

Agro-Processing Industries in India—Growth, Status and Prospects

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ABSTRACT

Agro processing is defined as set of techno-economic activities, applied to all the produces, originating from agricultural farm, livestock, aquacultural sources and forests for their conservation, handling and value-addition to make them usable as food, feed, fibre, fuel or industrial raw materials. Agro processing sector has experienced expansion during last 5 decades, starting with a handful of facilities which were mainly operating at domestic/cottage level. The paper provides a summary of the growth history of the sector covering role of R&D, recent trends vis-a-vis crop-wise status of agro processing industrialization and problems, export trends, SWOT analysis and thrust areas for future for achieving greater role of this sector in the national economy.

1. INTRODUCTION

Agro processing could be defined as set of techno-economic activities carried out for conservation and handling of agricultural produce and to make it usable as food, feed, fibre, fuel or industrial raw material. Hence, the scope of the agro-processing industry encompasses all operations from the stage of harvest till the material reaches the end users in the desired form, packaging, quantity, quality and price. Ancient Indian scriptures contain vivid account of the post harvest and processing practices for preservation and processing of agricultural produce for food and medicinal uses. Inadequate attention to the agro-processing sector in the past put both the producer and the consumer at a disadvantage and it also hurt the economy of the Country.

Agro-processing is now regarded as the sunrise sector of the Indian economy in view of its large potential for growth and likely socio economic impact specifically on employment and income generation. Some estimates suggest that in developed countries, up to 14 per cent of the total work force is engaged in agro-processing sector directly or indirectly. However, in India, only about 3 per cent of the work force finds employment in this sector revealing its underdeveloped state and vast untapped potential for employment. Properly developed, agro-processing sector can make India a major player at the global level for marketing and supply of processed food, feed and a wide range of other plant and animal products.

2. HISTORICAL PERSPECTIVE

By the middle of the nineteenth century, common agro processing industries included hand pounding units for rice, water power driven flour mills, bullock driven oil ghanies, bullock operated sugarcane crushers, paper making units, spinning wheels and handloom units for weaving. In British India, during the year 1863, a note was written by the Governor of Madras state, Sir William Denison to the government of Madras state for laying greater stress on agriculture and agro processing (Royal Commission, 1928). Based on this, a set of improved machinery was brought from England for demonstration and adoption. It included threshing machines, winnowers, chaff cutters, besides steam ploughs, steam harrows, cultivators, seed drills and horse hoes. The demonstration continued at Saidapet near Madras till 1871 with little outcome.

Importance of agro-processing sector was first realized and documented after the disastrous famine of Bengal during 1870's. Report of the Famine Commission, set up by the British Government, in its report submitted in 1880, clearly stated the need for agricultural improvement and improved post harvest infrastructural development specifically, rail network. Need was also felt for incorporating chemical interventions in the agricultural sector and precision farming through agricultural mechanisation manned by engineers. The Royal Commission on Agriculture setup by the British Government, conducted a detailed study. In its report published during the year 1928, it called

for scientific approach to the sector and stressed for developing rural industries and cooperatives.

Realizing the importance of the agro-processing sector for rural development as a tool for POORN SWARAJ (complete self rule), Mahatma Gandhi during 1930's promoted CHARKHA (spinning wheel) and balanced nutrition by setting example and writing articles in his famous magazine "Harijan". It was continued by his followers namely, Narhari Bhavé, Binoba Bhavé and Jay Prakash Narayan. They promoted self-dependence through KHADI and village industries.

The R&D institutions developed by the British for taking care of agricultural and rural industries included: The Imperial Agricultural Research Institute, Pusa; Indian Veterinary Research Institute, Mukteshwar; Dairy Research Institute at Bangalore; Poona Agriculture College; Public Agriculture College, Saidapet (Madras); Sibpur Engineering College (Bengal) etc. Horticultural Research Station was created at Chaubatia (U.P.) in Kumaon Hills for horticultural research including packaging and transportation improvements.

Post independence era in India witnessed rapid growth in agro processing sector specifically during 1980s. It followed the first phase of the Green Revolution that had resulted in increased agricultural production and the need for its post harvest management. The importance of the sector was realized by the business community leading to diversification from grain trading to processing. Lead was given by the rice processing industry, followed closely by wheat milling, paper and pulp industry, milk processing sector, jute industry, sugarcane processing and oils extraction through solvent plants. In some areas like the solvent extraction industry, the growth in installed processing capacity has been far higher than the supply of the raw materials. However, in other areas like fruits and vegetable processing, the growth has not been encouraging on account of poor demand for processed products by the consumers. In such cases, the industry has also not been able to develop the demand adequately.

3. TRENDS IN AGRICULTURAL PRODUCTION

At the start of the twentieth century, Indian agriculture was in a stage of subsistence. By the year 1925-26, the total area under some major crops in undivided British India was: rice – 32 mha, wheat – 9.6 mha, sorghum – 8.2 mha (Royal Commission on Agriculture (1928)). The yields were very low. In the year 1950-51, India produced only 50 million tonnes of food grain and a variety of other crops.

By the year 2000-2001, India started producing about 700 million tonnes (Mt) of biological materials per year including food grains, oilseeds, fruits, vegetables,

Table 1. Production status change over last fifty years

Commodity	1950-51, Mt	Mt
Food grains	50	206 (99-2K)
Oil seeds	5	24.5
Fruits	12	41
Vegetables	10	72
Potatoes	1.7	25 (24.2) (1998)
Onion	1.0	5.5 (4.75)
Mushroom		40 kt
Livestock & Poultry		
Milk	17	78 (99-2K)
Meat	0.7 (1971-72)	4.6
Eggs	10 bn(#) (1980-81)	30 bn(#) (99-2K)
Fish	0.75	5.6 (99-2K)
Marine		2.9
Fresh water		2.7
Honey	0.7 kt (1963-64)	5.5 kt
Coconut	4.5 bn(#)	15 bn(#)
Spices		3
Sugarcane	57	309.4
Certified seeds		0.75
Lac	40 kt	20 kt
Fibre crops		
Cotton	0.7	2.5
Jute	0.67	1.67
Coir	0.13 (1954-55)	0.34
Wool	32 kt (1980-81)	45 kt

sugarcane, milk, eggs, meat, fish, tea, coffee, fiber crops, floricultural produce, forest produce and so on. The country has diverse agro-climatic conditions and consumer preferences and hence it produces a vast variety of agricultural and livestock materials. Table 1 gives the change in agriculture production over the last fifty years. As could be seen, India holds a major share for some of these products in the global context. However, their market potential is not being fully realized due to poor post harvest management and inadequate infrastructure and programme for processing of agro-produce.

