V. POST-HARVEST TECHNOLOGY FOR EMPLOYMENT GENERATION IN RURAL SECTOR OF INDIA

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Abstract

The present population of India is about 1.05 billion, which is 17% of total world population of about 6,150 million. Though India has only 2.3% of total land area on the planet earth, it supports the survival of a substantial portion of world population. Every human being on planet earth wants prosperity, happiness and security. To achieve this goal, diversification and modernization of agriculture for higher productivity and equitable distribution of food commodities and other necessities of life are needed. In developing countries, it could be achieved to a great extent through selective mechanization of agriculture and appropriate post-harvest management and value addition in the production catchments, leading to employment generation in the rural sector and minimization of losses of the harvested biomass. Thereby, enhancing per capita availability of food, fiber and other essential commodities of life from the same area without any lapse of appreciable time, which otherwise, would have been difficult to get through the production process taking 4-6 months of time, energy and inputs.

It may be noted that India is a predominantly an agricultural economy and 65-75% of its population live in villages/rural sector and earn their livelihood through agriculture. Rural population of India was 91% in 1901 and now it is projected that by 2006, it would be about 65% and may reach to 50% by 2020. Rural people migrate to urban areas for employment and better amenities of life. Such opportunities are presently not available in rural areas but could be created through selective mechanization of agriculture and appropriate post harvest management and value addition to the harvested biomass in the production catchments.

India produces about 450 million tons of raw food materials of plant and animal origin which are refined, stored and transformed into various usable products using conventional and modern post-harvest and food processing technology. It involves operations like cleaning, grading, drying, storage, milling, packaging, transport, marketing and utilization. At the end of each operation, value is added to the product. The lowest and the highest monetary values of a food commodity are, respectively, when it is in raw and fresh form and when it is in processed and ready to consume/eat form. Post harvest and food processing technology are commodity and location specific. It enhances and augments per capita food availability form a unit arable land and other resources by preventing avoidable post harvest losses and adding value to the fresh agro-produces. It also creates opportunities for employment and income generation. Integration of production agriculture with on-farm primary processing is needed to have higher and sustainable production, productivity and better quality end products for domestic and export markets. It, therefore, demands establishment of Agro Processing Centers in the production catchments itself to facilitate backward linkage with farmers, have fresh and best quality raw food materials for processing and value addition, minimize material movements, check migration of rural people to urban areas for jobs and thereby reducing pressure on public utilities in urban areas. Such center would be a very strong tool for rural reconstruction and its upliftment. It would help in reducing rural-urban disparity and ensuring household food and nutritional security for all

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at an affordable cost. The technology is available but political will and commitment is required to implement the programme to shape a new India in the new millennium where every one would be healthy and happy. It is in the interest of the nation and its people.

The proposed action program is as under:

- Continued monitoring of status of processing and utilization of different crops/ commodities, processes, quality assurance, energy audits and economic competitiveness.
- Development and promotion of on-farm storage and rural warehouses for perishables, semi-perishables as well as durables that minimize storage and associated losses, enable growers/herdsmen/fishermen having capacity to negotiate with forces of marketing, provide off-season goods to local people at cheaper rates and raw materials to entrepreneurs/industry with dividends to both.
- Study of post-harvest physiology, senescence, ripening, respiration etc. of different crop varieties and commodities as influenced by time, temperature, humidity, mechanical injuries/interaction, etc.
- Development of HACCP and food safety measures for different commodities and products and developing mechanisms to apply and certify them, setting up of referral laboratories and human resource development capacities in good/biosafety.
- Harnessing biotechnology and genetic engineering that enhance shelf life, quality, and nutritive value; provide protection against post-harvest insects, pests and mycotoxins; improve products market appeal and product recovery, and ultimately make the products cheap and globally competitive.
- Modernization and cost reduction of cleaning, grading, sorting, milling, processing and packaging equipment for food grains, oilseeds, horticultural crops, animal products and fish; noise and pollution control/effluent treatment.
- Modernized packages of processing and utilization of agricultural commodities/crops and their residues and that of under utilized plants in to products in demand as well as developing processes and pilot plants for high value futuristic products or their intermediate stages needed by industry.
- Development of processes and processing machinery for diversified products from commercial crops like cotton, jute, sugarcane, lac, etc.
- Development and adaptation f color sorter for removing discolored fractions in milled rice, dal and fruit sorting lines.
- Develop and commercialize diet convenience and specialty foods and agro process.

