



Report on
Bioactives and
Functional Foods
Safety, Benefits and Challenges



Knowledge Center on Functional Foods, Immunity and Gut Health

About ILSI India and K-FFIG

ILSI India is an entity of the International Life Sciences Institute (ILSI), headquartered in Washington DC., USA. ILSI India provides scientific inputs and secretariat assistance to the South Asian Region. It has headquarters in New Delhi. It is a scientific, non-profit organization.

ILSI India designs programs to foster multi-sector collaboration for conducting, summarizing, and disseminating science related to most pressing health issues in the region. ILSI strategy encourages global action on identifying and then resolving outstanding scientific questions in the four thematic areas that capture the core of ILSI / ILSI India's work: Food Safety, Risk Science and Toxicology, Nutrition and Health, Sustainable Agriculture and Nutrition Security. They also help elucidate new opportunities for driving scientific progress. All activities follow Principles of Scientific Integrity which are part of ILSI Mandatory Policies.

More information can be downloaded from: <http://www.ilsi-india.org>.

Gut Microbiome is an exciting new field of research. As the science of microbiome and the role of food based approaches in strengthening it over a lifetime is emerging ILSI-India launched **Knowledge Center on Functional Foods, Immunity and Gut Health (K-FFIG)** - a center of excellence - in New Delhi in October 2019. The Knowledge Center acts as a Think Tank, involving stakeholders from Government, Academia and Industry, that works towards sharing relevant research and technological developments in the area of human microbiome and functional foods. **K-FFIG** has undertaken several activities including: organization of **Scientific Meetings**, undertaking Surveys, sponsoring **Research**, publishing Monographs and articles in journals, creating **Resource Center** on latest studies on Microbiome and Gut Health and Functional Foods including Probiotics and Prebiotics. For more information visit: <http://www.ilsi-india.org/kffig.htm>.

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Foreword

Bioactive molecules come from a wide range of nutrients and non-nutrient substances. These Bioactive molecules form part of several supplements as well as other food matrices presently available in the consumer market. In order to maintain quality and also to confirm their efficacy and their safety it becomes necessary to follow certain scientific principles. This ILSI India K-FFIG Seminar focused on various aspects related to these Bioactive molecules and substances.

The first step is to have sufficient information on the molecular structure, its absorption, bioavailability, metabolic activation, effective dose, tolerable upper limit etc. before formulations are made. Bioactive molecules even if they do have history of safe use, should be considered on par with an Investigational New Drug and all the information relevant to the approval of an Investigational New Drug is also applicable to Bioactive molecules. Consumption of these Bioactive molecules are expected to give certain health benefits and these benefits should be measurable through appropriate analytical methods or biomarkers studies.

This Seminar had experts from various fields and the information provided in this Report will act as a guiding tool for those interested in developing a product with beneficial Bioactive molecules or for regulators and consumers to make an informed choice based on the genuineness and science based product line so that consumers get the appreciable benefit and at the same time do not have any adverse effects either due to unrealistic quantities of the Bioactive molecules being consumed or due to interaction between the Bioactive molecules and other pharmacological or nutrient substances which are also being consumed.



Dr. B. Sesikaran
Chairman
K-FFIG Governing council

Introduction

Bioactive compounds are extra nutritional constituents present in small quantities in many food products including fruits and vegetables, nuts, oils, legumes and whole grains. There is a variation in the chemical structure and functions and they are grouped under different categories e.g. carotenoids, flavonoids, carnitine, choline, coenzyme Q, dithiolthiones, phytosterols, phytoestrogens, glucosinolates, polyphenols, and taurine. Since vitamins and minerals elicit pharmacological effects, they can be categorized as bioactive compounds as well.

Most of the bioactive compounds have antioxidant, anti- carcinogenic, anti-inflammatory, and anti-microbial properties. Bioactive compounds are being studied intensively for their protective effects on health including Cardiovascular Health, Diabetes, Cancer and Inflammation. Globally many studies are being conducted to isolate the Bioactive Compounds, study the mode of action and health effects and build a data base using the modern technologies like Artificial Intelligence.

Since Bioactive components are expected to play an important role in health maintenance in the future. **K-FFIG** organized a Seminar on “ Bioactives and Functional Foods – Safety Benefits and Challenges” on 4th August 2022 to:

- *Look at evidence on health effects.*
- *Discuss the need to generate information on the bioavailability of bioactive food components and the effective dosage required in humans to optimize health benefits.*
- *Find out whether there are any safety issues and the regulatory guidelines for their usage.*
- *Identify the challenges and research needs.*

The Seminar was addressed by **8 Leading Experts** including 4 Panel of Experts: **Dr. B. Sesikeran**, Chairman, K-FFIG Governing Council, Former Director, ICMR-National Institute of Nutrition, Hyderabad; **Dr. Shobha A. Udipi**, Hon. Director, Integrative Nutrition and Ayurceuticals, Medical Research Centre-Kasturba Health Society, Mumbai; **Dr. Subrota Hati**, Assistant Professor, Dept. Dairy Microbiology, SMC College of Dairy Science, Kamdhenu University, Gujarat and **Ms. Rini Sanyal**, Director, Global Regulatory Affairs & Product Compliance – India Herbalife International India Pvt. Ltd., New Delhi.

Panel of Experts included: **Prof. (Dr.) J. B. Prajapati**, Chairperson, Verghese Kurien Centre of Excellence (VKCoE), Institute of Rural Management, Gujarat; **Dr. D. B. Anantha Narayana**, CSO, Ayurvedye Trust, Bangalore & Responsibility Chair S P Nutraceuticals FSSAI; **Dr. Subarna Roy**, Scientist G & Director, ICMR-NITM, ICMR-National Institute of Traditional Medicine (NITM), Karnataka and **Dr. Madhusudan Soni**, Toxicology Consultant, Florida.

The Seminar mainly discussed Basic Principles for Assessment of Bioactive Molecules - Mechanisms of Action, Efficacy, Safety, Interaction and Evidences, Bioactive Molecules from Traditional Indian Products, Production and Characterization of Novel Biofunctional Peptides derived from Fermented Milks using Potential Lactic Cultures (in silico & in vitro study) and Regulating the Use of Bioactive Substances –National and International Approaches. It also Discussed Challenges and Research Needs by panel of expert. Around 250 participants registered from India and other Asian Countries representing Government, Research Institutes, Industry and Academic Institutions.

Key Findings

Claims

- Claims that are associated with Food Supplements, Pro- and Prebiotics, Herbal Products, Bioactive Molecules and Functional Foods should be substantiated by scientific data on their Safety, Efficacy and Effect on Health and/or Pathological conditions.

Use of Bioactive Molecules

- It is very essential to have in-depth knowledge and understanding about the Mechanisms of Action, Pharmacokinetics and Toxicokinetics of Bioactive Molecules.