4. EXTENT OF POST HARVEST LOSSES

On account of poor post harvest management, the losses in farm produce in India have been assessed to be of a very high order. Various studies have estimated post production losses in food commodities to the tune of Rs. 75,000-1,00,000 crore per annum. Table 2 provides a view of the extent of losses and the monetary value of the lost produce in terms of quantity and quality. It may be mentioned that the estimated loss includes losses during storage, handling and milling/processing. It does not include losses at consumer's end.

It is also estimated that the extent of losses could be brought down to less than 50 per cent of the existing level on proper transfer and adoption of agro processing technology. For reducing the rest of the losses, new

Table 2. Present level of production of different types of food commodities and their estimates of post-harvest losses

Type of food commodity	Present level of production			Post-harvest losses		
	Quantity (Mt)	Average price (Rs/t)	Value (Rs. in Crore)	%*	Quantity (Mt)	Monetary value (Rs. in Crore)
1. Durables (cereals pulses, oilseeds, etc.)	230	10,000	230,000	10	23.0	23,000
2. Semi-perishables (potato, onion, sweet potato, tapioca etc.)	40	3,000	12,000	15	6.0	1,800
3. Perishables (fruits, vegetables, milk, meat, fish, eggs etc.)	210	15,000	315,000	20	42.0	63,000
Total/Average	480	11,604	557,000	14.8	71.0	87,800

* On a conservative scale

initiatives need to be called for. Hence, it would be in the long term interest of the economy to invest in developing suitable infrastructure such as proper grain storage structures, cold stores and processing systems to avoid the losses.

5. R&D IN AGRO PROCESSING SECTOR

Significant increase has taken place after early fifties in the number of institutions engaged in agro processing research. In the area of teaching, presently there are 18 universities/colleges offering first degree, 11 offer post graduate and 7 offer Ph.D. degree.

Among R&D organizations in the area of agro-processing, ICAR has 17 Institutes with some component of Post Harvest Technology (PHT), CSIR has 3 laboratories, State Agricultural Universities have 18 programmes, IITs have 2 programmes and 11 other organizations have similar programme. Some of the leading government funded R&D Institutes (based on their infrastructure and sanctioned scientific manpower) in 2000-2001 were: CFTRI, Mysore; CIPHET, Ludhiana; IARI, New Delhi; NDRI, Karnal; DFRL, Mysore; CIAE, Bhopal; IIT, Kharagpur; GPBUA&T, Pantnagar; IGMRI, Hapur; TNAU, Coimbatore; PAU, Ludhiana; GAU, Anand; RAU, Udaipur; BCKV, Kalyani; OTRI, Anantpur; PPRC, Thanjavur; MERADO, Ludhiana; MPKV, Rahuri; ILRI, Ranchi; IVRI, Izatnagar; NIRJAFT, Kolkata; CIRCOT, Mumbai; IISR, Lucknow; IGFRI, Jhansi; KVIC Mumbai; HBTI, Kanpur and PHT Institute, Pune. The ICAR has a system of All India Coordinated Research Projects (AICRP) in various important areas. In the field of PHT, there are 4 AICRPs: (1) All India Coordinated Research Project on Post Harvest Technology (21 centers in the country, coordinated from CIPHET, Ludhiana), (2) Processing, Handling, and Storage of Jaggery and Khandsari (5 centers, coordinated from IISR, Lucknow), (3)

Application of Plastics in Agriculture, Plant Environment Control & Agricultural Processing (5 centers, coordinated from CIPHET, Ludhiana) and (4) Post Harvest Technology of Horticultural Crops (8 centers, coordinated from IARI, New Delhi). Also, there are other AICRPs that have a component of PHT. These are (1) Renewable Sources of Energy for Agriculture and Agro-based Industries (16 centers, coordinated from CIAE, Bhopal), (2) Farm Implements and Machinery (21 centres, coordinated from CIAE, Bhopal), (3) Utilization of Animal Energy with Enhanced System Efficiency (6 centers, coordinated from CIAE, Bhopal), (4) Human Engineering and Safety in Agriculture (4 centers, coordinated from CIAE, Bhopal). Besides these, there are about 60 ad-hoc research projects operating in different SAUs, universities, IITs, CSIR Institutes and other laboratories that have been working on problems related to PHT. A number of Universities have programmes in the area of agro processing. Some of the state governments also have been supporting R&D activities on agro processing in a number of their laboratories/departments.

Although nearly 2000 scientists were associated with agro-processing R&D in the year 2000-2001, only about 200 out of them could be considered as full time R&D workers in agro-processing.

R&D Work in agro-processing carried out in India during the last 50 years categorized as follows:

- Studies on physical, biochemical, nutritional, and engineering properties/characteristics of different food, feed, fibre, and industrial raw materials.
- Response studies of different biological materials w.r.t. their storage, handling, and moisture conditioning.
- Refinement of traditional equipment and processes for production of different foods, feeds, fibres and fuel materials for better quality, higher capacity,

energy efficiency, and reduced drudgery to workers.

- Development of new produces and processes for better nutrition, convenience and taste.
- Enhancement of shelf life of the produces, safe storage/packaging and development of better performing materials.
- Better economic utilization of agricultural residues, by-products and recycling of wastes.
- Design and Development of instruments and equipment for post harvest operations and their evaluation, feasibility analysis, field trails/multi-location evaluation etc.
- Design, layout planning and development of pilot plants, agricultural produce bulk handling systems and area specific agro-processing models.
- Studies and modeling/simulation of post harvest systems and industry for the purpose of optimization, forecasting and policy analysis.
- Energy auditing and use of non-renewable sources of energy for post harvest operations.
- Product quality analysis, sensory evaluation and consumer acceptance studies.
- Work conditions, safety and pollution control.

Among large number of technologies developed, the most popular ones include:

1. Agriculture produce refinement equipment such as, cleaners, graders and driers for on-farm operations as well as industrial operations.
2. Processes and equipment for parboiling of rice, preparation of puffed rice and flaked rice.
3. Development of processes and equipment for processing of pulses to produce dhal for higher recovery and better quality.
4. Development of driers using agricultural residues, by-products and solar energy.
5. Adoption and development of processes, and equipment for production of protein rich produces such as full fat soy flour, soy drink/ soy milk, soy paneer (TOFU) and soy fortified baked products.
6. Development of equipment such as, leaf cup and *dona* making machine, multipurpose mills, mini flour mill, grain pearlers, maize dehuskers, shellers, groundnut decorticators, fruit graders, juice extractors, high recovery mechanical oil expellers and improved storage structures for cereals, pulses, oilseeds, onion and potato.
7. Processes and equipment for production of high quality ground spices and spice mix, development of raw materials and processes for production of instant sweets, curries, snack foods, instant soft drinks, *idli*, *dosa*, *sambhar* mixes/powders, egg

powder, production and packaging of milk products such as *shrikhand*, butter milk, *paneer*, *ghee* and sweets.

