Intellectual assets management and transfer in food science sector in Indian research and development organizations

Vikram Singh¹ · Kajal Chakraborty²

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Abstract In recent years, the food science sector has gained importance since the society is focusing on high-quality and safety foods. With a specific end goal to meet this societal need, the research and development organizations in India have adopted innovative technical and research processes, which gave more accentuation on intellectual assessment in food processing industry. The global Intellectual Property regime in food science sector had witnessed an increment in the number of patents filed and granted during 2006–2010. Ever since there has been a gradual increase in the number of patents applied mainly in food processing industries by research organizations related to food sciences, for example, those working under the aegis of ICAR and CSIR in India. In this study, a review has been done on the intellectual assets generated by ICAR and other national research organizations in India, in the food science sector. Emphasis has been given on the global relevance of these assets, modes of IP protection and technology transfer mechanisms followed by different public and private organizations.

Keywords Intellectual assets · IPR · IPC · Patents · Partnerships · Trademarks · Technology transfer

Introduction

The food processing industry in India ranks fifth in the world in exports, production and consumption. This segment is

growing at a faster pace through reinforced linkages between industry and agricultural producers. This industry accounts for 32 % of the country's total food market, 14 % of manufacturing GDP, 13 % of India's exports and 6 % of total industrial investment. It is also recognized as a 'sunrise industry' of India, which covers a wide range of products such as fruits and vegetables; meat and poultry; milk and milk products; alcoholic beverages; fisheries; plantation; grain processing; and other consumer product groups. The Indian food and grocery market is the world's sixth largest market, with retail contributing 70 % of the sales. It is projected to grow at the rate of 10.4 %, touching US\$ 482 billion by 2020 (www.mofpi.nic.in/).

The government has accorded high priority to food processing sector, with a number of fiscal reliefs and incentives, to encourage commercialization and value addition to agricultural produce, for minimizing pre/post harvest wastage, generating employment and export growth. National Food Processing Policy of India aims to increase the level of food processing from 10 % in 2010 to 25 % in 2025. (www.makeinindia.com/).

India was the eighth largest country in terms of research and development (R&D) investments in 2013, accounting for 2.7 % of global R&D expenditure and was expected to increase to US \$ 44 million in the subsequent years from US\$ 40 billion in 2012 (www.ibef.org/). In order to meet the R&D objectives and strategies envisaged under the India's new Science, Technology and Innovation (STI) policy (2013), the research institutions should focus on creation, management and transfer of innovative intellectual assets. Intellectual assets management in food science sector in Indian research and development organizations is of particular interest due to the recent development of functional food industry. The Indian Council of Agricultural Research (ICAR) is an autonomous organization under the Department of Agricultural Research

✉ Vikram Singh
kmmnms@gmail.com

¹ IP & TM Unit, ICAR, New Delhi 110012, India

² Central Marine Fisheries Research Institute, Kochi 682 018, India

and Education (DARE), Ministry of Agriculture, Government of India. The Council is the apex body for coordinating, guiding and managing research and education in agriculture including horticulture, fisheries and animal sciences in the entire country (www.icar.org.in/). ICAR established a three tier Intellectual Property (IP) management system in the year 2006 to manage the intellectual assets, where each institute is equipped with knowledge, manpower and freedom of decision, governed by the “Guidelines for Intellectual Property Management and Technology Transfer/Commercialization” (ICAR 2006). In order to institutionalize this system ICAR launched a scheme titled “Intellectual property management and transfer/commercialization of Agricultural technology scheme” in its XIth plan budget, which has completed 5 years in 2012. This scheme is being given more focus in XIIth plan budget (2012–17) and rechristened as National Agriculture Innovation Fund (NAIF) with major emphasis on innovation and incubation components.

The objectives of this review were to know the intellectual assets of food science sector and their IP management status in ICAR and other national research organizations and evaluation of technology/IP transfer mechanisms followed by different public and private organizations, and their present status.

Materials and methods

This study is the outcome of assessments of reports, schedules and data of the XIth plan scheme for IP management at ICAR; and food research related IP data from websites of Indian Patent Office (IPO), World Intellectual Property Organization (WIPO), European Patent Office (EPO), United States Patent and Trademark Office (USPTO), Council of Scientific and Industrial Research (CSIR), Defence Research and Development Organization (DRDO) and other paid IP search engines.

As part of the data collection for evaluation and assessment, the Intellectual Property & Technology Management (IP & TM) Unit of ICAR developed three preforma, namely, Self-Review, IP Data-Updation and Result Framework Document (RFD). These performas’ pertain to the management of IP portfolio, commercialization of technologies, outreach activities, capacity building in IP management etc. The structure of the performas’ and criteria set for evaluation, were prepared by experts in IPR field, by taking into account the suggestions from officials of Zonal Technology Management Unit (ZTMU) and Institute Technology Management Unit (ITMU). These were also included in divisional documents of IP & TM Unit for ISO 9001:2008 Certificate, which was authorized and audited by Bureau of Indian Standards (BIS). The information for Self review and IP Data updation were collected on annual basis and Results-Framework Document (RFD) on monthly basis since 2008, from all ICAR institutes.

