



**CSIR-CFTRI**

# **PERFORMANCE REPORT**

## **2012-13**

**CSIR - Central Food Technological Research Institute  
Mysore - 570 020, India**

A large, decorative banner with a wavy, ribbon-like shape. It has a light blue gradient fill and is outlined with a darker blue and green border. The text 'CSIR-CFTRI PERFORMANCE REPORT' is centered within this banner in a bold, red, sans-serif font.

**CSIR-CFTRI  
PERFORMANCE REPORT**

**2012-13**

**CSIR-Central Food Technological Research Institute**

(A constituent laboratory of Council of Scientific & Industrial Research)

**Mysore - 570 020, India**

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Director  
CSIR-Central Food Technological Research Institute, Mysore  
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Team CSIR-CFTRI



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

It gives me immense pleasure to present the Annual Performance Report of CSIR-CFTRI for the period 2012-13 to the benefit of all the stakeholders.



The year 2012-13 was important to us in terms of R&D stimulus received from the Council of Scientific and Industrial Research (CSIR) for pursuing major activities under XII plan projects. These include AGROPATHY, WELFO, LIPIC and Nutri-ARM with CFTRI as the nodal laboratory, in which two of the projects are meant for creating centres of excellence in lipidomics and molecular nutrition. Along with 19 ongoing in-house projects, a few more in-house projects were initiated for a period of one year, after due discussion and evaluation in the 'OPEN FORUM' with the participation of the entire S&T staff. Notable among these include the project entitled, 'Value-added products from Moringa leaves' which is intended to address malnutrition by providing milk as an affordable source of protein from plant sources. R&D activities were also supported by a total of 63 Grant-in-Aid Projects and a large number of industry-funded projects during this period.

In human resource development, the AcSIR activities were strengthened along with other flagship programs of the Institute such as M.Sc. (Food Technology), Certificate course in Milling Technology and Short-term training programs targeted for SMEs and entrepreneurs on a regular basis. Progress was realised in terms of inducting young minds into various research groups as a total of 16 new Technical Officers joined the Institute. Remarkable progress was achieved towards establishing a Nutraceutical Park as a joint venture between CFTRI and Government of Karnataka for promoting entrepreneurs and industry in the emerging areas of nutraceuticals and functional food, aligning with the vision of founders of the Institute. Apart from creating a separate cell for coordinating CSIR-800 programs, the Institute also participated in TECHVIL programs and a couple of new projects were initiated to fulfill the 800 mandate earnestly.

There has been enormous support from S&T and administrative staff in realising various accomplishments throughout the period. I would like to thank each one for giving their best. I wish to acknowledge the guidance and support provided by Prof. Samir K. Brahmachari, Director General, CSIR (New Delhi); Chairman and members of the Research Council and Management Council in driving our research. The achievements have been possible due to their efforts and cooperation as well. It is also my duty to thank all the stakeholders, including the various funding agencies who have been kind and supportive of our creative ideas.

Looking forward for further fillip in our R&D activities in the next year as well.



**Date: 26 September 2013**  
**Place: Mysore**

**Prof. Ram Rajasekharan**  
**Director**  
**CSIR-Central Food Technological**  
**Research Institute, Mysore**

## Publications

■ Research Papers	215
■ Reviews	17
■ Book Chapters	29

## Projects

■ Grant-in-aid	63
■ Consultancy	56
■ Sponsored	33

## Industrial Development

■ Patents Filed	4
■ Technologies Transferred	62
■ Short Term Courses Conducted	33

## Human Resource Development

■ M.Sc. Students Passed Out	21
■ ISMT Students Passed Out	20
■ Ph.D Degree Awarded	24

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## Achievements in Brief

## 1. Research Papers Published

### SCI Papers

- 1 Abhijith K.S., Thakur M.S., Application of green synthesis of gold nanoparticles for sensitive detection of aflatoxin B1 based on metal enhanced fluorescence, *Anal. Methods*, 2012, **4(12)**, 4250-4256
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- 9 Ambati Ranga Rao, Sindhuja H.N., Shylaja M. Dharmesh, Udaya Sankar K., Sarada R., Ravishankar G.A., Effective inhibition of skin cancer, tyrosinase and antioxidative properties by astaxanthin and astaxanthin esters from green alga *Haematococcus pluvialis*, *J. of Agri, Food Chem.*, 2013, **61**, 3842-3851
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## Reviews, Book Chapters & Papers in Proceedings

### Reviews

- Chalamaiah M., Dinesh Kumar B., Hemalatha R., Jyothirmayi T., Fish protein hydrolysates: Proximate composition, amino acid composition, antioxidant activities and applications: A review, *Food Chem.*, 2012, **135(4)**, 3020-3038
- Chandini S. Kumar, Subramanian R., Jaganmohan Rao L., Application of enzymes in the production of RTD black tea beverages: A Review, *Critical Reviews in Food Sci. Nutri.*, 2013, **53(2)**, 180-197
- Ezhilarasi P.N., Karthik P., Chhanwal N., Anandharamakrishnan C., Nanoencapsulation techniques for food bioactive compounds: A Review, *Food Bioprocess Technol.*, 2013, **6(3)**, 628-647
- Gopala Krishna A.G., Raja Rajan R.G., Bhatnagar A.S., Rice bran: Chemistry, production and applications - A review, *Beverage Food World*, 2012, **39(5)**, 31-36
- Indrani D., Venkateswara Rao G., Research and developments in South Indian *Parotta* technology - A review, *Indian Food Industry*, 2012, **31(5&6)**, 33-41
- Mahejbin Khan, Nakkeeran E., Umesh Kumar S., Potential application of pectinase in developing functional foods, *Annu. Rev. Food Sci. Technol.*, 2013, **4**, 21-34
- Negi P.S., Plant extracts for the control of bacterial growth: Efficacy, stability and safety issues for food application, *Int. J. Food Microbiol.*, 2012, **156(1)**, 7-17
- Pushpa S. Murthy, Madhava Naidu M., Sustainable management of coffee industry by-products and value addition - A review, *Resources, Conservation & Recycling*, 2012, **66**, 45-58
- Rahath Kubra I., Jagan Mohan Rao L., An impression on current developments in technology, chemistry and

### Book Chapters

- Amit Kumar Rai, Meera Bhagat, Anu Appaiah K.A., Wine fermentation: Microbial ecology and their influence on biochemical changes during fermentation, In: Recent advances in Microbiology, *Ed: Tiwari S.P., Sharma R., Singh R.K.*, Published by: Nova Science Publishers Inc. (USA), 2012, 421-440
- Amit Kumar Rai, Swapna H.C., Bijinu B., Bhaskar N., Application of fermentation technique for effective recovery of (after) valuable biomolecules from animal and fish processing waste, In: Recent advances in Microbiology *Ed: Tiwari S.P.*, Published by: Nova Science Publishers Inc. (USA), 2012, 441-460
- Aradhya S.M., Jayashree K., Policegoudra R.S., Polyphenols from fruits and vegetables and their health benefits II, In: Polyphenols : Chemistry, dietary sources and health benefits, *Ed: Jian Sun, Nagendra Prasad, Amin Lsmail, Bao Yanu, Xiangrong You, Li Li*, Published by: Nova Science Publishers Inc. (USA), 2012, 51-83

- 4 Balasubramanya C, Ravi Prakash R.D., Anil Kumar P.K., Nidheesh T., Suresh P.V., Enzymatic production of chitooligosaccharides using chitosanase of *Nocardia* sp. In: Emerging trends in biotechnology, Ed: *Saritha G Bhat*, Published by: Directorate of Public Relations and Publication, CUSAT, Kochi (India), 2012, 55-63
- 5 Chhanwal N., Anandharamkrishnan C., Design and optimization of food processing equipments using computational fluid dynamics modeling, In: Engineering applications of computational fluid dynamics, Ed: *M.A.R. Sadiq Al-Baghdadi*, Published by: International Energy and Environment Foundation, 2012, 1-26
- 6 Hemavathi A.B., Umesh H. Hebbar, Raghavarao, K.S.M.S., Reverse micellar extraction of bioactive compounds for food products, In: Enhancing extraction processes in the food, Ed: *Nikolai Lebovka, Eugene Vorobiev, Farid Chemat*, Published by: CRC Press - Taylor and Francis (USA), 2012, 399-436
7. Matche R.S., Sathish H.S., Packaging machinery, In: Handbook of frozen food processing and packaging, Ed: *Da-Wen Sun*, Published by: CRC Press Taylor & Francis Group Boca Raton, 2012, 779-816
- 8 Namitha K.K., Negi P.S., Enhancement of natural antioxidants in plants by biosynthetic pathway modulation. In: Chemistry and pharmacology of naturally occurring bioactive compounds, Ed: *Gautam K Brahmachari*, Published by: CRC Press - Taylor and Francis (USA), 2013, 483-528
- 9 Negi P.S., Stability of phytochemicals at the point of sale, In: Handbook of plant food phytochemicals: Sources, stability and extraction, Ed: *Tiwari B.K., Nigel P., Brunton, Charles S. Brennan*, Published by: John Wiley and Sons Ltd., (New York), 2013, 375-395
- 10 Prabodh Halde, Subhprada Nishtala, Anu Appaiah K.A., Kulkarni D.N., Skill development in the Indian food processing sector, In: Evolving corporate education strategies for developing countries: The role of Universities, Ed: *Pandu Ranga Narasimharao B., Rangappa Kanchugarakoppal S., Tukaram U. Fulzele U.*, Published by: IGI Global, 2012, 186-198
- 11 Rahath Kubra I., Jagan Mohan Rao L., A perception on essential oil of ginger, In: Natural essential oils - fragrances and flavours, Ed: *Akhil Baruah, Subhan C. Nath*, Published by: Aavishkar Publishers and Distributors (Jaipur), 2012, 3, 42-77
- 12 Ramesh Kumar P., Prakash V., Innovations in functional food industry for health and wellness, In: Innovation in healthy and functional foods, Ed: *Dilip Ghosh, Shantanu Das, Debasis Bagchi, Smarta R.B.*, Published by: CRC Press, Taylor & Francis Group. (USA), 2012, 5-12
- 13 Rastogi N.K., Raghavarao K.S.M.S., Advances in reverse osmosis technology for the processing of fruit juices, In: Membrane processes for sustainable growth, Ed: *Basile A., Cassano A.*, Published by: Nova Sciences Publishers (UK), 2012, 1-24
- 14 Rathinaraj K., Sachindra N.M., Valorization of by-products from animal products based food processing industries. In: Valorization of food processing by-products, Ed: *Chadrsekaran R.*, CRC Press (USA), 2012, 649-685
- 15 Ravi Prakash R Desai, Balasubramanya C., Nidheesh T., Anil Kumar P.K., Suresh P.V., Enzymatic preparation of chitooligosaccharides using chitosanase of *Penicillium monoverticillium* produced by solid state fermentation, In: Emerging trends in biotechnology, Ed: *Saritha G Bhat*, Published by: Directorate of Public Relations and Publication, CUSAT, Kochi (India), 2012, 64-72
- 16 Ravishankar G.A., Sarada R., Vidyashankar K.S., Venu Gopal, Kumudha A., Cultivation of micro-algae for lipids and hydrocarbons and utilization of spent biomass for livestock feed and for bio-active constituents, In: Biofuel co-products as livestock feed: Opportunities and challenges, Ed: *Harinder P.S. Makkar.*, Published by: FAO (Rome), 2012, 423-445
- 17 Sangeetha R., Baskaran V., Assay of carotenoid composition and retinol equivalents in plants, In: Food and nutritional components in focus No. 1, Vitamin A and carotenoids: Chemistry, analysis, function and effects, Ed: *Victor R. Preedy*, Published by: Royal Society of Chemistry, 2012, 221-249
- 18 Sowmya R., Sachindra N.M., Hosokawa H., Miyashita K., Antioxidative properties of seaweed components, In: Seaweed: Ecology, nutrient composition and medicinal uses, Ed: *Vitor H. Pomin*, Published by: Nova Publishers (USA), 2012, 137-162
- 19 Suresh P.V., Nagendra Prabhu G., Seafood, In: Valorization of food processing by-products, Ed: *Chandrsekaran M.*, Published by: CRC (USA), 2012, 685-736
- 20 Thakur M.S., Selvakumar L.S., Assay by biosensor and *Chemiluminescence* for vitamin B12, In: B vitamins and folate chemistry, analysis, function and effects, Ed: *Victor R.*, Published by: Royal Society of Chemistry (London), 2013, 439-457
- 21 Umesh H. Hebbar, Rastogi N.K., Microwave heating of fluid foods, In: Novel thermal processing techniques for liquid foods, Ed: *Cullen P.J., Brijesh K. Tiwari, Valdramidis*, Published by: Elsevier, 2012, 369-404

### Proceedings

- 1 Ashna Ibrahim, Jilmi Jose, Nidheesh T., Suresh P.V., Shrimp alpha-chitosan: Natural decontaminant for fresh market chicken meat, In: *Proceedings of National Symposium: Emerging Trends in Biotechnology*, CUSAT, Kochi (India), 2012, 64-72
- 2 Borse B.B., Jagan Mohan Rao L., Biochemical fingerprinting and sustainable utilization of tea plantation biomass (pruned tea leaf) for novel value added products, In: *Proceedings of the Third Intl. Seminar on Sustainable Utilization of Tropical Plant Biomass through Biotechnology*, SUPBT, December 13-15, 2012, 21-25
- 3 Borse B.B., Jagan Mohan Rao L., Bio-chemical profiling of Indian black teas and novel quality index, In: *Proceedings of the Second National Conference on Recent Trends in Food Science and Nutrition Research*, October 30, 2012, 18-19
- 4 Giridhar P., Mahendranath G., Akshatha V., Ravishankar G.A., Enhanced yield of food colourant annatto from seeds of *Bixa orellana* L.: The efficacy of polyamines floral spray, In: *Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci.*, October - December 2012, 82(4), 553-556
- 5 Jilmi Jose, Ashna Ibrahim, Nidheesh T., Rathina Raj K., Suresh P.V., Bio-preservation of egg using chitosan, In: *Proceedings of National Symposium: Emerging Trends in Biotechnology*, 2012, 95
- 6 Manilal P., Varadaraj M.C., Digital library of traditional foods of India: TKDL model, In: *Proceedings of the International Conference on Trends in Knowledge and Information Dynamics*, Bangalore, July 10-13, 2012, 796-802
- 7 Thakur M.S., Application of nanotechnology for food safety and quality assessment, In: *Proceedings of Nutritional Society of India*, Sri Venkateswara University, Tirupathi, November, 16-17, 2012, 45-50

### Short Communications, Invited Articles and Popular Science

#### Short Communications

- 1 Rajalakshmi H., Umesh Kumar S., Ravi Kumar K., Evidence for the improvement of thermostability of the maltogenic alpha-amylase of *Aspergillus niger* by negative pressure, *Starch - Stärke*, 2012, 64, 646-651

#### Invited articles

- 1 Gopala Krishna A.G., Coconut oil: Science, technology and applications, *AOCS J.*, 2012, 23(6), 395-399

### Popular Science

- 1 Sharma K.V.S.A.S., Manavate nashiseetea? Pralayada lekka hege?, Vijayavani, 25 November 2012 (Weekly Supplement)
- 2 Sharma K.V.S.A.S., Fighting fire with DNA, Deccan Herald, 26 March, 2013 (Science Supplement)

### Books Published

1. Red beet biotechnology - food and pharmaceutical application, Ed: Bhagyalakshmi N., Published by: Springer (New York), 2013 (*Details of contributing authors with title and page nos. are listed below*)
  - Bhagyalakshmi N., Sowbhagya H.B., Red beet - An overview, 1-45
  - Shivapriya M., Kotamballi N Chidambara Murthy, Shruthi Nagaraju, Bhagyalakshmi N., Stability of betalain pigments of red beet, 55-74
  - Nandini P. Shetty, Jorgensen K., Jorgensen H.J.L., Red beet as a model system for studying vacuolar transport of primary and secondary metabolites, 75-90
  - Bhagyalakshmi N., Cell and tissue culture studies in *beta vulgaris* L, 175-198
  - Bhagyalakshmi N., Red beet hairy root cultures, 199-250
  - Bhagyalakshmi N., Thimmaraju R., Peroxidases and other enzymes from red beet hairy roots, 283-334
  - Bhagyalakshmi N., Thimmaraju R., Downstream processing of red beet hairy roots, 335-372
  - Bhagyalakshmi N., Techno-commercial aspects of relevance to red beet, 409-425

### Monograph

- Thakur M.S., Monograph on biosensors, *National design and research forum*, The Institute of Engineers, 2011, 11-56

### 2. Patents filed

- Artificial ripening device for bananas and similar fruits
- A composition and method to control rotifer infestation in microalgal culture systems
- An improved process for production of turmeric powder from fresh turmeric rhizomes
- A formulation for Ready-to-prepare compacted instant soup tablets and a process for the preparation thereof

### 3. Processes released for commercial exploitation

Sixty two processes were released for commercial exploitation to 124 parties and forty two processes were demonstrated to 79 licensees. Details are given below:

- Baking powder
- Blends of coconut oil with other edible oils
- Cereal flakes: Rice
- Chicken wafers
- *Chikki* / nutra *chikki* - 3 formulations
- Chilli sauce
- Coffee concentrate
- Cola flavour concentrate
- Compounded asafoetida
- Dehydrated egg cubes
- Egg wafers
- Energy food: New formulation
- Fermented and dehydrated ready mixes for *Idli* / *Dosa* batter
- Fruit & vegetable canning
- Fruit jams & jellies preparation
- Fruit spread: Fruit juice, sugar & honey
- Fruit syrups & squashes
- Garlic powder
- Ginger paste
- Indian traditional food: *Imli Poha*
- Liquid fruit: Banana
- Maize flakes
- Malted *Ragi* flour (Enzyme rich)
- Malted weaning food
- Mango pulp: Bulk preservation for RTS beverage
- Meat pickles: Fish, prawn, chicken, mutton
- Meat wafers: Chicken, fish, prawn, meat, egg, pork
- Milk chocolate
- Modified atmosphere packaging of minimally processed vegetables: Bitter gourd, cauliflower, fenugreek leaves, onion, cucumber
- North Indian (Punjabi) *Halwa* mix
- Online fortification of *atta* (whole wheat flour) / *Maida* (refined wheat flour)
- Orange flavour concentrate for manufacturing of soft beverage
- *Paushtik* *atta*

- Pickles & chutneys: Preparation
- Pulse based papads
- Ready mix: *Chakli*
- Ready mix: *Dosa*
- Ready mix: *Idli*
- Ready mix: *Jamun*
- Ready mix: *Jamun*, *Jelebi* and chilli sauce
- Ready mix: *Vada*
- Ready spice mixes: *Rasam*
- Ready spice mixes: *Sambar*
- Ready spice mixes: *Sambar*, *rasam* & *pulao*
- Ready to eat convenience food : *Khakhra*
- Ready to use *Dosa* batter in retail packs
- Ready to use *Idli* batter in retail packs
- RTS fruit juices
- RTS fruit juices & beverages
- Rural based biotechnological production of *spirulina*
- Shelf stable *Biryani* paste
- Shelf stable *Chapati*
- Shelf stable chicken titbits
- Shelf stable ready to eat foods thermo processed in retort pouches (veg)
- Sugarcane juice bottling
- Tamarind juice concentrate
- Tomato products
- Tomato products - Ketchup
- Traditional HAE / RTC meat / poultry products
- Tutti fruity
- Vegetable dehydration: Onion
- Virgin coconut oil

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

Sl no.	Type of project	No. of completed projects	New projects under-taken	Total no. of proj. carried out
1	Consultancy	23	18	56
2	Sponsored	9	12	33
3	Grant-in-Aid	11	36	63

**5. M.Sc. / ISMT / Short-term courses**

Sl. No.	Academic Programme	Degree/Certificate Awarded
1.	M.Sc. (Food Technology)	21
2.	Certificate course in Milling	20
3.	Short-term courses	575

**6. Symposia, conferences and events organised / sponsored by CSIR-CFTRI**

- **DBT Sponsored Brainstorming Session** (May 31, 2012)

Brainstorming session on “Functional Foods for Immunomodulation” sponsored by Dept. of Biotechnology was held .

- **Presentation ceremony of awards, medals, scholarships and certificates to students of M.Sc. (Food Technology) & Flour Milling Technology Certificate Courses** (July 13, 2012)

Dr. Rajesh Luthra, Head, Human Resource Development Group, CSIR HQ, New Delhi graced the occasion as the Chief Guest and presented awards, medals, scholarships and certificates to the students and addressed the gathering. Dr. G. Venkateswara Rao, Acting Director, CSIR-CFTRI, presided.

- **Workshop on “Recent Trends in Nutrition and Food Safety”** (August 2, 2012)

Workshop on “Recent trends in nutrition and food safety” was held on August 2, 2012 in the Institute. Mr. N. Krishnakumar, Regional Scientific Affairs Manager, Nestle Nutrition Institute briefed about the workshop. Dr Harsh Vardhan Batra, Director, DFRL, Mysore, presided the function.

- **CSIR Foundation Day** (September 28, 2012)

The CSIR Foundation Day was celebrated in which Dr. Harsh Vardhan Batra, Director, Defence Food Research Laboratory, Mysore, graced the occasion as the Chief Guest and delivered the CSIR Foundation Day lecture. Prizes were distributed to the children of CSIR-CFTRI staff who had won competitions organized as part of celebrations. On this occasion, mementoes and shawls to the CSIR-CFTRI staff who retired during the previous year and mementoes to the

staff who had completed 25 years of service were also distributed. Prof. Ram Rajasekharan, Director, CSIR-CFTRI, Presided.

- **Hindi Fortnight Celebration** (September 28, 2012)

As a part of Hindi Fortnight celebrations at CSIR-CFTRI, variety of competitions in Hindi was conducted for employees, research scholars, project assistants and students of the Institute. A report on the various activities carried out in the Institute under the official Language Implementation Programme was presented by Shri C.P. Arunan, Administrative Officer, CSIR-CFTRI. Prizes to the winners of competitions were presented by Dr. Harsh Vardhan Batra, Director, DFRL, Mysore on this occasion.

- **VALUEFISH** (October 4, 2012)

The National conference on Research, Production & Marketing of Value Added Fish Products - Present status & Future directions was held on October 4, 2012 at the Assembly Hall, CSIR-CFTRI. Prof. K.S. Rangappa, Vice Chancellor, KSOU, Mysore inaugurated the conference. Dr. T.K. Srinivasa Gopal, Director, CIFT, Kochi, delivered the keynote address on “Present status and potential of value added products from freshwater fish”. Prof. C. Vasudevappa, Senior Executive Director, NFDB, Hyderabad was the Guest of Honour. Prof. Ram Rajasekharan, Director, CSIR-CFTRI presided over the function.

- **CSIR-CFTRI Foundation Day** (October 22, 2012)

The Institute celebrated the Foundation Day in which Prof. Desirazu N. Rao, Department of Biochemistry, Indian Institute of Science, Bangalore graced occasion as the Chief Guest and delivered the Foundation Day Lecture entitled “*Helicobacter pylori* restriction modification enzymes: Unknown treasures”. Prof. Ram Rajasekharan, Director, CSIR-CFTRI presided.

- **XXII Indian Convention of Food Scientists and Technologists (ICFoST)** (December 6-7, 2012)

The theme of this conference was SAFEST (Safety Assurance of Foods through Emerging Science & Technology) Innovations. The programme was inaugurated by Dr. K Alagusundaram, Director, Indian Institute of Crop Processing Technology, (ICPT), Thanjavur. Prof. Ram Rajasekharan, Director, CSIR-CFTRI presided over the function.

- **XXVII National Carbohydrate Conference** (December 13-15, 2012)

XXVII National Carbohydrates Conference on Prospects and perspectives of glycoscience and allied technologies was held on December 13-15, 2012 in the Institute. The inaugural address was delivered by Chief Guest, Shri Uday Merchant, Managing Director, Lucid-Hydrocolloids, Mumbai. Prof. Ram Rajasekharan, Director, CSIR-CFTRI presided over the function.

- **44<sup>th</sup> Shanti Swarup Bhatnagar Memorial Tournament (Indoor-zonals)** (January 20, 2013)

Inaugural function of 44<sup>th</sup> SSBMT was held on January 20, 2013. Her Highness, Maharani Pramoda Devi Wadiyar and Grand Master & chess prodigy Mr. M.S. Tej Kumar graced the occasion as the Chief guests. Prof. Ram Rajasekharan, Director, CSIR-CFTRI and President FRIG delivered the presidential address.

In the valedictory function held on 23<sup>rd</sup> January, 2013, Ms. Poojashree Venkatesha, International Tennis Player distributed the mementoes and certificates to the winners and addressed the gathering. Presidential address was given by Prof. Ram Rajasekharan, Director, CSIR-CFTRI.

- **National Science Day** (February 28, 2013)

National Science Day was celebrated in which Dr. Lalitha R. Gowda, Chief Scientist, CSIR-CFTRI gave a lecture on "Raman Spectroscopy: The technique and its relevance". Prof. Ram Rajasekharan, Director, CSIR-CFTRI, presided.

