Priorities and Constraints of Postharvest Technology in India

Ananthaswamyrao Ramesh*

Abstract

India has undergone a massive transformation from "a food grains importer" to "an exporter". It is reported to be the third largest producer of food grains in the world after China and USA. Yet it is predicted that the country will have to import food grains at the rate of 45 million tons/year by 2030 AD. India's population growth is estimated to be 1.8%/year, and to meet the increased demand due to increased population and changing food habits, growth rate of food grains should amount to 2.2 to 4.45% for different food grains. Adoption of efficient postharvest processes will be a major boosting factor in achieving this growth rate.

The bulk of the food grains in India is marketed in their primary form and very little processing is done in the fields. Majority of the food-processing industries in India is included in what is known as "Small-Scale Industrial Sector (SSIS)", with limited vision and resources. SSIS has limited organization capacity to plan for long-term investments (both towards producers and consumers) and technology development. Small-scale operations, with associated small-capacity machinery and lack of sustained effort to improve designs have resulted in inefficiency in many cases. High energy costs and high packaging costs have also restricted the rapid growth of the industry. There is a need for the development of efficient small-capacity field-drying equipment, preferably, based on solar energy, and equipment based on latest technologies is currently needed by the industry. The industry has been rapidly changing recently and shows signs of rapid development, being considered as a "Sunrise Industry", with vast potentials for export.

Introduction

India has successfully overcome the acute shortages witnessed in the country in the early sixties, culminating in the worst period following the two droughts in 1965-66 and 1966-67. It has also been possible to achieve a greater resilience in agricultural production, to avoid a marked decrease of agricultural production even in the wake of highly adverse weather conditions. India is reported to be the third largest producer of food grains in the world after China and USA. Table 1 shows the production of selected agri-horticultural produce during recent years. Table 2 shows India's share in world production of major agricultural products.

The 21st century will witness an increase in the commercialization of agriculture. Presently, the agriculture sector in India provides livelihood for two-thirds of the population and accounts for 30% of the GDP. Contribution of agricultural products to the country's export exceeds 20%.

* Central Food Technological Research Institute, Mysore, India

Table 1 Production of some agri-horticultural produce (million tons)

	1992~93	1993~94	1994~95	1995~96	1996~97	1997~98 (Targets)
Rice	72.9	80.3	81.8	77.0	81.3	83.0
Wheat	57.0	59.8	65.8	62.1	69.3	68.5
Coarse cereals	30.6	30.8	29.0	29.6	34.3	33.5
Pulses	12.8	13.3	14.0	12.3	14.5	15.0
Oilseeds (9)	21.7	21.3	22.1	25.0	25.5	25.5

Sources: The Hindu Survey of Indian Agriculture, 1997 and Solvent Extractors Association Handbook, 1996.
Economic Survey of India, 1997~98, Goverment of India.

Table 2 India's share in world production of major agricultural products (1996)

	India *1,000MT		World *1,000MT		Share %
	1995	1996	1995	1996	1996
Cereals	198,170	214,082	1,902,280	2,049,578	10.45
Wheat	63,007	626,020	5,411,120	584,874	10.71
Rice (paddy)	120,710	120,012	550,193	562,259	21.34
Maize	9,800	8,660	514,710	576,821	1.50
Pulses (total)	15,621	15,414	56,260	56,774	27.15
Dry beans	4,140	4,140	18,102	18,639	22.21
Dry peas	561	561	11,221	10,945	5.13
Chickpeas	6,208	6,000	8,866	8,908	67.36
Lentil	792	792	2,791	2,819	28.10
Vegetables	64,671	64,672	566,367	565,523	11.44
Fruits	39,197	39,197	401,720	413,932	9.47
Nuts	9,050	8,850	47,824	45,444	19.47
Plantation crops	260,374	255,902	1,178,774	1,204,062	21.25

Source: FAO Production Year Book 1996

However, there is a growing concern about the long-term sustainability of the development in agriculture. It is predicted that the country will have to import food grains at the rate of 45 million tons per year by 2030 AD (Swaminathan, 1998). India's population growth rate is estimated to be 1.8% per year, and to meet the increased demand due to increasing population and changing food habits, the growth rate of food grains needs to range from 2.2% to 4.45% for different food grains (Paroda, 1998). The average growth rate remained at 3.5% during the last five years.

Preharvest situation

As mentioned earlier, although India has achieved self-sufficiency in agricultural production and is able to meet the current needs in the country, besides exporting several commodities, the sustainability of this situation in the long run is a cause for concern. The major reasons for the prevailing skepticism about the ability of India to balance its food budget during the decade 2005-2015 are as follows (Swaminathan, 1998).