The collected information were analyzed and evaluated against the IP asset databases of other research organizations like CSIR and DRDO, and IP offices like IPO and WIPO. The details such as processing status of patents and trademark applications filed by ICAR institutes, their IPC, mode and status of commercialization and their impact/outcome were studied.

The International Patent Classification (IPC), built up by the Strasbourg Agreement 1971, accommodates a various leveled arrangement of language independent symbols to classify patents (or utility models) as indicated by the distinctive areas of technology to which they relate. The specialized substance of all the patent records published worldwide is arranged utilizing this framework. The publishing office allots IPC symbol(s) which are substantial at the time of publication. The text of the IPC can be found in the WIPO website. The intellectual assets management in food science sector falls under the IPC classes (A) Human necessities, (B) Performing Operations; Ran-sporting, (C) Chemistry; Metallurgy, (E) Fixed Constructions, (F) Mechanical Engineering; Lighting; Heating; Weapons; Blasting, (G) Physics and (H) Electricity.

Results and discussion

Management of intellectual assets of food science sector

Intellectual assets tend to achieve the greatest benefits when combined with other assets (Basu et al. 2003). To manage and protect these resources, the ICAR institutes utilize different IP tools, such as, patents, trademarks, copyrights, and designs. While taking into account the overall patent applications filed since 2009 at IPO, ICAR stands at 3rd position among other scientific research and development organizations in India. In the year 2011–12, ICAR could able to gain the 2nd position, finishing narrowly behind CSIR. The Fig. 1 showed an analysis of IPO data base (IPO Annual Reports 2009–10, 2010–11, 2011–12, 2012–13, 2013–14), where CSIR was the leading R&D organization in patent application filing from 2008 to 09 onwards, followed by DRDO and ICAR. This trend of growing IP protection in ICAR is the outcome of a contiguous efforts put for IP awareness and implementation by the three tiers IP management system.

IP scenario of ICAR in food science sector

Patents

It is an important IP tool which is governed through the Indian Patent Act 1970, where the law recognizes the exclusive right of a patentee to gain commercial advantage out of his invention. The first patent application IN62566 was filed on 12th

Fig. 1 Patent filing trend of R&D organizations at IPO

December, 1957 by ICAR for “A Process of Preparation of Fat Liquors from an Indigenous Non-Edible Oil”. Sardine fish oil by sulfating the oil under suitable conditions and thereafter mixing it with mineral oil and the like, which was granted on 23rd February, 1959, followed by IN704016 for “Continuous Ghee Making Machine” in 1960; IN132165 for “A Process for Manufacture of Buffalo Evaporated Milk” in 1972; and IN160280 for “Processing of Whey for the preparation of Acidophilus whey drink ‘Acido whey’” in 1985 to National Dairy Research Institute (NDRI), Karnal (Suman and Pandey 2014). In continuation to this, two additional patents were granted to ICAR viz. “An Automatic Brine Dispenser for Delivering Correct Quantities of Brine into Cans during Prawn Canning Operation” (IN137830) and “A process for the preparation of Bacteriological Peptone From Miscellaneous Fish” (IN137785) in 1973. All these patent applications were filed by individual researchers based on their available resources and interest in the field of IP, which continued till 2000, with 21 patent applications filed by four ICAR institutes viz. NDRI at Karnal, Central Avian Research Institute (CARI) at Izatnagar, Central Tuber Crop Research Institute (CTCRI) at Kerala, and Central Institute of Fisheries Technology (CIFT) at Cochin from 1952 to 2000.

With the emergence of TRIPS agreement and other IP related acts/schemes during the 90’s, the awareness regarding the IP protection and its importance among the scientific community also increased. This in turn led to the filing of 41 patent applications by nine ICAR institutes from 2001 to 2005. In order to meet the requirements of TRIPS agreement and enhance the protection of IP enabled research, ICAR had implemented its IPR guidelines and launched an IP specific scheme in XIth plan period (2007–2012) in the year 2006. These efforts led to the successful filing of 86 patent applications in different streams of food processing during 2006–10 by the twelve ICAR institutes. Other than these efforts, ICAR had also launched one national level World Bank funded project viz. National Agricultural Innovation Project (NAIP), with a specific component for value chain development and IP protection, which added 57 more applications in this field from

2011 to 2014 by involving 18 ICAR institutes. In this way 29 ICAR institutions filed 205 patent applications in food processing sector from 1952 to 2014.

