of the Student	Title of the Thesis	Guide
• Hemalatha N	Lutein and its metabolites in the modulation of hyperglycemia induced mitochondrial dysfunction in the retinal pigment epithelium	Dr. Baskaran V
• Kalai Selvi	Tea catechins and preparation of their mineral complexes useful as micronutrient supplements	Dr. Nagarajan S
• Kalpana Devi	Extraction, enrichment and quality assessment of albumins and globulins from rice bran	Dr. Subramanian R
• Mallikarjuna BG	Insights into the mode of action of obestatin: The role of PPAR $\gamma$	Dr. Uma V Manjappara





Name of the Student	Title of the Thesis	Guide
● Mallikarjuna SE	Dietary components against chemoresistance and chemotoxicity: Role of galectin -3 / survivin interplay in <i>in vitro</i> and <i>in vivo</i> models	Dr. Shylaja M Dharmesh
● Rateesh Krishnan	Influence of processing technologies on mineral composition of pearl millet and development of iron enriched beverage	Dr. Meera MS
● Sadashivaiah	Studies on the effect of long-chain omega-3 fatty acids and oleic acid on dyslipidemia induced retinal complications in experimental animals	Dr. Ramaprasad TR
● Sandanamudi Anudeep	Moringa oleifera seed soluble fiber: It's prebiotic and hypocholesterolemic implications	Dr. Radha C
● Swapna Sonale R	Characterization of bioactive compounds from neem ( <i>Azadirachta indica A Juss</i> ) obtained by supercritical fluid carbon dioxide process	Dr. Ramalakshmi K

**b) AcSIR**

Name of the Student	Title of the Thesis	Guide
● Achintya Kumar Dolui	Profiling and functional characterization of rice bran lipases	Dr. Vijayaraj P
● Amarjeet Kumar	Extension of shelf life of fresh mango and tomato fruits with special reference to control anthracnose disease by using plant based volatile bioactive molecule(s)	Dr. Kudachikar VB
● Aruna P	Fractionation of pomegranate seeds for oil and its utilization in the development of value added products	Dr. RP Singh
● Chinmayee CV	Microbial milk clotting enzymes: Specificity, structure and food applications	Dr. Sridevi A Singh



Name of the Student	Title of the Thesis	Guide
• Debashree Chanda	Development of amadori and heyns compounds as angiotensin converting enzyme (ACE) inhibitors	Dr. Nanisankar VH
• Hrishikesh A	Ionic liquid-based aqueous biphasic extraction for purification of phycocyanin	Dr. KSMS Raghavarao
• Lohith K	Biotherapeutic propensity of probiotic yeasts on candidiasis	Dr. Anu Appaiah KA
• Naveen Kumar JK	Ferritin enriched wheat based food products and their iron bioavailability efficacy	Dr. Prabhasankar P
• Nida Ume Salma	Studies on the efficacy of flax seed protein in the prevention of alcohol induced hepatic damage	Dr. Jyothilakshmi A
• Prakruthi Appaiah	Designing, expression and characterization of large neutral amino acid rich protein for possible application in phenylketonuria	Dr. Prasanna Vasu
• Rahul G	Understanding the mechanism of Polyunsaturated Fatty Acid (PUFA) accumulation in chia ( <i>Salvia hispanica</i> ) seeds	Dr. Ajay W Tumaney
• Saritha G Pandit	Evaluation of red pigment from <i>Talaromyces purpureogenus</i> CFRM02 against alcohol-induced liver disease (ALD) and its toxicology	Dr. Mohan Dhale
• Sijil P V	Accumulation of omega-3 fatty acid rich lipid in indigenous freshwater microalgae and biochemical mechanisms involved	Dr. Chauhan VS
• Smitha Padmanabha	Studies on the modulatory effects of lutein and unsaturated fatty acids on experimentally induced cataract in rats	Dr. Baskaran V
• Sushma U	Studies on the detection of melamine in food samples	Dr. Alok K Srivastava
• Varun Kumar	Identification of potential peptide/s from pigeon pea by-product inhibiting 3-hydroxy-3-Iglutaryl coenzyme a reductase enzyme	Dr. Purnima Kaul Tiku





Name of the Student	Title of the Thesis	Guide
• Vedashree M	Gingerols and their derivatives for food applications: A technological perspective	Dr. Madhava Naidu M
• Vidya CH	Characterization of galactosidases from fungal sources and their applications in preparation of specialty foods	Dr. Sridevi A Singh
• Vinayak Uppin	Omega-3 fatty acids and zerumbone in modulation of dyslipidemia induced brain inflammation and cognitive impairment	Dr. Ramaprasad TR
• Yoya Luithui	Processing of Job's tear ( <i>Coix lachryma-jobi</i> L.) for the development of food ingredients	Dr. Meera MS

**c) CSIR-CFTRI Annual Awards 2019-20**

• **Best Research Publication Award for Basic Sciences**

Pramod Kumar P., Harish Prashanth K.V., Low molecular weight chitosan (~20 kDa) protects acrylamide induced oxidative stress in *D. melanogaster* by restoring dopamine and KIF5B levels, *Carbohydrate Polymers*, 2019, 222, 115005

• **Best Publication Award for Applied Research**

Sijil P.V., Adki V.R., Sarada R., Chauhan V.S., Strategies for enhancement of alpha-linolenic acid rich lipids in *Desmodium* sp. without compromising the biomass production, *Bioresource Technol.*, 2019, 294, 122215

• **Best Student Award - M.Sc. (Food Technology)**

Ms. Aarthi A.R.

• **Best Student Award - ISMT**

Mr. Mohamed Umair Muhammadh Imran

• **Best Technology Transfer Award**

**Dr. Suresh D. Sakhare** & Team, Flour Milling, Baking & Confectionery Technology Dept., Process for online fortification of Atta (whole wheat flour)/ refined wheat flour (maida)

• **Individual Award for Maximum ECF generation**

Dr. Pushpa S. Murthy, Spices & Flavour Sciences Dept.



**d) Individual Awards**

Award Title	Instituted by	Awardee
• Fellow	Royal Society of Biology	Dr. Halami PM
• Emerging Scientist Award	VDgood Professional Association, Tamil Nadu	Mr. Ramesh G
• Senior Scientist	Microbiologist Society of India	Dr. Halami PM

**e) Recognitions by Academies**

Recognition	Instituted by	Awardee
• MRSB	Royal Society-London	Dr. Rajagopal K
• Subhash Bhatnagar Memorial Award - 2019	AFST(I), Mysore	Mr. Chetana R
• Life Time Achievement Award	The Society of Tropical Agriculture, 11th ICAHPS 2020, New Delhi, India	Dr. Prabhasankar P
• Young Scientist Award	The Society of Tropical Agriculture, 11 <sup>th</sup> ICAHPS 2020, New Delhi, India	Dr. Aashitosh A Inamdar



Dr. Chetana R, Senior Technical Officer, Traditional Food & Sensory Science Dept., receiving the Subhash Bhatnagar Memorial Award – 2019 instituted by AFST(I), Mysore



## f) Other Recognitions

Awardee	Member / Panel Expert & Host Institution
<ul style="list-style-type: none"> <li>Dr. Sridevi Annapurna Singh</li> </ul>	Chairperson, Task Force for BIS Committee on Drinking Water and Carbonated Beverages Sectional Committee, FAD14; Member, Committee to examine the issue of Diary Analogies of Ministry of Health & Family Welfare (Food Regulation Section), Govt. of India
<ul style="list-style-type: none"> <li>Dr. Umesh Hebbar H</li> </ul>	Member, Advisory Committee, ICT, Mumbai for UGC funded project under CAS-II Project; Member, National Level Committee formed by MoFPI under Pradhan Mantri Kisan Sampada Yojana to provide inputs on cost estimation for setting up of fruits and vegetable processing plants; Member, Food and Agriculture Division Council (FADC), BIS; Member, BoS in Food Science and Technology, University of Mysore; Member, BoS in Food Technology, JNTU, Ananthapur (AP); Member, BoS in Food Technology, Kongu Engineering College, Erode (TN); BoS in Food Technology, Bannari Amman Institute of Technology, Sathyamangala (TN)
<ul style="list-style-type: none"> <li>Dr. Madhava Naidu M</li> </ul>	Member, Turmeric Task Force Committee 2020, Spice Board; Head of ISO delegates (India); Research Committee Member, Coffee Board, Govt. of India; Member, Chilli Task Force Committee; Regional Advisory Group Member, ICAR, KVK, Hardanahalli
<ul style="list-style-type: none"> <li>Dr. Negi PS</li> </ul>	Convener, Fruits, Vegetables and Allied Products Sectional Committee (FAD 10 / Panel IV) of BIS; Expert Member, Technical Advisory Committee (TAC) of Technology Development and Utilization Programme for Women (TDUPW), DSIR; Member, Scientific Panel for Fruits and Vegetables and their Products (including dried fruits and nuts), FSSAI; Expert Committee Member, MoFPI to review curriculum and course content under the capacity building component of PMFME scheme; Expert Member, Fruits and Vegetables Processing Appraisal Committee of MoFPI to review the proposals received from States / UTs for Common Incubation Centre establishment under PMFME scheme



Awardee	Member / Panel Expert & Host Institution
<ul style="list-style-type: none"> <li>Dr. Alok K Srivastava</li> </ul>	<p>Chairman, BIS - Food and Agri. Sectional Committee (FAD 28) on “Test Methods for Food Products”; Member, Scientific Panel of FSSAI on “Method of Sampling and Analysis”; Member, Scientific Panel of FSSAI on “Cereals, Pulses &amp; Legumes and their products (including Bakery); Member, FSSAI Working Group on Front of Panel Labelling; Member, FSSAI Working Group on Methods for ingredients and products under Nutraceutical regulations; Nodal Coordinator, Network of Scientific Collaboration on Food Safety &amp; Applied Nutrition (NetSCoFAN) of FSSAI for “Foods of Plant Origin” group</p>
<ul style="list-style-type: none"> <li>Dr. Asha Martin</li> </ul>	<p>Member, Scientific Panel on Sweets, confectionery, sweeteners, sugar and honey (FSSAI); Principal Member, Technical committee on “Food Biotechnology” Sectional Committee (FAD 23) of the Food and Agriculture Division, BIS; Member, BoS in Food Sciences and Nutrition, University of Mysore; Expert Member, Project Review and Steering Group (PRSG), Ministry of Electronics &amp; Information Technology</p>
<ul style="list-style-type: none"> <li>Dr. Devendra Haware</li> </ul>	<p>Member, BIS FAD 6 on Stimulant foods</p>
<ul style="list-style-type: none"> <li>Dr. Prasanna Vasu</li> </ul>	<p>Alternative Member, Chemical Hazards Sectional Committee of Chemical Science Division of Bureau of India Standards; Member, Sectional committee, Test methods for food products (FAD 28) of the Food and Agriculture Division, BIS; Member, Sectional committee, Alcoholic Drinks (FAD 29) of the Food and Agriculture Division, BIS</p>
<ul style="list-style-type: none"> <li>Mrs. Vanajakshi</li> </ul>	<p>Alternative Member, Technical Committee of BIS - FAD 14 Drinking water and carbonated beverages</p>
<ul style="list-style-type: none"> <li>Dr. Gothwal PP</li> </ul>	<p>Technical Member, State Level Empowered Committee for appraisal of Food Processing Industry, Govt. of UP; Expert to establish Incubation Centre at Department of Food Science &amp; Technology, GB Pant University of Agriculture &amp; Technology, Pantnagar (Uttarakhand) under PMFME scheme</p>



Awardee	Member / Panel Expert & Host Institution
<ul style="list-style-type: none"> <li>Dr. Madan Kumar P</li> </ul>	Advisory Committee Member and Examiner for Diploma course in Food Safety Management, Sri Sankara Arts and Science College, Kanchipuram (TN)
<ul style="list-style-type: none"> <li>Dr. Usharani D</li> </ul>	Member, NetSCoFAN expert from Foods of Plant origin and part of Scientific Panel on Oils and Fats; Principal Member, Chemical Hazards Sectional Committee of Chemical Science Division, BIS
<ul style="list-style-type: none"> <li>Dr. Muthukumar SP</li> </ul>	Member, FAD 3, Apiary Industry Committee, BIS; Member, BoS in Biomedical Sciences, JSS Academy for Higher Education & Research (JSS AHER); Nominee, Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA), Govt. of India; Member, Institutional Biosafety Committee, JSS Academy for Higher Education & Research (JSS AHER), Mysuru
<ul style="list-style-type: none"> <li>Dr. Syed Musthapa M</li> </ul>	Panel Expert, Research Advisory Board (RAB), JSS Medical College, JSS AHER, Mysore; Member, Board of Studies in Biological Sciences, Periyar University (TN)
<ul style="list-style-type: none"> <li>Dr. Harish Prashanth KV</li> </ul>	Member, Research Advisory Committee (RAC), Adichunchangiri University, Karnataka; Research Advisory Member, MIMS, Mandya under the Department of Health Research and Family Welfare, Govt. of India and Department of Medical Education, Govt. of Karnataka; Member, BoS in Food Science and Nutrition (PG), YCM, University of Mysuru; Member, Board of Examination, Department of Food Technology, Davangere University, Davangere
<ul style="list-style-type: none"> <li>Dr. Rastogi NK</li> <li>Dr. Sarada R</li> <li>Dr. Negi PS</li> </ul>	Listed in the top 2% researchers in the world as per the Stanford University (USA) database in 2020





### g) Best Research Papers / Posters Awards

**International Virtual Conference on Emerging Trends in Food Protectants and Infestation Control [ET- FPIC 2021] by Pesticide Science Study Group (PSSG) & Food Protectants and Infestation Control Department, CSIR-CFTRI, Mysuru. Feb 24-25, 2021**

- Ishrat Jahan, Rohith H.S., Vivek Babu C.S., Halami P.M., Molecular interaction of cry protein toxic to stored grain pest
- Jameema Sidhic, Vivek Babu C.S., Halami P.M., ITS marker based genomic mining of *Aspergillus* spp. in perspective of stored grain management
- Urvashi Sahu, Pratiksha Prabhakar Gawali, Ezhil Vendan S., Fumigant toxicity of selected phytochemicals against *Callosobruchus maculatus* adults and investigation of phytochemical residue removal process on the fumigated pulses
- Pooja V. Reddy, Archana V. Remesh, Bincy K., Vivek Babu C.S., Investigation of diversity and dominance of fungal biota in stored grains and oil seeds and their control by aromatic essential oils
- Archana V. Remesh, Bincy K., Vivek Babu C.S., Biorationals for control and management of stored grain insects
- Kriti Gopal R.V., Sumithra Devi S., Potential of *Ocimum tenuiflorum* essential oil and its major constituent Eugenol as biofumigant in stored grain insect pests management

- Priyadarshini V., Sumithra Devi S., Ezil Vendan S., Decontamination of chlorpyrifos residue on fresh vegetables by selected botanicals based aqueous solutions
- Manjunatha Prabhu B.H., A case study: Analysis of ultrasonics as reliable option for rodent control

### Research Papers / Poster awards in other seminars

- Ramesh Kumar Kushwah, Anthati Mastan, Vivek Babu C.S., Molecular insights on endophyte assisted biosynthesis of specialized plant metabolites, International virtual conference on Plant Specialized Metabolism and Metabolic Engineering (PSMME 2020), Lucknow, Oct 14-16, 2020
- Mahadev Latha, Ipsita Jena, Vijayaraj P., Arabidopsis seed storage protein exhibits lipase activity during germination, International virtual conference on Plant Specialized Metabolism and Metabolic Engineering (PSMME-2020), CSIR-CIMAP, Lucknow, Oct 14-16, 2020
- Sundararaman A., Sajjan Achi, Halami P.M., Genomic analysis and *in vivo* effect of probiotic *Bifidobacterium longum* NCIM 5672 for its immunomodulatory properties in arthritis induced wistar rats, 5th Biennial conference of Probiotics Association of India & International symposium on Probiotics & Immunity: Way forward to Microbial Therapy. Nov 19-20, 2020
- Samar Sayed Ibrahim, Ezhil Vendan S., Garlic volatiles based nanoemulsion as



- potential bio-fumigant for disinfestation of bruchid on stored pulses, International Conference on Emerging Trends in Biotechnology (ICETB), VIT, Vellore, Dec 14-16, 2020
- Uma Maheshwari, Physicochemical characterization and Nutraceutical properties of fixed oil from fenugreek seed fractions. International symposium on spices as flavours, fragrances & functional foods (SYMSAC X), Kozhikode, Kerala, Feb 09-12, 2021
  - Nidhi Sori, Saarik P.K., Mahejabin Khan, Pectin based prebiotics for prevention of Covid-19 infection, National Webinar on Emerging Trends in Allied Health Sciences (ETAHS-2021), Anand, Gujarat, Feb 13, 2021
  - Janhavi P., Ravindra P.V., Muthukumar S.P., Studies on the sour mangosteen (*Garcinia xanthochymus*) bioactives and their modulatory effects in diet induced hyperglycaemic mice model, 4th AMIFOST, Amity Institute of Food Technology, Amity University Uttar Pradesh and Nutrition Society of India, Noida, Uttar Pradesh, Dec 21, 2020
- h) Editors / Editor-in-Chief / Co-Editor / Executive Editor / Associate Editors of reputed journals**
- mBio, American Society for Microbiology (Rajagopal K)
  - International Journal of Fermented Foods, SASNET (Rajagopal K)
  - Protein Journal, Springer (Rajagopal K)
  - International Journal of Peptide Research & Therapeutics, Springer (Rajagopal K)
  - Journal of Food Process Engineering, John Wiley, USA (Navin K Rastogi)
  - International Journal Membrane Sci. Technol., Cosmos (Navin K Rastogi)
  - Journal of Food Measurement and Characterization, Springer (Prabhasankar P)
  - Indian Food Industry, AFST(I), Mysore (Negi PS)
  - BMC Complementary Medicine and Therapies, BMC, Part of Springer Nature, New York, USA (Negi PS)
  - International Journal of Genuine Traditional Medicine, Association of Humanitas Medicine, Seoul, Republic of Korea (Negi PS)
  - Frontiers in Paediatrics, Frontiers (Kunal Sharan)
- i) Editorial and Advisory Boards**
- The Indian Journal of Nutrition and Dietetics, Avinashilingam Univ., Coimbatore (Sridevi A Singh)
  - Frontiers in Microbiology, Frontiers (Rajagopal K)
  - Frontiers in Microbiology, Frontiers (Rajagopal K)
  - Frontiers in Cellular & Infection Biology, Frontiers (Rajagopal K)
  - 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)
- Frontiers in Endocrinology, Frontiers (Kunal Sharan)
- Frontiers in Oncology, Frontiers (Gopinath M)
- EC Nutrition, Ecronicon (Sudheer Kumar Y)
- Blue Biotechnology, Nova Publishers, USA (Prabhasankar P)
- International Journal of Immunology (Prabhasankar P)
- Journal of Food Science and Technology, Springer (Aashitosh A Inamdar)
- International Journal of Food Science and Nutrition Engineering, Scientific & Academic Publishing Co. Rosemead, CA, 91731, USA (Matche RS)
- International Journal of Agriculture Food Science & Technology (IJAFST), Research India Publications, Delhi (Matche RS)
- International Journal of Knowledge Management and Information Technology (IJKMIT), Research India Publications, Delhi (Matche RS)
- Indian Journal of Nutrition, Open Science Publications, Hyderabad (Matche RS)
- Journal of Food Science, IFT, Chicago, USA (Negi PS)
- Signpost Open Access Journal of Organic and Biomolecular Chemistry, Research Signpost, Thiruvananthapuram, India (Negi PS)

- Research & Reviews: Journal of Food Science and Technology, STM Journals (Harish Prashanth KV)
- Frontiers in Nutrition, Frontiers Media, Switzerland (Muthukumar SP)
- Frontiers in Sustainable Food Systems, Frontiers Media, Switzerland (Muthukumar SP)
- Journal of Laboratory Animal Science, Laboratory Animal Scientists' Association, India (Muthukumar SP)
- Non-coding RNA research, KeAi (Syed Musthapa M)

## 10. Participation in Exhibitions

- **Workshop cum training programme on Value addition to Fruits, Vegetables and Spices, Jan 4-8, 2021:** Organised by CSIR-CFTRI, sponsored by APEDA, Imphal
- **Workshop cum training programme on Value addition to fruits, vegetables and spices processing, Feb 15-19, 2021:** Organised by CSIR-CFTRI, sponsored by APEDA, Guwahati
- **Food Expo-2021, Feb 26-27, 2021:** Organised by MSME Kanpur, Dept. of Horticulture and Food Processing, Govt of UP, Bundelkhand Chamber of Commerce, Jhansi and ICAR-RLB, Central Uni. Jhansi held at Chamber of Commerce Bhawan, Jhansi
- **Regional Agri Fair, Mar 8-10, 2021:** Organised by Central Agricultural University, Imphal



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

- **EDP cum Skill Development Program on Food Processing for the prospective women entrepreneurs** (March 7-8, 2021)

Forty women entrepreneurs from various SHGs working in Uttar Pradesh under Women's Empowerment Program of NABARD participated.