1 Increasing population is leading to higher food demand and reduced availability of arable land and irrigation water.
2 Improved purchasing capacity and higher percentage of urbanization will lead to higher per capita grain requirement.
3 Increase in marine fish production is not commensurate with population growth. Increase in meat production is also not significant.
4 There is an increasing damage to ecological foundations of agriculture, such as land, water, forests, biodiversity and atmosphere, which may adversely affect agricultural production.
5 No dramatic technological breakthroughs are forecast, which could help to halt the fatigue of the "Green Revolution".

There is no option for India except to produce more food, income and livelihood opportunities from less per capita arable land and irrigation water. Since the term "Green Revolution" denotes the improvement of production through the productivity pathway, India needs an environmentally and socially sustainable green revolution, a phenomenon referred to by Prof. M.S.Swaminathan, a doyen of Indian Agricultural Research, as "Ever-Green Revolution" (Swaminathan, 1998). This has to be achieved through well-planned integration of the tools of biotechnology, information technology, space technology, renewable energy and recycling technologies with traditional wisdom and technology.

Whatever India has achieved in the agricultural production front, has been possible as a result of the research support provided by the National Agricultural Research System (NARS) of the country. NARS has the Indian Council of Agricultural Research (ICAR), a Government of India body as the apex coordinating and funding body at the national level and the State Agricultural Universities at the State level (Paroda, 1998).

Agriculture in modern times necessitates appropriate machinery for ensuring timely field operations and processing. Agricultural engineers in India have developed a variety of marketable machines for field applications which are used extensively. Although most of the agricultural implements in India are still manufactured by village artisans, a number of items of equipment such as steel plows, cultivators, harrows, seed drills, loaders, hoes, balers, forage harvesters, plant protection equipment, threshers and tractors are manufactured largely in the organized sector of industries (Gyanendra Singh, 1997). Mechanical power is used mainly in irrigation. A large variety of irrigation pumps, drip and sprinkler irrigation equipment is manufactured in the country and adopted by farmers. The Central Institute of Agricultural Engineering, Bhopal, under the aegis of ICAR coordinates the mechanization programs at the national level (Gyanendra Singh, 1997).

Yield of food grains per hectare is significantly low in India, as compared to some other countries (Table 3). But this is seen as an opportunity to increase agricultural production, to meet the increased demands during the next century. Indian agricultural research will adopt new approaches for the increase of productivity through enhanced use of high-yielding varieties of seeds, diversification, postharvest processing and conservation of agro-biodiversity. Strengthening agricultural research information and linking scientists with the farmers through institute-village-link programs, development of integrated pest and nutrient management approaches, watershed development for rainfed areas and strengthening of partnership with international research institutions are some of the priorities identified (Paroda, 1998).

Table 3 Average yield of agricultural produce (kg per hectare)

Country	1995	1996	1997
Crop: Cereals Total			
China	4664	4919	4897
Japan	6006	5902	5902
India	2144	2146	2373
Crop: Wheat			
China	3733	3741	5930
Japan	2932	3548	3548
India	2559	2493	2705
Crop: Paddy			
China	6022	6206	11958
Japan	6343	6191	6191
India	2784	2828	2839

Source: FAO Quarterly Bulletin of Statistics: Vol. 10, 1997.

Postharvest situation

A significant proportion of foods produced in India is marketed in their primary form in and around producing centers. For instance, although India is the largest producer of fruits and vegetables in the world, only about 2% of this horticultural produce is processed into secondary or tertiary products. In contrast, other developing countries like Malaysia and Brazil process and package over 70% of their horticultural produce. Though certain governmental policies may be responsible for this situation, many technological and sociological factors contribute to this low conversion of food materials into value-added products. Indian people still prefer to eat fresh foods rather than processed ones. They would rather not eat foods that are not available than consume processed packaged foods. Seasonal fruits and vegetables are consumed largely during the respective seasons.

The second factor is the purchasing capacity of the Indian population. The Indian per capita income is around US$ 1,200 per year and even with the so-called middle income group amounting to about 200 million people, per capita income does not exceed US$ 5,000 per year. Although, a large proportion of the country population cannot afford to purchase processed foods, the population that can afford to purchase and consume processed foods is still large enough to provide a good market for processed foods. The National Council of India for Applied and Economic Research (NACER) has predicted that by the year 2005, the number of households in India, having an annual income of less than Rs. 100,000 (US$ 2,500) will decrease to 43% against the present level of 70%. This factor coupled with socio-economic changes like greater urbanization and increase in the number of working women will result in a higher demand for processed food. This sector and export sector form the main market for the Indian food-processing industry. Though the food-processing industry in India is still in its formative phase, it is given the status of a sunrise industry and showing encouraging growth rates.