Identification of Biomarkers

- There should be clear markers for identity, structure, physiological outcomes, as well as the efficacy and toxic levels of bioactive molecules and functional foods.

Novel Alternatives for Treatment and Prevention of Diseases

- Out of three the important pillar of life is **Ahara** i.e. Diet in Ayurveda which is responsible for health and disease. There are numerous plant materials that can be used as foods in diet and have been attributed with health benefits. Several food items and preparations regarded as **Anna-Aushadis**, have been shown to have health benefits beyond their value as a food. Many food substances with medicinal value are extensively being explored for their bioactive molecules. This will help to facilitate standardized quality of food; development of target-specific natural products and scope for discovery of medicinal products or nutraceuticals.
- Bioactive peptides offer a new means to promote health or provide health benefits beyond their basic nutritional role. Globally there is a tremendous interest in promoting the use of food proteins or bioactive peptides as novel alternatives for present pharmaceutical therapeutics in the treatment and prevention of high blood pressure and other lifestyle diseases.

Safety of Bioactive Molecules

- Establishing the Safety of Bioactive Molecules is important. It should be stable in food under customary conditions of packaging, storage, distribution and use.
- Risk assessment is scientific tool for assessing the safety of a nutrient/ ingredients/ bioactive molecules. It can be used to develop Safe Upper Limit which can form the basis for determining the RDA.

Regulatory Framework

- Globally there is no defined regulatory framework on use of bioactives in food products, called by various names such as: Functional Food, Nutraceutical and Dietary Supplements. However, they can fall under different regulations based on positive health outcomes: EU General Food Law Regulation in Europe and in U.S. as USFDA regulations. Asia Pacific regions or in Association of Southeast Asian Nations (ASEAN) Consultative Committee for Standards and Quality Traditional Medicines and Health Supplements Product Working Group (ACCSQ TMHS PWG) has been working on the harmonization of Health Supplement standards and requirement.
- In India, The Food Safety Standard Authority of India (FSSAI) is responsible for regulating the products called Health Supplements, Nutraceuticals or Functional Foods. The Food Safety & Standards of Health Supplements, Nutraceuticals, Food for Special Dietary Uses (FSDU), Food for Special Medical Purposes (FSMP) & Novel Food provide scope for use of purified molecules /isolates / extracts provided under Schedule III, to be marketed as 'Nutraceuticals' to extract the benefit of the active ingredient such as lycopene, phytosterol, resveratrol etc. - also known as bioactive compounds.

OPENING SESSION

Opening Address

Dr. B. Sesikeran, Trustee, ILSI India Board and Chairman K-FFIG

In his Opening Address **Dr. Sesikeran**, Chairman K-FFIG mentioned that during the time of pandemic great deal of information was generated on how inflammation within the body or how severe chronic diseases makes people more susceptible to Corona virus. It also focused attention on importance of healthy lifestyle and uses of several well-known traditional foods which help in fighting against the Corona virus because these foods are loaded with several small

molecules which act as a drug or could be called nature's pharmacy. These foods not just served the nutritional need but also served the health needs. There is robust data available and published in very well-known journals.

He said that the Seminar focused on the new area of Bioactive molecules, their health benefits and safety and identify the data gaps and areas where research need to be conducted.

Welcome Address

Ms. Rekha Sinha, Executive Director , ILSI India

Ms. Rekha Sinha thanked all the Experts and participants for joining the Seminar and briefly explained about ILSI and ILSI India. She said that ILSI is a global, non-profit federation dedicated to generating and advancing emerging science and ground-breaking research to ensure foods are safe, nutritious and sustainable.

ILSI India is an entity of the International Life Sciences Institute (ILSI), headquartered in Washington DC., USA. ILSI India provides scientific inputs and secretariat assistance to the South Asian Region. It has headquarters in New Delhi. ILSI / ILSI India convene scientists at the forefront of research on Nutrition, Food Safety and Sustainability and operate within a framework of the highest Principles of Scientific Integrity. ILSI's trusted experts and volunteers around the world work synergistically and transparently across academia and the public and private sectors. ILSI / ILSI India work is guided by code of ethics, scientific integrity and organizational standards of conduct. She informed that ILSI Federation have published 35 scientific publications; organized 111 Workshops, Conferences, & Scientific Meetings and had 64,316 Science Video views on YouTube.

ILSI India works on most pressing health issues in the region particularly relating to the four thematic areas: Food Safety, Risk Science and Toxicology, Nutrition, Health and Wellness, Sustainable Agriculture and Nutrition Security. It works on Tripartite basis i.e. with scientists from Government, Academia and Industry.

Ms. Sinha informed that Knowledge Center on Functional Foods, Immunity & Gut Health (K-FFIG) - a Center of Excellence - in New Delhi was launched in October 2019. The Knowledge Center acts as a Think Tank that works towards sharing relevant research and technological developments in the area of human microbiome and functional foods.

She also drew attention on K-FFIG works which are as follows: K-FFIG has its own Website; It Sponsors Studies; Has created Resource Center on latest research on Gut Microbiome, Its role in promoting Health and Immunity and how it can be Strengthened by Food Based Approaches - Functional Foods, Probiotics and Prebiotics; organizes Scientific Meetings and brings out K-FFIG Research Briefs which is a Monthly Newsletter.

Keynote Address

Basic Principles for Assessment of Bioactive Molecules

Dr. B. Sesikera

Chairman K-FFIG, Former Director, National Institute of Nutrition (ICMR), Hyderabad

Bioactive molecules are nature's pharmacy. They are present in hundreds within each plant or its components and other biological materials. Human survival was dependent on these molecules, and only a few have been harnessed. They are now part of health supplements/ food supplements, traditional medicines, nutraceuticals etc. Definition of some of the important terminologies are given below:

- **Functional Food** are food or food ingredients which give an additional health benefit over and above their nutritional benefits (Food Safety and Standards Authority of India - FSSAI).
- **Nutraceuticals** are food ingredients which are used like a pharmaceutical - a product isolated or purified from foods that is generally sold in medicinal forms not usually associated with food. A nutraceutical is demonstrated to have a physiological benefit or provide protection against chronic disease (Health Canada).
- **A Dietary Supplement** is a product that contains nutrients derived from food products that are concentrated in liquid or capsule form.
- **Health supplement** is a category of foods, which consists of a concentrated source of nutrients (like proteins, minerals, vitamins, amino acids) and / or other ingredients with nutritional or physiological effects, singly or in combination, whose purpose is to supplement the normal diet (FSSAI).
- **Ingredient** means plant or botanicals and their extracts, probiotics, prebiotics, and molecules / isolates as listed by FSSAI in its Schedule II, III and IV.
- **Nutraceutical** is a category of foods which consists of extracts, isolates and purified chemical compounds having a physiological benefit and help to maintain health (FSSAI).
- **Nutrient** means vitamins, minerals, amino acids and other nutrients as specified by Food Authority from time to time (FSSAI).