8. Equipment for high recovery of sugarcane juice, processes for production of high quality jaggery and liquid jaggery.
9. Processes, equipment and pilot plants for production of various industrial raw material from lac including dyes and pharmaceutical products.
10. Improved technology for processing of jute sticks to yield jute fibre and impregnation, preparation of jute based textile materials and bags.
11. Control of stored grain insects by using chemical and physical methods, storage structures for on-farm, trade, and process plant level operations.
12. Processing and canning of meat, meat products and fish.

Some work has also been done in the area of processing forest produce such as oil extraction from oil bearing materials, collection and processing of resins and production of dyes, chemicals and pharmaceutical products. The latest developments have been in the area of floriculture. Due to high export potential, R&D work has been initiated at some centres on pre-cooling, packaging, and transport of cut flowers and low cost designs of green houses. Agro-processing models have also been developed for some of the agro-climatic regions in the Country.

In the area of agro-processing of fruits and vegetables, development of tools and techniques for harvesting, pre-cooling of freshly harvested produce, minimal processing, controlled ripening, juice extraction, concentration and storage has been done. Similarly, in the area of spices & condiments, floriculture, production of mushrooms, honey, eggs and fish, technologies have been developed for post harvest loss reduction and value addition.

6. GROWTH OF AGRO PROCESSING SECTOR

Starting with a small number of processing facilities in 1950-51, a fairly well spread network of processing facilities has developed in the Country. Various estimates suggest the number of processing units in 2000-2001 as: atta chakkis and small hammer mills - 2,70,000, rice hullers - 90,000, rice shellers - 11,000, huller-cum-shellers - 12,000, modern rice mills - 30,000, bullock/ electricity operated oil ghannis - 2,00,000, oil expellers - 55,000, dhal mills - 12,000, roller flour mills - 700, rice flaking and puffing units - 2,000, bakery units - 54,000, solvent extraction plants - 700, vanaspati plants - 100, fruits and vegetables processing plants - 5,000, dairy plants - 450, cold storage units - 3,000, licensed units in organized sector for meat processing - 165, pork

Table 3. Recent trends in agro processing technologies

S.No.	Crop/ Item	Recent products, processes, trends and technologies
1.	Rice	Fully automatic modern rice mills Partially cooked/quick cooking rice Breakfast cereals and value-added products
2.	Wheat	Attractive packaging and branding Fully automatic roller flour mills Whole bran wheat flour Fortified wheat flour Attractive packaging and branding Large number of baked products
3.	Maize	Automatic chapatti making machines Corn flour-packaged and branded Corn flakes and value-added products including ready-to-eat snacks (salted & sweetened) Starch material, corn oil with specific consumer desired attributes Cattle feed Baby corn
4.	Coarse Cereals	Large, automatic corn processing plants Value-added products including breakfast foods & extruded fortified tasty products Industrial raw materials
5.	Pulses	Automatic processing units for pulses with driers, colour sorters and packaging unit Attractive consumer packaging with branding Cold storing of processed pulses Snack foods and other value added products
6.	Soybean	Production of full fat soy flour/enzyme active soy flour for bakery and fortified foods Ready-to-eat snack foods

processing units – 144, fish processing units - 18 and so on. Major problems faced by these units have been: (a) low capacity utilization, (b) poor recovery of the finished product from the raw materials, (c) problems of arranging adequate working capital and its management, (d) low product quality and (e) unreliable assured power supply. Strong R&D support will have to be continued to overcome these and many other problems to ensure that our agro-processing technology becomes competitive at the global level. As stated earlier, in spite of the problems, agro-processing technology in India has continued to make steady progress towards modernization. Table 3 gives information of the latest development trends in respect of major crops/crop groups.

7. CROP AND COMMODITY WISE STATUS OF AGRO-PROCESSING INDUSTRIES AND PROBLEMS

The commodity-wise growth of agro-processing industries in the country during the years 1950 to 2000 has been as given below.

Rice Processing Industry

Starting with 20.6 Mt of rice production during 1950-51, the country has come a long way to produce about 89.48 Mt of rice in the year 1999-2000. Similarly, in processing sector, the technology has undergone significant changes. Earlier, hand pounding, pedal

operated system and Engleberg huller units were common for milling of paddy. By the year 1998-99, there were nearly 30,000 modern rice mills using rubber rolls for paddy dehusking. Of these, more than 5,000 are large rice mills with parboiling facility and nearly 100 have colour sorters for removal of discoloured rice for export market.

Innovations in rice processing include improved process of parboiling developed at IIT, Kharagpur; CFTRI, Mysore; PPRC, Thanjavur and other R&D centres. Starting from sun drying, the technology for drying of paddy now includes use of a variety of driers, specifically for parboiled paddy. Continuous flow LSU type driers have been most commonly used units followed by tray driers (batch type). Thermic fluids are used as medium of heat transfer for heating the air used for drying in a large number of rice mills. Though efforts have been made to improve the rice hullers, limited success was achieved in improving their performance with respect to reduction in broken percentage. Rubber roll technology for dehusking has now been well established. Efforts are ongoing to find use of tafflon to replace rubber rolls for economy.

Several types of rice bran stabilizer have been designed and tested. Chemical method developed at CFTRI, Mysore; steam heating at IIT, Kharagpur, electrical heating method developed at Pantnagar could find limited applications in Industry. Stabilization through extrusion technology has also been tried with

limited application of expanders. Among most common value-added products of rice include puffed and flaked rice used as snack foods.

Rice and wheat form the major part of government operated procurement system and storage. In the month of March 2001, the total stocks of rice and wheat in FCI/CWC and other government owned godowns were about 35 million tonnes for the public distribution system, for processing industry and for future use.

