G20 भारत 2023 INDIA

वसुधैव कुटुम्बकम्
ONE EARTH • ONE FAMILY • ONE FUTURE
ಒಂದು ಭೂಮಿ . ಒಂದು ಕುಟುಂಬ . ಒಂದು ಭವಿಷ್ಯ

MANAGE
HYDERABAD

KSTA
BANGALORE

AGRIPRENEURSHIP DEVELOPMENT

Editors:

Dr. A. M. Ramesh
Dr. Sushrirekha Das
Dr. Shahaji Sambhaji Phand

Edition: 2023

KSTA, Bengaluru & MANAGE, Hyderabad

AGRIPRENEURSHIP DEVELOPMENT

Jointly Published By

Karnataka Science and Technology Academy (KSTA), Bengaluru

&

MANAGE, Hyderabad

AGRIPRENEURSHIP DEVELOPMENT

Editors: Dr. A. M. Ramesh, Dr. Sushrirekha Das and Dr. Shahaji Sambhaji Phand

Edition: 2023

ISBN: 978-93-91668-77-8

Citation: Dr. A. M. Ramesh, Dr. Sushrirekha Das and Dr. Shahaji Sambhaji Phand (2023). Agripreneurship Development [E-book] Hyderabad: Karnataka Science and Technology Academy, Bengaluru & National Institute of Agricultural Extension Management, Hyderabad, India

Copyright © 2023 Karnataka Science and Technology Academy, Bengaluru & National Institute of Agricultural Extension Management (MANAGE), Hyderabad, India

This e-book is a compilation of resource text obtained from various subject experts of Karnataka Science and Technology Academy, Bengaluru & MANAGE, Hyderabad, on "Agripreneurship Development". This e-book is designed to educate extension workers, students, research scholars, academicians related to fishery science about the Agripreneurship Development. Neither the publisher nor the contributors, authors and editors assume any liability forany damage or injury to persons or property from any use of methods, instructions, orideas contained in the e-book. No part of this publication may be reproduced or transmitted without prior permission of the publisher/editors/authors. Publisher and editors do not give warranty for any error or omissions regarding the materials in this e-book.

Published for Dr. P. Chandra Shekara, Director General, National Institute of Agricultural Extension Management (MANAGE), Hyderabad, India by Dr. Srinivasacharyulu Attaluri, Program Officer, MANAGE and printed at MANAGE, Hyderabad as e-publication.

MESSAGE

National Institute of Agricultural Extension Management (MANAGE), Hyderabad is an autonomous organization under the Ministry of Agriculture & Farmers Welfare, Government of India. The policies of liberalization and globalization of the economy and the level of agricultural technology becoming more sophisticated and complex, calls for major initiatives towards reorientation and modernization of the agricultural extension system. Effective ways of managing the extension system needed to be evolved and extension organizations enabled to transform the existing set up through professional guidance and training of critical manpower. MANAGE is the response to this imperative need. Agricultural extension to be effective, demands sound technological knowledge to the extension functionaries and therefore MANAGE has focused on training program on technological aspect in collaboration with ICAR institutions and state agriculture/veterinary universities, having expertise and facilities to organize technical training program for extension functionaries of state department.

India is an agrarian country. Agriculture remains a key sector of the Indian economy accounting for around 25 percent share in the gross domestic product. Increased number of people and unemployed graduates living in rural areas are migrating to urban areas in search of jobs. But the country is unable to create ample job opportunities along with economic development. Very poor infrastructure and facilities in rural areas aggravated the population pressure on the urban infrastructure. In this situation this e-book tries to examine the aspects of taking agricultural entrepreneurship or agripreneurship as a career and the solution of the problem. In this new millennium the need is combined, and a composite model is based on the basic principal rural employment provider shaping the profile of local entrepreneurs.

It is a pleasure to note that, Karnataka Science and Technology Academy (KSTA), and MANAGE, Hyderabad, Telangana is organizing a collaborative training program on “Agripreneurship Development” from 12-14 December 2022 and coming up with a joint publication as e-book on “Agripreneurship Development” as immediate outcome of the training program.

I wish the program be very purposeful and meaningful to the participants and also the e-book will be useful for stakeholders across the country. I extend my best wishes for success of the program and also I wish Karnataka Science and Technology Academy (KSTA) many more glorious years in service of Indian agriculture and allied sector ultimately benefitting the farmers. I would like to compliment the efforts of Dr. Shahaji Phand, Center Head-EAAS, MANAGE, Dr. Sushrirekha Das, MAANAGE Fellow, MANAGE Hyderabad and Chief Executive Officer KSTA, for this valuable publication.

Dr. P. Chandra Shekara
Director General, MANAGE

FOREWORD

Agriculture has been the mainstay of our economy, which adds to the overall wealth of India. It was considered a low-tech business, which is dominated mainly by small landholdings. However, in recent times, the situation has changed significantly due to economic liberalization and globalization. Successful farming in the present knowledge-based economy requires knowledge not only of the latest technological tools for raising crops and farm animals but also of how to operate a successful enterprise.

Entrepreneurship transforms an idea or vision into a new business or an improvement of an existing business. One of the strategies for economic progress is the creation of employment through entrepreneurial ventures. Thus, entrepreneurship is recognized as the engine of economic growth across the globe. Hence, developing entrepreneurship capabilities among the younger generation is of paramount importance.

In view of this, the promotion of entrepreneurship in the agricultural sector assumes significance for boosting agricultural businesses as well as increasing the value-addition of agricultural products. This will reduce unemployment, increase efficiency in resource utilization, and finally, enhance the income of the farming community.

In this context, I am delighted that the Karnataka Science and Technology Academy (KSTA), Bengaluru, and the National Institute of Agricultural Extension Management (MANAGE), Hyderabad jointly conducted a three-day free online training program on “Agriprenuership Development” during 12-14 December 2022 for young graduates of science, engineering, and agriculture as well as entrepreneurs through CISCO WebEx platform. The training module was designed to enable participants from different states to understand entrepreneurial opportunities in agriculture, horticulture, dairy, veterinary, fisheries, and apiculture. I am sure, talks by the domain experts would have helped participants to broaden the horizon of their knowledge in entrepreneurship development in the field of agriculture.

I am happy that a compendium of lecture notes has been brought out in the form of an e-book for the benefit of the participants. I hope it will serve as an information guide for the participants to refer back.

I compliment the coordinating team of KSTA and MANAGE for the successful conduct of the online training program.

Dr A. M. Ramesh
Chief Executive Officer
KSTA, Department of Science and
Technology, Govt. of Karnataka, Bengaluru

Content

Chapter 1

Progress of Technology Commercialization and Incubation support at ICAR – Status & Prospects

Sudha Mysore
CEO, Agrinnovate India Limited, Pusa, New Delhi-12

Introduction

In the face of growing threat of accelerating climate change, global focus is shifting towards plant-based alternatives as a means for climate resilient ecosystems to meet the food requirements of global population. Such a change in priority is also seen in the growing global awareness towards a shift in daily 'diets' away from the meat-based ones towards healthier and balanced ones involving fruits and vegetables that provides cheaper yet nutritionally secure alternatives. A reiteration of this fact that speaks volumes about the changing priority is the UN declaration of the year 2021-22 as 'the International Year of Fruits & Vegetables' to raise awareness about balanced nutrition and to direct policy towards efficient management of production with minimizing post-harvest losses and wastage.

Shifting Focus towards technology commercialization

Research institutions and Universities world over are considered as the primary sources of 'Innovative technical knowledge' packaged as 'improved technology' that aid significantly in productivity enhancement. In the field of agriculture, majority of the research institutions, largely publicly funded, tend to be the primary sources of such technical knowledge, which are disseminated to primary stakeholders, viz., farmers for adoption. These research institutions and universities often fail to undertake large scale dissemination of such knowledge, due to limited infrastructure and manpower available with them. Radical changes have been seen across the globe in the institutional policies of Universities and R&D institutions towards development and dissemination of technologies, post WTO regime through the adoption and implementation of Trade Related Intellectual Property Rights (TRIPs). Universities and Research institutions are being primed to secure appropriate intellectual property rights protection for their technological innovations, which are then licensed out for commercial production through public private partnerships to entrepreneurs on mutually agreed terms and conditions for a prescribed period and geographic territory. Furthering this concept, some research institutions and universities have also initiated establishing commercial ventures for nurturing and supporting technology based sustainable business enterprises that act as the technological ambassadors of the university. Some such models of setting up of Technology Transfer Offices (TTOs) and incubation facilities have sphere headed a paradigm shift in quicker and easier dissemination of university research results for larger /wider adoption and enhanced societal benefit. These models also are of immense value for promoting the other societal goals of balanced nutrition using cheaper and better alternatives through sustainable technology-based production systems.

Thus, technology generation and its protection and management through appropriate intellectual property rights at the university/R&D institution level becomes imperative, requiring institutionalizing (i) technology identification and its protection' (ii) technology valuation and management, and (ii) setting up and building associated business management leads. The technology management thus includes among others, research

strategy, planning & conduct of research; invention disclosure, IP protection and technology transfer processes, besides start up/spinoffs support that promote sustainable businesses based on technological solutions emanating out of university research.

The Technology development at Universities and the legal implications of Licensing and commercialization for the growth and development of nation as it is understood world over could well be traced back to the 1980s to the US of A passing of the historic Bayh-Dole Act, USA (Bayh Dole Act, PI 96-517, 1980).

Among others, the significant highlight of The BAYH – DOLE ACT 1980 is, the need for research findings of research in universities to be filed for IP protection and to ensure commercialization upon licensing; the acknowledgement of the government support for the research by the scientist in IP protection and provide confirmatory license to the government. The revenues and royalties earned from such ventures are then shared with the inventors; a portion of it provided to the University and department/ college; and the remainder used to support the technology transfer process.

The reason that the Bayh-Dole act has become so instrumental to university technology transfer process stems from the fact that it speeded up the commercialization process of federally funded university research and helped new industries to develop quicker and also helped form public private partnerships through technology transfer.

Emulating the US, in the post WTO period, GOI also attempted to bring forth a Protection and Utilization of Public Funded Intellectual Property Bill, India, 2008 (PFIP Bill), that was proposed with an objective to provide incentive to create intellectual property and the mechanism for its protection similar to the objectives of the Bayh dole bill.

Further, in accordance with WTO and TRIPS, India started adopting and implementing its IP policy and technology commercialization protocols which started taking shape by the early millennium. This increased awareness has led to development of institutional IPR policies and guidelines at the key national research organizations like, CSIR, ICMR, ICAR – and at key academic institutions alike (Table 1)

Innovative Initiatives

Several innovative schemes also sprang into action that promoted institutionalized pathways for encouraging public private partnerships through innovative technologies. Significant among these include,

Table 1: Institutional IPR policies and support structures

Sl No	Organization	IPR related Unit/ Commercialization Unit
1	IISc, Bangalore	Society for Innovative Development (SID), Centre for Scientific and Industrial Consultancy (CSIC)
2	IIT, Bombay	The Society for Innovation and Entrepreneurship (SINE),
3	IIT, Delhi	Foundation for Innovation and Technology Transfer (FITT)
4	BARC, Mumbai	Technology Licensing Cell (TLC)

5	ISRO	ANTRIX (a GoI owned company)
6	DRDO	C Tech
7	CSIR	NRDC (a company)
8	DBT	BIRAC, BCIL

(i) New Millennium India Technology Leadership Initiative (NMITLI)

NMITLI, is one of the largest public-private partnerships in R&D in India, started by the Government of India, and monitored through the CSIR. NMILTI seeks to discover and harmonize the strengths of publicly funded R&D institutions, academia and industry, and through this process, catalyze scientific and technological innovation in some selected niche theme areas. From 2000 to date, NMITLI is engaged with 1700 researchers, 60 projects and 280 partnerships worth Rs 550 crores.

(ii) The Small Business Innovation Research Initiative (SBIRI)

The SBIRI is a scheme initiated by the Department of Biotechnology in 2005 to generate ideas through a unique process involving technology producers and users with the aim of generating products that could only be produced with the help of the private sector. The SBIRI scheme is modeled on the lines of the Small Business Innovation Research (SBIR) grants of the US that fund small business development of biomedical discoveries. Timely product development is the sole undeviating goal under this scheme, and this is facilitated through the active engagement of the private sector from the time of its inception, the scheme has received more than 400 proposals from around 250 private sector companies.

(iii) National Agricultural Innovation Project (NAIP)

The Government of India launched the NAIP, with support from the World Bank. A 6-year programme, initiated in 2006 and completed in 2014, was implemented by the Indian Council of Agricultural Research (ICAR) with an aim to accelerate the collaborative development and application of agricultural innovations into profitable business houses. The programme was built on its precursor, the National Agricultural Technology Project (NATP). The NAIP accorded high priority to the generation and transfer of innovative agricultural technologies. A key/ novel feature of NAIP was its use of competitive funds to establish consortia of research, enterprise and developmental organizations on selected themes, with actors engaged in all stages of a value chain, from supply of inputs to support startups and small entrepreneurs.

Initiatives of ICAR into Technology Commercialization modules - Status and progress

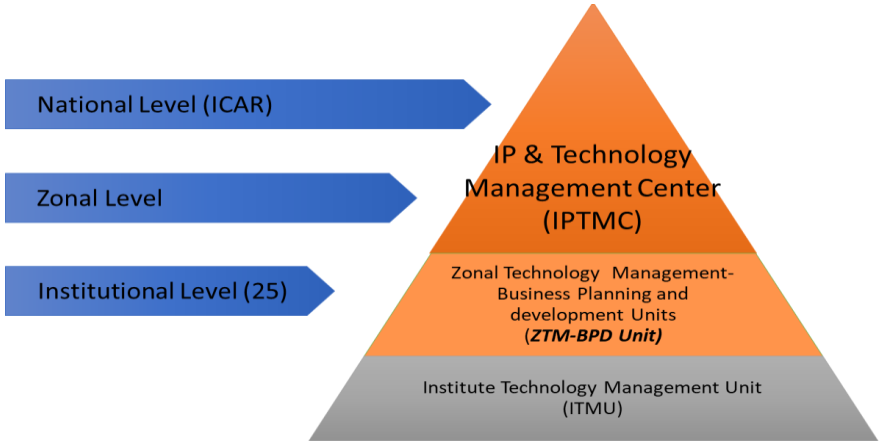
Indian Council of Agriculture Research (ICAR), the apex body of all agriculture-based research and development in India has adopted its own 'intellectual property rights policy' and has brought out an institutionalized system of technology management that protects and manages intellectual property, monitoring the commercialization and technology transfer activities of the ICAR institutes under its purview.

ICAR's has adopted a three-tier system of technology commercialization process effective since 2007 with Intellectual Property & Technology Management (IP&TM) Unit at the HQ as the top tier, Zonal technology Management Centres (ZTMCs) as the middle tier and Institute Technology Management Units (ITMUs) at individual institute level for effective technology transfer. Initiated in 2007 with support from the NAIP, the scheme covered about 25 ICAR-institutions to begin with. The scheme has successfully been implemented in

over 92 of the research institutions under the purview of ICAR as on date, with functional technology transfer offices, whose primary role is identification of technologies, protection through appropriate IPRs and commercialization through issue of 'non-exclusive licenses' on mutually agreed terms and conditions with public/private sector institutions/companies.

A total of around 1600 technologies emanating from around 90 odd research institutions have been commercialized through the Institute Technology Management Units (ITMUs) over a span of a decade from 2007, fetching ICAR a gross realization of around Rs 40 crores. One of the important feature of this scheme was imbibing the feature of identifying and protecting technologies through appropriate IPR regimes including patents.

Fig 1: Three tier system of Technology Transfer through Commercial licensing @ ICAR



Initiation and establishment of a system of Technology identification, protection, commercialization and management at ICAR could be said to have brought about a paradigm shift in the technology dissemination and adoption across ICAR institutions, besides also acting as enablers of change predominantly in,

- Increasing the outreach of innovative, efficient farming practices and products to larger sections of the society,
- Imbibing the essential skill and knowledge of identifying unique technologies and according appropriate protection mechanism and
- Enhancing the skill levels of executives with working knowledge on Intellectual property protection and technology management and basic negotiating skills for commercializing technologies through appropriate Capacity building.

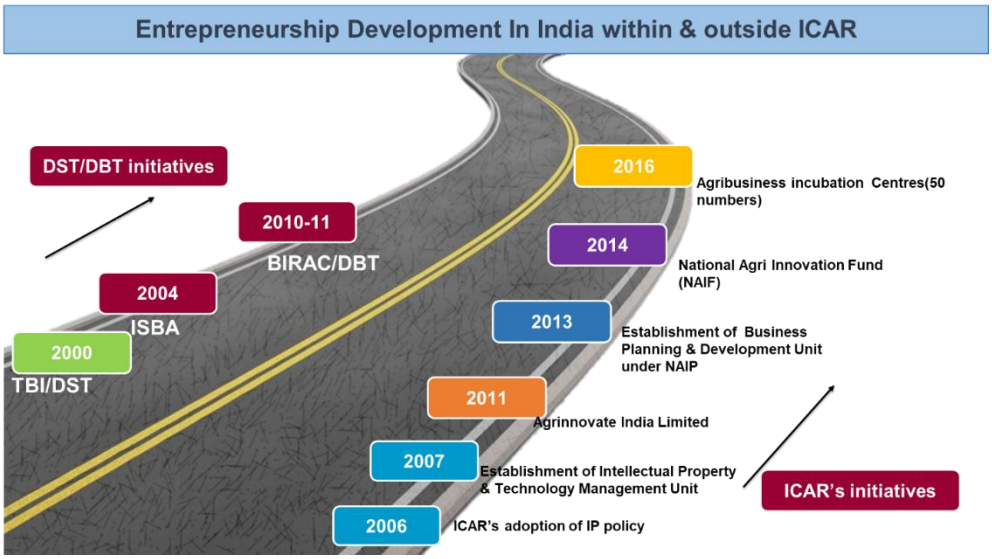
Evidence supports that a number of agricultural technology-based enterprises have been established based on ICAR technologies and their spread across crops and regions.

Incubation and start up support

In realization of the fact that some of these technology transfers often required scaling up and the licensees require handholding support both for scale up and to reach the market, ICAR initiated the Incubation activities through financial support from the World Bank funded National Agriculture Innovation Project (NAIP) since 2009. A total of around 22 incubation centres have been established for effectively supporting the licensees through a technology-based incubation process for a period of 18-24 months in each one of these incubators operating across ICAR research institutions covering a wide range of disciplines including crops, horticulture,

fisheries and dairy. With the adoption of Incubation system, ICAR successfully embarked onto the journey of start up support in line with the DST and other institutions (Fig 2)

Fig 2: Milestones of Entrepreneurship Support



The process & examples

Incubation and start up support at ICAR research institutions have resulted in one of the most successful examples of 'technology-based incubation models'. Technology based incubation model promotes startups to license a technology from a research institute and start production and marketing utilizing the institute's infrastructure and marketing network prior to starting their own production. While startup policy promotes innovative solutions for specific problems of agriculture, the model of technology-based incubation is essential for agricultural sector. The fact that the technology-based incubation facility of ICAR promotes market ready technologies that fulfill statutory compliances and regulatory frameworks, makes it easy for budding entrepreneurs to head start their businesses with immediate effect. A total of over 200 Incubatees (virtual and real) have benefited from these incubation support activities, few have already broken even and have also obtained national and international recognition and funding support (AgRIM 2018)

National Agriculture Innovation Fund (NAIF)

Subsequent to the NAIP, ICAR has initiated and continued the financial support for incubation facilities through the National Agricultural Innovation Fund (NAIF) since 2016 onwards. A total of 25 institutions under the ICAR have been successfully operating incubation facilities promoting individual entrepreneurs and MSME enterprises license and scale up technologies. Besides, some of these incubation facilities are also encouraging new ideas and help early stage innovations through R&D support for scale up.