Bioactive Molecule

Bioactive molecules are a naturally occurring molecule from any living system- plant / animal / fungi / bacteria/ algae / terrestrial / marine which has a demonstrable and measurable biological

activity e.g. anti proliferative, anti oxidant, anti infective, growth promoting, cholesterol lowering etc.

An Example :

- Carrot is a - Food – vegetable
- Carrots prevent blindness due to Vitamin A deficiency – Functional Food
- β carotene in carrot - pro Vitamin A – Bioactive Molecule
- β carotene supplements – Nutraceutical/ Food Supplement

More examples of Bioactive Molecules, Source and Health Benefits are given in *Appendix -1*.

Use of Bioactive Molecules – Important Considerations

There should be an in-depth understanding of mechanisms of action of Bioactive Molecules, Pharmacokinetics and Toxicokinetics and clear markers of their identity, structure, physiological outcomes, as well as the efficacy and toxic levels. Studying interactions with other molecules both from food as well as drugs are essential as an additional safety measure. It is important to have data and information on the following to authenticate their use:

Historical Characterization

- Identification of sources of Bioactive Compound – Taxonomy of plant- for example: Lycopene is found in Tomatoes, Red Carrots, Red Capsicum and Water melon.
- Information on history of safe human use – traditional or published data (FSSAI)- requires that the product is used for 30 yrs in country of origin or 15 yrs in India).
- Finding out safe level of consumption / upper safe limit through food should be known e.g. 6 gms of Fenugreek was used in food preparations at household level whereas NIN was recommending 20 gms as functional food (traditional as functional) so toxicology had to be assessed.

Physico Chemical Characterization

- Structure of the compound, molecular formula- chemical fingerprint.
- Available single or a family of molecules.
- Category and variants e.g. Carotenoids/ Curcuminoids.
- Molecular weight, solubility, stability etc.
- Thermodynamic and spectral data.
- Isolation of compound/ sample separation, synthesis.
- Purity of final substance and impurities.

- Preservation, storage, interactions with other substances.

Pharmacokinetics

Following needs to be worked out: Bioavailability; Absorption; Half life; Effect on Gut Microbiome; Accumulation in tissues; Distribution; Metabolism and Excretion.

Biological Activity

There should be method of assessing and quantifying this activity and validated assay methods- in vitro and in vivo methods, ED 50 and Toxicokinetics.

Bioinformatics

Bioinformatics is available on traditional foods. Their molecular structure is known. The bioactive molecule structure is put in the data base of allergen, drugs, toxins and see whether it matches with any other harmful molecules. It has to be assessed whether it will also do the same harm. It can be assessed very fast. Structure function similarities with other known molecules need to be studied. Further Allergen Database; Toxicity Database and Drug Interaction Database have to be consulted.

Biomarkers Identification

Biomarkers should be identified and validated for their predictive value. More specifically Markers related to level of consumption and bioavailability should be worked out: Plasma levels of the Bioactive molecule should be examined. Markers correlated to outcomes are indicator markers/ effect markers: Stanol consumption and Serum Cholesterol. Further if the markers are related to risk of disease they are known as susceptibility markers. For example ratio of LDL cholesterol to total cholesterol and risk of Cardiovascular Disease (CVD).

Principles for Addition of Dietary Active Compounds in Foods

Following needs to be taken into account while planning the addition of dietary active compounds to foods:

- a) Active compounds should be present at a level which will not result in either excess or insignificant intake.
- b) Should be sufficient to exercise its beneficial effect.
- c) Should not result in an adverse effect on the metabolism of any other nutrient.
- d) Should be stable in food under customary conditions of packaging, storage, distribution and use.
- e) Should be biologically available from the food and
- f) Methods of measurement should be available.

Studies to Assess Health Effects

Any claims about health benefits of a product requires evidence of its efficacy. Data has to be generated through clinical trials. There is a need to identify on whom the study has to be conducted i.e. Indian men / women / children / elderly. When human studies have to be considered data from other countries can be used (Indian settled abroad).

If data is not available new studies can be undertaken. These can be: Comparative study, Placebo Vs. Nutraceuticals, if Placebo cannot be done then study can be conducted with: Low dose Vs. High or Traditional vs. Test. Clear cut end points / Outcomes should be established.

As more studies are conducted, new insights may emerge. There can be scientific contradictions e.g. as regards Vitamin E, Beta-carotene – benefits have been seen in case control but increased mortality and morbidity in Randomized Control Trials (RCT) have been found. It is known that long term selenium increases risk of type 2 DM at level of supplementation (200 µg – ½ SUL). Folic acid supplementation is also in question. While making health claims validation and substantiation are essential.

Safety Assessment

Safety Assessment is essential to from health point of view and to get approvals for recommending their use. Evaluation of efficacy as well as safety assessments should be based on sound scientific principles and evidence. Risk Assessment is an important tool to understand and allow use of food / food ingredient. It incorporates the following steps: Hazard identification (Adverse effects); Hazard characterisation (including dose-response assessment); Exposure assessment; Risk characterisation; Risk-benefit analysis.

It is important to work out safety levels, Adverse effect level –LOAEL / NOAEL, Safe Upper Limit and Acceptable Daily Intake. The effect in physiological

states like pregnancy, young children, lactation need to be looked at. While working out safe levels intake from dietary sources as well as supplements should be taken into account).

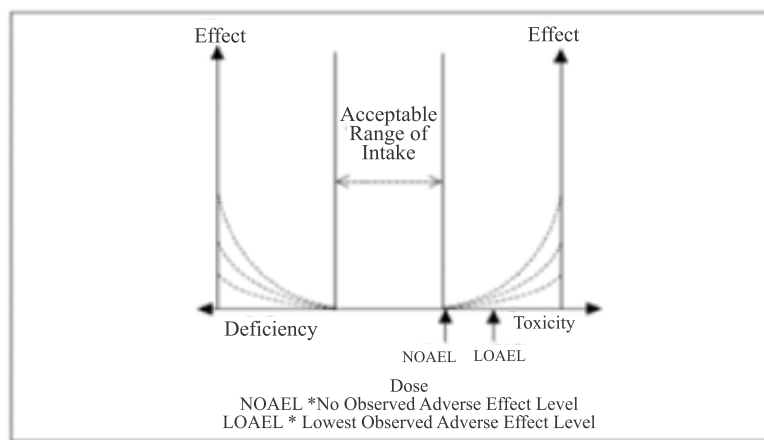
Extrapolating LOAEL (Low Observed Adverse Effect Level) to derive NOAEL (No Observed Adverse Effect Level) (based on human data)

- If adverse effect is a biochemical change with no clinical or organ correlation – factor is 3.
- E.g. Serum transaminase levels were elevated at 30mg dose i.e LOAEL.
- Then NOAEL will be $30/3 = 10$ mg.
- If adverse effect was a serious toxic change then NOAEL will be $30/10 = 3$ mg.