- **EDP cum Skill Development Program on Food Processing** (Mar 18, 2021)

EDP cum Skill Development Program on Food Processing for the thirty five prospective participants under NAHEP-Centre for Advanced Agriculture Science & Technology project funded by ICAR at CSA University of Agriculture and Technology, Kanpur.

### 12. Support Department Activities

- IRINS - a web based Research Information Management (RIM) was launched through the implementing agency INFLIBNET. The database has about 140 profiles of S&T staff from the Institute. The library also provides access to around 4183 e-journals through CSIR consortium and the usage of e-journals is over a lakh.
- A web-enabled application was launched by mapping CSIR-CFTRI technologies against One District One Product (ODOP) under PMFME Scheme.

*Societal*

*Programmes*





## Outreach Activities

### I. Establishment of CSIR-CFTRI COVID-19 testing centre

Aligning with the CSIR's efforts to step up testing of COVID-19, CSIR-CFTRI established a Testing Centre at the premises of Govt. Ayurvedic HighTech Panchakarma Hospital, Mysuru. The centre was inaugurated on Aug 10, 2020 by DG-CSIR, Dr. Shekhar C Mande and District Commissioner Shri. Abhiram G Sankar, IAS and Shri. L. Nagendra, MLA, Chamaraja Constituency, Mysuru in the presence of Director, CSIR-CFTRI. The centre was tested 1,75,508 samples as on Mar 31, 2021.



### II. Sero surveillance for COVID-19

Serological study was conducted in the Institute (Sep 15-16, 2020) under a project initiated by CSIR-IGIB, titled "Phenome India- A long-term longitudinal observational cohort study of health outcomes". With the rise in COVID-19 across country, CSIR-IGIB initiated this study to identify various risk prediction tools for several major diseases including COVID-19. The primary objectives of this study was to develop accurate diagnostic and prognostic tools using

various digital biomarkers, prior conditions such as cardiometabolic disorders and their effect on COVID-19 frequency, in which the COVID-19 burden will be ascertained using serology-based assay.



### III. Covid-19 outreach efforts

CSIR-CFTRI launched a series of outreach efforts to mitigate Corona Virus pandemic in the country. These include, augmenting the Covid Testing at Mysore Medical College (MMC &RI) and Mandya Institute of Medical Sciences (MIMS), hand sanitizers to front-line Covid warriors including hospital staff and RTE food supplements to the migrant population stuck in major cities due to lockdown. The Institute networked with large number of organisations including government departments, Industries and NGOs across the country in playing a major role in the Covid management efforts.

#### a) Augmenting the testing services at MMCRI & MIMS

The Institute provided two RT-PCR and one automated RNA extraction units to scale the Covid testing facility established in Mysore Medical College & Research Institute (MMC & RI) in the first week of April, when the Covid



infections were on the rise in Mysore. Further, the centre was then testing the samples collected from neighbouring districts also. With this intervention, the Testing lab could increase the capacity. The Institute also provided a Refrigerated Centrifuge unit to Mandya Institute of Medical Sciences (MIMS) to start Covid testing facility in the month of June 2020.



#### **b) Hand sanitizers**

The Institute prepared hand sanitizers as per WHO specifications and distributed to local Administration, Holdsworth Memorial Hospital, Mysore and State transport services.



#### **c) Herbal sanitizers**

Herbal sanitizers of around 500 litres was prepared and distributed to Covid warriors.

#### **d) Supply of cardamom flavoured water to Covid-19 health warriors**

In response to Covid-19 pandemic situation, CSIR-CFTRI decided to supply immunity boosters to Covid-19 health warriors.

Accordingly, 47,000 bottles (500 ml each) of cardamom flavoured water as immunity booster was distributed.



#### **e) RTE food supplements**

CFTRI distributed large quantity of Ready-to-Eat (RTE) food products manufactured using CFTRI's technologies in association with government departments and NGOs during the lockdown period. The beneficiaries included migrant labourers, Covid warriors, State police force across cities such as Delhi, Bangalore, Mandya and Mysore. Almost 40 tonnes of food





products were supplied which included High Protein Biscuits (11 tonnes), High Protein Rusks (6 tonnes), Fortified Mango & Fruit bars (6 tonnes), Spirulina chikki (1.75 tonnes) and Flavoured water (15 tonnes). The food was manufactured by CFTRI licensees as per the Institute's specifications and supply chain logic was provided by Government agencies such as Income Tax Department (Bengaluru), Indian Society of Agriculture Professionals (ISAP), New Delhi, Zila Panchayat (Mysore & Mandya) etc.

#### **f) Fumigation services**

Phosphine fumigation is the prominent technique used to manage stored product insect pests worldwide. Accordingly, CFTRI team carried out fumigation of stored grains at JSS Technical Institution campus and JSS women college in Mysore.

### **IV. Ready-to-eat food during Amphan cyclone**

CSIR-CFTRI despatched ready-to-eat, instant food mixes, easy cooking and bakery products for distribution to Amphan Cyclone victims. Dr. Raghavarao KSMS, Director, CSIR-CFTRI said, "We are more than happy to help, but pray that such instances are rare and far apart in time," indicating how the back-to-back calamities affect people's lives. The Institute despatched a total of 39 tonnes of food products to Kolkata such as ready-to-eat vegetable pulav and sambar rice (14 tonnes), instant poha (5 tonnes) and high protein biscuits (15 tonnes). The Nestle India Ltd., Nanjangud also contributed maggi noodles (5 tonnes) under its Corporate Social Responsibility programme. CFTRI licensees

manufactured products viz Instant meals, RTE meals and biscuits for distribution. The food products were delivered at the Office of the Principal Secretary, Govt. of West Bengal.

### **Skill Development Programmes**

#### **1) Capacity Building Training Programs on Food Processing for SC-ST aspiring / budding and existing Entrepreneurs Under the aegis of National SC-ST Hub Ministry of MSME, Govt. of India (Jan - Mar, 2021)**

Inauguration of Capacity Building on Food Processing for aspiring and existing Entrepreneurs (SC-ST) under NSSH, Ministry of MSME was held on January 18, 2021. Mrs. A. Kokila, Head, National SC-ST Hub, Regional Office, Bengaluru inaugurated and Dr. Sridevi Annapurna Singh, Director, CSIR-CFTRI presided the inaugural function.

Training programme were conducted under the aegis of National SC-ST Hub, New Delhi for the second successive year (2020-21) covering 5 key areas of food processing. One of the key focus of this programme was capacity building of SC/ST entrepreneurs in the area of Food Processing This training program was for aspiring / budding and existing SC-ST entrepreneurs to build their capacity on







entrepreneurship and technical skills in the area of food processing. Details of the training programmes are given below:

- Nutri-Cereal Process & Products Technology
- Traditional Sugar Confectionery and Concept of Sensory Science for product development
- Entrepreneurship development program on Processing Spices, Coffee and Tea
- Wheat Milling and Baking Technology
- Fruit and Vegetable Technologies for value addition

A total of 88 candidates attended the training programme.

## **II) Farmer's Training Program under PMFME Scheme, Sponsored by Dept. of Agriculture, Government of Karnataka & KAPPEC (Dec 2020 - Mar 2021)**

Farmer's Training on Food Processing under 'PMFME' (PM Formalisation of Micro food processing Enterprises) Scheme in association with Dept. of Agriculture, Govt. of Karnataka was launched on January 19, 2021 by Sri. B.C. Patil, Hon'ble Minister of Agriculture, Govt. of Karnataka. Shri B. Sivaraju, MD, KAPPEC, Govt. of Karnataka explained in brief about the scheme. Dr. P. Chandra Shekara, DG-MANAGE, Hyderabad and Shri S.I. Chikkanagoudra,



Chairman, KAPPEC, Govt. of Karnataka were present. Dr. Sridevi Annapurna Singh, Director, CSIR-CFTRI presided.

Ministry of Food Processing Industry (MoFPI) has launched the Pradhan Mantri Formalization of Micro food processing Enterprises (PMFME) scheme under the Aatmanirbhar Bharat Abhiyan with the aim to enhance the competitiveness of existing individual micro-enterprises in the unorganized segment of the food processing industry and promote formalization of the sector. The scheme to be implemented over a period of five years during 2020-25 with a total outlay of Rs. 10,000 crore. The scheme has a special focus on supporting groups engaged in agri-food processing such as Farmer Producer Organizations (FPOs), Self Help Groups (SHGs) and Producers Cooperatives along their entire value chain. The objectives of scheme are to build capability of microenterprises to enable: i) Increased access to credit by existing micro food processing entrepreneurs, FPOs, Self Help Groups and Co-operatives; ii) Integration with organized supply chain by strengthening branding & marketing; iii) Support for transition of existing 2,00,000 enterprises into formal framework; iv) Increased access to common services like common processing facility, laboratories, storage, packaging, marketing and incubation services; v) Strengthening of Institutions, research and training in the food processing sector; and vi) Increased access for the enterprises, to professional and technical support. The scheme adopts One District One Product (ODOP) approach to reap the benefit of scale in terms of procurement of inputs, availing common services and marketing of products. ODOP for the scheme will provide the



framework for value chain development and alignment of support infrastructure. As State Technical Institute for Karnataka, CSIR-CFTRI is supporting State Nodal Agency in implementing the scheme in the state. Through a number of training programmes to Master Trainers, District Level Trainers, District Resource Persons, Farmers, SHGs, Individual Entrepreneurs, contributing immensely towards skill development and knowledge sharing. Technological support will also be provided to entrepreneurs who wish to adopt CSIR-CFTRI technologies under the scheme. CSIR-CFTRI is also setting up Common Incubation Center, based on ODOP to support to entrepreneurs and startups.

Under this scheme, training programmes were conducted aligning with One District One Product (ODOP). A total of 321 Farmers/FPO entrepreneurs across the state were trained on the following topics.

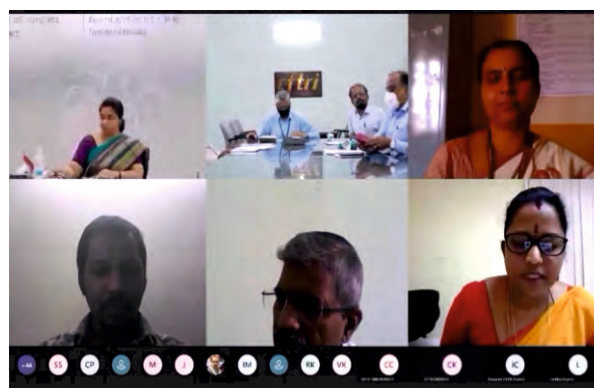
- Fruits and Vegetables Processing
- Plantation Products
- Bakery Products & Confectionery
- Millet Processing
- Processing of Millets & Pulses
- Processing of Meat & Marine Products
- Processing of Oil seeds



### III) Technology Entrepreneurship Development Programme (TEDP) on Innovation & Entrepreneurship (Feb 25 - Mar 30, 2021)

Technology based Entrepreneurship Development Programme (TEDP), "Innovation and Entrepreneurship" sponsored by Department of Science and Technology (DST) was held on virtual platform. Ms. C.N. Meena Nagaraj, IAS, Director IT&BT and MD, KITS, Govt. of Karnataka inaugurated the programme. Dr. Bharathi S. Meti, HoD Dept. of Biotechnology, BEC Executive director (BEC STEP), Bagalkot as DST observer made her remarks.

There were 30 entrepreneurial aspirants across India covering about 15 States/UTs. The topics included the opportunities in food processing sector, novel food technologies, regulatory issues, entrepreneurship etc. in addition to the overview of indigenous technologies available / developed by CSIR-CFTRI. Along with in-house faculty, experts from academia and industry, startups leaders delivered lectures. A total of 38 internal and 40 external faculties shared their expertise, insights and motivational tips for the benefit of the participants.







#### **IV) Hands-on training programme on Processing of fruits, vegetables and spices for value additions in North Eastern India (Jan 4-8, 2021, Feb 16-20, 2021)**

Two training programmes of each 5 day duration were conducted at Imphal and Guwahati. The programmes was sponsored by the Agricultural and processed food products export development authority (APEDA), Govt. of India.

Training modules included in hand-on-training to the participants with the locally available seasonal fruits and vegetables and also the underutilized fruits. In each programme, the participants were 50 each in number from different districts of respective states - Manipur and Assam. Most of the participants are having experience in food processing and some of them having their own units and their products



are in local markets. The team consisting of four scientists from CSIR-CFTRI, Mysuru and a few resource persons conducted theory classes and demonstrate the following value added products: Candies: papaya, ginger, wild apple, plum; pickles: mixed vegetable, king chilli, turmeric etc.; Jam and preserve. Squash and Ready-to-Serve (RTS) beverages (orange, pineapple, underutilized fruits); Ginger paste, Garlic paste, Chilli sauce, Turmeric powder, many more.

The participants were also made aware of Machineries & equipment required for production of above processed products, Food safety and food laws & regulations, Food packaging requirements, Requirements for setting up of food processing industries, MSME schemes, APEDA schemes and many more.

#### **V) Training to women SHGs (Jan 18-23, 2021)**

Helping women self-help-group with suitable CSIR-CFTRI technologies, and providing them all the necessary scientific and technical input will definitely improve the socio-economic status of the rural people. CSIR-CFTRI signed a MOU with GRAAM, a well known local NGO, so that the identified technologies may be transferred free of cost. Accordingly, two technologies, malted ragi based weaning food, and a convenience flour mix suitable for stiff porridge (mudde, a traditional yet popular food), were identified. A SHG group (14 members) near to Mysore identified by the GRAAM, was trained for a week for two different technologies. The SHG is in progress to purchase the machineries for setting up the plant. CSIR-CFTRI team visited the proposed building for



setting up the plant. CSIR-CFTRI is also providing the technical specifications for procurement of the machineries.



#### **VI) Farmer Centric Activities (Mar 29, 2021)**

One day farmer's centric training programme on Food Processing was conducted for Women Entrepreneurs from Inner Wheel Club of Mysuru AISIRI, Mysuru. 25 ladies participants attended the training programme.



#### **VII) Summer Research Training Programme (SRTP) (Aug 1-31, 2020)**

CSIR - Summer Research Training Programme (SRTP) was conducted in the virtual mode. A total of 216 students were enrolled along with faculties affiliated to UGC / AICTE / Universities etc. The programme included assignments from the identified mentors, lectures by CFTRI scientists and eminent scholars of the country. E-certificates were issued to the successful candidates.

#### **VIII) Incubation Centre Activities**

##### **I) Food Business Accelerator at CFTRI**

CSIR-CFTRI inaugurated a "Food Business Accelerator" on August 31, 2020 to augment its startup Innovation System in the Campus. While speaking on the occasion, Director, CSIR-CFTRI commented that the centre would be a boon to budding entrepreneurs and startups who have the Proof-of-Concept ready. He also opined that Prime Minister-Formalisation of Micro Enterprise (PMFME) Scheme launched under 'Aatma Nirbhar Bharat' would help more microenterprises enter into the food processing scenario.





The Centre will provide opportunities for prospective entrepreneurs and startups to be part of the Accelerator Facility for a short period. These companies can explore the avenues for product development, Scale-up operations, packaging and shelf-life studies for commercialising their products. Expert mentoring sessions also will be available for sharpening the technical and business skills in fulfilling the tasks effortlessly. The Centre supports a total of 8 suites covering over 2000 sq. ft.

**ii) NPIC-CIF**

M/s Dhriti Biosolutions, Mysuru, one of the NPIC Incubatee, won award under the category of alternative to multi-use plastic bags in the event, 'Textile Grand challenge 2019' organized by Ministry of Textiles, Govt. of India. The award session was chaired by Hon'ble Union Minister, Ms. Smiritilrani. M/s Magnimous Infotech Pvt Ltd., Bangalore won the Millennium Alliance 2020 award in the category of Covid 19 Innovation challenges. Further, two new Startups have joined the Incubation center while two of the companies have successfully exited.

**JIGYASA**

As part of the JIGYASA activities, following webinars were coordinated / arranged:

- Food processing: Current status and future directions, Jun 22, 2020 by Dr. KSMS Raghavarao, Director, CSIR-CFTRI
- Science behind what we eat, Aug 20, 2020 by Dr. Sridevi Annapurna Singh
- Half a day webinar on Chemistry for high school students and teachers was conducted in association with Agastya Foundation
- In coordination with Jawahar Navodaya Vidyalaya, Mysore CSIR-CFTRI participated for launching of Vigyan Jyothi programme, Dr. Sridevi Annapurna Singh, Director, CSIR-CFTRI spoke on women achievers in Science & Technology as a Chief Guest during inauguration on Mar 24, 2021

# *Progress Under R & D Projects*





## ENGINEERING SCIENCES

### Continuous jowar roti making machine

(Ramesh G)

Prototypes of hand operated and fully automated jowar roti machine were developed with a partnering industry. Trials on prototype model were conducted to evaluate the functioning of the units.



Continuous Jowar Roti Machine (Automated)



Jowar Roti Machine (Hand Operated )

### Nano-filtration membrane for the processing of vegetable oils (Rastogi NK)

Installation and trial runs of the pilot model unit were completed. Shortcomings noticed during trial runs were rectified and the unit was suitably modified to meet performance criteria. Work has been initiated for the pre-treatment of oil-hexane miscella for degumming, desolventization, membrane screening, and evaluation of membrane separation.

### Continuous rice cooking machine

(Sathyendra Rao BV)

Several trials were conducted on the continuous rice cooking prototype with raw, parboiled and steam rice of different varieties. Drawings for

the scale-up version 100 kg/h were finalised and fabrication work with an outsourced partner is in progress.

### Processing of spices, gums and juices by alternate technologies (Rastogi NK)

High pressure process (HPP) system was checked for integrity and trials with water was carried out at 400 MPa without heating. HPP trial for preserving tender coconut water was carried out for 3 batches at 500 MPa for 5 min and 3 batches at 300 MPa, 45°C for 5 min. Further, product quality evaluation & storage studies are in progress.

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

Zinc oxide (ZnO) nanoparticles synthesised using phytoextracts were incorporated into methyl cellulose (MC) biopolymer matrix to develop MC-ZnO films. The antibacterial performance of MC/ZnO films and neat MC film were tested against two food borne pathogens; *Salmonella enterica* and *Escherichia coli* by disc diffusion method. The neat MC film displays no inhibition against both inoculated bacteria, while ZnO loaded MC nanocomposite films indicate concentration-dependent antibacterial activity, i.e. nanocomposite films with higher content of ZnO (5.0 wt %) reveal increased zone of inhibition than films with low ZnO (1.0 wt%) loading. UV shielding performance of MC-ZnO bio-nanocomposite films were investigated by measuring the transmittance (%) in UV-Vis region. The neat MC film displayed high transmittance in UVA



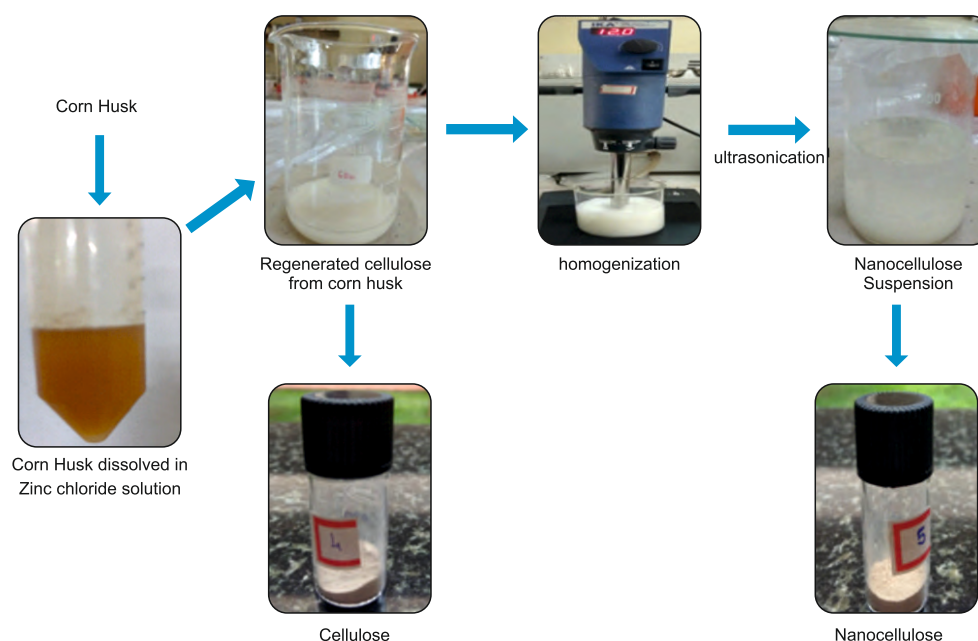


(86.3%) and UVB (80.9%) region, whereas after incorporation of phytosynthesised ZnO nanoparticles transmittance got reduced to 15.7% and 16.8% in UVA (320 nm-400 nm) and UVB (320 nm-400 nm) regions respectively. Hence these films can act as an effective active packaging material against food-borne bacteria.