- **XXXIV Annual Meeting of Plant Tissue Culture Association (India) and National Symposium on Plant Tissue Culture and Biotechnology for Food and Nutritional Security** (March 11-13, 2013)



Inauguration of XXII Indian Convention of Food Scientists and Technologists (ICFoST) held at CSIR-CFTRI. Prof. Ram Rajasekharan, Director, CSIR-CFTRI is seen with other dignitaries on the occasion



Inaugural session of XXVII National Carbohydrates Conference at CSIR-CFTRI : A view from the dais

Inaugural function of 44<sup>th</sup> SSBMT Indoor Zonal meet at CSIR-CFTRI





Dr. Harsh Vardhan Batra, Director, Defence Food Research Laboratory, Mysore, delivering the CSIR Foundation Day lecture



Prof. Desirazu N. Rao, Professor, Department of Biochemistry, Indian Institute of Science, Bangalore addressing the staff on CSIR-CFTRI Foundation Day



Release of conference souvenir by Prof. K.S. Rangappa, Vice Chancellor, KSOU, Mysore at National conference on Research, Production & Marketing of Value Added Fish Products - Present Status & Future Directions at Mysore. Prof. Ram Rajasekharan, Director, CSIR-CFTRI is seen with other dignitaries on the occasion



Dr. R.A. Mashelkar, Former DG, CSIR, at CSIR-CFTRI stall during 100<sup>th</sup> Indian Science Congress at Kolkata

## 7. Awards and Recognitions

### a) Ph.D. Degree awarded

- **Ponnala Raghavendra** (Biotechnological studies on phytate degrading lactic acid bacteria: Screening, isolation, characterization and application)
- **Usha Rani M** (Microbiological and molecular characterization of cellulose producing *Gluconacetobacter* sp.)
- **Akshatha Venugopalan** (Differential expression analysis of genes involved in bixin biosynthesis in *Bixa orellana* L.)
- **Divya KH** (PCR-based detection of food isolates of *Yersinia* species and its behavioural pattern in selected foods)
- **Anila N** (Genetic transformation of *Dunaliella bardawil* with astaxanthin biosynthetic gene(s) from *Haematococcus pluvialis*)
- **Diwakar BT** (Studies on immunomodulatory effects of omega-3 fatty acid rich garden cress oil in animal model)
- **Mamatha BS** (Absorption kinetics, biotransformation and biological functions of lutein and its metabolites in rats)
- **Vishwanathan KH** (Soybean processing for soymilk and by-product utilization using membrane technology)
- **Harish Babu BN** (Biochemical and immunological investigations of food allergy to eggplant (*Solanum melongena* L.))
- **Prathibha DV** (Isolation and characterization of lactic acid bacteria from cereals and legumes for elucidation of potential functional properties)
- **Deepa G Muricken** (Cloning, expression and site-directed mutagenesis of the Bowman-Birk inhibition of horsegram (*Dolichos biflorus*))
- **Darukeshwara J** (Studies on changes in chondroitin sulfate / dermatan sulfate in kidney during diabetes and modulation by a potent plant material)
- **Rahath Kubra I** (Investigation on chemical constituents of *Zingiber officinale* and their in vitro activity studies)
- **Roopa BS** (Role of alginate in gel formation: Characterization and applications for developing textured products)
- **Khamrunissa Begum** (Investigations on the influence of selected organophosphorus insecticides on experimentally-induced diabetes in rats)
- **Ramakrishna A** (Studies on development of high frequency somatic embryogenesis and regulation of secondary metabolites in *Coffea canephora* P.Ex.Fr.)
- **Madhukumar MS** (Bioactive xylo-oligosaccharides from Bengal gram (*Cicer arietinum* L.) husk)
- **Hemalatha MS** (Studies of enzymes and pentosans on wheat flour in relation to functionality and nutritional quality)
- **Meesha Sharma** (Preparation and characterization of omega-3 enriched vegetable oil and its nutritional evaluation)
- **Mabel Merlen Jacob** (Microbial transglutaminase: Purification, characterization and bioactive properties)
- **Shetty Santoshkumar Mohan** (Cloning and expression profiling of polyphenol oxidase from eggplant (*Solanum melongena* L.))
- **Lakshmi MC** (Biotechnological approaches for the extraction and purification of selected biomolecules from *Glycine max.*)
- **Shubra Pande** (Studies on the hypolipidemic and antioxidant effects of tender cluster beans (*Cyamopsis tetragonoloba*) in experimental animals)
- **Dhanalakshmi K** (Studies on the changes in physico-chemical properties and chemical constituents of turmeric powder during agglomeration)



**b) Individual Awards**

Sl. No.	Award Title	Instituted by	Awardee
1.	Amulya 2012	Karnataka State Innovation Council, Bangalore	Jagan Mohan Rao L Ramalakshmi K Raghavan B Borse BB
2.	Amulya 2012	Karnataka State Innovation Council, Bangalore	Pura Naik J Madhava Naidu M Srinivas P
4.	Chaturbhuj Gordhandas Merchant Memorial Lucid Hydrocolloid Award	Association of Carbohydrate Chemists & Technologists (India)	Salimath PV
5.	Best Article Award in the Journal, Indian Food Industry - 2012	Association of Food Scientists and Technologists (India), Mysore	Mukesh Kapoor
6.	Laljee Godhoo Smarak Nidhi Award 2012	Association of Food Scientists and Technologists (India), Mysore	Shylaja M Dharmesh Modi VK
7.	National Award for Teaching Excellence in Food Technology	Indus Foundation, Delhi	Vasudeva Singh

**c) Recognitions by Academies**

Recognition	Instituted by	Awardee
• Fellow	Association of Microbiologists of India	Renu Agrawal
• Fellow	Association of Carbohydrate Chemists and Technologists, India	Vasudeva Singh
• Fellow	Royal Society of Chemistry, Cambridge	Vasudeva Singh

**d) Other Recognitions**

Fellowship / Programme	Awardee	Host Institute
• UNU-KIRIN Fellowship, 2012-2013	Mahejibin Khan	National Food Research Institute, Tsukuba, Japan
• CSIR Raman Research Fellowship	Prakash M Halami	University of Minnesota, USA
• Indian National Science Academy, New Delhi and German Research foundation (INSA-DFG)	Prakash M Halami	University of Frankfurt, Germany

**e) Best Research Papers / Posters awards**
**I. ICFOST-XII, CSIR-CFTRI, Mysore, December 6 - 7, 2012**

- 1 Neha Singh, Usha Dharmaraj, Sathyendra Rao B.V., Preparation and quality characteristics of flakes from multi grain composite flour (Best poster)
- 2 Ragavan K.V., Selva Kumar S.L., Thakur M.S., Functionalized aptamers as nanobioprobes for ultrasensitive detection of bisphenol-A in water samples (Best poster)
- 3 Madhu A.N., Gobinath D., Srinivasan K., Prapulla S.G., Synergistic effect of *L. plantarum* and fructooligosaccharides (FOS), in prevention of 1, 2 dimethyl hydrazine induced colorectal cancer in rats (Best poster)
- 4 Suresh D Sakhare, Inamdar A.A., Pallavi R., Prabhasankar P., A novel roller milling process of obtaining the fiber-rich fraction (FRF) from fenugreek seeds (*Trigonella foenum-graecum*) (First prize)
- 5 Umesh S.S., Sai Manohar R., Indiramma A.R., Akshitha, Akhilender Naidu K., Biscuits enriched with microencapsulated omega-3 fatty acid (alpha-linolenic acid) rich garden grass seed (*Lepidium sativum*) oil: Physical, sensory and storage quality characteristics of biscuits (First Best poster)
- 7 Vinod Kumar, Lalitha R. Gowda, Horsegram Bowman-Birk inhibitor: The contribution of interdomain disulfide to thermal and proteolytic stability (Best poster)
- 8 Nitin Rohidas Sonar, Goveas L.C., Sainik M., Maya Parkash, Halami P.M., Nutritional value and sensory analysis of traditionally fermented bamboo shoot-based foods of Arunachal Pradesh and Manipur (Best oral presentation award)
- 9 Prasanth Kumar P.K., Gopalakrishna A.G., Physico-chemical characteristics and nutraceutical distribution of different fractions of crude palm oil (Second prize)
- 10 Aduja Naik, Maya Prakash, Ravi R., Raghavarao K.S.M.S., Storage study and quality evaluation of coconut protein powder (Second prize)

**II. CARBO - XXVII, National Carbohydrate Conference, CSIR-CFTRI, Mysore, December 13-15, 2012**

- 1 Mallikarjuna S.E., Shashirekha M.N., Muralikrishna G., Rajarathnam S., Characterization of Hemicellulose - B, Isolated from the fruiting bodies of *Lentinula edodes* (Best poster)
- 2 Anindya B., Gobinath D., Prapulla S.G., Production of prebiotic isomaltooligosaccharides by trans-

glucosylation of maltose using microbial alpha-glucosidases (Best poster)

**III. XXXIV Annual meeting of plant tissue culture association (India) and National symposium on plant tissue culture and biotechnology for food and nutritional security, CSIR-CFTRI, Mysore, March 11-13, 2013**

- 1 Akshatha Venugopalan, Giridhar P., Ravishankar G.A., Tracking expression pattern of bixin biosynthetic pathway genes through transcript analysis vis a vis annatto pigment production during fruit development in *Bixa orellana* L. (Second prize)
- 2 Akitha Devi M.K., Giridhar P., Enhanced isoflavones accumulation induced by the combination of plant growth regulators in cell suspension cultures of *Glycine max*. (Second prize)
- 3 Akula Ramakrishna, Giridhar P., Ravishankar G.A., Indoleamines (serotonin and melatonin) influence plant morphogenesis and formation of secondary metabolites in *Coffea canephora* (First prize)
- 4 Vidyashankar S., Chauhan V.S., Sarada R., Bio-prospecting microalgae as sustainable source of nutritionally important fatty acids (First prize)

**IV. National level conference on computational biology, pharmaceutical sciences and life sciences, Maharani Lakshmi Ammami College Campus, Bangalore, November 23- 24, 2012**

- 1 Ravikiran Kumar, Renu Agrawal, Rheological properties, sensory attributes and flavouring compounds in probiotic *Bacillus* sp. millet fudge for better health and wellness (Best poster)
- 2 Sohini Jana, Renu Agrawal, Sensory attributes and formation of short chain fatty acids in a blend of cereals, millets and pulses with probiotic *Lactobacillus* sp. for improvement of human health (Best poster)

**V. Research Papers / Posters awards in other seminars**

- 1 Kavitha M.D., Chauhan V.S., Sarada R., Ravishankar G.A., Biotechnological aspects for improving biomass, phycoerythrin and lipid content in *Porphyridium purpureum*, World congress on Biotechnology - 2012, Leonia International Centre for Exhibitions & conventions, Hyderabad, May 4-6, 2012 (Second best poster)
- 2 Prakruthi A., Sunil L., Prasanth Kumar P.K., Gopalakrishna A.G., Physico-chemical characteristics and stability aspects of coconut water and kernel (meat) along with commercial coconut products, Functional Foods in health and wellbeing, Bangalore, June 2, 2012 (Best oral presentation award)
- 3 Ninekha, Renu Agrawal, Role of yeast and bacteria in probiotic functional properties to improve human

health, International conference on exploration of biotechnology by students scholars and researchers-2012, Department of Biotechnology, Shridevi Institute of Engineering and Technology, Tumkur, Karnataka, June 8-9, 2012 (First best oral presentation award and citation)

- 4 Divyashri G., Prapulla S.G., Can metabolites of probiotics ease behavioural psychology: Benefits beyond GI disorders!!, First Annual Conference & International Symposium (PAI), Probiotic Association of India and NDRI, Karnal, August 27-28, 2012 (Best poster)
- 5 Girish Chandran, Muralidhara, Aqueous extract of *Selaginella delicatula* abrogates 3-nitropropionic acid induced oxidative impairments and mitochondrial dysfunction in mouse brain, 30<sup>th</sup> Annual Conference of Indian Academy of Neurosciences and International Symposium on Translational Neuroscience, Amritsar, October 27-30, 2012 (Best poster)
- 6 Sunil Kumar R., Aishwarya S., Mallikarjuna S.E., Dharmesh S.M, Antiulcer potential of Bael (*Aegle marmelos*): Balancing of muco defencive and aggressive factors, 81<sup>st</sup> Annual SBC Conference, Kolkata, November 8-11, 2012 (Best poster)
- 7 Neeraj Katiyar., Selva Kumar S.L., Thakur M.S., Gold nanoparticles based colorimetric aptasensor for theophylline, 3<sup>rd</sup> International conference and exhibition on analytical and bioanalytical techniques, Hyderabad, November 22 - 24, 2012 (Best poster)
- 8 Snigdha M., Aflatoxin uptake and transport in groundnut plants in National seminar of plant physiology held at Acharya NG Ranga Agricultural University, Hyderabad, December 12-14, 2012 (Young scientist award for oral presentation)
- 9 Shobharani P., Halami P.M., Sachindra N.M., Fermentative recovery of anticoagulant and antioxidant compound from *Sargassum* sp., International Conference on algal Biorefinery, IIT, Kharagpur, January 10-12, 2013 (Best poster)

#### f) Editors of journals

- Journal of Food Science and Technology (Vijayendra SVN, Prabhasankar P, Bhagyalakshmi N, Srinivasan K, Pratape V, Bhaskar N, Modi VK)
- Indian Food Industry (Vijayendra SVN, Prabhasankar P, Bhaskar N)
- Blue Biotechnology, Nova Publishers, USA (Prabhasankar P)
- International Journal of Immunology (Prabhasankar P)

- Guest Editor - Trends in carbohydrates (TCR)-e-Journal (January-March 2013 issue) (Muralikrishna G)

#### g) Editorial Boards

- International Journal of Food Science and Nutrition Engineering, USA (Matche RS)
- International Journal of Food Science and Technology (Jagan Mohan Rao L)
- Recent Patents on Food, Nutrition & Agriculture (Jagan Mohan Rao L)
- Research & Reviews: Journal of Food Science and Technology (Madhava Naidu M)
- Journal of Agriculture, Food and Environment (Thakur MS)
- American Journal of Biopharmacology, Bio-chemistry and Life Sciences (Shylaja M Dharmesh)
- African Journal of Food Science (Shylaja M Dharmesh)
- Advisory Board Member, Trends in carbohydrates (TCR)-e-Journal (Muralikrishna G)
- The International Journal of Agriculture Food Science & Technology (Matche RS)

#### 8. Participation in Exhibitions

- **AGRI INTEX 2012:** Coimbatore District Small Industries Association (CODISSIA), Coimbatore, May 30 - June 3, 2012
- **MSME exhibition and seminar 2012:** IED Lucknow, Indira Gandhi Pratisthan, Lucknow, July 6 - 8, 2012
- **AGRITECH INDIA 2012:** CSIR, New Delhi, Bangalore, July 25 - 27, 2012
- **Food Technology Expo 2012:** CSIR, New Delhi, July 27 - 29, 2012
- **Emerging Kerala 2012:** Kerala State Industrial Development Corporation Ltd. Trivandrum, Kochi, September 12 - 15, 2012
- **FOOD FEST 2012 exhibition and seminar 2012:** Key2Green, Pvt. Ltd., New Delhi, Indira Gandhi Paristhan, Lucknow, October 18 - 20, 2012
- **Agrowon Agri-Expo 2012:** Pune, December 1 -5, 2012
- **XXII ICFOST:** CFTRI, DFRL, AFST(I), CFTRI Campus, Mysore, December 6 -7, 2012
- **Margadarshi:** An exhibition on career counselling, Vijaya Vithla Junior College, Mysore, December 26, 2012
- **100<sup>th</sup> Indian Science Congress:** Indian Science Congress Association, Kolkatta, January 3 - 7, 2013

- **Agrovision 2013:** Vidarbha Economic Development Council (VED) and MM Activ SCI-Tech Communications, Nagpur, January 24 - 27, 2013
- **Bangalore India Bio 2013:** Vision Group on Biotechnology, Government of Karnataka, Bangalore, February 4 - 6, 2013. Best exhibitor award for overall excellence was conferred to CSIR stall
- **8<sup>th</sup> Nutra India Summit 2013 and NuFFoods Expo:** Mumbai, March 13 - 16, 2013
- **Showcasing of Agricultural Technologies and Media Meet:** Central Institute for Subtropical Horticulture, at CISH, Rahamankhera, Lucknow, March 30, 2013

### 9. Support department activities

In the library, access to 5602 journals through CSIR e-journals consortium were provided to staff and students through National Knowledge Resource Centre(NKRC) network. Also access was facilitated for web of science, Derwent Innovation Index and ORBIT.

The Central Instrument Facility & Services department provided centralized analysis services to support research

activities. New instruments such as Rheometer Anton paar, Eppendorf Centrifuge, Incubator Shaker Innova - 40 and ICP Horiba Ultima were added to the existing facility. In-house training to research students on operation and sample analysis with various instruments were conducted during this period.

The computer centre maintained the Institute LAN and other services including the Wi-Fi enabled internet access in the campus.

Guided tours for 182 groups which include students, official trainers and entrepreneurs for a total of 4200 visitors were conducted by the Information & Publicity department during this period.

Load sharing with the 600 KVA and 380 KVA DG sets was managed for enabling uninterrupted power supply to various Institute activities by EMM department. Also a solar water pumping system was commissioned in the M.G. Halli campus of the Institute. Setting up cold rooms in Food Microbiology and Fruit & Vegetable Technology department is under progress.

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## Progress Under R&D Projects

## VALUE ADDITION TO AGRICULTURAL RESOURCES

### *Preservation of fruits and vegetables*

#### *Sapota*

Optimisation of post harvest treatments, storage conditions, for quality maintenance and extension of storage life of sapota fruits were tried. Suitability of stored fruits for product development was also carried out. Optimally matured and firm sapota fruits were harvested from local orchard. Uniform maturity, colour and size were ensured prior to the treatment with various concentrations of cell wall hardening chemical agents. Optimisation of time and concentration of the post harvest treatments were carried out and stored at low temperature. Results indicated that sapota pre-treated with 3% CaCl<sub>2</sub> had better retention of fruit colour, texture and other quality parameters. The shelf life of treated sapota fruits was extended up to 24 days as against 16 days in untreated control fruits stored at low temperature.

#### *Watermelon*

Physico-chemical composition of watermelon cultivars viz. dark green and pale green were studied. Thermal processing of watermelon puree in glass bottles and cans were conducted. Canned watermelon chunks in syrup and watermelon candy were developed. The products were highly acceptable with respect to sensory qualities with shelf life up to 90 days at room temperature.

### *Value-added products*

#### *Grapes*

Anthocyanin-rich value added products from black grapes were developed. Ready-to-serve beverage containing peeled whole grapes showed higher anthocyanin content than normal grape beverage. Anthocyanin enriched grape products developed include, dehydrated black grapes (48.5 mg/100 g), grape jam (2.40 mg/100 g) and grape candy from peeled grapes (10.3mg/100g). Chemical and sensory quality profiling of the products during storage are under progress.

#### *Pumpkin*

Four commercial cultivars of pumpkin viz., Disco, Arjun, Nati long and Nati round were screened for the physico-

chemical composition. Cultivar Nati endowed with highest carotenoid content was selected for development of different nutraceutical products. Pumpkin dry powder was obtained by spray drying, drum drying and hot air drying methods. Rheological and chemical properties, storage studies of dried powder of pumpkin and optimisation of various process parameters for the development of instant beverage mix, pumpkin custard and jam are under progress.

#### *Papaya*

Raw and ripe papaya were procured from local orchard and analysed for physico-chemical compositions. Raw papaya fruit is rich in ascorbic acid (86 mg/100 g) whereas ripe fruits are rich in carotenoids (2699 µg/100 g) and ascorbic acid (43 mg/100 g). Dehydrated components of raw and ripe papaya viz. peel, pulp and seeds were analysed for chemical composition and proteolytic enzyme activity. The enzyme activity was found to be very high in peel and pulp portion of the raw fruit. Papaya pulp from ripe fruits was used for the development of spray-dried powder. Development of instant beverage mix from papaya powder and storage are under progress.

#### *Cucurbitaceous fruits*

L-Citrulline content in cucurbits like cucumbers, melons and gourds were analysed. Among the screened cucurbits, cucumber, muskmelon and Mangalore cucumber had high concentration of citrulline ranged between 42 mg to 90 mg/gm (dry weight). Product development from the cucurbits is being explored.

#### *Seabuckthorn*

Seabuckthorn (SBT) puree (10-40%) was incorporated to explore the possibility of SBT pasta preparation. Incorporation of 30% SBT puree in semolina resulted in balance between colour intensity and acidity of SBT pasta and concentration less than 30% resulted in decrease in colour intensity in the pasta strands, while higher concentrations resulted in undesired level of acidic products. Concentrations of NaHCO<sub>3</sub> (0.12-0.48) did not reduce acidity in the SBT pasta. The cooking quality of SBT puree pasta was found to be acceptable because of negligible loss after cooking.

### *Underutilized fruits of Nilgiris*

Passion fruit syrup was made from two varieties of passion fruits (*Passiflora mollissima* and *Passiflora ligularis*). The banana passion fruit (*Passiflora mollissima*) had higher ascorbic acid, minerals (Ca, Cu, Mg and Fe), total phenolic content and antioxidant activity, when compared to round passion fruit (*Passiflora ligularis*). There was a reduction in ascorbic acid content after processing, whereas increase in minerals was noticed in both the syrups.

### *Tree tomato*

Citric acid was the most abundant organic acid (1.75-2.19 g/g FW) followed by malic acid (0.06-0.22 g/g FW) and oxalic acid (0.007-0.012 g/g FW) in tree tomato (*Solanum betaceum*) pulp and juice. Total acid content in tree tomato fruit was 2.26 g/g FW. Pectin from tree tomato was analysed. The degree of esterification ranged between 50 and 80%.

### *Cactus (Opuntia ficus-indica L.) Mill*

The ripe fruits (cactus pear) yielded peel (~40%), pulp (~40%), and seed (~10%) and fruit waste (~10%) on fresh weight basis. The pulp had a brix of 8°, total sugars 4.2%, acidity 0.2% and pH 3.65. Pectin was isolated from defatted, mucilage – free peel of cactus fruit using three acid solvent systems. Rhamnose and galactose were the major sugars. The degree of esterification was estimated to be ~85%.

Cladode was observed to be a good source of K, Ca, Mg, Na, Fe and Zn. Toxic elements such as Cd, Cu, Cr and Ni were well within the permissible limits. Pb and As were below detection levels. Pulp was found to be a good source of K (8763 mg), Na (1243 mg), Ca (176 mg), Mg (95 mg) and Fe (52 mg) per kg on dry weight basis. Cd, As, Hg and Se were below detection levels/within permissible limits. Accordingly, both cladode and fruit can serve for edible purposes as food supplements, without toxicity endanger from the angle of mineral constitution.

The beverages prepared from cactus fruit pulp with and without mucilage (0.1%) were stored at room temperature. The evaluation of sensorial and microbiological qualities is under progress.

Pulp, mucilage and products prepared from them (RTS beverages) were examined for potential bioactivity including antioxidant, anti-proliferative, DNA/cytoprotective, tyrosinase inhibitory properties. Pulp showed free radical scavenging activity with  $IC_{50}$  of 133  $\mu$ g (dry wt.) while health beverage prepared from 10% pulp showed  $IC_{50}$  of 400  $\mu$ L. Significant inhibition of the enzyme –  $H^+K^+$ -ATPase was observed by ferulic acid and caffeic acid contents in fruit pulp at  $IC_{50}$  of 27.1  $\mu$ g/mL and 33.6  $\mu$ g/mL GAE (lanzoprazole at 19.0  $\mu$ g/mL).

### *Value added products from kokum (Garcinia indica)*

The scale-up and storage studies of kokum paste with and without preservatives in various types of containers were carried out. Also the development of products such as kokum powder, kokum fruit bar, Instant solkadhi mix, RTS carbonated kokum beverage and kokum-honey RTS beverage are under progress.

### *Bamboo shoots*

The hydrocyanic acid of bamboo shoots was removed from the tender bamboo shoots (TBS) slices by heat treatment. The process conditions for the dehydration of TBS slices were standardized and the final product was prepared (4% moisture). The product was found stable even after 6 months of storage at 27°C.

### *Ready-to-use meat based spreads*

Chicken liver was used to produce chicken based 'functional food' in the form of a spreads. Ingredients and process were optimised based on the emulsion characteristics and stability of the product. The other by-products such as chicken gizzard, lungs and blood were found not suitable for product development with respect to functional and sensory attributes. The pasteurised liver spread with sodium benzoate and TBHQ, was found to have lower thiobarbituric acid (TBA), peroxide value (PV), free fatty acid (FFA), and hence inhibits lipid oxidation and prevents rancidity to an extent of 15 days under refrigerated storage (4°C).

### *Edible by-products of poultry processing*

The condition for the fermentation of chicken gizzards using lactic acid bacterial cultures was standardized. After fermentation, the liquid portion was separated by filtration and both liquid and residue was freeze dried. During fermentation, reduction in pathogen and increase in lactic acid bacteria was observed. The fermented products had very good anti-microbial and antioxidant properties.

### *Meat industry by-products for food and feed applications*

Protein isolates from the gizzard and liver of the chicken were prepared using pH shift method. Maximum protein solubility for both liver and gizzard was at pH 3.0 and 10.0. Water absorption capacity of the alkali-solubilized isolates was more than that of acid solubilized isolates in both tissues. Emulsion activity increased towards alkaline pH in all the protein isolates.

### *Chitosan and its derivatives as bio-preservatives*

$\alpha$ -Chitosans were prepared by alkali deacetylation of chitin extracted from shrimp exoskeleton. Chitosan solutions showed better antioxidant and anti-microbial activity for use in food as a bio-preservative and functional ingredient. Coating of eggs with chitosan increased the

shelf life by 3 weeks, at 21 and 31°C, as compared with controls, as observed by improved physical and microbial quality of egg. Incorporation of chitosan at 20% level to mutton kofta improved the keeping quality at refrigerated temperature. Results suggested that mutton kofta could be prepared by using 20% (w/w) chitosan as functional agent without much detrimental effect on its physicochemical and sensory qualities.

#### *Multiplex PCR of selected meat pathogens*

Studies were carried out to develop PCR techniques for the detection of different *Salmonella* serovars targeting different genes. PCR conditions were standardized for simultaneous detection of 4 serovars of *Salmonella* in a single reaction. Conditions were also standardized to detect *Salmonella typhimurium* in chicken meat by inoculation studies.

#### *Detection of adulteration in meat and meat products*

In the present study, short segments of the mitochondrial cytochrome b gene isolated from the meat samples viz., chicken (*Gallus gallus*), sheep (*Ovisaries*) and cattle (*Bosindicus*) were employed. The gene was amplified using custom made universally designed primer by employing PCR, which showed distinguished signal band. Similarly, profiles of Total Genomic DNA (TGD) of the meat samples along with PCR-amplified genes were analysed by subjecting them to restriction digestion (Rsal, TaqI), in which only Rsal could digest the chicken's gene. However, the TGD of sheep and cattle could not be digested with Rsal enzymes, and as it shows a difference in pattern, the TGD could be used directly to differentiate between these two species.

#### *Ready-to-use sorghum based products*

The sorghum chakli / murukku mix contains 10.1% moisture, 11.2% protein and 2.1% fat. The product was good in taste, crisp in texture with 7.5 N hardness. Also instant sorghum soup mix was prepared. The instant sorghum soup mix was free flowing with pleasant colour L (brightness) 79.85, Average colour index  $\Delta E$  26.4, and desirable taste, with 12% protein, 3.2% fat, 17ml sediment volume and 393 kcal energy.

#### *Value addition to small millets*

Studies indicated that cyclopiazonic acid (CPA) is mostly concentrated in the husk fractions and that can be removed by dehusking. Traditional processing methods such as soaking, cooking, roasting and microwave treatments were found to be effective in reducing CPA content in millets.

Bioprocessing of finger millet seed coat by xylanase and cellulase enhances the polyphenols content and antioxidant activity. Physical and functional properties of the food ingredient made from ragi seed coat showed

its suitability for use in instant products.

#### *Detoxification of *Jatropha curcas* seed for meal feed*

*Jatropha* seed cake (JSC) is a by-product generated after biodiesel production. The production of biodiesel from non-edible feed stocks has been receiving considerable attention recently, as a renewable source of energy. Presence of anti-nutritional compounds and toxins restricts its application in livestock feed. Hence the JSC was assessed for its suitability as substrate for production of lipase and protease from *Aspergillus versicolor* CJS-98 by solid-state fermentation (SSF). Present study was also focused on the biodetoxification of anti-nutrients and toxins in JSC. The SSF parameters were optimised for maximum production of lipase and protease. Under the optimised conditions, the JSC supplemented with maltose and peptone (2%), adjusted to pH 7.0, moisture content 40%, inoculated with  $1 \times 10^7$  spores per 5g cake and incubated at 25°C, produced maximum lipase, 1288U/g and protease, 3366 U/g at 96 hours. The anti-nutrients like phytic acid (6.08%), tannins (0.37%), trypsin inhibitors (697.5 TIU/g), cyanogenic glucosides (692.5 $\mu$ g/100g) and lectins (0.309mg/ml) were reduced to 1.70(%), 0.23(%), 12.5 (TIU/g), 560.6( $\mu$ g/100g) and 0.034(mg/ml) respectively. The main toxic compound phorbol esters content in the JSC was reduced from 0.083(%) to 0.015(%) after SSF. SSF is a viable approach to utilize the huge amount of seed cake generated after extraction of biodiesel, for production of industrial enzymes and biodetoxification of anti-nutrients and toxins.

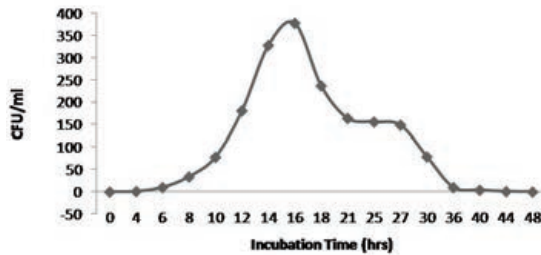
#### *Marine carotenoids*

Common carp fingerlings were fed with feed containing crude carotenoid extract, astaxanthin fraction and astaxanthin ester fractions separated from crude extract at different levels. After 14 weeks of feeding, fish were exposed to sub-lethal dose of ammonia for 96 hrs. Activities of the enzymes LDH, SGOT and SGPT, which are indicative of liver damage, were determined before and after exposure to ammonia, as markers of fish health. The growth was higher in fishes fed with ester fraction and crude extract. The enzyme activity of fishes fed with carotenoid containing feed was slightly lower than that of control before exposure to ammonia indicating the benefits of feeding carotenoids to fish. After exposure to ammonia, enzyme activity increased considerably in fish fed with control feed. The activity also increased in carotenoid fed fish but the increase was significantly lower than that in control fish indicating the protective effect of carotenoid, against ammonia induced stress in fish.

#### *Biomolecules from agro-processing wastes*

Resistant starch (RS) was isolated from Bengal gram, which consisted of 79% of glucose with slight





Growth curve of *Lactobacillus fermentum* grown on 2% resistant starch

contamination of arabinose. Five species of *Lactobacillus* and two species of bifidobacterial cultures were screened for utilization of RS (from Bengal gram). *Lactobacillus fermentum* showed the highest activity. Standardization of substrate concentration (RS) for fermentation studies was carried out and found that the bacterial growth was maximum with 2% RS. Growth curve of *Lactobacillus fermentum* grown on 2% RS was prepared and maximum growth was observed at time intervals of 12 to 16 hours.

Bengal gram husk is very rich in non-starch polysaccharides (NSP), which were extracted sequentially using cold water, hot water, 0.5% ammonium oxalate (AO), 0.5% EDTA and alkali. The sugar composition of water, hot water, AO and EDTA extracted polysaccharides indicated rhamnose, arabinose, xylose, mannose, glucose and galactose in different ratios were also determined. Pectic polysaccharides isolated by 0.5% AO and EDTA contained 60.2 and 62.4% uronic acid respectively, which are comparatively higher than the rest of the dietary fibre components. Pectic polysaccharides were subjected to acid and enzyme treatments to obtain pectic oligosaccharides in different yields.