Extrapolating NOAEL to derive SUL (based on ANIMAL data)

- If NOAEL is 10 mg.
- SUL = $10 / 10 \times 10 = 0.1$ mg.
- Factor of 10 for inter species variation.
- Factor of 10 for inter individual variation.

Figure 1. Theoretical Dose Response Relationship in Humans



Evaluation of the Generally Recognized as Safe (GRAS) Status

Whenever there is sufficient evidence of safe use historically or traditionally or based on robust pre-clinical and clinical data these molecules are given a GRAS (Generally Recognized As Safe) status by the USFDA that is accepted by other regulators.

Information Required by USFDA for Evaluation of the Generally Recognized As Safe (GRAS) Status of as a Food these include: **Part I: Basis of Conclusion** (Name and Address of Organization; Name of Substance; Intended conditions of Use; Statutory Basis for GRAS Conclusion; Exemption from Premarket Approval Requirements); **Part II: Identity and Technical Information** (Description; Botanical identification; Specifications; Manufacturing Process; Biologically Active Constituents); **Part III: Dietary**

Exposure (Technical Effects; Intended Use Levels and Food Categories; Estimated Daily Intake from the Intended Use; Exposure Summary); **Part IV: Self Limiting Levels of Use; Part V: Experience Based on Common Use in Food; Part VI: Narrative** (Data Pertaining to Safety; Common Knowledge of Safe Use; Toxicity Studies; Acute Toxicity Studies; Repeat-dose Toxicity Studies in Animals; Other Animal Studies-Carcinogenicity, Mutagenicity; Human Clinical Studies; Biochemical and Pharmacological Effects Expert Panel Review, Summary and Discussion; Expert Panel Conclusion) and **Part VII: Supporting Documents and References.**

Conclusion

To translate new knowledge into product, ensure Safety and Quality, evaluate efficacy, make content Claim or evaluate product for specific health outcomes and then make a product Claim.

Whenever claims made on the efficacy of Bioactive there should be molecules backed by adequate clinical evidence. Regulatory requirements should be met, and they keep getting updated as the science advances.

TECHNICAL SESSION

1. Bioactive Molecules from Traditional Indian Products

Dr. Shobha A. Udipi

Research Director & Head and Hon. Director Integrative Nutrition and Ayurceuticals,
Kasturba Health Society-Medical Research Centre, Mumbai

Worldwide there has been a great interest in Bioactive Molecules, particularly in the health-promoting properties of natural foods. India has a continued live tradition of Ayurveda for over 5000 years, which has an epistemic perspective on health, food and nutrition that differs from modern nutrition and biomedicine. Scope of knowledge discovered in traditional knowledge systems and science are fundamentally different. Modern science provides detailed knowledge about parts of physical and biological nature whereas traditional knowledge systems is based on holistic knowledge of physical, biological, and spiritual fields that pervade nature. In Ayurveda outside world is being understood on ontological basis of Panchamahabhutas i.e. five elements-earth, water, fire, air, and space and these are set to correspond to each of the 5 senses, viz. smell, taste, vision, touch, and sound.

In Ayurveda dietary / lifestyle changes are considered an integral part of therapeutic management and form an important component for maintenance / promotion of good health. The eating guidelines in Ayurveda, determinants of food utility and food group classification in Ayurveda are given in **Appendix -2**.

Ayurveda regards Ahara (food) as one of the three important pillars of life and as being responsible for health and disease. There is a considerable flexibility in the usage of Ayurvedic Ingredients i.e. from Ahara- to Ahar- Aushadha to Aushadha- Ahar to Aushadha.

Several food items and preparations regarded as **Anna-Aushadis**, are actually **Anna** and they have therapeutic properties which shown to have health benefits beyond as a food. They are Barley, Kulith /

Horse Gram, Udad / Black Gram, Priyangu / Charoli, Upavaka / Indrayava, Honey, Amla, Jamun, Dates, Milk, Cinnamon, Clove, Bale Fruit and Shadangodak (Decoction liquid prepared by using 5-6 herbs). These food substances with medicinal value are extensively being explored globally for identifying the bioactive molecules. This facilitates having standardized quality food, development of target-specific natural products and scope for discovery of medicinal product(s)/nutraceuticals.

The path of reverse nutraceuticals and dietetics (experience-experiments-evidence) in Ayurveda has been pursued by Medical Research Centre, Mumbai with focus on scientific aspects and the biological plausibility for their specific health benefits. Reverse Nutraceuticals has much potential of developing global novel products inspired by products already being safely used in the field.

Reverse Nutraceuticals begins with **Nutra epidemiology**. It includes study of **classical texts and historical evidence** on usage of ingredients. **Human observational studies** provide case reports or detailed anecdotes of individual experiences by a physician or a sensitive patient. **Experiential nutra studies** are **open labelled studies**, using common target symptoms and routine investigations as assessments, in a sample group as determined by earlier observations. **Exploratory studies: In vitro, in vivo and clinical studies** targets relevant to clinically documented effects. **Experimental studies – Human nutra studies** - are controlled studies for safety and efficacy with defined serving size and defined indications.



Potential Bio-Active Molecules In Select Products

Horsegram (Kulith): *Dolichus Biflorous* Linn

There are some clinical studies on Horsegram which has described antiurolithiatic effects and it could be due to:

- Diuretic effect
- Presence of binding proteins

- Antioxidants attributable to saponins - amphiphilic nature
- Lectins: activity in yush- 16HU/g, raw horsegram - 5.33HU/g
- Polyphenols

Turmeric (Nisha/Haldi) - The Golden Spice

Turmeric has at least 6000 years of documented use and in ancient Vedic societies it was called "the herb of the sun". It has 53 synonyms in Sanskrit. It is considered to be a preservative, keeping foods safe in a land of heat and hunger. In the western world it is only in the 20th century when the research on turmeric was started seriously. Serious attention on its health effects was given from early 1920's in Germany.

Many of the foods contain numerous (100s) of molecular constituents, each of them has a variety of biological activities. For example some of them are "PLEIOTROPY" in nature.

Turmeric contains:

- 20 - molecules having antibacterial properties
- 14-molecules having cancer preventives properties
- 12 - molecules having anti-tumor properties
- 12-molecules having anti-inflammatory properties and
- 10 - molecules with anti-oxidant effect.

Most research has been done with curcuminoids (95%) although in the raw state their content is only 3-5%.

Curcuma Longa: Traditional Use

There are tremendous numbers of uses that have been mentioned traditionally for Curcuma Longa or Haldi. These include:

- Cure for acne, skin allergy, eczema, itching, scabies.
- Use as an ingredients in mosquito repellent.

- Tackle chicken pox, ring worm, small pox infections
- Effective in throat infection and hemorrhage
- Prevention of anemia possibly because haldi is a good source of iron as indicated by Indian Food Composition Table and
- Effective for diabetic wounds etc.