### Biodegradable disposable materials and food packaging films (*Jeevan Prasad Reddy*)

Cellulose was isolated from corn husk by dissolving in zinc chloride solution and regenerating in water. Subsequently, nanocellulose was obtained from corn husk cellulose using highspeed homogenization followed by ultrasonication. Cellulose and

nanocellulose thus obtained were further characterized using Fourier-transform infrared (FT-IR) spectroscopy. A distinct peak positioned at  $1736\text{ cm}^{-1}$  in the spectrum of corn husk can be attributed to the ester linkage of the carboxylic group of ferulic and p-coumaric acids of lignin and/or hemicellulose, which was absent in the spectrum of cellulose and nanocellulose due to the removal of hemicellulose and lignin from the corn husk fibers upon dissolution in zinc chloride solution. The process for extraction of cellulose from ligno-cellulosic method is simple and cost-effective and the nanocellulose obtained has a high potential to be used as reinforcing filler for the preparation of bionanocomposite films.



Isolation of cellulose and nanocellulose

## TECHNOLOGY DEVELOPMENT

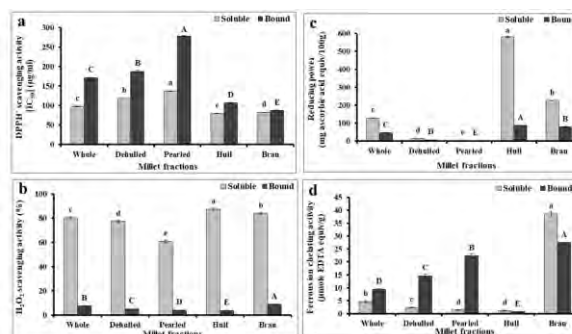
### Synbiotic beverage for healthy aging (Negi PS)

Biotics-related food products are receiving a lot of attention due to their prospective health benefits, and the demand for non-dairy probiotic beverages is on the rise as an alternative to dairy probiotics due to increased vegetarianism, absence of allergens and low cholesterol content. The experiments with fruit juices (pineapple and papaya) inoculated with probiotic strains (*L. casei*, *L. plantarum*, *L. helveticus*, and *L. rhamnosus*) in combination with prebiotics (inulin, pectin, fructooligosaccharides and xanthan gum) showed the storage stability of 2 months for pineapple and papaya juices (with 1% inulin and *L. rhamnosus*) at 4°C. These synbiotic juices showed the cell count of more than 6 log CFU/ml at the end of storage and maintained nutritional and nutraceutical properties. The pumping rate, pharynx muscle structure and worm speed in synbiotic pineapple juice supplemented nematodes were similar to standard vitamin E, but better than the control, in the nematode model of aging.

### Milled fractions of little millet (Sreerama YN)

Little millet was milled to obtain four fractions viz., dehulled grain, hull, pearled grain and bran. Bran fraction is the main reserve for protein, fat and total dietary fibre as well as iron and calcium. Dehulling and pearling processes resulted in variation in the content of linoleic, oleic and palmitic acids. However, pearling reduced the antinutrients mainly saponin, phytic acid and trypsin inhibitory activity. The phenolic compounds are predominant in hull

and bran fractions. Among the soluble fractions, sinapic and caffeic acids are the principal phenolic acids while ferulic, vanillic and p-coumaric acids were abundantly present in bound fractions. Kaempferol, quercetin and apigenin were the major flavonoids detected in all fractions of little millet. Hull and bran fractions rich in phenolics offered significant contributions towards antioxidant activity. However, pearled fraction with higher levels of daidzein was found to be the most active divalent metal chelator. These fractions of little millet can be used as functional food ingredients.



DPPH radical scavenging (a), hydrogen peroxide scavenging (b), reducing power (c) and metal chelation (d) activities of soluble and bound phenolic extracts in different milled fractions of little millet. Values in each property having the same letter [a, b, c, d, e (soluble)] or [A, B, C, D, E (bound)] are not significantly different ( $p \leq 0.05$ )

### Black gram milling industry by-products as ingredients of extruded and snack foods (Meera MS)

Black gram milling is mainly done for dehulling of the seed coat and splitting the cotyledons into two halves - dhal. This processing involves removal of husk, germ,



aleurone layer and plumule as by-products. Presently these by-product fractions are underutilized and used as animal feed only. The by-products were fractionated to obtain a protein rich fractions. The protein rich by-product was texturized by extrusion and compared with commercial soy based texturized vegetable protein (TVP). To further improve functional properties, the by-product fraction was blended with soy protein isolate or soy flour and extruded. It was observed that foaming properties improved marginally while the emulsifying capacity and stability improved considerably by 50% and above. The extruded blended product had improved protein digestibility. The study revealed that the texturized black gram by-product can be an alternate source of TVP that can be explored for the preparation of texturized products.

#### **Multipurpose flour and biscuit for phenylketonurics** (*Shruti Pandey*)

Aim of the present study was to develop flour with low phenylalanine content which can be further used to prepare chapaties, biscuits, etc. The flour was prepared using corn starch, potato starch, gelatine, carboxy methyl cellulose (CMC), in an appropriate ratio with nutrient pre-mix. Two variants of flour were prepared, without CMC (sample A) and with CMC (sample B). Moisture content of (12-13%), protein (11-12%), fat 0.016% and ash (0.26-0.41%) respectively were found in the flour samples. Phenylalanine content in flour was found to be 287.5 mg which was within the permissible limit for phenylketonurics. The flour was used to make biscuits and was studied for the physical parameters (Diameter, thickness,

weight and spread ratio), colour, textural and sensory attributes. The protein content, ash content and fat content of the biscuits ranged from 5-6%, 0.27-0.41% and 20-25% respectively. The sensory score for sample B biscuits was rated higher compared to sample A, but both were acceptable.

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

The project aims to determine the gastroprotective effect of morin-enriched extract from guava leaves in ethanol-induced rat gastritis model. The rats were pre-treated with morin enriched extract at three different concentrations (10, 50, 100 mg/kg BW) for a week before subjecting to ethanol insult (70% ethanol (3.5 ml/kg BW)). In the pre-treated groups, there was significant reduction in the oxidative stress markers compared to ethanol control group. Also, the macroscopic and microscopic examination of gastric tissues confirmed the protective effect of morin enriched extract compared to ethanol control group. Morin enriched extract from guava leaves could be used in functional food for gastritis.

#### **Ragi based nutritious foods suitable for community feeding** (*Usha Dharmaraj*)

Three different ragi based products namely, ragi based chatuua, ragi laddu mix and ragi laddu were formulated after preliminary trials. The physico-chemical properties of the products were evaluated. Ragi based chatuua is a ready-to-eat extruded powder which can be consumed after reconstituting either with milk or water. The product was formulated similar to wheat based chatuua, which is the main



product in the take home ration scheme of government of Odisha. The ragi based chatuua was evaluated for its quality characteristics. It was observed that the product contains 12.5 g protein, 5.5 g fat, 2.3 g of minerals with 65 g of carbohydrates per 100 g of the sample. The product also contained 279 mg of calcium and 2.4 mg of zinc and provided 326 Kcal of energy. The preparation of the ragi laddu was optimized, and it was observed that the mix contained 16.7 g of fat, 10.9 g of protein and 164 mg of calcium per 100 g of the sample with an energy of 462 Kcal. However, single laddu of 20 g will provide 3.34 g of fat, 2.18 g of protein and nearly 33 mg of calcium with 92 Kcal of energy. The shelf-life of the ragi chatuua and laddu mix indicated that products are shelf stable for 3 months.



Ragi Laddu

#### **Nutri-whole ragi extruded instant beverage mix (Jayadeep A)**

In order obtain the health benefits of whole finger millet with seed coat, germ and endosperm, a ready mix was made through optimizing the extrusion conditions like barrel temperature, screw configuration, speed, etc., drying, size reduction, blending with milk powder and micronutrient fortification. The product is ready to reconstitute in hot water with protein, dietary fibre, calcium and 25% of RDA of iron, zinc, folic acid, vitamin B12, A & C.

The product is ideal for all, especially adolescent girls and women as it can provide micronutrients and phyto-nutrients.



Extruded Whole Ragi



Extruded Whole Ragi flour



Nutri Whole Ragi Instant Beverage Mix



Re-constituted beverage

#### **Millet and pseudocereals for nutritionally enriched products (Usha Dharmaraj)**

Little millet is one of the important small millets which is known for its protein, iron and phytochemical contents. The grains were subjected to fractionation to prepare Flour 1, Flour 2, Pollard, Fine husk and Coarse husk streams. The milling yield and particle size of the different fractions were evaluated. It was observed that, the moisture content of grain showed significant influence on the milling yield of the different fractions. More than 70% of the F1 fraction was below 100 $\mu$  size indicating the fineness of the flour. Whereas, the particle size of the F2 fraction remained below 150 $\mu$ . Pollard fraction contained bran fraction and hence showed a particle size of 250 $\mu$ , while the particle size of the coarse and fine husk were in the range of 300 to 700 $\mu$  respectively. The colour values indicated that, the fractions





exhibited yellow colour in prominence and the lightness values were also high indicating that the flour is comparable to any other cereal flour. The millet contains husk as a non-edible portion. However, the grains are milled along with its husk. Hence, the fractions need to be evaluated for its ash contents with special emphasis of acid insoluble ash. Accordingly, the moisture, ash and acid insoluble ash contents of the fractions were estimated. It was observed that the acid insoluble ash contents of the F1 and F2 fractions are within 0.3 mg/100g which is the safe upper limit for any edible cereal flour. As expected the other two fractions namely, fine and coarse husk exhibited comparatively higher values for acid insoluble ash. The acid insoluble ash contents of pollard fraction ranged between 0.6 to 0.8 g / 100 g. The three fractions, namely F1, F2 and pollard were evaluated for their nutrient profile.

*Preparation of protein and mineral rich corn flakes:* Grain amaranth was fractionated to prepare different streams namely, bran, perisperm and endosperm rich fractions. The coarse husk fraction of grain amaranth is an edible stream and known for its calcium, protein, iron and dietary fiber contents. Hence, it was proposed to utilize the coarse husk fraction in the preparation of a ready-to-eat corn flakes and optimize the process parameters for the same. Accordingly, the coarse husk fraction was pulverized into fine flour and evaluated for its nutritional parameters. The fraction was blended with corn flour to prepare the composite in different proportions ranging from 10 to 40 g/100 g. The process parameters for preparation of the flakes were optimized. The quality characteristics of the ready-to-eat flakes were evaluated. A

steady increase in the protein, minerals and the dietary fiber contents was observed with increase in the grain amaranth fraction indicating the feasibility of incorporation of amaranth bran into RTE corn flakes for the nutritional improvement.

### **Empowering ragi and other small millets growers of Odisha** (*Usha Dharmaraj*)

Ragi is one of the major millets grown throughout Odisha and about 10 lakh quintals of ragi are grown every year. The State was keen to introduce ragi in the Take Home Ration (THR) in the State. CSIR-CFTRI had undertaken the project on processing ragi and other millets using suitable methods to enable these millets for introduction in THR and other government-funded schemes. Ragi was processed by different treatments and subjected to milling to prepare semolina. It was observed that, with processing, the endosperm becomes harder and the yield of the semolina was increased. The physicochemical characteristics of the semolina fractions were evaluated. Protein content was higher for 500 $\mu$  fraction (7.99 g / 100 g) compared to 250 $\mu$  fraction (5.70 g / 100 g). Similarly, calcium (371.79 g / 100 g), zinc (3.14 g / 100 g), ash (2.18 g / 100 g) and dietary fibre (19.29 g / 100 g) contents were also higher for 500 $\mu$  fraction. The instant mixes from ragi semolina are being formulated.

### **Cowpea tofu as a functional food** (*Mohankumari HP*)

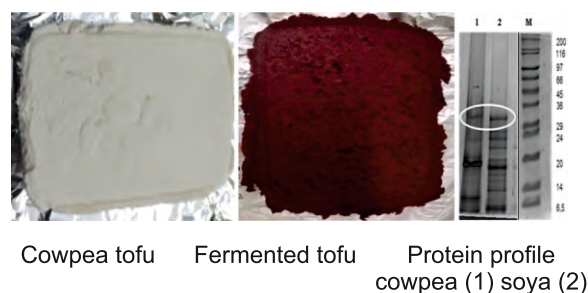
Cowpea is also a rich source of protein like soybean, mainly comprised of globulin fraction (50-70%). There is a growing evidence that cowpea protein, probably through its peptides,





is able to reduce hypercholesterolemia, a major cause of cardiovascular diseases. These peptides and other metabolites derived through fermentation process can improve the nutritional value and health benefits among all the processed foods. Hence the value addition to cowpea or its product tofu may be achieved by fermentation with *Monascus purpureus*. Cowpea tofu and *M. purpureus* fermented cowpea tofu were prepared characterized for its stability, texture enhancement and bioactive properties to claim its health benefits. Cowpea purchased from a local market was seed sorted and dehulled. Tofu was prepared from the soaked grain by extracting milk. The yield of tofu was expressed as the fresh weight (g) of tofu obtained from 1000 ml of cowpea milk. Tofu prepared with different coagulants was evaluated for physicochemical properties, protein profile, colour values and texture profile. The textural parameters of tofu such as hardness, cohesiveness, springiness, gumminess and adhesiveness were evaluated. The moisture content of different tofu varies from 6.6-10.4%. The effects of different coagulants by varying concentration were investigated and difference between the yield of various coagulated tofu was observed. Maximum yield of tofu (289 g) was obtained by citric acid (0.8%) with moisture  $9.56 \pm 0.32\%$  and  $23.4 \pm 0.42\%$  water holding capacity compared to other tofu. The L values for the cowpea tofu ranged from 78.6 to 82.6 while  $a^*$  and  $b^*$  values ranged from 0.28 to 2.07 and 12.22 to 14.05, respectively. There was no significant difference on the color in different coagulated tofu. The L values of the fermented tofu is 4.15 while  $a^*$  and  $b^*$  values are 25.08 and 7.16, respectively. While significant difference

in colour value was observed between fermented and unfermented tofu. The SDS-PAGE results revealed the similarity between cowpea and soya tofu protein profile.



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

Three different egg beverage mix formulations were prepared by blending egg albumin powder with sugar powder, skim milk powder, defatted soy flour, salt, citric acid and flavour and evaluated for their physicochemical and sensory quality. The protein content in the beverage mix was in the range of 31-39% and fat content in the range of 2.5-3.4%. There was not much difference among the 3 formulations concerning density, hygroscopicity, flowability, cohesiveness and colour. Water absorption capacity of formulation C (containing soyflour) was better compared to the other 2 formulations. Addition of soyflour reduced the foaming capacity of the mix considerably. The sensory evaluation of egg beverage prepared from beverage mix indicated that formulation C was superior to the other two formulations with respect to taste, flavor and overall acceptability. Egg yolk was fractionated by centrifugation in two main fractions viz., granules and plasma. Centrifugation at 8000 rpm at 4°C for 45 minutes resulted in better separation of granules and plasma. Protein content in the egg yolk granules was increased considerably, while the fat content was



reduced. The cholesterol content in the egg yolk granules was reduced by 45%. Mayonnaise with less egg yolk was formulated. Partial replacement of egg yolk in mayonnaise with vegetable proteins such as soy protein, wheat gluten and wheat germ protein isolate (WGPI) provided better emulsion results. Conditions were optimized for the preparation of bromelain digested whole egg white protein hydrolysate (WEWPH). The optimized conditions of bromelain hydrolysis were, time (25 h), pH (9) and E/S ratio (1:100). Water-soluble peptides from the WEWPH exhibited strong radical scavenging activities.

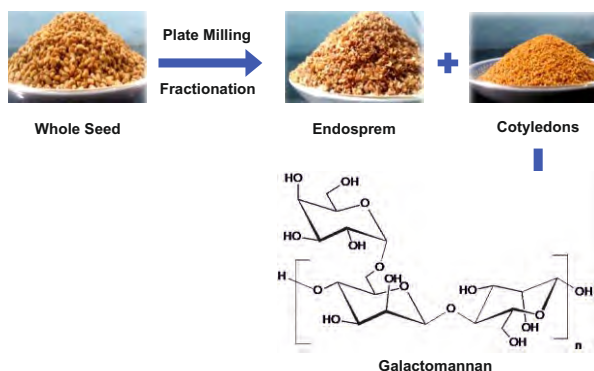
#### **Silkworm pupae products (SWP) for human and animal consumption and composting** (Sachindra NM)

For the evaluation of SWP in poultry feed, it has been planned to use whole SWP (WSWP), defatted WSWP, cuticle-free SWP (CSWP) and defatted CSWP. Hence studies were carried out to prepare cuticle free SWP and analyze the samples for their composition. Fish meat bone separator was successfully adopted to separate cuticle and pulp from spent SWP. The yield of cuticle free pulp by passing the wet whole SWP through meat bone separator was 70 - 75%. The separated pulp was dried at 65°C for 15 h to obtain the dried cuticle free pupae meal. The yield of dried cuticle free meal from the whole pupae was 18-20%. To reduce the drying time, the use of drum drier is being attempted. The protein content in the WSWP meal was 52-53% with a chitin content of 3.5%. The protein content in CSWP was 54-55% with a chitin content of 0.35%. The separation of cuticle and pulp from whole pupae resulted in 90% reduction in chitin content in the pulp. The

WSWP and CSWP were subjected to defatting by solvent extraction and the samples are being analyzed for composition. The formulation for layer feed and broiler feed has been finalized and the raw material (SWP meal) is being prepared as per the quantity required to make different feeds to initiate the feeding experiment.

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

*Galactomannan extraction from fenugreek seed husk:* Fenugreek (*Trigonella foenum graecum* L.,) seeds were fractionated to selectively extract galactomannan (GM) from the husk, in turn increasing extraction efficiency and yield. The defatting step has been omitted owing to the lower fat content of the husk, hence only water and ethyl alcohol are used in the process and minimizes the use of solvent, paving to the formulation of green technology in GM extraction. Crude GM yielded twice and pure GM yielded 3.25 times more the yield that can be obtained through whole seed samples. GM can be used as a soluble dietary fibre and is a valuable bioactive compound in management of diabetes mellitus due to its potential to inhibit glucose hydrolyzing enzymes. Further, *in vitro* experiments are in progress.





*Gingerols for food applications:* 6-Gingerol rich extract was incorporated into ice-cream, which was further analysed for its colour, texture, sensory and microbial properties. Based on the sensory analysis, sample 2 (100:0.5) was taken into consideration, and microbial quality was evaluated. The microbial quality of the sample was compared with the FSSAI standards. According to the FSSAI standards, the aerobic plate count of the ice cream samples should not exceed  $1-2 \times 10^5$  cfu/g, coliforms  $10-1 \times 10^2$  cfu/g, *S. aureus*  $10-1 \times 10^2$  cfu/g with the absence of *Listeria monocytogenes*, *E. coli* and *Salmonella* spp. in 25 g of the samples. The flavoured ice cream sample contained  $62 \times 10^4$ /g of the aerobic bacterial count,  $75 \times 10^1$ /g of coliform,  $2 \times 10^1$ /g of *S. aureus* and  $8 \times 10^1$ /g of *B. cereus* count. The sample showed no *L. monocytogenes*, *E. coli* and *Salmonella* spp. and quality raw material which are microbially safe was sourced. The ice cream prepared with freeze-dried ginger extract had the desirable sensory attributes with the novelty of ginger flavour. The microbial quality of the ice cream was compared with the FSSAI standards. Thus a functional ice cream with all the health benefits of ginger could be obtained by adding natural freeze-dried extract rich in 6-gingerol.

#### **Anti-carcinogenic potential of ginger phytochemical zerumbone (Bettadaiah BK)**

Zerumbone was isolated from fresh *Zingiber zerumbet* rhizomes using hydrodistillation process. Zerumbone analogues such as azazerumbone 1 and 2, zerumbal and zerumbenone were synthesized. Breast cancer

cells were revived and were treated with Zerumbone, Azazerumbone 1 and Azazerumbone 2. Cell proliferation assays were done using MTT assay. The percentage of living cancer cells after treatment of zerumbone, azazerumbone 1 and azazerumbone 2 after 24 h indicated more than 50% of cancer cells die indicating anticancerous activity of these compounds.