The Fig. 2 showed a continual growth in filing of patent applications (except 2011–14) and involvement of the ICAR institutes. These ICAR institutes belongs to different subject streams of agricultural research viz. Agricultural Engineering (3); Animal Science (11), Crop Science (2), Fisheries (2), Horticulture (8), and Natural Resource Management (3). Out of these 29 ICAR institutes, five institutes alone filed 73.45 % of patent applications viz. NDRI, Karnal (33.63 %); CIPHET, Ludhiana (19.03 %); CIFT, Cochin (10.62 %); CIRG, Makhdoom (5.31 %); and IVRI, Izatnagar (4.87 %), remaining 26.55 % applications were filed by 24 ICAR institutes.

Patent classifications

Patent applications were classified according to their subject area and utility in food science research. There were 10 research areas, whose inventions were filed for patenting, viz. milk based products and processes (31 %), food processing machinery (15.72 %), fish based products and processes (13.54 %), fruit and vegetable based products and processes (11.35 %), value added food products and processes (8.30 %),

Fig. 2 Trends of patent applications filing at ICAR

milk adulteration detection technologies (6.55 %), meat based products and processes (6.11 %), poultry based product and process (3.49 %), spice based products and process (2.18 %), and food product ingredients (1.75 %) (<http://www.techcorplegal.com/>). Among these different research areas, the milk based products and food processing machinery lead in IP protection, which was apparently due to the support of well established research system of NDRI at Karnal and CIPHET at Ludhiana (Fig. 3).

In the patent grant process the IPO publishes the complete patent applications with International Patent Classification (IPC) of WIPO, which has a total of eight sections (A to H). Till June, 2015 the IPO had published 127 patent applications of ICAR in food science sector with IPC codes, which falls in its seven sections (Fig. 3) viz. Section A-Human Necessities (64.56 %); Section C-Chemistry and Metallurgy (12.59 %), Section B-Performing Operations and Transporting (11.02 %); Section G-Physics (4.72 %); Section F-Mechanical Engineering, Lighting Heating, Weapons and Blasting, and Section D-Textiles and Paper (3.14 %) each; (1 %); and Section E- Fixed Constructions (0.78 %) (www.wipo.in/).

On further analysis of this classification using IP search tools, it was found that in Section- A, a total of eighty one applications were filed under its sub-sections A01, A21, A23, A47 and A61; whereas in Section-C, the total number of applications filed were sixteen under the sub-sections C07, C08, C11, C12, and C13. In Section-B 14 applications were filed under its sub-sections viz. B02, B03, B07, B26, B60, B62 and B65. Six applications were filed under the Section-G and its sub-sections G01 and G06. Four applications in each Section-F (F16, F17, F26 and F28) and Section-H (H02 and H04) had been filed; whereas one application was filed in Section-E (E04). Table 1 depicts these sub-classes with the

number of patent applications in major classes. The spread of patent applications in IPC as well as in subject specific classification indicates that, the ICAR institutes have a holistic approach of research and cover all the relevant areas of food processing. It also supports the research institutes to compete at national and international platforms, because IP protection is an important symbol for progressive research.

Present status

As per analysis of the IPO database the present status of above applications are as follows: 21 (13 %) patents were granted to six ICAR institutes viz. NDRI, Karnal (6); CARI, Izatnagar and CIPHET, Ludhiana (5 each); CPCRI, Kasargod (3) and CIFT, Cochin and CTCRI, Kerala (one each). The remaining applications were in the process of grant or at different steps at Indian Patent Office viz. applications not yet published (25 %) (newly filed applications), applications awaiting examination (23 %), and applications under examination (13 %).

Some of the applications were not accepted by the IPO for the grant process due to incomplete information about invention, which were classified as application deemed to be withdrawn U/S 11B (4) (9 %) (Request for examination was not filed within the time limit), applications abandoned U/S 21(1) (8 %) (Requirements were not met by the applicant), application abandoned under Section 9(1), (where applications were not filed completely) (3 %). These applications were filed from 2001 to 2006, when ICAR did not have specific guidelines for IPR and any scheme or programme for IP awareness. During this period the inventors neither have expertise nor support to write or to explain their claims. After implementing the IP management scheme at IP & TM Unit of ICAR, this problem was addressed through the ZTMCs and ITMUs. The present status

Fig. 3 Subject specific classifications of IP protected intellectual assets

Table 1 International Patent Classification (IPC) of patent application filed in food processing sector