One basic need for sound growth of the food industry is access to right technology covering process know-how and plant and equipment designs. Over the years, India has on its own developed a large number of technologies and absorbed and adopted many foreign technologies and machinery designs, with due innovations and modifications to suit the Indian processing industry. To achieve this objective, there are a number of agencies-mostly in the government sector, that develop new technologies and plant designs to meet the demand of the industry. The engineering industry in India has the necessary competence to construct high-grade processing plants. Among the institutions active in technology development, the Central Food Technological Research Institute (CFTRI), at Mysore plays a major role. As one of the 43 R& D laboratories set up under the Council of Scientific and Industrial Research of India, this Institute carries out technology development and transfer and implementation in a large number of food-processing fields. Besides, there are several other organizations active in the development of technologies and equipment for the food-processing industry. Prominent among them is the Defence Food Laboratory, also located at Mysore, postharvest technology groups in agricultural universities and Indian institutes of technology.

Priorities and constraints of postharvest processing

Wastage costs are estimated at Rs. 230 billion (US$ 5.75 billion) per year, according to a joint study by the internationally renowned consultants - Mc Kinsey & Co. and Confederation of Indian Industries (CII). Their report entitled, FAIDA (Food & Agriculture Integrated Development and Action) indicates that the high wastage and value loss are due to the lack of infrastructure, like storage and handling at the farm level. Transportation losses are also significant due to improper packaging, and temperatures of 40℃ during certain seasons prevailing in many parts of the country. A major lacuna in the Indian food-processing and preservation industry is the lack of adoption of proper field level processing operations. The importance of processing foods to stabilize them and protect them from spoilage has still not been fully realized by the Indian farmers. Although a number of good implements and machines are used for threshing and winnowing and some other field operations, drying is a major problem. Drying invariably consists of sun-drying. Drying is often improper and incomplete, which results is quality deterioration.

Availability of electric power at the field level for installing and operating hot air dryers is still a problem. There is an immediate need to identify and adopt efficient natural convection air dryers and solar dryers for field level application. The commodity-wise status of selected processing industries at factory levels is discussed below:

Further, the FAIDA report indicates that value-added foods will grow from Rs. 800 billion presently to Rs. 2,250 billion by 2005 AD. According to the report, the major growth opportunities will include mass-based, high volume, primary processing markets like processed milk, packaged wheat products and bakery products.

Paddy processing

India is the second largest producer of paddy, next to China. Paddy milling is only partly performed in organized rice mills, with a capacity of 1-4 tons per hour. A large amount of paddy is milled in what is known as huller mills (Engelberg hullers), with aspiration to separate husk and bran. Huller mills are mostly used for custom milling of paddy. However, as the shelling and polishing operations are simultaneously performed, the percentage of brokens is high and the bran becomes mixed with husk and is unsuitable for bran oil extraction. Considering the small amount of paddy handled in each mill, the huller mill owners are not enthusiastic about investing on large capacity paddy mills, which can produce products with a smaller percentage of brokens and high quality bran. CFTRI has developed and commercialized various designs which alleviate the problems associated with Engelberg hullers, including huller-huller mills and sheller-huller mills (Srinivas *et al.*, 1990).

India has developed expertise and infrastructure for machinery for the paddy milling industry, including parboiling systems, shelling/hulling/pre-cleaning and grading machinery. Recently several multinational companies have entered the field and made available latest types of machinery for the paddy milling industry. CFTRI has also developed efficient technologies for the production of flaked rice, rice noodles and fast-cooking rice.

Expertise is available both in terms of technology and plant and machinery for paddy by-product utilization. Rice bran oil is not fully exploited for edible purposes. India has a potential to produce 0.9 million tons of edible quality RBO per year. However, current production is estimated at 0.42 million tons of which 0.28 million tons consist of edible quality (unrefined) oil, mostly for the production of hydrogenated fat. Only around 50,000 tons are refined and sold as refined cooking oil. The reason for this non-realization of potential is attributed to the fact that the production of bran and extraction of bran for oil are conducted at different capacities and at different processing centers, with associated problems of collection and processing without any lapse of time. This situation has resulted in high FFA in the bran and most of the oil produced is to be used as soap stock. There is a need to install integrated units to mill paddy and utilize bran for edible oil extraction. Small solvent extraction plants with low solvent losses would also help the rice mill industry to produce high quality rice bran oil.