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

Coffee pulp (CP) is a major by-product (~ 30% dry weight) obtained during coffee processing. In the present study, CP was valorized as a functional food ingredient by exploring effects of different extractions on its phytochemicals, bio-activities and formulation of a novel probiotic beverage adding kefir micro-organisms. The proximate and mineral constitution of CP revealed considerable amounts of proteins ( $8.74 \pm 1.6\%$ ), crude fiber ( $9.84 \pm 1.8\%$ ), calcium ( $97.8 \pm 5.2$  mg / 100 g) and potassium ( $410 \pm 13.1$ mg / 100 g). Probiotic Coffee pulp beverage was formulated from steam treated coffee pulp, and were evaluated for physicochemical properties, sensory and shelf-life studies. The probiotic beverage had nutrients with, calorific value of  $42.58 \pm 15$  kcal. Organoleptic measured on hedonic scale (1-15 point) recorded 14 with higher acceptance of PB and its shelf life studies of depicted survival of the organisms up to 30 days. The kefir coffee pulp drink could be a novel healthy value-added product to make coffee industry become more sustainable.



### **Value added products from coffee leaves** (Pushpa S Murthy)

The efficiency of different drying methods like sun, shade, and cross-flow (45°C) with respect to its drying kinetics was assessed and its effect on the phytochemicals, volatiles, and antioxidant potential from *Coffea robusta* leaves was analysed. Further, the effect of different steeping methods in the development of a coffee leaf beverage was explored. Kinetics of the drying processes was modelled successfully by the Modified Page equation with an  $R^2$  of 0.99 designating cross-flow as a better and economical choice for drying owing to rapid drying rate and conservation of phytochemicals. Chlorogenic acid (CGA) was the major biomolecule accompanied by p-coumaric acid, quercetin, rutin, caffeine, trigonelline, and theophylline relating to its high antioxidant activity by ABTS and FRAP assays. Methyl salicylate was one of the major volatile compound imparting phenolic/medicinal wintergreen warm-spicy aroma followed by 2, 4-Decadienal in the dried coffee leaf powder. Hot infusions (HI) proclaimed significant extraction yield ( $47.7 \pm 0.23\%$ ), pH ( $6.54 \pm 0.03$ ), total polyphenols ( $89.93 \pm 2.25$  mg CGAE / g), CGA ( $33.01 \pm 0.47$  mg/g) and caffeine ( $5.2 \pm 0.15$  mg/g), with other phytochemicals ensued by cold infusions (CI) and cold brew (CB) with an appealing hue. The two principal components represent 63.6% and 36.4% of the total variance rendering HI as a better steeping process which was also established by the quantitative descriptive sensory analysis with HI having an overall balanced sensory profile. The valorization of coffee leaves and the approaches in designing a nutraceutical and functional beverage need to be explored further.

### **Nutraceutical food products by incorporating nano encapsulated curcumin** (Pooja Rao)

In continuation of the earlier work, bio-accessibility of nanoencapsulated curcumin was performed to determine the release profile of curcumin by mimicking the digestion process of human body with the help of enzymes and variations in parameters such as pH and temperature. It was observed that the release of native curcumin was higher in mouth than stomach and intestinal phase while the release of curcumin from nanoencapsulated samples was higher in intestine than mouth and stomach. This showed the nanoencapsulation of curcumin protected it to be released in mouth and stomach phase. Further, its high release percentage in intestinal phase showed its availability for absorption (*in vitro*). Further, cytotoxicity of native curcumin and nanoencapsulated curcumin in RAW 264.7 cells was determined by MTT-based assay and it was observed that nanoencapsulation of curcumin had reduced its toxicity. The inhibition of LPS-induced NO overproduction in RAW 264.7 cells was also studied and the nanoencapsulated curcumin was found to be more potent inhibitor than native curcumin that highlighted the effect of nanoencapsulation.

### **Natural colour and flavour-based bakery products** (Prabhasankar P)

*Study on the stability of total anthocyanin and total betalains in bread:* Stability of anthocyanin and betalain pigments were studied in steamed and baked breads. Addition of 1.5% and 2% betalains and anthocyanin extract powder were found optimal to impart an attractive reddish pink and purplish colour respectively. Colour





analyses of the bread dough indicates that the values of L (lightness), a\* (redness) and b\* (yellowness) decreased with increase in fermentation time in both the types of pigments. The steamed breads with betalain pigments contain 6.86 mg/100 g of betaxanthin, 16.63 mg/100 g of betacyanin and 23.49 mg/100 g total betalains. Baking of bread as opposed to steaming affected the stability of betalains showing a content of 6.70 mg/100g (betaxanthin), 14.10 mg/100 g (betacyanin) and 20.80 mg/100 g (total betalains) in the baked bread. Similarly, the extent of loss of total anthocyanin was higher in the baked bread.

*Study on the effect of beetroot powder on wheat dough rheology:* The effect of beetroot powder on wheat dough rheology was carried out to utilize beetroot powder (BP) in doughnut. The water absorption capacity of wheat flour

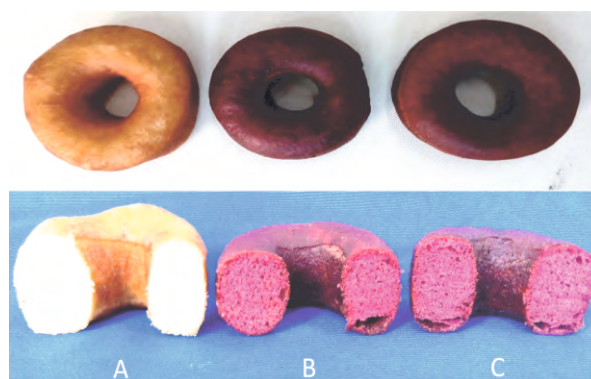
decreased from 55.5 BU to 51.2 BU with increasing amount of BP (5, 7.5, 10 and 12.5%). The dough development time decreased while a slight increase in dough stability was observed. The pasting properties of wheat flour as influenced by replacement of wheat flour with BP showed a marginal increase in the gelatinization temperature from 61.6°C to 62.4°C and a decrease in the peak viscosity from 865 BU to 783 BU. Extensograph characteristics showed that the addition of BP increased the resistance to extension whereas, extensibility decreased significantly. Based on quality and sensory characteristics of doughnuts, 10% BP was found to be optimum. Further, the volume and crumb texture of the doughnut improved with the use of emulsifiers and enzyme.



Steamed bread with anthocyanin



Steamed bread with betalain



A: 100% Maida; B: 90 (Maida)+10 (BP); C: 90 (Maida)+10 (BP) + CA, CA: GMS+SSL+α-Amylase





### **Millet based gluten-free bread**

*(Prabhasankar P)*

Complete proso millet bread was optimized using hydrocolloids. It helps in increasing the loaf volume and specific volume of optimized one compared to proso control. Hardness of optimized bread (109.78 N) was significantly lower than that of control (54.19 N). Microstructure studies showed better network formation in optimized bread which helps in holding gas produced during fermentation. Complete barnyard millet bread was optimized using extraneous protein and starch addition. The optimized bread had lower bake loss (%) and higher loaf and specific volume than control. Addition of protein source helped in maintaining the structure of bread. Storage quality evaluation of foxtail and proso millet was also completed. Moisture sorption isotherm studies of optimized millet-based bread premixes are in progress.

### **Value addition to buckwheat**

*(Crassina Kasar)*

Noodles were prepared from whole groat flour (WGF) and fine flour (FF) and their quality characteristics were compared. The contents of dietary fiber, slow digestible starch, resistant starch, total polyphenol content, total flavonoid content and minerals were higher in noodle from WGF. The prominent essential amino acid was leucine ( $7.23 \pm 0.65$  -  $8.52 \pm 0.64$  %) followed by phenylalanine ( $6.93 \pm 0.75$  -  $7.27 \pm 0.42$  %) and lysine ( $5.83 \pm 0.47$  -  $6.03 \pm 0.45$  %). The amount of rutin retained after processing was 998.22 mg/100 g in noodles from WGF and 148.21 mg/100 g in noodles from FF. Studies revealed that 75% buckwheat flour can be used to

produce noodles with enhanced nutritional profile. Incorporating improvers like gluten powder, emulsifiers and hydrocolloids can further enhance sensory and quality attributes of the buckwheat noodles.



Buckwheat noodle  
from fine flour



Buckwheat noodle  
from whole groat flour

### **Immune boosting wheat based food formulations** *(Prabhasankar P)*

A study was conducted to improve the nutritional and therapeutic values of the bread by including certain known Indian spices and herbs which could help in combating the present pandemic by boosting immunity and maintaining good health. Preliminary studies were carried out to standardize bread with a combination of spices in varied concentrations without affecting the organoleptic properties of the bread.



Control bread with different variations  
of immune boosting ingredients

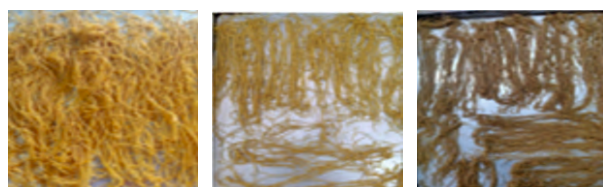
Physico-chemical properties of the breads were analysed and was found to be acceptable according to overall quality attributes. The specific volume of control bread was 3.7 cc/g



and 3.3 cc/g for experimental bread. However, the crumb firmness value was slightly higher with 695 g force for experimental bread and 605 g force for control bread. The experimental bread had pleasant flavour of spices with acceptable organoleptic properties. Further work on validation of immunomodulatory activity of experimental bread has to be taken up.

Wheat Germ (WG) based products:

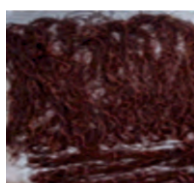
**Vermicelli:** Studies were undertaken to standardize pretreatment and milling protocols to obtain desired particle size of Wheat Germ (WG). Process parameters for extrusion with various additives and drying of the extruded product were optimized. Four varieties of vermicelli were prepared namely, plain, cardamom flavoured, chocolate flavoured and savoury (upma). Instant upma premix and flavoured payasam premix were also developed. Texture, colour and cooking characteristics of the WG based products were also studied. Proximate analysis, shelf life study, *in-vitro* starch and protein digestibility estimation are being carried out.



Unflavored  
Vermicelli

Cardamom  
Vermicelli

Savory  
Vermicelli



Chocolate  
Vermicelli



Savory Vermicelli  
Upma

**Fermented Wheat Germ (WG) extract based beverage:** Screening and selection of appropriate WG and its physico-chemical properties were evaluated. Process parameters like pre-treatment, moisture, particle size of the wheat germ were optimized. Studies were also undertaken to select appropriate strains of bacteria/yeast and fermentation conditions. Drying parameters were standardized based on mass recovery quantum, solubility and stability of the developed WG beverage.



Beverage premix samples

### **Micronutrient fortification of semolina, dalia, bansi rava (Suresh D Sakhare)**

Different micronutrient sources were screened for their water solubility properties for the fortification of dalia and semolina. Micronutrients such as iron, vitamin B<sub>12</sub> and folic acid were selected for the fortification of dalia. Among the various iron sources, iron EDTA was selected for the fortification of dalia, since phytic acid content in dalia is higher when compared to wheat semolina. Ready-to-cook products such as sweet porridge from the fortified dalia are under development. Pilot scale process at a capacity of 2400 kg/day was developed for the



fortification of dalia. Studies are underway to standardize fortification of semolina and effect of storage for the products (upma mix and rava idli mix) developed using fortified semolina.

#### **High protein food formulations with improved digestibility (Jyothi Lakshmi A)**

A complementary food mix comprising of wheat flour and a combination of pulse and milk proteins. The quality of the protein assessed based on amino acid composition and in vitro protein digestibility indicated a PDCAAS of 0.90. The formulation was dephytinised by endogenous phytase activation and thermal treatments. The formulation was fortified with iron and zinc salts to meet the requirements and further bioaccessibility of iron and zinc was enhanced by addition of promotive components such as fruit powders. The complementary food mix contained 17 g mg iron per 100 g of dry mixprotein, 11.9% fat, 433 kcals, 12 mg iron and 6 . The bioaccessibility of iron and zinc with all the selected fortificants and promoters was found to be 26% and 30% respectively in the final product. Based on microbial safety, quality and sensory analysis revealed that the product was safe upto 90 days under accelerated storage conditions and upto 180 days at ambient conditions in metalized foil. Qualitative descriptive analysis was done to study different acceptability parameters. The attributes were colour, texture, flavour, beany, bitter, sour, roasted cereal, gritty particle, smooth and overall quality. Score for overall quality of the product was around 8 out of 10. About 30 g of CFM meets 45% RDA for protein, 40% RDA for iron and 36% RDA for zinc.

#### **Probiotic lactobacilli involved in $\beta$ -manno-oligosaccharides catabolism (Mukesh Kapoor)**

UHPLC analysis of crude  $\beta$ -MOS produced from defatted copra meal by ManB-1601 hydrolysis showed presence of two species of DP2 and one species each of DP1, DP3 and DP4 copra  $\beta$ -MOS. Purification of copra  $\beta$ -mannooligosaccharides ( $\beta$ -MOS) mixtures using biogel P-2 size exclusion chromatography resulted in separation of  $\beta$ -MOS with various degrees of polymerization (Peak 4- DP 1; Peak 3-DP 2; Peak 2- DP3; Peak 1- DP 4). Purified copra  $\beta$ -MOS were structurally [ESI-MS and functionally (*in vitro* batch fermentation)] characterized. ESI-MS showed single species of DP4, DP3, DP2 and DP1 copra  $\beta$ -MOS. NMR analysis of DP4 copra  $\beta$ -MOS showed presence of one species of un-substituted mannotetrose. Batch fermentation studies for *Lactobacillus casei* and *L. helveticus* and food borne pathogens (*Escherichia coli*, *Salmonella typhi* and *Listeria monocytogenes*) showed that the growth of *Lactobacillus* spp. was improved in DP2 (by 0.5 log CFU/mL, A600 0.3) and DP3 (by 0.5 log CFU/mL, A600 0.3) supplemented media when compared to positive (FOS) control and negative (carbon free media) control. DP2 and DP3 were found to inhibit the growth of *E. coli* (by 0.5 log CFU/mL, A600 0.2), *S. typhi* (by 0.7log CFU/mL, A600 0.3) and *L. monocytogenes* (by 0.2 log CFU/mL, A600 0.3) when compared to the positive (glucose) control. The role of copra  $\beta$ -MOS towards inhibition of advanced glycation end products (AGE's) was evaluated by using in vitro BSA/glucose model. Copra  $\beta$ -MOS treated samples showed less absorption (240-340 nm) in comparison to glycated BSA (negative) and aminoguanidine (positive)





controls which suggested it's anti-glycating potential. The growth of *Bifidobacterium adolescentis* was studied on sparsely galactosylated  $\beta$ -MOS from copra (C-MOS) (mannose to galactose ratio of 1:14). It showed good growth in C-MOS ( $A_{600\text{ nm}} \geq 0.7$ , pH 5.5 of the utilized broth) after 72 h. Utilization of  $\beta$ -manno-oligosaccharides by *Bifidobacterium adolescentis* was also studied using TLC at different time points (0, 24, 36, 48 and 72 h). In all the cases *Bifidobacterium adolescentis* was found to utilize  $\beta$ -MOS between 24-72 h of growth in carbon free media supplemented with  $\beta$ -MOS. Growth curve of *Bifidobacterium adolescentis* was also studied on mono-sugars (glucose, galactose and mannose) and C-MOS. *Bifidobacterium adolescentis* was passaged thrice till 48 h (late exponential phase) on Glc, Gal and C- $\beta$ -MOS to remove any gene expression carryover. Thereafter, gene expression profile analysis using microarray approach was carried out. The global gene expression profile analysis revealed up-regulation of proteins including extra-cellular solute binding protein and sugar transporters which, could be involved in the capture and transport of  $\beta$ -MOS. Further, few glycoside hydrolases possibly involved in the hydrolysis of  $\beta$ -MOS were also up-regulated along with transcriptional regulators like LAC-I family DNA-binding proteins. pH induced fluorescence study showed that the tertiary structure of 6-phospho- $\beta$ -glucosidase from *Lactobacillus plantarum* WCFS1 was completely un-folded at pH 3 wherein it showed lowest fluorescence intensity ( $\lambda_{\text{max}}$  241.8) and 46 nm blue shift when compared to tertiary structure at pH 6 and 7. While, exposure to pH 10 resulted in a red shift of 6 nm with respect to

pH 6 and 10 indicating a more compact tertiary structure. A combined integration of partially hydrolysed guar gum (PHGG) and orange peel fibre (OPF) into low-fat, set-type yogurt was explored. PHGG 0.25% (w/v) + OPF fortified yogurt presented superior rheological, textural and physico-chemical properties in comparison to plain and other fortified yogurts during storage (28 days, 4°C).

#### **Galactomanno-oligosaccharides as potential therapy for inflammatory bowel disease** (Mukesh Kapoor)

Partial hydrolysis of fenugreek gum (FG) was accomplished by using physical methods of steam treatment (121°C at 15 psi for 1 h) and ultra-sonication (600 C at 40kHz for 1 h). Centrifugation and freeze drying of partially hydrolyzed fenugreek gum (PHFG) gave 50% yield on weight basis. PHFG had higher flow behaviour index (PHFG: 0.944, FG: 0.864) and exhibited decrease in viscosity (7.0 cp) when compared to un-hydrolyzed FG (30.0 cp). PHFG showed reduced (22.38%) average degree of polymerization (PHFG: 782.88, FG: 1008.55), average molecular weight (PHFG: 281838.2 Da, FG: 363078.05Da), apparent viscosity (PHFG: 5349, FG: 33.34), and consistency index (PHFG: 4.234, FG: 64.83). Structural characterization of PHFG by FTIR showed presence of characteristic bands. Altogether, PHFG showed no major functional group transformation when compared with FG.

#### **Protein beverage for diabetic population** (Sachin M Eligar)

Protein glycation leads to the development of AGEs and is known to be associated with diabetes, aging, atherosclerosis, and insulin



resistance. A feruloylated oligosaccharides (FOs) was isolated from millet bran, which inhibited the formation of AGEs. These FOs also showed potent antioxidant and anticancer properties. Scale-up studies for the extraction of FOs was established, and *in vivo* efficacy is being evaluated.

Adenosine monophosphate activated protein kinase (AMPK) is a potent metabolic regulator and an attractive target for antidiabetic activators. Studies have shown that trans-ferulic acid (TFA), a natural bioactive molecule of hydroxycinnamic acid derivatives is a potent activator of AMPK. It showed a maximum increase in phosphorylation of AMPK ( $3.72/3.3 \pm 0.10$ ;  $p < 0.001$  vs. high glucose (HG) control) in human liver cells (HepG2) and rat skeletal muscle cells (L6) under HG condition, where HG suppresses the AMPK pathway. It was observed that TFA increased activation of AMPK in a dose- and time-dependent manner and also increased the phosphorylation of acetyl-CoA carboxylase (ACC), suggesting that it promotes fatty acid oxidation; however, pretreatment with compound C reversed the effect. In addition, TFA reduced the level of intracellular reactive oxygen species (ROS) and nitric oxide (NO) induced by HG condition and subsequently increased the level of glutathione. Interestingly, TFA also upregulated the glucose transporters, GLUT2 and GLUT4 and decreased the phosphorylation of c-Jun N-terminal protein kinase (JNK1/2) in tested cells under HG conditions. Our studies provide critical insights into TFA's mechanism as a potential natural activator of AMPK, and it could be used as a therapeutic agent against hyperglycaemia. Large scale extraction of TFA has been established. *In vivo* efficacy of TFA

using diet-induced diabetic mice model is in progress. The above molecules will be tried in a reconstitutable protein beverage for the efficacy of the product.

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

Mitochondria (mt) are the major source and target of ROS including superoxide, byproduct of the electron transport activity, which can elicit apoptosis or mitophagy depending critically on the signaling balance. The SH3GL2 overexpressing cells produced large amount of superoxides as demonstrated by MitoSOX Red staining and exhibited increased mt fusion network compared to the control cells. Release of CYTC from mt to the cytoplasm is the central step in triggering mt apoptosis. Enhanced CYTC expression in the cytoplasm was observed compared to mt in all the SH3GL2 over expressing cells. Accompanied with these molecular and mt associated changes, reduced proliferation, invasion and anchorage independent growth of the SH3GL2 overexpressing breast cancer cells was observed. These observation suggest for a functional link between SH3GL2 and mt reprogramming leading to apoptotic induction in the breast cancer cells.