#### Enzymatic and fermentative methods for preparation of chicken liver hydrolysates

A total of 28 lactic acid bacteria (LAB) cultures were isolated from giblets (gizzard, liver & heart) collected from market. Of these 28 isolates, 11 had potent lipolytic activity. The chicken livers were also analysed for their proximate composition, all on dry weight basis. The chicken livers had moisture content of 72 to 76%. The protein content varied from 64 to 66%, fat content between 13 and 15.5% and the ash content varied from 4.2 to 6.2%. A single batch of hydrolysis using a commercial protease (Protex 7L; Genencor) and two native LAB isolates – one from tannery fleshings (CLF2) and the other from fish waste (LP3) – were evaluated for their hydrolysis efficiency. Protex 7L, CLF2 and LP3, resulted in 51.8, 53.7 and 52.4% degree of hydrolysis, respectively.

#### Shelf life of savoury items

The effect of frying media, barrier properties of packaging materials, packaging form (air and N<sub>2</sub>), ingredient of the

product and product with respect to surface area of packaging materials, was studied to extend the shelf life of selected Indian traditional savoury items. The products *Tengolalu* and *Shankarapouli*, along with the packaging materials polypropylene and metalized polyethylene terephthalate/polyethylene were selected for studies. Products recipe was standardized and their moisture sorption characteristics were studied. Both had a critical RH of 40% with respect to loss of crispness. 30-40% RH with the temperature 38-40°C was considered ideal as it keeps the product crisp and gives quick results for oxidative rancidity. Storage studies of both the products fried in refined varieties of sunflower, groundnut, palm and coconut oils individually and packed, was carried out. The results indicated that the shelf life of both the products were in the ratio SFO:GO:PO:CNO :: 1.0:1.5:3.0:>4.0. However, *Shankarapouli* with greater bulk density had lesser headspace for the same unit pack weight and better shelf life than *Tengolalu* because of less availability of oxygen.



Sweet *Shankarapouli*



Nitrogen packaging for *Tengolalu*

The polyvinyl alcohol/carboxymethyl cellulose blend films were prepared by film casting. Blend films were cross-linked with gamma irradiation (4, 6 & 8 kGy) and by incorporation of chemical cross-linking agent. The objective of blending and cross-linking was to improve the mechanical and barrier properties. The results showed that cross-linking influenced mechanical properties. Tensile strength increased by 54% in the case of chemical cross-linking. In the case of irradiation, cross-linking films, the tensile strength increased with increase in the dose of irradiation and a maximum at 8 kGy irradiation was observed. Tear strength increased to 20.11 kN/m and 32.45 kN/m for 4 kGy and 8 kGy

from control value of 2.56 kN/m. Bursting strength decreases by irradiation. But the decrease was less at high doses at irradiation (Control 77.5, 4 kGy, 44 & 8 kGy, 60 kg/cm<sup>2</sup>). There was no significant difference observed in solubility and water vapour barrier properties. The structural characterization by SEM indicated that irradiated sample was more homogeneous than control and FTIR spectra showed that there could be possible interaction between two molecules.

Major loss in transportation of oranges, is physiological loss in weight (PLW) due to transpiration. The quality of orange is also affected by PLW. Studies was carried out to extend the shelf life of oranges by shrink packaging and to reduce post harvest losses. The oranges were shrink packed into the linear low-density polyethylene (LLDPE) films by using shrink packaging machine. Shrink packaging of oranges showed substantial reduction in PLW, pulp to peel ratio, juice recovery, TSS, pH, titrable acidity and ascorbic content. Hence shrink packaging retards ripening and colour development, there by extends the shelf life up to 36 days.

Biodegradable blends of poly (propylene carbonate) (PPC)/poly (caprolactone) (PCL) films in different ratios were prepared by simple solvent casting method using chloroform. The static mechanical properties and spectroscopic characterization were also studied. Tensile tests showed that the strength at break increased remarkably up to 4 fold with the incorporation of 20% PCL to PPC (80/20 blend) and further increase in PCL ratio did not yield significant increase in strength. The oxygen transmission rate decreased with increased PCL ratio. The surface morphology of the two aliphatic polyesters PPC and PCL as well as their blends were studied. The studies on blending optimisation ratio of PPC with PCL provided a practical way to develop completely biodegradable blends with applicable comprehensive properties.

#### *Functional foods from agri and marine waste for value addition*

The palm kernel and red gram mill waste were used for isolating bioactive ingredients/proteins for value addition. Palm kernel meal (PKM), a by-product of palm kernel oil extraction, is the meat in the nut of the palm oil fruits. It is an under-utilized co-product of palm oil milling industry. Since PKM contain valuable crude protein, it can be used as a new and non-conventional source of proteins. Defatted PKM had 16% protein (micro-Kjeldahl) expressed on dry weight basis. Protein fractionation showed globulins to be the main storage protein accounting to about 41% of total protein. The albumin, prolamin and glutelin proteins accounted to about 17, 11 and 19% respectively. The extractability of proteins varies with different solvents and pH conditions. Effect

of ionic strength (NaCl) and alkaline conditions (NaOH) showed maximum protein extraction upto 35% and 50% respectively. Protein isolate prepared at 0.05% NaOH showed increased solubility at either end of the isoelectric point (pH 4.5). The *in-vitro* pepsin pancreatin sequential digestion revealed that the isolate prepared was highly digestible.

The protein concentrate (79% protein content) prepared was enzymatically hydrolyzed and analyzed for bioactive properties. The antioxidant activity of hydrolysate was assayed by DPPH free radical scavenging activity, reducing activity and metal chelating activity. The hydrolysates had an IC<sub>50</sub> value of 1.83 mg against DPPH free radical scavenging activity, 65.1 µg for metal chelating activity and reducing activity expressed in terms of ascorbic acid equivalents (117 µg of hydrolysate is equivalent to 1µg of ascorbic acid). The anti-hypertensive activity was analyzed by measuring inhibition against ACE-I enzyme having an IC<sub>50</sub> value of 0.26 mg. The hydrolysate was completely digestible by human gastrointestinal enzymes.

Pigeon pea (Red gram) seed being the most widely used grain in India, the under utilized milling by-products were used in the preparation of protein isolate. The by-products from dhal mill include pigeon pea powder, brokens, germ layer and seed coat. The polished powder with brokens (chunl/chunni) comprised of 15% protein, seed coat and germ layer comprising of 7% and 4% respectively. The chunl was selected for the preparation of protein concentrate. The protein was extracted at pH 8.5 and the isoelectric-point at pH 4.5. The protein concentrate was prepared by extracting the protein from chunl in water at pH 8.5 and precipitated at pH 4.5. The protein concentrate prepared had protein content of 68%.

#### *Shelf life extension of selected traditional foods*

Lesser known and locally available fruits and vegetables namely adavikakara (*Momordica tuberosa*), muskmelon (*Cucumis melo*), karonda (*Carissa carandus*), ber (*Ziziphus jujuba*), nelausiri or desiamla (*Phyllanthus acidus*), gherkins (*Cucumis sativus*), colocasia (*Colocasia esculentus*), yam (*Amarphophallus companulatus*) and beetroot (*Beta vulgaris*) were processed to prepare value added products. The physico-chemical analysis of various raw materials used in the study was carried out. Process parameters for the preparation of products namely sweet chutney from muskmelon; dehydrated product, preservation in brine and instant curry mix from adavaikakara; mixed sweet chutney, candy, pickle and khatta-meetha from karonda; ready to eat vadiyams, mixed fruit bar, instant chutney and khatta-meetha from local ber; sweet chutney and fruit bar from hybrid ber, syrup and marmalade from desi amla, dehydrated chips from colocasia and jam from beetroot were standardised. Storage studies were completed for sweet chutney from muskmelon and found

to be acceptable for a period of 6 months. Other products namely RTE vadiyams, mixed sweet chutney, mixed bar, fruit syrup, marmalade, dehydrated chips and beet root jam were analysed for storage. Traditional sweets of Andhra Pradesh namely *Kajjikayalu*, *Sunniundalu* and *Shankarpaly* were prepared by modifying the recipe to enhance the nutritional value using millet flours and pulses. These products were found acceptable and further studies are under progress.

#### High throughput analytical methods for food quality and safety

##### Development of analytical method for tetracyclines using ionic liquid (green solvent)

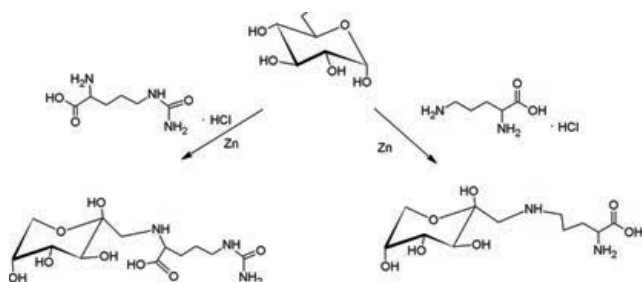
To obviate the expensive cartridge purification and also to eliminate the use of solvents, an analytical method for tetracycline residues in honey was optimised in LC-MS/MS using ionic liquid-ATPS, consisting of 1-butyl-3-methylimidazolium tetrafluoroborate ([Bmim]BF<sub>4</sub>) with organic or inorganic salts. IL-ATPS consisting of [Bmim]BF<sub>4</sub> with ammonium sulfate gave promising result.

##### Adulterants in milk and milk products

A method was developed to authenticate milk fat in ghee-based sweets by analysis of their lipid profile including triacylglycerol (TAG) and sterols using single short capillary column and single GC programming approach. The method was effective in detecting upto 5% level of adulteration. A study on milk, butter cream and ice cream samples indicated that specific milk and cream samples from local vendors contained starch, whereas ice creams from the local vendors contained saccharin and added colours. Work has been initiated to detect melamine in milk and milk products.

##### Synthesis of Maillard reaction conjugates

A synthetic method was optimised for the preparation of Maillard reaction conjugates of L-ornithine and L-citrulline with reducing sugar glucose and the accomplished compounds were characterized by <sup>1</sup>H, <sup>13</sup>C NMR and mass spectroscopic techniques. Stability studies of these conjugates are in progress.



Synthesis of fructosyl ornithine and fructosyl citrulline

#### Value added products from moringa leaves

Leaves from nine cultivars of moringa (Amar 32, PKM2, GKVK1, PKM1a, Bhagya KDM, Dhanaraj, CO1, PAVM and PKM1b) were analysed for moisture, protein and mineral composition of calcium, zinc, iron, sodium, potassium and magnesium. Protein in moringa leaf samples varied in the range 7.4 - 8.8% (33.5 - 39.4% on dry weight basis). Moringa leaves were found to be rich source of calcium (953-2134 mg/100g, dry weight basis) and potassium (1350-2160 mg/100g on dry weight basis). Iron content in moringa leaves varied between 12-21 mg/100g on dry weight basis.

Green milk powder developed from moringa leaves, using spray-drying technique, was studied for nutritional composition including fatty acid profile, vitamins (A, B1, B2 and niacin) and minerals (Ca, Fe). The green milk powder, thus developed had 10% protein and 0.5% fat content. Green milk powder was also evaluated for heavy metals.

Laboratory processed moringa leaf powder was evaluated for proximate composition. The protein content was found as 27%. The ether extract and the ash content was 4.0 and 8.0 respectively. The sugar profiles were studied by HPLC using an RI detector and aminopropyl column. Stachyose and verbascose were not detected in moringa leaf powder. Raffinose was present at 18.16 mg%. Among the disaccharides, maltose and sucrose were present at 80.8 mg% and 22.5 mg% respectively. The glucose and fructose contents were 74.9 mg% and 22.5 mg% respectively. The leaf powder was subjected to solubility studies at various pH (3-9) in water and 1M sodium chloride respectively. The protein solubility in water at various pH values was in the range 39-55% with the solubility minima of 39%. The solubility of proteins in 1M NaCl was 46-63% with the solubility minima of 46.7% at pH 4.0. The study shows that at isoelectric pH, the solubility minima were higher and the extent of precipitation of protein was lower compared to proteins from oil seeds. Thus preparation of protein concentrates from moringa leaf by isoelectric precipitation could not be done. The extractability of protein was higher in 1M NaCl, compared to water at various pH. This indicates that part of moringa leaf proteins is globulins. In order to prepare the protein concentrate from moringa leaf, the dried powder was extracted from a known quantity of sample using water and 1M NaCl and the protein was heat coagulated at 80°C at neutral and isoelectric pH. The precipitated proteins were washed and freeze dried and evaluated for protein content. The protein content of the concentrate prepared from 1M NaCl extract was higher (50-52%) compared to the concentrate prepared from water extract (44-46%) at neutral pH. There was no considerable difference in the protein content of

concentrates prepared by heat coagulation at neutral and isoelectric pH. The yield of protein concentrate was higher when 1M NaCl was used for extraction.

*Essential amino acids from plant sources*

Study was undertaken with the objective of formulating a protein mix with all essential amino acids. Soya flour, groundnut flour and sesame flour was selected for the formulation of oilseed protein mix. Protein mix with 90% protein was prepared and the proximate composition of the protein mix was determined.

*Value added processed products*

Value added products such as dehydrated slices from kundru and lotus root, pickles from raw kundru and lotus root, powder from fresh kundru and lotus root and chips from lotus root were prepared. The proximate composition analysis of value added products prepared from lotus root and kundru vegetables showed significant levels of essential micronutrients and nutrients. The storage studies of these products at room temperature indicated that the products stored showed no significant changes with respect to total soluble solids, acidity and total sugar, after 60 days of storage.



Processed products from kundru



Processed products from lotus root

*Value addition to tree borne oilseeds*

Detoxified karanja seed meal, rich in protein of 25% and > 0.5% oil after removing 60-80% of the anti-nutrients, such as tannins, phytates, protease inhibitors and saponins was developed. The seed meal was assessed for the nutritional potential of proteins and safety evaluation by rat bioassay for 8 weeks. No

mortality in groups fed with karanja seed proteins was observed. The meal at 50% protein replacement of casein, induced growth in rats with a PER of 1.7.

The detoxified karanja meal was also assessed for its potential use as a poultry feed ingredient. A feed formulation was prepared using detoxified karanja seed meal replacing 15 and 30% of the standard protein used in the standard poultry diet. The seed meal at 15% replacement showed a good growth response compared to the standard diet fed birds without any mortality. Safety studies revealed that no toxic effect was observed with respect to histopathology and hematology. Feed conversion ratio was 0.37 against 0.49 of standard diet fed animals, which reflects quality of proteins.

Detoxified simarouba seed meal, rich in protein of 58% and >0.5% oil after removing 80-90% of the anti-nutrients, such as alkaloids, protease inhibitors and saponins has been developed. Safety evaluation of feed formulation prepared using detoxified simarouba meal on broiler chicks was studied. The feed formulation was prepared by replacing the protein source with detoxified simarouba meal at 25% and 50% levels. Feed intake and body weight gain of all the chicks were recorded. The detoxified meal at 25% protein replacement in feed formulation has been recommended for use of simarouba meal as a source of protein in poultry feed formulation.

Two processes for the preparation of edible grade, karanja and simarouba seed meals were developed through simple methods of detoxification.

It was evident that methods involved minimum steps and it is feasible to reduce anti-nutrients by incorporating the detoxified meal up to 50% protein replacement in rat diet formulation and up to 15% protein in poultry feed formulation safely.

*Quality evaluation of Ready-to-Use flours from cassava*

Ready-to-Use (RTU) cassava flour with 3.3mg/100gm hydrocyanic acid content was prepared and incorporated at different level (0 to 30%) with wheat flour to prepare pan bread. Results showed that with 20% incorporation of RTU cassava flour along with emulsifier (0.5% sodium steroyl -2-laureate), sensory acceptable pan bread could be produced.

*Consumer acceptance studies*

About 50 samples of sweet *Shankarpouli* fried in different refined oils such as palm oil, sunflower oil, groundnut oil, coconut oil and ghee were subjected to sensory analysis periodically as part of shelf life study. Samples were packaged in 2 types of pouches, MET PE and PP, and were stored at 40°C, 30 to 40% RH. Samples fried in palm oil, coconut oil and ghee had good sensory quality and was acceptable at the end of 3 months.

Samples fried in groundnut oil and sunflower oil had developed rancidity by the end of 30 days. MET PE appeared to be a better choice as packaging material, for retention of texture and aroma.

Four samples of nutra spread containing different levels of nutraceuticals were subjected to sensory profiling and consumer acceptance studies. Based on the results of sensory profiling, nutra spread containing 3% nutraceuticals was used for consumer acceptance studies.

Three samples of grape juice were analysed at regular intervals for 40 days, as part of shelf life studies. At the end of the study, colour of one of the samples had decreased while that of the rest did not differ significantly. Fruity aroma was perceived to be less in all the samples. A decrease in perceived intensity of "Grape Like" aroma and sweetness was noted in these samples.

Eight samples of fermented bamboo shoot were analysed for sensory attributes. Non-oral sensory description was provided for the samples. Based on the sensory acceptability, three samples were selected for preparation of curry. Curry samples prepared from these

three-fermented bamboo shoot varieties were subjected to hedonic test. Results showed that all the three samples of curry were acceptable to majority of respondents.

Consumer acceptance study was conducted for products namely, Fruit Nectar and Fruit Bar developed as health products from Bael (*Aegle marmelos*). Results indicated that the fruit nectar samples had moderate acceptability. In the case of fruit bar, appearance and texture were rated favourably by majority of respondents. It was observed that the extent of lingering bitterness perceived in fruit bars was less compared to that of fruit nectar samples. It was felt that some masking agent is necessary in fruit nectar for improving its acceptability. It was also noted that the acceptance pattern of these health beneficial products vary when respondents are informed about the specific benefits of these products.

Sensory analysis was carried out for two samples of cactus beverage with and without mucilage. The results of the analysis showed that cactus beverage with mucilage had haziness, slight body with typical fruity aroma. Both the samples were found highly acceptable.

# HEALTH FOODS & NUTRACEUTICALS

## Biomolecules from moringa seeds

Moringa seed protein was extracted from defatted moringa seed flour. Effect of different salts on the extraction of protein from defatted moringa seed flour was studied. Experimental conditions like solvent to flour ratio, salt concentration and temperature on protein extraction efficiency (PEE) were optimized using response surface methodology (RSM). Among the ten different salts examined,  $\text{Na}_2\text{SO}_4$ , KCl, NaCl and NaBr displayed not only better PEE but also resulted in higher yield (~52% true protein) with a purity of >90%.

Carbohydrates from defatted moringa seed flour was extracted with water and ethanol. To improve the yield of carbohydrate content, different extraction methods like cold-water extraction and filtration were carried out. The carbohydrate content in the cold water extracted and filtered samples were 54 and 63% respectively. GC profile of the ethanol-extracted samples identified the presence of rhamnose, arabinose, xylose, mannose, galactose and glucose in the sample.

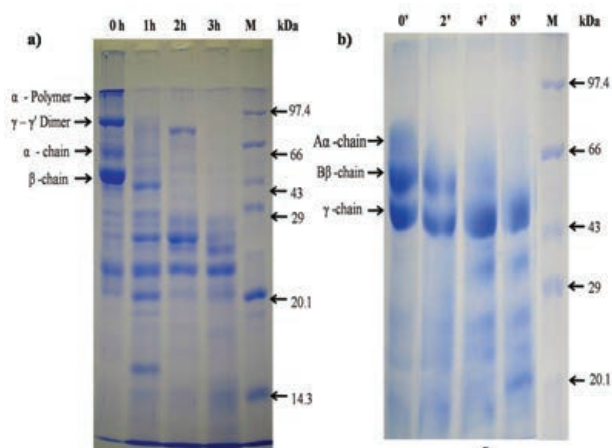
## Probiotic lactic acid bacteria (PLAB)

Ragi drink with varying concentrations of PLAB was prepared and different parameters were studied, *in vitro* and *in vivo*, in male wistar rats. The probiotic product was tested sensorially and was found to be active against *Citrobacter sp.* *In vitro* and *in vivo* studies showed that the probiotic ragi drink with a  $10^9$  cfu/ml has significantly lower amount of cholesterol and triglycerides compared to control. The weight of the liver also showed a reduction from  $11.35 \pm 0.34$  to  $10.34 \pm 0.63$ . The probiotic had a positive effect on reducing the weight of the liver. Also high fat diet incorporated with probiotic ragi drink in rats showed, cholesterol and triglycerides values of the serum decreased compared to control.

## Fibrinolytic enzyme

Among the several isolates characterized for proteases, one of the isolate tentatively identified as *Bacillus subtilis* was found to produce multiple proteases. SDS-PAGE analysis showed that the isolate produced 4 different proteases with fibrinolytic activity of approximate molecular weight 14, 21, 35, and 46 K Da under non-reducing condition.

Zymogram pattern of the isolate was identical with the reference culture, *Bacillus subtilis*168. Biochemical and molecular identification such as RAPD, phylogenetic analysis and 16S partial sequence analysis and species-specific primer PCR, revealed that isolate is *Bacillus subtilis* BR21. 20 $\mu\text{g}$  of crude protein obtained from culture supernatant could cleave all the four chains ( $\alpha$ -polymer,  $\gamma$ - $\gamma$  dimer,  $\alpha$ -chain and  $\beta$ -chain) of fibrin protein prepared from 100 $\mu\text{L}$  of clotted plasma in 3h of incubation at 37°C. In case of fibrinogen,  $\text{A}\alpha$ ,  $\text{B}\beta$  chains were highly susceptible for degradation where as  $\gamma$ -chain showed resistance for degradation during the initial period of incubation. The enzymes actively degraded fibrin and fibrinogen, highlights their potential application in releasing blood clot. Specific activity of the partially purified protein was 2.4 times higher compared to the culture supernatant. Protease inhibitors such as PMSF and EDTA at 5mM concentration have reduced the activity by 52.15 and 32.13% respectively, indicating the serine and metallo protease nature of the enzymes.



Sequential degradation of blood clot forming proteins by proteases of *Bacillus subtilis* isolated from fermented foods: (a) Fibrin: (b) Fibrinogen

## Monascus

Resveratrol was found in exotic fruits like mulberry and jamun and changes in biochemical parameters, antioxidant activity and resveratrol content after fermentation were identified.

Microorganisms from “*kamba koozh*” were screened for their ability to produce feruloyl esterase. Two hundred morphologically different isolates were obtained from 11 different “*kamba koozh*” samples. Eighty six strains showed the formation of halo zone around the colonies evidencing feruloyl esterase activity.

Hyper-pigmented *M. purpureus* mutant was found to be promising in bio-pigment, statin and GABA production as compared to its parent variety. Different varieties of rice and paddy were studied for the production of statins through solid-state fermentation of *Monascus*. Steamed rice was found to be the most potential substrate.

*Preservation of traditional fermented products*

Some of the traditional pickles and their ingredients like karindi, kempu chutney, hasiru chutney, balaka chillies and garlic chutney powder were collected along with tamarind, gongura, tender ripened red chilli pickle, either in raw form or ready to eat form. Proximate analysis revealed that these products were acidic in nature with a pH in the range 3.74 - 6.01. Karindi has high total lipid content (36%) and others are having less than 3%. Total sugar content ranged from 2.2 to 7.75%.

From these samples, a total of 24 yeast isolates were isolated and their sugar fermentation pattern was determined. Morphology, which helps in identifying the yeasts, was carried out by scanning electron microscope. Microbial profile of these products was determined. Except for three samples, the microbial load was found to be very low and in three samples, the count exceeded >10<sup>6</sup> cfu/g. The low microbial load was attributed to high spice contents of the product. However, in most of the products, yeasts and mould count exceeded the normal limit of 100 cfu/g.

*Diversity and genetic relatedness of lactic acid bacteria (LAB)*

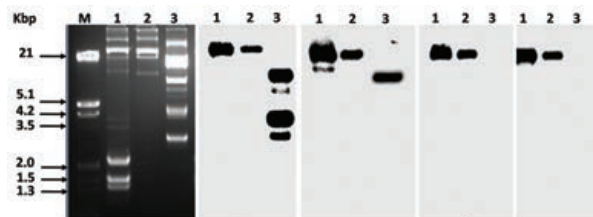
Dominant LAB species associated with *soidon* and *soibum* were identified. The species viz. *Lb. brevis*, *Leuconostoc lactis*, *Leuconostoc fallax*, *Lb. plantarum*, *Lb. acidophilus*, *Lb. delbrueckii*, *Lb. coryniformis* and *Enterococcus* sp. were present in *Soidon*. Similarly along with *Lb. brevis*, *Leuconostoc lactis* and *Leuconostoc fallax*, other species such as *Lb. coryniformis*, *Lb. brevis*, *Lb. plantarum*, *Lb. acidophilus*, *Leuconostoc* sp. and *Lactococcus* sp. were observed in *Soibum*. Strains of *Lb. plantarum*, *Lb. xylosus*, *Lb. fructosus* and *Lb. viredescens* were identified in *gundruk* and fermented *gundruk* along with *Lb. plantarum*, *Lb. plantarum*, *Lb. fermentum*, *Lb. casei* and *Pediococcus pentosaceus*.

Studies was carried out on the nutritional value and sensory attributes of traditionally fermented bamboo shoot foods. Total phenolic content, antioxidant property,

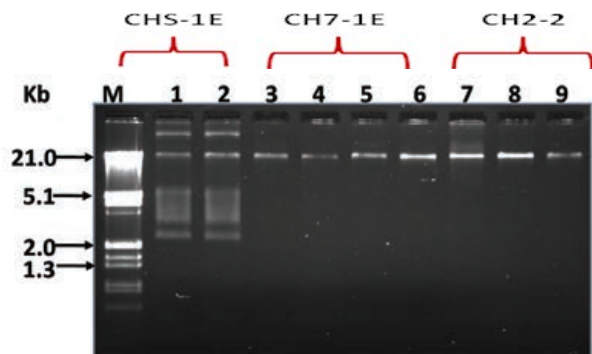
vitamin content and radical scavenging activity were assessed. Results showed that fermented bamboo shoots can be used as health foods and additives because of their rich nutritional value.

*Antibiotic resistant genes in lactic acid bacteria from poultry and meat products*

Antibiotic resistant lactic acid bacteria was screened from chicken and mutton raw meat samples. Resistant cultures were tentatively identified as *Enterococcus* and *Pediococcus*. Almost all strains were resistant to erythromycin, streptomycin, tetracycline and chloramphenicol with varied minimum inhibitory concentrations (MIC). MIC values of most of the resistant strains were found to be higher than the clinical breakpoints given by European Commission (2005). High incidence of resistant microflora is the result of the excessive use of antibiotics in poultry. These observations revealed that excessive antibiotic pressure through poultry feed is the sole cause for multiple antibiotic resistances among LAB.



Finger printing of acquired ER and TC genes in *Lactobacillus*



Plasmid profile of transconjugants

*Rapid detection of probiotic lactic acid bacteria*

The objective was to characterize probiotic potential of LAB, namely, acid and bile tolerance, antagonistic activity, antibiotic susceptibility of cultures, isolated from fermented dairy product and human samples. Tentative identification of isolated cultures was performed by morphological and biochemical tests.

LAB was isolated from dairy products and human stool samples. Based on the biochemical and morphological tests, isolates were grouped under genus *Lactobacillus*, *Enterococcus* and *Streptococcus* sp. Twenty three LAB showed inhibitory activity against *M. luteus* and

*P. aeruginosa*, whereas 24 cultures against *L. monocytogenes* and *Clostridium sp.* by spot inoculation. Among the screened isolates, 27 strains exhibited more than 30% survival rate at acidic pH-2 and pH-3. The growth percent in the presence of bile in all the tested strains was higher compared to growth at acidic pH. Moreover, isolates from stool sample, had greater resistance capacity to acid and bile, as compared to cultures isolated from dairy products. Most of the selected cultures were able to grow in the presence of vancomycin (25 µg), tetracycline (25 µg), streptomycin (10 µg) and gentamycin (10 µg), but were susceptible to ampicillin (10 µg) and erythromycin (15 µg). The results suggest the probable use of cultures in food industry, as probiotic isolates.

#### *Food grade Bacillus sp. as probiotics*

Studies were taken up for the isolation and characterization of *Bacillus sp.* for probiotic applications. Initially heat resistant flora with gram positive and catalase positive property were isolated from different milk samples (cow, buffalo, sheep, goat, donkey), from commercially available milk based dairy products and rhizobial soil, root and leaves samples of various medicinal herbs. Around 170 cultures isolated were further screened for antimicrobial activity against *Micrococcus sp* and these cultures showing the above property were selected and subjected to RAPD profiling. RAPD dendrogram depicted two major groups, which were further divided in 2 subgroups. 17 cultures representing each group were tested for non-haemolytic property using 7% sheep blood agar media.

Eight cultures with non-haemolytic property were studied for their growth at acidic pH in the presence of bile at different time intervals. Six cultures (CDM4-3c, Csm1-1a, HN-S1, HR-1, AR-S4 and Kcu7-1) showing better survival was subjected to growth at simulated gastrointestinal condition. Under gastric condition all the cultures showed 4-5 log reductions compared to control and under intestinal condition (pH 8.0; 0.1% trypsin/0.1% pancreatin) all the cultures showed only 2-3-log reduction. Comparatively, Csm1-1a, HN-S1, CDM4-3c and AR-S4 showed better survival under such condition.