Need for a corporate structure:

Further, ICAR with an objective of enhancing its visibility and to cater to a number of growing needs of different institutions and following the models adopted across the globe, has established a 'corporate face ' that could promote technology transfers in a centralized manner Agrinnovate India Limited (AgIn), a Government of India Enterprise which was incorporated under the Companies Act, 1956 (No.1 of 1956) since October, 2011, under the direct administrative control of DARE, Ministry of Agriculture & Farmers' Welfare.

Role and activities of AgIn a Public sector enterprise

AgIn within the capacity of one of its kind Public Sector Enterprise (PSE), beholds the primary function as, 'one stop shop' for market ready regulatory compliant technologies from across national ICAR supported research institutions for promoting technology commercialization through 'non-exclusive' licensing for domestic as well as International clientele. AgIn also is envisaged to facilitate the process of large-scale sourcing and supply of unique bio-based products for mass production with appropriate legal and statutory compliances; facilitate professional service functions of National Agriculture Research and Education System (NARS) and to help enhance the pace of commercialization through capacity building for national and international clientele.

The array of technologies in the Agrinnovate's basket include, seed and planting material in the form of improved varieties, hybrids and advanced breeding lines of cereals, pulses and horticultural crops; bio inputs like bio-fertilizers, bio pesticides; growth promoters, post-harvest and value-added products; diagnostics, vaccines, easy adulteration detection kits for plants, animals and fisheries and simple implements and equipment. (The complete details about various technologies and how to access them for commercial license is available at www.agrinnovate.co.in)

Process of Technology access through Agrinnovate

Agrinnovate as a one stop shop for all agricultural technologies has been incorporated into the revised Intellectual Property Rights and technology commercialization guidelines 2018 (revised). Agrinnovate also adopts stringent guidelines and a systematized process such as technology valuation and pricing, ensuring regulatory complaint technologies ready for market, AgIn provides 'non-exclusive' commercial licenses of technologies to clients for commercial scale production both within and outside the country after a thorough 'due diligence'.

The AgIn's website has been revamped and is available as bilingual; provides a glimpse of technologies available; a description about each one of the technologies and holds an expression of interest box at the end of each description.

Interested individuals/companies can identify technology of their choice and send their intent, the AgIn team approaches them through e-mail and facilitate the process of technology transfer by sharing the terms of trade with the client, execute a MoU and help transfer the technology through the institute. AgIn adopts a 70:20:10 revenue sharing model with each one of the ICAR institutions/ State Agricultural Universities and ICAR.

Though AgIn was incorporated during 2011, it started commercialization activities only since 2018-19, and has thus far commercialized over 350 technologies to over 100 or more clients including both domestic and overseas transfers. Standard operating procedures, transparent and quick execution of agreements and ensuring client satisfaction are the specialties of AgIn. The fact that the National Agriculture Research System (NARS) is in need of such an effective institutionalized operating model, makes AgIn a much sought after one.

Technology Development and dissemination in Horticulture

The agro climatic suitability has provided the scope for India registering a steady growth rate of over 4% per annum in horticultural crop sector including fruits, vegetables, ornamentals and plantation crops and mushrooms since the millennium. Horticulture production has registered a phenominal growth from a mere 96 mt in 1990-91to 320.5 mt in 2019-20, surpassing even the food grain production in India. As is well known, India, as the second largest producer of fruits and vegetables in the world be holding the position of global

leader in the production of a variety of horticultural crops (Viz., Banana, Mango, Lime & Lemon, Papaya and Okra) accounting for % of global horticultural crop area and % of global production has huge untapped potential.

Horticulture sector in India is a major driver of growth in the last few decades due to its potential for higher remuneration than the agricultural sector (food grains mainly). The total horticulture production has increased

from 211.2 million tonnes in 2007-08 to 311.71 million tonnes in 2018-19, surpassing the total food grain production in the country. Total horticultural crop production is estimated to be 326.58 million tonnes by 2020-21, an estimated increase of 4.8 percent over 2018-19.

The contribution of public sector research for the phenomenal growth of horticulture sector cannot be under mined despite the dominance of private sector in some of the crops. While research efforts and focus on innovative technologies holding commercial potential are the primary contributors, the efforts at their wide spread adoption by research institutions and ICAR cannot be undermined. It is of significance to understand and appreciate the innovative methods adopted by Indian Council for Agricultural research (ICAR), the premier organization for promoting agricultural research and development in India, in the direction of protecting technologies through appropriate IPR protection, valuing them and ensuring wider dissemination through issuing commercial technology licenses and promoting incubation and start up support.

Breakthrough technologies in Horticulture

A total of 26 research institutions engaging over 3000 scientific and technical manpower, the horticulture division of ICAR is one of the largest resource for horticultural crop technologies. A total of over 239 varieties and 50 hybrids have been developed and disseminated in more than 40 crops in the last decade or so. Over the last few decades, the division has been focusing on the development of varieties and hybrids for higher yield potential, quality and resistance to various biotic and abiotic stresses.

Some of the important breakthrough technologies besides the hybrids and disease resistant types in various crops include, true seed production in potato; identification and populating Root stock technology in grape; high density planting in fruits like mango and guava, ...etc.

The commercial technology basket of horticulture although includes the seed and planting material but has huge potential for bio-based products like bio pesticides, bio fertilizers, value added products, implements and machines etc., Technologies involving bio-based products such as *Trichoderma harziaunm*, t. viridie, pascillomiseces etc have been standardized are highly useful for enhancing productivity and also reduce the cultivation expenses. A number of entrepreneurs avail commercial licenses for these products. A consortium of microbes, Viz., Arka microbial consortium registered as a PGPR has shown potential for control of several diseases such as the bacterial blight in pomegranate. Biofertiliser or crop based foliar formulations for enhancing crop growth and yield also have found a potential commercial value. Use of banana pseudo stem for bio formulations, have been disseminated to over 20 or more licensees for wider adoption of these technologies.

Use of banana Pseudostem based bio formulation for the control of pests; bio capsule for commercial production of spices and condiments; fusicont, a latest technology for the control of fusarium wilt of banana caused by race 4 etc are some of the most popular and widely adopted technologies from horticulture commercialized through Agrinnovate.

Although technology commercialization through licensing has been proven to be a game changer, for quicker, wider adoption, the process does involve several constraints and impediments.

Constraints and Impediments

- **Nature and Characteristics of the technologies:**

  The technologies represent wide range of diversity requiring different regulatory compliance needs and specificities, identifying a suitable commercialization pathway poses an impediment

- **Low resource base**

  Financial requirements for obtaining regulatory compliance of some products being very high, often the institutions face resource constraints. Public sector organizations are constantly under the dilemma of deciding between large scale commercialization Vs subsidization to benefit small and marginal farmers.

- **Demand for special pricing**

  A number of private companies tend to exploit the technology commercialization process through pressure tactics for special and concessional pricing, under the gambit of benefiting small and marginal farmers. While the public sector organizations are compelled to adopt a 'no-exclusive licensing model, demand for exclusive licenses from private companies is ever increasing.

- **Collaborative research for Permitting improvements**

  Some of the technologies at concept stage may be commercialized, however, some companies try to add their own inventions and seek as their own defaming ICAR institutes.

Way Forward

There is a need to adopt new approaches in commercializing technologies

(i) Moving towards limited exclusivity: Its high time that ICAR in consultation with the inventors adopts a model of limited exclusivity through EOI and technology auctioning through AgIN.

(ii) Consortia approach for seed and planting material: ICAR/ AgIn should encourage private seed industry to form consortia to avail the repository of germplasm at appropriate value

(iii) Seed funding and equity-based participation: AgIn should explore the possibility of seed funding to encourage startups and adopt equity-based funding models

Proposed integrated system for efficient IP protection and management

Keeping in view the diverse systems and the multitude of constraints, a centralized model that encompasses an integrated approach to be promoted as a unique Government of India enterprise that integrates existing mechanism of technology transfer, incubation and start up support and at the same time indemnifies the organization at large.

Under this proposed model, effort is being made to bring the existing approaches under a single umbrella so that multiple duplicating mechanisms would get integrated.

Agrinnovate Tech: The primary function of technology transfer through licensing will be dealt under this programme through a centralized portal where all the potential technologies from within the NARS (ICAR institutions and SAUS) will be listed and marketed through other digital platforms for large scale domestic and foreign licensing. Such a centralization would also help make the system leaner and more effective by reducing the number of 'active technology transfer offices 'in the system.

Agrinnovate Enterprise Scale up: This arm of the integrated system would identify potential enterprises involving technology back up for specialized scaling up process. Agrinnovate would provide the much-needed financial support and help scale up the commercial production process, thereby paving way for enhanced income for the organization. This could also include large scale production or sourcing of IP enabled technology products for supply. Such an initiative would help the licensees get validation of their products and also assured market of quality products, at the same time an assured income for the organization.

Agrinnovation and start up support: This arm of the integrated system would help promote startups through technology or business incubation models. The system would involve a specialized selection process ad according financial support and also equity-based participation. Other components on need-based capacity building, entrepreneurial development support and technology enabling facilities for both domestic and foreign could effortlessly get added to this arm.

Chapter 2

Entrepreneurship Opportunities in Dairy Sector in India

Dr. K. P. Ramesha
Head, Southern Regional Station, National Dairy Research Institute, Adugodi, Bangalore-560030
Email: headsrsndri@gmail.com

Entrepreneurship is an important process by which knowledge is converted into products and services. An entrepreneur identifies opportunities and seizes opportunities for economic benefits. The process of Business Incubation for Entrepreneurship is a critical organizational support mechanism for fresh entrepreneurs at the initial stage. A typical high quality Business Incubator provides the essential services to a budding entrepreneur includes physical infrastructure, administrative support, management guidance/mentoring, help in formulation of a business plan, technical support, Intellectual Property advice where applicable, facilitating access to finance and encouraging networking with the greater and relevant business community. Southern Regional Station of ICAR-NDRI also has AIC-SRS-ICAR-NDRI Foundation which is providing incubation facility and helping Entrepreneurship Development in dairy sector.

Indian Dairy sector

Livestock rearing has been an integral part of the socio-economic and cultural fabric of rural India since time immemorial. Livestock sector is the critically important component of Indian Agriculture, providing growth and sustainability to Agriculture sector. Dairy animals in India are reared with multiple objectives besides providing milk, also provide a diverse range of output for agriculture, irrigation, manure, transport, fibre and leather goods and their rearing systems are different from developed countries. The percentage share of the livestock sector has increased from 24.38 % in 2014-15 to 30.87 % in 2020-21 in the Gross Value Added (GVA) of the agriculture and allied sector. Dairying is the farm sector's growth engine and income from milk exceeds combined income from paddy, wheat and sugar cane incomes. The value of milk is more than the total value of all grains and pulses put together (2019-20). Milk group has highest contribution to livestock sector output (68.22%). Dairy is the largest agricultural commodity contributing 5 percent of the national economy, and employing more than 8 crore farmers directly About 70% of milk is produced by marginal and small farmers owning 2 to 4 animals. The different production systems like zero input low output, low input moderate output, intensive input high output are characteristics of dairy production system in India (Ramesha and Divya, 2013).

India has been the leading producer and consumer of dairy products worldwide since 1998 with a sustained growth in the availability of milk and milk products. The dairy industry in India was valued at INR 14,899.8 Billion in 2022 (imarc 2022). In early 1970's, India's milk production was almost 1/3 of US and 1/8 of European countries but today it is about twice the US and 25% more than EU. India is ranked 1st in milk production contributing 23 per cent of global milk production. Milk production in the country has grown at a compound annual growth rate of about 6.2 per cent to reach 209.96 million tonnes in 2020-21 from 146.31 million tonnes in 2014-15. According to the Periodic Labour Force Survey (PLFS) conducted from July 2019 to June 2020, the percentage of people engaged in animal production and mixed farming is 2.85 and 1.58, respectively. The average value of livestock product exports was ₹449 billion, comprising 2.1 percent of the total export earnings,

during 2020-21. Livestock Sector has continuously been growing at Compound Annual Growth Rate (CAGR) of 7.93% (at constant price) from 2014-15 to 2020-21, which is comparable to CAGR of manufacturing at 4.93% (at constant price) and Services at 4.82% (at constant price) and in contrast to Agriculture (Crop Sector) CAGR of 2.05% (at constant price). In India, technology led increase in milk production has happened during the period. Now the contribution of white revolution surpasses the contribution of green revolution. Today the challenge is to produce more from less resources for more people. Dairying has good potential for employment generation both in rural and peri-urban areas besides being a source of liquidity and very crucial in doubling the farmers' income. The total bovine (cattle & buffalo) population in India is 302.79 Million in 2019, increase of 1.0% over 2012.The total number of cattle and buffalo populations in the country is 192.49 and 109.85 million in 2019 respectively. Buffaloes, Crossbred cows and indigenous/Non-Descript cows contribute nearly 45%, 28% and 20 % respectively of the milk produced. Exotic cattle and Goats contribute about 3 % each to milk production (Annual Report 20221-22 of DADF). The per capita availability of milk is around 427grams/day in 2020-21.

Strengths of Indian Livestock Sector

The constant and sustainable growth of livestock production despite limited investment from public and private sector itself shows the strength of the sector. The low production cost of milk compared to other countries is another remarkable strength. India is also the world's largest and leading buffalo germplasm holder besides holding various breeds of cattle and goat with unique characteristics. There is huge internal demand for livestock produce and India is surrounded by countries that are deficit in animal produce, thus offering huge potential way of enhancing the farmers' income by means of export. Presently, the livestock sector in India is going through some major changes. The opportunities in dairy sector include technology driven production enhancement in low producing animals and value addition to produce which offers entrepreneurship development and business opportunities. For productivity enhancement, it is essential to have multipronged strategy involving technology generation (Research), technology dissemination (Extension), technology users (farmers) and supporting mechanisms (input supply, market credit) and quality improvement through technological interventions.

Challenges:

There are many challenges in genetic improvement of dairy animals in India mainly due to mostly small herds with non-availability of recorded data, challenging environment, low inputs and poor management in most of the areas, uncontrolled mating and indiscriminate cross breeding. Quality milk and milk product production and completion from various other countries are also challenges faced by entrepreneurs.

Entrepreneurship generation in livestock sector

In the era of WTO, a vast amount of entrepreneurship opportunities exists for the livestock owners, interested persons as well as for the professionals engaged in dairy sector. Especially with the rise in demand for hygienic milk, organic milk and meat products high scope exists for commercializing the livestock enterprises. There is a tremendous scope of promoting the rural cattle and buffalo rearing in India into commercial micro enterprises through entrepreneurship development programme and favorable government policies. Apart from rearing of dairy animals and dairy processing industry, vast scope of generating additional income and employment exists in dairy input industry, livestock product processing units and organic livestock production units which can be harnessed for increasing employment and farmers' income.

Scope for entrepreneurship development in dairy sector includes:

1. Technologies which reduce the cost of production and increase the benefit to the farmers including following technologies for entrepreneurship opportunities:

- New technologies that are simple and time saving, labour saving

- ♦ Processing units and agro produce manufacturing units.
- ♦ Inputs manufacturing units like livestock feed units, feed supplements, medicines, bedding materials viz. mat etc.
- ♦ Service centers
- ♦ Supply Chain Management

2. Commercial dairy farming and integrated livestock farming offer entrepreneurship opportunities:
   - ♦ Dairy farming, calf rearing, heifer rearing. One has to match the genetic resources (breed/species) to the environment (including resource and demand)
   - ♦ Goat farming
   - ♦ Integrated farming
3. Dairy input industry
   - ♦ Commercial feed and fodder production
   - ♦ Commercial green fodder/ hay/silage production
4. The following technologies also offer scope for entrepreneurship development:
   - ♦ Artificial Insemination
   - ♦ Rearing Bulls for Service
   - ♦ Embryo transfer technology
   - ♦ Quality semen production and AI
   - ♦ Heifer raising and meat animal raising
   - ♦ Commercial milk and meat production
   - ♦ Calf raising
   - ♦ Greener technologies aimed at reducing methane production from ruminants
   - ♦ The biosensor system is likely to aid livestock keepers in taking precise decisions
   - ♦ Pertaining to breeding, feeding and healthcare of livestock.
5. Animal health technologies- particularly Vaccines and diagnostics great scope for entrepreneurship development
6. Feed technologies-prebiotics, probiotics, feed additives etc.
7. Value addition to livestock produce: Processed convenience and value-added animal products. There is tremendous scope for entrepreneurship in the area of traditional dairy products, functional dairy foods, fortified dairy products, and convenience foods.
8. Animal waste management: Vermicompost, Panchagavya, Organic manure, value added products
9. Technologies to reduce post-harvest losses and value addition to livestock produce

Processing technologies

Processing technologies to reduce post-harvest losses and value addition offers lot of scope for entrepreneurship development and business opportunities. Value addition to milk and supply chain management offers huge entrepreneurship opportunities along with employment generation. In India most of the milk is sold as milk, however by converting into products entrepreneurs could get profit. The demand scenario for milk and milk products in shown in the below figure.

By value addition to milk once can get huge profit. There are entrepreneurship opportunities in traditional dairy products. There is huge demand for dahi, butter, ghee, chhanna/khoa based sweets. There is demand for quality dairy products viz. Halwas, Gulab Jamun, Kheer / Payasam, Pedhas, Sandesh, Rosogollas, Podo and Dry Mixes and many more products in Indian market. Entrepreneurs could utilize the regional/location specific demand for traditional dairy products.

There is huge demand for convenience foods viz.

- Ready to eat foods- Frozen foods, desserts, Retort foods
- Ready to use foods – Mixes, Powders, Concentrates
- Ready to drink/ Ready to serve beverages – Concentrates, Dehydrated Powders, Beverages etc

Presently there is huge demand and entrepreneurship opportunities in the areas of Organic dairy products, functional dairy foods, fortified, low fat and Low sugar dairy products. There is huge scope and entrepreneurship opportunities in manufacturing and international trading of SMP, WMP, Cheese, Caseins and butter.

Production of Biosensors for entrepreneurship generation

The concept of biosensors technology applied to livestock production mainly based on the miniaturized electronic mechanics (MEM) are being used into several stage of production such as feeding, detection of oestrus, diagnosis and controlling of animal disease, detecting metabolic testing in animal husbandry, as well as to individual identification and monitoring. Have very good business opportunities.

Livestock waste management and entrepreneurship generation

Animal waste management is most essential from economic, environment and empowerment angle. Animal waste management involves production, collection, storage, process and utilization. Improved utilization of manure like feed production for fish in aquaculture, energy (methane gas) or algal growth as fertilizer will also help to improve profitability. Dung is essential for vermiculture and organic agriculture. Animal wastage like dead skin is utilized in leather industries. Blood and bones could be used efficiently in bone meal, blood meal etc. Efficient usage of animal wastage using appropriate technological interventions will earn revenue to farmers and reduce ill effects on environment. There is lot of scope for entrepreneurship development in the area of animal waste management.