### **Regulation of Cytochrome p450 fatty acid monooxygenases by nutraceuticals (Mahesha G)**

The project is an attempt to connect three distinct areas of biomedical research involving cytochrome p450 fatty acid monooxygenase, peroxisome proliferator-activated receptor, and nutraceuticals. The objective is to see the role played by cytochrome P450 fatty acid





monooxygenase in diabetes and its complications modulated by nutraceuticals via PPAR's. PPAR's belong to a subfamily of the nuclear receptor superfamily of ligand-inducible transcription factors, and three PPAR isotypes encoded by separate genes have been identified, PPAR $\alpha$ , PPAR  $\beta/\delta$ , and PPAR $\gamma$ . PPARs control the expression of gene labyrinth involved in adipogenesis, lipid metabolism, inflammation, and the maintenance of metabolic homeostasis. CYP genes have the PPAR response element (PPRE) in their promoter region. Nutraceuticals can act as ligands for PPARs. So investigating the role played by cytochrome P450, PPARs, and nutraceuticals in the course of the metabolic syndrome would lead to the design of better therapies to improve insulin sensitivity, control and cure diabetes mediated complications. Identification of new nutraceuticals that regulate cytochrome p450 via PPARs is therapeutically relevant. The experimental design is to identify potent nutraceuticals by using computer-aided drug design, *in vitro* and *in vivo* methods which potentially bind to the PPAR receptors  $\alpha$ ,  $\beta/\delta$ , and  $\gamma$ .

#### **Antimicrobial protein/peptide for food industry** (*Rajagopal K*)

New protein-based antimicrobials from GRAS microorganisms are considered as a better replacement for conventional antibiotics in the food industry. Antimicrobial peptides from beneficial microbes was isolated and characterized in the lab. Its function was found comparable with the other commercially available antimicrobials. The molecule works in very high temperatures, in harsh conditions such as acidic and alkaline. Further, it will be highly suitable for the food industry because it would work in the presence of metal salts,

detergents and enzymes. It does not cause any harm after consumption, instead, it cleans up the harmful pathogenic bacteria.

#### **Milk or legume protein based nutritional supplementation in infants** (*Sridevi A Singh*)

The preparation protocol for whole milk powder and ragi based supplementary food was standardised so that the final product is microbially safe and with acceptable organoleptic characteristics. The formulation has been taken up for the field trials at Chitradurga district, Karnataka State, specially to children with stunted growth in the age group 6-9 months. Each unit packet of the product contains 46 g of the sample which will be cooked for 2-3 min with water before consumption. The field trials are conducted in association with St. John's Hospital, Bangalore. About 135 kg of the product packed in 2926 pouches has been supplied to the target group in different batches. The product contained 13.6 g protein, 20.89 g fat, 3.51 g ash and 57.6 g carbohydrates per 100 g, with a calorific value of 473 kCal. The product also contained about 500 mg of calcium, 370 mg of phosphorus, 13 mg of vitamin B3, 4.14 mg of vitamin B6 and 24 mg of vitamin C. The field trials are in force and the results of the efficacy studies are being compiled.

#### **Black rice momospremix** (*Amudha Senthil*)

Momos premix was developed using black rice flour and millet flour as major ingredients, which are rich in nutraceuticals. Two premixes were prepared by blending black rice flour and foxtail millet flour at the ratios of 70:0 (S1) and 60:10 (S2). The formulation and processing parameters for momos premix were standardized. The nutrient composition of the premix (S1 and S2)



and the sensory quality of the products (M1 and M2) were analyzed. The proximate composition of premix samples showed that the moisture content of 9.50%, fat 2.04-2.84%, ash 1.34-1.35% and protein 10.63-12.30%. Colour values  $L^*$ ,  $a^*$  and  $b^*$  did not show significant difference among the samples. The antioxidant content of the momos premix showed the presence of good amounts of antioxidants which are essential for human health. Anthocyanins, a group of flavonoids, which are the main bioactive principles present in black rice, ranged from 43.8-54.0 mg in the premix. Consumer acceptance test showed that both the products (M1 and M2) are acceptable and incorporation of black rice up to 70% in the premix did not affect the quality of the product. Incorporation of black rice enhanced aroma and nutritional value to the product.

#### **Black rice RTC foods (*Babylatha R*)**

Ready-to-reconstitute products like black rice nutri-kheer and jamun mix from black rice were developed. The developed kheer mix is microbiologically safe and has a good shelf-life due the processing methods used such as flaking, drying and roasting. As per the microbiological testing the product can be used safely by consumer up to 4 months. The RTC product can be reconstituted with 5 times its weight with water, boiled and garnished with roasted cashew and raisins. Black rice jamun mix was developed using milk powder,



RTC-Jamun mix



RTC-Nutri-kheer

vanaspathi and food additives. The sensory quality of black rice gulab jamun samples has no significant changes from the reference sample and overall the samples have been preferred by the panellists / consumers. It is concluded that the black rice gulab jamun is one of the best ways of making a tasty aromatic sweet and also can replace the maida based regular gulab jamun in a healthy manner.

#### **Black rice chikki (*Chetana R*)**

Two types of black rice chikki with or without groundnut were standardized. Chikki with popped black rice had a crunchy and crispy texture. The anthocyanin content ranged between 53.2 to 81.7 mg/ 100 g.



Popped Chikki



Popped GN Chikki

#### **Black rice instant breakfast strings (*Jayadeep A*)**

Through optimization of the conditions of grain thermal processing, size reduction, dough preparation, extrusion and hydrothermal treatments, instant black rice breakfast strings were developed. This can be consumed by adding 25 g to hot milk. Minimal polishing of



black rice (3%) is resulting in only partial loss of bioactives and can be used for development of value added products.

### **Black rice volatile compounds using GC-MS** (Jeyarani T & Shivaswamy)

Black Rice is unique as compared to other rice varieties because of its colour and flavour. The rice taken for the study was found to contain 2.6% fat which was rich in unsaturated fatty acids (73.9%) containing 35.3% PUFA. The major fatty acids were palmitic, oleic and linoleic acid. Long chain fatty acids such as arachidic, behenic and lignoceric acids contributed to 3% of total fatty acids. The presence of higher amount of linoleic acid (34.6%), an essential fatty acid belonging to  $\omega$ -6 fatty acids category can contribute to significant health benefits. Volatile organic compounds were extracted from Black Rice using Liken-Nickerson apparatus and analysed using GC-MS. Nearly thirty compounds that includes alcohols, aldehydes, ketones and hydrocarbons were identified. Among the compounds identified, the four major ones were limonene, *o*-cymene, 2-carene and *o*-guaiacol. Interestingly a unique compound, benzyl isothiocyanate which was not seen in other rice varieties was found.



Black Rice



Flour



Instant breakfast strings



Re-constituted product in milk

### **Plant based formulation in immunomodulatory therapeutic and antiviral therapy against Covid-19** (Iboyaima Singh)

*Houttuynia cordata* Thunb (Tokningkhok in Manipuri) which is indigenous to North-East India and China is utilized by various ethnic groups of the NE regions in the form of salads, vegetables or spices as well as in various medicinal purposes traditionally. The antioxidant activity of the components of *H. cordata* Thunb, demonstrated that the leaf extracts possess the major phenolics and flavonoids compounds such as gallic acid, p-coumaric acid, cinnamic acid, quercetin, caffeic acid, ferulic acid, cinanserin, cinnamic acid and salicylic acid wherein leaf extracts showed higher contents than the rhizome extracts. *In-silico* studies (Docking) of various phenolic acids on 3CL pro for their inhibition properties were carried out. Quercetin, cinanserin and caffeic acid showing good inhibition of 3CL pro enzyme activity were found to be present in leaf and rhizome extracts of *H. cordata*. Good immunity can retard the viral invasion and its establishment within the system. *H. cordata* is well known for antiviral activity. Hence, value-added products viz. powders, groundnut chikkies with 10% leaves or rhizome powder and ready-to-serve beverages from leaves and rhizomes have been developed.

### **Ayurvedic food formulation and assessment for immunomodulatory effect**

(Madan Kumar P)

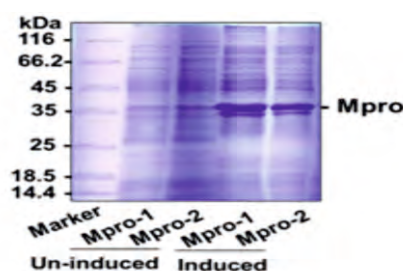
The study aimed to examine whether the bioactive compounds of ayurvedic food formulation inhibit the enzymatic activity of SARS-CoV-2 Mpro. In total, 96 bioactive compounds were selected and docked with



SARS-CoV-2 Mpro. From docking and molecular dynamics studies, it was observed that bioactive compounds of ayurvedic food formulation showed minimized binding affinities with SARS-CoV-2 Mpro. Overall, the results illustrated that there are potential bioactives in the ayurvedic food formulation which could be used as SARS-CoV-2 Mpro inhibitor for COVID-19.

### Functional validation of COVID-19 Main Protease (Mpro) inhibitors (Vijayaraj P)

The study was aimed to identify and validate the functionality of nutraceutical molecules for the Mpro inhibition. The coding region of the Mpro gene was cloned into the bacterial expression vector, and the positive clones were confirmed by nucleotide sequencing. The protein expression was achieved by IPTG induction, and the purified recombinant protein was used as an enzyme source for the inhibitor screening. The inhibitory potential of the nutraceuticals molecules will be validated by the gel-based activity-based protein profiling (ABPP) strategy.



Expression of COVID-19 main protease

### Immunity-boosting shelf-stable probiotic curd enriched with *Bifidobacterium longum* 5732 (Prakash M Halami)

The work aims to prepare a probiotic curd enriched with *Bifidobacteria* that helps boost immunity in

the Indian population upon consumption. The viability of bacteria was observed to be high on the 0th day, and the minimum viability of probiotics for consumption according to the probiotic food requirement was reached during the 21st day. *Limosilactobacillus fermentum* and *Bifidobacterium longum* lost their viability during storage for 21 days. *Bifidobacterium longum* NCIM 5672 genome sequence has a GC content of 59.6% and 1900 coding sequences. Whole genome sequence of *Limosilactobacillus fermentum* MCC 2760 yield in 2267305bp of one circular chromosome of around 2192 encoding sequences with 15 ribosomal RNA, 59 tRNA encoding genes and GC content of about 51.4%.

### Spirulina and *D. hamiltonii* as prophylactic and ameliorative nutraceutical adjuvant to COVID-19 virus therapy (Giridhar P)

Two important compounds from *Decalepis hamiltonii* and spirulina were tested for their anti-inflammatory potential using macrophage cells. *D. hamiltonii* tubers and spirulina water extracts were analysed for the total phenolic content and total flavonoid. The antioxidant potential of the extract was analyzed in *D. hamiltonii* and spirulina water extract. Cytotoxic effect of spirulina and *D. hamiltonii* in macrophage cell lines were analysed. LPS treated cell lines were treated with extracts and the IL-6, IL-10 and analysis was carried out and the data showed that these two extracts had a good antioxidant potential. Dry powder was formulated using spirulina and *D. hamiltonii* which showed good antioxidant potential.



**A cleaner processed ayurvedic food formulation and assessment for immunomodulatory effect**  
(Sandeep N Mudliar)

The polyherbal food formulation in compliance with FSSAI norms has been prepared using cleaner processing options involving non-thermal and non-chemical methods for higher recovery and stability of key metabolites. It has been scientifically and favourably assessed for its safety and efficacy in cell lines and animal model and the technology is in the process of transfer to the industry partner for scale-up at 100 kg scale.

**Biomolecules from spices and plantation crops for the prevention and control of COVID-19** (Nagarajan S)

The efficacy of biomolecules to control covid-19 from the spices such as black cumin (*Nigella sativa*), kokum (*Garcinia indica*) and turmeric (*Curcuma longa*) has been initiated. Accordingly, the components, garcinol, cyanidin-3-glucoside and cyanidin-3-sambubioside were isolated by innovative approaches of using natural pectin as stationary phase. Similarly, thymoquinone was isolated from black cumin seeds in good yields (25-30 % of essential oil) and the same has been converted into dithymoquinone by photo induced dimerization method. All these molecules were characterized by spectroscopic method as UV, NMR along with other physicochemical methods. In continuation of these, the studies were carried out to check the cytotoxicity test of these components by MMT assay on Beas2b cells to optimize the IC<sub>50</sub> values. Further work is being undertaken to study the efficiency of M-protease and ACE-2 inhibition studies.

**Sensory lexicon for selected coconut based products** (Asha MR)

A sensory lexicon (comprehensive collection of sensory descriptors) for coconut based products was developed. Among the products employed for this purpose, some were commercial samples procured from two different local supermarkets and some samples of coconut oil were obtained from a retail dealer. Other products developed in the institute were sensorily evaluated. Over forty samples were procured which were categorized under various classes such as coconut cookies, coconut cream, coconut milk, spreads, beverage mixes etc. A trained panel generated over 400 sensory descriptors for various categories of coconut based products mentioned, using "Free Choice Profiling" method (Descriptive Analysis). Definitions for these sensory descriptors, along with suitable examples are given in the sensory lexicon developed.

**Coconut flour in improving functional, rheological and nutritional properties of wheat dough** (Roopa BS)

Moisture sorption isotherms of whole wheat flour (WWF), coconut flour (CF) and composite flour were determined at relative humidity (11-92%) using a gravimetric technique at constant temperature (27±2°C). The results show that, the MSI of WWF and CF is almost similar and sigmoid in nature with increasing equilibrium water content at constant temperature. During the study, it was observed that flour loses its initial moisture content initially from 11-32% RH, and attained equilibrium moisture content from above 44-56%. The curves start rising at



56% considered as critical for WWF and 64% for coconut flour based on the flour characteristics at particular EMC. The similar study was followed for composite flour made from whole wheat flour (WWF) and coconut flour (CF) at ratio 20%, 25% and 30%, indicated the similar sigmoid curve trend, which is close to whole wheat flour. The MSI study of individual and composite flour with EMC, CMC exposed at different RH are studied and quality characteristics are noted and designed to study storage studies at accelerated ( $92\pm2\%$ , RH/ $38\pm1^\circ\text{C}$ ) and ambient conditions ( $65\pm5\%$ , RH/  $27\pm2^\circ\text{C}$ ) withdrawal at every 15 days and 30 days intervals, respectively. The physico-chemical parameters such as moisture, pH, colour change, alcoholic acidity and peroxide value were analysed. There is a marginal moisture gain, pH, colour and acidity values for WWF, CF and composite flour during 30 days storage period at accelerated condition, however stable at ambient studies.

#### **Reactor for processing of coconut-based beverages** (*Sudheer Kumar Y*)

This project is intended to address the challenges by developing new reactors like a continuous flow reactor (0.5-1 L/min) with Dean Vortex Technology and concepts for reactor testing for the non-thermal processing of beverages. Dose delivery validation was carried out using the accurate optical properties which are the main parameters in dose calculations. UV-C low-pressure collimated beam system was used for testing the coconut-based beverages. These UV-C reactors was used for disinfection of pathogens in coconut-based beverages. UV-C irradiation offers opportunities for horticultural and food

processing industries to meet the growing demand from consumers for healthier and safe food products.



UV-C Reactor

#### **Fruit pulp/ peels and vegetable based snack bar** (*Jyothirmayi T*)

Utilization of pomegranate peel as source of bioactive principles such as ascorbic acid, polyphenols, carotenoids and dietary fibre was studied. In addition, extraction and incorporation of carrot and beetroot shreds in the preparation of snack bar to standardize the processing method was assessed for nutritional composition, colour, texture and microbial quality of snack bar at 0 days. The 6 month shelf life of the snack bar was tested for its energy content. Also studies were carried out to optimize the composition and process parameters for foam mat drying of banana pulp into free flowing powder in custard and the product was found highly acceptable.

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

Awareness and skill training programmes were conducted on food processing and preservation at Nabarangpur, of Orissa. Under the programme, various technology related



training programmes suitable for rural micro units were organised for 45 persons in association with the district administration.

**Extension of shelf life of millets** (*Jyothirmayi T*)

Jowar, foxtail and pearl millet were exposed to solar radiation, heating in a cabinet tray dryer and microwave heating and roasting to reduce the infestation. Microbiological evaluation on infestation was carried out and storage studies are in progress.

**Pre & post harvest treatment protocol for mango varieties of North India** (*Gothwal PP*)

The effects of post-harvest treatment of mango fruit (cv. Amarpali & Chausa) on the extension of shelf life at two different storage temperatures (cold storage and ambient condition) was conducted. Under the study, Amarpali and Chausa mangoes showed better storage period at a temperature of 12-13°C. The physiochemical parameters studies were

found to be within the limits and products prepared from ripened mangoes were acceptable.

**Plant-based protein hydrolysate devoid of phenylalanine** (*Arun Kumar V*)

The ultimate goal of the proposed study was to provide a comparative index for enhancement of iron bioavailability by ferritin and lactoferrin to address the iron fortification in the diet to alleviate iron deficiency anaemia. Commercially available whey protein was used to conduct the study. Total protein content in the whey protein was estimated by Kjeldal method and 10% protein solution was prepared. Filtration was carried out using amplicon 50 MWCO and 100 MWCO to remove the lower and higher molecular weight proteins. Lactoferrin (Lf) was estimated using ELISA and further it was confirmed with immune blot. Further the iron contents were estimated in the Lf enriched fraction.



## TRANSLATIONAL RESEARCH

### Health food formulations (*Nandini CD*)

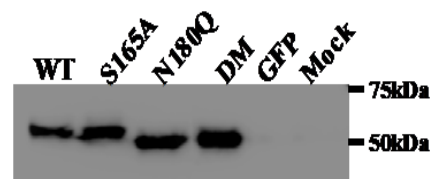
Efforts are being made to develop diabetic friendly food formulation that can activate an energy sensor molecule thus helping in glucose disposal. AMPK activation was determined in MDCK cells after subjecting the bioactive in native form to various heat treatments. AMPK was activated in both heat-treated and non-heat-treated samples. A premix was prepared so that it can be incorporated into various traditional foods such as chapati, dosa and idli. These products were found sensorily acceptable. Efforts are on to determine the bioactive levels in premix-incorporated products and their activation of AMPK in both cell culture and animal models.

### Functional food product for diabetics that can modulate PPAR $\gamma$ (*Nandini CD*)

Full agonists of PPAR $\gamma$  are one of the main drugs prescribed for type 2 diabetics. However, their continuous usage is marred by side effects. Safer alternatives such as selective PPAR $\gamma$  modulators (SPARMS) are being extensively developed. Hence, research has been undertaken extensively to determine SPARMS from plants/food sources that can be consumed to confer health benefits. Bioactives were isolated from young mulberry leaves using green solvents and the heat stability and PPAR $\gamma$  modulating activity of the extracts were determined. Good stability was obtained in the green solvent employed and increased phosphor PPAR $\gamma$  was observed on treatment with the isolated bioactives.

### Nanovesicles for treating chronic ulcers (*Gopinath M*)

Chronic foot ulcer is one of leading cause of the lower extremities amputations in 25% of diabetic ulcer patients. Follistatin like-1 (FSTL1) is novel protein which aids in skin cell migration in acute wound healing and is absent in diabetic ulcers. FSTL1 encapsulated in edible plant derived nanovesicles which could promote wound healing in chronic ulcers is being investigated. FSTL1 is known to be glycosylated at aa N180 and phosphorylated at aa S165. Hence, to identify which isoform of FSTL1 is required for wound closure, both eukaryotic expression constructs with wild type, S165A, N180Q and S165A/N180Q double mutants were created. Mutations were confirmed and expression of wild type and mutant proteins in 293T cells have been confirmed by western blot. These proteins are currently being encapsulated in ginger and citrus fruit-derived nanovesicles and are evaluated for wound closure activity.