IP-CLASS	Sub-Section	Subject Area	No of Applications
Section A — Human necessities (81)			
A01: Agriculture; Forestry; Animal Husbandry; Hunting; Trapping; Fishing (9)	A01D	Harvesting; Mowing	1
	A01F	Threshing	1
	A01G	Horticulture; Cultivation of Vegetables, Flowers, Rice, Fruit, Vines, Hops, or Seaweed; Forestry; Watering	2
	A01J	Manufacture of Dairy Products	1
	A01K	Animal Husbandry; Care of Birds, Fishes, Insects; Fishing; Rearing or Breeding Animals, not Otherwise Provided for; New Breeds of Animals	4
A21: Baking; Equipment for Making or Processing Doughs; Doughs for Baking (1)	A21D	Treatment, e.g. Preservation, of Flour or Dough for Baking, e.g. by Addition of Materials; Baking; Bakery Products; Preservation Thereof	1
A23: Foods or Foodstuffs; Their Treatment, Not Covered by Other Classes (58)	A23B	Foods or Foodstuffs; Their Treatment, not Covered by other Classes	1
	A23C	Dairy Products, e.g. Milk, Butter, Cheese; Milk or Cheese Substitutes; Making Thereof	17
	A23G	Cocoa; Cocoa Products, e.g. Chocolate; Substitutes for Cocoa or Cocoa Products; Confectionery; Chewing Gum; Ice-Cream; Preparation Thereof	1
	A23J	Protein Compositions for Foodstuffs; Working-Up Proteins for Foodstuffs; Phosphatide Compositions for Foodstuffs	2
	A23L	Foods, Foodstuffs, or Non-Alcoholic Beverages not Covered by Subclasses A21D or A23B-A23J	30
	A23N	Machines or Apparatus for Treating Harvested Fruit, Vegetables, or Flower Bulbs In Bulk, not Otherwise Provided for; Peeling Vegetables or Fruit In Bulk; Apparatus For Preparing Animal Feeding-Subs	7
	A23P	Apparatus for Treating Harvested Fruit, Vegetables, or Flower Bulbs In Bulk, not Otherwise Provided for; Peeling Vegetables or Fruit In Bulk; Apparatus For Preparing Animal Feeding-Subs	7
A47: Furniture; Domestic Articles or Appliances; Coffee Mills; Spice Mills; Suction Cleaners in General (1)	A47J	Kitchen Equipment; Coffee Mills; Spice Mills; Apparatus for Making Beverages	1
A61: Medical or Veterinary Science; Hygiene (12)	A61B	Diagnosis; Surgery; Identification	3
	A61D	Veterinary Instruments, Implements, Tools, or Methods	2
	A61K	Preparations for Medical, Dental, or Toilet Purposes	7
Section B — Performing operations; Ransporting (14)			
B02: Crushing, Pulverising, or Disintegrating; Preparatory Treatment of Grain for Milling (1)	B02C	Crushing, Pulverising, or Disintegrating in General; Milling Grain	1
B03: Separation of Solid Materials Using Liquids or Using Pneumatic Tables or Jigs; Magnetic or Electrostatic Separation of Solid Materials from Solid Materials or Fluids; Separation by High-Voltage Electric Fields (1)	B03B	Separating Solid Materials Using Liquids or Using Pneumatic Tables or Jigs	1
B07: Separating Solids from Solids; Sorting (2)	B07B	Eparating Solids from Solids by Sieving, Screening, or Sifting or by Using Gas Currents; other Separating by Dry Methods Applicable to Bulk Material	1
	B07C	Postal Sorting; Sorting Individual Articles, or Bulk Material Fit to be Sorted Piece-Meal	1
B26: Hand Cutting Tools; Cutting; Severing (4)	B26B	Hand-Held Cutting Tools Not Otherwise Provided For	2
	B26D	Cutting; Details Common to Machines for Perforating, Punching, Cutting-Out, Stamping-Out or Severing	2
B60: Vehicles in General (2)	B60B	Vehicle Wheels	1
	B60P	Vehicles Adapted For Load Transportation or to Transport, to Carry, or to Comprise Special Loads or Objects	1
B62: Land Vehicles for Travelling otherwise than on Rails (2)	B62B	Hand-Propelled Vehicles e.g. Hand Carts or Perambulators; Sledges	2
B65: Conveying; Packing; Storing; Handling Thin or Filamentary Material (2)	B65B	Hand-Propelled Vehicles, e.g. Hand Carts or Perambulators; Sledges	1
	B65D	Containers For Storage or Transport of Articles or Materials	1

Table 1 (continued)