Further these cultures were analyzed for their antimicrobial activity against food borne pathogens. Antioxidant activity was 30-40% as analyzed by DPPH assay, reducing potential of 80-90% and H<sub>2</sub>O<sub>2</sub> scavenging of about 65-70%. Adhesion property of each culture showed varying percentage of adhesion with different hydrocarbons used, xylene (25-50%), toluene (30-50%) and hexadecane (12-40%). Antibiotic susceptibility of these cultures was analysed using octadisc.

All the selected *Bacillus* cultures showed better survival at acidic pH and bile salt concentration, which is an important criteria, for probiotic application. In addition,

the representative cultures exhibited additional beneficial properties including antimicrobial activity, antioxidant activity and adhesion property. Confirmatory studies of non-virulent property of selected cultures by molecular methods and taxonomic identification of the cultures by 16S rDNA sequencing are in progress.

#### *Nutritionally enriched millet based products*

Two varieties of the millets such as proso millet and foxtail millets were procured. Nutritional composition of the grains along with physical, engineering and functional properties, for the whole grain as well as for the polished grains were determined to characterise the grains. It was found that functional properties significantly varied between these varieties. Foxtail millets have more water absorption capacity compared to the proso millets. Nitrogen solubility for foxtail millets in both water and salt was found more as compared to proso millets.

#### *Pigeon pea seed coat phenolics*

Milled fractions of the two most widely cultivated and high yielding varieties of (ICP 187115 and C-11) pigeon pea (*Cajanus cajan*) were evaluated for their nutritional and antinutritional characteristics. Protein content of these fractions ranged from 23.1-24.6 g/100 g in cotyledon and 6.4-8.1 g/100 g in seed coat fractions. Fat content was highest in embryonic-axe fractions and lowest in seed coat fractions. Crude fiber content was higher in seed coat fractions than embryonic axe and cotyledon fractions of both the varieties. Seed coat fractions had high dietary fiber content (18.6-28.2 g/100 g), made up of mainly insoluble dietary fiber. Most of the phytic acid and oligosaccharides were located in the cotyledon fractions whereas, phenolic compounds in higher concentrations were found in seed coats. Significantly higher concentrations of proteinaceous and phenolic inhibitors of digestive enzymes were found in cotyledon and seed coat fractions, respectively. Phenolic compounds from seed coat fractions were extracted with distilled water, aqueous ethanol (80%), aqueous acetone (70%) and aqueous methanol (80%) containing 1% HCl. Aqueous methanol solvent extracted the highest level of total phenolics at about 98.8 mg of gallic acid equivalents per gram of seed coats from ICP 187115 variety followed by aqueous acetone, distilled water and aqueous ethanol. Determining the phenolic indexes and characterization of individual phenolic compounds in the seed coats of pigeon pea varieties, are under progress.

#### *Nutraceutical enriched traditional foods*

Oils were extracted from wheat bran and wheat germ using solvent extractor and analyzed for carotenoid content. Wheat germ oil had six-fold higher carotenoid content than wheat bran oil. Antioxidant activity study was performed on wheat bran and wheat germ oil using free radical DPPH and IC<sub>50</sub> values observed were in the



following order as gallic acid (GA) <  $\alpha$ -tocopherols < ferulic acid < wheat germ oil < wheat bran oil. Present study showed that wheat germ oil had strong IC<sub>50</sub> than wheat bran oil and lesser than other standard phenolics (GA,  $\alpha$ -tocopherols and ferulic acid). Followed by GA,  $\alpha$ -tocopherol showed strong IC<sub>50</sub>, which is the major component of the wheat germ oil minor components.

#### *Bioactive molecules from Indian niger seeds*

Niger seed oil was evaluated for its major and minor constituents, stability and radical scavenging activity. Enhancement of bioactive molecules, stability and radical scavenging activity of niger seed oil was also attempted. Niger (*Guizotia abyssinica* (L.f.) Cass.) seeds procured from the local market, were subjected to oil extraction using different polarity solvents. Oil content of niger seeds by different extraction solvents were found to be in the range of 31.8-41.3 g/100g seeds. Quality characteristics of extracted niger seed oils showed colour (40.0-490.0 Lovibond units), free fatty acids (3.6-12.3 g/100g oil), peroxide value (3.2-7.8 meqO<sub>2</sub>/Kg oil), iodine value (137.6-140.3 gI<sub>2</sub>/100g oil), saponification value (177.3-185.9 mgKOH/g oil), unsaponifiable matter (1.3-4.3 g/100g oil), linoleic acid (69.4-73.2%) and trilinolein (31.2-33.4%). Bioactive molecules of extracted niger seed oils revealed total tocopherols (171.9-345.8 ppm), total phenolics (247.1-2647.7 ppm), total sterols (1249.6-6309.3 ppm) and total carotenoids (18.9-181.0 ppm) with  $\alpha$ -tocopherol (154-276 ppm) and vanillic acid (176-1709 ppm) as the major tocopherol and phenolic compound. Ethanol extracted oil showed 13.9 fold better oxidative stability and IC<sub>50</sub> value of 9.2 mg/ml as compared to hexane-extracted oil.

Studies suggest that Indian niger seeds are rich source of edible oil, linoleic acid and bioactive molecules. The inherent bioactive molecules contribute to the stability and radical quenching ability of niger seed oil. The extractability of these bioactive molecules can be increased by the use of polar solvents. Ethanol proved to be a good solvent for extraction of niger seed oil, which is rich in bioactives. Ethanol extracted niger seed oil demonstrated 1.9 fold increase in tocopherols, 8.6 fold increase in phenolics, 4.7 fold increase in sterols, 6.7 fold increase in carotenoids, 13.9 fold increase in oxidative stability and 4.4 fold increase in radical quenching ability as compared to hexane extracted niger seed oil.

#### *Nutraceutical composition of red palm oil*

Crude red palm oil (10 Kg) was fractionated into a liquid red olein fraction (77%) and solid red palm stearin (23%). Red palm olein (RPO) is a rich source of natural antioxidants. These antioxidants are lost during refining of crude RPO (CRPO). CRPO containing 11.73% free fatty acid (FFA) was deacidified using enzyme

(immobilized *Rhizomucor miehei* (RM) lipase), solvent {ethanol (EOH)} and chemical (aqueous NaOH) deacidification methods and its physico-chemical properties and nutraceutical retention was evaluated. The deacidified RPO showed variations in melting point, viscosity and colour; but there were no changes in refractive index and specific gravity. The acidity (11.37%) of RPO was reduced to 0.9% for RM, 0.42 for ethanol and 0.07 for NaOH based deacidification. Peroxide value (7.2 meqO<sub>2</sub>/Kg) increased to 11.7 for RMRPO, 17.8 for EtOHRPO and NaOHRPO. Saponification value (204.3), iodine value (55.7) and unsaponifiable matter (0.74%) and fatty acid composition did not change during deacidification. The level of mono and diglyceride increased for RMRPO. The level of trisaturated and triunsaturated TG was reduced for RMRPO. Carotenoid retention was upto 98% observed for EtOHRPO. The highest retention of phytosterol (94%), total tocopherol (71%), squalene (72%), coenzyme Q10 (99%) and total phenolics (35%) were shown by RMRPO. RMRPO showed the EC 50 value of 21.8 mg/ml and high oxidative stability which indicates the improved antioxidant retention and stability than EtOHRPO and NaOHRPO. Results showed that RM based deacidification can be effectively utilized for the preparation of nutraceutical rich stable RPO.

#### *Phytosterol ester of ALA*

The physico-chemical characteristics of rice bran oil (RBO) and rice bran oil deodorizer distillate (RBO DOD) were analyzed. Analysis of phytosterols data between RBO and RBO DOD revealed that DOD contains 22.3 times more phytosterols content than the oil. Even the unsaponifiable matter content of the DOD was 6 times higher than the oil. Hence, RBO DOD was used as the source for the preparation of pure phytosterols. As the unsaponifiable matter was rich in phytosterols, phytosterols of 85% purity were prepared from the unsaponifiable matter with 60% recovery of the phytosterols.

#### *Extraction of nutraceuticals and their evaluation*

Flax seed, niger seed and sesame seed cakes, almond and groundnut skin, pomegranate, blue grape and apple peels were taken to isolate phytochemicals/nutraceuticals present therein. They were pre-defatted, dried and subsequently extracted with aqueous ethanol and aqueous methanol to isolate the active factors. The isolates were desolventized under vacuum resulting in phytochemical concentrates. These concentrates were loaded on silica gel columns separately to isolate polar and non-polar fractions for the assessment of antioxidant properties.

#### *Preparation of foods with nutraceuticals*

A ready to eat snack was prepared using ajwain and leafy vegetables; pudina, betel and curry leaves. These

leaves were freeze dried and incorporated into the formulations. Two types of basic formulations were tried, with whole-wheat flour and the other with besan flour. Fat in the dough was kept at 10-12% level and the products were dried at low temperatures. The dough was sheeted manually to about 2-3 mm thickness and cut into required shapes.

The formulation with besan flour resulted in a product with gritty texture and was slightly hard whereas that prepared with wheat flour was crunchy, light but slightly soft. Breaking strength of both the snacks prepared ranged between 6-25N. Addition of gelatinised starch increased crunchiness of the product but it was found hard. Further studies are being carried out using wheat flour and varying the levels of heating, addition of leafy vegetables/ spices and different drying stages to obtain a crunchy product with added nutrients/nutraceuticals. The effect of adding these leaves on colour, texture and sensory analyses of low fat snacks was studied. Moisture in all the products ranged between 2.1 to 3.7 %, breaking strength ranged between 1.8 to 3.0 N. Addition of spicy leaves showed a green colour in all the products. The total colour difference, (D E) was low at 4% level, but at 6 and 8% levels were also similar. Sensory evaluation of the low fat snack at 4, 6 and 8% levels showed that with 4% addition was highly acceptable. At the higher levels, bitterness was observed. The total polyphenols and antioxidant activity in betel leaves was the highest followed by curry and pudina leaves.

These formulations with a few variations were extruded into small globules and the product obtained was coated with the spices such as ajwain and freeze dried leaves along with salt and other additives.

#### *Nano emulsion*

Preparation of PUFA rich microemulsions using the binding materials of gum acacia, whey protein and lipid was carried out. The microemulsions were characterised for encapsulation efficiency, encapsulation yield, oxidative stability and microstructure by scanning electron microscopy.

#### **Trans fatty acids**

##### *Vegetable butter for use as trans free margarine*

Mango fat was blended with palm olein oil at 10, 20, 30 and 40% levels and vegetable butter was prepared in the lab scale. The hardness of the blend containing 30% oil was comparable with commercial butter. When 10% butter was incorporated, the shining appearance and the flavour characteristics of the experimental sample improved. This study showed the potential for mango fat to be used as vegetable butter and trans free margarine.

##### *Uptake of trans-fatty acids by macrophage lipids and effect on inflammatory mediators*

The majority of trans fatty acids (TFA) consumed from diet comes from partially hydrogenated vegetable oils (PHVO), which contain 10-40% TFA. Consumption of TFA is known to enhance the risk factors for heart diseases. TFA may have adverse effects by interfering with essential fatty acid metabolism. Essential fatty acids are precursors for prostaglandins and leukotrienes, which are involved in inflammation. Alpha-linolenic acid and oryzanol may regulate the production of prostaglandins and leukotrienes by macrophages.

##### *Lipoprotein metabolism*

The effect of trans fatty acids on plasma lipid and lipoprotein concentrations were explored. The major source of dietary trans fatty acids was partially hydrogenated fats and products formulated with these fats, such as commercially prepared baked and fried foods. A smaller proportion of dietary trans fatty acids come from ruminant animal fats found primarily in meat and full fat dairy products. In order to study the mechanism of the differential effect of the trans fatty acids on the lipoprotein metabolism, various genes associated with the lipoprotein metabolism were selected for the gene expression studies such as beta actin. A 2-fold decrease was observed in the case of rats, fed with vanaspati for the gene LPL and a two-fold increase for cholesterol 7 alpha hydroxylase gene in ghee fed rats, with no significant change with the vanaspati fed rats.

##### *Tender and mature coconuts*

Studies on the physico-chemical characteristics, nutraceutical contents and effect of storage by using established methods were carried out on coconut kernel and coconut water in comparison with industrial coconut products and commercial coconut products. The coconut water and kernel were freeze dried, flash evaporated and heated at two different temperatures (in case of coconut water), and checked for its stability. The fatty acid composition in terms of MUFA and PUFA decreased whereas the SFA increased with maturity of kernel. The phenolics of oil extracted from copra was 0.5 mg/100 g of oil and through various method of incorporation it was increased to 6-16 mg%. The commercial coconut oil had TPC of 11 mg%. The coconut water had 0.7-2 mg% of growth hormones and after processing, it changed marginally. Indole acetic acid, indole butyric acid, naphthalenic acid and 2,4-dichlorophenoxy acetic acid were present in coconut water. The coconut milk was extracted and tested for moisture and fat content of residue and coconut milk along with mature coconut. The oil was extracted under lab conditions and fatty acid composition, peroxide value, free fatty acid value, iodine value, colour and phenolics content were

determined. The PV was 1-2 meq/kg of oil, FFA 0.03-0.3%, Iv 5-11, colour 1-5 and phenolics content was 0.07-3 mg%. Finally nutritional composition of raw and cooked copra was tested. Potassium was found to be more among all the minerals. Based on the chemical composition of the tender and mature coconut water and meat and the dried materials, combinations were worked out to prepare health foods. Initial studies on water activity measurements and determining ERH data were carried out. Large batch (5kg) of these products was prepared and storage studies are in progress.

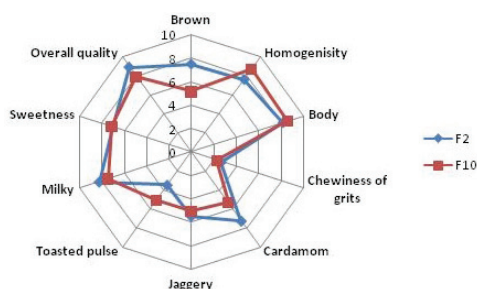
*Nutra coconut oil*

Sesame seeds and flax seeds were expelled to remove the oil to obtain cakes. These cakes were further solvent extracted to remove the residual oil present. Expelling was done through ghani and hydraulic press. Total defatted cakes were used to isolate bioactive concentrates using methyl alcohol, ethyl alcohol and 20% aqueous ethyl alcohol using soxhlet and open heating system. Bioactive factors like polyphenols, sesamol,  $\beta$ -carotene and tocopherols along with antiradical activity using DPPH were estimated for all these concentrates. Results indicated that soxhlet process is better than the open heating process as far as the yield of concentrates are concerned. However among the solvents, ethyl alcohol is a better solvent for sesame seed cake and flax seed cake soxhlet extraction, but aqueous ethanol was a better solvent for flaxseed cake open heating extraction. Estimation of bio-actives like polyphenols, sesamol,  $\beta$ -carotene tocopherols and antiradical activity were carried out.

Sesame and flaxseed cakes were used to isolate the bio-active concentrates which were further subjected to finger printing using HPLC, GLC and spectrophotometric methods. The bioactive factors namely polyphenols, tocopherols,  $\beta$ -carotene sesamol, isolariceresinol were estimated using HPLC method. Individual oil like coconut oil, flaxseed oil and their blend 70:30 were used to estimate their fatty acid composition.

*Health beverages*

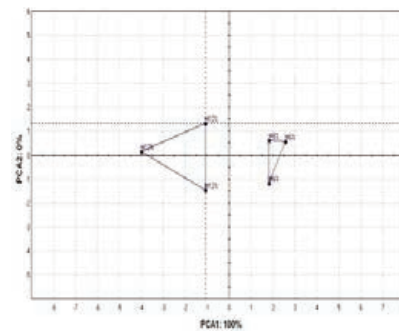
Several formulations of kheer based on jaggery and wheat grits were developed and the method of preparation was standardized. Sensory analysis of selected samples revealed the high overall quality of these products.



Sensory profile of wheat grits based kheer

Presence of jaggery was found to contribute yellowness to the colour of sample. GC-MS studies indicated that several compounds other than 1,8-Cineolen and  $\alpha$ -Terpenyl acetate probably added to the overall quality of the product in terms of enhanced flavour.

Preparation of health beverages based on basil and mint was standardized. The descriptive analysis showed the difference between the aroma component for the beverage when it was prepared with sugar and citric acid due to synergistic effect. In the absence of sugar and citric acid, the difference in the aroma levels was difficult to identify by the discrimination tests, probably due to antagonistic or suppression properties of flavour. Consumer acceptance study showed good acceptance for these beverages. GC-MS analysis identified major compounds present in basil and mint essential oil and indicated 32 compounds in basil and 28 in mint essential oil. Major ones include Caryophyllene, P-Mentane and Germacrene D. Instrumental analysis using e-nose showed aroma pattern matching and e-tongue taste pattern matching for basil and mint based health beverage. Antioxidant properties of these health beverages were also measured.



Taste pattern matching of basil beverages using electronic tongue

A benchmark study on high protein drink from wheat grass has been studied by extracting the juice from the wheat grass cultivated indoors. The typical grass flavour from the young wheat plant is not acceptable to consume as such. Adding other flavour components, such as cardamom, ginger, cumin and mango, reduced the flavour of wheat grass. Standardization of wheat grass drink is under progress.

A ready to eat nutricereal - jaggery based nutraceutical health food was developed by blending green gram flour, pearl millet, wheat flour and pumpkin seeds at different proportions. Two different formulations were standardized and they were subjected to preliminary sensory evaluation studies.

*Prebiotic oligosaccharides*

The isolate PFS08 capable of producing significant titers of transglucosylating glucosidase was identified as *Aspergillus niger* based on growth pattern of mycelia and spores under microscope. Five different media were

also evaluated for the production of alpha glucosidase. The  $\alpha$ -glucosidase production was highest in the screening media in 192 hours of fermentation, which contains maltose as inducer. The time course study indicated that during the initial 120 hours (log phase) of fermentation, the biomass concentration (g/l) increased significantly, reaching a maximum of 46.51 g/l after 96 hours of fermentation. After this period, the biomass concentration started decreasing and the production of enzymes including  $\alpha$ -glucosidase was started. The  $\alpha$ -glucosidase activity was not significant during the initial hour of fermentation and the maximum  $\alpha$ -glucosidase activity (0.121 U/ml) was observed at 192 hours of fermentation. During the first 72 hours of growth, the pH of the medium decreased from an initial 5.5 to 2.74, followed by an increase until reaching 6.08 after 144 hours. The glucosidase (0.1 units /ml) from PFS 08 was used for IMO production with 40% maltose in citrate buffer (0.05 M, pH 5.5) at 55°C for 120 hours. The maximum IMO production of 45% was observed after 54 hours of reaction. It mainly consisted of panose (21.01%), isomaltose (12.04%), isomaltotriose (2.81%) and tetrasaccharides (9.7%). ESI/MS analysis also confirmed the presence of di-saccharide, DP2 (maltose, isomaltose), tri-saccharides, DP3 (maltotriose, panose, isomaltotriose), tetra-saccharides, DP4 in the reaction mixture. Penta-saccharide, DP5 was also detected by ESI/MS, which was not detected in HPLC due to their less concentration.

#### *Healthful meat based products*

Binders like wheat flour, soy flour and corn starch in combination with or without milk powder were screened which are found most suitable for making a stable emulsion using chicken meat or liquid egg as a base material. For the development of chicken spread, cooked chicken (60%) mixed with wheat flour (3.5) in combination with skim milk powder (1.7%), resulted in desired consistency with respect to its rheological properties. To meet the emulsion characteristics, average 7.5% oil was found to be optimum level. To extract salt soluble proteins from meat and to reduce desired level of water activity, common salt (4%) was added during processing. To regulate the pH of the product, a combination of malic acid (0.4%) and citric acid (0.4%) was found to be optimum, based on sensory profile of the product. The spread was stabilized at pH 3.8. Pasteurization of the product at 73-85°C for a few seconds resulted in emulsion break and altered significantly the rheological properties of the spread. Therefore, only unpasteurised product was packaged in laminated metalized polyester pouches with and without nitrogen and stored at room temperature and at refrigeration temperature for further studies. The physico-chemical, microbiological and sensory properties of the spread were evaluated. The proximate composition of the product was moisture 59.9%, lipids 11.5%, protein

17.1% and ash contents 4.58%. The water activity and thermal stability of the spread was 0.94 and 8 ml/100 gm, respectively. The total plate count in unpasteurized sample was 2.4 logcfu/g, whereas, *Staphylococcus*, *Salmonella*, *E. coli*, yeast and mould was not detected on zero days. The Hunter colour units of the samples for L, a, b, chrome, and hue values were 72.78, 0.27, 11.09, 11.09 and 88.63 respectively. The viscosity of the spreads was 9500 Pas. Other rheological parameters studied were shear rate, shear stress, amplitude sweep and frequency sweep. The storage studies are in progress. Also development of an egg spread has been initiated.

#### *Healthful texturized egg products*

The compatibility of egg liquid for the development of novel emulsion type cooked egg sausage by replacing ~ 70-75% chicken meat was studied. Different levels of liquid egg in combination with varied levels of chicken meat were studied using appropriate statistical design for standardizing the process. 50% egg liquid in combination with 25% chicken meat was found significant ( $P \leq 0.05$ ) with respect to textural characteristics compared to other variations. Sensory and physico-chemical results also substantiated the same. Subsequent compositional variation was focused on the liquid egg part of the product. Egg liquid contents (50%); individually whole egg, egg albumen and egg yolk were mixed with optimised quantities of chicken meat (25%), lipids (15%) and binders-fillers and spices (10%) to obtain a stable emulsion. The emulsion was stuffed in cellulose casings, steam cooked and cooled for further quality evaluations. The pH of whole egg sausage (WES), egg albumen sausage (EAS) and egg yolk sausage (EYS) was measured. EYS showed lowest moisture content and highest lipid content, while in the case of EAS, the reverse was observed. 100% water holding capacity and thermal stability of cooked emulsion was recorded. EAS had the optimum emulsion characteristics and textural properties compared to WES and EYS. EAS had better cohesiveness and chewiness compared to WES. The EYS were firmer and had more gummy forces than WES and EAS. The changes in lipid oxidation, physical properties, textural profile and colour traits of the product during frozen storage were also studied. The standard plate counts, yeast and mould counts were within the specified limits during storage. *Staphylococcus aureus*, *E. coli*, *Salmonella* and *Shigella*, however, were not detected in any sample throughout storage period. Sensory evaluation revealed that the product had good overall acceptability during storage. Among the variations, EAS was ranked to be the best.

#### *Nutraceutically important molecules from microalgae*

Soybean (*Glycine max* L.), of JS 335 variety was used to enhance the level of isoflavones content under *ex vitro*

conditions. Biotic elicitors were prepared, using two fungal cultures, *Aspergillus niger* and *Rhizopus oligosporus*. The effect of floral application of two biotic elicitors - *Aspergillus niger* and *Rhizopus oligosporus* at different concentrations were evaluated. Compared to an untreated control, all elicitors applied influenced a marked increase in individual as well as total isoflavones level in soybean seeds. Daidzein and glycitein were generally more responsive to elicitors than genistein. Of the two elicitors applied, a maximum increase in total isoflavone content was observed under the influence of 0.1% *A. niger* compared to control. Apart from this, leaf callus suspension cultures of *Glycine max* (Indian variety, JS 335) were established and treated with various combinations of plant growth regulators and its influence on biomass as well as isoflavone production at various time intervals were reported. All the plant growth regulators increased the biomass as well as isoflavone production. Highest total isoflavone content (3.1% dry weight) was observed in 1 mg/L NAA and 0.1 mg/L Kinetin combination and highest biomass with 1.5 mg/L 2, 4-D and 0.1 mg/L kinetin combinations. In comparison with seeds of soybean, the cell suspension cultures augmented isoflavone concentration (10-30 times). Results suggest the cell suspension cultures could be used for scale up studies in bioreactors to offer high content of bioactive isoflavones.

#### *Micronutrient enhancement in coriander*

Coriander foliage is a rich source of pro-vitamin-A carotenoids and phenolics useful to human health. It was evidenced that foliar-application of elicitors, methyl jasmonate (MeJa) and salicylic acid (SA), differentially elicited total carotenoids,  $\beta$ -carotene, lutein and chlorophylls and profoundly enhanced total phenolics, particularly the chlorogenic acid, in GS4 Multicut and Mahak, the cultivars with high and low carotenoids respectively. In both cultivars, MeJa (10  $\mu$ M) rapidly enhanced carotenoids, whereas SA (10  $\mu$ M) elicited mainly phenolics. Elicitation improved superoxide scavenging of anion radicals by three fold in the case of total carotenoids (IC<sub>50</sub> 5.01  $\mu$ g/ml) and 1.2 fold in case of total phenolics (45.5  $\mu$ g/ml), whereas hydroxyl radical scavenging activities of respective extracts (2.64  $\mu$ g/ml and 18.01  $\mu$ g/ml) accounted for about seven fold higher efficacy than extracts from control foliage. These observations indicated that precise elicitation is a novel natural method for significant enhancement of important compounds in coriander.

Coriander (*Coriandrum sativum* L.) is also a rich source of folic acid. Therefore, different growth regulators and stress inducers like benzyl amino purine (BAP), kinetin (Kn), abscisic acid (ABA), methyl jasmonate (MeJa) and salicylic acid (Sa) were tested on coriander callus cultures. Folic acid was found to increase in all treatments, where best treatments have shown an

increase upto two fold. In addition, it was found that salicylic acid differentially elicited different forms of folates, 5-methyltetrahydrofolate, 5-formyltetrahydrofolate and 10-formyltetrahydrofolate and enhanced their stabilities during microwave drying and bio-accessibilities from fresh and dried foliage. The first two compounds nearly doubled and the third increased six-fold post-elicitation, with all three showing concomitant increase in bio-accessibilities. Although a slight decrease in bio-accessibility was observed in dried foliage, over two fold increase of each form of folate upon elicitation would deliver much higher levels of natural folates from this traditional culinary foliage, which is widely used in many cuisines. Elicitor-mediated folate enhancement also imparted reduction of oxidative status and the enhancement of antioxidant enzyme activities in coriander foliage.

Carrot *in vitro* culture of *Early nantes*, a local variety carrot was raised on Murashige and Skoog's medium, containing 6-benzylaminopurine (BAP) and 1-Naphthaleneacetic acid (NAA) and IAA in different combinations. The initial callus raised from stem nodes and leaf petioles were repeatedly sub-cultured to obtain un-differentiated calli and further experiments were done using various levels of auxins and cytokinins. Freshly initiated calluses of *Early nantes*, a local variety carrot, were raised on a MSB5 medium. These calli were transferred to MSB5 medium supplemented with various concentrations of kinetin and IAA for multiplication and anthocyanin induction. The cultures were incubated at 24 $\pm$ 1°C temperature under 16/8 h (light/dark) photo period and sub-cultured at 15-day intervals. For anthocyanin induction in callus cultures, MSB5 were supplemented with 4, 5, 6 and 7% sucrose. Maximum induction of anthocyanin was obtained on MSB5 medium containing 1.5 mg/L IAA and 0.2 mg/L of kinetin. To investigate the effects of sodium nitroprusside (SNP) on induction of anthocyanin the callus were transferred to MS medium containing 0.5 mM SNP. The calli, which was transferred to SNP, developed colour faster than the control, was without SNP. The anthocyanin concentration is to be further analyzed.

#### *Cafestol and kahweol and selection of somaclonal variants for value addition*

The anti-nutritional diterpenes cafestol and kahweol profiles in coffee bean samples, influence of roasting and brewing methods on cafestol and kahweol profiles in beans and brew, establishment of *in vitro* cultures of *C. canephora* were studied. Subsequent studies have indicated that both the crude and purified fractions of coffee bean extracts including brew samples exhibited varied antioxidant activities as evidenced from free radical, hydroxyl radical scavenging assays. No anti-inflammatory and immunosuppression activity was found in all these samples. A significant reduction in both

diterpenes under the treatment of antiauxin TIBA, anti-cytokinin lovastatin and ethylene action inhibitor silver nitrate was evident. There was 25-32% elevation of cafestol and kahweol in presence of paclobutrazol. This may be due to the gibberellin inhibitory nature of paclobutrazol that would possibly elevate ent-kauronic acid pool, which is also a precursor for cafestol and kahweol. The role of TIBA, lovastatin and silver nitrate at physiological levels in somatic embryos for reduction in cafestol and kahweol are not known and further investigations in this regard are required. Variants were developed through somatic embryogenesis for reduced levels of cafestol and kahweol and their low levels were maintained from regeneration stage to 1-year-old hardened plant stage sustainably.