FSTL1 expression in transfected 293T cells

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

Sorghum bicolor protein hydrolysates (SPH) and derived bioactive peptides generated by



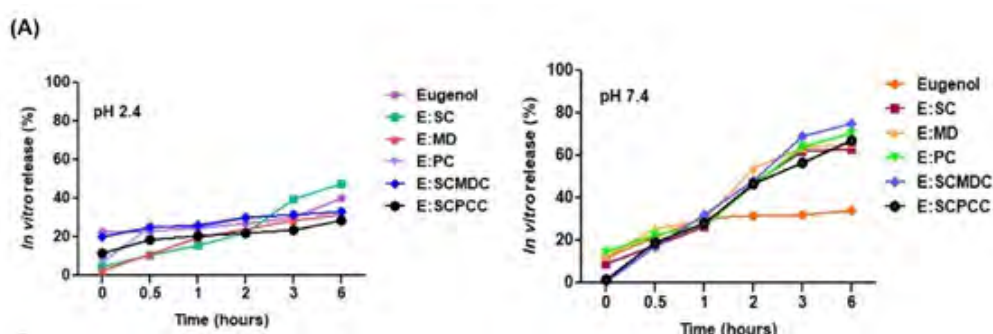


simulated gastrointestinal digestion were studied for DPP-4 inhibitory properties using *in vitro* and *in situ* assays. Identified peptides, LSICGEESFGTGSDHIR (PEP1), SLGESLLQ EDVEAHK (PEP2) and QLRDIVDK (PEP4) displayed potent DPP-4 inhibition with IC<sub>50</sub> values of 73.5, 82.5 and 8.55  $\mu$ M respectively. DPP-4 inhibition mechanism by the peptides was investigated by DPP4-peptide inhibition kinetics, molecular docking and microscale thermophoresis binding studies. The peptides bound to DPP-4 with micromolar affinities and PEP4 showed significantly increased affinity. The mixed type enzyme inhibition by peptides suggested that the peptides either block the active site of DPP-4 or changes the enzyme conformation via a secondary binding site. Overall, the results demonstrate that sorghum seeds are an adequate source of peptides with DPP-4 inhibitory properties that could be used in functional food formulations.

### Nanoencapsulated Eugenol (NE) (Poornima Priyadarshini CG)

Alzheimer's disease (AD) is characterized by the build-up of signature extracellular

amyloid plaques and intracellular neurofibrillary tangles (NFTs) containing hypophosphorylated Tau proteins. Reports have established the role of active components of several essential oils (EO's) in reversing aging, extending lifespan and improving stress tolerance. However, the *in-clinical* applications / therapeutic strategies using EOs for the management of AD are compromised due to blood-brain-barrier. The proposed project aims to synthesize and characterize nanoencapsulated eugenol using the oil-in-water technique. The chemical composition was optimized using Taguchi design. Turbidity studies revealed higher stability of nano emulsion prepared with Maillard conjugate (SCMDC) compared to protein or polysaccharides alone. *In vitro* enzymatic release study showed 31 and 74% release of eugenol (E) after 6 h at pH 2.4 and 7.4, respectively. In comparison to native eugenol, E:SCMDC eugenol showed reduced toxicity and enhanced antioxidant activity. These findings suggested that nanoencapsulated eugenol (E:SCMDC) have a huge potential in nutraceutical and therapeutic applications.



*In vitro* release profile of eugenol at gastric pH 2.4 and intestinal pH 7.2.



### **Lactucaxanthin mediated modulation of oxidative stress and retinal angiogenesis** (Baskaran V)

Protective effect of lactucaxanthin (Lxn) on hyperglycemia-induced oxidative stress and hypoxia in streptozotocin-induced diabetic rats and RPE cells was determined. Angioprotective property of Lxn and lutein in rats revealed their multi-target (oxidative stress, hypoxia, ER stress and inflammatory) action. Hyperglycemia caused oxidative, ER stress and inflammation with elevated levels of protein carbonylation, lipid peroxidation, angiogenic markers expression, suppressed antioxidant activity and tight junction protein in the serum and retina. Lxn administration lowered the protein carbonylation (37%), lipid peroxidation (40%) via down regulating oxidative stress, ER stress and inflammatory cytokines. Lxn augmented antioxidant activity and tight junction protein expression in RPE cells and maintained its integrity. For the first time, this study elucidates the anti-angiogenic property of Lxn. Lxn would be a promising therapeutic candidate to manage not only diabetic retinopathy (DR) progression and also can serve as an adjuvant along with drugs used against DR.

### **Thermogenic food with marine algae and its safety** (Baskaran V)

An efficient dietary supplement to manage obesity and associated complications using brown algae as a source of potential bioactives remains a major challenge due to heavy metals and microbial contamination, lack of awareness of health benefits and limited dietary exploitation. In this study, to overcome such limitations, *Padina tetrastromatica* and

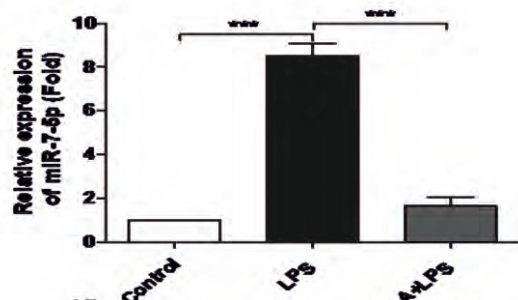
barley-based thermogenic food (TF) was prepared and its safety examined in C57BL6 mice. TF at 0 (control), 50, 100, 200, 500 g/kg diet was fed for acute study and 0, 5, 50 g/kg diet for sub-acute toxicity studies. Feeding TF did not affect general behavior, food and water intake, growth or survival of animals. Hematological and clinical indices did not reveal differences between TF fed and control groups. However, male and female mice showed significantly lower levels of plasma cholesterol and triglyceride levels in groups fed 5 and 50 g/kg diet of TF. Post-mortem examination revealed no differences in macroscopic or microscopic changes in vital organs. The results demonstrated that food with *P. tetrastromatica* did not produce any adverse effects even at higher doses in mice upon acute and subacute treatment. Hence, TF could be used to manage obesity.

### **Regulation of apoptosis in BEAS 2B cells** (Divya P)

Bronchial epithelial cells act as the first barrier to contact the exterior environment in the airway and plays a crucial role in lung diseases. Balancing the proliferation and apoptotic events of these cells are vital in maintaining epithelial cell homeostasis in pathological conditions. Gastrin releasing peptides (GRPs) are vital mitogens for normal human lung epithelial cells and plays a role in proliferation of bronchial epithelial cells. In this study, bronchial epithelial cells (BEAS 2B) were used to establish the LPS-mediated apoptosis by determining up regulation of microRNA miR-7-5p by using quantitative real time PCR. Upregulated miR-7-5p reduced the expression levels of target genes GRP and Raf 1 which are



antiapoptotic. The activity of miR-7-5p was further confirmed by transfecting the cells with miR-7-5p mimic and inhibitor. Cells treated with miR-7-5p mimic showed enhanced apoptosis and inflammation. Whereas, miR-7-5p inhibitor alleviated apoptosis related changes. Astaxanthin (2  $\mu$ M) was found to have better antioxidant activity in reducing the level of miR-7-5p and increased protein expression levels of Grp and Raf 1 by 3-folds. Results confirm that astaxanthin alleviate bronchial cell apoptosis and increased cell proliferation. Hence, astaxanthin exert its antiapoptotic activity in part through suppression of miR-7-5p and upregulating its target genes Grp and Raf-1.



Astaxanthin on LPS-induced miR-7-5p levels

### Pro-inflammatory dietary factors (AGEs) in age-related disease (Singh RP)

Accumulation of AGEs leading to cellular oxidative damage and tissue injury is known to cause cellular dysfunction and senescence. AGE-R1 is an anti-AGE receptor associated with the removal of AGEs counteracts oxidative stress, aging and related disease. However, prolonged exposure to AGEs results in the down regulation of AGE-R1 and exacerbates aging and disease condition. Dietary bioactives are known to regulate numerous cellular pathways involved in health and disease. The

ability of bioactives from *Boerhavia diffusa* stimulate AGE-R1 expression and modulate metabolic dysfunction and cellular senescence was studied. The ethanol extract of *B. diffusa* root powder showed high polyphenol content with significant radical scavenging activity and anti-glycation activity, as measured by their inhibitory effect on AGEs formation (AGE-BSA and MG-BSA). The HPLC profile and mass spectral analysis of bioactives of *B. diffusa* showed the presence of Boeravinone B and E as major components. The Boeravinone B and E were further purified and their inhibitory effect on formation of AGEs was evaluated by the fluorescence emitted by AGEs.

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

Glycosaminoglycans, ergosterol, phenolic acid concentrate and zerumbone were used to study the high fat induced effect and its associated complications like cognitive dysfunction. Ameliorations of various parameters of high fat effects such as body weight gain, OGTT, insulin levels, lipid profile, liver and adipose tissues appearance (colour and weight) and other anti-oxidative properties were clearly indicated in the results. Use of such bioactives in day-to-day life through various food products may be more effective in reducing obesity and its complications. Combinations of above bioactives are being used in developing food products. Mayonnaise, on a trial basis, was prepared by incorporating both zerumbone and phenolic acid concentrates. Further modifications and fine tuning of the product is under progress.



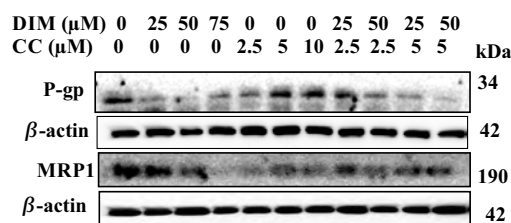
### Fermented tender coconut water with lactic cultures (Suresh Kumar G)

*Lactobacillus plantarum* (PS) and *Lactobacillus helveticus* (HS) culture was scaled up using MRS media and fermentation process of tender coconut water was optimized. PS showed better biomass and good amounts of secondary metabolites as well as decrease in pH at 37°C. Significant antimicrobial activity was observed in fermented material, compared to the unfermented sample. This could be due to secondary metabolites produced during the fermentation, which possess microbial inhibiting properties. The food product developed using fermented material was found sensorily acceptable. Scale-up, animal experiments for the health beneficial studies as well as storage stability of the product is under progress.

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

The tumor relapse due to the resistance to chemotherapeutics is the major problem associated with breast cancer treatment. The role of dietary bioactive in overcoming chemoresistance in breast cancer was investigated. The major player involved with drug resistance is drug efflux transporters. The ability of diindolylmethane (DIM), a dietary bioactive rich in cruciferous vegetables, in enhancing the efficacy of Centchroman (CC) by modulating the drug efflux transporters in human breast cancer cells was investigated. CC is a selective estrogen receptor modulator, having promising therapeutic efficacy against breast cancer. The combination of DIM and CC

synergistically inhibited cell proliferation and induced apoptosis in breast cancer cells. This novel combination has also hindered the stemness of human breast cancer cells. Molecular docking analysis revealed that DIM had shown a strong binding affinity with the substrate-binding sites of P-gp and MRP1 drug-efflux transporters. The expression of ABCB1 was highly elevated in human breast cancer. Intriguingly, DIM enhanced the intracellular concentration of CC by inhibiting the P-gp and MRP1 expression (panel A) as well as activity. The intracellular retaining of CC has increased its efficacy against breast cancer. Overall, DIM, a dietary bioactive, enhances the anticancer efficiency of CC through modulation of drug efflux ABC-transporters in breast cancer cells. Therefore, DIM-based nutraceuticals and functional foods can be developed as adjuvant therapy against human breast cancer.



DIM inhibits the expression of drug-efflux inhibitors in human breast cancer cells

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

The study was carried out with the aim to identify active lipases through functional omics approach. During seed germination, lipolytic enzymes are involved in mobilizing lipid reserves for proper seedling growth and development. Lipases and esterases, which belong to SH superfamily play a crucial role



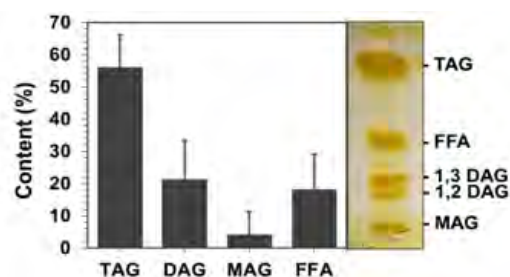


during this reactivation of metabolism. Conventional genomic and proteomic approaches have provided enormous information about the presence and expressional profile of rice (*Oryza sativa*) enzymes. However, such studies fail to provide insights into the functional status of the identified enzymes. The major limitation of such abundance-based methods is that the abundance of mRNA is often weakly correlated with protein function due to post-transcriptional and post-translational modifications. To fill such gaps, activity-based protein profiling (ABPP), a revolutionary chemo-proteomics tool to unlock the active players involved in rice seed germination on a global scale was adopted. The application of ABPP, in combination with mass spectrometry, provides information about functional enzymes irrespective of their abundance. ABPP approach is applied to reveal the activity of lipases during seed germination in rice (*Oryza sativa*) and profile the active serine hydrolases. The active sites of 43 SHs encompassing lipases/esterase, GDSL lipases, serine proteases, serine carboxypeptidases, ABHD protein, pectin acetylesterases and other SHs were successfully mapped. Each SHs are active at different time points of seed germination to support the required enzymatic process, revealing the dynamic nature of the active proteome (Activome). The mRNA expression levels of those genes encoding the identified SHs were further analyzed using microarray. The lipidome analysis by High-Resolution Mass Spectrometry revealed distinct patterns of molecular species distribution in individual lipid classes and shed light on the metabolic connections between lipid mobilization and rice seedling growth. Changes in the mobilization of storage lipids and their

molecular species remodelling were correlated with the expression of the identified lipases and their activity in a time-dependent manner. Further, the physiological significance of the identified SHs and their importance under biotic stress with *Fusarium verticillioides* infection, a seed-borne pathogen were studied. The infection impairs lipolytic activity, eventually reducing the seedling growth. Together, the study unveiled a much-needed portfolio of active enzymes mediating the process of germination. The data generated through these approaches will provide further stimuli for advancing fundamental research and deciphering the role of lipases in lipid homeostasis during rice storage and germination.

#### **Edible eicosapentaenoic acid and docosahexaenoic acid-enriched oil from fish-industrial discard (Vijayaraj P)**

An enzymatic and non-refining, bleaching and deodorisation (RBD) approach to effectively utilize and convert crude fish oil (FO) into edible FO enriched with eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) was proposed. Crude FO contains ~60% of triacylglycerol and 10-20% free fatty acids (FFA) with other glycerides such as diacylglycerol (DAG) and monoacylglycerol (MAG). The enzymatic process was developed



Glycerides composition of crude fish oil



for enhancing the triacylglycerol (TAG) content in the FO, and above 90% conversion was achieved. Further, the EPA and DHA enriched TAG fraction was separated by a non-RBD method. The optimization and scaling-up of the process are in progress.

### **Modulation of lipid accumulation by genetic and nutraceutical interventions**

(Ajay W Tumaney)

*Aurantiochytrium limacinum* is a marine protist capable of accumulating a large amount of the omega 3 fatty acid docosahexaenoic acid. It was hypothesized that expression of *A. limacinum* DGAT genes in plants can augment the omega 3 content of plants. *Arabidopsis thaliana* is a model plant and therefore selected for the study. Two DGAT genes from *A. limacinum* was identified and isolated.

### **Interaction among safety peptides and their role in energy homeostasis**

(Uma Manjappara)

Obestatin and Nt8U, the N-terminal fragment analog of obestatin are shown to reduce food intake and gain in body weight and also reduced epididymal and perirenal fat in mice. Many reports and previous studies describe interactions between satiety peptides in the regulation of food intake and reducing body weight. The gut peptides under different metabolic conditions are not released individually but simultaneously to regulate food intake and digestive signals. Towards studying the possible interactions amongst satiety peptide, the effect of obestatin and Nt8U on other satiety peptides (like CCK8, GLP-1, oxyntomodulin and peptide YY), high-fat fed C57BL/6 mice were administered with the peptides obestatin and Nt8U for a period of

four weeks intraperitoneally and monitored their body weight and food intake. Orlistat was used as the positive control and compared with the treatment groups. The body weight of mice treated with obestatin was reduced compared to saline treated group. Lipid parameters were analysed in plasma and found reduced levels of triglycerides and cholesterol in Nt8U administered group. The plasma enzymes SGPT, SGOT, ALP and LDH assays, weight and appearance of the organs showed the vital organs were unaffected by the treatment. Further experiments on the effect of these peptide on other peptides like CCK-8, GLP-1, Oxm, peptide YY which shows any interactions are being carried out.

### **Metabolic engineering of *Saccharomyces cerevisiae* for production of linalool**

(Sarma MVRK)

*In-silico* flux-balance analysis of the genome scale metabolic model, iMM904, has led to the identification of handful of overexpression gene targets for enhancement of acetyl-coA flux in *S. cerevisiae* which is precursor molecule for sterol pathway. Out of these two gene libraries were prepared. Codon optimized linalool synthase (LIS) for *S. cerevisiae* was obtained from Genscript. Two variants of LIS, viz., fLIS and tLIS indicating full length LIS gene with native plastid target signal and its truncated derivative by removing plastid sorting signal, respectively, were expressed in CENPK 2.1 C strain. These strains were designated as SA4 and SA5 and a maximum of 0.637 mg/L of linalool was observed in case of SA4 strain. Later, co-expression of tHMG1 (truncated HMG1-CoA reductase), which is considered as the rate-limiting enzyme in the



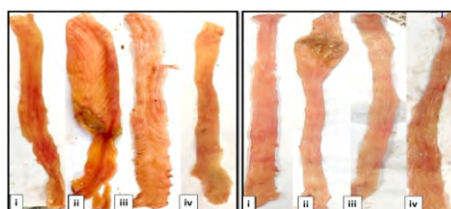
sterol pathway, was carried along with fLIS to generate strain SA7. The maximum amount of linalool in SA7 was observed to be 0.447 mg/L. The co-expression of tHMG1 has not improved the linalool synthesis beyond fLIS manifestation and studies are being carried to understand this phenomenon. Multiple analytical procedures were carried to standardize the synthesis of linalool. Solid-phase extraction (SPE) using C18 cartridges and solid-phase micro extraction (SPME) using fiber coated with DVB-CAR-PDMS (50/30  $\mu$ m) were used. All the volatiles were analyzed using GC-MS and the linalool peak was observed at the retention time (RT) of 9.39, followed by  $\alpha$ -terpineol at the RT of 11.16.

#### **Bio-waste management for value added biotechnological products** (Swaroop Rani D)

Churned canteen food waste was treated with  $H_2SO_4$  at different concentration and heat treated. Pre-treated canteen food waste was used as cultivation medium for the production of vitamins, polyphenols, pigments and enzymes. B-complex vitamin production was reported with *Lactobacillus* culture. *Monascus* cultures cultivated in canteen food waste media for the production of pigments. A 10 kg biogas reactor was designed and utilised for the studies in production of methane. Methane biogas production studies were carried out using the pre-treated canteen food waste mixed with methanogenic consortia resulted in 56% of biogas. Canteen waste was also used for production of  $\beta$ -glucosidase using an *Aspergillus* strain. It was observed that, using the 25% waste (corresponding to approximately 2% reducing sugars) a maximum of 4337 U/L was obtained.

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

Study was carried out to purify peptide antibiotics having mode of action inhibiting RNA biosynthesis. The extract was separated by RP-HPLC wherein active peak eluted at 12 minutes was obtained exhibiting beta-gal activity against yvgS reporter. MALDI-TOF MS spectrum of HPLC fraction showed the antibiotic peptide mass at 1701Da. The health benefits of *Bacillus licheniformis* 2514 was studied on two disease conditions such as Crohn's disease and ulcerative colitis. Upon the induction of inflammation, the weight of the rats' reduced and diarrheal condition appeared. On the supplementation of *Bacillus licheniformis*, the inflammation level were decreased which resulted in the colon morphology. As a part of food application, the probiotic carrot shreds were formulated using *Bacillus licheniformis* 2514. The optimum bacterial viability was achieved in 40% sugar concentration. One hundred million bacterial cells per ml were added and viability varied from  $6.6 \times 10^7$  to  $6 \times 10^5$  upon 10% to 70% sugar solution. Brix level varied from 11 to 51. The product's moisture was 16 to 18 after drying. Optimum viability and texture were optimized in shredded carrots.



Ulcerative colitis

Crohn's disease



**Ready to use multi-grain idli and dosa batter with extended shelf life** (*Rohini Karnat*)

For multigrain idli preparation, grains were incorporated at different levels by replacing black gram in the traditional idli batter ratio. The increase in titratable acidity ranged between 0.17- 0.24, and the decrease in pH value of idli batter ranged between 6.40 to 4.50. The rise in volume, pH, titrable acidity, reducing sugar (RS) and total sugar content, moisture, microbial analysis, ash, protein, dietary fiber of batter after fermentation were evaluated. After fermentation, the fat content in the multigrain batters from IM-2 to IM-10 decreased (0.79-0.01%), and there was an increase in dietary fiber ranged from (0.87-1.25-%). The reducing sugar and protein content also increased. Multigrain idlis (IM-2 to IM-10) resulted in improved textural values and bulk density compared to control idlis. The multigrain idlis had the better nutritional profile, and sensory attributes were evaluated.