IP-CLASS	Sub-Section	Subject Area	No of Applications
Section C — Chemistry; Metallurgy (16)			
C07: Organic Chemistry (5)	C07D	Heterocyclic Compounds	2
	C07G	Compounds of Unknown Constitution	1
	C07H	Sugars; Derivatives Thereof; Nucleosides; Nucleotides; Nucleic Acids	1
	C07K	General processes for the preparation of peptides: Growth factors; Growth regulators	1
	C08B	Polysaccharides; Derivatives Thereof	1
C08: Organic Macromolecular Compounds; Their Preparation or Chemical Working-Up; Compositions Based Thereon (1)			
C011: Animal or Vegetable oils, Fats, Fatty Substances or Waxes; Fatty Acids There from; Detergents; Candles (2)	C11B	Producing, e.g. by Pressing Raw Materials or by Extraction from Waste Materials, Refining or Preserving Fats, Fatty Substances, e.g. Lanolin, Fatty Oils or Waxes; Essential Oils; Perfumes	2
C12: Biochemistry; Beer; Spirits; Wine; Vinegar; Microbiology; Enzymology; Mutation or Genetic Engineering (6)	C12N	Micro-organisms, e.g. protozoa; Compositions thereof	3
	C12Q	Measuring or Testing Processes Involving Enzymes or Micro-Organisms	3
C13: Sugar Industry (2)	C13D	Sugar Industry	1
	C13J	Sugar Industry	1
Section E — Fixed constructions (1)			
E04: Building (1)	E04C	Structural Elements; Building Materials	1
Section F — Mechanical engineering; Lighting; Heating; Weapons; Blasting (4)			
F16: Engineering Elements or Units; General Measures For Producing and Maintaining Effective Functioning of Machines or Installations; Thermal Insulation In General (1)	F16D	Couplings For Transmitting Rotation	1
F17: Storing or Distributing Gases or Liquids (1)	F17B	Gas-Holders of Variable Capacity	1
F26: Drying (1)	F26B	Drying Solid Materials or Objects by Removing Liquid There from	1
F28: Heat Exchange In General (1)	F28F	Details of Heat-Exchange or Heat-Transfer Apparatus, of General Application	1
Section G — Physics (6)			
G01: Measuring; Testing (5)	G01N	Investigating or Analysing Materials by Determining Their Chemical or Physical Properties	5
G06: Computing; Calculating; Counting (1)	G06F	Electric Digital Data Processing	1
Section H — Electricity (4)			
H02: Generation, Conversion, or Distribution of Electric Power (2)	H02J	Circuit Arrangements or Systems for Supplying or Distributing Electric Power; Systems For Storing Electric Energy	2
H04: Electric Communication Technique (2)	H04M	Telephonic Communication	1
	H04R	Loudspeakers, Microphones, Gramophone Pick-Ups or Like Acoustic Electromechanical Transducers; Deaf-Aid Sets; Public Address Systems	1

revealed that an aggregate of 18 % applications were published, whilst 7 % of the total number of patent applications was under consideration for final sealing.

Granted patents

Twenty one patents were granted to six ICAR institutes, out of which some important patents are as follows:

Machinery- Automatic brine dispenser, continuous ghee making machine, coconut deshelling machine, manually operated tender coconut punch and cutter, whey-mango beverage, biotechnological interventions to extract starch flours from cassava.

Methods- Determining maturity of intact mango in tree, preparing cooked chicken roll and stock, and mustard oil based chicken gizzard pickle.

Processes- Commercial manufacture of Kradi (semi-soft cheese), conversion of paddy husk ash into bleaching material for edible oil, buffalo evaporated milk, preparation of bacteriological peptone from miscellaneous fish, preparation of fat liquors from an indigenous non-edible oil, preparation of mixed chicken loaf, preparation of low cholesterol ghee, dehulling of mustard seeds, preparation of acidophilus whey drink “Acido whey”, production of absorbable surgical sutures from fish gut collagen, and technique for processing of the mustard seed for reducing refining cost and improving quality of oil.

Trademarks

Trademarks are any sign or combination of signs capable of distinguishing the goods or services of one undertaking from those of the other. The TRIPS Agreement provides initial registration and renewal for a term not less than 7 years, and shall be renewable indefinitely. This IP tool has been effectively utilized by a total of 26 ICAR institutes and had registered 70 trademarks for their food products and processes. Out of these 70 trademarks 67 were filed in between 2009 to 2015, which show the awareness effect of IP based schemes and capacity building programmes in ICAR institutes.