Significant achievements have been recorded in packaging technology for milled rice for ready-to-cook applications in domestic market and export. Quick cooking rice has been developed at DFRL, Mysore and CFTRI, Mysore. The technology is being used for making available food supplies to defence personnel in boarder areas under war or war like situations. Rice is partially cooked and packed under highly sanitary conditions. It is autoclaved and supplied for safe use upto 6 months of period. Rice bran oil is a common form of edible oil besides its application in industry specifically as soap stock. For utilization of rice husk, a number of efforts were made at GBPUA&T, Pantnagar; PAU, Ludhiana; CFTRI, Mysore; IIT, Kharagpur; TNAU, Coimbatore; PPRC, Thanjavur and other R&D laboratories. Its application as sources of furfural, high grade silicon, insulation material, particle board and as source of fuel have been well demonstrated. However, rice husk is being used only as source of fuel in rice mills, in making particle boards, in poultry houses as bedding material and in land fills. Similarly, paddy straw has found limited applications as cushioning material in packaging of fruits and for preparation of soft boards. It is extensively used as cattle feed in many parts of the country.

The upcoming areas in rice processing R&D include high capacity dehuskers and more efficient polishers improved technology for storage of paddy and rice, on-farm/community level drying of paddy, mechanical handling systems for grain markets and millers, cold storage of rice and down stream products, products diversification in the form of flakes, puffed rice, snacks, bakery items, quick cooking and ready-to-eat rice etc.

The recovery of brown rice as obtained from the hullers, shellers, and modern mills could be in the range of 62-64, 65-67 and 68-70 per cent, respectively. The potential yield of rice is 70-72%. The need is therefore, to promote modern rice mills and develop milling technology for fine rice. If all paddy is milled in modern rice mills, 3 million tones of additional rice worth Rs. 15,000 million could be obtained.

Wheat Processing Industry

Wheat is a major crop of India. In the year 1950-51,

the country produced 6.5 Mt of wheat, that has increased to 76 Mt by the year 2000-2001. India has emerged as the second largest producer of this cereal in the world. Wheat contains 12% bran, 3% embryo and 85% flour. It is mainly processed for flour (*atta*), *maida*, *suji* and *dalia*.

In last 50 years, harvest and post harvest technology of wheat has advanced substantially. The most significant development has been the use of self propelled harvester combines used for harvesting and threshing of wheat. From a small figure of about 20-30 combines during 1950-51 imported from USSR by the State Farm Corporation of India, the number has now grown to nearly 6,000 combines. In the year 1998-99, there were about 27 lakh *atta chakkis* (7.5-10 kW rating) and 700 roller flour mills in the country. This number has risen from 53,000 *atta chakkis* and 200 roller flour mills in 1971-72. The figures were much lower 50 years back.

The industry could grow on account of R&D inputs starting from the design and development of a variety of threshing machines. Mud bins, wooden plank and mud plastered bins, gunny bags and metal bins have been in use by the farmers for storage of wheat for food and for seed purposes. The traders and government agencies use gunny bags and godown type structures for storage of wheat. For transit level storage, CAP structures have been in use. Metal bins have gained popularity among farmers in the capacity range of 0.2-1.0 tonne of grain storage. As wheat is usually harvested at low moisture content, drying has not been a major problem except for untimely rains.

A number of commercial organizations have been offering processing units for handling, cleaning, grading, drying, storage, treatment and bagging of wheat for seed and food applications. Wheat is now increasingly being used in the form of bread, biscuits, *suji* and *atta*. Wheat flakes and puffed wheat as breakfast cereals has been gradually picking up. In the area of wheat milling, Central Food Technology Research Institute, Mysore; Central Institute of Agricultural Engineering, Bhopal and a number of other R&D institutions have developed mini flour mills for higher efficiency in small scale. Traditionally used smaller size *atta chakkis* may face problems of declining clientele. Better mechanized chakkis (with lower pollution level and better energy efficiency) are likely to increase in number. The number of roller flour mills is also likely to increase steadily, however, majority of the mills may continue facing the problems of low capacity utilization and working capital constraints. These units would need to function through vertical integration of operations for sustaining profitability and achieve cost reduction through

appropriate automation and computerization. Increase in demand is also expected in grain handling machinery, silo systems in grain markets and seed processing machinery.

Trends in consumer preferences suggest increasing demand for baked products. Demand for bread is likely to grow faster than the demand for biscuits. Presently bread is consumed mostly in large cities. Its consumption is expected to grow in smaller towns also. States with higher per capita income would continue to lead in the consumption of baked products. Among diversified products, full bran wheat bread has also been gaining popularity.

Processing of Coarse Cereals

Production of coarse cereals has risen from 15.4 to 32.0 Mt between 1950-51 and 2000-2001. The growth has not been as rapid as in case of wheat and rice. It is because of low profitability of these crops for farmers. Till 1950s, we were dependent on manual methods of harvesting of these crops, bullock treading, storage in mud bins and gunny bags and milling by manual chakkis or water mills. By the year 1998-99, power operated equipment were available for all operations including threshing, pearling and milling. For storage of coarse cereals, metal bins have been designed at IGSI, Hapur; CIAE, Bhopal; CFTRI, Mysore; PAU, Ludhiana and several of the other R&D Centres. For drying of freshly harvested HYV sorghum or maize, hot air driers using agriculture residue as a source of fuel are now in use.

Technology has also been developed for production of value-added products from coarse cereals such as extruded snacks developed from ragi at CFTRI, Mysore; ragi based snacks at UAS, Bangalore and IIT, Kharagpur; corn products at GNDU, Amritsar; ready-to-eat traditional foods with storage life of 6-9 months at DFRL, Mysore and sorghum-soybean fortified foods at IIT Kharagpur. The trends indicate that coarse cereals are now increasingly used as cattle feed, speciality/occasional foods, and industrial products such as starches. Efforts are required to develop high yielding varieties of coarse with desired characteristics for different uses and to explore new food uses. Safe storage of the flour produced from most of the coarse cereals has been a problem due to its high degree of perishability. This problem needs to be solved.

Processing of Pulses

India produced 8.4 Mt of pulses in the year 1950-51. The production grew to a level of about 14 Mt by the year 2000-2001. Starting with nearly 500 dhal mills in the country in 1950-51, there were about 15,000 dhal mills of 100-500 TPD capacity in the year 2000-2001.

Pulses were generally stored in gunny bags or in small tin containers under straw cover during 1950s. By the year 2000-2001, metal bins and gunny bags (with prophylactic treatment by insecticides) were in use. Research at CIAE, Bhopal; CFTRI, Mysore; JNKVV, Jabalpur and GBPUA&T, Pantnagar has revealed that pulse grains need to be stored at 20-22 degree Celsius in partially airtight containers at 8-10 per cent moisture content for long duration storage. A number of plant based mild insecticides and insect repellents (such as, neem seed powder) have been developed for safe storage of seeds.