Wheat milling and processing

Wheat and its milled products constitute one of the major sources of protein in the Indian diet besides pulses. Most of wheat is converted into wheat *atta* (whole wheat flour) mostly by using stone mills or other types of plate mills (more than 0.32 million in number). In addition, there are over 850 roller flourmills, with varying designs and capacities all over the country, some of them imported and some others manufactured in the country. These mills produce white flour, semolina with different particle sizes and refined whole wheat flour (*atta*). In roller flour mills, *atta* production is limited to 5-6% of the total wheat products. They concentrate on the production of white flour in different fractions for use in the manufacture of bread and other bakery products. Both stone mills and roller mills, can hardly be classified as efficient ones. Recently, Indian machinery manufacturers have produced efficient mills, with high extraction yields and low specific energy consumption. For instance, cleaning efficiency of some of the Indian roller mills is 98% as compared to 99% in the most advanced countries (Prakash, 1998). Energy consumption is still high. Several multinational companies have started manufacturing wheat and rice mills in the country.

Atta from roller mills contains streams of fine bran, powdered germ and other finely powdered products. They are low in protein as compared to white flour. One of the major staple foods of India is the *chapathi*, an unleavened flattened bread baked on open pan. *Atta* is preferred for making *chapathis*. In view of the increasing demand for high quality *atta*, which is expected to reach a value of Rs. 150 billion, the industry is gearing up to pre-pack and market as branded *atta*, which is some times enriched with proteinaceous legumes such as Bengal gram and soya flour. For achieving a longer shelf-life, the moisture content of *atta* is brought down to less than 10%, for which separate fluidized bed dryers are used. The recent trend is to integrate these dryers with the main mill.

Pulse milling industry

Pulse milling industry, where more than 75% of the pulses produced in the country are milled, is the third largest food-processing industry in the primary processing sector, after paddy and wheat. Production of pulses reached 14.9. million tons during the period 1997-98. The process essentially consists of pre-cleaning, pretreatment to loosen the husk, dehusking, splitting and grading. The industry, both processing and machinery-wise is rather primitive, resulting in a large amount of powdering and low yield of whole split pulses. Before milling, pulses are dried. The industry has adopted sun-drying, which is a slow process and during the monsoon, drying takes several days. The products include split pulses (whole and broken), husk and powdered pulse. For dehusking, the pulses are passed through an abrasive pearling machine several times. This is the major cause of powdering and low yield. CFTRI has made significant developments in this area, including processing and equipment for hot air-drying and conditioning which will facilitate the removal of husk in an improved pulse pearling machine (Kurien and Ramesh, 1978), efficient husk aspiration, splitting of husked material in a specially designed splitting machine and final grading. Recently, CFTRI has also developed a range of small capacity pulse dehusking machines and versatile *dal* (split pulse) mill (Pratape *et al.*, 1993). These technologies have improved yields in pulse mills, besides resulting in low energy consumption.

Oilseeds and edible oil

Indian edible oil industry is not sophisticated and is progressing in an uncertain manner. The country, which used to be a perennial importer of edible oils and oilseeds, has almost reached a stage of self-sufficiency and has succeeded in reducing imports. The production amounted to around 26 million tons in 1996-97, accounting for 9.7% of the global production

(Virupakshappa and Kiresur, 1998). The country is also a major producer of oilseed meals and exporter of meal. There is still a gap in the supply and demand and in some years import was resorted to. Oil palm is seen as an alternative and long-term source of edible oil. The expansion of area under oilseeds is a major source of growth in oilseed production. However, in future, since the scope for area expansion is limited , productivity increase should take a lead in bridging the supply-demand gap. The increasing productivity trend from 600kg per hectare to 850kg per hectare in the early nineties is expected to continue (Virupakshappa and Kiresur, 1998).

On the processing side, while adequate expertise in terms of technology, plant and machinery is available for extraction, refining and hydrogenation processes, in the field of production of value-added products, especially the use of technologies like molecular distillation, supercritical fluid extraction, the country is really lacking.

Another constraint both for domestic use for edible purposes is the presence of toxin and high fiber content in extracted meals. CFTRI has developed technologies for the production of protein isolates and hydrolysates from groundnut and soybean meal. New technologies have also been developed for upgrading the quality of both oil and meal for the sunflower oil industry. The Institute is also providing assistance to the industry in absorbing and adopting supercritical fluid extraction for certain value-added products.

There is a need for overall improvement of technology, plant and machinery to increase edible oil yields from different oilseeds and rice bran, technology for value-added products and to upgrade oilseed meals both for domestic consumption and export.

Spice processing

India is ranked as the largest producer, consumer and exporter of spices. Cultivation of a wide range of spices is possible due to the different agro-climatic conditions in the country. Total production of spices in India is 225,000 tons valued at Rs. 120 billion. Spices are exported raw (cleaned and graded) or as value-added products such as ground spices, curry powder, spice mixes, spice oils and oleoresins.