Looking into the present agricultural production and postproduction scenario in India, the most appropriate action for employment generation in rural sector is primary processing and value addition in production catchments. Technology for establishing such agro-processing complex in rural areas are available in India and requires to be adopted and should be demonstrated through pilot plant. This will not only help in reducing post production losses, generating employment opportunities in rural sector and higher income to farmers but also provides better quality products to the consumers at reduced rates. This will also leads to the economic utilization of by-products enriching animal health through feed, and soil via composting. Thus, agro-processing in production catchments will benefit people, livestock and the mother earth.

Integrated Intensive Farming System (IIFS) including rural based post-harvest activities are recommended for the overall development of the rural sector. IIFS would create employment and income generation opportunities and thereby enhance the living standard of the people

A. Introduction

India is a predominantly an agricultural economy and 65-70% of its population live in villages/rural sector and earn their livelihood through agriculture. Rural population of India was 91% in 1901 and now it is projected that by 2006, it would be about 65% (Table 5.1) and may reach to 50% by 29,020. Rural people migrate to urban areas for employment and better amenities of life. Such opportunities are presently not available in rural areas but could be created through selective mechanization of agriculture and appropriate post-harvest management and value addition to the harvested biomass in the production catchments.

Table 5.1. Indian rural and urban population during the 20th century and beyond

Year	Population, million			Annual compound growth rate, %	Rural population, %
	Rural	Urban	Total		
1901	212.5	29.9	233.4	-	91.0
1911	226.2	25.9	252.1	0.56	89.7
1921	223.2	28.1	251.3	-0.03	88.8
1931	245.5	33.5	279.0	1.04	88.0
1941	274.5	44.2	318.7	1.33	86.1
1951	298.6	62.5	361.1	1.25	82.7
1961	360.3	78.9	439.2	1.96	82.0
1971	439.1	109.1	548.2	2.20	80.1
1981	523.9	159.4	683.3	2.28	76.7
1991	628.7	217.6	846.3	2.14	74.3
2001	688.4	324.0	1,012.4	1.79	68.0
2006 (Projected)	710.0	385.0	1,070.0	1.55	65.0

Source: Anonymous, 2001.

Food is essential for human survival. It is produced through agriculture. At present, India produces about 450 million tons of food items of plant and animal origin (Table 5.2). Raw food materials are transformed into edible products during post-harvest phase, which starts from production and ends at consumption. 5-50% of food items get lost in the post-production system. The extent of loss depends on the type of food commodity i.e. whether it is durable, semi-perishable or perishable. At least 50% of this loss could be prevented using appropriate post-harvest technology and equipment. This enhances and augments per capita food availability from unit arable land. Thereby resulting in an overall increase in productivity, employment and income. The total food grain production in India has increased from 51 million tons in 1950-1951 to about 211 million tons in 2001-2002 and the productivity increase has been from 522 kg/ha to more than 1,700 kg/ha (Table 5.3).

Table 5.2. Production of plant and animal origin major food commodities in India, 2002-2003

Food commodities, million tons (Mt)			
Plant origin		**Animal origin**	
? Cereals	185	? Milk	83
? Pulses	13	? Meat	5
? Oilseeds	18	? Fish	6
? Vegetables	90	? Egg	2
Plantation products (spices, Condiments, tea and coffee)	3		
Sub total	354		94
Total production of food commodities of plant and animal origin = 354 + 96 =450 Mt			

Source: Anonymous, 2001 and Singhal V., 2003.

B. Scopes, importance and the role of post-harvest technology

Post-harvest technology is an integral part of agricultural production and utilization system and it plays a key role in loss prevention, value addition and employment and income generation. There are four ways of increasing per capita food and fiber availability. One is to increase the area under agriculture, second is to increase the productivity, third is to control the population and the fourth one is to prevent post-harvest losses. Considering the limited and dwindling land and water resources, slow growth in productivity and ever increasing population; minimizing post-harvest losses is one of the most effective and economical ways of increasing per capita food availability.