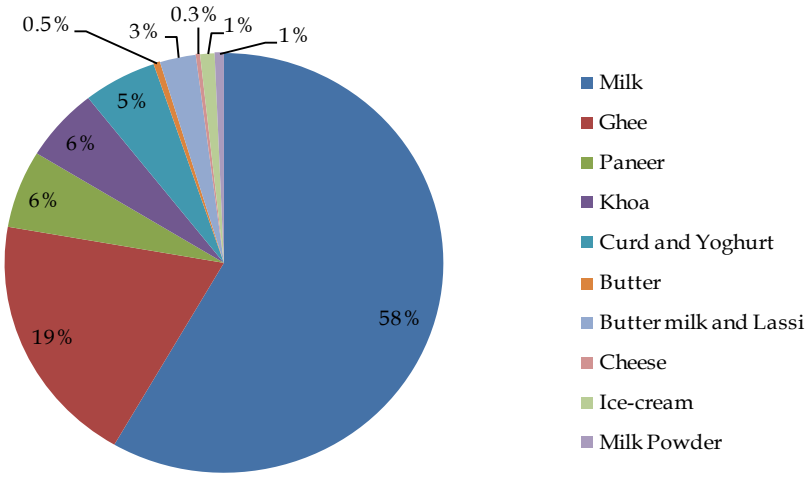
Technologies developed by ICAR-NDRI

Scientists of ICAR-NDRI including Southern Regional Station (SRS) have developed various technologies which could be utilised for entrepreneurship development. Recently developed technologies from SRS include

- Development of Farm level cooling system for milk and process mechanization for Indigenous Dairy Products
- Storage System by custom designed Phase Change Materials for chilling of milk
- Standardized Process technology for preparation of the convenience mix for Gasagase Payasam and Rice Kheer by Dry-Crystallization method
- Prototype of intravaginal wireless sensor device for remote monitoring of calving process in dairy cows
- Male fertility biomarkers and Skewing of sex ratio in dairy cattle towards female offspring
- Harnessing the potential benefits of co-products of dairying
- Bio-fortified fertilizer using the beneficial microbial isolates

Some of the Other technologies from ICAR-NDRI which could be purchased by entrepreneurs include:

- Paper Strip for Detection of Antibiotic/Pesticide Residues in Milk
- Technologies for Ascertaining Microbiological Quality of Dairy Foods
- Development of functional dairy products and eco-friendly packaging
- Integrated dairy development and impact analysis of technology interventions
- Technologies for manufacturing various value added dairy products



Epilogue

There are huge entrepreneurship opportunities in both dairy production and dairy processing area in India. The milk productivity of indigenous cattle and buffaloes could be enhanced substantially by adoption of various modern technologies for selection and faster multiplication of genetically superior germplasm and adoption of improved animal management strategies where scope for entrepreneurship opportunities exists. There exists tremendous scope for entrepreneurship development and business opportunities in dairy sector by utilising technological advancement both in dairy production and dairy processing area. There are huge opportunities for entrepreneurs in the area of input supplies, value addition to milk and milk products including traditional dairy products, functional, fortified and convenience dairy foods.

Note: This article contains some parts of earlier presentations of the author in different conferences/trainings

Chapter 3

Prospects of Cultivation, Processing and Value Addition of Medicinal and Aromatic Plants

Dr. Channayya Hiremath
Senior Principal Scientist & Head CIMAP, Bengaluru

The number of species of living organisms on earth is estimated to be about 13.6 million, which includes about 2,50,000 species of plants. Out of these, 35-70,000 species of higher plants may have been used for medicinal purposes at one time or another in different traditional medical practices. About 5,000 species of higher plants have been exhaustively studied by the pharmaceutical industries as a source of new drugs. More than 120 drugs of known chemical structure, which are extracted from 95 species of higher plants, are used globally in allopathic medicine. Some of the important pharmaceuticals obtained from plants are listed in Table 1.

It is estimated that there are about 47000 species plants in India, out of which 17000 are Angiosperms, representing 6% of world's known flowering plants. Nearly 8000 plants have been recognized for medicinal use in various traditional systems of medicine in India. There are more than 9000 pharmacies manufacturing over 20,000 Ayurvedic proprietary formulations and 1000 classical formulations. Annual turnover of AYUSH industry (Ayurveda, Siddha, Unani and Homeopathy) is estimated to be over Rs 8000 crores. The value of total exports of medicinal plants and their products is about Rs 1000 crores.

There are about 1300 plant species in India which are known to be aromatic, out of which hardly 65 plant species have demand in world market. India is second and third largest producer of essential oils, in terms of value (195m US$) and quantity (16000 t), respectively, next to USA and Brazil, respectively. Estimated country-wise production of essential oils is given in Table 2 and estimated production of essential oils in India is given in Table 3. During 2010-11, India exported about 2800 t of essential oil valued at Rs. 32744 lakhs, with menthol mint oil accounting for about 70% and 60% of the quantity and value, respectively, of the total essential oils export. Some of the major essential oils exported are given in Table 4. India is credited as the fourth largest economy after USA, China and Japan and second fastest growing economy and therefore offers one of the largest markets for manufactured items of mass consumption. It also has largest youth population in the world. It has a strong Aromatic Chemical Industry producing multiple products, with stockists and dealers spread across the country.

Medicinal and aromatic plants (MAPs) have some unique features as compared with normal field crops which growers need to take into consideration before taking up their cultivation. In MAPs, quality of the produce is more important than yield as it determines the marketability of the produce. Variety or the starting planting material is the most important input as it determines both yield and quality of the produce. In MAPs morphologically similar plants can differ in quality and quality is not apparent visually. Quality assessment requires sophisticated instruments and, generally, cannot be done at the farmer's level. Therefore, mistake made at the stage of selection of starting planting material can be costly both in terms of money and time. Authentic planting material can ensure quality to a great extent and can be obtained from Government organizations, Universities and reputed industries offering buy-back of the produce. Since MAPs have a specific market, the demand for a particular plant needs to be assessed and its production taken up with buy-

back arrangement, particularly for medicinal plants. These plants are grown for their chemical constituents whose synthesis is enzymatically controlled. Therefore, standardization of cultivation practices under local conditions may be necessary and adaptability over wide range of agro-climatic conditions is variable and requires expert advice. Limited availability of plant stock, particularly of vegetative propagated plants, and relatively high cost of planting stock may necessitate on farm pre-multiplication for taking up cultivation.

Many MAPs are generally more profitable than many field /horticultural crops. Some of them can also be grown as intercrops. They are less labor intensive, less susceptible to damage by birds or pests and diseases or theft. There is scope for value-addition through processing and therefore for generation of employment through development of ancillary industries. Essential oils from aromatic plants are low-volume high value products and have longer shelf-life at room temperature than horticultural plant produce. Some of them can be grown on marginal lands. They offer scope for co-operative / contract farming.

Table 1: Important Essential oils plants grown in south India and their uses

Plant	Botanical Name	Principal Chemical Constituents	Industrial Uses
Java citronella	Cymbopogon winterianus	Citronellal, citronellol, geraniol	Perfumery, raw material for various aroma chemicals
Coriander	Coriandrum sativum	Linalool, linalyl acetate	Flavouring food and pharmaceuticals, perfumery
Davana	Artemisia pallens	Davanone, davanofurans	Flavouring cakes, pastries, tobacco, beverages, high grade perfumes
Eucalyptus	Eucalyptus citriodora	Citronellal, iso-pulegol, citronellol	Perfumery
Scented Geranium	Pelargonium graveolens	Citronellol, geraniol, linalool	Perfumery and flavouring
Jasmine	Jasminum grandiflorum	Linalool, benzyl acetate, indole, eugenol, benzyl benzoate	Perfumery
East Indian lemongrass	Cymbopogon flexuosus	Citral	Flavours, cosmetics, perfumes, manufacture of vitamin A
Linaloe	Bursera delpechiana	Linalool, linalyl acetate	Cosmetics, soaps
Palmarosa	Cymbopogon martinii	Geraniol, geranyl acetate, linalool	Perfumery
Patchouli	Pogostemon cablin	Patchouli alcohol, sesquiterpene hydrocarbons	Perfumery
Rosemary	Rosmarinus officinalis	1, 8-cineole, linalool, myrcene, camphene	Perfumery
Sandalwood	Santalum album	□-santalol, □-santalol, and □–santalene	Perfumery

Distillation, Standardization and Quality Aspects of Essential Oils

Distillation methods for aromatic plants

Distillation is the process of separation of the components of a mixture of two or more substances by virtue of the differences in their vapor pressure. Essential oils from aromatic plants are extracted by the process of steam distillation. In principle, when steam is injected into an aromatic herb, it imparts its latent heat to the mass by way of condensation on the surface of herb which ultimately causes evaporation of oil. Steam and oil vapors rise to top of the distillation still and then to the condenser together and the necessary current to lift the vapors of oil from the surface of herb is provided by steam.

Types of distillation: There are 3 types of distillation:

1. Water or hydro-distillation
2. Water and steam distillation
3. Direct steam distillation

Storage and packing of essential oils

The distilled oil should be left to stand for a few hours. Anhydrous sodium sulphate (approximately 3%) is added to remove moisture. It has to be ensured that oil should not contain any moisture before packing. Stainless steel or aluminium drums are used for packing large quantities. Essential oil thus stored should not be exposed to air and sunlight; otherwise there will be deterioration in the quality of oil.

Fractional Distillation

Essential oils are made up of mixture of chemical compounds present in a definite composition. This mixture of chemical compounds can be separated into individual pure compounds by fractional distillation method. For example, from Palmarosa essential oil, we can separate Linalool, Geranial and Geranyl acetate as pure compounds. These pure compounds are used as starting materials for preparation of value-added products. In principle, when essential oils are heated under reduced pressure, due to differences in their boiling points, the chemical compounds present in it are get separated in fractionating column at certain temperature and pressure.

Standardization and Quality Aspects of Essential Oils

Essential oils are the odoriferous principles derived from aromatic plants. The essential oils have been known to mankind for many centuries. The oil of turpentine was well known to ancient Greeks. For the past two thousand years, the preparation of odoriferous principles from plants has been an important occupation. This has developed into a large industry in the past fifty years.

Essential oils are important raw materials for a number of industries and their use is wide spread and varied. India has been a traditional exporter of many essential oils like sandal wood oil, davana oil, Japanese mint oil, palmarosa oil, lemongrass oil, nutmeg oil and jasmine and tuberose flower concretes. In view of the rising demand for perfumes and flavors, there is great scope for increased production of essential oils.

Standardization of essential oils

Standards are laid down by national and international agencies to satisfy the requirements of perfumery and flavor industries. Standardization is one of the important steps taken to encourage systematic growth of the industry for production of a uniform and acceptable product. It will stimulate the domestic industry and also help the widest sector of producers and consumers. Quality control of the essential oil also enhances the

status of the aroma industry and could help in raising the quality of products that meet stringent international standards.

A standard may be:

a) A minimum value of a particular component of the essential oil. For example, minimum acceptable percentage of geranial in palmarosa oil/ citral in lemongrass oil.

b) A maximum value in the case of the solubility of the essential oil in alcohol of a given strength at a particular temperature.

c) A maximum level in case of unacceptable toxic component.

d) A pair of minimum and maximum limiting values within which the material is acceptable.

e) A graph representing the composition of a mixture such as an essential oil or a perfumery compound whose purity is indicated. The graph is the result of the test the material is subjected to.

Work on the formulation of standards is undertaken by International Standards Organization (ISO). The organization assigns the job on various subjects to subcommittees. International standards for essential oils are generally oriented towards formulation of separate specifications for the same oil originating from different geographical regions.

In India, the Bureau of Indian Standards (BIS) earlier known as ISI was entrusted with the job of preparing standards of essential oils and perfumery materials. The Bureau of Indian Standards has so far published nearly 80 monographs on essential oils and perfumery compounds.

Analysis of the essential oils

Gas Chromatography-Mass Spectrometry (GC-MS) analysis: The gas chromatograph coupled with a mass spectrometer has made it possible to identify chemical components present in essential oils. Even trace components and isomers in essential oils which contribute significantly to the odour value can be identified.

Processing Technologies for Medicinal Plants

Plant kingdom is a rich source of therapeutic agents for the prevention and cure of various ailments of human beings and animals since the ancient times. Plants contain secondary metabolites chemically classified into lipids, terpenes (monoterpenes, sesqui terpenes, diterpenes, and triterpenes), alkaloids, steroids, phenolics (chalcones, flavonols, flavonoids, flavonones, and coumarins), saponins and volatile oils. Each of these secondary metabolites have function in an ecological role, as pollinator attractants, represent chemical adaptations to environmental stresses, or to be responsible for the chemical defense of the plant against microorganisms, insects and higher predators, or even other plants. These secondary metabolites are the potential sources of crude drugs. Biologically active secondary metabolites and their derivatives are widely used in the treatment of variety of human ailments.

In the past few years, there has been a tremendous increase in the number of drugs derived from various plant sources mainly because of the due recognition of medicinal and aromatic plants the world over coupled with the basic realization that drugs and essential oils derived from plants are much safer to use and are easily available at a price within the reach of a common man, with least side effects as compared to synthetics.

Though the usage of herbal and naturally based medicines have traditionally been used in Indian system of medicines since ancient times like Ayurveda, Siddha and Unani, the utilization of the whole plant or other crude preparation for therapeutic or experimental reasons can have several drawbacks like:

1. Variation in the amount of the active constituents with geographic areas, from one season to another season, with different plant parts and with different climatic and ecological conditions.

2. Co-occurrence of undesirable compounds which can cause synergistic, antagonistic or other undesirable and possibly unpredictable modulations of the bio-activity.

3. Bio-activity losses due to variability in the collection, drying, preparation of the raw material and storage.

4. Adulteration of the plant material.

5. The difficulty in drug standardization.

Thus, the isolation of pure natural product with bio-activity other than the crude drug has become necessary and also has several advantages, which include:

1. Administration of the pure bio-active compound in reproducible, accurate doses with obvious benefits from an experimental or therapeutic point of view.

2. Qualitative and quantitative analytical methods for particular compound or for the group of compounds can be developed. This is more useful in the screening of plants for potential toxicity and quality control of bioactivities for human and animal consumption.

3. Structure determination of bio-active compounds. This will enable the production of synthetic material, incorporation of structural modification and rationalization of mechanism of action. This will in turn lead to reduced dependency on plants as source of bio-active compounds where by saving ecological system and will enable investigations of structure/activity relationship there by development of new compounds with similar or increased activity and less toxicity. Further this will help in saving the rare plant species before they become endangered.

National Cancer Institute (USA) started in 1959 screened more than 1,84,000 plant extracts covering 3500 plant genera during a period of 20-25 years and several very interesting drugs leads like camptothecin, taxol etc., were obtained. During the last five decades bulk production of plant based modern drugs has become an important segment of Indian pharmaceutical industry. In India also both public funded R&D institutions like CSIR-CDRI, CSIR-CIMAP, CSIR-IIIM and private R&D institutions spending considerable time and money in screening medicinal plants for bio-active compounds.

Some of the most important plant based chemotherapeutic agents currently in use are reserpine, an antihypertensive drug from *Rauvolfia serpentina*; vinblastine and vincristine from *Catharanthus roseus* for the treatment of, lymphocarcoma and leukaemia in children; tenoposide and etoposide developed from the antineoplastic agent Podophyllotoxin, a constituent of *Podophyllum* spp. currently being used against testicular cancer, small cell lung cancer and lymphomas; Paclitaxal generally known as Taxol, a diterpenoid constituent *Taxus* spp. is effective in the treatment of metastatic ovarian cancer and has potential use in the treatment of lung cancer, metastatic breast cancer and malignant melanoma; Irenotecan, an analogue of quinoline alkaloid camptothecine first isolated from *Camptotheca acuminata* is being used for the treatment of lung, ovarian and cervical cancers. The herb *Artemisia annua* L. has been traditionally used in China for treatment of fevers yielded an effective antimalarial sesquiterpene peroxide artemisinin, an active agent against both chloroquine sensitive and chloroquine resistant strains of *Plasmodium falsipaum* and *P. vivax* and is equally effective against cerebral malaria. Some of the biologically active compounds have proved to be useful as a tool in biological and biochemical research. Forskolin, a diterpene from the roots of an Indian plant *Coleus forskohlii* is being used in the purification of adenylate cyclase and in receptor binding assays. Colchicine, another alkaloid first isolated from *Colchicum autumnale* and also available in good yields from an Indian plant *Gloriosa superba,* is used in the treatment of gout and has been known in Europe since 78 A.D. Colchicine is widely used in plant breeding for inducing polyploidy.

India has been exporting huge quantities of medicinal plants and their extracts to foreign countries since last several years. These materials are being processed by the pharmaceutical industries abroad for the preparation of the active principles.

In order to prepare the bio-active principles, systematic processing of the crude drug extracts of the plants have to be carried out and in several cases the process involves a number of steps as the crude plant extracts are generally highly complex mixture of different group of compounds with varied functional groups. However, with improvement of modern technologies it has become possible to further separate the individual bio-active compounds.

The purity of the products can be determined by their physico-chemical constants like melting point, boiling point, optical rotation etc., as well as the study of their spectroscopic properties. The spectroscopy techniques used for structure identification of pure compounds are UV, IR, NMR and Mass Spectroscopy. Thin Layer Chromatography, HPTLC and HPLC are usually employed for determining their purity and quantitative estimations.

Chapter 4

Processing of Fruits and Vegetables

Dr. G. K. Sadananda
Assistant Professor, College of Horticultural Sciences, Bengaluru

Indian and global scenario on production and processing of fruits and vegetable

The Green Revolution and subsequent efforts in India to increase food production through the application of science and technology have resulted in food self-reliance. The impetus provided by the government, state agricultural universities, state departments of agriculture, and other organizations has resulted in increased food production through the evolution and introduction of numerous hybrid varieties of fruits and vegetables, as well as improved management practices. Fruits and vegetables are among the perishable commodities. They are important ingredients in the human dietaries. Because of their high nutritional value, they contribute significantly to human well-being. They are the cheaper and better source, the protective foods. Agriculture is the mainstay of the economy in developing countries. Among the most important are fruit and vegetable processing. Therefore, fruit and vegetable processing has been engaging the attention of planners and policy makers as it can contribute to the economic development of rural population. The utilization of resources both material and human is one of the ways of improving the economic status of family.

India is endowed with a remarkably heterogeneous area characterized by a great diversity of agro climatic zones. It allows for production of a variety of horticultural crops such as fruits, vegetables, flowers, spices, plantation crops, root and tuber crops, and medicinal and aromatic crops. Fresh horticultural crops are diverse in morphological structure, composition and general physiology. Thus, commodity requirements and recommendations for maximum postharvest life vary among the commodities. In this way processing and postharvest management of fresh products plays a major role.

Scope of PHM of fruits and vegetables

1. Increase Food Supply: PHM can save the produced food from spoilage for consumption and thereby help in increasing the food availability.
2. Employment Generation: PHM activities such as harvesting, sorting, grading and packaging can provide gainful employment to unskilled and skilled people.
3. Value addition: PHM and processing can add value to the fresh as well processed products and the producer or farmer can good return of his produce.
4. Export Earning: A large number of fruits and vegetables are traded in the world market. Our country is exporting grapes, mango and other green vegetables.
5. Rural Industrialization: Development of processing industry and packaging house units in the rural areas will help in rural Industrialization as well.

Importance of PHM of fruits and vegetables

1. India has the potential to grow all types of fruits and vegetables because of the varied agro-climatic diversity. The total production in the country of fruits and vegetable is over 75 million tonnes and 133 million tonnes, respectively.

2. The post-harvest losses, valued at Rs.230 billion, have been estimated to the extent of 20- 40%
3. Post-harvest management has the potential to create rural industries the women farmers can be transformed into producer-cum-processors, helping them earn more income.
4. India has the potential to grow all types of fruits and vegetables because of the varied agro-climatic diversity. The total production in the country of fruits and vegetable is over 75 million tonnes and 133 million tonnes, respectively.
5. The post-harvest losses, valued at Rs.230 billion, have been estimated to the extent of 20- 40%
6. Post-harvest management has the potential to create rural industries the women farmers can be transformed into producer-cum-processors, helping them earn more income.

Various avenues of processing fruits and vegetables

Drying and Dehydration

The practice of drying of foodstuffs, especially fruits and vegetables, for preserving them is very old. Both the terms 'drying' and 'dehydration' mean the removal of water. The former term is generally used for drying under the influence of non-conventional energy sources like sun and wind. If fruits or vegetables are to be sun-dried, they or their pieces should be evenly spread in single layer on trays or boards and exposed to the sun. In sun-drying, there is no possibility of temperature, and humidity control. The hottest days in summer are, therefore, chosen so that the foods dry very fast, thus preventing them from getting spoiled due to souring. Souring or turning acidic is usually due to growth of microorganisms which convert the carbohydrates in the food to acid. Quick removal of moisture prevents the growth of these microorganisms.