**Plant cell wall deconstructions of crop-residues 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%. SEM, XRD and FTIR protocols were used for visualization and characterization of the complex morphology and macromolecular structure of plant cell wall of crop residues

before and after pre-treatment. The inhibitors such as furan aldehydes, organic acids, 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 pre-treatment (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. The optimization of parameters involved in fermentation process was carried out by varying one variable at a time (OVAT) method. The xylitol yield at varying xylose concentration was found to be in the range of 0.89-9.47 g/L. The maximum yield of 0.48 g xylitol/g of xylose and productivity of 0.13 g/L/h was obtained under 30°C and 200 rpm at optimized xylose concentration of 2%. The maximum xylitol concentration of 9.47 g/L was found at 2% xylose concentration. Further decrease in xylitol yield was observed because of substrate inhibition.





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

The low thermal pre-treatment system followed by anaerobic digestion has been 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 m<sup>3</sup>) has been installed at a model dairy and commissioned. Pre-treated FOG sludge was used as substrate for anaerobic digestion at 33°C in a shaker incubator. Substrate to inoculum ratio (v/v) of 0.5 (1:2) was maintained with TS of 6.2%. The experiments were carried out for three representative samples from Nandini dairy at Mysore and one representative sample from Amul dairy, Nagpur. FOG sludge was treated with lipase enzyme for 18 h and 24 h and was subjected to anaerobic digestion. Enzymatic treatment was analyzed for changes in fatty acid pre- and post-enzymatic pretreatment. Further, the lipase pre-treated FOG sludge was compared with untreated for methane enriched biogas production. It was found that sludge treated with lipase enzyme for 18 h showed 5.7-fold enhancement with respect to untreated FOG sludge. Anaerobic digestion of pre-treated FOG sludge is scaled up to 10 L scale anaerobic digester and is in operation. It was operated for varying substrate concentrations at 130 and 100 rpm. It was observed that 2% and 3% substrate concentrations operating at 130 rpm gave high methane content in comparison with other concentrations. The samples from pilot scale anaerobic digester located at model dairy was collected for a period of 4 months. The inlet and outlet FOG sludge samples were carried for various physico-chemical parameters such as

COD, total solids, TSS, TDS, VS and alkalinity. 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 bioreactor has been developed at 20 L scale in the laboratory, which will be scaled up to pilot scale at model dairy shortly.

### **Engineered production of stearidonic acid in Chia (*Salvia hispanica*) (Sreedhar RV)**

*Buglossoides arvensis* is a Himalayan plant naturally accumulating the highest known percentage of unusual omega-3 fatty acid, stearidonic acid (SDA) in its seeds. By transgenic expression in *Saccharomyces cerevisiae*, fatty acid desaturase 2, fatty acid desaturase 3 and delta-6-desaturase1 (BaD6D1) genes of *Buglossoides arvensis* were functionally characterized. The BaD6D1 was further expressed in arabidopsis under the control of the oleosin promoter. SDA content of 0.4-0.7% of total fatty acids was noticed in transformed plant seeds. Low levels of SDA may be due to the inability of inherent acyltransferases to accumulate non-native fatty acid - SDA. Functional characterization of four major acyltransferases of *B. arvensis* is in progress. Improvement of seed yield, oil content and SDA levels for commercial cultivation is challenging in *B. arvensis*. Chia (*Salvia hispanica*) is a rich source of ALA which can serve as a substrate for the synthesis of



SDA by BaD6D1. Genetically transforming Chia with BaD6D1 gene to study the synthesis and accumulation of SDA is under progress.

#### **Stable anthocyanin in *Saccharomyces cerevisiae* (Nandini P Shetty)**

Specific anthocyanin biosynthetic genes from Gerbera hybrid, *Arabidopsis thaliana* can be introduced to yeast (*Saccharomyces cerevisiae* or *Pichia pastoris*) strains to produce flavonoid precursors of anthocyanin. This study reports the in silico analysis, molecular cloning and expression of anthocyanin pathway genes to produce stable anthocyanins in yeast.

#### **High performance hybrid process development for CO<sub>2</sub> sequestration (Ajam Shekh)**

Five different microalgal species viz. *Asterarcys quadricellulare*, *Chlorella sorokiniana*, *Chlorella* sp., *Chlorella lewinii*, and *Nannochloropsis oceanica* were isolated from local habitats, purified and identified using 18s rDNA sequencing. Amongst these, *Nannochloropsis oceanica* (isolated from rock pools of Diveagar seashore, Pune, Maharashtra) was chosen for the study due to its high EPA content. Further, *N. oceanica* was cultivated using closed photobioreactor to study the effect of CO<sub>2</sub> concentration and light intensity on biomass and lipid production with special emphasis on EPA content. Under various cultivation conditions tested so far with respect to CO<sub>2</sub> concentration and light intensity, the biomass productivity of 120 mg/l/d with EPA content of 25-30% was achieved. Also, the metagenomics analysis of spirulina cultivated under different pH conditions was done to understand the change in population dynamics of spirulina cultivation medium. Further, the studies on

chemical free extraction and purification of C-PC from spirulina biomass are in progress.

#### **Biodiesel production using indigenous microalgae of North-East India (Chauhan VS)**

The effects of nitrogen sources on cell growth and lipid accumulation of freshwater green microalgae species was studied. In order to investigate the effect of nitrogen sources on the cell growth and biochemical composition of the fresh water microalgae, seven different N sources, including NaNO<sub>3</sub>, KNO<sub>3</sub>, Ca(NO<sub>3</sub>)<sub>2</sub>, (NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub>, NH<sub>4</sub>Cl, CH<sub>3</sub>COONH<sub>4</sub> and glycine extract were compared. The highest lipid content of 23.2% was obtained in NH<sub>4</sub>Cl treated cultures. Highest biomass productivity (40 mg/l) and photosynthetic efficiency was observed in cultures which used sodium nitrate or urea as the nitrogen source. Ammonium bicarbonate resulted in the lowest lipid productivity of 14%.

#### **Hydrogen peroxide as signaling molecule for enhanced lipid biosynthesis (Ajam Shekh)**

*Chlamydomonas reinhardtii* CC124 was chosen to study the effect of various stress inducing chemicals on ROS linked lipid enhancement. Dose and time dependent studies were carried out with H<sub>2</sub>O<sub>2</sub> and Brefeldin A, which clearly indicated the positive correlation with their dose and intracellular ROS generation. Further, the ROS synthesized in the cell was linked to lipid enhancement. Interestingly, ROS induced lipid synthesized by *C. reinhardtii* CC124 was found to have not much significant difference in its FAME composition. In order to compare with standard lipid enhancing nutritional stress condition, the above chemical treatment conditions were compared with



nitrate and phosphate depletion which also corroborated the link between stress-ROS-lipid enhancement. Further, the molecular biological studies to understand the mechanism behind ROS induced lipid enhancement are in progress.

**Regulatory genes involved in pungency in *Capsicum* sp. (Giridhar P)**

The main aim of the project was to decipher the functional role of ethylene regulatory factors Erfs and Jerf on the capsaicinoid biosynthesis pathway. As a prelude to this high end molecular biology work, it is necessary to establish high pungent variety based *Capsicum callus*

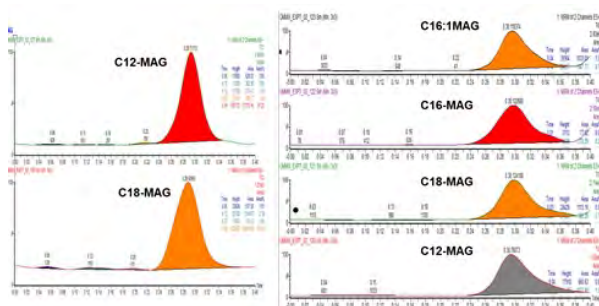
cultures and *in vitro* plants to use for genetic transformation studies with the prepared constructs. Accordingly, low and high pungent variety of chilli was procured from authentic source along with bird eye chilli seeds (which were very high in pungency) and established potted plants. Simultaneously, seeds were put for *in vitro* germination. The obtained seedling parts were used for initiation of callus. As of now, one low pungent and one moderately pungent variety of chilli cultures were established. The callus growth curve and capsaicin content in established culture analysis are under progress.



## FOOD PROTECTION AND SAFETY

### Monoacylglycerols and diacylglycerol isomers in margarines and milk products (Usharani D)

Esters of monoacylglycerides (MAG) and diacylglycerides (DAG) belonging to the E 471 emulsifier series were investigated in dairy products and margarines using mass spectrometry and Nuclear Magnetic Resonance (NMR) spectroscopy. Structural characterization of 1-MAG and 1,2-DAG and 1,3 DAG were performed by  $^1\text{H}$  and  $^{13}\text{C}$  NMR. A LC-MS/MS method for monoacyl glycerols was developed with limit of detection of 3 ppb using internal standard 18:1 (d7) MAG. Fatty acid profiling of the emulsifiers using gas phase chromatography and LC-MS/MS revealed that lauric, palmitic and stearic acid were the predominant MAG species. Market survey of desserts and inter and intra lab validation of method is in progress.



LC-MS/MS spectrum of Monoacylglycerols (MAG) of different chain length observed mostly in the dairy products

### Bio-fumigant formulation stability during short-term and long-term storages (Ezil Vendan S)

A bio-fumigant formulation (BFF) comprising of garlic and peppermint essential oils and allyl disulphide phytochemical was evaluated for its fumigant toxicity and insecticidal activity against the pulse beetle *Callosobruchus maculatus* adults. BFF was stored at room condition and the insecticidal activities and physico-chemical characteristics evaluated at regular intervals upto six-month storage period. Within 24 h of fumigation exposure, 100% mortality of *C. maculatus* adults was observed at 25  $\mu\text{L/L}$  air concentration for short-term and long-term stored BFF samples. GC-MS analysis revealed increase in allyl disulfide, diallyl disulfide and menthone levels and decrease in diallyl trisulfide, menthyl acetate and allyl sulfone levels in BFF samples with increasing storage period. Physical appearance of BFF changed from pale yellowish to pale brownish with the increase of storage duration ( $r^2 = 0.97$ ). No negative correlation was observed between fumigant toxicity and phytochemical changes in the BFF stored samples. Results suggests that the BFF insecticide was effective against *C. maculatus* and it can be stored up to six-months period.





## CSIR PROJECTS

### COVID-19 Projects

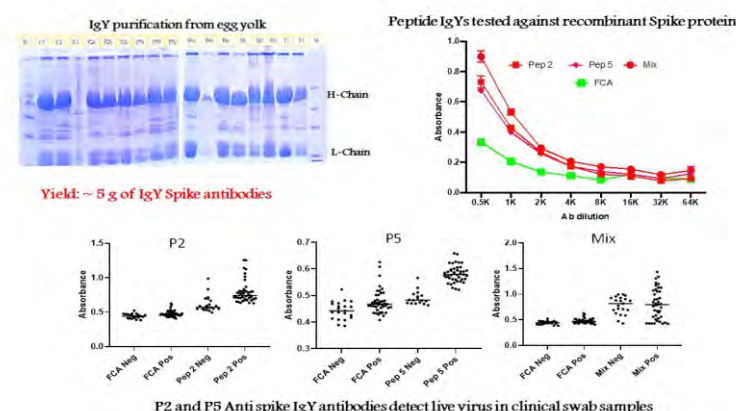
#### Dipstick kit for precise detection of COVID 19 infection (*Poornima Priyadarshini CG*)

The present project aims to develop a method for detecting SARS-CoV-2 infection in patient saliva/swab samples using antibodies generated in chicken against SARS-CoV-2 spike protein derived antigenic peptides. To generate specific antibodies that can detect SARS-CoV-2 virus but not SARS-CoV in live samples, a set of five peptides was designed. These peptides were designed based on two criteria: a) peptide sequences specific to SARS-CoV-2 spike protein and not homologous to SARS-CoV spike protein, and b) using a structure-based design criteria, peptides that are exposed on the surface of SARS-CoV-2 spike protein. This ensured that the antibodies generated will detect the intact virus in live swab/saliva samples. Out of the five peptides immunized either individually or in combination of all five (mix), two peptides (pep 2 and pep 5) and mix combination gave rise to significant antibody titers against the immunized peptide and against the

recombinant spike protein trimer. Further, large quantities (3-5 g) of the anti-spike polyclonal antibodies secreted in eggs was purified using cost-effective PEG method. The antibodies generated against the two peptide and mix peptides were further validated for their reactivity against COVID +ve swab samples with < 35 Ct values for both N gene and ORF1ab gene using a sandwich ELISA procedure. Hence, the three antibodies generated in this study can be used for applications to develop ELISA based detection kits for live/dead SARS-CoV-2 virus in swab/culture/saliva samples, to develop ELISA based detection kits for SARS-CoV-2 spike protein, and to develop a point of care, lateral flow dipstick device as self-diagnosis for COVID-19.

#### Aptamer for recombinant SARS-CoV-2 spike glycoprotein S1 (*Praveena Bhatt*)

The aim of the present work was to express SARS-CoV-2 spike glycoprotein-S1 viral antigen in *P. pastoris* and generate highly sensitive aptamer against the viral protein for its





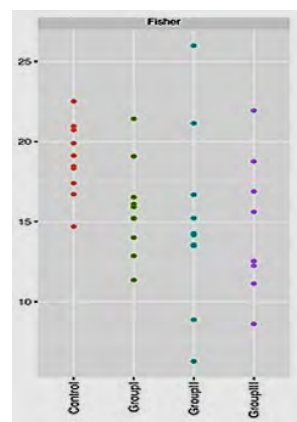
application in diagnostics. A process for the full-length expression of codon optimized S1 gene in *P. pastoris* cell factory followed by its one-step purification using Ni-NTA affinity chromatography was developed. An automated feeding strategy was established for high cell density cultivation of this recombinant strain to synthesize the required antigen protein. Approximately, 180 mg/L of purified protein was obtained after Ni-NTA purification. The recombinant protein was subjected to SDS-PAGE and the expression of S1 was confirmed using western blot analysis and LC-MS. High affinity aptamers against the viral spike protein were generated using a modified protocol of BioLayer Interferometry based SELEX (developed in the lab). Among the enriched oligonucleotide pool, the lead sequence was characterized for its binding affinity. Primary validation of the aptamer sequence for its ability to bind to viral protein was carried out using the concentration dependent binding assay as well as ACE binding inhibition assay. Both *in vitro* and *in silico* studies indicated that the selected aptamer could bind with nanomolar affinity to the RBD region of S1, indicating its potential application in Covid 19 diagnostics. Developing an aptamer-based detection platform for SARS-CoV-2 with an industrial partner is under progress.

### **Pectin-derived prebiotics as adjuvants for prophylactic treatment of corona (Mahejibin Khan)**

A cross sectional prospective study was performed on RT-PCR confirmed COVID-19 patients and Covid-19 RT-PCR negative, healthy volunteers. IFN $\gamma$ , TNF $\alpha$  and IL-21 profiling was done from plasma samples and

gut bacterial analysis was performed after obtaining metagenomics data of stool samples. Patients with variable COVID-19 severity showed distinct gut microflora and peripheral interleukin-21 levels. Lachnospiraceae, Ruminococcaceae, *F. prausnitzii* and *Roseburia* spp. and *Prevotella* were found negatively correlated with disease severity. Low firmicute / bacteroidetes ratio, consequent to depletion of fiber utilizing bacteria, *F. prausnitzii*, *B. plebius* and *Prevotella* and increase in bacteroidetes, associated gut microbiota dysbiosis was associated to Covid-19 disease severity. It was concluded that loss of functional attributes of signature commensals in the gut, due to dysbiosis, is a predisposing factor of Covid-19 pathophysiology.

Activation of mucosal immunity and balancing Th response in mice model through pectic oligosaccharide (POS) supplementation confirms immune enhancing benefits of POS. Modulation of gut microbial diversity and increased counts of *Prevotella* and other fiber utilizing bacteria involved in immune activation and protection against various inflammatory disease provide insight into the mechanism of POS.



Alpha diversity of gut microbiome of healthy and Covid-19 diseased groups



## Focused Basic Research / Niche Creation Projects

### Non-digestible carbohydrates as functional mimics of human milk oligosaccharides (Ravi Kumar)

Mother's milk is recommended for all infants. However, in some cases breast feeding is inadequate or unsuccessful for medical reasons. For such scenarios, infants are fed with formula milk. Existing infant formulae do not induce similar effects of mother's milk due to lack of small but complex carbohydrate structures known as human milk oligosaccharides (HMOs). These HMOs shapes and modulate the gut microbiota during infancy. There is an increasing interest in the development and identification of new carbohydrates / oligosaccharides having such prebiotic effects. Under this project, the role of non-digestible carbohydrates from natural sources structurally similar to HMOs that can mimic its function would be characterized. In this regard, the extraction and purification of potential oligosaccharides from plant and marine sources has been initiated. In future, their specificity as a carbon substrate for infant gut bacteria will be studied.

### Chito-conjugates of spice bioactive and clove oil nano-encapsulated polymeric films (Pooja J Rao)

The preparation of chito-conjugates with spice bioactives was initiated. In this regard, non-hydrophilic bioactives such as tetrahydrocurcumin, dehydro-zingerone, and zingerone were made water-soluble by conjugating with chitosan scaffold using suitable catalysts. The different methods for extraction of clove oil have been employed to get a higher yield. The extracted clove oil was nanoencapsulated using suitable carrier to achieve an average particle size of 247 nm where more than 60% particles were below 100 nm. The zeta potential was in the range of -24 to -26 mV.

### Metabolites from *Ulva lactuca* and development of functional food products (Revathy Baskaran)

Seaweed *Ulva lactuca* was collected from the seashore of Mandapam area of Ramanathapuram, Tamilnadu. Following the optimized process, the powder was obtained and analysed for different chemical parameters. The average total phenolic content of powder was 127 mg GAE/ 100 g and total flavonoids content was 130 mg QUE / 100 g.





### **Prototype of machine learning based ripening classifier (RIPETECH)**

(Vijayanand P)

Initial studies on ripening using ethylene and calcium carbide are being undertaken and various analytical parameters are being studied. The selected mango variety will be used for carrying out the experimental studies on ripening. The effect of ripening method on the changes in the physico-chemical characteristics of the fruit will be investigated to identify the features affecting the ripening process.

### **Structure-function relationships in enzymes**

(Ravi Kumar)

Flavin adenine dinucleotide synthetase (FADS), a bifunctional prokaryotic enzyme, is involved in the synthesis of two vital cofactors, flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD). The biochemical characteristics of FADS from *Staphylococcus aureus* (Sa) was investigated. The SaFADS possesses riboflavin kinase (RFK) and FMN adenylyl transferase (FMNAT) activities that transforms riboflavin to FMN and FMN to FAD, respectively. The FMNAT domain also exhibits reversible FAD pyrophosphorylase activity (FADpp). Previous study exhibited the requirement of reducing environment for both FMNAT and FADpp activities. Additionally, the role of conserved K289 and F290 residues present on the RFK domain was proved. Chromosomal shape and topological changes are monitored by condensins, i.e. structural maintenance of chromosome proteins (SMC), MukB and MksB. SMC are vital proteins involved in this task. SMC protein is a family of highly conserved chromosomal ATPases

among the three life phyla, i.e. bacteria, archaea and eukaryotes. It has been shown that *Mycobacterium smegmatis* SMC forms a functional complex with ScpA and ScpB accessory proteins. However, scpb deletion mutant of *M. smegmatis* showed no growth defects.

### **SREBP inhibitors as novel therapeutics for non-alcoholic fatty liver disease**

(Madan Kumar P)

Non-alcoholic fatty liver disease (NAFLD) is a severe global health problem and recent scientific evidence has suggested increased sterol regulatory element binding protein (SREBP) activation as one of a major characteristic of NAFLD. Studies targeting SREBP activation with food bioactives for NAFLD treatment is very limited. Therefore, this study will investigate a novel molecular approach to decipher the actions of SREBP inhibition by SREBP inhibitors, which could lay the groundwork for the future development of new drugs for NAFLD. Selected food bioactives, which are earlier shown to exhibit hepatoprotective effects are further tested for SREBP inhibiting potential. LX-2 cells (human hepatic stellate cells) treated with a food bioactives showed cytotoxicity in a dose and time dependent manner. Cell cycle profiling by PI staining showed G0/G1 cell cycle arrest in food bioactive treated cells.

### **Deciphering the mechanism of host endophytes coevolution enhanced secondary metabolite production and crop productivity**

(Nandini P Shetty)

Turmeric (*Curcuma longa*) is an important spice primarily valued for its colour, aroma and its antioxidant property. Curcuminoids are an important group of secondary metabolites





formed in the turmeric rhizome. Curcumin, demethoxycurcumin and bisdemethoxycurcumin are the three major curcuminoids out of which curcumin plays an important role. The important feature of the plant is that the rhizome provides a habitat for various bacteria and fungi. Some of these endophytes have growth promoting properties and also help in the production of secondary metabolites. This study aims to determine the curcumin content using HPLC in rhizome samples collected from different geolocations. The isolation of bacterial and fungal endophytes from the rhizomes will aid in the understanding of host-endophyte interactions for the production of secondary metabolites.