*Proteins, enzymes, protein derived products and nutraceuticals from oilseeds and cereals*

Investigation was undertaken to identify the optimum ratio of iron: zinc for food matrices. Oilseed flour were fortified with ratios of iron and zinc as recommended by ICMR for different age groups. At higher ratios of zinc, bioaccessibility of iron was inhibited. Similarly at higher ratios of iron, zinc bioaccessibility had decreased in all oilseed matrices. In mixed protein isolate at an iron:zinc ratio of 2:1, iron increased zinc bioaccessibility and zinc increased iron bioaccessibility.

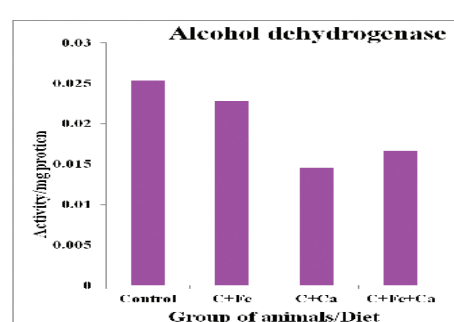
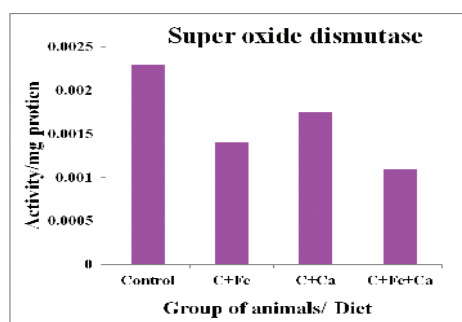
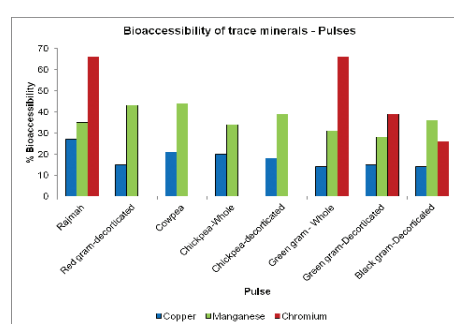
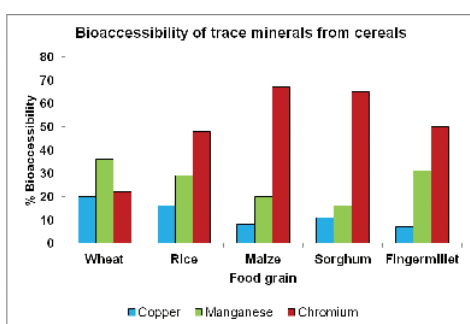
Caseinophosphopeptides was added to iron/zinc fortified soya flour. The negative effect of the fortificant on the bioaccessibility of native minerals was counteracted by the caseinophosphopeptides. The influence of the fortified minerals on the bioaccessibility of native minerals varies

by the food matrix. Dietary ligands as caseinophosphopeptides can aid effective multinutrient fortification.

*Bioactive compounds from native and germinated green gram*

Green gram was milled into dhal and the by-products obtained were separated into husk, germ, plumule and aleurone layer. They were extracted with different solvents and estimated the total polyphenols, carotenoids and chlorophyll content. Acetone extract of these fractions showed antioxidant activity and the activity was comparable to that of BHA. These acetone extracts also showed anti-diabetic property and protection against DNA damage by free radicals. The free and bound phenolic acids in the extracts were determined.

Oxidative enzymes like peroxidases, polyphenol oxidases and polyphenol contents in ungerminated and germinated (sprouted) seeds were determined. Peroxidase activity in sprouted seeds was much higher (300-fold) than unsprouted seed. Of the various tissues of the sprouted grain, root had the highest peroxidase activity followed by shoot and root peroxidase was subjected for purification. Partially purified preparation of sprouted green gram had at least 3 isoforms of peroxidase, while the shoot part of the germinated seed contained high enzyme activity and mainly one form of peroxidase. Further purification and characterization of peroxidase is under progress. Total polyphenol content in the husks of sprouted grain was relatively less compared to unsprouted seeds husk. During



Activities of liver zinc-containing enzymes

germination, exudate is a major by-product and it exhibited antioxidant activity and choline esterase inhibition activity.

#### *Bioavailability studies*

Influence of supplementary levels of iron and calcium individually and in combination on zinc status was studied with animals maintained on diets supplemented with iron/calcium/ iron+calcium at supplemental levels. Zinc status was compromised in the animals maintained on diets containing supplemental of iron+calcium, both individually and in combination for six weeks, as indicated by lowered activities of zinc-containing enzymes in serum and liver. Staple cereals and pulses

were analyzed for the content of copper, manganese and chromium. Pulses had higher copper and manganese content and bioaccessibility than cereals. The bioaccessibility of copper ranged from 6.5 to 20.3%, while that of manganese ranged from 15.5 to 36%. Bioaccessibility of chromium was highest in maize (66.7%), and lowest in wheat (22%). Kidney bean had the highest bioaccessible copper (27.3%), whole green gram had the lowest (13.8%). The bioaccessibility of manganese was highest in cowpea (43.5%), and lowest in decorticated green gram (27.5%). The bioaccessibility of chromium was highest in cowpea (43.5%) and lowest in decorticated green gram (27.5%).

# INNOVATIVE FOOD PROCESSING

## Microwave processing

The effect of microwave energy pre-treatment of cinnamon powder on volatile oil yield was studied in comparison with the conventional hydro-distillation method. Microwave treatment of cinnamon powder at 200 Watts, 50°C, for different periods of time was carried out. Microwave treatment for 5 minutes yielded highest yield of oil (3.09%) as compared to (2.34%) in conventional hydro-distillation. Microwave treatment for 7 minutes also yielded 3.09% oil, equivalent to 5 minutes, but percentage recovery of oil was faster. An increase in the concentration of the major principle compound of the oil, cinnamaldehyde was observed with microwave energy absorption. Microwave assisted extraction shows promising results in terms of yield of oil and also the content of major flavour component

## Treatment for turmeric rhizomes

In the present investigation, freshly harvested turmeric rhizomes were collected and drying experiments were conducted by adopting microwave at different power levels, hot air drying and traditional open sun drying after curing. The turmeric rhizomes were cut into 2mm thickness pieces using a slicer and used for drying in microwave and hot air driers. The dried samples were analysed for moisture, volatile oil, colour and curcuminoids content. Results indicated that microwave processing at 800 Watts was not only faster in drying but could maintain the intrinsic quality viz., volatile oil, colour and total curcuminoid content. Microwave drying method is an effective alternative to traditional open sun drying, where retention of curcumin, volatile oil and colour was high, with less drying time.

## Volatile oils from *Ferula asafoetida* varieties

Asafoetida (*Ferula assa-foetida*) is the dried latex (gum oleoresin) exuded from the underground rhizome or taproot of several species of *Ferula*, which is a perennial herb. *Ferula asafoetida* is one of the essential spices and finds wide application in food preparation and as a digestive aid. The volatile oils of two different varieties of asafoetida, namely Irani and Pathani extracted by hydro-distillation were studied for their anti-microbial properties against various strains of food borne bacterial and fungal organisms by agar well diffusion assay, followed by determination of minimum inhibitory concentration (MIC). Pathani yielded

10.6% of oil compared to 1.9% of Irani and was more effective against bacteria such as *E. coli* and *B. subtilis*. The MIC for *E. coli* and *B. subtilis* was of 0.5 µL. The scanning electron microscopy (SEM) studies revealed that membrane disruption of the bacterial cells might have been caused by the bioactive component propenyl secondary butyl disulphide. Fungal organisms were more susceptible to Irani compared to Pathani variety with inhibition zone of 16 mm and 32 mm with *Penicillium* sp and *A. ochraceus* in disc diffusion assay and MIC with 0.1 µL. The SEM exhibited shrivelling of hyphae with irregular branching, loss of linearity and complete inhibition of sporulation in the tested fungal organisms. The results indicate the use of Pathani as an effective anti-bacterial and Irani as anti-fungal agents. They also can find applications in therapeutic, pharmaceutical and preservative applications.

## Bioactivity of *Solanum nigrum*

The plant *Solanum nigrum* Linn (Solanaceae) is commonly called as black nightshade in English. *Solanum nigrum* is a potential herb with various medicinal properties. Among the two, the subsp. *nigrum* possessed high antioxidant activity. Further investigations were carried out using the *S. nigrum* sub species *nigrum*. The fresh leaves of *S. nigrum* were extracted with different solvents i.e. polar and non-polar by using conventional, Soxhlet and microwave methods. The dried extracts were obtained by removing solvents by rotary-evaporator and water by lyophiliser. The yields of the different solvent extracts were determined for antioxidant activity and  $\alpha$ -amylase inhibiting assay of extracts was evaluated. The microwave energy was significant and yielded maximum of 14.42% with 71.23% antioxidant activity. Preliminary optimisation to obtain best yield by microwave was optimised by full factorial design (FFD) considering time, temperature, power, solvent concentration and solid solvent ratio with response factors of yield, antioxidant activity and  $\alpha$ -amylase inhibitory activity. Based on the results of FFD, the factors such as temperature, solid solvent ratio and solvent concentration were considered. Final optimisation was carried out using response surface methodology. Maximum yield of 24% with 85% antioxidant activity followed with 68.4%  $\alpha$ -amylase inhibitory activity was obtained.



### *Terpene alcohols, phenols and halides*

A new catalytic protocol for the synthesis of 2,3-unsaturated 1-O-glycosides of phenols via Ferrier reaction was developed. Reaction of substituted phenols (e.g., carvacrol from oregano and thymol from Ajowan) with 3,4,6-tri-O-acetyl-D-glucal in the presence of  $ZnBr_2$  in  $CHCl_3$  under microwave irradiation proceeded rapidly in a stereo-selective fashion to afford the  $\alpha$ -glucosides preponderantly in excellent yields (56-96%). The synthetic methodology outlined is applicable to primary, secondary, tertiary, allylic as well as benzylic alcohols, where in the corresponding  $\alpha$ -alkyl 2,3-unsaturated pyranosides were formed with high stereo selectivity. All the compounds were isolated, purified and characterized using IR, 1D, 2D NMR and HRMS. In this reaction no formation of any C-glycoside was observed.

### *Tea Concentrate*

Value added products, starting from black/green tea, were developed. Black tea was extracted in a batch of 50 L potable boiling water for 30 min. at pilot plant. Further on extraction/concentration, 40L (1°Brix) extract was obtained. This was subjected to further concentration in a single effect evaporator and 2L (22°Brix) extract was obtained to which sugar was added to raise the TSS to 85°Brix. This black tea concentrate was filled and packed in airtight food grade plastic cups (stored at RT) and studied for sensory quality over a year and found acceptable. Further work on using green tea is in progress.

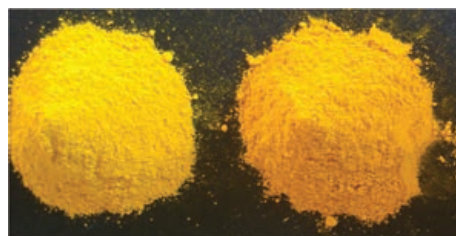
### *Bioactivity of CTC black tea*

Microwave extraction has been considered as a potential alternative to traditional solid-liquid extraction for isolation of phenolic compounds. Aqueous and alcoholic (ethanol and methanol) extracts of CTC black tea obtained by MAE were analysed for total yield of extracts, TPP, TF and TR and bioactivity evaluation (RSA). It was found that MAE at 160 W (80°C) for 3 min. resulted in optimal yield as well as high RSA of the extracts. MAE was compared with conventional extraction methods. The method is efficient, reliable and faster with the increased extraction efficiency of radical scavenging compounds. The extracts showed RSA >90% even at the concentration of 30 ppm. Thus MAE extraction is predictable and process control can be achieved for scale up and commercial application. The batch size and material to solvent ratio needs to be viable for the process scale-up.

### *Turmeric powder from fresh turmeric rhizomes*

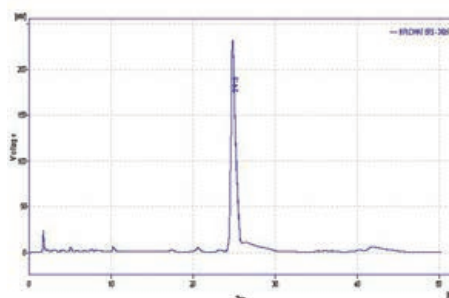
The improved method consists of grading/separation of fingers from mother rhizomes followed by thorough washing with running tap water or water under pressure to remove the soil, stones, dirt and other foreign materials. Washed rhizomes were subjected to a slicing machine to obtain a slice thickness of 1-3 mm. Slices were dried by a

mechanical drier at controlled temperature to obtain dried turmeric slices, which has moisture content of 8-10%. Dried slices were packed in gunny bags or subjected to hammer mill for size reduction/powdering and passed through 25-40 mesh to get fine hygienic turmeric powder. Powder was packed and stored. Scale-up studies are under progress.



### *6-gingerol rich conserve*

Process parameters such as pre-treatment particle size and suitable solvent for the preparation of gingerol rich fraction from fresh ginger was standardized at laboratory level (1 kg batch). Further, the pre-treated fresh ginger was analyzed for 6 gingerol content by TLC and HPLC. Results showed that improved method contains high 6-gingerol than control traditional dried ginger. Further, 6-gingerol rich conserve was subjected to silica gel column chromatography to obtain pure 6-gingerol.



HPLC profile of 6-gingerol

### *Chilli oleoresin*

A new process was developed for obtaining oleoresin of improved colour and pungency from *byadgi* chilli, comprising of steps such as treating powder of chilli by mixing with a multi enzyme preparation, incubating at a particular range pH, granulation and drying the enzyme treated chilli powder to bring down the moisture level of about 5-12%, soaking and extracting using a selected solvent for a period ranging between 1h to 3h; repeating the extraction and pooling the extracts, and concentrating the pooled extract to obtain improved quality oleoresin with enriched pungency and colour. Further, scale-up studies are in progress.

### *Microwave drying of Onions*

Onion (*Allium cepa*) was subjected to conveyerised microwave drying and microwave assisted extraction at different experimental condition and their effect on ACE

inhibitory activity was evaluated by an optimised procedure for extracts and fractions. The fractionation of microwave assisted extracted sample gave more potential active compound which was isolated by silica gel column chromatography using chloroform and methanol mixture. This compound indicated a positive for Molisch's test and showed that, it is a sugar derivative. Further this was subjected to acid hydrolysis using 2N HCl and the sugar unit was identified as glucose by TLC followed by NMR analysis and was characterized as quercetin-glucoside.

#### Agglomerated and fabricated foods

The objective was to study the properties of food powder and changes due to processing, with an emphasis on application, for developing different food formulations, including instant products. The process of agglomeration was carried out using the methods such as agglomeration by conventional (tray) drying, agglomeration by drum drying, growth agglomeration (granulation), such as, wet granulation where moisture and whey protein concentrate are used as binders, and pressure agglomeration (extrusion agglomeration). A model powder system like cornstarch was selected for agglomeration studies. Properties of powder like bulk density, wettability, sinkability, water absorption capacity (WAC), powder flow property and microstructure was studied by varying the moisture content, type and level of additives. Extrusion agglomeration appears to be a promising method for agglomeration and instantization of particulate foods. The process of agglomeration of cornstarch particles obtained by moistening, steaming and granulation was optimised by employing artificial neural network (ANN).

#### Cryopulverisation and spouted bed roasting

Keeping the coffee beans fresh is important to maintain the flavour and aroma of drinks made using these beans. Many techniques such as vacuum packing have been used to maintain the freshness of coffee beans. Besides sulphur in the coffee proteins resulting from the amino acids cysteine and methionine, several sulphur-containing

compounds which are present in coffee plays an important role for the aroma and flavour. Demand exists for flavoured quality coffee which are affordable. An alternative method that could be used to reduce energy costs while maintaining quality and safety was attempted for the processing of coffee beans. The steps involved include cryogenic cooling of the material followed by roasting and assessing the quality parameters. Accordingly green coffee beans (pea berry) were roasted in the indigenously designed spouted bed roaster, followed by quenching with liquid nitrogen and grinding in cryogrinder and hammer mill.

#### Downstream processing

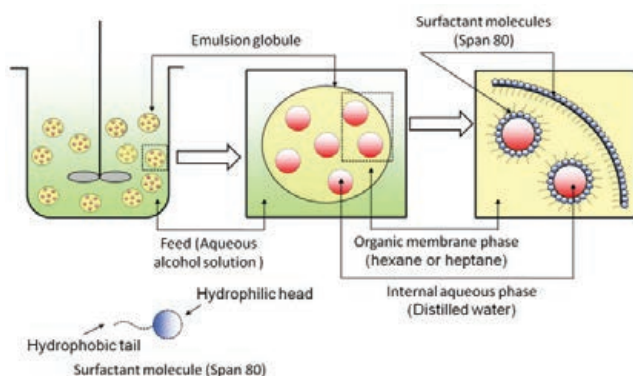
Liquid emulsion membrane (LEM) containing reverse micelles was used, for the downstream processing of lipase from *Aspergillus niger*. The membrane phase consisted of surfactants [cetyltrimethylammonium bromide (CTAB) and Span 80] and co-solvents (isooctane and paraffin light oil). Various process parameters on extraction of lipase from aqueous feed were optimised to maximize activity recovery and purification fold. Mechanism of lipase transport through LEM, consisted of three steps, namely solubilization of lipase in reverse micelles, transportation of reverse micelles loaded with lipase through the liquid membrane, and release of the lipase into internal aqueous phase. Also conditions for activity recovery and purification were optimized. This work indicated the feasibility of LEM for the downstream processing of lipase.

#### Application of liquid emulsion membrane

Liquid emulsion membranes are water/oil/water type double emulsion. They consist of three phases, namely, the innermost phase, which is usually aqueous, the intermediate phase, an organic solvent (membrane phase) and the outer phase again aqueous. Liquid emulsion membranes are stabilized by an adsorption of a surfactant at the interface. The transport of selected component takes place through the membrane phase either by concentration gradient or by facilitated diffusion using carriers. The optimisation of conditions for the extraction of alcohol from aqueous alcohol solution, grape wine and colour extract solutions by using liquid emulsion membrane was explored. Repeated extraction resulted in 92.9% extraction at fourth stage. Alcohol was also extracted from colour extract solutions of different sources, where 90% and more extraction was observed at the fourth stage of extraction.

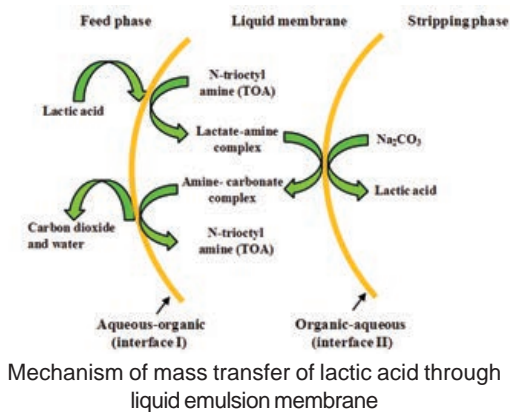
#### Lactic acid pertraction using liquid emulsion membranes

Optimisation of the conditions for the pertraction of lactic acid from aqueous solution using liquid emulsion membrane (LEM) was explored. Pertraction of lactic acid by LEM took place by using carrier-mediated transport. The transport mechanism of lactic acid through



Schematic representation of the stabilization of liquid emulsion membrane

n-trioctylamine (TOA)-heptane membrane phase when  $\text{Na}_2\text{CO}_3$  aqueous solution is used as a strip solution was explained. At the aqueous-organic interface (interface I), the lactic acid passes through the interface and reacts with TOA to form lactate-amine complex, which diffuses across the membrane and it reacts with the stripping solution ( $\text{Na}_2\text{CO}_3$ ) at interface II leading to the formation of amine-carbonate complex. The complex, in turn, diffuses back to the interface I, where it dissociates into carbon dioxide and water along with regeneration of TOA. Based on the design, optimal conditions for obtaining higher pertraction were obtained. The graphical optimisation of super-imposed contour plots fulfilled the conditions to obtain percentage lactic acid recovery ( $Y_1$ ) >95% and percentage membrane phase recovery ( $Y_2$ ) > 80%.



#### CFD Modelling

Effect of bread rotation on temperature profile and starch gelatinisation was studied using computational fluid dynamics (CFD) modelling. Moving reference frame was used for bread motion. Bread rotation of 2.6 and 5 rpm were used for the modelling. Simulation results predicted that for 2.6 rpm, bread center temperature reaches  $98^\circ\text{C}$  in 540 s whereas conventional baking takes 1260 s. A model prediction also shows that increase in rotation speed does not decrease the processing time. Therefore, rotation of bread can be used to reduce the baking process time.

#### Micro encapsulation of probiotics

Synbiotic microcapsules (*Lactobacillus plantarum*+Fructooligosaccharide-FOS) were prepared using spray drying and freeze drying encapsulation methods by incorporating five different wall material combinations such as, FOS, FOS+whey protein isolate (WPI), FOS+denatured whey protein isolate (DWPI), FOS+maltodextrin and FOS+sodium alginate. Synbiotic microcapsules obtained from spray drying encapsulation method yielded higher final moisture content. FOS+WPI and FOS+DWPI combination of the wall materials yielded above 95% encapsulation efficiency for both methods of encapsulation. Under the storage condition

(60 days at  $4^\circ\text{C}$ ) freeze dried microcapsules showed only 9% survival loss, whereas 16% survival loss was observed for spray dried synbiotic microcapsules. Freeze dried synbiotic microcapsules shows porous, spongy and flake like structure. Combination of different wall materials with FOS reduces the hygroscopicity and FOS combined with DWPI wall material effectively protected the probiotic bacteria in simulated gastric juice (pH 2.0+0.3% pepsin) and intestinal juice (bile) condition than the other combinations of wall materials.

#### Nano encapsulation of polyphenols

Microencapsulation is an enduring technology for protection and controlled release of food ingredients. Green tea (*Camellia sinensis*) is a rich source of polyphenols especially catechins, theanine, quercetin and flavour compounds. These polyphenols have various health benefits such as antioxidant, anticancer, anti-mutagenic properties, as well as cardio protective effect. However, these polyphenols are thermally sensitive and prone to epimerisation at high temperature ( $>100^\circ\text{C}$ ) and are highly unstable at alkaline pH. Hence, the polyphenols was extracted from green tea leaves using hot water extraction technique at  $100^\circ\text{C}$  for 30 minutes. Then the extract was encapsulated using whey protein isolate, maltodextrin and skimmed milk powder, as wall materials, through spray drying. The encapsulated powders were analyzed for moisture content, powder morphology, encapsulation efficiency, solubility studies and antioxidant activity. It was found that whey protein isolate encapsulates exhibited higher encapsulation efficiency and skimmed milk encapsulates had higher antioxidant activity.

#### Processing of liquid foods

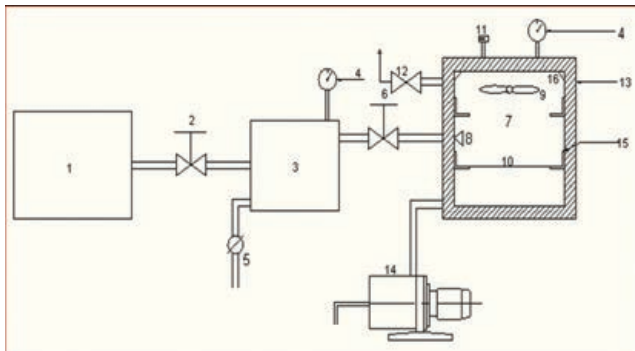
Design of an ozonator suitable for the processing of liquid foods have been completed and the fabrication is in progress. The unit consisted of oxygen concentrator, ozone generator, ozone analyser, reaction chamber along with flow control valve, ozone output control, ozone tubing and ozone diffuser. The specifications of the ultrasound-generating device were finalized.

Sugarcane juice samples were subjected to ultrasound treatment (70 W, 5-10 min). The analysis of total plate count indicated that natural microflora was reduced by almost 2 log cycles in 10 minutes exposure time. The ultrasonic treatment at higher power (700 W, 100% amplitude, 2.5 min) resulted in approximately 5-log reduction for *B. cereus* in a broth at pH 4.0 and the resulting temperature was  $10^\circ\text{C}$ . The effect of pH and total solids are also being assessed.

#### Superheated steam processing

A versatile superheated steam processing system that can be operated in combinations such as i) Superheated steam heating at normal pressure, ii) Superheated steam

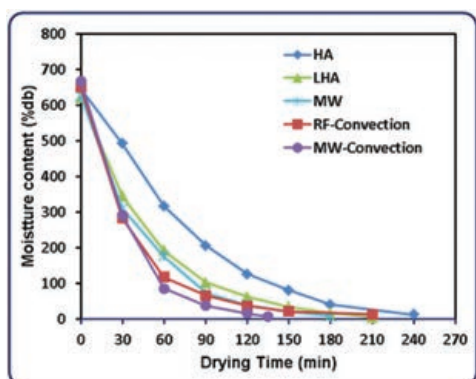
heating under low pressure, iii) Infrared assisted superheated steam heating and iv) Infrared heating under vacuum was developed. The developed unit can be used to process food materials up to a temperature of 350°C and for unit operations such as blanching and drying of food materials.



Schematic diagram of superheated steam processing (SHS) system integrated with other components

Studies on superheated steam blanching indicated that it could be effectively used for blanching of capsicum slices. Processing at 120°C for 1 min. was sufficient to inactivate both PPO and POD to the desired level and this duration was less than that of dry blanched (MW/IR) or conventionally blanched capsicum slices. Retention of ascorbic acid was also higher in superheated steam blanched slices as compared to other methods. The other nutrients such as  $\beta$ -carotene, protein and chlorophyll were fairly good. Processing at high temperature resulted in higher shearing force, indicating change in texture as compared to control. However, the value was less than that of dry blanched slices. The study indicated that superheated steam blanching could be explored as a potential blanching method for capsicum. Studies on dry blanching (MW/IR) methods indicated that it could be effectively employed for enzyme inactivation. The time required for dry blanching was slightly higher, as compared to water and steam blanching, due to intermittent heating.

Studies on drying of onion slices indicated that hybrid drying is quicker than conventional hot air drying or drying

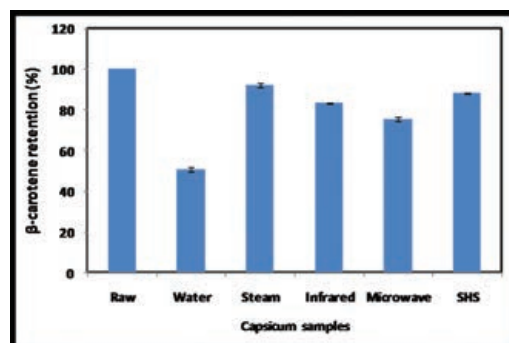


Moisture curves for drying of onion slices by different methods

with electromagnetic radiations alone. Hybrid drying with MW and hot air was superior in terms of drying time and product quality when compared to combination of RF and hot air. Pre-treatment with superheated steam followed by low humidity air-drying marginally reduced the drying time, while it also reduced the retention of volatile oil content. Sequential drying with IR and hot air drying did not show any significant change in drying characteristics. However, the colour and oil retention were significantly affected.

*Field assisted processing of vegetables and spices*

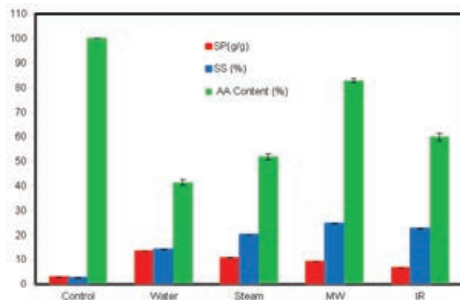
The dry blanching of vegetable (red bell pepper and potato) using RF and comparison with other electromagnetic radiations and conventional processes was studied. Dry blanching of red bell pepper (slices) and potato (slices and cubes) using infrared (IR), microwave (MW) and radio frequency (RF) radiations were attempted and its performance was compared with conventional water and steam blanching methods. Processing conditions (time and temperature) were standardized on the basis of degree of enzyme inactivation (peroxidase, polyphenol oxidase). Effect of blanching methods on retention of micronutrients such as ascorbic acid,  $\beta$ -carotene and protein, besides product shrinkage, structure and texture (shearing force) were analyzed.