In the area of milling of pulses, CFTRI developed a dhal mill that has the advantage of not being dependent on natural sun shine. It involves subjecting the pulse grain to high temperature (120 degree Celsius) for short time and the dehusking by carborundum rollers resulting in higher dhal recovery. For small entrepreneurs in rural areas, dhal mills have been designed at CIAE, Bhopal; PDKV, Akola; IIPR, Kanpur, TNAU, Coimbatore; GBPUA&T, Pantnagar and CFTRI, Mysore. These units in specific regions have gained popularity as these are low investment machines which can be owned and operated with low risk.

In a number of dhal mills, improved machinery including cleaners, graders, magnetic separators, washers, driers, polishers, colour sorters and packaging systems are being used. With complete phasing out of hand operated dhal chakkis, commonly used during 1950s, the technology has turned fully mechanized and more-and-more urban based. There is a need to evolve more efficient machines and processes for pre-treatment of the grain, dehusking, sorting, polishing and packaging in order to improve dhal recovery and consume less energy. Also, there is a need for product diversification and development of technology for quick cooking and ready-to-eat dal.

Oilseeds Processing

Besides, animal based fat specifically obtained from milk and milk products, edible plant oils have been the major source of oils and fats for most of the population in the country. In the year 1950-51, the country produced 5.2 Mt of oilseeds. Production by the year 2000-2001 had increased to 24.5 Mt. In the year 1950-51, most of the oilseeds were crushed in either bullock operated oil ghanies or a few mechanical oil expellers. Both of these resulted in high volume of edible oil left in the cake. By the year 2000-2001, there were nearly 2.5 lakh oil ghanies, 60,000 oil expellers and 700 solvent extraction plants. Besides, there were 200 oil refining units in the country and 100 units for production of hydrogenated oil (Vanaspati). Per capita availability of edible oils is

still very low at 8.0 kg per capita per year in the country. Out of this, 2 kg/capita is imported oil.

R&D Institutions in the country have been working on pre-treatment of oilseeds for higher recovery of oil. Steaming has been found as one of the most useful methods for pre-treatment. On mechanical oil expellers, a number of Institutions including CFTRI, Mysore; CIAE, Bhopal; RAU, Udaipur; OTRI, Anantpur; HBTI, Kanpur and KVIC, Mumbai have done significant work on mechanical oil expellers. KVIC tried to improve the design of bullock operated oil ghanies to make them suitable for operating on 1.5 kW electric motor. Hence, the capacity of these units has improved significantly. These units produce pungent oil that is being traditionally liked by the consumers. The oil produced from *ghanies* is also being mixed with oil obtained from mechanical oil expellers to produce pungent oil. In the area of solvent extraction of oil from traditional and non-traditional oilseeds, a large number of researches have been done. A number of chemical solvents have been tried. However, for reasons of economy, food grade hexane has been accepted commercially for solvent extraction of edible oil. Work done at different R&D Institutions also reveals that for long duration storage, oilseeds need to be put in metal containers with limited aeration. Hence, metal bins designed at IGSI, Hapur; CIAE, Bhopal; GBPUA&T, Pantnagar and other centres have become popular. Due to shortage of edible oil in the country, efforts have also been directed to obtain edible oil from non-traditional sources including rice bran and oil palm. On refining, the quality of these oils has been reported satisfactory for edible purposes.

In the area of packaging of edible oils, significantly rapid growth has been recorded specifically in commercial sector. Polypacks and plastic containers have gained popularity over traditionally used metal containers about 30-35 years ago. The future areas of research include application of bio-technology for enhancing yield of edible oil from different oilseeds, application of de-oiled cake for food purposes through protein isolation and health applications of edible oil for treating various physiological disorders.

Production of oilseeds is 24.5 million tonnes. Out of the total production, 7% is used for seed, 8% for food, and 85% for oil extraction. Export of meal/oilseeds cake has been worth Rs. 15,000 million. Refinement of meal/cake for food products development could be of high importance. Oil expeller with lighter weight, high energy efficiency and capable of extraction up to 90% oil and above needs to be developed for decentralized oil milling. Hydraulic press, batch solvent extraction, extrusion-expelling and physical refining, also need to be considered and tried.

Besides other oilseeds, soybean has gradually become an important crop of India. Its production is around 5.3 million tonnes. Soybean is a special legume. It has 40% protein and 20% oil. India has 154 solvent extraction plants and 60 soyfood units. Average recovery is 17.7% for oil and 82.4% for meal. Soymeal contains about 48% protein. Its export has been worth Rs.15,000 million/year. Soy foods are nutritious and economical and must be promoted. A strategic plan for expanded and diversified use of soybean for food and feed in India for the next 25 years should be made and implemented. This crop has a great potential to enhance nutrition and health of the people and alleviate poverty.

Processing of Fruits and Vegetables

Joint effort of R&D institutions, farmers, government agencies and the trade has resulted in India emerging as a major producer of fruits and vegetables in the world. In the year 2000-2001, the country produced about 45 millions tonnes of fruits and 80 millions tonnes of vegetables. It was next to China in production of vegetables and topped in production of fruits. However, the growth in post harvest sector has not kept pace with the production. Even during the year 2000-2001, there were only 6,000 fruits and vegetable units in the country that had grown from a figure of about 1,000 during 1950-51. Less than one per cent of the total produce was processed, though the installed capacity of the processing industry has grown steadily from 0.27 Mt in 1980 to about 3 Mt in 2000-2001.

Significant developments in technology include better understanding of the process of ripening of fruits, optimum harvesting time, pre-cooling of freshly harvested produce, cold storing of the raw fruits and vegetables, sorting, cleaning, waxing, packaging technology for fruits. At CFTRI, DFRL, IIHR, Bangalore; IARI, New Delhi; GBPUA&T, Pantnagar; IIVR, Varanasi and HPKV, Palampur; a number of technologies have been developed. Most significant work has been recorded in the technology for ripening of the fruits under controlled conditions. Production of juices and value-added products including jams, jellies, pickles, canned products etc. has become a commercial success. The industry using indigenous technology includes units engaged in juice extraction, concentration of juices, canning and production of several of the products like jams, jellies, canned fruits, dried vegetables etc. Technology is still being imported for establishment of large scale exported oriented units for production of items like banana paste, concentrates of various fruit juices, sorting, cleaning, washing, waxing and packaging of raw fruits and vegetables.