Dehydration means the process of removal of moisture by the application of artificial heat under controlled conditions of temperature, humidity and air flow. In this process a single layer of fruits or vegetables, whole or cut into pieces or slices are spread on trays which are placed inside the dehydrator. The initial temperature of the dehydrator is usually 43°C which is gradually increased to 60-66°C in the case of vegetables and 66-71°C for fruits.

There are three basic types of drying process:

1. Sun drying, solar drying;
2. Atmospheric drying including batch (kiln, tower and cabinet driers) and continuous (tunnel, belt, belt-trough, fluidized bed, explosion puff, foam- mat, spray, drum and microwave);
3. Sub-atmospheric dehydration (vacuum shelf/belt and freeze driers)

Spray Driers: Spray driers turn out a greater tonnage of dehydrated food products than all other kinds of driers combined. There are various types of spray driers designed for specific food products. Spray driers are limited to foods that can be atomized, such as liquids and low-viscosity pastes and purees. Atomization into minute droplets results in drying in a matter of seconds with common inlet air temperatures of about 200°C. Since evaporative cooling seldom permits particles to get warmer than about 80°C and properly designed systems quickly remove the dried particles from heated zones, this method of dehydration can produce exceptionally high quality with many highly heat-sensitive materials, including milk, eggs, and coffee.

Drum or Roller Driers: In drum or roller drying, liquid foods, purees, pastes, and mashes are applied in a thin layer onto the surface of a revolving heated drum. The drum generally is heated from within by steam. Driers may have a single drum or a pair of drums. Typical products dried on drums include milk, potato mash, heat-tolerant purees such as tomato paste, and animal feeds. But drum drying has some inherent limitations that restrict the kinds of foods to which it is applicable.

Freeze-Drying: Freeze-drying can be used to dehydrate sensitive, high- value liquid foods such as coffee and juices, but it is especially suited to drying solid foods of high value such as strawberries, whole shrimp, chicken dice, mushroom slices, and sometimes food pieces as large as steaks and chops. These types of food, in addition to having delicate flavours and colours, have textural and appearance attributes that cannot be well preserved by any current drying method except freeze-drying.

Differences between Conventional and Freeze Drying

Sl No	Conventional Drying	Freeze Drying
1.	Successful for easily dried foods such as seeds, fruits and vegetables.	Successful for most foods but usually limited to those not successfully dried by other methods.
2.	Generally it is not satisfactory for meat products.	Successful for cooked and raw animal products.
3.	Conventional drying is a continuous processing.	Freeze drying is a batch processing.
4.	Temperature between 37 and 93°C generally used.	Sufficiently low temperature is used to prevent thawing.
5.	Drying usually at atmospheric pressure.	Drying usually below 4mm Hg pressure
6.	Drying time may be short, usually less than 12 hours.	Drying time generally between 12 and 24 hours.
7.	Evaporation of water from food surface.	Moisture loss by sublimation of ice without passing through the intermediate liquid stage.
8.	Solid dried particles.	Porous dried, highly hygroscopic particles, reconstitute readily.
9.	Higher density than the original food.	Lower density than the original food.
10.	Odour frequently abnormal.	Odour usually natural.
11.	Slow rehydration, usually incomplete.	Rapid, complete rehydration possible.
12.	Colour usually darker.	Colour usually natural.
13.	Flavour may be abnormal.	Flavour generally natural.
14.	Storage stability good, tendency to darken.	Storage stability excellent.
15.	Costs generally low.	Costs generally low.

Vacuum Frying

Vacuum frying is a frying process that is carried out at pressures well below atmospheric level. It has been used for different foods, but mostly fruits and vegetables. The latest reports include apple, apricot, banana, jackfruit, green and gold kiwifruits, carrot, mushroom, potato, shallot, sweet potato and purple yam. The main factors that influence fried products are the frying time-temperature combination of the cooking process; the correct combination of which is necessary to produce a food product with acceptable physical attributes.

Stages of vacuum frying includes depressurization at 1.33-10Kpa, frying and de-oiling, pressurization and cooling the product to room temperature. There are two important qualities that indicate the shelf life of vacuum fried products, crispness and rancidity. Hence it was recommended to use aluminum foil laminate bag with nitrogen flushing in packaging of vacuum fried products.

Fermentation

Decomposition of carbohydrates by microorganisms or enzymes is called 'fermentation'. This is one of the oldest methods of preservation. By this method, foods are preserved by the alcohol or organic acid formed by microbial action. The keeping quality of alcoholic beverages, vinegars and fermented pickles depends upon the presence of alcohol, acetic acid and lactic acid, respectively. Care should be taken to seal the fermented products from air to avoid further unwanted or secondary fermentation. Wines, beers, vinegar, fermented drinks, fermented pickles, etc., are prepared by these processes.

Wine: Wine is a beverage resulting from the fermentation by yeasts of the grape juice with proper processing and addition. India produces around 17.6 million litres on area of approximately 6000 acres. Major wine production is concentrated in the states of Maharatra (90%) and Karnataka (7%). Wine varieties are Arka vati, Arka shyam (indigenous), Cabernet Sauvignon, Merlot and Chardonnay (exotic).

Processing of Grape Wine

a) Selection of fruit : The grape berries should be ripe and fresh. Blemished. Ones should be rejected. White wine is produced from varieties having greenish or yellowish skin. Red wines derive their colour from red pigment present in the skin or flesh of colored varieties. The different species and varieties of grapes suitable for wine making are given in the following table.

b) Crushing : It is done with the help of a basket press. Before crushing the grapes their stems and stalks are removed. Crushed material (must) is put in jars which should not be filled more than three-fourths.

c) Addition of sugar : Cane sugar is added to maintain at least 20 per cent total soluble, solids but not more than 24 per cent. If the grapes are sour, 70 g of sugar are added for each kg of grapes.

d) Adjustment of pH: If necessary, pH of juice has to be adjusted. If it is too low, the juice is diluted with water; if too high, tartaric acid is added to lower it. If water is added more sugar has also to be added to raise the percentage of total soluble solids. Usually an acid content of 0.6 to 0.8

e) Addition of preservative : Potassium metabisulphite (KMS) is added at the rate of 1.5 g for every 10 kg of grapes, mixed and allow to stand for 2 to 4 hours. KMS inhibits growth of wild yeasts and spoilage organisms.

f) Addition of wine yeast: Wine yeast, e.g., Saccharomyces ellipsoideus inoculum is added at the rate of 20 ml for every 5 kg of grapes, about an hour after the addition of preservative. If the yeast is not available then potassium metabisulphite is not added. The yeast present in the skin of grapes can also ferment and produce wine but it is not of good quality.

g) Fermentation : Grapes are allowed to ferment for two days in a cool place, i.e., at 22 to 28°C. The mouth of the jar is covered with cloth during fermentation.

h) Filtration : The contents are filtered through a thin muslin cloth or a filter aid on the third day and the filtrate again allowed to ferment in a cool place for another ten days without any disturbance. During this period yeast cells and other solids settle at the bottom.

i) Racking : Syphoning off the fermented wine to separate it from the solid deposits is known as racking.

j) Fining and Filtration : The newly prepared wine is sometimes not clear and requires fining and filtration. A suitable fining agent, e.g., bentonite, is added. All the colloidal material settles down along with bentonite.

The clear wine is syphoned off and filtered if necessary. Alternatively, the wine is stored in a refrigerator for about two weeks and thereafter the clear wine is syphoned off.

k) Aging (Maturation) : The clear wine which is syphoned off is filled into bottles or barrels. These should be filled completely and sealed airtight. The wine is allowed to mature for 6 to 8 months in a cool place. Sometimes fermentation continues in the bottle with the result that the cork flies off or bottle cracks. Wine loses its flavour during aging because of which barrels of oak wood are generally used for storing it. The wood imparts a fine aroma to the wine.

l) Packing: The volatile acid content of wine, mainly acetic acid, should be low. High content of volatile acids (0.09-0.20 g/100 ml. in terms of acetic acid) indicates that acetic acid bacteria are active during fermentation. It is often desirable to pasteurize the wine to destroy spoilage organisms and coagulate the colloids that cause cloudiness. Generally wines are pasteurized at 82 to 88°C for 1-2 minutes and then bottled. The bottles are closed with crown corks of good quality, pasteurized at 65°C for about 20 minutes, then cooled and stored.

Ethnic wines:

⇒ Naara Aaba: kiwi winery in Arunachal Pradesh. Fruits are brought from Ziro valley. Gained popularity in the Greece and China.

⇒ Wild berry Beverages: This fresh and deliciously sweet wine is made from fresh juicy strawberries. Their best-selling 'Come On Charlie' is a neat masterpiece. The fruit is picked from the farms of Mahabaleshwar

⇒ Coorg Wines: The Coorgi women often take pride in making various flavours of fruity homemade wines. There are various fruity flavours like Pomegranate, Chikku, and Gooseberry. Coorg Wines is bringing the Coorgi wine culture to the rest of India.

⇒ Resvera Winery is India's only winery that makes wine out of Jamun also known as Java plum or Indian blackberry. There are two varieties of Jamun wine by Resvera -Pure Jamun, which is made with pure Jamun, and Jamun Lite Wine which is a deep rose wine.

⇒ Rhythm Winery: Located in Khadakwasla, just 20 km away from Pune city. They offer a variety of fruit wines like Kiwi, Strawberry, Pineapple, Plum, Peach, and Alphonso Mango flavours. The company offers plume, raspberry, and mulberry wines all year round.

Pickling: The preservation of food in common salt or in vinegar is known as pickling. It is one of the most ancient methods of preserving fruits and vegetables. Pickles are good appetizers and add to the palatability of a meal. They stimulate the flow of gastric juice and thus help in digestion. Pickling is the result of fermentation by lactic acid forming bacteria, which are generally present in large numbers on the surface of fresh vegetables and fruits. These bacteria can grow in acid medium and in the presence of 8-10% salt solution, whereas the growth of a majority of undesirable organisms is inhibited. Lactic acid bacteria are most active at 30°C, so this temperature must be maintained as far as possible in the early stage of pickle making. When vegetables are placed in brine, it penetrates into the tissues of the former and soluble material present in them diffuses into the brine by osmosis. The soluble material includes fermentable sugars and minerals. The sugars serve as food for lactic acid bacteria which convert them into lactic and other acids. The acid brine thus formed acts upon vegetable tissues to produce the characteristic taste and aroma of pickle.

Minimal processing

Technology of preservation of food by minimum application of heat (thermal minimal processing) and using non-thermal methods (PEF, magnetic fields, high pressure, ultrasounds, ozone) so as to obtain a shelf stable productive having fresh-like qualities and minimum losses in nutritional, sensory and functional properties.

Minimally fresh processed fruit and vegetables are prepared for consumption by using light combined methods such as washing, cutting, grating, shredding, pulling the leaves off, etc. and packing at chilling temperatures under polymeric films that are able to generate optimum modified atmosphere packaging (MAP) conditions. It is also named as fresh-cut or ready-to-eat, is commonly free from additives and only needs minimal or no further processing prior to consumption.

Irradiation / Cold sterilization

Sterilization of food by ionizing radiations is a recently developed method of preservation which has not yet gained general acceptance. The unacceptable flavour of some irradiated foods and the fear that radioactivity might be induced in such food has come in the way of its greater use. Different organisms are sensitive to radiation to different extents, e.g a dose of 102 to 10^7 rad kills microorganisms, 102 to 10^6 rad kill insects and 102 to 102 rad are lethal to humans. Sprouting of potatoes, onions carrots, etc., are inhibited by 102 to 10^4 rad. In case of microorganisms, the approximate sterilizing dose for bacterial endospores is 3.0×10^6 rad, while that for yeasts and fungi is 5.0×10^4rad.

Ionizing radiations can be used for sterilization of foods in hermetically sealed packs, reduction of the spoilage flora on perishable foods, elimination of pathogens in foods, control of infestation in stored cereals, prevention of sprouting of potatoes, onions, etc

Aseptic Canning

Aseptic canning is a technique in which food is sterilized outside the can and then aseptically placed in previously sterilized cans which are subsequently sealed in an aseptic environment. This process, also known as Martin aseptic canning, was first commercialized in 1950. The method is basically a short-time, high-temperature sterilization process. It combines flash pasteurization and cooling with aseptic packaging of fluid and semi-fluid products, thus eliminating the retorting and subsequent cooling phases.

Individual Quick Frozen Food (IQF)

IQF is a method to freeze separate food items very quickly. It the guarantees high food quality, food safety, preservation of size, taste, and cell structure. The principle behind mechanical IQF is fast and cold air circulation that flows horizontally and is guided over individual items to freeze them very quickly. It is also called flash –freezing.

Types of IQF freezer IQF freezer

1. Mechanical IQF freezer
    - Its based on the cold air circulation
    - Flow from underneath the bed
    - Balance the aerodynamic for optimum
2. Cryogenic IQF freezer
    - Immerse the product in liquid nitrogen at very low temperature
    - Moving the product & avoid block or lump
    - Good freezing result but higher production cost

Fruit beverages:

Fruit beverages are easily digestible, highly refreshing, thirst-quenching, appetizing and nutritionally far superior to many synthetic and aerated drinks. They can be classified into two groups:

a. Unfermented beverages: Fruit juices which do not undergo alcoholic fermentation are termed as Unfermented beverages. They include natural and sweetened juices, RTS (ready-to-serve), nectar, cordial, squash, crush, syrup, fruit juice concentrate and fruit juice powder. Barley waters and carbonated beverages are also included in this group.

b. Fermented beverages : Fruit juices which have undergone alcoholic fermentation by yeasts include wine, champagne, port, sherry, tokay, muscat, perry, orange wine, berry wine, nira, and cider.

Unfermented Beverages

1. Natural juice (pure juice) : It is the juice, as extracted from ripe fruits, and contains only natural sugars.
2. Sweetened juice: It is a liquid product which contains at least 85 per cent juice and 10 per cent total soluble solids.

Ready-to-serve (RTS): This is a type of fruit beverage which contains at least 10 per cent fruit juice and 10 per cent total soluble solids besides about 0. 3 per cent acid. It is not diluted before serving, hence it is known as ready-to-serve (RTS).

Nectar : This type of fruit beverage contains at least 20 per cent fruit juice/pulp and15 per cent total soluble solids and also about 0.3 per cent acid. It is not diluted before serving.

Cordial: It is a sparkling, clear, sweetened fruit juice from which pulp and other in-soluble substances have been completely removed. It contains at least 25 per cent juice and 30 per cent TSS. It also contains about 1.5 per cent acid and 350 ppm of sulphur dioxide. This is very suitable for blending with wines. Lime and lemon are suitable for making cordial.

Squash: This is a type of fruit beverage containing at least 25 per cent fruit juice or pulp and 40 to 50 per cent total soluble solids, commercially. It also contains about 1.0 per cent acid and 350 ppm sulphur dioxide or 600 ppm sodium benzoate is diluted before serving. Mango, orange and pineapple are used for making squash commercially. It can also be prepared from lemon, lime, bael, guava, litchi, pear, apricot, pummelo, musk melon, papaya, etc., using potassium metabisulphite (KMS) as preservative, or from jamun, passion-fruit, peach, phalsa, plum, mulberry, raspberry, strawberry, grapefruit, etc., with sodium benzoate as preservative.

Crush: This type of fruit beverage contains at least 25 per cent fruit juice or pulp and 55 per cent total soluble solids. It is more or less similar to squash, contains about 1.0 per cent acid and is diluted before serving.

Syrup: This type of fruit beverage contains at least 25 per cent fruit juice or pulp and 65 per cent total soluble solids. It also contains 1.3-1.5 per cent acid and is diluted before serving. Fruits like phalsa, aonla, jamun, pomegranate, grape, lemon, orange and sometimes ginger can be used for the preparation of syrup. It is also prepared from extracts of rose, sandal, almond, etc.

Fruit juice concentrate: A fruit juice from which water has been mostly removed by heating or freezing is known as concentrate. Carbonated beverages are prepared from this. They contain pure juice with at least 32 per cent total soluble solids.

Barley water: Fruit beverage which contains at least 25 per cent fruit juice, 30 per cent total soluble solids and 0.25 per cent barley starch is known as barley water. It also contains about 1.0 per cent acid. Barley water is prepared from citrus fruits such as lime, lemon, grapefruit and orange and of these lime and lemon are mostly used.

Carbonated beverages: The use of fruit juices would increase the nutritive value of carbonated beverages. The juice can be directly carbonated, or can be stored as such, or in the form of concentrate for carbonation

whenever necessary. Carbonated beverages can keep well for about a week without addition of any preservative. If the products are to be kept for a longer period, 0.05 per cent sodium benzoate must be added.

Jam: Jam is a product made by boiling fruit pulp with sufficient sugar to a reasonably thick consistency, firm enough to hold the fruit tissues in position. Jam contains 0.5-0.6 percent acid and invert sugar should not be more than 40%. Apple, pea, sapota (chiku), apricot, loquat, peach, papaya, karonda, carrot, plum, strawberry, raspberry, mango, tomato, grapes and muskmelon are used for preparation of jams.

Jelly: A jelly is a semi-solid product prepared by boiling a clear, strained solution of pectin-containing fruit extract, free from pulp, after the addition of sugar and have the original flavor of the fruit. It should be of attractive colour and keep its shape when removed from the mould. It should be firm enough to retain a sharp edge but tender enough to quiver when pressed. Guava, sour apple, plum, karonda, wood apple, loquat, papaya, and goose berry are generally used for preparation of jelly.

Marmalade: This is a fruit jelly in which slices of the fruit or its peel are suspended. The term is generally used for products made from citrus fruits like oranges and lemons in which shredded peel is used as the suspended material.

Papad: These are the traditional Indian snacks made from the flours (cereals/starch rich vegetables) or from the pulp of the fruits and vegetables. It is usually blended with sugar solution (aam papad) or with spices and they are sun dried. In India the papad market is around 1000 crore, it is extremely at high demand in domestic market.

Flour: These are the new age food and gluten free products. Fruits and vegetable flours are the dehydrated and powdered form, which has the flavour and nutrients of fresh fruits and vegetables. Commonly used fruits and vegetables for flour preparation are beets, squashes, broccoli to bananas, apples and mangoes.

Chutneys and sauces/ketchups: They improve the digestion and are good appetizers. Fruits such as mango, apple, plum, apricot and peach and vegetables like tomato, cauliflower, turnip, carrot are the raw materials used. Ginger, garlic, onion, herbs, spices, etc. are added for flavour. Sometimes powdered cloves are added. Since the flower head of clove contains tannin which causes browning, black neck ring formation takes place in sauces/ketchups if whole cloves are used. Hence cloves should be used only after removing the flower head. Vinegar, tamarind pulp, and pomegranate seeds (anardana) impart acidity. Sweetness is provided by sugar and jaggery, and salty taste by common salt. Chutneys and sauces do not get spoilt due to the presence of vinegar, salt, sugar and some spices. Chemical preservatives are sometimes added to prevent spoilage. Iron and copper equipments should not be used in the preparation of chutneys and sauces as these metals are acted upon by vinegar.