Effect of blanching methods on retention of  $\beta$ -carotene

Water and steam blanching of red bell pepper needed lower processing time (1.0 min and 1.5 min, respectively) compared to RF (10.5 min), IR (6.0 min) and MW blanching (3.0 min). MW blanched red bell pepper slices retained higher amount of ascorbic acid (94.7%). Dry blanching with RF (1.4 amps) and MW (22.1 W/g) as compared to slices blanched by other methods facilitated higher extraction of  $\beta$ -carotene (186.13 and 118.6%, respectively) compared to water (60.3%) and steam blanching (88.3%). Dry blanching resulted in moisture loss (1-6%) and shrinkage, which could be responsible for higher shearing force observed in dry blanched slices. In the case of potato (5 mm slice), MW blanching required lesser duration (50 s) compared to IR, steam and water blanching (10, 2 & 1.5 min, respectively) to

inactivate peroxidase enzyme to the desired level. RF blanching was not effective for this purpose under the operating conditions employed. MW blanching resulted in higher ascorbic acid content (82.9%) and starch solubility (24.6%) compared to other methods, followed by IR blanching. Swelling power of starch, which is an indicator of water imbibing capacity, was higher in water and steam blanched potato slices as compared to that of dry blanched. All the blanched samples required lower shearing force (3.6-8.1 N) compared to control (14.3-26.3 N), indicating the softening of tissues. Scanning Electron Micrographs indicated that method of blanching has a role on the extent of effect on cell structure. Dry blanching eliminated the loss of soluble solids as well as generation of effluents, which are the drawbacks of conventional blanching methods. The study indicated that dry blanching could be employed for enzyme inactivation in vegetables without significantly affecting the product quality.



Ascorbic acid (AA), starch solubility (SS) and swelling power (SP) in potato slices blanched by different methods

#### Nutraceuticals and functionality of various grains

Instant string hopper prepared by hot water reconstitution from both IR 64 and Jyothi is superior in having less coarseness, chewiness and off taste and was well acceptable compared to conventional one. Increase in fat (~65%), iron (49%) and zinc (37%) was observed during parboiling of buckwheat, which is beneficial for its use. Less polishing of brown rice resulted in retention of protein in bran. Protein content was more in bran from the rice variety, Agonibora. Starch in parboiled rice varieties - Jyothi and IR-64 was cross-linked in alkaline medium with different sodium tri-metaphosphate (STMP) concentrations and phosphorus content was within the limits of FSSAI. Grain Amaranths was moistened and milled to get flour fractions which can be used for specific purpose. Hammer milled samples of sorghum had more iron and zinc, probably because of more bran. Small millet when germinated had more total phenolic, total flavonoid and proanthocyanidin contents (1.5-2.0 folds) over the native millets, which can be advantageous for use in products. Quality of popping of proso and foxtail millets were improved, after moisture adjustment to 15%, which gave 20% more yield of popped grains.

#### Fish processing machinery

Fried fish (whole or products thereof) forms an essential part of a kiosk that sells fish. A fryer has been developed which is useful for submerged frying of fish, meat and other traditional foods products. The kiosk type fryer can fry upto 10 kg fish per hour. The heat source for the fryer is LPG and the consumption is around 0.2 kg/h. A PCR based method for the detection and differentiation of meat species with single set of primer of mitochondrial cytochrome b gene was also attempted with an objective to develop a method that can detect adulteration of fish meat with other meats as well as meats of different fish species itself, both in raw as well as cooked form. Also, fish meat based noodles were formulated and are being analysed for its composition. A SS based fish-meat bone separator (FMBS) with an improved design was developed, fabricated and validated for its efficiency. The machine was improved with modifications in its meat picking ability. A prototype of fish scaler has been developed and is ready for testing and evaluation. A prototype of fish filleter has been conceptualised and its design and fabrication is under progress.

#### LPG based liquid food pasteurization system

LPG for the continuous pasteurization of liquid food and for sealing of filled pouches was used. A new design has been made for the continuous production of pasteurised liquid foods. The unit has a product storage tank, LPG ignitron system, heat exchanger, temperature display, product receiver tank, DC powered solenoid valve and a dispenser.

This system generates product temperature ranging from 65-85° C and depending on the pH of the product and the  $P_{90}$  requirement, the heating time will be calculated. The newly designed system is being fabricated and will be tested for various liquid products.

#### Bakery, pasta and other traditional products

Study on the effect of pre-treatment, roasting time on physico-chemical parameters and texture analysis of wheat was carried out. The process of roller milling for fractionation and influence of conditioning moisture on milling of fenugreek were studied. The milled fractions were characterized for nutritional and rheological analysis.

Processing of filling for cookies using fruits was carried out. Fresh fruits were processed with other ingredients to obtain sheets of fruits. The sheets were cut into required dimensions and fruit filled cookies were made. The formulation and consistency of cookie dough was optimised. Rheological characteristics of mango ginger incorporated wheat flour were carried out. Standardization of formulation and processing conditions

for aromatic rhizome incorporated soup sticks were carried out.

Influence of whey protein on pizza dough rheology, followed by standardization of ingredients and processing conditions for high protein pizza base was carried out. Standardization of formulation and processing conditions for the preparation of protein enriched baked bar were carried out using soya protein isolate and garden cress seeds as exogenous protein source. Modified gluten hypoimmunogenic pasta was developed and validated with immunochemical methods. Optimisation of processing for low GI fresh and dried noodles using pea flour was carried out. Rheological and quality characteristics of samosa were studied. A standard laboratory method for the preparation and evaluation of *Upma* was developed. Effect of protein and fiber rich ingredients on the quality characteristics of *Upma* was studied.

#### *Continuous microwave pasteurization/sterilization system*

Microwave heating systems were installed which contains cavities such as square, circular and elliptical. Further the system was equipped with peristaltic pumps to control the flow rate of fluids from 1-5000 ml/min., fibre optic sensors for measurement of online temperature during the microwave processing, data logger and paperless recorder were used for online recording of data during MW processing. Digital energy meter was installed to measure the energy consumptions at a single point. To enhance the absorption of energy in fluids more efficiently, several applicators were designed and got fabricated for the microwave continuous heating system. Preliminary trials were carried out in a domestic microwave oven with different applicators to study the efficacy of the applicators by measuring different parameters such as flow rate, rise in temperature, energy consumption and found that the helical-spherical glass applicator was more efficient in terms of uniform heating and maintaining constant outlet temperature. Microwave heating efficiency was found to be 80%. Efficacy of microwave heating system on sterilisation was also tested, by passing the water inoculated, with a loop full of fungal organisms and found that no colonies were observed to grow at pH 4.25 and 4.98.

Processing of blended fruit and vegetable juices such as pomegranate and carrot; jamun and beetroot; grape and muskmelon; papaya and grapes were carried out by microwave heating with helical-spherical applicator using optimized data of flow rate of juice at 250 ml/min passed through the microwave system at power level of 1800 Watts to achieve 95 to 99°C. The juice obtained in the continuous processing was crown corked in pre-

sterilised glass bottles and kept for storage studies. The physico-chemical properties such as pH, brix, acidity, PPO activity, sugars, mineral content, colour, total phenols assay, engineering food properties, thermal conductivity, thermal death time, specific heat, density and microbial analysis (total plate count) were measured. Development of continuous microwave heating system and further studies are under progress.

#### *Annatto seed separator*

A prototype for the separation of annatto seeds from harvested and dried pods was designed and fabricated. Annatto pods were procured locally and parameters like moisture, density, bixin content and texture properties were analysed. The annatto seed separator developed and fabricated with 200 kg/hr capacity consists of a hopper, shaker, aspirator, frame, two cylindrical drum (inner and outer) having 12 mm diameter fins attached to the peripheral inner and outer cylinder acts like beater. The concentric cylinders consist of beaters with different pitch of 40 mm, 45 mm and 50 mm of a 700 mm span of cylinder. The inner cylinder was fixed to a shaft of 25 mm diameter, which is supported by the two supporting pedestal bearing. Outer cylinder was fixed permanently on the frame. Separation of annatto seed from the annatto pod was achieved by passing the annatto pod to the gap between the concentric cylinder through the hopper where the seed was separated from the pod by impact and shear force applied by the beaters. After separating of seed from the pods, it was passed through the blower pipe, where the blower sucks dust and husk. The remaining seeds will be falling on the shaker, which have perforations of 3 mm and 8 mm to facilitate separation of dust and other immature seeds. The machine was tested and evaluated for its working performance. Maximum bixin content was retained at 300 rpm. The dehulling efficiency of the machine was 92.5% and specific energy consumption was 4.03 kJ/kg.



*Preparation of foods using vacuum frying*

Deep-fat fried snacks/food usually contain 30-45% oil where as health conscious consumers normally prefer low-fat snacks/food. The acceptance level will also increase if the product has higher level of nutrients such as protein and  $\omega$ -3 fatty acid. Baking and microwaving of the low-pressure extruded sample were carried out and compared with frying (control) of the same. Chakli (5±0.5 cm) type snacks/ food was prepared by combining flour of grams, grains (corn, ragi, rice), oilseeds (linseed, sesame, groundnut, soybean) and purslane (*Portulaca oleracea*) using baking (220±2°C, 15 min), microwaving (80 W, 2 min) or frying (170±2°C, 5 min). The results indicated that the overall sensory as well as instrumental quality of the product prepared by microwave was found to be comparable with deep-fat fried product. The use of microwave processing in place of frying resulted in significant (p<0.05) reduction in oil (24.44-8.12 %) content, increase in protein (2.19-29.36 %) and  $\omega$ -3 fatty acids (2.4-35.0%) contents without jeopardizing the sensory quality of the product.

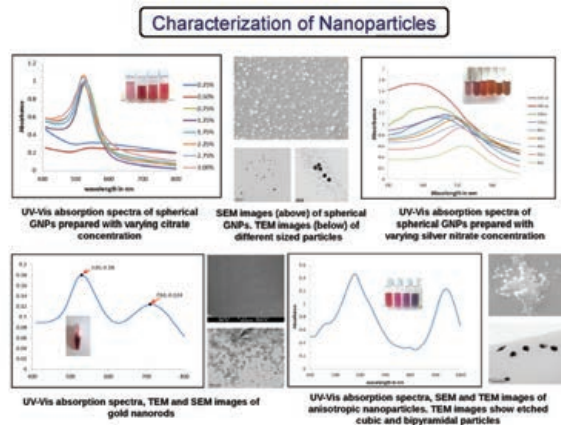
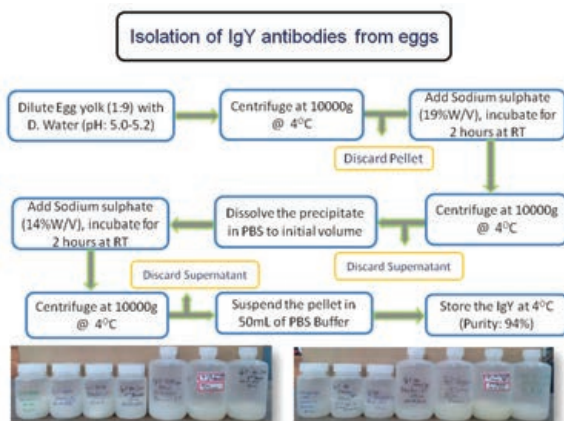
This study indicated that the application of microwave could be a feasible technology for production of low-fat snacks/food, with higher amount of protein and  $\omega$ -3 fatty

acid contents.

*Monitoring of biologically important molecules*

Hapten was synthesized for BPA using EDC-NHS conjugation method by selecting BPA analogue (BHPVA) to BSA and used for generating IgY. Anti-BPA IgY antibodies are successfully generated using animal models in poultry layers. It includes the injection of booster doses at every 15 days, to step up the anti-BPA antibody fraction in the yolk. IgY from the eggs collected daily was isolated using sodium sulphate precipitation method. The isolated IgY found to contain antibodies against BSA and BPA and anti-BPA IgY was selectively purified using sepharose CL-4B column. The purified IgY from the eggs are lyophilised to powder form and stored at 4°C till further use.

Steps were taken to synthesize different size and shape gold and silver nanoparticles for biosensor application. Water soluble mono disperse quasi-spherical gold nanoparticles were synthesized and characterized using SEM and spectrally. Synthesized GNPs were found to be in the range of 15-25 nm and found to be stable over four weeks at room temperature. Gold nano rods capped with CTAB was synthesized and characterized spectrally.



## LONG TERM STRATEGIC RESEARCH

### *Mass cultivation of selected microalgae for hydrocarbon production*

Bio-prospecting of 186 natural water bodies/habitats of 10 states of India was undertaken by the collection of water samples for isolation of algal strains. A total of 41 microalgal isolates were isolated, purified and maintained as monoalgal cultures. Morphological characterization and growth characterization of microalgal isolates has been completed. Lipid estimation and fatty acid profile of all the isolates by GC has been completed. Based on the data on lipid content, 12 algal isolates were identified as containing >30% lipid content (w/w) and 9 isolates as containing 20-30% lipid content (w/w). The data on fatty acid profile indicated the presence of oleic acid, palmitic acid, palmitoleic acid, alpha linolenic acid and linoleic acid. A few of the microalgal isolates showed the presence of lauric acid, myristic acid, docosanoic acid and tetracosanoic acid. Enhanced lipid accumulation under nitrogen and salinity stress, observed under lab conditions, was validated in outdoor ponds. Based on the data on hydrocarbon content, two microalgal isolates were identified as containing 40% or above hydrocarbon content (w/w). Six isolates showed 13 to 20% of hydrocarbon content (w/w) with another 6 isolates showing 10%-11% hydrocarbon content (w/w). GC analysis of hydrocarbon profile indicated that majority of the peaks occurred in the <C-15 to C-20 carbon chain length followed by C-20 to C-30 region. Outdoors adaptation studies were carried out for two hydrocarbon and three lipid producing isolates, where indigenous strain identification for algal lipid and/or hydrocarbon was done for the first time. A method to control rotifer (predator) infestation in outdoor algal cultures were developed. This method was also found to be effective in control of predator ciliates and other protozoans. Based on these studies, a two-stage cultivation method to enhance the lipid and hydrocarbon content of microalgal biomass has been recommended. Harvesting of biomass and recycling of media has been studied for outdoor cultivation. An exclusive algal R&D facility, including open outdoor raceway ponds was created. Molecular identification of selected isolates was completed. Spent biomass has been evaluated for its safety/toxicity in animal model for its possible application as a feed. A treatment method was evolved to reduce high ash content in the harvested algal biomass.

### *Value added products based on microalgae*

Sixteen microalgal strains were evaluated for their CO<sub>2</sub> tolerance up to 20% v/v. Low-density polyethylene sleeves (LDPE) were used for culturing the microalgae. All the strains were CO<sub>2</sub> tolerant up to the tested levels; however the growth and productivity in response to CO<sub>2</sub> varied among the strains. *Scenedesmus* and *Desmodesmus* genera responded better to CO<sub>2</sub> in terms of productivity compared to other strains. The average biomass yield of *Scenedesmus* strains was between 1-1.5 g/l and productivity above 0.05 g/l/day. The lipid content was above 15-20% indicating their improved ability to capture CO<sub>2</sub> and convert it to value added products. The biomass yield and productivity saturated at 5% CO<sub>2</sub> v/v for other strains such as *Oocystis* sp., *Ankistrodesmus* sp., *Quadrigula* sp., *Chlorococcum* sp., *Kirchneriella* sp., however the yield at 5% CO<sub>2</sub> was two fold higher compared to ambient CO<sub>2</sub> in these strains. Based on the initial screening, four isolates *Scenedesmus obtusus*, *Scenedesmus dimorphus*, *Scenedesmus* sp. (H-2) and *Desmodesmus* sp. (SSSU) were short listed for further studies. The fatty acid composition of all the strains was analysed. The composition varied among the strains in response to CO<sub>2</sub> supplementation, however palmitic, oleic and alpha linolenic acid was found to be major fatty acids.

### *Potential bioactive from elite plants*

The seed samples of *Hibiscus cannabinus*, *H. sabdariffa*, *Rumex vesicarius*, and *Basella* spp. were collected from local markets of Andhra Pradesh. Seedling based plants were established under green house conditions. Among these *H. cannabinus* is green, but *H. sabdariffa* contains red stem and petioles and also red veins in leaf. In the case of *Basella* spp., both green and red twine plants i.e. *Basella alba* and *B. rubra* were grown. Analysis of respective pigments profile in different leafy vegetables indicates that the major pigment identified in leaves of *H. cannabinus*, *H. sabdariffa*, *R. vesicarius* and *B. alba* were carotenoids. However, in case of *B. rubra* leaves the content of carotenoids was very less, but betalains were more. Similarly the pigment (betalains) in purple-red fruits of *B. rubra* was recorded. Analysis of phytoconstituents viz., total carbohydrates, total proteins, reducing sugars, non-reducing sugars, total phenolics, cellulose, moisture



content, total chlorophyll, niacin, ascorbic acid and total flavonoids were carried out with leaves of all the selected plant.

*In vitro* shoot cultures of *Hibiscus* spp. and *R. vesicarius* were established using seedling explants. In the case of *H. cannabinus* and *H. sabdariffa* callus cultures from seedling leaf, cotyledonary leaf, and hypocotyl explants was initiated on MS medium containing 1.0 - 4.0 mg/l BA + 0.1 to 2.0 mg/l NAA. The obtained callus cultures were sub-cultured onto the optimised medium for maintenance and also to get organogenesis. Experiments are in progress to establish suspension cultures of the same.

#### Neurotoxic insecticides

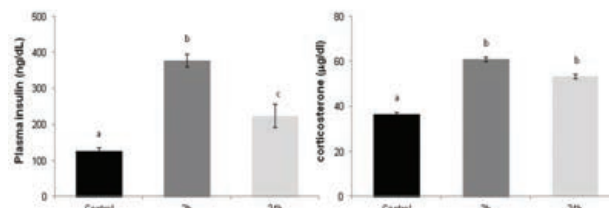
Basal slowing response was studied in *C. elegans* exposed to MPTP (1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine) and MCP to determine their behavioural responses. Worms treated with various concentrations of MPTP/MCP showed a decrease in the number of body bends and a significant decrease in the dopamine content. Photomicrographs of worms treated with MPTP/ MCP revealed loss within processes of CEP and ADE neurons as revealed by a moderate reduction in GFP expression.

Dopamine content and behavioural deficits were assessed in mice exposed to varying concentrations of monocrotophos. Mice treated with varying concentrations of MCP showed a significant decrease in dopamine content in a dose independent manner and also a significant decrease in the neurobehavioral deficits. MCP also elicited a significant decrease in the dopamine content and neurobehavioral deficits as compared to the same dose when it was co-exposed with MPTP.

#### Organophosphorus insecticides

The impact of repeated exposure to monocrotophos on glycemic and endocrine regulation as well as lipid profile and key liver metabolic enzyme activities in rats was explored. Monocrotophos (dose 1.8mg/kg b.w. /d for 45d; 1/10LD<sub>50</sub>) caused marginal increase in blood glucose levels (2 hours after last dose) without impact on lipid profile. However, circulating insulin levels were significantly higher in monocrotophos-treated rats, a trend that was evident even after 24h of the last dose. Monocrotophos elicited significant hypercorticosteronemia with concomitant increase in activities of gluconeogenesis enzymes in liver. Hepatic glycogen reserves were depleted in monocrotophos treated rats with concomitant marginal increase in glycogen phosphorylase activity. Hepatic glucokinase activity was higher in monocrotophos treated rats. Our results clearly demonstrate that repeated exposure results in blunting of responses with regard to impact of monocrotophos on glycemic balance. Repeated exposure

to monocrotophos is associated with up-regulation of both glycogenolytic and gluconeogenic potential of liver.



Impact of repeated exposure to monocrotophos on circulating insulin and corticosterone in rats

#### Protection of grains

A survey and collection of phosphine resistant insect samples was completed in both Karnataka and Goa States. Standard zigzag sampling procedures using a hand trier was followed to draw samples from wheat and rice stacks stored at the food storage depots of Food Corporation of India. 12 sampling points from four directions at top, middle and bottom portions of the bag stack was done. About 3-5 kg of grain sample was taken and sieved using standard sieves for insect collection.

The stored product insect pests of wheat and rice namely *Tribolium castaneum*, *Rhyzopertha dominica*, *Sitophilus oryzae* and *Cryptolestes ferrugineus* were collected from the depots of Food Corporation of India, across Karnataka and Goa. A standard questionnaire was filled with each of the collection. In total, about 55 strains of *Tribolium castaneum*, 3 strains of *Cryptolestes ferrugineus*, 18 different strains of *Oryzaephilus surinamensis*, 8 strains of *Rhyzopertha dominica* and 17 strains of *Sitophilus oryzae* were collected. The survey and collection of phosphine resistant insect samples has been initiated in Maharashtra as well.

#### Phytochemicals for the control of stored product insects

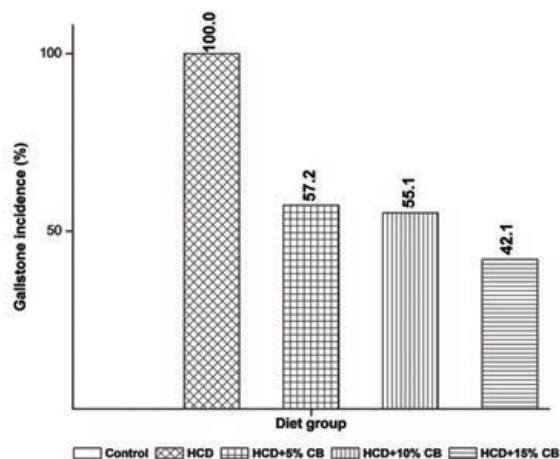
Studies were conducted by the extraction of leaf, stem, and roots from *Trichilia connaroides*, *Clerodendron inerme* and *Ajuga* species, to non-polar, medium polar and polar fractions. These fractions were screened for the insecticidal activity such as repellent and mortality bioassay on stored product insects. For this purpose, the plant materials were collected from Jambhatti forest near Belgaum (Karnataka) and *Ajuga* species from Jammu and Himachal Pradesh. Scientists of ICMR, Regional Centre (Belgaum), IIIM (Jammu) and IIHBT (Palampur), did the authentication of plant material. Plant material such as leaf, root and stem was freeze-dried and ground by blending machine. About 100 grams of above plant material were subjected to soxhlet and cold method using methanol, ethyl acetate and petroleum ether. The individual extracts were concentrated to dryness under vacuum. High yield was procured from the soxhlet method through methanol. This concentrate

was used to test the insecticidal activity such as repellency rate. *Ajuga* methanol extract showed good repellency rate compared to other two plant extracts.

Repellency test of all above plant methanol extract against *Rhyzopertha dominica* was evaluated. The average repellency of 1000, 750, 500, 250 and 150 ppm concentrate from all the three plants achieved class III, class IV and class V respectively after 24 hours observation. The methanol-extract concentrate of *Ajuga* species was found to be more than the other two plants. LC<sub>50</sub> and LC<sub>90</sub> of all plant extract against *Rhyzopertha dominica* were determined. These plant extracts can be exploited as promising stored product insect control agents.

#### Antilithogenic influence of dietary tender cluster beans

Providing a lithogenic diet containing 0.5% cholesterol to experimental mice for 10 weeks resulted in cholesterol supersaturation in gall bladder bile, which induced the formation of cholesterol gallstones (CGS). To evaluate the anti-cholelithogenic potential of dietary tender cluster bean (CB), the freeze-dried powder of tender CB was included in the lithogenic diet at 5, 10 and 15% levels. Dietary CB reduced the cholesterol gallstone incidence by 43, 46, and 58% at the respective doses. There was a marked reduction in biliary cholesterol and hence the cholesterol saturation index. This was also corroborated by beneficial modification of altered ratios of cholesterol to phospholipid and cholesterol to bile acid in the bile. Dietary CB countered the alterations in serum and liver cholesterol and lipid profiles caused by the lithogenic diet. A separate animal study was conducted to evaluate the anti-cholelithogenic effect of a combination of dietary tender CB and garlic, which is a known hypocholesterolemic spice. Tender CB (10% dehydrated powder) and garlic (1% dehydrated powder) were included individually and in combination in the high cholesterol diet (HCD) for 10 weeks. Incidence of CGS was lower with a combination of these ingredients



Effect of dietary tender cluster bean (CB) on the incidence of cholesterol gallstone in mice maintained on high cholesterol diet (HCD)

compared to individual treatments. Data on the lipid profile of bile, serum and liver suggested potentiation of the antilithogenic influence of CB by garlic.

#### Synergy among spice and dietary fibre

Dietary fenugreek seeds (10%) and garlic (2%) were evaluated both individually and in combination for their beneficial influence on lipid profile of blood, liver and heart muscle in high cholesterol fed rats. Serum cholesterol particularly LDL-associated cholesterol was lowered, cholesterol: phospholipid ratio and atherogenicity index in serum was also lowered by the combination of fenugreek and garlic. Both fenugreek and garlic countered the elevated hepatic cholesterol and triglycerides, the effect being higher in the case of combination. Favourable effect was also seen on cholesterol: phospholipid ratio as well as triglycerides in heart tissue. The data suggest that dietary fenugreek and garlic might have higher cardio protective influence when consumed together.

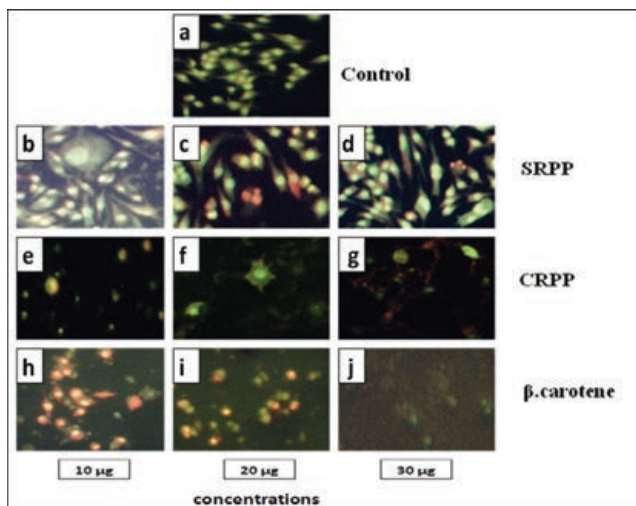
Dietary fenugreek seeds (10%) and onions (3%) were evaluated both individually and in combination for their beneficial influence in streptozotocin induced diabetic rats. Hyperglycemia, glucosuria, polyuria, proteinuria, loss in body weight, urinary excretion of urea and creatinine, etc., were significantly ameliorated by these three dietary interventions with the combination producing the maximum beneficial effect. The data suggest that dietary fenugreek and onion produces higher anti-diabetic influence when consumed together.

#### Anticancer and antiulcer components from selected dietary sources

Experimentation on the anticancer and antiulcer potential revealed the multi-step active anticancer and antiulcer activity from several dietary pectic polysaccharides both in *in vitro* and *in vivo* models. However, it was crucial to address their usefulness under inflammatory conditions, since the later co-exists with cancer/ulcer due to carcinogens/ulcerogens.

The potential immunomodulatory effect of carrot (CRPP)/tomato (ToPP)/bael (BAPP)/swallow root (SRPP) pectic polysaccharides on macrophage cells – RAW 264.7, UV/MNU induced inflammations leading to cancers was examined. Results indicated that proliferative potency of raw cells were decreased by 53% and 33% at 10 µg/5 x 10<sup>4</sup> cells/well concentration by SRPP and CRPP respectively as evidenced by MTT assay. Apoptosis was confirmed by differential staining response by acridine orange and ethidium bromide staining followed by microscopic observations. In order to ascertain the immunomodulatory role, levels of nitric oxide (NO) and a cytokine – IL2 were measured by specific colorimetric and immunoassays respectively. Results indicated significant increase in the release of NO and IL2 levels by SRPP

and CRPP treatment, compared to that of untreated controls; while TOPP and BAPP modulated the inflammatory cancers effectively. Regarding antiulcer potency of pectic polysaccharide, data indicated that MPTPP (Modified Processed Turmeric Pectic Polysaccharide) exhibited better antiulcer potency with inhibition of ulcer scores. Infection being a major cause of ulcerations, antiulcer property was evaluated in inflammatory model. Data indicated that inflammation in fact worsened the ulcers and was efficiently modulated by the selected dietary components. Overall data suggest that anticancer potentials could be due to immunomodulatory potential of the polysaccharides. However, the mechanisms through which the immunomodulatory mechanisms help in offering anticancer/ antiulcer properties are to be elucidated.

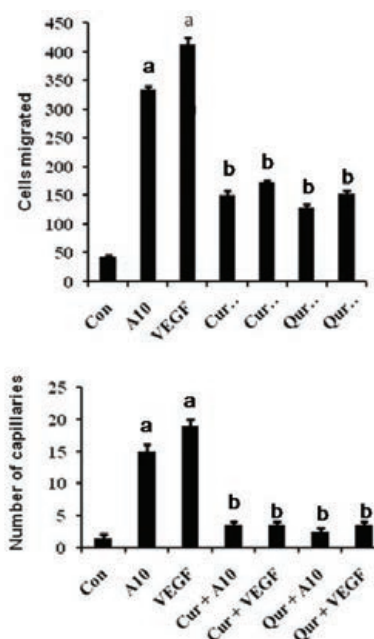


Effect of swallow root (SRPP) and carrot pectic polysaccharide on cancer cell death. SRPP - swallow root pectic polysaccharide and CRPP - carrot pectic polysaccharides induced apoptosis of Raw-264.7 - tumour cell

*Diabetes-related complications in kidney and brain and modulation by dietary factors*

Vascular dysfunction is a main feature in diabetic nephropathy. Abnormal angiogenesis is known to occur in diabetic nephropathy. Angiogenesis - the development of new blood vessels from pre-existing ones - is involved in physiological events and in pathological disorders. Interestingly, the progression of both diabetic retinopathy and nephropathy is altered by vascular growth factor signalling through receptor tyrosine kinases, specifically involving the VEGF-A and angiopoietin families. Anti-angiogenic treatments can prevent the progression of diabetic nephropathy in animal models of diabetes. Role of curcumin and quercetin as therapeutic approach to prevent diabetic vascular complications was evaluated using wound healing/scratch assay and angiogenesis assay in terms of tube formation.