By the year 1998-99, share of different products in

the total processed fruits and vegetables was; pulp and juice 27%, jams and jellies 10%, pickles 12%, ready-to-serve beverages 13%, syrups 8%, squashes 4%, tomato products 4%, by canned vegetables 4% and other products 18%. The industry has been facing problems of low capacity utilization, technological obsolescence and marketing. It has to work under the constraints of high fluctuations in raw material quality and fluctuating market price, poor technology for handling and storage, inadequate R&D support for product development, high cost of energy and uncertainty in availability of adequate quantity for processing purposes, inadequate and expensive cold chain facilities and varying requirement of processing conditions from one material to another. Future R&D has to focus on the issues of economically producing value-added products and product diversification, besides the issues mentioned above.

Sugarcane Processing Industry

Sugarcane production was 310 Mt in the year 2000-2001. About 80% of the cane produced is milled, about half for the production of refined white sugar in the organized sector with the sugar mills located in the production catchments in public, private and co-operative sectors and about 42% for the production of Jaggery and Khandsari. Based on sugar recovery, minimum price scheme has been introduced. Mills have loose tie-up with the growers, some of them provide critical input support to the growers. Apparently, it is working well. But there have been cases where farmers burnt their crops in the absence of remunerative prices. For Jaggery, canes are crushed, clarified and concentrated. Gur as sweetener has better nutritional profile than white sugar. It is possible to refine the process and the product for greater competitiveness and realize export potential specially where people of Indian origin are located. Energy efficient furnaces, concentration pans, clarificants, moulds and storage are needed for Gur. Khandsari units used open pan in place of vacuum pans for concentration and the sugar obtained is of lower quality compared to white sugar from mills. Sugar recovery in Khandsari is much lower. These units depend on grid supply or diesel generators for mechanical/electrical power or both when grid power or both when grid power supply is erratic and diesel gensets are kept as standby power sources. This increases the cost of production of Khandsari. Bagasse, tops, dry leaves and molasses are by-products. Modern sugar mills with co-generation meet their entire energy needs, both thermal and electro mechanical from these bagasse fired boilers – steam turbine units. They feed extra power to grid or save 15-20% bagasse for the use as feedstock or paper making. Jaggery promotional and

regulatory measures have been taken by the Government to improve quality and production. Large number of sugar mills are using outdated processes and equipment, some of them not only use entire bagasse but also use wood.

Cotton Processing Technology

Cotton is a natural textile fibre. Traditional cotton textile industry could not face onslaught of modern high speed spinning, weaving and surface finish technologies. Small scale textile industry supported by Swadeshi and Khadhi and Village Industries Commission face serious labour problems also. Cotton seeds are valued as feed and oilseed and the stalks are used as fuel. However, stalks yield excellent paper and pulp, particle boards and microcrystalline cellulose (MCC). Cotton hulls also yield good particle board and furfural. Cotton willow dust can be used for production of bio-gas. Cotton wastes can be used for mushroom production. There is scope for income and employment generation if cotton stalks are utilized for pulp and paper making.

Processing of Jute

Jute has the distinction of having ushered India into industrialization era. Both jute production and manufacture of jute-based products are highly labour intensive, concentrated mostly in Eastern India. Mini jute carding and spinning mills have now been developed which allow decentralized production of utility items from jute but these are not popular yet. For each tonne of jute, 2-3 tonnes of jute sticks are produced. Chemically these resemble hardwood. Sticks are traditionally used as fuel wood and low cost structural material. Jute sticks yield excellent particle boards and the technologies are now fully commercial. Jute sticks are a good feedstock for paper pulp. The sticks can also be used as fuel for steam and power generation.

Processing of Animal Produce

Meat and poultry production in India has been about 4.6 Mt per year with goats and sheep contributing 54%, buffalo and cattle 26%, poultry 13% and pig 7%. It is mostly used fresh. Efforts are on to develop infrastructure for export of both fresh and processed meat and poultry. Production is essentially decentralized and rural based. Poultry has done well remaining in rural sector and developing network of marketing in distant remunerative markets. Hygiene in slaughter houses and use of blood, viscera and other wastes is not satisfactory. The meat from culled birds, goats and buffaloes is tough textured, better suited for processed meat products. However, there is no tradition of using processed meat products in India, yet.

Fish & Fish Products Processing

India, with its 7,500 km long coastline and an exclusive economic zone of 2.02 million square km; 191,024 km of rivers & canals and 4.4 million hectares of reservoirs and fresh water lakes has an enormous potential for fisheries. In 1999, the country had an estimated 1,81,284 traditional fishing crafts; 44,578 motorized traditional crafts, 53,684 mechanized fishing boats and about 200 deep-sea vessels in operation.

Fish processing in India is done almost entirely for export. Open sun dried fish and fish meal are the only major exceptions. At present India has – freezing units, - cold stores, - ice plants, - canning units and – fish meal plants. Capacity of most of these processing and storage units is small when compared to the facilities in fish processing industry in technologically advanced countries. The total fish processing and storage facility in India grossly is inadequate compared to the potential for fish production and processing. Inland fisheries need low cost palletized feeds and special containers to transport fingerlings and fish. More rearing ponds are needed. Techniques to reduce seepage loss of water have to be introduced. Obsolete fishing gear needs replacement with better gear. Extensive network of refrigerated handling, transport, storage and retailing has to be put in place. Also, we have to make better use of fish waste and by-products.

Processing of Commercial Crops

The commercial crops include spices, condiments and crops such as gorgon nut (*makhana*), water chestnut, bettle leaves, tobacco etc. Post harvest operations of these crops are highly energy intensive and there is a scope for reducing energy consumption and improvement of quality through proper cleaning, grading, drying/dehydration, milling, grinding and other operations. India has been a leading producer, consumer and exporter of spices like black pepper, cardamom, chillies, spice oils and oleoresins. It produces about 3.0 Mt of spices valued at over Rs. 60,000 million. About 7% of the total production is exported. Contribution of R&D to PHT of spices includes equipment and processes for cleaning, grading and packaging of whole spices and production of value-added products such as oleoresins and spice oils. Institutions like CFTRI, DFRL, Indian Institute of Spices Research and some of the SAUs including TNAU, Coimbatore have contributed significantly to this development. Projected world trade in spices in 2001 AD was estimated to about 6.25 lakh tonnes, valued at US\$ 3 billion and projected export from India at that time was about 10% of the world trade. To achieve and maintain India's share in the trade, the quality of spices and their products will have to be

improved. New products like dehydrated pepper, freeze dried green pepper, ginger candy, ginger beer/in-brine/squash, ginger flakes have to be developed. Development of internationally accepted quality products, packed under hygienic conditions need attention in this context. Similarly, in the area of PHT of other crops, contribution of R&D basically has been on raw materials refinement, product quality enhancement and diversification.