Curcumin: Diverse Targets And Molecular Mechanisms

Curcumin has tremendous number of targets and molecular mechanisms. Curcumin performs these effects by modulating signaling pathways with many molecular targets such as enzymes, adipokines and receptors, insulin signaling pathway, transcription, protein kinases, gene

expression and others.

Reverse Pharmacology of *C. Longa* Linn

Studies done on *C. longa* Linn at Kasturba Health Society-Medical Research Centre, Mumbai are described below:

Sl. No.	Activity	References
1	Anti-mutagenic property of curcumin (<i>in vitro</i> by Ames test)	Bhide et al 1986
2	Reversal of the DNA damage in patients of oral submucous fibrosis.	Hastak et. al 1997
3	Chemopreventive activity in patients of oral submucous fibrosis	Pillai D, 1997.
4	Phase I evaluation of safety and tolerability in healthy volunteers	Joshi et. al 2003
5	Insulin -sensitising and antidiabetic activity	Vaidya et al, CSIR-NMITLI report

Curcuma Longa (T. Oil) has Anti-Mutagenic, Anti-Cancer, and Anti-Inflammatory Properties

A study on Antimutagenic *in vitro*: Ames test. Anticancer and Anti-Inflammatory in patients at SMF shows that after treatment for 3 months there was clinical improvement; increase in interincisal

opening to various degrees; decreased Micronuclei (Buccal & Peripheral) and increased antioxidants and biochemical parameters remained within normal range.

Amlaki Rasayana: Amala / Gooseberry

Rasayana strengthens the defense mechanism of the body and deals with the rejuvenation and regeneration. Guruprasad et al (2017) studied the effect of Amlaki rasayana on the telomerase activity of the cells which maintains telomere length, implicated in ageing and various diseases – shortening of telomere during ageing is controlled chiefly by telomerase activity. Certain Rasayanas promote immunomodulation and healthy ageing and are used to improve quality of life in aged individuals by protecting the telomere length.

Few examples of different Rasayanas and their beneficial effects are:

- Amalaki Rasayana prepared from Amalaki / amla; widely used in the Indian traditional system of medicine as a cardiac, cerebral and intestinal tonic. *P. Emblica* (Indian gooseberry) is a good source of ellagic acid, gallic acid, quercetin,

kaempferol, emblicanin, flavonoids, glycosides proanthocyanidins and vitamin C.

- Vayasthapana Rasayana is reported to promote longevity, prevent ill health and block geriatric symptoms.

As Rasayana, Amalaki has been found to have beneficial effect on: general health, age related changes, voice, sensory organs, physical capacity, psychological improvement and complexion. It was also found that administration of amlaki with milk is significantly effective against insomnia, constipation, digestive weakness. In another study when it was used to extent of (0.5%) as food supplement there was increase in fecundity, size of salivary gland with additional cycles of DNA endo -replication, thermo tolerance, starvation tolerance, median life span, and shortening of developmental time.

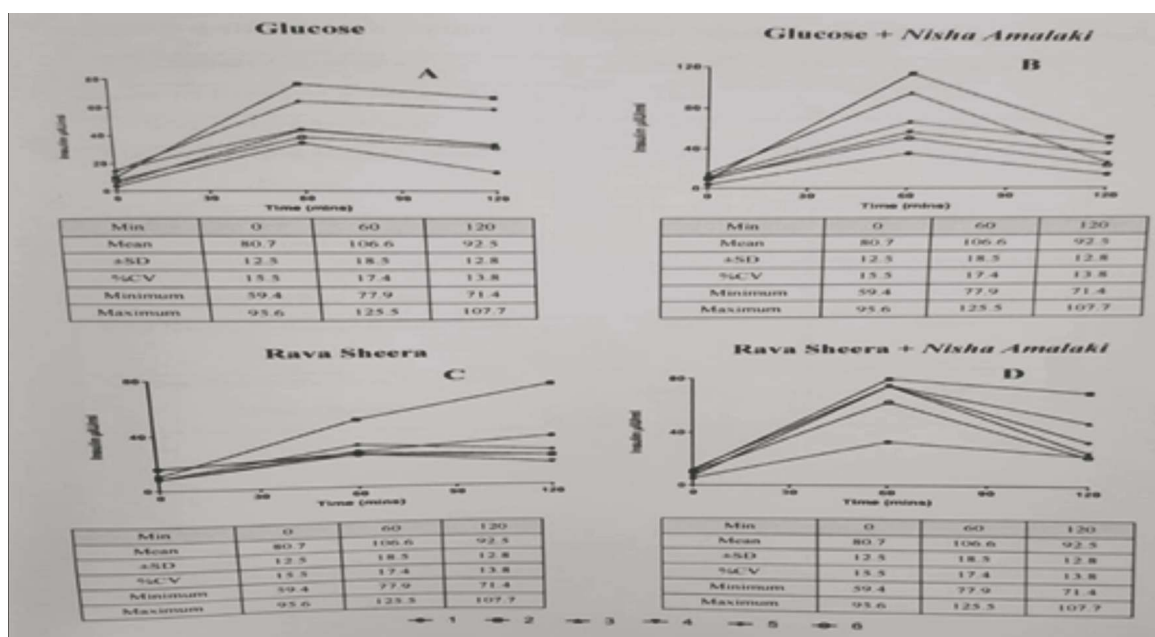


Fig: Insulin Responses of Volunteers to Various Treatments:

A) Glucose B) Glucose + Nisha Amlaki C) Rava Sheera D) Rava Sheera+Nisha Amlaki

Source: Pawar A(2018) Effect of Nisha Amalaki on the Glycemic Index and Insulin Response to Rava Sheera . MSc Dissertation submitted to SNTD Women's University

This study shows the effect of Nisha Amalaki on the glycemic index and insulin Response to Rava Sheera. Researchers have used Nisha amalaki in the ratio of 2:3. The 10 grams of Nisha Amalaki was given along with glucose or with rava sheera. Graph of the study in the above (Fig 1) shows that they improve insulin responses to some extent and glycemic response was also much better.

Summary of Results of Studies on Haridra (DM001) and Amla (DM 002)

DM001

- Protects against STZ induced damage RIN cells
- Not mediated via MDA
- Inhibits insulin secretion
- Reduces angiogenesis
- Anti-oxidant activity
- Anti-aggregatory effects: mediated through curcumin
- Dose dependent inhibition of aldose reductase activity at higher concentration

DM002

- Protection against STZ induced damage RIN cells
- Mediated through in MDA
- Increased insulin secretion
- Stimulates angiogenesis
- Increased glucose uptake
- AKT phosphorylation
- GLUT4 translocation
- Gallic acid active, not ellagic acid

DM-FN-01(Nisha Amalaki)

- Insulin sensitization: *in vitro* & *in vivo*
- Inhibition of protein glycation *in vitro*
- Antioxidant and anti-inflammatory
- Antimutagenic and DNA protection
- Tablets do not interact with metformin
- Most widely used-unstandardized

Sunthi: Dried Ginger

Studies on Sunthi have shown that it has beneficial effects on morning stiffness, pain on

rest, gastrointestinal upsets, dysuria (burning sensation during urination), blood in stool and on mild fever. It also reduces Ritchie's Articular Index

(pain, swelling and warmth) and improves mobility.