The industry is attempting to maintain quality standards to meet the standards prescribed by importing countries. To meet these stringent specifications, the industry has to adopt suitable technology packages for postharvest operations. Contamination of spices by mycotoxins can be avoided, provided the produce is immediately dried and moisture levels are brought down to safe levels (Sivadasan, 1900). Like in the case of cereals, field drying is a problem here also. Prolonged sun-drying leads to increased mold count and other quality problems. Many of the processing operations are manual, adding to the bacterial load. Furthermore, sun-drying in open yards also results in pilferage due to bird pick and rodent menace. The country has to adopt appropriate technologies and machines. Some of these technologies are available in the country and are being used by a few industries. For example, technologies for cleaning and washing of black pepper and process for thermal sterilization of selected spices are available at CFTRI. The industry is slow in adopting them. In many cases transfer of technology is a limiting factor (Peter, 1997).

Fruits and vegetables

Fruit and vegetable processing is another major sector offering a large potential for exports. India today is the second largest producer of fruits and vegetables. A variety of fruits and vegetables, both tropical and temperate are grown here. This industry is characterized by very high postharvest losses. According to the vision document of the Technology Information, Forecasting and Assessment Council (TIFAC) the losses range from 14-36% in the case of fruits and 10-25% in the case of vegetables (Table 4). In 1996, there were more than 4,000 processing units of various capacities in the country. In the export front, mango and grapes rank first accounting for more than 70% of the total exports. Among vegetables, onions accounted for 90% of the exports. Even in large processing units, many processing operations are manually performed, leading to low production rates. The industry also suffers from high packaging costs. A large number of processed fruits and all processed vegetable products are packed in OTS cans. Can costs are high and hence the processed F&V products are costly. Bulk aseptic packing in bag-in-box and bag-in-drum are adopted by many export-oriented industries, mainly for fruit pulps and concentrates. Indigenous technologies are not available for aseptic processing and packaging of particulate products such as cut fruits and vegetables. Lack of cold chains leads to high spoilage rates. Quality of fruits and vegetables received at processing units is not uniform. There are a large number of gaps in the availability and requirement of processing machinery (Ramesh, 1993). There is a need to develop machinery of relatively low capacity, for aseptic bulk packaging and a number of efficient preparatory machines. There is also a need

Table 4 Postharvest losses in various fruits and vegetables

Name of the fruit/vegetable	Postharvest losses as a percentage of production %
Banana	12−14
Mango	17−37
Citrus (orange)	8−31
Guava	3−15
Apple	10−25
Pineapple	5−20
Grapes	23−30
Beans & peas	7−12
Brinjal	10−13
Cabbage	7−15
Cauliflower	10−15
Garlic	1− 3
Onion	15−30
Potato	15−20
Tomato	10−20

Source: Figures based on the study conducted under Indo-US Aid Project for the estimation of postharvest losses in fruits and vegetables (1986~90) as reported in "Advances in Horticulture" edited by K. L. Chadha, 1993.

for developing packaging systems and low-cost packaging materials for use in this industry.

Quality management and training

Two areas need immediate attention of all concerned. Trained manpower is needed for management, production control, quality control, plant design, operation and maintenance and marketing of products. This is rather a neglected area. Agencies like CFTRI, agricultural universities and Indian institutes of technology are fulfilling this need to some extent.

Drawing up quality awareness program at all stages of food production, pre-processing, postharvest processing, transport handling and marketing is an immediate requirement. Many industries are gearing up themselves to adopt HACCP for their production operations. The industry will not be able to market its products if this factor is neglected. Export performance of the industries will significantly depend upon their adoption of quality management measures such as ISO 9000, GMP and HACCP.

Machinery is mainly supplied by chemical processing machinery manufacturers and some multinational food machinery manufacturers. In the small-scale sector, several firms have developed their own design and are meeting the needs of the food-processing industry. The design and quality of manufactured products are far from satisfactory in many cases. There is an urgent need to adopt hygienic design standards for equipment (Ramesh, 1992).

Conclusion

India has a large potential to be a leading producer and exporter of agro-foods in the world. Relatively low yield per hectare and inadequate field level processing and mechanization are the major problems, the latter being the cause of spoilage and wastage of products. Lack of cold chains, long distances involved and poor road conditions in some areas cause further damage.

The industry is seen as a sunrise industry, in spite of all the problems to be addressed. The country has the capability to solve all its technological problems, including design of plant and machinery. Adoption of suitable quality management systems is essential.

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