Processing of Plantation Crops

Plantation crops contribute substantially to the national economy with export earning of Rs. 12.4 billion. Coconut alone contributed Rs. 1.72 billion by way of exports during 1996-97. However, the coconut based industry in India has been in the infancy stage. There is considerable scope of product diversification, viz. production of coconut milk and milk powder, coconut cream, shell powder, shell charcoal etc. Coconut wood utilization needs more attention. In case of other crops, financially viable technologies for product diversification need to be developed. Such products are arecanut fat, tannin, areuline, other chemicals from arecanut, honey/ chocolate coated or salted kernels from cashewnuts and value added products from by-products. The post harvest operations in these crops need to be mechanized. Though the technology has been developed for desiccated coconut, coconut cream and other products, it needs refinement. At CPCRI, Kasargod, a coconut dehusker has been developed for manually opening the nuts. Another motorized unit is under development. Copra drier using LDPE cover and batch type hot air copra drier using agricultural waste as source of fuel have also been developed at CPCRI, Kasargod; KAU, Thrissur and TNAU, Coimbatore. In case of the plantation crops like oil palm, necessary efforts are required for processing and value addition, especially with regard to quality of products, energy inputs, packaging etc. to meet the international quality standards and to reduce the cost of production. Processing of cocoa beans at small scale also needs attention.

Processing of Medicinal and Aromatic Products

The plant based pharmaceuticals, herbal medicines, perfumery, cosmetics, fragrances and food flavour industries have recorded a phenomenal expansion in last 50 years and as a result, this sector figures in high annual growth rate industries in agri-business. The market for plant based pharmaceuticals in the year 1994 was estimated to range between US\$ 32-43 billion. The world essential oil production at raw materials level was estimated to be about Rs. 32 billion of which 55-60% goes to food flavours, 15-20% as fragrances and the

remaining is broadly used as starting raw material for isolation of aromatic chemicals. In terms of market share in production value, India is sliding downwards and presently stands at sixth rank with only 6% share in world trade. The R&D work on PHT of medicinal and aromatic plants had been confined to the IBRI, Lucknow and a few of the CSIR and ICAR laboratories. The thrust has been harvesting of the plants, curing/drying, and extraction of the medicinal and aromatic substances. The export earnings could be increased by innovations in the field of post harvest technology for increasing productivity and improving quality. In case of medicinal plants, studies need to be conducted to develop testing procedures/analytical facilities to meet stringent international standards and to carry out product/process development for low cost chemicals from both raw materials and other by-products.

Apiculture Produce Processing

Bee-keeping i.e., rearing the bees in artificial hives to produce honey and other products offers an immense potential for providing employment to rural folk in India where many evergreen and moist deciduous forests, orchards etc. constitute good bee keeping areas. The unique feature of bee keeping is that the capital investment required is small and unlike many other industries, it does not need raw material in usual sense as nature offers the same in the form of nectar and pollen. The equipment required, viz; bee boxes of standard sizes, honey extractor smoker, hive tools etc. have been researched and improved in design and these can be manufactured even in small rural carpentry and black smithy shops. Improved bee hives have been developed which make honey production much easier than the traditional long hanging hives. In general, equipment like smoker, comb foundation sheet machine, honey extractor, queen excluder, honey tank and uncapping equipment have been developed by R&D organisations namely, KVIC, Mumbai; PAU, Ludhiana and IARI, New Delhi. There is need for R&D to develop suitable equipment in this reference and for product diversification. Good work has also been reported by GNDU, Amritsar in improving quality of honey through proper processing and measuring its bio-chemical and engineering properties that could be used by processing industry.

Processing of Traditional Foods

India has a very strong base of traditional food products, which have been developed under varied agro-climatic, geographical and socio-cultural situations over the centuries. Besides, conventional *chapaties*, these may include expanded, puffed, flaked, extruded,

fermented products, sweets, instant mixes, breakfast foods, bakery products, beverages, health and special foods. The production of traditional foods during 1996-97 has been estimated nearly 30 times more than that of all western style high cost processed foods in the Indian market. There is an urgent need to upgrade the conventional foods technology so that the industrial manufacturing of products can be promoted and the scope of marketing expanded.

There can be substantial domestic and export demand for traditional foods. Production of Bikaneri *Bhujia* for export and frozen *Idli* for domestic markets are some of the successful examples. A *chapatti* making machine developed at CFTRI, Mysore for defence canteens and hotels is a fine example of modernisation of traditional food sector. Similarly, long life *chapatti* and *paratha* technology developed at DFRL, Mysore has been a success story for providing food of liking for many defence personnel working in remote and frontier areas.

Technologies during last 50 years have also been developed for *gulabjamun* mix, *idli* and *dosa* mixes and a variety of other food items to suit to Indian palate. R&D has contributed significantly in rapid growth of processing units and trade in traditional food sector however much more needs to be done.

Floriculture

Flowers and plants have always been an integral part of human living. Besides their aesthetic importance, they are also useful in improving the quality of life. Ornamental plants play a very important role in environmental planning of urban and rural areas for abatement of pollution, social and rural forestry, wasteland development, afforestation and landscaping of outdoor and indoor spaces. Floriculture is also an important agri-business with potential for export trade.

The area under floriculture in India has increased to nearly 40,000 ha, which constitutes around 17% of total global acreage. In spite of such a large area, production value is very low. The quality of Indian produce is poor and not acceptable in international market. The produce quality deteriorates further due to improper packaging, storage and transportation. Major contribution of R&D in this area has been in the form of raising varieties that are more attractive and flower life is longer. Also, technology has been developed at IIHR, Bangalore; IARI, New Delhi; UAS, Bangalore; HPKV, Palampur; GBPUA&T, Pantnagar and PAU, Ludhiana for longer shelf life of cut flowers.

Floriculture is largely an export oriented agro-industry. There are 14 flowers in the world cut flower trade. The trade is growing at the rate of 15% per annum. Yet Indian exports are limited only to a few flowers

namely, Gladiolus, Chrysanthemums, Jasmine and Orchids. India's share in the world floriculture trade is a minuscule with 0.59% exports during 1992-93 valued at Rs. 149.1 million. Cultivation of high quality varieties under protected conditions, proper tools and equipment, appropriate packaging and storage can create a niche for Indian flowers in the world market.