After treatment with different medium for 24 hours, number of cells migrated due to AGEs was more than that in the control groups. Cell migration ability of the HUVEC that was enhanced due to AGE was significantly ameliorated by curcumin and quercetin. Tube formation is a multi step process involving cell adhesion, migration, differentiation and growth. Increase in AGEs concentration increased tube formation. Vascular endothelial growth factor (VEGF) was used as a positive control for tube formation. Dietary antioxidants, curcumin and quercetin ameliorated the AGEs-induced tube formation and it was significant compared to positive control, VEGF.



Effect of curcumin and quercetin on advanced glycation end products (AGEs) induced cell migration assay  
 Con=control; A10=AGEs (10 µg/ml); VEGF=vascular endothelial growth factor (10 µg/ml); Cur + A10= curcumin (20µM) + AGEs (10 µg/ml); Cur+ VEGF=curcumin (20µM)+VEGF; Qur + A10= Quercetin (20µM) + AGEs10; Qu+VEGF+ Quercetin (20µM) + VEGF  
 Data shown is the mean±sd of three independent experiments. a = statistically significant at P<0.05 when AGEs and VEGF compared to control, b = statistically significant at P<0.05 compared to AGEs and VEGF alone

*Neurotoxicity in amelioration by dietary phytochemicals and amino acids*

A GSH-depleted larvae model and evidenced higher susceptibility of larvae to Rotenone-induced oxidative stress, mitochondrial dysfunction and neurotoxicity was developed. Further, using this model, the protective effects of Selaginella extracts (methanol extract and flavonoid rich fractions) were demonstrated. Third instar larvae fed *Selaginella delicatula* aqueous extract (SDAE) and flavonoid fraction (SDFF)-enriched diet (0.01, 0.05%) showed significant diminution in the endogenous levels of oxidative markers and enhanced antioxidant status.

In an acute co-exposure (24h) paradigm, *Selaginella* extracts significantly alleviated the Rotenone-induced oxidative stress, mitochondrial impairments and completely restored the activity levels of AChE, while dopamine levels were partially restored.

#### Neuromodulatory efficacy of *Selaginella*

The hypothesis that treatment with *Selaginella* can ameliorate 3-nitropropionic acid (3NP)-induced motor deficits and neurotoxicity in mice were examined. Male mice provided with oral supplements of SDAE (400 mg/kg bw/d, 15d) were injected with 3NP (50 mg/kg bw/d, i.p., last 5d). 3NP mice exhibited significant motor deficits (reduced stride length, stride path behaviour, increased beam walk latency and reduced open field behaviour) and SDAE supplements prevented the onset of neurobehavioral deficits. SDAE pre-treatment markedly attenuated the 3NP induced oxidative impairments and activity of mitochondrial complex II, citrate synthase and membrane potential in striatum.

#### Inflammatory mediators

In addition to polyunsaturated fatty acids of dietary oils, minor components also play important role in modulation of parameters like blood and tissue lipid levels, inflammatory mediators and lipid peroxidation. Rice bran oil (RBO), sesame oil (SO) have almost similar fatty acids level compared to groundnut oil (GNO), and vary only in their minor components level when compared to GNO. RBO is rich in oryzanol and SO is rich in sesamin and lignans. RBO and SO were passed through activated silicic acid column in order to separate the minor components from its triglycerides. The separated triglycerides and minor components were fed to rats (N=4) for 30 days and blood and tissue parameters were analyzed. The data on interaction between unsaturated fatty acids and minor components of RBO and SO in terms of its effect on blood and tissue lipids, lipid peroxidation and inflammatory mediators was reported. No significant change in body weight and organ weights were observed between experimental groups and control groups. Removal of minor components from RBO and SO significantly ( $p < 0.001$ ) reduced its hypolipidemic effect compared to unstripped RBO and SO. Similar trend was observed with respect to lipid peroxidation in white blood cells and retina. The fatty acid composition did not alter significantly in rats fed RBO and SO stripped off from its minor components compared to those fed on RBO and SO with its minor components.

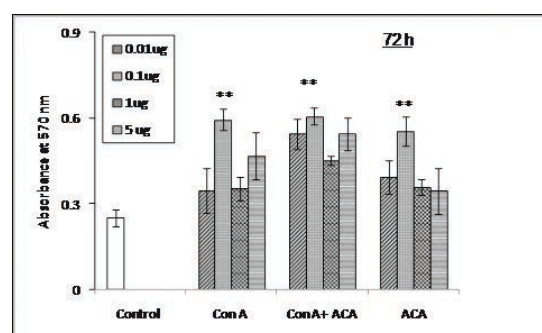
The data on interaction between unsaturated fatty acids and minor components of RBO and SO in terms of its effect on blood and tissue lipids, lipid peroxidation and inflammatory mediators were studied. Removal of minor components from RBO and SO significantly ( $p < 0.001$ )

reduced its hypolipidemic effect compared to unstripped RBO and SO. In another study, structured lipid containing medium chain fatty acid like capric acid was prepared using salmon oil triglycerides by adopting response surface methodology.

#### Neuro and immunomodulatory effects of selected metals and dietary components

The effect of water-soluble curcuminoids and lipophilic curcumin was tested on *ex-vivo* rat platelet aggregation using agonists arachidonic acid (AA), adenosine diphosphate (ADP) and collagen. Curcuminoids and curcumin inhibited platelet aggregation in a dose dependent manner. The inhibitory effect of curcuminoids was found to be 2-6 folds higher than curcumin with respect to AA, ADP and collagen. The inhibitory potency of curcuminoids was found to be 40 fold higher than aspirin with respect to AA induced platelet aggregation. TxA2 is an AA derived inflammatory mediator liberated from activated platelets during platelet aggregation and it is a potent platelet aggregator. Curcuminoids and curcumin dose dependently inhibited TXB2 formation in platelets during AA induced platelet aggregation indicating the possible inhibition of COX-1 and thromboxane synthase in platelets. Platelets have an active 12-lipoxygenase (12-LOX) enzyme and it forms 12-hydroperoxy derivative (12-HETE) from AA, during platelet aggregation. Mono and dihydroxy derivatives of AA are reported to inhibit platelet aggregation. Curcuminoids were found to inhibit 12-LOX enzyme and inhibit formation of 12-HETE in platelets during aggregation induced by AA. Thus curcuminoids were found to inhibit AA metabolites namely TXB2 and 12-HETE during platelet aggregation and thus prevent platelet aggregation. Further detailed mechanism of action of curcuminoids on platelet aggregation and other inflammatory mediators are being investigated.

Onion (*Allium cepa* L.) lectin (tetramer of four 12 kDa subunits; yield: 4 mg/kg) shows a specific hemagglutination activity of ~8550 units/mg for rabbit erythrocytes.



Proliferation of murine thymocytes by onion lectin (OL) [ $*p < 0.05$ ;  $**p < 0.01$ ;  $***p = 0.001$  to  $0.005$  vs. control]

Onion lectin at 5  $\mu\text{g/ml}$  concentrations shows a 2.5-fold increase in the proliferation activity compared to untreated murine splenocytes ( $p < 0.001$ ). Further, it

displays macrophage activation by enhancing phagocytosis of yeast cells by murine peritoneal macrophages. Ajowan (*Trachyspermum ammi*) polysaccharides obtained from ground ajowan seeds by ethanol precipitation were assessed for immunomodulatory activity. Ajowan polysaccharides showed a marked increase in the proliferation of splenocytes (proliferation index of 3) and NO release by macrophages was 3.5-fold higher compared to control ( $p < 0.005$ ). The yield of polysaccharides was 2 g/100 g dried ajowan. The polysaccharides were acidic in nature.

Aqueous extracts of dried powders of basil (*Ocimum sanctum*) and ashwagandha (*Withania somnifera*) produced protein yields of 0.2 g/100 g and 0.1 g/100 g, respectively. Only tulasi proteins at 1 and 10 µg showed a 2-fold increase in lymphoproliferation against control. Nitric oxide (NO) release from rat peritoneal exudated cells showed a 5-fold increase in the case of basil proteins (0.1 µg) and a 7-fold increase in the case of ashwagandha proteins (0.1 µg).

*Lutein and astaxanthin metabolites*

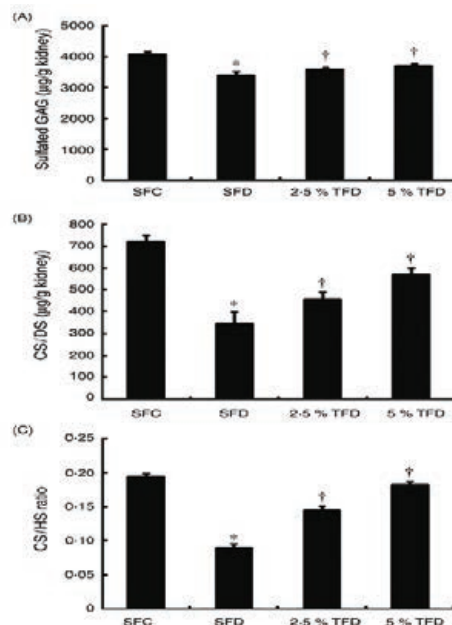
The aim of this investigation was to characterize the oxidation products of lutein and to compare them with biologically transformed dietary lutein in intestine, plasma, liver, and eyes of rats. The positive ion of the carotenoids was recorded by LC-MS with atmospheric pressure chemical ionisation module. In the studies involving rats, a diet devoid of lutein was fed for 2 weeks to induce deficiency followed by gavages of micellar lutein for 10 days. The characteristic fragmented ions resulting from photo-oxidation of lutein were identified as 523 ( $M^{++H^+} - 3CH_3$ ), 476 ( $M^{++H^+} - 6CH_3$ ), and 551 ( $M^{++H^+} - H_2O$ ). In the eyes, the fragmented molecules resulting from lutein were 13-Z lutein, 13'-Z lutein, 13-Z zeaxanthin, all-E zeaxanthin, 9-Z lutein, 9'-Z lutein, and 3'-oxolutein. Epoxy-carotenoids were identified in liver and plasma, whereas anhydro-lutein was identified in intestine. This study emphasizes the essentiality of dietary lutein to maintain its status in the retina.

In another study, astaxanthin metabolites were not detected after repeated gavage of astaxanthin for 15-days to rats that resulted in detectable levels of its metabolites in blood and liver. As a result of astaxanthin intubations to rats, beta-carotene and elevated retinol levels were detected in plasma and liver. The presence of astaxanthin ( $m/z$  597 ( $M^+H^+$ ), beta-carotene ( $m/z$  537 ( $M^+H^+$ ) and retinol ( $m/z$  287 ( $M^+H^+$ ) was confirmed by LC-MS analysis. LC-MS analysis revealed an intermediate compound in liver, which was characterized as echinenone ( $m/z$  551 ( $M^+H^+$ )).

*Diabetic nephropathy and modulation by selected food materials*

Diabetes results in changes in structural and functional characteristics of kidney chondroitin sulfate/dermatan

sulfate (CS/DS), and the influence of dietary factors on kidney CS/DS was explored. Effect of *Tinospora cordifolia*, a potent anti-diabetic plant was taken for the study. It was supplemented with AIN76 diet at 2.5% and 5% levels. *T. cordifolia*, ameliorated increased blood glucose, urine sugar, glomerular filtration rate and microalbuminuria. Increase in glomerular area, hallmark of diabetic nephropathy was contained in 5% *T. cordifolia* fed animals. Decrease in sulfated glycosaminoglycans, molecules responsible for permselectivity of various macromolecules, was decreased in kidney of diabetic rats, which was prevented to various extents in *T. cordifolia* - fed animals. Structural variations were also modulated by feeding *T. cordifolia*. Results indicated that consumption of diet supplemented with *T. cordifolia* has beneficial effects in the diabetic condition, which in turn exerts positive influence on CS/DS metabolism in kidney.



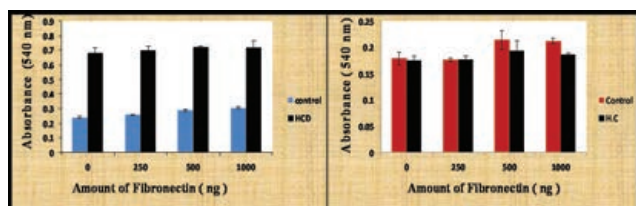
Sulfated glycosaminoglycans (GAG) in the kidney of control, diabetic and *Tinospora cordifolia* (TC)-fed diabetic rats. SFC – Starch-fed control, SFD –Starch-fed diabetic, TFD – TC-fed diabetic (2.5 and 5%)

*Glycosaminoglycans in macrophages during diabetes and hyper-cholesterolemia and impact of dietary modulators*

Macrophages play an essential role in cholesterol metabolism as it takes up cholesterol from tissues and effluxing it to HDL for metabolism in liver. Glycosaminoglycans (GAGs) are one of the classes of molecules responsible for cholesterol efflux along with ApoE. The effect of pathological conditions on changes in glycosaminoglycan moieties were determined.

Male wistar rats were made hypercholesterolemic (HC) and hypercholesterolemic with diabetes (HCD) by feeding animals with 0.5% cholesterol supplemented in the diet.

Hypercholesterolemia and diabetes was ascertained by measuring cholesterol/ glucose levels in blood. Macrophages were isolated from peritoneal cavity and 95% viability was observed. No change in cell number was observed. Cytoadherence was tested against extracellular matrix components such as glycosaminoglycans and laminin, fibronectin and type IV collagen. Difference was observed with respect to adhesion of macrophages in macrophages isolated from HC and HCD rats.



Cytoadherence of unstimulated macrophages from control, hypercholesterlemic and hypercholesterlemic / diabetes rats to fibronectin

#### Neuroameliorative effects of spice actives

The neuroameliorative effect of geraniol (Ger) and curcumin (Cur) against acrylamide (ACR) induced oxidative stress, neurotoxicity and mitochondrial dysfunctions in a *Drosophila* model is investigated. Adult male flies were exposed (7 d) to ACR (5 mM) with or without Ger and Cur (5 and 10  $\mu$ M) in the medium. Both spice actives significantly reduced ACR induced mortality, locomotor dysfunction and alleviated the enhanced levels of oxidative stress markers. Depleted levels of reduced glutathione (GSH) and total thiols resulting from ACR exposure were restored along with increased activity of detoxifying enzymes. Further, spice actives attenuated ACR induced -mitochondrial dysfunctions and restored dopamine levels both in head and body regions. The protective effect of Ger and Cur against ACR was comparable in terms of phenotypic and biochemical markers. These findings were validated in an ACR- induced neuropathy model employing co-exposure treatment and post exposure treatment paradigms

#### n-3 fatty acid rich Garden cress (*Lepidium sativum* L.) seed oil as dietary supplement

Garden cress seed oil (GCO) is rich in  $\alpha$ -linolenic acid (ALA) and it is prone for autooxidation. Microcapsules of GCO were prepared with whey protein concentrate (WPC-70), with oil content of 25g/100g and microencapsulation efficiency of 64.8%. Biscuits were prepared with microencapsulated GCO (MGCO) at 20g/100g and also with GCO at 5.0 g/100g by replacing flour and fat respectively. No significant loss of ALA was observed in MGCO supplemented biscuits. Biscuits supplemented with MGCO had ALA content of ~1g/100g

and 55% higher protein content compared to control biscuits. They also showed a slight decrease in diameter, spread ratio and weight compared to control biscuits. Biscuits were packed in metalized PET film pouches, stored at three different temperatures and humidity (90% RH/38°C for 3 months), (30-40% RH/38-40°C for 4 months) (65% RH/27°C for 5 months). No significant change was observed in moisture, peroxide value (PV) and ALA in GCO supplemented biscuits under various storage conditions. Sensory attributes of MGCO supplemented biscuits were comparable to control biscuits. Thus, biscuits supplemented with MGCO were found highly nutritious with essential fatty acids and protein with essential amino acids.

#### Marine carotenoids in modulating age-related macular degeneration and retinol deficiency

Retinol (vitamin A) deficiency (RD) is associated with adverse biochemical changes in the body. Carotenoids protect against the effects of RD by various mechanisms including provitamin-A and antioxidant property. This study reports the bioconversion of marine carotenoid astaxanthin to retinol in RD rats. RD rats were fed astaxanthin-supplemented diet (42 mg astaxanthin/ kg diet) for 4 weeks while a separate group of RD rats was continued on the diet devoid of retinol (control). Blood and liver tissues collected were analyzed for astaxanthin and retinol by HPLC and LC-MS (APCI) techniques. Feeding a diet with astaxanthin resulted in the increased retinol levels in plasma (96%) and liver (97%) compared to control. Astaxanthin levels in plasma and liver were 72.1 ng/ml and 142.9 ng/g respectively. In addition to astaxanthin, alpha-carotene was also detected in the samples. LC-MS analysis confirmed the presence of  $\beta$ -carotene and echinenone in the plasma and liver. It was concluded that astaxanthin can also get convert to retinol.

The comparison of the antioxidant effects of  $\beta$ -carotene, astaxanthin, fucoxanthin and lutein in relieving lipid peroxidation (Lpx) and modulation of antioxidant enzymes in rats was studied. Lutein deficient rats were fed with  $\beta$ -carotene, astaxanthin, fucoxanthin or lutein (200  $\mu$ M/ rat/day) orally for 14 days. A separate group received basal diet (control). Plasma and liver were analyzed for lipid peroxide and glutathione levels and also activity of antioxidant enzymes. Lipid peroxidation was suppressed ( $p < 0.05$ ) in plasma and liver on feeding  $\beta$ -carotene (15% and 9%), astaxanthin (24% and 50%), fucoxanthin (35% and 30%) and lutein (10% and 37%) compared to controls. SOD activity in plasma and liver elevated on feeding  $\beta$ -carotene (8% and 23%), astaxanthin (55% and 54%) fucoxanthin (31% and 50%) or lutein (12% and 29%) compared to control. Catalase activity in plasma and liver increased on feeding  $\beta$ -carotene (5% and 30%), astaxanthin (63% and 68%),

fucoxanthin (36% and 70%) or lutein (19% and 63%) compared to controls. Glutathione reductase activity in plasma and liver elevated on feeding  $\beta$ -carotene (23% and 63%), astaxanthin (32% and 130%), fucoxanthin (48% and 106%) or lutein (36% and 54%) compared to controls. Glutathione level also increased in plasma and liver on feeding  $\beta$ -carotene (1.4 and 3.4 fold), astaxanthin (2.2 and 4.3 fold), fucoxanthin (1.9 and 2.54 fold) or lutein (1.8 and 3.8 fold) compared to control. To conclude, supplementing marine carotenoids decreased the lipid peroxide levels and increased the activities of antioxidant enzymes in both liver and plasma of carotenoid supplemented groups demonstrating higher antioxidant potential of astaxanthin and fucoxanthin.

#### *Preparation of Lutein - PLGA nanoencapsules*

Lutein extracted from marigold petals was purified with an aim to use for nanoencapsulation. Lutein-PLGA nanoencapsules were formulated by solvent evaporation technique with PLGA as carrier. The PLGA nanoencapsules loaded with lutein was prepared using PVA as surfactant (1%) showed that the nanoencapsules formed were in the range 100-600 nm in size. The mean average of the prepared nanoencapsules was around 200 nm. Sonication leads to reduction in size of particles. It was found that 15-21 minutes of sonication of the polymer is ideal to obtain narrow nano-ranged particles. The addition of organic phase into aqueous phase leads to nanoprecipitation resulting the formation of nanoparticles. The lyophilized nano powder resuspended in water formed a very fine dispersion and appeared to be soluble, unlike lutein, which is completely insoluble in water, with undissolved particles with layer formation clearly visible in the suspension. Dry, lyophilized powder of nano lutein has good stability and readily dispersed in water without any aggregation. The enhanced aqueous solubility of nano-sized lutein particles could be attributed to their larger surface area, which promotes dissolution. The surface morphology and the size of the nanoencapsules were analyzed. SEM micrographs showed that the PLGA nanoencapsules formed were spherical in range and less than 300nm in size. It was further confirmed by Atomic Force Microscope.

The anticancer property of nanoencapsulated lutein was studied using cancer cell lines. The human colorectal cancer (DLD-1) cells, human acute promyelocytic leukemia (HL-60) cells and HepG2 cells were cultured in RPMI-1640 supplemented with 10% of heat inactivated fetal bovine serum or DMEM medium with antibiotics. Cells were cultured (5 X 203) as per the standard procedures. After 24 hours of incubation, cells were treated with lutein dissolved in DMSO or lutein loaded nanoparticles. After 72 hours of incubation, MTT solution was added to study the cell viability. Results

demonstrated that in all the cell lines used the cell suppression effect of nanoencapsulated lutein was higher than the control and the effect was dose dependent.

#### *Obestatin and its fragments*

A host of satiety peptides have been experimented upon in an effort to alter energy homeostasis under obese conditions. Here, the specific interest was to study obestatin, a 23-residue C-terminal amidated peptide produced mainly in the stomach. In the studies, which aimed to understand the primary structure to function relationship in obestatin, the N-terminal 13 residues of obestatin very closely mimicked obestatin though as expected with lower potency. Introduction of unusual amino acids into this N-terminal fragment has rendered the peptide as potent as obestatin. Key genes that might be differentially regulated upon administration of these peptides have been identified by mRNA profiling. Initial studies were done on normal mice as to establish unequivocally the ability of obestatin, its fragments and fragment analogs in lowering blood lipid levels and stored fat. The effect of obestatin and the modified N-terminal thirteen residue fragment analog (Nt8U), for their ability to counter obesity in obese mice and to study the effect of these peptides on the mouse brain at the genomic level as the mechanism of action of obestatin to be further explored.

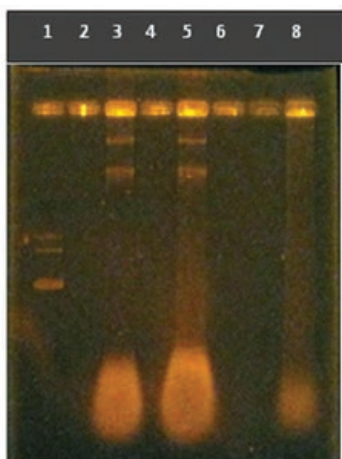
#### *Diversity by OSMAC*

Number of fungal strains were screened and evaluated for enzyme inhibition. CFR107 culture was selected for the OSMAC study as it showed comparatively high inhibition for alpha glucosidase, tyrosinase and acetylcholine esterase. Effect of different culture media in CFR107 were studied, wherein it was seen that while yeast malt extract, czapek dox broth, tryptone soy broth, the media supported growth but the amount of crude extract was low. Fungal broth was taken as standard media (basal media) for the OSMAC study. A new approach was attempted to identify compounds from extracts of different culture media showing inhibition against defined enzyme. Based on the HPLC, it is assumed that for  $\alpha$ -glucosidase inhibition, the compound could be at retention time (RT) of 1.5 minutes, tyrosinase at RT of 13.3 minutes, cholinesterase at 4.9 minutes and topoisomerase at 18 minutes. Further work on the isolation and structure determination of the isolated compounds are under progress.

#### *Microbial L-asparaginase*

Out of several bacterial cultures screened, 12 organisms showed Asparaginase production. Genomic DNA was isolated from these isolates and ASN gene was amplified. The PCR products were purified and purified product of ASN gene were ligated to pTZ57R/T vector and cloned in to *E. coli* DH5 $\alpha$ .

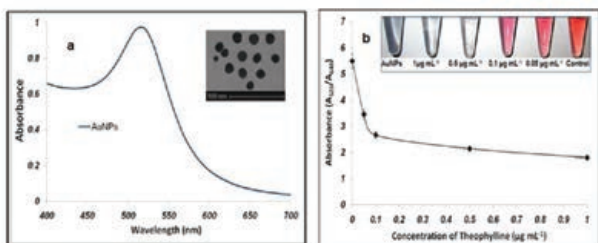
The PCR product was transformed into competent cells of *E. coli* BL 21 using pET 101 vector. The transformants were selected on luria antibiotic agar. The selected clone tested for protein expression. The clone chosen was grown on 10L fermentor. The cells were harvested from fermentor grown cells, enzyme isolated from cells by sonication, purified by Ni NTA column and characterized.



Ligation of ASN gene into pTZ57R/T vector. Lane 1- pTZ57R/T vector without insert. Lanes 3, 5, 8- pTZ57R/T vector with gene insert

#### Caffeine from waste tea leaves

Biotransformation of caffeine was carried out using fungal strain. The caffeine biotransformed products were determined by analytical techniques. The potent fungal strain F-7 shows maximum degradation up to 94%. This isolate was further characterized and was identified as *Fusarium sp.* Its ability can be utilized for large-scale production of therapeutically important biotransformed products, such as theophylline and methyl xanthine, having anti-cancerous and anti-inflammatory properties.



(a) Absorption spectra of gold nanoparticles and TEM image of gold nanoparticles (AuNPs) confirming the average size of 11 nm. (b) Plot of absorption ratio ( $A_{520}/A_{640}$ ) vs. theophylline concentration

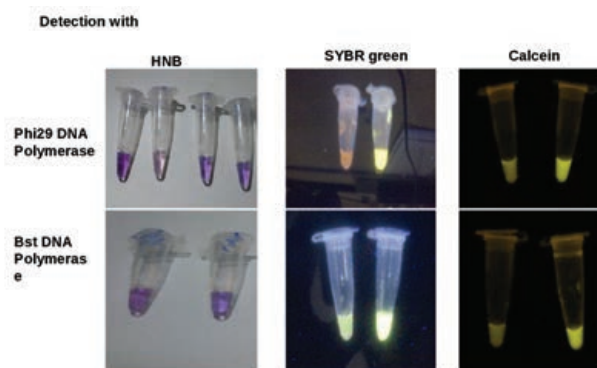
A simple calorimetric aptasensor based detection system to examine theophylline up to a minimum concentration of 50 ng/ml was designed using RNA aptamer and AuNPs. This system showed a fine response to therapeutically relevant theophylline with comprehensible discrimination between its analogues such as caffeine. This cost-effective rapid method can be applied for onsite analysis.

#### Nanobiosensors

The objective was to assess the occurrence of enterotoxigenic *B. cereus* from selected food samples. An

attempt was made to detect the *hblA*, *bceT*, *cytK*, and *entFM* toxin genes simultaneously by multiplex PCR and loop mediated isothermal amplification (LAMP) methods. Attempts were also made for the detection of all these four toxin genes simultaneously from food samples in less than 24 h with this mPCR method.

Design of LAMP primers for the toxins of *Bacillus cereus* and other harmful pathogens, development of multiplex PCR detection system for *B. cereus* toxins and optimisation of LAMP conditions for BceT toxin of *B. cereus* and its detection method using HNB, Calcein and SYBR green are in progress.

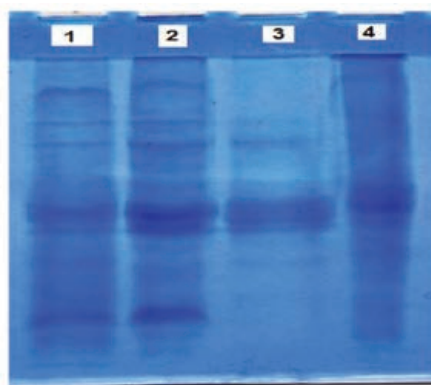


Detection/Amplification of *bceT* toxin genes from *Bacillus cereus*

Detection/amplification of *bceT* toxin genes from *Bacillus cereus*

#### Biosensors for assessing the microbiological quality of foods

Isolation and purification of enzymes for biophoton production from firefly and bacterial systems were carried out. Purified firefly luciferase enzyme was used for the detection of microbial contamination in food, milk and fish samples. Freshness of the fish was also assessed using firefly luciferase enzyme.



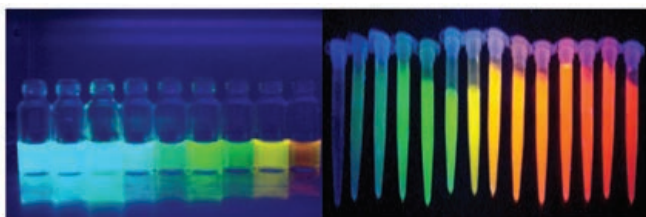
Native PAGE profile of bacterial luciferase

Antibodies were raised against selected food borne bacterial toxins SEB-A in chicken for biosensor applications.