Trademark classification in India refers to 34 categories for goods and 8 for services. These trademarks were classified according to their subject domain, namely, Horticulture (10): banana, coconut and vegetable based products and process, spices and their outputs; Animal Science (8): meat products and process, and Mithun by-products; Crop Sciences (7): crop based food products and pickle and juices; and Fisheries Sciences (7): Fish based food products and process. As per Goods & Service details in Indian Trademark Act 1999, 45 classes are there to register the products, logos, process at Trademarks registry. ICAR institutes registered their logos, products, services, and process in 18 trademark classes’ (<http://intellectualpropertyindia.co.in/>), viz. in Goods: Class-1 (chemical products used in industry, science and agriculture), Class 5 (pharmaceuticals and other preparations), Class 7 (machines, machine tools, motors and engines), Class 8 (hand-operated implements), Class 9 (apparatus and instruments for scientific research in laboratories), Class 18 (leather, leather imitations, travel goods), Class 22 (raw fibrous textile materials), Class 29 (foodstuffs of animal origin as well as vegetables), Class 30 (foodstuffs of plant origin), Class 31 (foodstuffs for animals), Class 32 (non-alcoholic beverages), Class 33 (alcoholic beverages except beers); and Services: Class 35, 40, 41, 42, 44, 45 where services provided by persons, individually, institution or collectively, in relation to agriculture, horticulture and forestry or industry.

The above IP protection details revealed that ICAR as an apex body of research in agricultural sector manages its IP resources with continual growth and proper maintenance, which generate different collaborations, consultancies, contract research and services. Efforts in this direction reached to one step ahead of it by transferring these assets to their end-users. IP protection is a source of repute in scientific community for the researchers as well as organizations.

IP scenario of CSIR in food science sector

CSIR is a contemporary R & D organization, with a dynamic network of 38 national laboratories, 39 outreach centres, 3 innovation complexes and 5 units in India. It has pioneered India’s intellectual property movement where it granted 90 % of US patents granted to any Indian publicly funded R & D organization. On an average CSIR files about 200 Indian patents and 250 foreign patents per year. About 13.86 % of CSIR patents were licensed, a number which is above the global average (www.csir.res.in/).

In CSIR, 25 laboratories works on food science based research mandates and projects. These laboratories started protecting their research outcomes in food science sector by filing the first patent in Great Britain in 1942 by CFTRI, Mysore. This trend continued till 1980’s on individual’s research interest basis, but after implementation of WTO guidelines and TRIPS agreements this scenario changed with increasing trend in IP protection. In an analysis the year wise trend of IP filing at CSIR shows that 65 patent applications were filed from 1942 to 1990; followed by 46 applications were between 1991 to 2000; but in 2001 to 2010 this number increased by 249 which shows the impact of IP awareness at organizational as well as national level (www.patinformatics.com).

This trend continued with filing of 57 patent applications from 2011 to 2015. The total number of granted patents to CSIR is 3106, whereas CFTRI alone has the credit to obtain a total number of 348 granted patents in India and abroad. Out of total number of patent applications filed by the CSIR laboratories, 55 were filed in different countries through Great Britain (4) and USPTO (51) by ten CSIR labs; where CFTRI, Mysore alone has been granted with 25 patents (www.patestate.com/, CSIR patents in force 2015).

IP filing trend at IPO in food science sector

Indian Patent Office (IPO) classified its patent application according to their area of inventions, viz. chemical, drug, food, electrical, mechanical, computer/electronics, biotechnology, engineering and other fields, whereas food based inventions were categorized separately. In an analysis of Annual Reports of IPO from 2001–02 to 2013–14 for food based research inventions, it was found that a total of 4518 patent applications [455 (1997

to 2000); 643 (2001 to 2005); 1972 (2006 to 2010); and 1488 (2011 to 2014)] were filed and 1595 applications [415 (1997 to 2000); 420 (2001 to 2005); 567 (2006 to 2010); and 193 (2011 to 2014)] were granted to different national and international institutes in food science sector. This growing trend in filing patent application and their grant apparently emphasize the importance and market demand of food science sector research in India as well as in other concerned countries. The Fig. 4 gives an overview of the trend in patent filing at IPO in food science sector, which showed the continual growth in IP protection in this field. The importance of food sector increased due to the change of food habits and availability of food items in the global market (IPO 2009, 2010, 2011, 2012, 2013).

IP filing trend at WIPO in food science sector

WIPO is the global forum for intellectual property services, policy, information and cooperation, which is a self-funding agency of the United Nations, with 188 member states, with a mission to lead the development of a balanced and effective international intellectual property (IP) system that enables innovation and creativity for the benefit of all. The Patent Cooperation Treaty (PCT) assists applicants in seeking patent protection internationally for their inventions, helps patent offices with their patent granting decisions, and facilitates public access to a wealth of technical information relating to those inventions. By filing one international patent application under the PCT, applicants can simultaneously seek qualification on protection for an invention in 148 countries throughout the world (www.wipo.int).