**Strategies to reduce mycotoxins in cereal grains during storage condition through "Seed-Endophyte" interactions** (*Vivek Babu CS*)

Maize seed samples having specific traits (heat and drought tolerant) from different parts of Karnataka (Mysore/Raichur/Davangere) were collected. Three maize seed samples were subjected to endophyte analysis through culture independent approaches (V3-V4 and ITS sequencing/metagenomic analysis). Sourcing of aflatoxigenic and non-aflatoxigenic *Aspergillus* strains and initial screening of aflatoxin producing capability has been carried out. Biocontrol potential of seed endophytes against aflatoxigenic *Aspergillus* strains and parallel studies on isolation and characterization of seed endophytes from different maize genotypes is under progress.

**Capsicum and flax seeds improvement through genome editing** (*Nandini P Shetty*)

Fruits come in a different variety of forms with both dry and fleshy types being essential

components of the human diet. One of the crucial phases of fruit development is accompanied by ripening, which is related to softening. Cell wall degrading enzymes are involved in the softening of fruit, and there are several enzymes that degrade the cell wall of the fruit. N-glycan processing enzymes are reported to play important roles during fruit ripening associated with softening.  $\beta$ -Xylosidase, a member of the N glycan processing enzyme family have an important role in the degradation of the cell wall of several crop plants. To study the role of xylosidase in the senescence of bell pepper, the gene in the fruit will be knocked out which is responsible for coding  $\beta$ -xylosidase using the CRISPR-Cas9 gene-editing tool and further work will be done by using protein analysis and gene expression studies.

**Biofertiliser, biorefinery, biofeed and recovery of biopolymers from fishery waste** (*Tanaji G Kudre*)

Present study investigated the use of fish oil derived from marine fish processing discards as well as the low-cost solid heterogeneous base catalyst for sustainable production of biodiesel. The physicochemical properties such as moisture content, ash content, free fatty acid value, iodine value, fatty acid composition and viscosity of marine waste oil were evaluated. The characterization of solid heterogeneous base catalyst prepared by calcination of egg shell, shrimp shell and crab shell at 900°C for 4 h was carried out to determine their catalytic performances. The transesterification of marine fish waste oil using calcined egg shell catalyst was optimized using RSM, and the results revealed that the optimum conditions for a maximum biodiesel



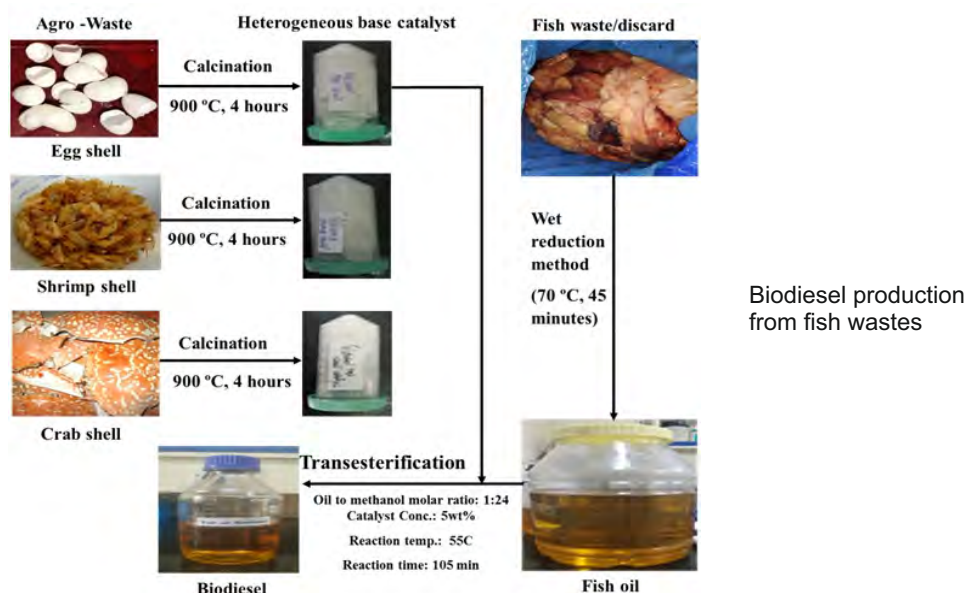
yield of 86.5 wt.% from marine fish waste oil using calcined egg shell catalyst were methanol to oil molar ratio of 24:1, catalyst concentration of 5 wt.%, reaction temperature of 55°C, reaction time of 105 minutes at constant stirring rate of 200 rpm. TLC, FTIR and GC analysis confirmed the conversion of marine fish waste oil to biodiesel. From the current study it can be concluded that fish processing discards and heterogeneous catalyst prepared from waste could be helpful in achieving sustainable biodiesel production.

## Fast Track Translational / Fast Track Commercialization Projects

### Rapid honey adulteration detection system (Prasanna Vasu)

The detection of adulterated honey is of considerable challenge. The usual practice is to independently check the different parameters

like, the water content, sugar content, acidity, Hydroxymethylfurfural (HMF) value, ash content, etc., in order to determine the quality of a given honey sample. However, measuring and employing a single parameter for the classification reduces the accuracy of the classification. Thus, in this project a multi-parameter-based honey quality classification is proposed to ensure a better accuracy. The design of a parameter detector and a classifier which can automatically complete the classification of a given sample is also presented. The proposed system is a handy tool for accurate, quick, low cost and simple honey quality checking. This will be validated using EA-/LC-IRMS analysis, which can unequivocally distinguish the adulteration sugar, whether it is from C3 or C4 plants. An array of honey samples, genuine and adulterated with C3 and C4 sugars at different levels are prepared, analyzed by IRMS, and are now ready for testing using the handy tool.





### **Arabinoxylan from wheat bran and its incorporation in low dietary fiber food products** (*Sachin M Eligar*)

Arabinoxylan (AX) is an important dietary fiber known to have many health benefits, including prebiotic, hypoglycemic effect, antioxidant, hypocholesteremic, improved immune health, and anticancer properties. The process of isolation of soluble and insoluble arabinoxylan from wheat bran was optimized. The process is cost-effective with improved recovery and yield. Incorporation of soluble and insoluble AX into bakery and meat products was carried out. Incorporation at different percentages didn't affect the product characteristics. The addition of AX into low dietary food products will give value addition to the product and health benefits to the consumers.

### **Export protocol (sea route) for fresh pineapples** (*Negi PS*)

Although India is the fifth largest producer of pineapple (7% of total world production), it occupies 33rd position among pineapple exporting countries. Export of pineapple to the long distance markets is being done by air, and non-availability of sea protocol is limiting its export in large quantities. However, the low temperature storage required to extend the shelf life of fresh pineapples is reported to cause internal browning (IB). At present, there is no effective method to control IB in pineapple, which limits its prolonged storage and export by sea transport. Experiments with the anti-browning agents to control internal browning in pineapple resulted in delaying internal browning, and the shelf life of untreated pineapples (2 wks) increased to 4 wks in

cysteine hydrochloride treated fruits. The shelf life was also enhanced in ascorbic acid (3 wks), citric acid (3 wks), sulphur dioxide (4 wks), and 4-hexylresorcinol (4 wks) treated fruits.

### **Minimally processed fruits with extended shelf life** (*Revathy Baskaran*)

Pilot scale storage studies for bulk handling of minimally processed fruits like apple, papaya, pineapple, jackfruit and pomegranate were completed. Shelf life of the fruits under refrigerated storage of minimally processed apple, papaya, jackfruit, pineapple and pomegranate are 10, 12, 15, 12 and 21 days respectively at  $4 \pm 2^\circ\text{C}$ .



Jack fruit

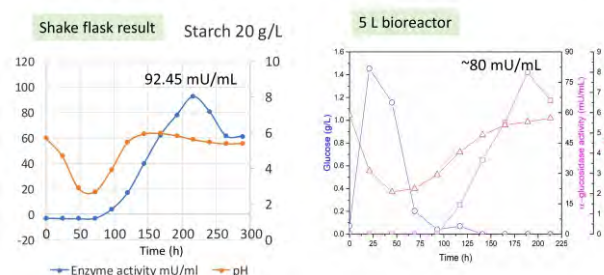
Mixed fruits

### **Isomaltooligosaccharides (IMO) using indigenous transglucosidase from starch sources** (*Sarma MVRK*)

In the present study, an indigenously isolated *A. niger* NCIM 1400 strain (non-pathogenic and non-niger) has been established for transglucosidase activity which aids in preparation of IMO. This strain when cultivated in 5 L bioreactor using tapioca starch, resulted in maximum of 80 U/L at the end of 189 h as compared to 92.45 U/L in shake-flask results at the end of 215 h. Using starch for production of  $\alpha$ -glucosidase instead of maltose has lowered



the medium costs almost 10-fold, however resulting in similar activity value. Thus produced  $\alpha$ -glucosidase when dosed along with Mashaid (starch saccharifying enzyme) for pretreated tapioca starch (treated with Solubaid, starch liquefying enzyme) resulted in 35% isomaltooligosaccharides (comprising majorly 20% panose, 12% isomaltose, 3% higher oligosaccharides) at 200 mL scale. The yield of IMO is being optimized at bench reactor scale using different combinations of starch degrading enzymes. This process is being scaled for 100 litre for both enzyme and IMO production.



Comparison of  $\alpha$ -glucosidase synthesis during cultivation at shake-flask and 5 L reactor

## Mission Projects

### Advancing Technological Leads for Assuring Safety of Food (ATLAS)

#### Edible and biodegradable materials for electrostatic coating to fruits and vegetables for enhanced shelf-life (Matche RS)

Trails were conducted on the formulation of different edible coating materials, considering different fruits and vegetables like tomato, strawberry, etc. With respect to suitable parameters, characterization of the coating materials was done i.e., the viscosity, resistivity and also the chargeability of the materials. Besides that the SOP for materials synthesis

were prepared. Different perishable fruits and vegetables with distinguished properties of coating material to enhance the shelf-life with the help of electrostatic spraying technology were identified.

#### Native and recombinant bacteriophage based nanoprobe/biocontrol formulations for food preservation and food safety (Poornima Priyadarshini CG)

The project aims to isolate, characterize and develop bacteriophages based biocontrol formulations with enhanced bactericidal activity to contain food contamination in natural way. Efforts have been made to isolate novel phages from poultry, livestock farms and sewage sources using spot assay and soft agar overlay plating techniques. The results showed that the isolated phages were distinct and highly specific to their hosts. The phage preparations were purified by PEG precipitation methods and the host range was tested against different bacterial strains. The phage DNA was extracted for genomic analysis and generation recombinant bacteriophages.

#### Ethylene and oxygen scavenger to increase the shelf life of food products (Matche RS)

*Ethylene scavenger:* Optimization of developed scavengers and kinetic studies of the scavenging reaction is in progress. Ethylene scavenger were prepared from agricultural by-products treated at different conditions with different activation temperature and time. This ethylene scavenger was compared with commercially available chemical-based ethylene scavengers. Agricultural by-products and industrial by-products at 500°C and 600°C show constant





scavenging capacity for 5 days, while in commercial ethylene scavenger there is a decrease in the scavenging capacity. The rate of reaction increased 10 times as the activation temperature of the material increases, and it is easily saturated due to vigorous reaction.

*Oxygen scavenger:* Various materials were studied for oxygen scavengers. Six hybrid adsorbents were prepared to carry out the research work on oxygen scavengers. A total of 18 materials were explored to study the scavenging of oxygen. All materials were extensively carried out at various proportions with respect to volume and time. Some of the materials were activated by UV light at 365 nm for 15 minutes. NICSW and NICUS scavengers showed encouraging results as compared to other scavengers.

#### **Integrated approaches for bioactives and value addition for floral resources under 'CSIR Floriculture Mission'**

##### **Natural bioactive agent immobilized freshness keeper** (*Matche RS*)

Raw materials with bioactive compounds in agricultural produce and by products for freshness keeper were selected. Based on their keeping quality, natural bioactive compounds were extracted from the selected agricultural waste like lemon leaves, neem leaves, moringa leaves, takala leaves etc. Different extracts were mixed with different proportions to optimize the freshness keeper quality which were then incorporated into packaging material for vase life studies of different fresh cut-flowers like rose, gerbera, etc. Preliminary shelf-life studies were tested. It was found that one of the optimized proportions

of freshness keeper increased the shelf life compared to the control which showed signs of wilting of cut rose flower, fungal growth, microbial attack and thus loss of freshness after 12 h and with the developed freshness keeper paper the same sign was observed after 26 h.

##### **Isolation of marigold floral volatiles, pigments and spent utilization for value added products** (*Bettadaiah BK*)

Marigold (*Tagetes erecta*) oleoresin was collected as per the method available on a bulk scale starting with 50 kg of flowers available in the local market (bright orange color). Oleoresin was collected for the purpose of utilizing for the lutein extraction by hydrolysis process. The specifications of the oleoresin were conforming to the standards. *Tagetes erecta* flowers were collected from the local market. The aerial parts of the flowers were separated and dried at 40°C in hot air oven. About 2 kg of dried plant material was subjected to steam-distillation for 4 h and the resultant emulsion was collected. The oil has been extracted using ethyl acetate which was later evaporated and the concentrated oil was stored in a sealed vial at low temperature for the analysis. The essential oil was obtained as yellow liquid in a yield of 0.5 ml on dry weight basis. GC analysis of the same is in progress.

##### **Integral approaches for bioactives and value addition for floral resources** (*Rastogi NK*)

With a focus to provide the value addition and implementation of agro technologies to the concerned commodities such as chosen flowers the work has been initiated. Accordingly, to extend the durability of fresh flower by



implementing novel technologies, extraction of natural bioactive compounds by an upgraded technology for alternative source of food grade colour or other food additives from floral resources contemplated.

**Development of biopesticides from chrysanthemum and marigold** (*Nandini P Shetty*)

Many important bioactive such as alkaloids monoterpenoids and flavonoids are present in the flowers of marigold and Chrysanthemum. Understanding pyrethrins mode of action would help in development of novel botanical formulation which can target wide pest groups. Preliminary analysis of the different concentration of flower extract has shown around 80% knockdown effect on cowpea

pest the *Callosobruchus maculatus* adults. Knockdown effect of flower extract powder of Chrysanthemum on the *Callosobruchus maculatus* adults at four different concentrations has been carried out. More than 80% lockdown effect was observed within 1 h of exposure of 1.77 mg/cm<sup>2</sup>- 7.08 mg/cm<sup>2</sup> flower extract powder treatment. The particle size analysis results indicated that 269.23 µm powder particles persisted on the body surface of *C. maculatus* adults and caused significant lockdown effects. Based on GC-MS analysis results, the pyrethrin, jasmoline and chrysanthemol are found as major bioactives in the flower extract powder of Chrysanthemum, which might cause neurotoxicity that leads to knockdown effects in the *C. maculatus* adults.



## Other Extramural Programs

### **Cameroonian nutritional spice extracts against obesity and diabetes** (*Uma Manjappara/ Achille Parfait AN*)

The work chemically characterizes and investigates the *in vivo* beneficial effects of hydro-alcoholic extracts of two Cameroonian spices, focusing on obesity-related hepatic lipid parameters in high fat-fed C57BL/6 mice. Hydro-ethanolic extracts were prepared and characterized by RP-HPLC-PDA and UPLC-Triple TOF-ESI-MS/MS analysis. They were orally administrated for 30 days in different doses (100 mg.kg<sup>-1</sup> B.W and 200 mg.kg<sup>-1</sup> B.W) to obese C57BL/6 mice. Liver tissues were subjected to histological examinations, and lipid content estimation, as well as FAME analysis were performed. Oral administration of the extracts at 200 mg.kg<sup>-1</sup> B.W significantly reduced food intake, body weight. The decrease of the weight of the liver, hepatic and plasma lipid content was observed. Plasma enzyme (SGOT, SGPT, ALP) estimation showed no damage to vital organs. Results obtained from this study showed that *Xylopi* *parviflora* (A. Rich.) Benth and *Aframomum citratum* (Pereira ex Oliv. et Hanb.) K. Shum decreased hepatic lipid accumulation in high-fat-diet-induced obese C57BL/6 mice and confirmed, at least in part, the previous *in-vitro* and *ex-vivo* analysis.

### **Biohydrogenation enzymes from rumen bacteria** (*Ajay W Tumaney/Rani Rathi*)

Biohydrogenation is the process by which, owing to the reduced atmosphere in the rumen, bacteria saturate polyunsaturated fatty acids in

forage diet to saturated fatty acids. A bacterial strain that is not documented for significant biohydrogenation activity has been isolated and characterised. The isolate could biohydrogenate alpha linolenic acid (C18:3), linoleic acid (C18:2), and oleic acid (C18:1). Based on the 16S rDNA and RecA sequencing, the strain was identified as *Clostridium perfringens* strain 4928STDY7387880. Further, biohydrogenation enzyme-Conjugated Linoleic acid Reductase (CLA-R) was cloned from *Butyrivibrio proteoclasticus* based on sequence similarity with CLA-R characterised from *B. fibrisolvens*. Oleate hydratase was cloned from isolated *Clostridium perfringens* based on sequence similarity with *Lactococcus* species. Expression and activity characterisation of these enzymes is underway to elucidate the biohydrogenation pathway *in vitro*.

### **Acyl-CoA diacylglycerol acyltransferase role in accumulation of long chain polyunsaturated fatty acids in *Aurantiochytrium limacinum*** (*Ajay W Tumaney/Ayushi Dalmia*)

*Aurantiochytrium limacinum* is a heterotrophic marine protist that produces high amounts of docosahexaenoic acid (DHA). The biological significance of DHA, an important omega-3 fatty acid is well established, but the mechanism of DHA accumulation in triacylglycerol (TAG) is poorly understood. TAG is the main storage molecule of lipids. Acyl:CoA Diacylglycerol Acyltransferase (DGAT) is an important enzyme of the TAG synthesis pathway and therefore DGATs from *A. limacinum* was studied. The putative enzymes were cloned into yeast cells and functionally characterised.



Two functionally active DGATs and a bifunctional DGAT/WS were identified and characterised from *A. limacinum*.

**N-glycoprofiling of lactoferrin from milk sources** (*Gnanesh Kumar BS/ Simran Mattad*)

Lactoferrin (Lf) is a multifunctional glycoprotein abundantly present in colostrum and milk of mammals. It exerts various biofunctionalities at both protein and peptides level. In addition, the N-glycans (covalently linked oligosaccharides) present in Lf is diverse and has beneficial effects in the gut. Lf from bovine milk sources is particularly interested as it is used as dietary supplement. In the present study, the LC-MS/MS method was optimized to probe complete glycan diversity of Lf from bovine colostrum, which revealed interesting unknown features. This protocol was employed to unravel Lf glycan diversity from other lesser known milk sources for their functional characterization.

**Molecular mechanism of colistin resistance among food-borne pathogens and food bacteria** (*Prakash M Halami/ Mousumi Ray*)

Ninety-eight different types of colonies of colistin-resistant lactic acid bacteria were isolated from thirty-three different animal and vegetable samples using selective MRS agar media with colistin antibiotic (8, 16 µg/ml). Among them, the final selection was made based on their tolerance in a higher concentration of colistin (512-1024 µg/ml) and survivability percentage against colistin. Among these selected isolates, three isolates were characterized by the presence of the colistin resistance mcr gene. Sensitive isolates also

experimented for subinhibitory effects in the presence of colistin antibiotic and showed mutational gene amplification. Colistin resistance bacterial cultures were subjected for whole genome sequencing to establish molecular evidences.

**Endoxylanase induced enhancement of the nutraceutical components and bioactivities of red rice bran** (*Jayadeep A/ Sapna I*)

The effect of various concentrations of endoxylanase from bacterial (EXB) and fungal (EXF) origin in enhancing the content of nutraceuticals and bioactivities of red rice bran compared to non-enzyme treated bran (control) was studied. At specific concentrations, EXF increased caffeic, vanillic and ferulic acid in soluble phenolics along with cycloartenyl ferulate, β-sitosteryl ferulate and δ, γ, α-tocopherols and tocotrienols. Whereas EXB enhanced catechin and p-coumaric acid in bound phenolics along with 24-methylenecycloartenyl ferulate and campesteryl ferulate. The bioactivity assays and correlation study showed that EXF treated bran exhibited scavenging activities against superoxide anion and inhibition of human LDL oxidation with caffeic acid and α-tocotrienol exhibiting positive correlation. While EXB treated bran exhibited reducing power, DPPH<sup>•</sup> and hydroxyl radical scavenging activities with β-sitosteryl ferulate and soluble phenolics demonstrating positive correlation. Thus, endoxylanase treatment is a potential approach for processing the rice bran into a functional food ingredient having higher bioactivities.



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