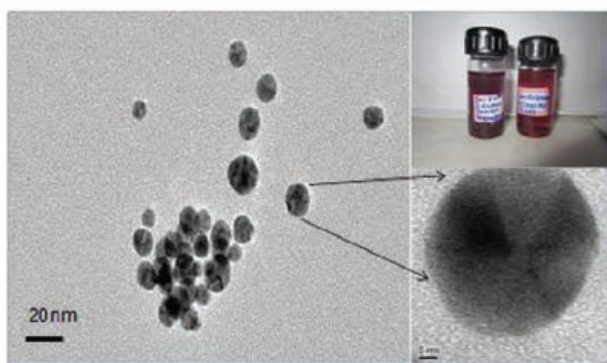
Synthesis of quantum dots and gold nanoparticles were carried out in aqueous medium for the application in food samples. Characterization of nanoparticles by UV spectra and TEM studies were carried out.



Bioconjugation of nanoparticles were carried out and bioconjugated QD were used for studying the fluorescence resonance energy transfer (FRET). The FRET is used for the detection of formaldehyde in fish.



Quantum dots of different size and emission properties



Transmission electron micrograph of biologically synthesized GNPs (Inset picture shows the colloidal solution of GNPs)

A lab instrument for photons detection was developed. Also a prototype biosensor based on bioluminescence for assessment of microbial quality and freshness of meat, fish and milk as well as monitoring food hygiene/sanitization was developed. A bio-luminometer was designed and is equipped with an avalanche photo diode (APD), an amplifier and a regulated power supply.



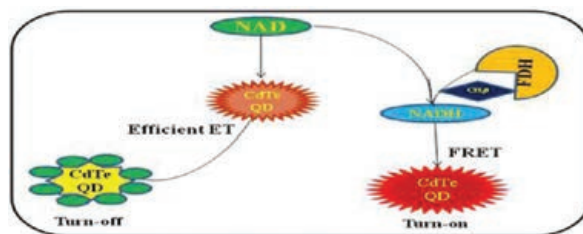
Avalanche photodiode based bioluminometer developed in the Institute

Development of rapid method for determination of milk freshness and efficient microbial extraction from real milk samples was examined along with validation. The level of ATP in the sample was determined by activity of the enzyme. Reaction includes 180 µl of the assay buffer (0.1 M Tris-acetate pH 8.0, containing 10 mM MgSO<sub>4</sub>, 2 mM EDTA and 10 mM Mannitol), 10 µl of enzyme extract, 5 µl of substrate (1 mg/ml) and the reaction was initiated by the addition of 5 µl of extracted solution containing ATP. The luminescence of the reaction mixture

was measured using luminometer and expressed as relative light unit (RLU).

*Biosensor for the monitoring of formaldehyde in processed fish samples*

Unique properties of QDs suggest that the replacement of organic fluorophores in FRET studies with QDs could lead to an experimental setup, which would be ultra sensitive, economical and easy to configure as well as to provide the capability to make simultaneous measurements of different macromolecular systems. These features should allow QD-FRET based nano sensors to generate a very distinct signal efficiently. The work was aimed at investigating the possibility of using CdTe QDs as plug-in's to route resonance energy from NADH and monitor NAD<sup>+</sup> dependent formaldehyde dehydrogenase.



Depicting NAD based "turn off" and NADH based "turn on" of QD fluorescence

**Avian single chain monoclonal antibodies technique for analysis of food**

Heptachlor was used to make hapten for endosulphan. The pre-hapten 1,3,4,5,6,7,8,8-octachloro-2-hydroxy-4,7-methano-3a,4,7,7a-tetrahydroindane obtained was succinylated and purified by preparative TLC. Both hapten 1 and hapten 2 were used for conjugation to proteins.

**Stored product infestation control**

*Novel organophosphates, organic intermediates and phytochemicals*

Karanjin, a furoflavanoid isolated from karanja oil was subjected to demethylation. Karanjin (10 mmol) was dissolved in dimethylformamide and iodocyclohexane (100 mmol) was added and the mixture was refluxed overnight. Demethyl karanjin was obtained as a grayish solid, which was analyzed by thin-layer chromatography using toluene+ethyl acetate (70+30). The structure of the product was confirmed by <sup>1</sup>H and <sup>13</sup>C NMR. This was used as starting material to prepare organophosphates. Demethyl karanjin (1 mmol) was dissolved in acetone and potassium carbonate was added and the mixture was stirred for 30 min. O,O-Diethyl chlorothiophosphate was added and the mixture was stirred for 4 hours. Thin-layer chromatography was performed to analyze the product using acetone+light

petroleum (20+80).  $^1\text{H}$  and  $^{13}\text{C}$  NMR spectra showed the formation of O,O-diethyl O-(4-oxo-2-phenyl-4H-furo[2,3-h]chromen-3-yl) phosphorothioate. Similarly, starting with demethyl karanjin and O,O-dimethyl chlorothiophosphate, the second organophosphate viz., O,O-dimethyl O-(4-oxo-2-phenyl-4H-furo[2,3-h]chromen-3-yl) phosphorothioate was prepared and its structure was confirmed by NMR. Insecticidal activity of the two compounds has been evaluated against *Stegobium paniceum* stored-product insects.

#### *Plant materials as grain protectants*

About forty plant materials were evaluated against *Sitophilus oryzae* and *Callosobruchus chinensis*. Rhizomes of *Curculigo orchoides*, fruits/seeds of *Helianthus* sp., *Syzygium cumini*, *Carthamus tinctorius*, *Cyperus esculentus*, *Prosopis juliflora*, *Terminalia* spp., *Linum* sp., *Morinda*, *Helecteres isora*, *Asnebia* sp., etc. *Curculigo*, *Syzygium cumini*, *Helianthus* and ladies finger seeds were insecticidal and inhibited  $F_1$  population.

#### *Essential oils (EOS) and chemical compounds on growth and morphogenesis of Aspergillus and Penicillium species*

*Aspergillus* and *Penicillium* sp. were tested against few EOS (cinnamaldehyde, guaiacol, thymol, vanillin and eugenol) at three concentrations i.e., 0.5, 1.5 and 3.0  $\mu\text{L}/\text{mL}$  on PDA plates. Eugenol is more inhibitory than EOS tested as it arrested the growth in all 3 concentrations tested.

#### *Production of secondary metabolites by Penicillium sp. isolated from soils and food grains*

From both the samples mentioned above, 26 sp. of *Penicillium* were isolated, and subjected for metabolite production using antibiotic test broth (ATB) on rotary shaker, batch wise.

#### *Investigations on screening of some plant products/macronutrients against storage insects - adulticidal, ovicidal, ovipositional and IGR activity against few storage pests*

Some plant products belonging to *Malvaceae* and *Solanaceae* family were subjected to different solvent extraction methods. The extracts were assayed against *C. chinensis*, *C. maculatus*, *S. oryzae*, *R. dominica* adults for their adulticidal, ovicidal, ovipositional and IGR activities. Some extracts were found to be effective against *C. chinensis* and *C. maculatus* insect pests.

Fortification of synthetic and natural macronutrients like proteins into the flour materials was assayed against *T. castaneum*, *E. cautella* and *C. cephalonica* insect pests. The successful developments from egg to adult stages

were observed. Comparatively it was found to be effective against *T. castaneum* and also against *E. cautella* and *C. cephalonica* insect pests at 5 -10% level concentrations.

#### *Evaluation of phosphine-inert gas/bio fumigant mixtures for stored product infestation control*

#### *Toxicity of phosphine + nitrogen mixtures on the adults of S. oryzae*

Culture of *Rhizopertha dominica* and *Sitophilus oryzae* was initiated using the adults isolated from stock culture. The toxicity studies on the adults of *S. oryzae* were carried out as per FAO method (1975). The adults of *S. oryzae* were exposed to different concentrations of phosphine with 30 % nitrogen over different exposure periods such as 8, 16, 20, 24 and 48 hrs. The post fumigation observations showed that the mixtures of phosphine + 30%  $\text{N}_2$  proved effective in insect control compared to the untreated ones (only phosphine). However, an increase in the mortality response was observed when the exposure periods were enhanced in both treatment and the control. The studies on the toxicity of phosphine + 30% nitrogen against the adults of *S. oryzae* indicated that there is a positive correlation between the exposure period and the mortality of the adults evidenced by the  $\text{LC}_{50}$  concentrations obtained.

#### *Toxicity of phosphine + CO<sub>2</sub> on mixed age cultures of Rhizopertha dominica*

The toxicity of phosphine (varying concentration) to different combinations of carbon dioxide mixtures from 10% to 30% were carried out for 6 and 7 days exposure period, at  $27 \pm 2^\circ\text{C}$  and  $65 \pm 5\%$  relative humidity. After a post-fumigation period of 7 days, mortality assessment was carried out. Likewise, observations were carried out for every 7 days interval for 4 weeks and the data obtained were subjected to probit analysis to arrive at an  $\text{LC}_{50}$  concentration regime. The mortality response of mixed age cultures of *R. dominica* over 6 and 7 days of exposure period to phosphine and phosphine +  $\text{CO}_2$  mixture showed a significant reduction in the  $\text{LC}_{50}$  concentration required to bring about maximum mortality in the mixed age cultures of *R. dominica*.

#### *Effect of bio-fumigant on the adults of stored product insect pests*

The bio-efficacy of *Pithecellobium dulce* was tested against the adults of *S. oryzae* and *R. dominica*. Experiments were carried out at 1000 ppm and 2000 ppm for six variable dosages. The post treatment observations signified that at 0.004 dosage at 1000 ppm concentration resulted in 6.81% mortality, while at 2000 ppm concentration, the mortality response

was about 11.86% in *R. dominica*. However, considerable difference in mortality response was observed at 0.004 dosage, the trend was not the same for 0.012 dosage over 48 hours exposure. The maximum mortality obtained at 0.012 dosage for 48 hours exposure was about 26.50 and 27.87 at 1000 and 2000 ppm concentrations. The same trend was also observed when adults of *S. oryzae* were treated to *P. dulce* over 48 hours exposure.

*Effect of sub-lethal concentrations of phosphine inert gas mixtures on the adults of S. oryzae*

Studies were carried to find out the effect of phosphine inert gas mixtures on the adults of *S. oryzae* and their impact on their reproductive potential. So, the adults of *S. oryzae* were exposed to different sub-lethal concentrations for the selected exposure periods. After the exposure periods, immediate mortality assessments were carried out followed by weekly observations to note down the number of adults emerged. A positive correlation was observed between the mortality of insects with respect to the exposure periods. The mortality was observed to be maximum in the treatments involving 24 and 48 hours of exposure to phosphine + 30% nitrogen.

*Mechanistic insights into sublethal effects of pesticides*

Deltamethrin at sublethal concentrations in grains elicited decreased adult emergence without affecting the egg laying in *Callosobruchus chinensis* and also only marginally inhibited AChE activity while CaE activity was significantly decreased.

Exposure of worms to DDVP at sublethal concentrations drastically reduced the number of eggs laid. While control worms survived up to 30 days, worms exposed to DDVP survived only for 26, 25 and 24 days thus exhibiting 13, 17 and 20% reduction in survival period. AChE activity was only marginally inhibited in worms exposed to 0.1 and 1.0 µM DDVP. CaE activity was significantly decreased in worms, exposed to all the concentrations of DDVP.

The effects of MCP and CPF on brush border enzymes and redox state markers of small intestine in rats were

investigated. MCP treatment reduced acetylcholinesterase (AChE) activity while brush border disaccharidases like sucrase, maltase, lactase and trehalase showed increased activity. Similarly CPF administration resulted an increase in sucrase and maltase activities. Of the two insecticides selected for the study, MCP was found to have more impact on intestinal enzymes.

*Coffee pulp effluent treatment*

Strains such as *Pichia kudriavzevii* isolate Y1-SSD, *Pichia kudriavzevii* and *Candida tropicalis* were identified, which are capable of degrading pectin and polyphenols. Fermentation experiments were carried out using a specially designed plug flow digester, which has a gyrator system attached to circular platform. The plastic bag used was one-time sterilizable pouch of 1 L capacity. The coffee pulp was inoculated with the yeast cultures. The temperature was maintained around 24-30°C. pH of the substrate was 3.9-4.2. Total sugar, total polyphenols, and COD were analysed in the fermented samples. Gas production was analysed using water displacement method. There was a reduction in the production of gases like hydrogen sulphide and oxides of sulphur. Further studies using individual strains are in progress.

Field trials were carried out in ten estates in the three districts of Karnataka state, which are involved in commercial pulping. Experiments were setup to handle about 15 lakh/day of effluents.

Due to presence of pectic acid and other acid components, the effluent remained acidic. The pH ranged from 3.5 to 4 in raw pulp. The treatment of the same with the microbial cultures increased the pH. The COD range in the untreated coffee effluent was more than 15,000-20,000 mg/l. Post treatment results showed drastic decrease in the COD ranges. At the end of the treatment, COD was in the range of 4000-5000 mg/L.

The clarity in the treated lagoon indicated the effectiveness of the treatment, whereas in control lagoon scum formation was observed which further lead to anaerobic fermentation and obnoxious odour production.



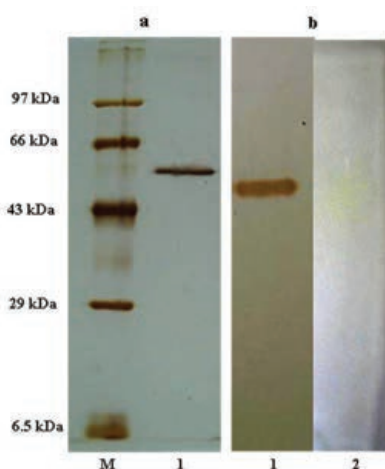
# PROGRESS UNDER XII PLAN PROJECTS

## Biological Science Cluster

- **Wellness through foods and nutraceuticals (WELFO)**

### Probiotics

There has been a growing interest in the use of oligosaccharides as prebiotics to modulate gut microbiota with an aim to improve the gut health in recent time. Though xylo-oligosaccharides (XOS) have been increasingly used as prebiotics, information pertaining to the enzymes used by lactobacilli to degrade these substrates is scanty. Present investigation reports the purification and characterization of  $\beta$ -D-xylosidase from *Lactobacillus brevis* NCDC01 grown on XOS. Three sequential steps consisting of ultra-filtration, DEAE cellulose ion-exchange and Sephacryl S-100 gel filtration chromatographies were employed to purify the enzyme to apparent homogeneity and it was found to be monomeric on SDS-PAGE with an apparent molecular mass of ~58.0 kDa. The pH and temperature optima were 6.0 and 40°C respectively. The enzyme remained stable over a pH range of 5.5 - 7.5 and up to 50 °C for 30 min. Under optimum pH and temperature with *p*-nitrophenyl  $\beta$ -D-xylopyranoside as a substrate, the enzyme exhibited a  $K_m$  of 0.87 mM. The enzyme does not require any metal ion for activity or stability but is



SDS-PAGE (12%) of the fractions obtained during the purification. Lane M - marker proteins with relative molecular masses indicated on the right; lane 1 - purified  $\beta$ -D-xylosidase (b) 1 - Native page of purified  $\beta$ -D-xylosidase; 2 - zymogram of purified  $\beta$ -D-xylosidase

completely inhibited by  $Hg^{2+}$ ,  $Pb^{2+}$ , *p*-chloromercuribenzoate (PCMB), oxalic acid and citric acid.

The work on isolation and characterization of Bifidobacteria from human source antagonistic to *H. pylori* has been initiated. Several standard bifidobacterial cultures have been procured that include *Bf. longum* DGO10A, *Bf. lactis* Bb12, *Bf. braves*, *Bf. adolestences* and *Bf. bifidum*. Preliminary investigation on antagonistic properties of bifidobacterial cultures against range of food borne pathogens are underway.

### DHA nanoemulsion

DHA nanoemulsion was prepared by oil in water (O/W) emulsion with emulsifier of tween-40 through high speed homogenizer (HP), ultrasonicator (US), high pressure homogenizer (HPH) and combination of HP+HPH, US+HPH and HP+US techniques. The mean droplet size and distribution was analyzed by particle size analyzer. Stability of nanoemulsion was investigated by colour and phase separation with different storage conditions such as room ( $28 \pm 1^\circ C$ ), refrigeration ( $4 \pm 1^\circ C$ ) and oven ( $70 \pm 0.2^\circ C$ ) temperatures. Further, FTIR spectra confirmed the presence of DHA in all the nanoemulsified samples. Rheology analysis of shear rate verses shear stress and apparent viscosity was also analysed. This study indicated that HP, US, HPH, HP+HPH, US+HPH and HP+US nanoemulsions produces 1.57 nm, 1.27 nm, 1.43 nm, 1.39 nm, 1.72 nm, 1.61 nm mean droplet diameter, respectively. Thus, this prepared nanoemulsified DHA can be used for food and pharmaceutical application to improve the bioavailability of DHA.

### Green tea polyphenols

Green tea polyphenols are unstable and thermally labile; highly susceptible to oxidation and prone to epimerization that adversely affect their bioactivity. To circumvent such problems, extraction of polyphenols from quick mechanically expressed tea leaves juice (QMETLJ) and its freeze dried portion (FD - QMETLJ) were carried out at room temperature. Extraction of FD - QMETLJ by different concentrations of ethanol and liquid-liquid partition of QMETLJ by dichloromethane, diethyl ether, chloroform, hexane and ethyl acetate was carried out to obtain polyphenol concentrates.

- **Lipidomics center (LIPIC)**

Under the LIPIC project, creation of a state-of-art Lipidomics Research Centre is under progress. Details of progress achieved under various other activities are given below.

- **Breeding for high seed oil yielding basil (*Ocimum spp.*)**

Total 52 germplasm lines were collected from diverse eco-geographical locations: South India, North India and North-East India, encompassing 4 different species: *O. tenuiflorum*(36), *O. basilicum*(11), *O. gratissimum*(4) and *O. kilimandscharicum* (1). The germplasm lines are diverse both genetically (wild types, cultivars, selections, etc.) and chemically (Eugenol, Methyl Eugenol, Linalool, MethylChavicol, Camphor, Caryophyllene, Elemene, etc.). 27 germplasm collections and 6 checks were made for evaluating yield components, yield (seed and oil) and quality (fatty acid composition) parameters. Observations on yield components were made. The experimental materials are to be observed for yield (seed and oil) and quality parameters.

- **Genetic Improvement of Chia (*Salvia hispanica*) seeds**

After successful evaluation of adaptability and suitability of Chia (*Salvia hispanica* L.) for commercial cultivation in tropical South Indian conditions, its genetic improvement by developing high yielding lines, lines with higher oil content and modified fatty acids profile suitable for cooking and other nutritional requirements were explored. With no public genomic information or database available, setting up a public information platform for functional genomics studies are planned.

Through transcriptome sequencing of developing seeds of Chia by Next Generation Sequencing (NGS) technologies and analysis with powerful bioinformatics tools, the process of understanding of the transcribed gene and pathway information has been initiated. An insight into spatial and temporal control of gene expression and integrated model involving biochemical pathways and differentially expressed genes (DEGs) during lipid biosynthesis can reveal the gene expression profile, important genes and their levels of expression. It helps identify, characterize and modify the potential transcripts of interest. Also identification and characterisation of cDNA-SSR (Simple Sequence Repeat) markers are underway to facilitate trait mapping and linkage mapping making marker-assisted breeding more feasible.

A simple and practical method for removal of excess mucilage formed during the hydration of Chia seeds has been developed which helps formulation of various food products using Chia seeds without interference of mucilage. The oil content, fatty acids profile, protein content and amino acid composition of an improved line of Chia has also been estimated.

- ***Salvia hispanica* transcriptome data mining and cloning of MAGAT and OLEOSIN**

Raw transcriptome data of *Salvia hispanica* (Chia) which was in the form of assembled contigs, were analysed by various bioinformatics tools. The primary aim of this exercise was to identify transcripts encoding protein involved in lipid metabolism. The mRNA sequence corresponding to various lipid related gene were retrieved from NCBI and used as query sequence for performing stand-alone BLAST search by using "BLAST+". Two interesting lipid biosynthesis related transcripts were identified; one encoding a soluble monoacylglycerol acyltransferase (MAGAT) and other an oilbody associated protein oleosin (OLE). Both these proteins contains H(X-)4D an acyltransferase motif, moreover the MAGAT sequence contains an GX SXG lipase motif. Conserved protein domains were examined using the conserved domain database at NCBI and the pfam database. The multiple sequence alignment ClustalW was used to identify conserved motif and active site mapping. The sequences corresponding to the ORF of both the genes were amplified using sequence specific primers and cDNA from leaf as template, the amplicon was confirmed by nucleotide sequencing. The amplicon were cloned into a galactose inducible yeast expression vector (pYES2). The recombinant proteins were heterologously expressed in *Saccharomyces cerevisiae* BY4741 strain. The expression was confirmed by immunoblot analysis.

- **Yeast transcription factors for lipid metabolic changes**

Yeast deletion strains that showed high accumulation of lipids (triglycerides for example) were studied for their transcriptional regulation. Five important transcription factors that play an important role in regulating the lipid metabolic genes were identified and their binding to these genes have been biochemically confirmed along with promoter validation assays. Morphological changes were also observed in these strains by SEM studies. One of these transcription factors has also been found to play an important role in regulating the lipid metabolic genes involved in cell ageing. Nuclear localization for one of the transcription factors has been for the first time found by GFP studies. Studies using MS/MS methods of the yeast lipidome is underway.

- **Bio-prospection of plant resources and other natural products (BioprosPR)**

Bioprospection of plant resources and other natural products: Exploitation of biomolecules from natural sources with special reference to endangered plants of Asclepiadaceae.

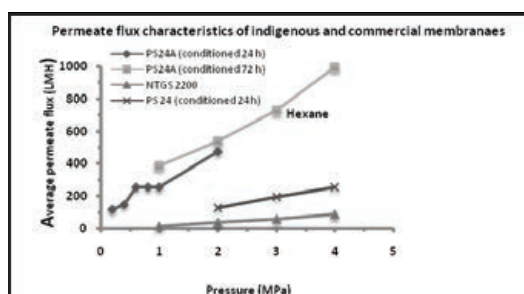
The targeted three plant genera belong to Asclepiadaceae viz., *Decalepis hamiltonii* (swallow root), *Hemisdesmus indicus* (Sarsaparilla), *Ceropegia candelabrum*

(candlestick cerpegia) were collected from different places, their identification was carried out. Respective plants were maintained under green house conditions for further studies. The tubers of *D. hamiltonii* were subjected to steam distillation to get volatile compounds which were further extracted with different solvents to separate 2-hydroxy – 4-methoxy benzaldehyde which is the flavour rich fraction. Confirmation of the same was done by analytical methods. Similarly the tubers of *H. indicus* were extracted with solvents to separate aroma rich fraction. *D. hamiltonii* *in vitro* seeds germination was obtained, and the same will be used to establish *in vitro* cultures for further studies. *In vitro* cultures of *D. hamiltonii* were established by using nodal explants. Callus suspension cultures were also established and the same will be used for biotransformation studies. The work is in progress to characterize different extract fractions from respective plant tubers and also biochemical profiling to identify biomolecules is in progress.

### Chemical Science Cluster

- **Membrane and adsorbent technology platform for effective separation of gases and liquids (MATES)**

Partial refining of vegetable oils, solvent recovery and separation of value added products using solvent resistant polymeric membranes (SRNF & SRUF) was undertaken.



Organic solvent nanofiltration and ultrafiltration has emerged as the new frontier in membrane-based molecular separation. The evaluation of solvent resistant membranes for the select processes with emphasis on extraction and purification involving organic solvents are aimed at CFTRI and the necessary indigenous solvent resistant membranes will be developed by the nodal lab, CSMCRI, Bhuvanesar. A few commercial manufacturers were also identified for the supply of solvent resistant membranes.

Permeate flux-pressure characteristics of two polysulphone membranes varying in thickness were studied along with a hexane resistant gas separation

membrane (NTGS-2200). Indigenous UF membranes (PS24 and PS24A) exhibited greater flux compared to commercial gas separation membrane (NTGS-2200). PS24A showed greater flux compared to PS24 owing to lesser membrane resistance in agreement with their thickness. Selectivity and hexane stability of these membranes need to be assessed further.

- **Encapsulated Microorganisms for Environmental Protection (EMEP)**

Major objective of the project is to dehydrate the microorganisms employing different feasible methods and use them for the environmental applications such as bioremediation, effluent treatment and nitrogen fixation to the plants. Experiments were carried out using yeast as the model microorganism to standardize the dehydration protocols. The work components related to preliminary scanning of commercial brands of yeast powder, identification of carrier materials for spray drying trials of yeast, standardizing the operating conditions for spray drying and comparison of results for the selection of most suitable carrier material were carried out.

Spray drying was found feasible in the case of yeast, the representative microbe. Also the presence of yeast cells was confirmed by microscopy. Corn starch was found to be most suitable with respect to yield of dry yeast powder. Maltodextrin found to be the most suitable carrier material with respect to viability of the cells. Combination of the best carrier materials identified till now (corn starch and maltodextrin) may give synergistic effect.

The following were also initiated either as a Supra projects / Network projects with CSIR-CFTRI as the nodal / participating lab

- New approaches towards understanding and to accelerate drug discovery (UNDO)
- New initiatives to boost agriculture productivity through maximizing pre- and post-harvest yields (AGROPATHY)
- Nano-materials: Applications and impact on safety, health and environment (NanoSHE)
- Creation of advanced research facility in molecular nutrition (Nutri-ARM)
- Zero emission research initiative for solid wastes from leather (ZERIS)
- Development of sustainable processes for edible oils with health benefits from traditional and new resources (People Hope)
- CSIR knowledge gateway and open source private cloud infrastructure (KNOWGATE)
- Measurement innovation in science and technology (MIST)

# CSIR-800 ACTIVITIES

Two training programmes related to mango slices in brine and canning of mango slices, osmo-dried mango slices were conducted for the participants (60 trainees) from the Krishnagiri cluster.

### *Utilisation of mango fibre waste in bakery products*

Mango fibre waste (MFW) procured from Krishnagiri was used as such in the preparation of muffins. The dried mango fibre waste was ground into powder (DMFWP) to utilize in the preparation of muffins. The dehydrated powder had around 43% of insoluble dietary fiber and 20% of soluble dietary fiber. The trials for the preparation of muffins were carried out using MFW and DMFWP at various levels. With MFW incorporation of 60g instead of wheat flour had moderately yellow crumb colour and mango flavour. With increase in the addition of DMFWP, the mango flavour predominantly increased especially beyond 20%. Evaluation of the product has been carried out with respect to physical and sensory parameters. Further work is in progress.

### *Mango pulp powder*

Canned mango pulp procured from Krishnagiri was used for development of spray dried powder. Spray dried powder

had typical mango flavor and color. Study of physico-chemical properties of the product is in progress.

### *TECHVIL Programme*

CSIR-CFTRI participated in a TECHVIL programme organized by CSIR-IMMT, Bhubaneswar during February 19 - 21, 2013 at Koraput, Odisha. The team from CFTRI interacted with local farmers, NGOs, SWGs and State government officials. Details of value-addition with ragi, ginger, turmeric and niger seeds were shared with interested groups.

### *Outreach programme*

An outreach programme was organised for the benefit of SHGs from K.R. Nagar (Mysore) under Spoorthy Janabhivrudhi Samaste on May 11, 2012. Ragi based processing technologies developed by CSIR-CFTRI were demonstrated on this occasion.



A large, wavy banner with a blue-to-teal gradient and a light green shadow effect, containing the text 'List of Staff as on 31.3.2013'.

**List of Staff as on 31.3.2013**



**Ram Rajasekharan . . . . . Director****Director's Office**

Ramesha CP  
Rao PVR  
Umashankar B  
Venkatesh G

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Papanna  
Renu Agrawal  
Salimath PV  
Varadaraj MC  
Vijaya Kumar BV  
Lalitha R Gowda

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Akhilender Naidu K  
Baskaran V  
Jagadish L Urs  
Kalpana Platel  
Mahadevamma  
Muralidhara  
Muralikrishna G  
Muthukumar SP  
Prasad Rao UJS  
Raja Shekar KL  
Ramesh HP  
Rathina Raj K  
Shylaja M Dharmesh  
Singh RP  
Venkatesh YP  
Venkatesha P  
Venkatesha V  
Vishwanatha S

**Central Instruments Facility & Services****Vatcharavelu K (Head)**

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Harish Raj V  
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Shivaswamy  
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Sulochanamma  
Umapathi H

**Food Engineering****Udaya Sankar K (Head)**

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Francis JV  
Gadigeppa Bammigatti  
Girish Kempanna Ghiwari  
Jagannatha MK  
Javaraiah K  
Jayaprakashan SG  
Kamala G  
Khanapuri MS  
Manohar B  
Mukunda K  
Murali YN  
Nagaraju VD  
Nanjundiah  
Parande AK  
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