Honey / Madhu

Honey is valued highly in Ayurveda because of its application i.e. it can be used internally as well as and externally. Honey's composition highly varies, depending on type, flowers, and pollen that bees collect. It has greater than 180 components including – Fructose (38%), glucose (31%) disaccharides- maltose, sucrose, maltulose, turanose etc. It contains Vitamins (riboflavin, niacin, folic acid, pantothenic acid, vitamin B₆, ascorbic acid), Minerals (Ca, Fe, Zn, K, P), Organic acids: (citric, succinic, lactic, malic and gluconic acid) and Amino acids, Proteins.

Honey has antioxidant, antimicrobial, nematocidal, antifungal, anticancer, and anti-inflammatory activities. In Ayurveda, it is used for internal and

external applications. Mainly for treatment of eye diseases, cough, thirst, phlegm, hiccups, blood in vomit, leprosy, diabetes, obesity, worm infestation, vomiting, asthma, diarrhoea and healing wounds. It is useful in Hyperlipidemia. Navin Madhu acts as laxative.

Honey has Shodhana (purification), Ropana (healing), and Sandhana (union) properties. It is useful for topical application on wounds and mouth ulcers. Ayurveda mentions Yogavahi properties of Madhu i.e. when honey is used with other herbal preparations it enhances the medicinal qualities of those preparations and also helps them to circulate in whole body.

TECHNICAL SESSION

2. Production and Characterization of Novel Biofunctional Peptides derived from Fermented Milks using Potential Lactic Cultures (in silico & in vitro study)

Dr. Subrota Hati

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Kamdhenu University, Anand, Gujarat

Milk is known to contain about 10,000 bioactive compounds in different concentration with the advent of nutraceuticals and functional foods. Gradually, consumption of functional dairy products, particularly probiotic fermented milks are increasing to combat the lifestyle diseases. Milk bioactive peptides are inactive within the original protein, but once released, function as regulatory compounds with hormone like activity. They are also known as '*functional peptides*' derived from food and exert different physiological health effects. This activity is based on their inherent amino acid composition and sequence. However, Lactic acid bacteria (LAB) have strong proteolytic system allowing for degradation of milk proteins for their growth. At present, milk proteins are the most important source of bioactive peptides.

A variety of naturally formed bioactive peptides have been found in fermented dairy products, such as yoghurt, dahi, probiotic dairy foods and cheese. Bioactive peptides are released upon fermentation of milk using different live proteolytic microorganisms or proteolytic enzymes derived from such microorganisms. Fermentation of milk with certain dairy starters, peptides with various bioactivities can be formed and detected in an active form even in the final product i.e. fermented milk and cheese. They can be absorbed and reach peripheral organs.

Following Table provides information on Bioactive peptides released from milk proteins by proteolytic enzymes of different microorganisms.

Microorganism	Precursor Protein	Peptide Sequence	Bioactivity
<i>Lactobacillus helveticus</i> and <i>Saccharomyces cerevisiae</i>	β -casein, α -casein	Val-Pro-Pro, Ile-Pro-Pro	ACE inhibitor, Antihypertensive
<i>Lactobacillus</i> GG enzymes + pepsin and trypsin	β -casein, α s1 casein	Tyr-Pro-Phe-Pro, Ala-Val-Pro-Tyr-Pro-Gln-Arg, Thr-Thr-Met-Pro-Leu-Trp	opioid, ACE inhibitor, immunostimulating
<i>Lb. helveticus</i> CP90 proteinase	β -casein	Lys-Val-Leu-Pro-Val-Pro-(Glu)	ACE inhibitor
<i>Lb. helveticus</i> CPN 4	whey proteins	Tyr-Pro	ACE inhibitor
<i>Lb. delbrueckii</i> ssp. <i>bulgaricus</i> IFO13953	α -casein	Ala-Arg-His-Pro-His-Pro-His-Leu--Ser-Phe-Met	Antioxidative
<i>Lb. rhamnosus</i> + hydrolysis with pepsin and Corolase PP	β -casein	Asp-Lys-Ile-His-Pro-Phe, Tyr-Gln-Glu-Pro-Val-Leu, Val-Lys-Glu-Ala-Met-Ala-Pro-Lys	ACE inhibitor Antioxidative
<i>Lb. delbrueckii</i> ssp. <i>bulgaricus</i>	β -casein	Ser-Lys-Val-Tyr-Pro-Phe-Pro-Gly-Pro-Ile	ACE inhibitor

Source : Dziuba and Dziuba, 2014⁹

Anand Agriculture University has done studies on Bioactive peptides from different sources of milk and the health effects. Generally, **caseins** are composed of all amino acids required for the growth of Lactic acid bacteria in milk to high cell density. The LAB cultures used in one of the study were: ***Lactobacillus casei* MTCC 25062 (NK9)**, ***Lactobacillus fermentum* MTCC 25067 (LF)**, ***S. thermophilus* MTCC 5460 (MD2)**, ***L. helveticus* MTCC 5463 (V3)**, ***L. rhamonosus* MTCC 5945 (NS4)**, and ***L. fermentum* M4**.

Lactic cultures were evaluated for their pepX activity, dipeptidase, tripeptidase, proteolytic activity, hydroxyl free radical scavenging activity, superoxide free radical scavenging activity, ACE-inhibitory activity and anti-oxidative activity.

Proteolytic activity and pepX activity of NK9 and LF in **goat milk** significantly ($P < 0.05$) increased with the incubation periods. The peptide production of 10 kDa permeate was significantly higher than permeates and retentates of 3 and 5 kDa. Goat milk fermented with NK9 (3 kDa permeate) produced peptides DERFFDDK which has encrypted with the hypertensive peptides (DERF, RFF and FFD) as well as LF showed peptides sequence of MMKSFFLVVTILALTLP which was encrypted with the hypertensive tripeptide (FFL, FLV, ILA and LTL).

The peptides sequences obtained from fermented **soy milk** with MD2 produced the amino acid sequences i.e. IPP, AIPP, QSAP which showed ACE inhibitory activity and matched with bovine casein and whey proteins reported by Anna and Jerzy (2009), Marta et al. (2007) and Tania et al., (2013) on AHTPDB. Similarly, MD2 also produced YLA and VAP which had ACE inhibitory activity. **Camel milk** fermented with LF showed QSAPGNEAIPP peptide sequence derived from Kappa-casein (119–122) which have encrypted

the hypotensive tripeptide (IPP) reported by Nakamura et al. (1995). **Goat milk** fermented with *Lactobacillus fermentum* (M4) produced YIPIQYVLSR and HPHPHLSFMAIPPK peptides sequence from 2D-PAGE were matched with antioxidant fraction of IPIQYVL (fermented milk) and HPHPHLSFM (β - and κ -casein) on BIOPEP databases, respectively.