F.P.O. specifications for F and V products

Food product	Min. % of total soluble solids in final product	Min. % of fruit juice or prepared fruit in final product
Fruit syrup	65	25
Crush	55	25
Squash	40	25
Nector	15	20

Food product	Min. % of total soluble solids in final product	Min. % of fruit juice or prepared fruit in final product
RTS	10	10
Jam	68	45
Jelly	65	45
Syrup	65	-
Product	**Total sugar (%)**	**Reducing sugar as % of total sugar**
Candied and crystalline or glazed fruit and peel	Not less than 70	Not less than 25

F.P.O. Permissible limits of preservatives in food products

Food product	Preservative	Parts per million (PPM)
Squashes, crushes, syrup, cordials, juices.	Sulphur dioxide Benzoic acid	350 600
Jam, marmalade, preserve, jelly.	Sulphur dioxide Benzoic acid	40 200
Fruit and fruit pulp	Sulphur dioxide	350
Pickles and chutney	Benzoic acid Sulphur dioxide	250 100
Tomatoes and other sauces	Benzoic acid	750
Tomato puree and paste	Benzoic acid	250
Syrups and sharbat	Sulphur dioxide Benzoic acid	350 600
Wine	Sulphur dioxide	450

Chapter 5

Freshwater Aquaculture

Dr. Manjappa N
Associate Professor, Fisheries Research and Information Center, Hesaraghatta, Bengalore

India is the third largest fish producing country and the second largest aquaculture fish producer in the world. India contributes about 7% to the global fish production. The country is also home to more than 10% of the global fish biodiversity and is one of the 17-mega biodiversity rich countries. Around 14 million people are engaged in fisheries and its allied activities. Andhra Pradesh is the largest fish producer in the country followed by West Bengal and Gujarat. The total fish production during 2017-18 is estimated to be 12.60 million metric tonnes, of which nearly 70% is from inland sector and about 50% of the total production is from culture fisheries. More than 50 different types of fish and shellfish products are being exported to 75 countries around the world. Fish and fish products have presently emerged as the largest group in agricultural exports from India, with 13.77 lakh tonnes in terms of quantity and Rs. 45,106.89 crore in value. This accounts for around 10% of the total exports and nearly 20% of the agricultural exports, and contribute to about 0.91% of the GDP and 5.23% to the Agricultural GVA of the country.

Fisheries

Fisheries is an economic activity that involves harvesting fish or any aquatic organism from the wild (Capture Fisheries) or raising them in confinement (Culture Fisheries/ Aquaculture). It may be Traditional/ Small Scale Fisheries (SSF) for sustenance, or Large-Scale/ Commercial Fisheries for profit.

Fish (in general) is a cold-blooded aquatic organism that breathes with gills and swims with fins; they are categorized as Finfish and Shellfish.

Finfish are cold-blooded aquatic vertebrates that have gills, fins with rays, and scales covering the body.

Shellfish are cold-blooded aquatic invertebrate that have gills, various types of locomotory organs and a shell/ exoskeleton covering the body. They include crustaceans and mollusc.

Biodiversity: India has a large number of finfish species. As per the database of the National Bureau of Fish Genetic Resources (NBFGR), Lucknow, 2,508 species of native finfish have been recorded, of which 1,518 species are from the marine environment, 113 from brackish waters and 877 are from freshwater habitats. In addition, 291 exotic fish species also occur in India.

Freshwater Fisheries

Around 70% of India's fish production comes from inland waters, of which nearly 65% comes from aquaculture. Out of the total inland aquaculture production, Indian Major Carps are the most cultured freshwater fish followed by Exotic Carps, Minor Carps, Catfish and Trout. There are around 1300 Carp Hatcheries in India that produced seed and supply to fish farmers. The inland water resources of India can be categorised as follows:

Fish Diversity of India*	Number of Species
Marine Ecosystem	1518
Brackishwater Ecosystem	113
Freshwater Ecosystem	877
Sub-total	2508
Exotic Fishes	291
Total	2799

Inland Water Resources of India

Warmwater Resources	Extent
Rivers & Canals (km)	1,95,210
Tanks & Ponds (lakh ha)	24.14
Reservoirs (lakh ha)	31.50
Floodplain / Derelict Water Bodies (lakh ha)	8-12
Brackish water (lakh ha)	12.40
Saline / Alkaline affected areas (lakh ha)	12.00
Coldwater Resources	
Rivers (km)	8,253
Natural Lakes (ha)	21,900
Reservoirs (ha)	29,700

Catfish

Catfishes are a diverse group of ray-finned fish named for their prominent barbels, which resemble a cat's whiskers (but not all catfish have prominent barbell). Although catfish can generally be found in faster-flowing rivers and streams, some catfish species have adapted to living in shallow salt-water environments while other catfish species live their lives in caves underground. Most catfish are bottom feeders as they are negatively buoyant (which means that they usually sink rather than float due to a reduced gas bladder and a heavy, bony head). The air-breathing catfishes such as Magur and Singhi inhabit shallow waters, withstand low oxygen conditions and are referred to as "live fishes"; they are marketed live and fetch higher price.

Featherbacks

Featherbacks are adapted to flowing conditions and widely distributed in deep and clear waters in the rivers, beels, reservoirs and ponds. The Bronze Featherback is reported to enter brackishwater. They are carnivorous and predatory fish and feed on aquatic insects, mollusks, shrimps and small fishes and take insects and tender roots of aquatic plants during early stages of life. They are rich in nutritive value and commands higher market price despite the presence of a large number of intramuscular spines.

Small Indigenous Fish Species (SIFS)

They are defined as fish that grow to a maximum size of 25-30 cm in mature or adult stage of their life cycle. They inhabit rivers and tributaries, floodplains, ponds and tanks, lakes, *beels*, streams, lowland areas, wetlands and paddy fields. In India, out of 877 native freshwater fish species, about 450 are Small Indigenous Fish Species (SIFS). The maximum diversity of SIFS in freshwaters has been recorded from the North East Region followed by Western Ghats and Central India. About 62 SIFS have been categorized as food fish while 42 species as ornamental fish. Some cultivable SIFS are Mola, Climbing Perch, Barbs, Bata, etc.

Snakeheads

The snakeheads are members of the freshwater Perciformes fish family Channidae, native to parts of Africa and Asia. They inhabit swampy waters and their gills are adapted to breathe air. They can survive out of water for up to four days, provided they are wet, and are known to migrate up to 400 metres on wet land to other bodies of water by wriggling with their body and fins. They have a pair of air-chambers (suprabranchial cavity), developing from the pharynx, lined by vascular epithelium, take in air and function like lungs.

Snakeheads consume plankton, aquatic insects, and mollusks during early life stages and become predatory and cannibalistic as they grow. The snakehead meat has good taste, high nutrient and also has high pharmaceutical values. Snakehead also has all the essential amino acids for wound healing, especially glycine, which is important for the formation of human skin collagen.

Tilapias

Tilapias are a group of "Cichlid" fish native to the African Continent. In the Central African Countries, farming of Tilapias in ponds was introduced after Second World War and then soon spread to most of the tropical and sub-tropical countries of the world and hence they are referred to as international fish. Although most of the natural resources of Tilapias are found mainly in Africa, nearly 80% of the global Aquaculture production of Tilapias of about 5.0 million metric tonnes comes from Asia. Tilapias are considered the most important aquaculture species of the 21st century and they are being cultured in 100 countries of the world commercially, ranging from extensive to super-intensive scale.

Coldwater Fishes

Coldwater fishes occupy an important place amongst the freshwater fishes of India. The coldwater fisheries deal with fisheries activity in water where temperature of water ranges from 5 to 20 degrees centigrade. The gills of cold water fish are greatly reduced and the gill opening are smaller in size for adaptation to cold temperatures. Important coldwater fishes of India are Mahseers such as *Tor putitora*, *T. tor, T. khudree, T. mosal,* Snow Trout such as *Schizothorax richardsonii* and *Schizothoraichthys esocinus*, Mountain Trout such as *Barilius vagra*, *B. bendelisis,* other fish such as *Glyptothorax sp., Garra sp.,* etc.

Freshwater Prawns:

The Giant Freshwater Prawn, *Macrobrachium rosenbergii*, popularly known as SCAMPI, is the most important species. It is native to the Indo-West Pacific region, from India through Southeast Asia to Northern Australia. It has been introduced to several countries across the globe for aquaculture purpose. Males and females have different growth rates; the males exhibit heterogenous individual growth. Among males there are three different morphotypes (Small Males, Orange Claws and Blue Claws) which display social hierarchy. All three types of males are sexually active, and females that have undergone premating moult will pair with any type male to reproduce. A Blue Claw male protects the female until their shells have hardened but the other two show no such behaviour.

The second largest freshwater palaemonid prawn, *Macrobrachium malcolmsonii*, also called the Indian River Prawn/Monsoon River Prawn/Godavari Prawn, has great potential for aquaculture development in the

inland waters of the country. Freshwater prawn farming in India developed during 1999, after marine shrimp culture encountered disease problems.

Freshwater Crabs

Freshwater crabs are adapted to semi-terrestrial or terrestrial mode of life and known for their ability to complete the life-cycle independent of marine environment. They are generally omnivorous, feeding on plant material, live or dead animals such as fish, prawns, molluscs, etc., and sometimes cannibalism is also seen. Over 1300 species are known from the world, of which 96 species are found in India.

Fish and Health Benefits

Fisheries and Aquaculture have been considered as an important means of poverty elevation and food security besides promoting health and well being. Fish continue to be one of the most traded food commodities worldwide. It contributes to around 17% of the global population's animal protein intake. Around 125-210 million tonnes of fish is projected to be required by 2050 to meet the annual per capita requirement of 15-20 kg.

Fish is often referred to as ***"Rich Food for Poor People***" as it provides essential nourishment with both macronutrients and micronutrients. Fish contain low-fat high quality protein with omega-3 fatty acids and vitamins. Fish is rich in calcium and phosphorus and a great source of minerals, such as iron, zinc, iodine, magnesium, and potassium. On a fresh-weight basis, fish contains a good quantity of protein, about 18-20%, and all the eight essential amino acids including the sulphur-containing lysine, methionine, and cysteine. In general, fish have less fat than red meats and the fat content ranges from 0.2% to 25%. However, fats from fatty fish species contain the polyunsaturated fatty acids (PUFAs) namely EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) which are essential for proper growth of children, proper brain development in unborn babies, reduced risk of preterm delivery and low birth weight. The fat also contributes to energy supplies and assists in the proper absorption of fat soluble vitamins namely A, D, E, and K. Fish is a rich source of vitamins, particularly vitamins A and D from fatty species, as well as thiamine, riboflavin and niacin (vitamins B1, B2 and B3). Vitamin D present in fish liver and oils is crucial for bone growth since it is essential for the absorption and metabolism of calcium.

Fish is also called "***Brain Food***" as it helps in development and function of brain, and "***Heart Food"*** as it contributes to lower risks of heart attacks and strokes. Consumption of fish reduces risk of autoimmune diseases, including Type-1 Diabetes, prevents and treats depression, protect from age-related brain deterioration, help prevent asthma in children, protect vision in old age by lowering risk of muscular degeneration, improves sleep quality, lowers risk of cancer, blood pressure, Alzheimer's disease etc. Fish is soft, easy to cook and more easily digested than meat so even young children can be fed fish, contributing to improved nutrient intake.

Chapter 6

Apiculture; Livelihood and Entrepreneurship Opportunities

Dr. Badari Prasad P. R
Head, Dept of Agricultural Entomology, College of Agriculture, Gangavathi – 583227,
Koppal Dist. Karnataka

Bees are among the best-known pollinators and need a boost to save our forests and agricultural wealth. Honey bees make multiple visits to the same flower until they get all the nectar and pollen out of it. Pollen attached to bees passes between plants, pollinating them. Thanks to bees, we enjoy a range of food, from mangoes to apples. Many farmers rely on bee colonies to pollinate their plants.

In countries like India, Nepal, and Bhutan, farmers struggle with making a livelihood by relying on seasonal crops. A bad monsoon can cause them to lose earning of their whole year, leaving the survival of the farmers and their families in danger. To sustain a living, farmers indulge in activities like animal husbandry and fishing. One of such profitable and feasible activities is beekeeping. Beekeeping can generate a continuous income for such farmers considering that these countries are rich in the species of honeybees like *Apis dorsata, Apis laboriosa, Apis cerana indica, Apis florea, Apis mellifera, and Tetragonula iridipennis*. Apart from an economic alternative, beekeeping plays a crucial role in agricultural well-being and symbolizes the natural biological interdependence that comes from insects, pollination, and production of seed.

To encourage beekeeping, small-scale efforts like **beekeeping training** can be witnessed across the world. As a result, it is aiding people to boost livelihoods and safeguard the maintenance of habitat and biodiversity. The reasonably low start-up costs, labor requirements, and minimum land ownership render beekeeping as an attractive economic option out of poverty for the rural people, particularly women and young people.

Sustainable Livelihood

Bees are the world's best and largest source of pollination; beekeeping thus provides sustainable livelihoods during the off-season for agricultural communities and growth in alternate methods to boost incomes. To provide a booster shot to Sweet Revolution, which aims to increase honey production, the Government of India launched the National Beekeeping and Honey Mission. Under this, bee-keepers are given subsidies, training, equipment, etc., to skill themselves and get a headstart to becoming active bee-keepers.

Among farming communities, scientific beekeeping can yield an additional income and growth of 20-80 per cent, depending on the crop and season. Krishi Vigyan Kendras too, undertake training programmes for beekeeping to provide women, rural unemployed youth and forest communities with employment. In one of his Mann Ki Baat programmes, Prime Minister Modi lauded some bee-keepers who started apiculture from scratch and are now running successful businesses. He spoke about the role of beekeeping in the economy and its help to double farmers' incomes. He exhorted the youth to take this up as a profession and take advantage of the various government initiatives where skilling activities in apiculture are needed to uplift the vulnerable sections of the population

Recommendations

⇒ Beekeeping is a non-physically demanding work; it is also favorable for women and landless youth. So if such like off-farm activity be encouraged through special attention of women and youth, one step

forwarded in terms of the country‘s plan of Krishi Kalyan Abhiyan (KKA) which Emphasize greater participation of women and young people.

⇒ The Indian government has recognized the role of the apiculture and has put in its development agenda, mainly as a non-farm income generating activities, to increase income of the rural and urban households and to promote the export sector.

⇒ There is an encouraging support from the government and NGOs to develop micro and small scale enterprises in apiculture. It should be also understood that the market problem, beekeepers knowledge gap and extension support increasingly improving (though a lot still remains). This will give a possibility of increasing bee product export revenue and improving the production efficiency.

⇒ Application of advanced technology for collection, and processing of honey. Recognition of bee keeping as agro-industry.

⇒ Developing an efficient export marketing network to optimize the production and exports.

⇒ Livelihood of communities in rural mountains is mainly dependent on subsistence agriculture; they always require an alternative source of income.

⇒ Skill development or mentorship programmes for beekeeping include business management practices, niche skills like bee handling, nutrition, bee movement, observation and maintenance of machinery, and so on. To set up a home business, one would need regulatory compliances like registration, trade licence, FSSAI licence, BIS certification, and an import-export code, if there are plans to export.

⇒ Through a beekeeper training programme, one can learn the skills required to set up a honey manufacturing unit. There is a need to create specific training programmes on the technical aspects of bee-keeping and how to market and create a demand for other products like beeswax, propolis, flower pollen, bee pollen, and royal jelly. Bee farming or apiculture requires adequate moisture to produce a good, golden haul.

The Importance Of Apiculture For Rural Livelihoods

When apiculture forms part of people’s livelihood strategies there are various possible outcomes. Some of these outcomes will include income and material goods, but also non-material outcomes such as well-being and contentment. In terms of apiculture, the least visible livelihood outcome is the pollination of flowering plants, both wild and cultivated: this is an outcome impossible to quantify. Honey is a traditional medicine or food in nearly all societies and whether sold in a simple way at village level or packaged more sophisticatedly, honey generates income and can create livelihoods for several sectors within a society.

Beeswax is also a valuable product from beekeeping, although in some places its value is not appreciated. Industrialized countries are net importers of beeswax, and the supply comes from developing countries. The beekeepers and other people in a community can create further assets by using honey and beeswax to make secondary products, such as candles, beauty creams or beer. Selling a secondary product brings a far better return for the producer than selling the raw commodity. Bees also generate other products (pollen, propolis and royal jelly) that can in some situations be harvested, marketed and made into secondary products: all of this work effectively strengthening people’s livelihoods. Another crucial livelihood outcome is where, through strengthening people's livelihoods, beekeeping has managed to help a family become less vulnerable, strengthening their ability to look into the future, and reducing the chance that they will slip into poverty if a member of the family becomes ill or if a season is bad for farming or other activities. In addition to their

financial value, honey and beeswax have many cultural values and form part of ceremonies for birth, marriages, funerals, Christmas and other religious celebrations in many societies. Beekeepers are generally respected for their craft. All of these aspects are Livelihood Outcomes from the activity of beekeeping. While some may be difficult or impossible to quantify, they are real outcomes that strengthen people's livelihoods and therefore should be acknowledged by a beekeeping intervention.

Beekeeping: Creating employment opportunities

Diversification in apiculture offers additional potential and scope for production and marketing of other bee products such as pollen, propolis, royal jelly, bees wax, and bee venom in addition to honey. Furthermore, the sale of bee packages, as well as the rearing and sale of pedigree queen bees, provides a vast opportunity. Beekeeping does not demand a lot of land and labour making it favourable for women and emphasizes greater participation of women. It can also provide income in rural areas for the underprivileged population, who do not own crops or farms. Further, it can also augment income and improve food security in areas with limited agricultural production.

In addition, crops pollinated by bees are expected to produce higher yields and higher quality, often at no additional cost to the farmer. The products produced from the practice of beekeeping are sold at a good price in the market. It includes Honey Rs 250-300 per kg, Bees Wax Rs 330 per kg and Pollens Rs 1200-2300 per kg. It is harvested four times a year. On an average, one honey box gives four kilograms of honey in one season, so in four seasons it gives 16 kg, which sells on an average rate of Rs 250 per kg. So, if women farmers keep ten boxes per family, they can easily earn up to Rs 40,000 in a year by just selling honey, besides other products are sold at much higher price. It can be summarized as: Beekeeping provides financial, nutritional, and social benefits to low-income families without requiring land ownership or large capital investments, It can be used as an extra source of income or main source of income for farmers in rural areas, The villages have an abundance of nectar and pollen producing plants, It does not require the acquisition of additional land, No special education required, Honey is a nonperishable commodity, so it is easy to store.

Conclusion

- Beekeeping has a special advantage in India where majority of the farmers are small or marginal land holders and a large area is under horticultural crops
- Honeybees are a boon to mankind because beekeeping can be done for both pollination services and cherished products such as honey, beeswax, propolis, bee venom, and so on.
- Beekeeping is a low-investment, high yielding business which has emerged as a significant enabler of socio-economic growth of the rural masses.
- The demand for high-quality honey has increased over time due to its nutritional benefits. Expansion of beekeeping activities in villages will double farmers' income, create jobs opportunities, ensure food security and bee conservation, and boost crop productivity and pollination.
- Beekeeping is a non-physically demanding work; it is also favorable for women and landless youth. It may provide stability to the young, man and women.

Chapter 7

Ornamental Fish Farming

Dr. Harsha Naik
Assistant Professor, Fisheries Research and Information Center, Hesaraghatta, Bengalore

Ornamental fishes really are nature's wonderful creation. Ornamental fish keeping is the second most preferred hobby in the world and the number of hobbyists for ornamental fish keeping is rising day by day because it provides a great opportunity for entrepreneurship development and income generation. There are a number of promotional schemes from various government agencies, which would boost up aspiring entrepreneurs. The technology is quite simple and easy to take up and attain success.

The increasing demand for aquarium fishes gradually paved the avenue towards global trade of ornamental fishes. World trade of ornamental fish is estimated to be about Rs. 2000 crores, but, India's share is only Rs. 15 crores, which is very insignificant. Most of the fish species of North-Eastern region of India possess high values for their attractive coloration pattern, graceful behavior, peculiar body morphology and endemicity. The major shares of the country's ornamental fish export are captive collection from N-E states comprising about 85% of the total aquarium fish trade of India. Aquarium fish is now a favorite interest and aquarium fish selling is a favorite commercial business in most of the states in India.

The trade is largely confined to import of exotic decorative fishes from different states of India especially from Kolkata which are subsequently sold out on the basis of temporary direction. The majority of these fishes are captured prior to their first maturity and sold in the marketplace as food fishes. These indigenous ornamental fishes can easily be gathered in the wild sources and may be cultured and simmer for keeping in the aquarium.