Table 5.3. Production and productivity of food grains in India during the last 50 years

Year	Production, mt	Productivity, kg/ha
1950-51	50.82	522.00
1960-61	82.02	710.00
1970-71	108.42	872.00
1980-81	129.59	1,023.00
1990-91	176.30	1,380.00
1995-96	180.42	1,491.00
1996-97	199.44	1,641.00
1997-98	192.26	1,552.00
1999-2000	203.61	1,704.00
2000-01	209.80	1,636.00
2001-02	195.92	1,723.00
2002-03*	198.00	1,615.00
2003-04**	211.17	1,800.00
* Estimated ** Projected		

Source: Anonymous, 2001.

The present levels of post-production losses are (Ali, 1998):

- 5-15% in durables
- 20-30% in semi-perishables
- 30-50% in perishables

Present level of production of different types of food commodities and their estimated post-harvest losses along with monetary values are given in Table 5.4. It shows that various food items, to the tune of 65 million tons, worth Rs. 76,000 crores per annum, are lost during post-harvest phase. A substantial amount of these losses could be prevented if appropriate agro-processing centers having backward linkage with farmers to ensure constant supply of quality raw food materials are established and operated. Profit generated through value addition must also be shared with farmers who are only people in the world to create wealth every year, in the form of food, fiber and other commodities necessary for human survival. It can bring a sea of change in rural areas, where 65-70% population lives, in respect of economy, health and happiness.

Table 5.4. Production of different food commodities and their estimated post-harvest losses in India

Type of food commodity	Present Level of production			Post-harvest losses		
	Quantity Mt	Average price Rs/t	Value, Rs, Cr.	%	Quantity, Mt	Monetary value, Rs, Cr.
1. Durables (Cereals, pulses and oilseeds)	215	1,000	215,000	10.0	21.5	21,500
2.Semi-perishables (Potato, onion, sweet potato, tapioca)	40	3,000	12,000	20.0	8.0	2,400
3. Perishables (Fruits, vegetables, milk, meat, fish and eggs)	140	15,000	210,000	25.0	35.0	52,500
Total/Average	395	11,063	437,000	17.5	64.5	76,400

Mt = Million tons, Cr = Crore (10 million)
One US dollar = Rs. 50 (Rs=Indian Rupee)
Source: Ali, 1998.

C. Processing and value addition

The two major goals of PHT are loss prevention and value addition to the raw food commodities through preservation and processing. Raw food materials are cleaned, graded and then conditioned either for storage or processing. Processing is done to make raw commodities edible through primary and secondary processing and ready to eat through tertiary processing (see Fig. 5.1). At every stage of processing, value is added to the product. Estimated value additions to the raw food materials through primary and secondary/tertiary processing in India are 75% and 25% respectively. It, therefore, shows that primary processing has a greater role to play in improving the economic benefits to the farmers.