WIPO classified its PCT international applications according to 30 classifications under 5 major Sections based on the International Patent Classification (IPC) system. Out of these classes, one was named as Agricultural and Food Processing, Machinery and Apparatus (2003–2006) under Process Engineering Section. After 2006 this classification was changed and food science related inventions were placed under Chemistry with the name of Food Chemistry. WIPO patent

statistics from 2000 to 2012 was analyzed to know the international trends of patent filing in food processing sector (national and international through PCT) in different countries, which shows that 318,395 national [105,186 (2000 to 2004), 119,886 (2005 to 2009) and 93,323 (2010–2012)] and 11,832 international (PCT) [3741 (2000 to 2004), 3258 (2005 to 2009) and 4833 (2010–2012)] applications were filed in this sector (WIPO 2007, 2010, 2013, 2014).

The Fig. 5 illustrated the patent filing status of the 17 leading inventor countries in food science for the period of 8 years from 2003 to 07 and 2007–11, where, USA (22,845), China (19,283), Russia (17,015), Japan (15,083), and Korea (12,423) were the leading nations with 67 % share of total filed applications. Other than these countries 11 % applications were filed by other nations.

Transfer of intellectual assets

The incentive structures and the competencies of the national institutes determine the rate and direction of technological learning in a country (Patel and Pavitt 1994). It is of note that these institutions, which jointly and individually contribute to the development and diffusion of new technologies provide the framework to implement policies in a country as a whole. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artifacts which define new technologies (Metcalf 1995). Management of the intellectual asset and transfer through technology commercialization are parallel processes of radical and incremental innovation, the determination of technical and business feasibility, the creation of intellectual assets, and the development of a plan to enter the market (Chakraborty 2013).

Before implementing the XIth plan scheme of IP management at ICAR, its intellectual assets were generally used to transfer through institute extension system, where gap between demand and supply was unfilled. To bridge this gap ICAR as well as its World Bank funded National Agricultural Innovation Project (NAIP), introduced a system, where business aspect was introduced through Zonal Technology Management and Business Planning and Development Units (ZTM&BPDUs). This new system in collaboration with ITMUs developed a business environment for ICAR technologies. The objectives of this initiative was to promote relationships, communication and collaboration, strengthen interaction, encourage support and development of research with commercial potential, conversion of research results into new products and processes, and to secure reasonable compensation (DeGeeter 2010).

Intellectual assets

Intellectual assets are the technologies produced by the ICAR institutes, which may be an input, device, process, practice,

Fig. 4 Year wise patent filing at IPO in food science sector

Fig. 5 Country wise patent filing at WIPO in food science sector

implement, know-how, tool or group of multidisciplinary approach which developed through continuous selection, improvement, up-gradation, and association of existing and traditional practices, by using new methods of diagnosis/treatments from biological, physical and chemical sciences. A total of 145 such intellectual assets were developed by 28 ICAR institutes, which belonged to different research mandates of agriculture and allied sciences viz. CIPHET at Ludhiana (33.79 %); NDRI at Karnal (16.55 %); NRC for Banana, at Tiruchirapillai (5.52 %); CTCRI at Thiruvananthapuram and IARI at New Delhi (4.83 % each); 4.14 % by IIHR at Bangalore and IVRI at Izatnagar each; whereas 3.45 % each by NRCM at Hyderabad and IIMR at Hyderabad. CIFT and CMFRI, both at Cochin, and CPCRI at Kasargod shared 2.76 % each; and the remaining 10.35 % technologies were developed by a total of 16 other ICAR research institutes.

These intellectual assets were classified in eight subject specific areas according to their research domain, which were transferred by signing agreements with different public and private organizations viz. fruit and vegetable products and processes (33.33 %); crop based food products and processes (18.93 %); food processing machinery (14.40 %), meat products and processes (11.93 %); milk adulteration detection technologies (9.47 %); fish products and processes (5.76 %); milk products and processes (4.12 %) and bakery products and processes (2.06 %). The Fig. 6 indicates the technology development by the ICAR institutes and its transfer through Public-Private Partnerships (PPP), where fruit and vegetable (F&V) products and processes were leading in the total number of technologies developed by the ICAR institutes and its transfer to the end user, followed by crop products/processes and food processing machinery. The bakery products and processes were on least stage due to lack of implications of such research area in ICAR.

Some important intellectual assets which were transferred by respective institutes to different public and private organizations are as follows:

- *Fruit and vegetable products and processes*: Virgin coconut oil preparation by hot process, capsicum salsa, banana flour based baby food;
- *Crop based food products and processes*: Technology for groundnut milk, paneer and curd production, cassava extruded products, value added fried products and fried chips from tapioca;
- *Food processing machinery*: Litchi fruit peeling machine, Khoa making machine, continuous paneer making machine;
- *Meat products and processes*: Emulsion based chicken products, retort pouch technology for shelf stable meat products, technology for cured and smoked meat products;
- *Milk adulteration detection technologies*: Color based test for rapid detection of detergent in milk, detection kit of β -lactum antibiotic group in milk, strip based test for detection of maltodextrin in milk;
- *Fish products and processes*: Ready-to-serve fish curry in retortable pouches, fish based extruded product, Cadalmin-green algal extract;

Fig. 6 Subject specific classifications of intellectual assets

- *Milk products and processes*: Herbal Ghee, ready to cook milk chips technology, low cholesterol ghee; and
- *Bakery products and processes*: Iron fortified biscuits, pasta technology, breads and biscuits from black rice.