Ornamental fish farming or culture is the culture of attractive, colorful fishes of various characteristics, which are reared in a con ned aquatic system. Farmers and hobbyists mainly grow these fishes. Ornamental fishes can also be called living jewels. There are over 30,000 fish species reported around the world, of this about 800 belong to ornamental shes. They include eight closely associated families specially, Anabantidae, Callichthyidae, Characidae, Cichlidae, Cobitidae, Cyprinodontidae, Cyprinidae and Poeciliidae.

Aquarium fishes are broadly grouped into 2 categories on the basis of their breeding behaviour, viz., egg-layers (oviparous) and livebearers (ovo-viviparous). Egg-layers are further classified as egg-layers with no care (non-guarders), egg-layers with care (guarders), egg buriers, mouth-incubators, nest-builders and egg-carriers on the basis of parental care.

Egg layers

Important group of egg-layers are barbs, rasboras, goldfish, tetras, danios, betas, angelfish and gouramis. Among them barb is one of the most important groups. Barbs of Indian origin are rosy barb, striped barb and aruli barb. The major group of danios includes gaint danio, pearl danio and zebra danio. Among rasboras slender rasbora, glowlight rasbora and scissortail are the important ones. Goldfishes are the most preferred fish for the aquarium keepers. Some common varieties being comet, lion head, oranda, red cap, veil tail, shubunkin, bubble eye etc. The fish grows up to 20 cm in length, but starts breeding when it is only 6 cm long.

The tetras are small fishes of 3-8 cm length that originated from South America. Most common varieties are the black widow tetra, flame tetra, neon tetra and cardinal tetra. The species, *Betta splendens*, popularly known as Siamese fighter, occurs in varied colours. The males become aggressive in presence of other males. Angelfish is an important group of aquarium fish with different varieties such as black, veil tail, marble and albino. Among gouramies, three-spot gourami, pearl gourami, moonlight gourami, giant gourami and kissing gourami are the important species.

Live bearers

They give birth to young ones and reproducing only a few numbers of offspring in comparison to egg layers. Their breeding is relatively easy and development of young ones takesplace inside the female, which are released after about 4 weeks. The common livebearers include guppy, black molly, swordtail, and platy. The number of offspring produced bylivebearers is between 50-100. If properly fed with natural food, supplemented with better artificial feed, the mortality caused by predation/cannibalism could be checked therebysurvival rate of these offspring can be increased.

Breeding of Egg layers

Separate male and female hormones are produced in fishes. During spawning period the female releases eggs in the water and the male simultaneously release milt close to the eggs. The eggs are thus fertilized outside the body of the female (external fertilization). Based on the type of incubation egg laying fishes are further classified into five

Egg scatterers laying non-adhesive eggs

Zebra fish (*Danio spp.)* is considered as egg scatterer, which lays non-adhesive eggs. Like many aquarium fishes, zebra fish also eats away its own eggs and spawn after breeding.As the precautionary measure, the bottom of the aquarium should be loaded with a layer of round pebbles of about 6-8 cm diameter. The breeding pair has to be well fed with live food like small zooplanktons.

During breeding the male female ration should be maintained at 2:1 or 3:1. The female is introduced in the breeding tank one day earlier than the males. The eggs require 2-3 days hatching time, if the temperature is favourable. As soon as the tiny hatchlings are seen in the aquarium tanks the parents are to be removed. The hatchlings take 2 days to absorb their yellow yolk sac. After 2 days, they are fed with infusorians for 4 days. Subsequently rotifers and smaller zooplanktons can be fed for 1 week, after which they can be provided with powdered formulate feed.

Egg scatterers laying adhesive eggs

Gold fish (*Carassius spp.*) is considered as egg scatterer laying adhesive eggs. When secondary sexual characters appear, the male and female gold fishes are selected and kept in circular glass tanks (24''x 12''x 15'') or ferro-cement tank (3.5 ft. x 2.5 ft.) after disinfecting the containers with 1 ppm solution of potassium permanganate. The water used should be a mixture of ground and filtered pond water. The tanks should be placed where some early morning sunshine and no sunlight afterwards fall. Since goldfish eggs are sticky in nature, they require a surface to adhere. For this various artificial nets or submerged aquatic plants such as *Hydrilla* can be used. The nets should float close to the surface of water. Thewater temperature should be maintained between 20o and 30o C.

The spawner and milter in the ratio of 1:2 are released into the breeding tank in the late evening hours. Egg laying usually takes place within 6-12 hrs. The moment spawning is overnets should be transferred to a different container, or parent fishes are removed from the breeding tank. Generally a female lays about 2000-

3000 eggs. Healthy eggs are golden transparent at the beginning and gradually the transparency decreases. Unfertilized eggs will remain opaque. Under ideal condition, within 3 days, the eggs hatch-out with a hatching rate of 80-90%. When the young larvae start to float the nets and aquarium plants can be removed.

Egg depositors

Barbs (*Rasbora spp.*), small fishes that move in groups are ideal for a well-planted community aquarium. A temperature between 25° and 28° C is optimum for their breeding. They are difficult to breed but can lay up to 250 eggs/female. Like barbs they require soft, slightly acidic (pH 5.5) environment. After conditioning male and female are placed in a tank planted with flat leaved plants. Once spawning occurs, as indicated by the sliminess of the female fish, remove both parents from the breeding tank. The eggs laid on the underside of the flatlevels will hatch after 24-36 hr and the resultant hatchlings become free swimming after 3-5 days. At this stage the tiny hatchlings should be fed infusorians and newly hatched brine shrimp. As they grow bigger they should be fed zooplanktons, like *Moina* and *Daphnia*.

Egg buriers

Among the egg buriers, the killi fish (*Aplocheilus spp.*) is the most important. They lay their eggs in a soft peat at the bottom of the tank or in densely planted aquarium tanks. They are good jumpers; therefore, they should be kept in covered aquarium. The eggs are capable of remaining viable even under dried condition and hatching may be possible even after some weeks or months, when placed again in water. In drought condition, parents may die but their eggs remain alive until the next rain. They rarely grow up to 3-4 cm in total length and are short lived.

Nest builders

The common nest builders are Gourami, Siamese fighter and Angelfish. They are bubble nest builders and incubate their eggs in floating nests, specially made by the male fish.

Gourami (*Osphronemus spp.)*: Among the nest builders gouramis are the most popular. For breeding purposes males and females are kept separately in different tanks for a week and fed with live food. When the abdomen of female becomes grossly, distended with eggs it is transferred to a smaller breeding tank with water level of 5-6" at 28o-30oC. The tank should contain plenty of fine-leaf plants such as *Cabomba* and some floating plants. The water hardness of 100-200 ppm and pH of 7.0-7.5 are ideal.

After 1-2 days, mature male is introduced in the breeding tank. A transparent perforated plastic sheet or a glass is covered over the tank to keep the humidity and temperature at high level, which help to maintain the bubble nest in good condition. The male soon begins to build the bubble nest. This is possible by engulfing a large gulp of air at the water surface and converting it into many smaller bubbles that are passed into gill chamber and coated with an anti-burst agent before release. After making the nest, the female deposits a large number of eggs in the nest. After breeding, female is removed, while males guard the nest. Hatching takes place within 24-36 hr and the moment fry swim freely from the nest, males are removed from the tank. The young ones are given infusorians at this stage and after a week newly hatched artemia and small cladocerans are provided. As they grow they accept all kinds of prepared feeds.

Siamese fighter (*Betta splendens)*

Adult fish attain sexual dimorphism at a length of 6 cm. It is best to attempt breeding with fishes that are about 9-12 months old. Allow one male to every 2 or 3 females. Females should be at least the same size as the male. Males are kept in small aquaria of 2-5 litre capacity, while females are kept in tanks containing 25-50 litres of water. Another breeding tank containing 50 litres water (depth 15 cm) and having leaf plants like

Myriophyllum and *Cabomba*, is required. The tank has to be partitioned into two using fine mesh net. In one half females and other half male fish is placed. Water temperature is maintained around 27°C.

The male starts building a bubble nest quite quickly and once this is underway, the partition net is removed. At this crucial stage male should accept the female, otherwise male starts vigorous display of chasing which ultimately leads to fin tearing of female. Fighters often spawn in early morning and within a few hours 200-300eggs are laid. As the eggs are shed and fertilized, they sink to the bottom. Males then collect them in his mouth and spit them into the bubble nest. At the end of spawning females are removed and male is left to guard the nest for 3 days after which it is removed. The eggs hatch after 36-48 hr. The smaller fry become free swimming after 5 or 6 days during when they can be fed with infusorium and egg-yolk. After 3 or 4 days, frys generally accept fine dry foods. The temperature of the water should be warm at around 27° C.

Bubble nest of Siamese fighter fish

Angelfish (*Pterophyllum spp.*): The mature angelfish having straight top and bottom fins without any bowing or bend is selected. They should be healthy, strong, robust andactive. Unfortunately it is very difficult to differentiate between a male and female angelfish externally. In the beginning, 6-8 potential breeders are selected which can be set ina 100-litre tank and they are fed well with live food. The fish soon make pairs and start displaying breeding and courtship behavior. They spawn on broad-leaved Amazonsword plants in the aquarium. Angelfish prefer water with a 6.0–8.0 pH, with 6.5-7.4 being ideal, a water hardness of 50–130 ppm, and a temperature range of 24–30° C.

The female will deposit a line of eggs on the spawning substrate, followed by the male who will fertilize the eggs. This process will repeat itself until there are a total of 100-600 eggs.The pair will take turns maintaining a high rate of water circulation around the eggs by swimming very close to the eggs and fanning the eggs with their lateral fins. In a few days, theeggs will hatch and the fry will remain attached to the spawning substrate. During this period, the fry will not eat and will survive by consuming the remains of their yolk sacs. At oneweek, the fry will detach and become free-swimming. Fry can now feed on brine shrimp and after 2 weeks feed on powdered artificial feed.

Breeding of Livebearers

Unlike other fishes, female livebearers are fertilized internally by transferring milt to females by means of the males modified anal fin, the gonopodium. Breeding pattern of guppies and other fishes of this group vary and hence have been dealt separately.

Guppy (*Poecilia reticulate*)

Male guppy reaches up to 2.5 – 3.5 cm length, while the female is usually larger when fully grown. They thrive in a large well-planted tank with temperatures within 20 – 25°C. Gravid females with their abdomen enlarged are collected and placed in the breeding tank (30 cm x 20 cm x 20 cm) individually or pairs. Plants like *Cabomba* can be placed in the aquarium. Once individual females give birth to 20-200 young ones, the tank is aerated. For mass breeding of guppy a tank size (100 cm x 100 cm x 60 cm) is ideal, where aperforated cylindrical basket can be provided in one side of the tank encircled with fibrous plastic flowing filaments where the female can drop the young ones. Soon after birth, theyoung ones escape from their mother and enter into the perforated basket and latter the young ones are collected from the basket and placed in separate tanks, for further rearing.

Platy, Swordtail and Molly

The platies, swordtails (*Xiphophorus spp.*) take 6-8 weeks, while mollies (*Poecilia spp.*) 12-16 weeks to mature. Like guppies the male used to insert its gonopodium with milts into female, fish and eggs are fertilized inside the mother's body. After fertilization, the embryo grows to tiny young ones and becomes ready for free swimming within 4 weeks of gestation period. Platies, swordtails and mollies are quite hardy fish; they will breed well in most type of water, so long as it is not too soft or acidic. Addition of little aquarium marine salt or common salt to water (0.5 –1 g/litre) is beneficial for mollies.

Advantages of Ornamental Fish Farming:

- It gives joy to young and old folks.
- It allows relaxation of the mind and thus contributes to a healthy living.
- Children get to know more about nature and use their time productively.
- It generates a self-employment opportunity.

Breeding table of livebearers

Cultural practices of Ornamental Fish Farming

Most frequent culture facilities utilized for decorative fish are cement cisterns, glass aquaria, earthen ponds, earthen pots, etc. Three to four concrete cisterns are suf cient for a small scale rearing unit of 3 meters x 2 meters x 1meter and therefore are built above the oor level for simple drainage. All glass aquaria are favored for breeding purposes where drains and aerators can be utilized easily. Even, fish farmers with little earthen tanks may utilize them for rearing juveniles with all the food sh. Marginal farmers even can use big earthen pots of 1.5 meter in diameter to the rearing of larvae and juveniles. Normally, rainwater is your best source of water for ornamental fish culture. If the municipal distribution water is in use, before using, it is aerated for a few days for de-chlorination. The typical temperature of the rearing water in the region is 15 °C to 28 °C and the water pH is slightly alkaline. The majority of the species cultured favor soft to medium hard water.

Feeding and Care required in Ornamental Fish Farming:

The small farmers can't afford different readymade packed fish food pellets or purchasing of artemia cyst drum, which is pricey. But, they've successfully substituted reduced cost alternative live feeds. Different homemade nourish like whole-wheat bread, vegetable peelings, and rice will also be fed. But most farms rely on Daphnia, Tubifex worms and mosquito larvae. The fish culturists can amass Daphnia in the neighboring ponds by sieving through the ne mesh in the early morning. Tubifex worms and mosquito larvae are gathered in the sewer water stations. Normally, the farmers dispense the feed once daily. Overfeeding is much more damaging than underfeeding since the surplus feed destroys the water quality.

Species	Sexual dimophism	Size	Optimum water condition for breeding	Gestation period (days)	Young ones/ females
Guppy, Poecilia reticulate	Male is smaller with more flowing fins and pointed anal fin or gonopodium	Male 2.5-3.5 cm; female 5-6 cm	Temp. 20-28o C, water hardness, 50-100 mg $CaCO_3$/litre (moderately soft water)	21-35	20-100

Platy, Xiphophorus maculates	Male is smaller and slimmer with gonopodium. General coloration is red, gold, blue, black, brown etc.	Male 3-4 cm; female 4-5 cm	Temp. 23-28o C, water hardness, 50-100 mg CaCO3/litre (moderately soft water)	28-42	10-100
Sword tail, Xiphophorus helleri	Male is smaller and slimmer with gonopodium and pronounced sword like projection on caudal fin	Male 6-7 cm; female 7-9 cm	Temp. 23-28o C, water hardness, 50-100 mg CaCO3/litre (moderately soft water)	28-42	20-100
Black molly, Poecilia sp.	Male with gonopodium, dorsal fin is flowing and bigger. Males are smaller than females and slimmer also.	Male 7-8 cm; female 9 cm	Temp. 23-28o C, Aquarium salt at 0.5-1.0 g/litre	40-70	30-70

A beginner should start working on breeding of any live- bearer followed by gold fish or some other egg-layer species for getting familiar or acquainted with the procedures on how to handle and maintain brood fish and the youthful one. Good knowledge on the biology, feeding behavior and ambient condition of the fish are all prerequisites for breeding. Live food like Tubifex worms, Moina, earthworms *etc.* for brood-stock and larval phases need special attention. The creatures similarly need infusoria, artemia naupli, planktons like rotifers and smaller daphnia during the early phase. A unit for continuous production of live-food Is, therefore essential for the effective maintenance of the unit. In the majority of cases, breeding is simple, but larval rearing might require special care. As a supplementary feeding, the farmer could prepare on-site pelleted feed by using local agro-produce. To avoid health-related problems, a proper water quality needs to be ensured by installing bio filters. The ornamental fishes could be consumed at varying periods of the year.

Commercially important indigenous and non- indigenous species of Ornamental Fish Farming are listed below

Scientific Name of species	Common Name of Species
Botia lohachata	Reticulated loach
Brachydanio rerio	Zebra fish
Chandra nama	Glass fish
Colisa chune	Honey gourami
Labeo nandina	Pencil gold labeo
Lebeo calbasu	All black shark
Notopterus notopterus	Black knife fish
Oreichthys cosuatis	Hi fin barb
Puntius conchonius	Rosy barb
Puntius denisonii	Deni soni

Commercial varieties of exotic livebearers of species in Ornamental Fish Farming:

Scientific Name	Common Name
Poecilia reticulata	Guppy
Poecillia sphenops	Marble Molly
Poecillia velifera	Sail n Molly
Xiphophorus helleri	Swordtail
Xiphophorus maculates	Platy

Commercial types of exotic egg layers of species in Ornamental Fish Farming

Scientific Name of species	Common Name of species
Astronotus ocellatus	Oscar
Balantiocheilus melanopterus	Bala shark / Silver Shark
Betta splendens	Siamese Fighting Fish
Carassius auratus	Gold fish
Cichlasoma meeki	Firemouth Cichlid
Colisa lalia	Dwarf gourami
Cyprinus carpio var koi	Koi carp
Helostoma temmincki	Kissing gourami.
Labeo bicolor	Red-Tailed Black Shark.
Paracheirodon axelrodi	Cardinal Tetra.
Paracheirodon innesi	Neon Tetra.
Pterophyllum scalare	Angel sh.
Rasbora heteromorphy	Rasbora, Harlequin Fish.
Scleropages formosus	Asian arowana.
Symphysodon discus	Discus / Pompadour fish.
Trichogaster trichopterus	Three spot gourami.

Water management in Ornamental Fish Farming

Ornamental fish production unit requires a higher degree of expertise for greater water quality control as ornamental fish is very sensitive to poor water quality conditions. Many decorative fishes will perish in situations in which more powerful food fish species may survive. As cosmetic fish are stored in tanks longer quantities than their meals fish counterparts, water quality is the most critical. Where large quantities of fish have been stored in smallish distances, the build-up of nitrogenous wastes, most especially ammonia,

requires the manufacturer to implement steps to handle it correctly. Standard water exchange together with appropriate aeration overcomes this kind of difficulty in the tanks.

Health management of Ornamental Fish Farming

Appropriate water quality control in ornamental fish breeding and culture is the primary preventive measures since they are very sensitive to temperature as well as pH. The most common diseases of ornamental fishes are reported to be a white spot, mouth disease, tail and n rot. Some of these easily available and economic chemicals and medicines may be used as preventive measures.

The easily available chemicals and medicines for health management are typical salt @15-30 grams/Litre of water used as a bath treatment for 30 min as the disinfectant, methylene blue @ 2.5 grams/Litre of water inserted in aquarium water for water purification and aluminum sulfate or potassium permanganate @ 0.5-1 gram/Litre of water used as bath therapy for 1 min as disinfectant.

Tips for Ornamental Fish Farming:

- Breeding and rearing unit should be drawn up near a continuous supply of water and electricity. If the unit is situated near the flows, it will be excellent in which the unit can receive mobile water along with the rearing unit can be produced flow-through.
- Continuous availability of agro-based by-products like oil cakes, rice polish, and wheat bran, and animal-based protein like fish meal and prawn-head meal, will facilitate preparation of pelleted diet to your sh. The brood-stock selected for breeding should be of superior quality in order that they produce quality fish available. It is advisable that the young ones may be increased till their maturity.
- Breeding and rearing unit may be established rather nearer to airport/railway station so that live fish could be easily transported to internal market as also for export.
- A fish breeder could focus rather on a single marketable species to streamline control steps.
- Appropriate knowledge on market demand, customer preference and overall, the operation of a marketing network through personal contacts and the public relation is desirable.
- Pioneer and expert groups in this field may always be kept in touch with to keep an eye on recent developments in marketing in addition to research progress, through training.

Cost and profit of Ornamental Fish Farming

The profit of ornamental breeding and rearing unit depends upon the carrying capacity, candidate species, management practices and infrastructure. The marginal farmers that breed or rear the fish need to sell them earlier due to the absence of proper equipment and get less profit. It is better to rear the fish to an optimum size and get more profits rather going for large scale.

Bottom line of Ornamental Fish Farming

Culture and breeding of ornamental fishes can be a promising alternative for many individuals as well as unemployed youths. It requires little space and less initial investment than most other forms of aquaculture. For decorative fish farming, only a clear understanding of habits and biology of these fishes is required. It may be practiced even in urban areas with little alteration of backyard or roof of a house. As less manpower is needed, the women or the elders can run little home aquarium units and improve their social and economic upliftment. There are many Ornamental Fish Farming Training centers in metro cities. For a better

understanding of this business, it is very important to get training from the Institution, Organisation, Colleges and Training centres.