Bioactive peptides offer a new means to promote health and can provide health benefits beyond their basic nutritional role. There is a tremendous global interest in promoting the use of food proteins / peptides as novel alternatives for present pharmaceutical therapeutics in the treatment and prevention of high blood pressure and other life style diseases.

According to coherent market insight, 2019 the global bioactive peptide market size was valued at US\$ 3,265.2 mn in 2017, and is expected to exhibit a CAGR of 9.4% over the forecast period (2018–2026). North America dominated the global bioactive peptides market in 2017 and reported 35.9% market share in terms of revenue. More than 60 peptides have been approved by US Food and Drug Administration (FDA) as a medicines on the market and this is expected to grow significantly with approximately 140 peptide drugs currently in clinical trials and more than 500 therapeutic peptides in preclinical development (Fosgerau and Hoffmann, 2015).

These products with antihypertensive activity or antioxidative activities can be recommended for the management of hypertension or oxidative stress. Further, *in vivo* study is required to validate the health claim, particularly for antihypertensive or antioxidant peptides from fermented milks on small animal or human subjects.

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TECHNICAL SESSION

3. Regulating the Use of Bioactive Substances – National and International Approaches

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Bioactive compounds are defined as components of food that have an impact on physiological or cellular activities in the humans or animals that consume such compounds. They are mainly found in plants, animals, microbes and marine sources; have antioxidant, anti-inflammatory, and anti-

carcinogenic effects; and can be protective against various diseases and metabolic disorders. Such beneficial effects make them good candidates for the development of new functional food with potential protective and preservative properties.

Recent Advances in Production of Bioactive Compounds

A number of technologies are used for production of Bioactive Compounds such as Fermentation by probiotic bacteria and Ultrasound-assisted extraction. Several strategies and technologies

have been adopted for fortifying foodstuffs and increasing their nutritional value such as Vacuum impregnation, High-pressure processing and Encapsulation.

Regulatory Scenario

“Bioactive Compounds”, “Nutraceuticals”, and “Functional Foods” are some of the terms widely used in the food context, however, the margins between them all are not clear and are very often used interchangeably. Globally, so far, there is no

defined regulatory framework on use of bioactives in food products, however, whether the product is called a Functional Food or a Nutraceutical the positive health outcome is dependent on the active component/s present.

Indian Regulatory Framework

The term 'Bioactive Compound' is not defined in the Indian regulations, however, the Food Safety & Standards Health Supplements, Nutraceuticals, FSDU, FSMP & Novel Food Regulations provide scope for use of **purified molecules / isolates / extracts** included under Schedule III, to be marketed as 'Nutraceuticals' to extract the benefit of the active ingredient such as Lycopene,

Phytosterol, Resveratrol etc. which are also known as Bioactive Compounds. However, these products are not allowed to make Disease Risk Reduction Claims (DRR) without approval from Food Authority. Thus, it is logical to pursue the advancement with a clear regulatory pathway, so that the benefits are accessible through foods.

European Regulatory Framework

Term 'Bioactive Compound' is not defined in the European regulations. Lists of authorized compounds / foods appear in the corresponding regulations. Responsibility for the safety of these compounds / foods lies with the food business

operator placing the product on the market. They have to comply with the general food law. To facilitate this procedure, different guidelines exist at the European level to explain the tier toxicity testing approach to be considered.

Bioactive Compounds aimed to be used in food could fall under one (or several) of the regulations affecting:

- (i) food supplements,
- (ii) substance for the fortification of food,
- (iii) food for specific groups, and
- (iv) novel foods.

On the other hand, depending on the type of Bioactive Compound, they can be classified as :

- (i) vitamins and minerals,
- (ii) other substances, or
- (iii) botanicals

U.S.A Regulatory Framework

As per UFDA regulations, most nutraceuticals could be categorized as “dietary supplements”. As these are extracts, concentrates or combinations of vitamins, minerals, botanicals, herbs, or dietary substances “for use by man to supplement the diet by increasing the total dietary intake.” Producers of Nutraceuticals classified as dietary

supplements are required to register their facility with the FDA. Manufacturers have to make sure that the information on the product label is truthful and not misleading. Labeling standards for dietary supplements are clubbed together with those for foods.

Asia Pacific Regions or in Association of Southeast Asian Nations (ASEAN) Countries

Till now there is no uniform regulatory requirements in different regions for Nutraceuticals. ASEAN “Consultative Committee for Standards and Quality Traditional Medicines and Health Supplements Product Working Group (ACCSQ TMHS PWG)” has been working on the harmonization of Health Supplement standards

and requirement. The development of the harmonized technical standards and requirements has been completed and the ASEAN Senior Economic Official Meeting (SEOM) has given approval for the signing of the ASEAN Health Supplement Agreement by 3rd Quarter of 2022.

Other Organizations

IADSA- The Risk Assessment and Safety of Bioactive Substances in Food Supplements

Members of the IADSA scientific group with the guidance of experts in the bioactive substances have published **The Risk Assessment and Safety of Bioactive Substances in Food Supplements**. It is intended to complement IADSA's earlier publication on the safety of vitamins and minerals and safety methodology for non-essential nutrients (bioactive components) . It describes the method used in detail and sets out the results of its application to a selection of bioactive ingredients and details risk assessments performed on a selection of bioactive substances in food.

Bioactive Compounds have emerged as key food components related to healthy status and disease prevention. In future Bioactive peptides may also become very popular. They are utilized in foodstuffs to produce functional foods due to the

numerous health-promoting outcomes, such as imparting anti-hypertension, anti-thrombotic, anti-cancer, anti-microbial, anti-oxidant, and immunomodulatory to the human body.

Several natural sources of Bioactive Peptides are exploitable, including soybean, cereals germ, potato, nuts, dairy products, egg, and meat proteins. Moreover, marine microorganisms, for instance, microalgae, recently captivated increasing attention as a source of bioactive peptides.

Bioactive compounds are regarded as an interesting alternative for disease prevention and treatment, in various cases. Their value is enhanced by the consumer's preference for natural products with sustainable solutions for improvement of quality of life focused on personalized nutrition. Knowledge of chemistry of natural products together with their mechanistic approach is key elements for the development of new solutions for this sector.

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10. IADSA- The Risk Assessment and Safety of Bioactive Substances in Food Supplements

Panel Discussion on Challenges and Research Needs

Chair : Dr. B. Sesikeran, Chairman K-FFIG.

Panel of Experts

Prof. (Dr.) J. B Prajapati, Chairperson, Verghese Kurien Centre of Excellence (VKCoE), Institute of Rural Management, Gujarat; **Dr. D. B. Anantha Narayana**, CSO, Ayurvedic Trust, Bangalore & Responsibility Chair S P Nutraceuticals FSSAI; **Dr. Subarna Roy**, Scientist G & Director, ICMR-NITM, ICMR-National Institute of Traditional Medicine (NITM), Karnataka & **Dr. Madhusudan Soni**, Toxicology Expert, Florida.