Protected assets transfer

The transfer of protected IP assets is the prime responsibility of research organization like ICAR, having 205 patent applications at IPO and 32 trademarks filed by 13 institutes. Out of these protected assets, 23 patent applications and some of the trademarks were transferred to different organisations and stake holders through commercialization process. This was an important achievement, where 16 % of transferred assets were protected by IP law against the world average, which is less than 1 % (DeGeeter 2010). Thus 15 % partnerships were developed with IP protected assets within a short time span, which is a successful indicator for a research organization.

Partnership development

To transfer the IP enabled assets, 27 ICAR institutes (viz. CIPHET at Ludhiana (40.03 %); NDRI at Karnal (14.40 %); CTCRI at Trivatanpuram (6.17 %); NRC for Banana at Trichy (5.76 %); CIFT at Cochin (4.53 %); and remaining 28.81 % developed by 22 other ICAR institutes) developed 243 partnerships with 188 national and international organizations, during the period 1997 to 2005 (8), 2006 to 2010 (72) and 2010 to 2015 (163). These organizations were classified according to their domain area, regions, administration and control and found that 40.32 % partnerships were developed directly with entrepreneurs, followed by local organizations (28.49 %) which operate in the local areas (at district or block levels), 15.59 % State level companies, 6.45 % National level companies, 3.76 % State government departments, 2.69 % each by multinational companies and National Institutes.

Mode of transfer

To transfer the IP protected assets, the ICAR institutes used different mode of transfer, which fixed the responsibility of the partner as well as respective institutes for security, sensitivity and technical feasibility. All these technologies were assigned to the partners through signing of Memorandum of Understandings (43 %), licensing agreements (40 %), consultancy agreement (13 %), contract research agreements (2 %) and know-how and direct supply to different entrepreneurs and stakeholders (2 %). The score of MoUs is high; because most of the assets were in the form of know-how, which were transferred through technical assistance; advise, suggestions, onsite guidance etc.

Impact of IP management system

Harmonization of IP regimes, access to technologies required for research and development through easy licensing and/or patent exemptions especially for public goods oriented research would pave way for making private investment or private public participation attractive (Ramesha et al. 2010). As mentioned, 145 technologies in eight different streams of food science research to 188 partners. The partnerships spread over the country which include local entrepreneurs, state and national level companies, government organisations as well as national and international institutes.

DRDO-FICCI ATAC programme

The DRDO and Federation of Indian Chambers of Commerce and Industry (FICCI) initiated a collaborative programme in 2008 for commercializing the outcomes from 50 research laboratories in India, which was named as Accelerated Technology Assessment and Commercialization (ATAC). This programme was first of its kind to be undertaken by DRDO in association with FICCI to actively spinout several of DRDO's technologies for appropriate commercial markets both nationally and internationally. The technologies were assessed for commercialization and classified in 13 sub-heads as per their subject area. The Fig. 7 revealed that out of 91 food research based technologies, value added food processes lead the list with 31 % share, followed by cereal products (21 %); whereas herbal products and milk products and processes had a meager share of 1 %. The range of food technologies had similarity with the subject specific classification of ICAR technologies (www.drdo Ficci atac.com/). Other than ICAR and DRDO, the details about technology transfer were not shared on the websites as well as in research papers.

Conclusions

This review paper emphasizes on the intellectual property scenario in India's food science sector and the contributions made

Fig. 7 Food technologies of DRDO

by major research and development organizations in India, such as, Indian Council of Agricultural Research, Council for Scientific Industrial Research, Defence Research and Development Organization during the period of 2000–14. The subject specific classification of WIPO and sub-sections of these classifications in food science sector were analyzed for the patents filed by research and development organizations. The study revealed that during the beginning of the 21st century there was a delay in processing or rejection of filed patent applications due to the lack of awareness and expertise by the inventors to write or explain their claims. A significant change in the trend of IP filing, maintenance, and transfer of IP enabled technologies was noted during 2006–10 as many of the scientific institutes initiated various schemes and programs giving importance to IP awareness and management. The Food Science Sector was found to play a vital role in generating patents by the research and development organizations in India. Since 2006 till 2014, there has been a constant increase in the number of patents applied in food science sector with about 300 patent applications in the year 2013–14. The transfer of protected intellectual assets through partnership development with national and international organizations and the impact of IP management system in India have been discussed in this review.

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