Chapter 8

Introduction to Intellectual Property Rights

Sharat Kumar Pattar

Head – Patent Cell, Centre of Excellence, All India Institute of Speech and Hearing, Mysore

Intellectual Property (IP) is a special category of property arises from the intellect and ingenuity usually in the fields of arts, literature, science, trade, etc. Intellectual Property Rights (IPR) are the privileges of an individual to derive benefits from his / her IP and exclude others from doing so.

IP comprises of two branches

- Copyrights and Related Rights
- Industrial Property Rights.

Copyrights and Related Rights refer to the creative expressions in the fields of literature and art, such as books, publications, architecture, music, Sculptures, pictures, portrays, sculptures, films and computer-based software's/databases. The Industrial Property Rights refer to the Patents, Trademarks, Trade Services, Industrial Designs and Geographical Indications.

Tangible and Intangible property

Tangible properties are typically physical assets or property owned by a company or a person such as land, house, gold and car. Intangible properties do not have physical existence, yet they have a monetary value since they represent potential revenue such as copy right to a song, means the record company which owns copyright will get royalty each time the song is played.

IP in India

The first patent related legislation in India was Act VI of 1856, adapted from the British Patent Law of 1852. The objective of this legislation was to encourage the inventions of new and useful manufactures.

In India, the first patent (known as 'Exclusive Privileges' at that time) was awarded in 1856 to a civil engineer, George Alfred DePenning from Calcutta, for his invention, 'An Efficient Punkah Pulling Machine'

Types of Intellectual Property Rights - IPR:

Broadly Intellectual Property Rights has been divided in to Two main types viz: 1) Copyrights and 2) Industrial Property

1) Copyrights:

- It is branch of Indian law that protects the original work of authorship such as literary works, music, sound recordings, sculptures and computer programmes.
- The term of a protection in case of literary, artistic, dramatic and musical work is lifetime of an author plus sixty years after the death of an author from the beginning of the calendar year. In case of cinematographic film, sound recording, government work, public undertaking work and works of International Organization, the term of copyright is 60 years from the year of publication.

- It is not mandatory and non renewable.
- Application for the registration can be done by applying physically in the copyright office in Delhi or through speed/ registered post or through e-filing facility available on the official website of copyright office.

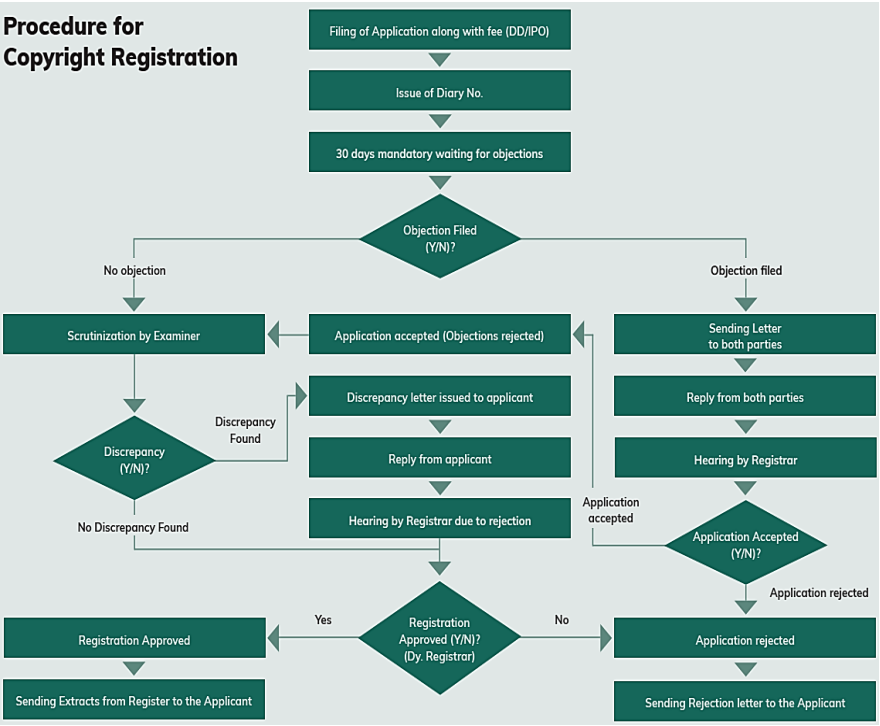


Image source: CIPAM-DPIIT IPR Awareness Manual 3

2) Industrial Property:

Industrial Property is further divided into two main areas: Trademarks and Geographical Indications

2.1) Trademarks

- It is a distinctive visual sign (word, symbol, Phrase) used by the individual to uniquely identify the origin of its products and distinguish its products from other entities.
- Comes under section 28(zb) of Trademark Act 1999.
- Period of protection varies but it can be renewed indefinitely. Generally, it will be for a period of 10 years and renewable for every 10 years at any four branches of Trademark registry i.e., Kolkata, Delhi, Chennai and Mumbai (Headquarters).

What cannot be registered as a trademark under section 9 of the trademarks Act 1999 in India:

- Lack of distinctive character
- Deceive or cause of public confusion
- Scandalous or indecent matter
- Hurt religious sentiments of any class or section of the society
- Attract objections under the emblems and names act 1950

- Having any connotation in India

2.2) Geographical Indication (GI)

- It identifies the goods having special characteristics originating from the definite region (country/ region /locality).
- Protects any agricultural goods or manufactured goods or any goods of Handicrafts or goods of industry including foodstuff originating from a definite geographical region.
- Initially, Period of protection will be for 10 years and renewable after every 10 years for an indefinite

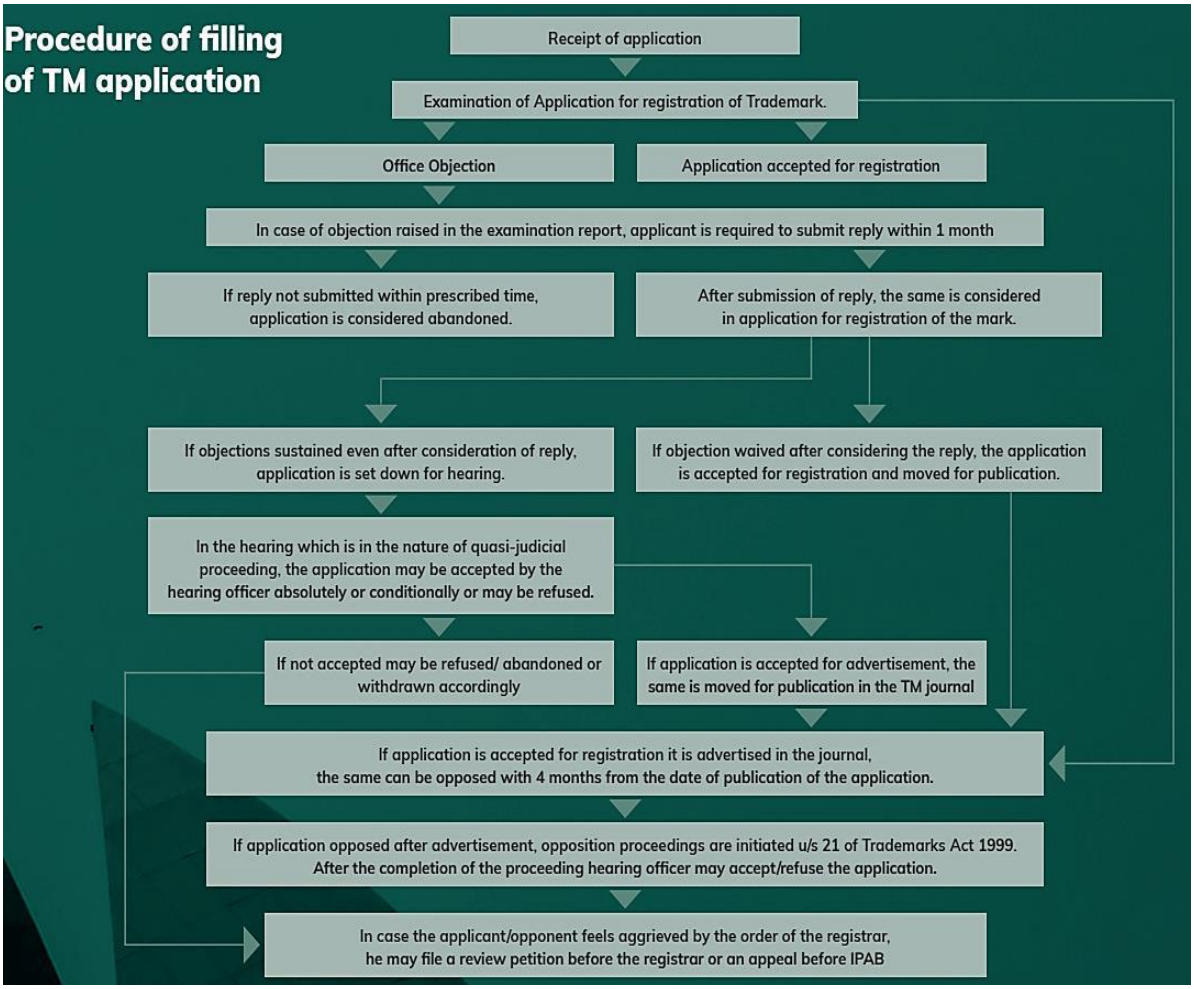


Image source: CIPAM-DPIIT IPR Awareness Manual 4

period of time.

- Application for the GI tag can be filed at the headquarters office located at Chennai, the application can also be filed online by accessing www.ipindia.nic.in/

GI Not Registerable under Section 9 of geographical indication of goods (registration and Protection) Act 1999,

- Deceive or cause confusion

- Use of which is contrary to law
- Contains any scandalous or action matters
- Likely to hurt religious susceptibility of any class or section of society
- Generic names which are no longer being used in particular territory

Geographical Indication Registration Flow-chart

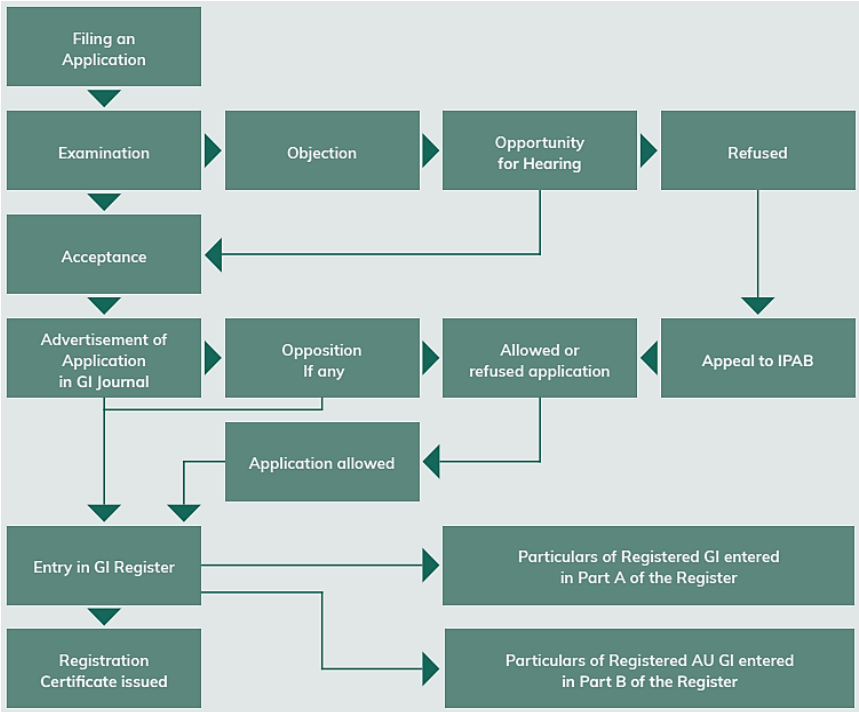


Image source: CIPAM-DPIIT IPR Awareness

2.3 Other categories

The other categories of Industrial Property comprised of 1) Patents 2) Industrial Designs and 3) Trade Secrete

2.3.1) Patent:

- It is a set of exclusives rights granted by the government of India to the patentee/ inventor for a specific period to derive benefit from his/her inventions and prevent others from practicing so.
- Criteria for patentability,
  a. Novelty
  b. Inventiveness
  c. Industrial application
- In India, Period of protection will be for 20 years from the date of filing application.
- A person who desires to get patent for his/her invention has to apply for patent office where applications for patent can be filed. If foreign companies want to get patent in India, It is essential to appoint an Indian patent agent to file an application for registration of patents in India.
- There are four patent offices in India. Situated in Mumbai, Chennai, New Delhi and Kolkata. Online

patent application can be filed through comprehensive online filing system at https://ipindiaonline.gov.in/epatentfiling

- What cannot be patentable in India:
  - Method of agriculture or horticulture.
  - Business tactics
  - Presentation of information
  - Traditional Knowledge
  - computer program
  - Topography of integrated circuits

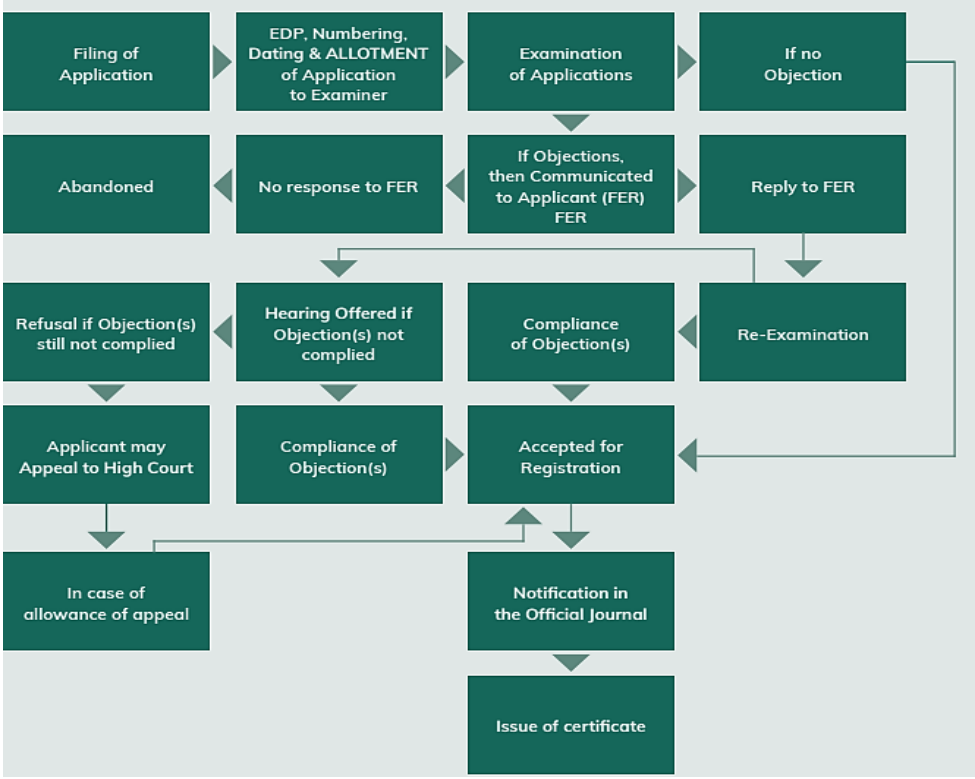


Image source: CIPAM-DPIIT IPR Awareness Manual 8

Patent Filing Procedure in India

2.3.2) Industrial Design:

It protects the visual features of shape, configuration, pattern, ornament or composition of lines or colours applied to the manufacturing product in two dimensional or three dimensional or in both forms.

The filing of the application can be done in any of the four offices i.e. Kolkata (head office), Delhi, Chennai and Mumbai under the Design Act, 2000 and and The Design Rules, 2001.

2.3.3) Trade secretes:

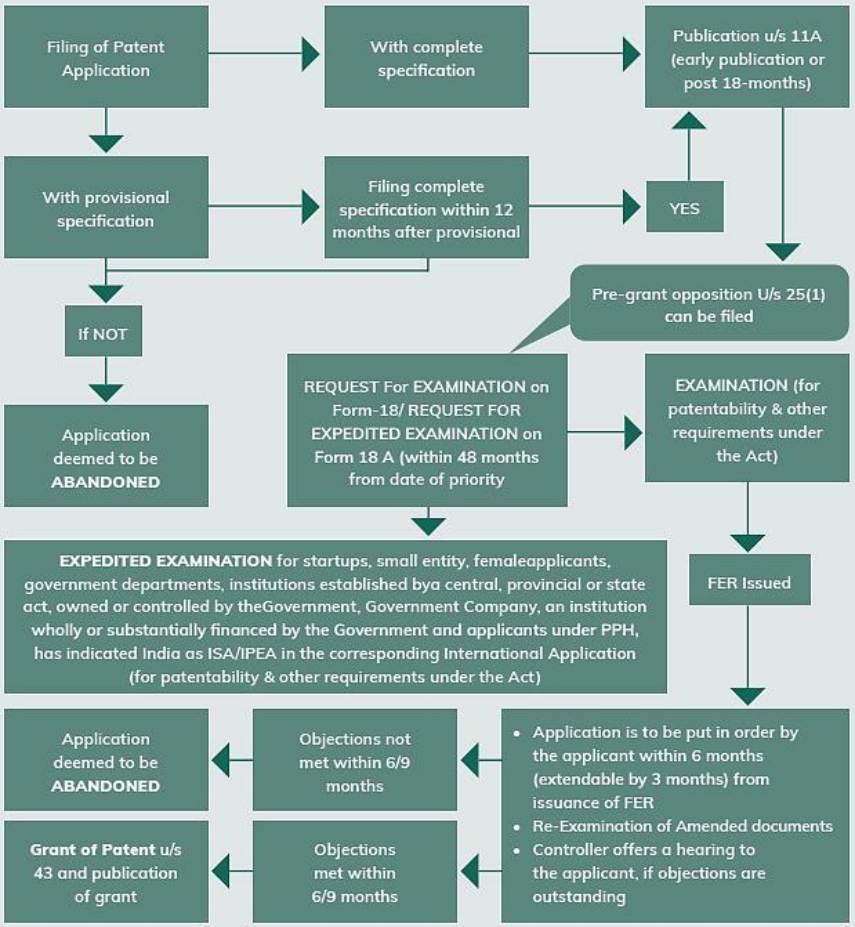
Individual owing the IP will not disclose the formula, process, device, or other business information to maintain an advantage over competitors and to promote its commercial interest.

- It is for unlimited duration.

What can be included under Trade secrets:

- Technical information like product formula and recipes, product design, manufacturing processes, computer code.
- Business and Financial information like customer list, consumer preferences, pricing information, marketing and business plans

Flowchart of design application registration



Chapter 9

Blue Revolution: Towards Achieving Nutritional Security

Dr. A M Ramesh[1] and Dr. Sushrirekha Das[2]

[1]Chief Executive Officer, Karnataka Science & Technology Academy, Bengaluru

[2]MANAGE Fellow, MANAGE, Hyderabad

1. Background

Capture fisheries and fish farming are playing a significant role in achieving food and nutritional security as well as in creating fisheries-based employment for millions of people across the globe. The total world fish production stood at 214 million metric tons in 2020. India ranks second in global fish production with a production of 14.16 million tonnes in 2019-20 with an annual growth rate of over 7%. Out of the total fish production, marine and inland sectors contributed 3.73 million tonnes and 10.43 million tonnes respectively.

The fisheries sector contributes 6.58% to the GDP of the agricultural sector, while 1.03% to the country's total GDP. India exported 13,69,264 metric tonnes of seafood worth around Rs.57,586 crore in the financial year 2021-22 amid many disturbances caused due to COVID-19 pandemic.