Following points emerged during discussion:

Challenges and Gaps

- **Infrastructure and Training Gaps**
 - There is a lack of formally trained researchers on ethical issue in Ayurveda, Siddha and Unani (ASU) or Ayurveda Health (AH).
 - Create a common platform for clinical trial under Drug Authority or FSSAI and develop guidelines which combines information from multiple departments and ministries so that uniformity will be maintained.
- **Gaps in Nomenclature system** used for botanical plant.
- **Gaps in the Pharmacopoeial Standards** - Only 645 single herbs and only 202 compound formulations are available in Ayurveda. The remaining compounds / formulations is not available.
- **There is a gap between Industry and Academia; Foods and Pharma Industries as well as Science and Medical Science Education** –These sectors should collaborate and should not work in silos to benefit research and bring out products to benefit public health. A lot of research work has been done in institution (Academia) on bioactive molecules or functional foods and this information can help the industry in the formulation of new product and to substantiate claims based on evidence. Food and pharma industries are intrinsically linked to each other and still they work separately. In case of science and medical science education the research which has been done by general science groups should be brought to the notice of medical community to help in establishing preventive health care system.

Claims

- Unsubstantial claim may mislead the consumer and will decrease the trust level among consumers regarding the product. Content Claim should be made. The claims should be made on ingredient or product and it should be supported with adequate amount of scientific data.
- **ILSI India should prepare Guidance Document on “Parameters for immune function to enable making product claims”.**
- Human intervention studies on nutraceuticals should be conducted for substantiation of claims linked to antioxidants activity and to understand potential interaction with selected medicines consumed.

- Products with antioxidants activities are approved based on safety data and general benefits by European Food Safety Authority (EFSA). As regards specific claims on benefit of antioxidant, these can be approved only if supported with a specific pharmacological health benefits. There is a need to look at EFSA's decision making process.
- FSSAI allows import of products on which claims are made on the basis of studies done abroad but not on Indian population in such cases manufacturer/ suppliers are given time to generate post-market data on health effect on Indian population and submit this to FSSAI for their consideration and permitting the use of such product within the country.
- While substantiating claims, in case of lack of data on Indian population western data which also incorporates data on Indians settled abroad can be used.
- FSSAI has set up a Committee to prepare guidelines on clinical trials as well as human intervention studies for food format.

Clinical Trials

- Clinical trials should be undertaken to assess safety and benefits on indigenous probiotic cultures and functional foods.

Studies

- Development of Bioactive Molecules / Nutraceuticals from Indian raw materials / traditional food .
- Database on evidence of the composition, the amount of ingredients in functional foods and health and safety aspects of the functional foods.

Generally Recognized As Safe (GRAS)

- In U.S. there is no definition for Functional Foods. FDA has created a new category called GRAS (Generally Recognize as Safe) in which Functional Food can be added. Hence, when functional food is added as food it should be safe for consumption for all sub-population (pregnant women, lactating women, children, infants and old age) because everyone will consume it and hence it become more challenging to bring Functional Foods into the market.

IEC

- Awareness should be created on how to choose foods which impart various health benefits. Such education can starts from school and can be part of school curriculum.
- Educate medical student on Bioactive Molecules and their presence in food (Nutraceuticals / Health Supplements / Functional Foods) as part of preventive health care strategies so that they can communicate the messages to the general public and to the patients for their benefit.

Sources and Benefits of Some Bioactive Molecules

Functional Component	Source	Health Benefit (Bioactive Molecules)
Alpha-carotene Beta-carotene	Carrots Beta-carotene fruits, vegetables	Neutralize free radicals
Lutein	Green vegetables	Reduce risk of macular degeneration
Lycopene	Tomato	Reduce risk of prostate cancer
Insoluble Fibre	Wheat bran	Reduce risk of breast or colon cancer
Beta-Glucan	Oats	Reduce risk of CVD
Soluble Fibre	Psyllium	„
Omega-3	Fish and fish oils	Reduce risk of CVD Improve mental, Visual functions
Flavonoids Anthocyanidins	Fruits	Neutralize free radicals Reduce cancer risk
Catechins	Tea	„
Flavanones	Citrus	„
Flavones	Fruits / vegetables	„
Stanol ester	Corn, soy, wheat	Inhibit cholesterol absorption
Fructo-oligosaccharides (FOS)	Onion	Pre biotics
Lactobacillus	Yogurt, other dairy	Gut health
Isoflavones: Daidzein Genistein	Soya-soy-based foods	Menopause, CVD Lower LDL
Lignans	Flax, vegetables	„
Proanthocyanidins	Cranberries, cocoa, chocolate	Improve urinary tract health Reduce CVD ? Complications of DM

Eating Guidelines in Ayurveda

Ayurveda's Guidelines on Eating are given below:

- Ushna (Hot & warm food)
- Snigdha (Unctuous food)
- Maatraavad (Proper quantity)
- Jeerne (After digestion)-
- Veeryaviruddhe (Avoid incompatible food)
- Naatidruta (Not too fast ...)
- Naativilambita (Not too slow...)
- Ishtadeshe (Pleasant ambience)
- Ishtasarovapakarane (Equipped with utensils)
- Ajalpannahasana (Avoid talking & laughing)
- Tanmanabhunjat (with full attention or mindful eating)
- Aatmaamabhisameekshya (Due regard to oneself)

Determinants of Food Utility

- Prakruti,
- Samyoga,
- Samskara, Matra,
- Desha (country),
- Kala(season),
- Upayogsamstha and
- Upyokta

Ayurveda's Food Group Classification

Ayurveda's Classifies Food into Several Groups and they are:

- Jala Varga (water)
- Ksheera Varga (Milk & Milk products)
- Dhanya Varga (Grains)
- Shimbi Varga (Pulses)
- Shaak Varga (Vegetables)
- Mamsa Varga (Meat)
- Matsya Varga (Fish)
- Phala Varga (Fruits)
- Ikshu Varga (Sugarcane & products)
- Vyanjana Varga (Condiments)
- Taila Varga (Oils)
- Madya Varga (Alcoholic beverages)
- Krutanna Varga (Processed food)

Latest Publications



K-FFIG Resource Centre

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A valuable compilation of recent studies in peer reviewed journals– 450 studies (2018 onward) and publications on:

- Microbiome and Gut Health – 190 Studies
- Immunity and Probiotics – 102 Studies
- Prebiotics – 31 Studies
- Functional Foods – 51 Studies
- Gut Microbiome and Neurological and Neuropsychiatric Disorders-30 Studies
- Gut Microbiome and Antimicrobial Resistance- 46 Studies

Contd....

Latest Publications