8. EXPORT TRENDS AND OPPORTUNITIES

India has been a traditional exporter of raw agricultural products like spices. Export of raw products has resulted in huge loss to Indian economy. After GATT agreement and WTO membership, processed products manufactured as per international norms only offered at competitive prices, can be exported. However, our processed products mostly do not meet the international standards. India's share in over US\$ 300 billion world trade in agricultural commodities is less than 1%. Agricultural exports used to be of the order of 30.6% of the total exports during 1980-81, which came down to 19.4% by 1990-91. Currently, it is at about 16% due to rapid growth in other sectors as well. Processed fruit and vegetable products have considerable export potentials and if it is properly utilized, growers, processors, traders as well as national economy will benefit. It requires correct assessment of world market, high quality of raw produce, high quality of processed product and competitive production cost.

9. QUALITY CONTROL & STANDARDS

Food processing industries cover a large spectrum of products of plant and animal origin. Quality has got to be maintained for domestic as well as export markets. In this respect, a number of organizations have come up for the formulation of standards and for monitoring their quality. These can be classified into two groups; a) compulsory legislation and b) voluntary standards.

Bureau of Indian Standards (BIS)

The activities of BIS in the field of agro-processing are two fold: a) formulation of Indian standards and b) their implementation through its voluntary and third party certification system. BIS has on its record over 700 Indian Standards related to food-grains and their products, bakery and confectionery items, sugar, edible starches and their products, processed fruit and vegetable products, protein rich foods, stimulant foods like tea, coffee and coca, alcoholic beverages, spices and condiments and food products of animal origin like milk and meat, fish, poultry etc. These standards, in general, cover raw materials permitted and their quality parameters, hygienic conditions under which the product is manufactured and packaging and labelling

requirements. The standards also prescribe, where required, freedom from toxic substances and contaminants.

In addition to the product specifications, which include both raw materials and final product, the Bureau of Indian Standards has brought out standards on glossary of terms for various industries and hygienic codes applicable to most of the food processing industries. To ensure that processed foods are free from pathogenic or spoilage micro-organism, limits are gradually being introduced in various specifications. In addition, separate standard methods of test for the sensory parameters have been laid down.

Containers are as important as the contents, as these may impart toxic elements to the food products and could pose potential dangers to health and safety, if they are not of the requisite quality. Indian Standards covering 6 thermoplastics namely, polypropylene isomers and ethylene acrylic acid have been published which describe the requirement of the particular thermoplastic and necessary additive along with their limits.

Informative labeling is also a very important area and the level should contain sufficient information to enable the consumers to know about positive nutritional characteristics such as protein, fat, dietary fibre etc., negative characteristics such as pesticides, residues, toxins etc. as also information regarding ingredients used, food activities, net contents etc. In this area, the Bureau has brought out a Code of Practice for labeling of Pre-packed foods covering general guidelines for labeling and guidelines on claims and nutritional labelling. However, in this area, much work still remains to be done.

10. GATT AND SANITARY/PHYTOSANITARY MEASURES

Agreement on the application of Sanitary and Phytosanitary Measures (The SPS Agreement concluded under GATT in 1994) came into effect in 1995 for developing international standards to ensure the safety of food for consumers and to prevent the spread of pests or diseases in animals and plants. These measures protect human/animal life from risks arising from additive contaminants, toxins or diseases – causing organisms in their food. The objectives of SPS can be accomplished in several ways as indicated below.

1. Requiring product to come from a disease free area
2. Inspection of products
3. Specific treatment of processing of products
4. Setting allowable maximum levels of pesticide residues or permitting the uses of only certain additives in food.

11. SWOT ANALYSIS OF AGRO-PROCESSING INDUSTRY INFRASTRUCTURE IN INDIA

Strengths

1. Round the year availability of raw materials.
2. Social acceptability of agro-processing as important area and support from the central government.
3. Vast network of manufacturing facilities all over the country.
4. Vast domestic market.

Weaknesses

1. High requirement of working capital
2. Low availability of new reliable and better accuracy instruments and equipments
3. Inadequate automation w.r.t. information management.
4. Remuneration less attractive for talent in comparison to contemporary disciplines.
5. Inadequately developed linkages between R&D labs and industry.

Opportunities

1. Large crop and material base in the country due to agro-ecological variability offers vast potential for agro processing activities.
2. Integration of developments in contemporary technologies such as electronics, material science, computer, bio-technology etc. offer vast scope for rapid improvement and progress.
3. Opening of global markets may lead to export of our developed technologies and facilitate generation of additional income and employment opportunities.

Threats

1. Competition from global players
2. Loss of trained manpower to other industries and other professions due to better working conditions prevailing there may lead to further shortage of manpower.
3. Rapid developments in contemporary and requirements of the industry may lead to fast obsolescence.

12. PLAN AND STRATEGY

The objectives of agro-processing programmes in India should be to:

- minimize product losses,
- add maximum value,
- achieve high quality standards,
- keep processing cost low,
- ensure that a fair share of added value goes to the producer

To achieve these objectives following strategy is suggested:

- (a) National plan for improvement and extension of agro-processing technology at farm, traditional small industry and modern industry levels should be prepared. The plan should take into account the diversity in resources and needs of different regions in the Country. It should include programme details and implementation schedule for the first four or five years. The progress of plan implementation should be periodically reviewed to allow adjustments and corrective measures, and to develop programme details for the years beyond the period under review.
- (b) Thrust areas for research and development should be identified and medium term research and development programme should be prepared and implemented to support the national plan for improvement and extension of agro-processing technology at different levels. Treatment and utilization of effluents from agro-processing industry should be included in the R.D. programme.
- (c) Emphasis should be put on the establishment of new agro-industrial plants in the production catchments to minimize transport cost, make use lower cost land and more abundant water supply, create employment opportunity in the rural sector and utilize process waste and by-products for feed, irrigation and manure.
- (d) Infrastructure in the production catchments selected for agro-industrial development should be improved. Because of uncertain grid power supply to rural areas, decentralized power generation using locally available resources may become an integral part of agro-industrial development. Similarly, if the raw materials and processed products are perishable or semi-perishable in nature, cold chain will have to be established.
- (e) The national plan should provide for management of agro-industrial activities in the catchment area, both by private companies and individuals as well as cooperatives.
- (f) Financial incentives and support should be provided on liberal scale to promote the modernization of agro-processing industry and for establishing new such industries in production catchments.
- (g) Arrangements to supply market information to the farmer and agro-processor should be put in place.