Being one of the 17 mega biodiverse countries in the world, India accounts for 10% of global fish biodiversity. From the deep sea to the rivers and lakes of the northern Himalayas, our country is blessed with a wide variety of aquatic fauna such as fish, molluscs, shellfish, etc. Studies have revealed that apart from 3137 indigenous species, we currently have 462 exotic species of fish. The fishing sector, which was a traditional livelihood activity in the fifties and sixties, has grown into a technology-based business in the last four decades.

2.0 Marine Fisheries

India's coastline is 8118 km long and the Exclusive Economic Zone (EEZ) covers an area of 2.02 million sq. km (0.86 million sq. km. on the west coast, 0.56 million sq. km. on the east coast and 0.60 million sq. km. around the Andaman and Nicobar Islands). There is good scope for marine fishing and fish farming in this vast aquatic space.

A study by the Central Marine Fisheries Research Institute (CMFRI) revealed that although the annual fish production in 2019-20 from the marine sector was 3.73 million tonnes, its potential is estimated to be 5 million tonnes. Marine fisheries play an important role in India's economy, providing employment and income to two million people. The total number of marine fishing boats is estimated at 2,80,491, which includes 1,81,284 traditional boats, 44,578 traditional motorized boats and 53,684 mechanized vessels. The share of fish production in traditional, motorized and mechanized sector is 9%, 26% and 65% respectively. The state of Gujarat leads in the total production of marine fisheries followed by Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka and Kerala.

Marine fisheries in India is mostly concentrated along the coast up to a depth of 100 m, while about 90% of the fish harvest comes from the area within 50m depth. In view of this, the coastal resources are under severe fishing pressure. Inshore fisheries have almost reached the Maximum Sustainable Yield (MSY) level, while deep-sea fisheries have so far concentrated solely on shrimp harvesting. Currently, only 12% of the total available resources are being harvested. Deep sea long line, purse seining and squid jigging vessels need to be introduced to harvest the available resources judiciously within our EEZ.

3.0 Inland Fisheries

India is rich in vast open inland water bodies such as rivers and canals, reservoirs, ponds, tanks, lakes, beels (a flat flood prone area found in Assam and West Bengal), wetlands and inland saline and backwater resources. Inland water resources consist of 0.38 million km long rivers and canals, 2.70 million ha of reservoirs, 2.47 million ha of ponds and tanks, 0.43 million ha of beels, 0.34 million ha of neglected water bodies/oxbow lakes and 0.96 million ha of brackish water area. The diverse cold-water fish resources are distributed in the medium to high-altitude streams, rivers, lakes and reservoirs of t country's Himalayas and North Eastern regions of the country.

The share of inland fisheries in the total fish production of the country in 1950-51 was 29%, while it has increased to 72% in 2018-19. In the inland fisheries sector, Andhra Pradesh is the largest fish-producing state in the Country followed by West Bengal. Both these states together account for 40% of the country's inland fish production. In recent years, the sector has focused on new initiatives and innovations, technology development, upgradation and fisherman's profitability. The Indian Council of Agricultural Research (ICAR), a few central government departments, state agricultural universities, and many research and development institutes have continuously undertaken research, which has contributed to the scientific progress of this field

4.0 Cold Water Fisheries

India is bestowed with vast and diverse cold-water fishery resources that are spread across ten states in the peninsular region of the Western Ghats and Himalayan ranges. Studies have revealed that cold water fisheries resources include 258 indigenous, exotic, farmed and non-farmed fish species belonging to 21 families and 76 genera. Fish species like Mahaseer, Trout, Berylius, Garra etc. grow in cold water. In recent years, trout farming has been undertaken in the hill states of Jammu and Kashmir, Ladakh, Himachal Pradesh and Sikkim. The cold-water/hill fishery resources are spread across the Himalayan and peninsular regions as upland rivers, streams, high and low-altitude natural lakes, and reservoirs.

5.0 Fish farming (Aquaculture)

Fish farming is one of the fastest-growing food production sectors globally. Seafood production per annum is growing at the rate of 8%, almost half of it is coming from fish farming. India ranks second globally in fish production and has enormous potential in aquaculture as well, growing at an annual growth rate of over 7%, which makes a significant contribution to the economy and nutrition of millions of people. The Indian fish farming system includes various species of fish and other aquatic organisms distributed in freshwater, brackish water and marine ecosystems and includes different farming systems.

5.1 Freshwater Fish Farming

The share of freshwater fish farming in total freshwater fish production is 95%. The three Indian Major Carps (IMCs) *Catla catla*, *Labeo rohita* and *Cirrhinus mrigal* account for about 80-90% of freshwater fish production, while Minor Carps, Catfish, Silver Carp, Grass Carp and Common Carp contribute about 10-20%.

The inability of these Asiatic carps to breed in captivity is due to the lack of required ecological stimuli that affect the secretion of an essential quantity of gonadotrophic hormones. Hence, extraneous hormones such as pituitary extract or synthetic hormones are injected into brood fish to induce them to breed. After the successful breakthrough in induced breeding of the Indian major carps in 1957 by Dr H. Chaudhuri and Dr K.H. Alikunhi, while silver carp and grass carp were introduced in India in 1959, a major expansion of fish farming in India was witnessed. The integrated farming system of three Indian Major Carps and three exotic carps was developed and fish farmers were trained. This led to a paradigm shift in fish farming, which led to a significant increase in the production and productivity of fish in the country.

In spite of the fact that India has vast freshwater resources, they are not fully exploited except for carp culture in limited scale. Fresh water fish culture employing composite fish culture technology has become popular for use in large number of tanks and ponds in the country.

After that polyculture, semi-intensive and intensive fish farming systems were adopted and the production from 5 to 15 tons per hectare was obtained. In recent years, fish farming technology has also progressed and various species such as small groupers, catfishes, murrels and tilapia have been successfully farmed. Freshwater prawn (Macrobrachium rosenbergii farming has the potential to make a great contribution to food and nutrition security in the country. However, the major deterrent to the further expansion of the prawn culture is the lack of an adequate supply of the post-larvae stage of prawn seed for stocking in the culture ponds. Till 2006, farming of these prawns was a godsend for the states like Andhra Pradesh, West Bengal and Kerala. However, there was a lot of decline in production since then because of inbreeding, diseases and stunted growth, as per statistics from Marine Products Export Development Authority (MPEDA). In this context, a genetic improvement program was initiated by the Central Institute of Freshwater Aquaculture (ICAR-CIFA), Bhubaneswar in collaboration with the World Fish, Malaysia to address stunted growth.

The culture of exotic freshwater catfish, pangasius (*Pangasianodon hypophthalmus)* is the fastest-growing fish across the world, which was introduced in India during mid 1990's. There has been a steady increase in the production of pangasius by small and marginal farmers of the country.

The production of pangasius in the country is estimated to be 850,000 metric tons, out of which about 500,000 metric tons (58.45%) come from Andhra Pradesh itself. The production of this fish was merely 0.2 million tons, which shot up to 0.7 million tons in 2012. At present, the aquaculture production of pangasius in India has gone up from 0.7 million tons to 0.855 million tons. In recent years, the culture of pungasius has become popular in states like Andhra Pradesh, West Bengal Bihar, Assam, Punjab, Haryana, Chhattisgarh and Jharkhand, which can produce 15 to 50 tons per hectare per year in mono culture. However, concern has arisen about the long-term sustainability due to diseases and its negative impacts on socio-economic aspects and biodiversity.

5.2 Brackish Water Aquaculture

The traditional brackish water fish farming system practiced in the Bheries of West Bengal and Pokali in Kerala has transformed into a commercial fish farming industry since the 1980s. Shrimp farming emerged as the fastest growing food production sector in the 1990s and contributed significantly to the Indian economy and exports.

Brackish water fish production in India was 0.75 million tonnes valued at Rs. 3,000 crore in 2017-18, mainly due to farmed shrimp species *Peneaus monodon* and *Peneaus vannamei*. Fish species like Chanos (*Chanos chanos*), Bhetki (*Lates calcarifer*), flat head-gray mullet (*Mugil cephalus*), pearl spot (*Etroplus suratensis*) and snub nose pampano (*Trachinotus blochii*) could be explored as new options in brackish water fish culture. However, breeding and rearing techniques for these species have to be developed to make them commercially viable.

In addition, 9 million inland saline soils are available in the states of Haryana, Punjab, Rajasthan, Uttar Pradesh and Gujarat, which are suitable for brackish water fish farming. It is reported that only 11% of the 3.9 million hectares of land including brackish waters, coastal lagoons, lakes, tidal creeks, canals and wetlands are currently being used for brackish water fish farming (NFDB, 2019).

Studies have shown that whiteleg shrimp (*Peneaus vannamei*) has been successfully reared in inland saline waters of Haryana and Punjab, and could be farmed commercially in other parts of the country as well. The backwater fish farming sector is expected to contribute significantly in the future. However, the main challenges in shrimp farming are the availability of disease-free seed (post-larvae), feed with a good F*eed Conversion Ratio* (*FCR*) and disease management strategy during the rearing period.

5.3 Marine Fish Farming

As both the human population and economic development are expected to grow at a faster rate in the coming decades, food fish consumption globally is projected to reach 21.4 kg per capita by 2031, up from 20.5 kg per capita during 2019-2021 as per the OECD-FAO AGRICULTURAL OUTLOOK 2022. Farming fish in cages and pens offers a better opportunity for higher production and helps to meet the growing demand for seafood. Fish provides about 10% of the animal protein intake for 3.2 billion people across the globe.

Aquaculture research and development in India was systematically initiated by the Central Marine Fisheries Research Institute (ICAR-CMFRI) in the 1980s. The National Institute of Ocean Technology (NIOT) and MPEDA have also contributed to the development of this sector.

Technologies are being developed for cultivating brackish water fishes, shellfish, and seaweeds, as well as producing marine fish fry for culture in captivity. As per the availability of marine resources in coastal states, union territories, and islands of the country, the country's projected aquaculture production is 8 to 16 million tonnes, while current production is very low. Hence, there is an urgent need to set up hatcheries in different coastal states for the production of fry of different varieties of fish, shellfish, and molluscans.

5.4 Ornamental Fishes

The global ornamental fish and aquarium accessories business is estimated to be 25 billion USD. Although there is a rich diversity of ornamental fish species, including about 200 freshwater and 400 marine fish species, India's share is less than 1% by volume, while about 12% by value. The North-East region and the Western Ghats are the two major hotspots for freshwater ornamental fish species. Apart from Andaman and Nicobar and Lakshadweep island groups, marine ornamental fishes are widely distributed in coral reef habitats of the Gulf of Mannar and the Gulf of Kutch.

The Indian ornamental fish trade currently consists mostly of exotic and farmed freshwater species. Most of the marine ornamental fish are caught in the wild, while only 1–10% of species in the trade are estimated to be captively bred, which is in contrast to the freshwater aquaria species, wherein 95% of species are currently bred in captivity. It must be highlighted that nearly all tropical marine fish and invertebrates are taken from coral reefs and adjacent habitats.

In view of the immense potential of indigenous ornamental fish breeds, the Central Government has identified this sector as an important sector and is giving priority to increasing their export and also meet the growing domestic demand. Currently, the domestic trade of ornamental fish is worth Rs. 300 crores, while it is expected to reach Rs. 1000 crores in a few years. It is estimated that around 10 million people are involved in the aquarium business in the country. Considering the immense potential of this sector, the Indian Council of Agricultural Research (ICAR) has undertaken a massive research and development project involving 7 fisheries research institutes in 2018 with the aim of developing and upgrading the breeding technology of important indigenous fish species.

6.0 Harvesting, post-harvest processing and seafood trade

In India 70% of marine fish is sold fresh, the remaining fish is processed, dried and smoked as well as used to produce fish feed. Indian exports of fisheries products mainly consist of frozen shrimps, fish, cuttlefish, squids, dried items, live, and chilled items. Among these, frozen shrimp is the largest exported marine product, which contributes to more than 53% of the total quantity and about 75.11% of the total export by value. Major markets for Indian fish and fish products include America, Southeast Asian countries, European Union (EU), Japan and Middle Eastern countries.

In 2021-22, the frozen fish, cuttlefish and squid contributed 6.08%, 3.61% and 4.94% of the total marine products export value, respectively. The same contributed to 16.55%, 4.31% and 5.53% of the total quantity exported in the same year. Indian marine exports are expected to reach USD 14 billion by 2025. MPEDA has

already proposed a roadmap to achieve this target, which constitutes necessary steps to enhance production and promote seafood.

ICAR-Central Institute of Fisheries Technology (ICAR-CIFT), Kochi, is playing a leading role in modernizing the fisheries and fish processing industry in India towards harvesting and post-harvest, food safety and maintaining quality in the fisheries sector

Many specialty fishery products such as fish mince, surimi, cutlets, fingers, patties, burgers, coated, and shrimp-based products are certified. Cookies, jellies and yogurts are being made from seaweeds on a pilot scale. Chitosan, fish oil, collagen, gelatin and pigments are being developed from fish and shrimp wastes.

7.0 Fisheries Policy and Regulations

Fisheries and aquaculture development in India are governed by several policies and regulations. The first act to regulate fisheries in the country during British rule was the Indian Fisheries Act of 1897. Among the various rules/laws/policies brought out in the post-independence era, the most important ones related to fisheries are:

- Wildlife Protection Act -1972
- Forest Conservation Act – 1980
- Environment Protection Act – 1986
- Coastal Zone Regulation Notification – 1991
- Deep Sea Fisheries Policy – 1991
- Biological Diversity Act – 2002
- Comprehensive Marine Fisheries Policy – 2004
- Coastal Aquaculture Authority Act - 2005
- National Marine Fisheries Policy – 2019
- Fisheries and Aquaculture Policy – 2019

Apart from these, the central government has recently brought out the National Policy for Fisheries, 2020, by integrating national policies related to inland fisheries, marine fisheries and marine fish farming. Along with this, various states have from time to time framed various specific rules related to inland and marine protected areas (Marine Protected Areas – MPA).

8.0 Blue Revolution

India launched the Blue Revolution during 1985-1990 in the Seventh Five Year Plan under the Fish Farmers Development Agency. The fundamental goal of the Blue Revolution was to develop, manage, and promote fisheries to double the farmers' income. The Hon'ble Prime Minister has called for a "revolution" in the fisheries sector and termed it the "Blue Revolution".

Dr Hiralal Chaudhuri and Dr Arun Krishnan are considered the pioneers of the blue revolution in India. Dr Chaudhuri was the architect of induced breeding and spawn production of the economically important carp species in captivity.

The Blue Revolution, with its multidimensional activities, is focused on increasing fish farming and fisheries production and productivity both in the inland and marine sectors. Objectives of this revolution were:

- Increasing fish production responsibly and sustainably for economic upliftment
- Modernization of fisheries using new technologies
- Providing food and nutrition security
- Creating employment and increasing export earnings
- Promoting inclusive development of the fisheries sector

- Empowerment of farmers

The Ministry of Agriculture and Farmers Welfare, Department of Animal Husbandry, Dairying and Fisheries has restructured the scheme by merging all the schemes running under Blue Revolution. A total of Rs.3,000 crore is being spent over five years for integrated development and management of fisheries under this revamped centrally sponsored Blue Revolution scheme as follows:

- National Fisheries Development Board (NFDB) and its activities
- Development of inland fisheries and aquaculture
- Development of marine fisheries, infrastructure and post-harvest operations
- Strengthening the database and geographical Information System of the fisheries Sector,
- Institutional framework for the fisheries sector
- Monitoring, Control and Surveillance (MCS) and other need-based Interventions
- National Scheme for the Welfare of Fishermen

9.0 Challenges to Fisheries and Fish Farming Growth

Increased capacity of fishing boats, overcrowding, water pollution and climate change are the major reasons for the year-on-year decline in fish production in the marine fisheries sector.

Two major constraints affecting marine resources are weak governance and overfishing. Overfishing is a major threat to global biodiversity. Besides, climate change, mechanized fishing and harvesting practices, lack of infrastructure (especially fishing ports and landing centers), lack of adequate cold chain for value addition and upgradation of processing facilities, post-harvest losses, and shortage of skilled manpower is also hampering fisheries growth.

Although the fish farming sector is growing rapidly, the main challenges are the non-availability of disease-free quality fish fry, fish feed with a good feed conversion ratio, disease problems and the non-availability of improved breeds. Although the diversity of fish breeds has provided some options, the production of fry of those breeds has not been as desired. The adoption of modern technology and scientific husbandry practices in inland fisheries is improving.

10.0 Conclusion

In order to harness the potential of the fisheries sector, it is necessary to overcome main constraints such as the high cost of fish feed, lack of value addition, post-harvest losses and in efficient cold chain system for transportation. Value addition of both farmed and capture fisheries would enable fish farmers to fetch more price. Exploration of deep-sea resources and discovery of new fishing grounds through applications of remote sensing and space technologies is a great promise. Further, capacity building of young fish farmers through hands-on training is essential to reduce pre and post-harvest losses.

New schemes like Sagarmala, Pradhan Mantri Matsya Sampad Yojana (PMMSY), Fisheries and Aquaculture Infrastructure Development Fund (FIFA) and Blue Revolution are aimed at increasing production and productivity in fisheries as well as strengthening infrastructure, post-harvest management, value chain, quality control, marketing and in creating employment for youth and women in this sector. Thus, in order to harness the full potential of the Blue Revolution, efforts need to be made to realize the sectoral goals with Blue Economy and Blue Growth initiatives, which will help to achieve nutritional security.

11.0 Reference:

1. CMFRI, 2022. Marine Fish Landings in India 2020. Technical Report, CMFRI Booklet Series No. 25/2022 (Accessed on 21st October 2022).
2. Department of Fisheries, 2022. Blue Revolution. https://dof.gov.in/blue-revolution (Accessed on 21st October 2022).
3. FAO. 2022. The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome, FAO. https://doi.org/10.4060/cc0461e (Accessed on 23rd October 2022)
4. GoI 2020. Handbook on fisheries statistics 2018. Department of Animal husbandry, Dairying and Fisheries, Ministry of Agriculture, Government of India, Krishi Bhavan, New Delhi https://dof.gov.in/sites/default/files/2021-02/Final_Book.pdf (Accessed on 23rd October 2022)
5. Lakra W.S. and Gopalakrishnan, A. 2021. Indian J. Fish., 68(1): 137-150. W.S. Lakra_IJF68(1)2021.pdf (Accessed on 22nd October 2022).
6. NFDB 2019. Aquaculture technologies implemented by NFDB. National Fisheries Development Board, Department of Fisheries Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India, Hyderabad, India, 58 pp. https://nfdb.gov.in/PDF/E%20Publications/14%20Aquaculture%20Technologies%20Implemented%20by%20NFDB.pdf (Accessed on 23rd October 2022)
7. Domínguez, L.M. and Botella, Á.S., 2014. An overview of marine ornamental fish breeding as a potential support to the aquarium trade and to the conservation of natural fish populations. Int. J. Sus. Dev. Plann. Vol. 9, No. 4 (2014) 608–632 © 2014 WIT Press, www.witpress.com; ISSN: 1743-7601 (paper format), ISSN: 1743-761X (online), http://journals.witpress.com DOI: 10.2495/SDP-V9-N4-608-632 (Accessed on 21st October 2022)
8. IBEF, 2022. Marine Products. https://www.ibef.org/exports/marine-products-industry-india. Accessed on January 12, 2023.

MANAGE
HYDERABAD

KSTA
BANGALORE

MANAGE, Rajendranagar,
Hyderabad - 500 030, Telangana,
email: helpline@manage.gov.in;
Phone: 040-24594509

Karnataka Science and Technology Academy,
Major Sandeep Unnikrishnan Road,
Vidyaranayapura Post, Bengaluru – 560 097
Email: ksta.gok@gmail.com
Phone: 080-29721550

ksta.gok@gmail.com
sushrirekha.manage@gmail.com

kstacademy
@kstacademy
kstacademy.in

Manage.hyd
@managehyd
manage.gov.in