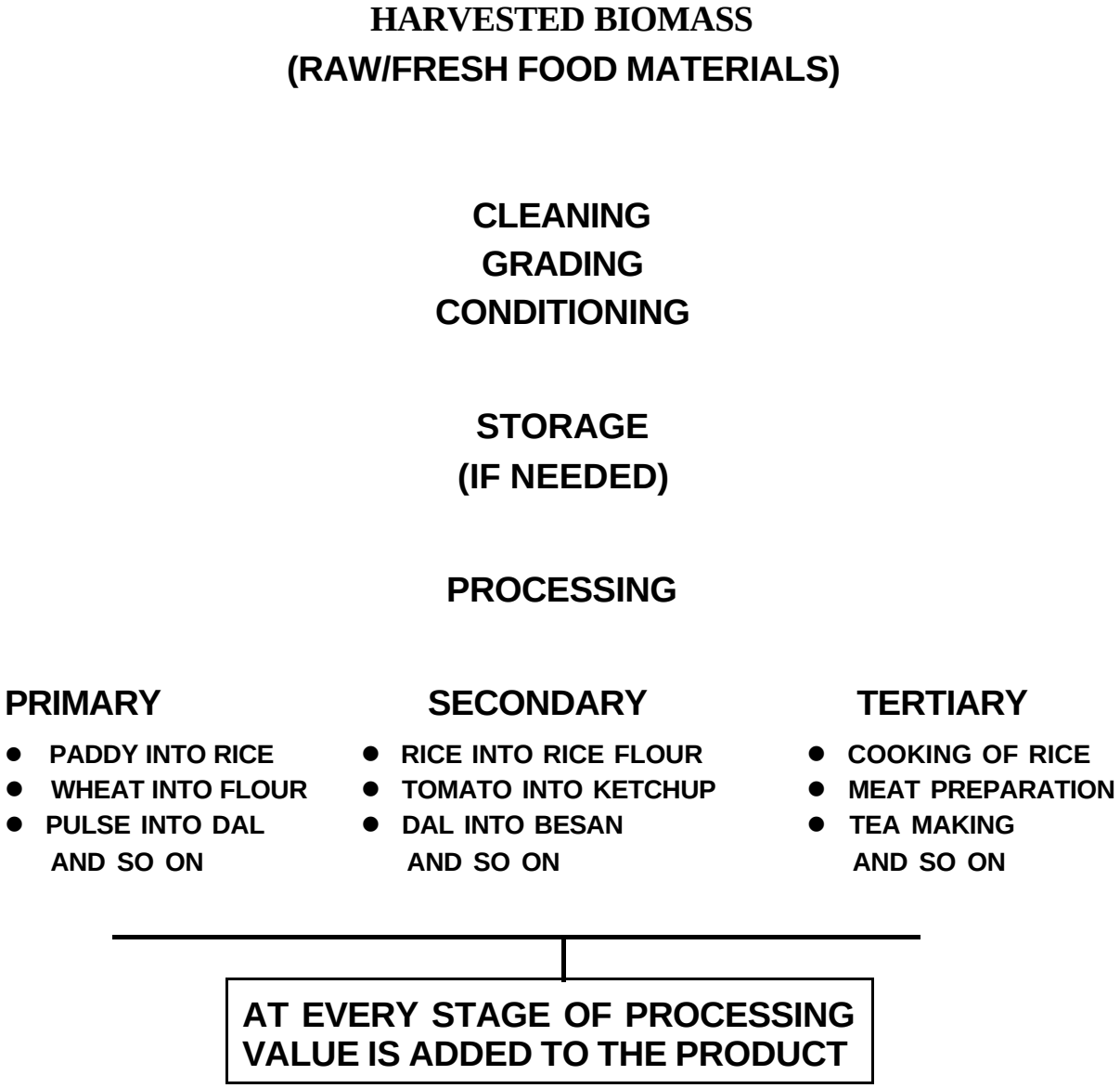

Fig. 5. 1. Flow diagram of value addition to the harvested biomass of plant and animal origin

The lowest and the highest monetary values of a food commodity are, respectively, when it is in raw and fresh form and when it is in processed and ready-to-eat form. Processing technology is commodity and location specific and it can be grouped as:

- Milling of cereals and pulses
- Oil expression and extraction
- Fruits and vegetable preservation and processing
- Processing of plantation, root and cash crops
- Animal product processing including that for fish

A wide range of tools, machines and equipment are used in post-production agriculture (Table 5.5). The globalization of trade may compel many agro processing industries to rely on an imported technology at a high cost and the advantage of such technology may be availed by a few who have an exclusive business interest. Majority of agriculture-based enterprises will continue to depend upon indigenous technology and, therefore, R&D through public support has to be strengthened to become globally competitive and serve small-scale food processing sector of the country.

Table 5.5. Present status and future projections of some of the post-harvest equipments in India

Name of the equipment	Number in 1991	Projected for 2010
• Cleaners & graders	110,000	450,000
• Dryers	7,000	50,000
• Maize shellers	65,000	125,000
• Flour mills	266,000	425,000
• Rice mills	125,000	160,000
• Dal mills	10,000	30,000
• Groundnut decorticators	150,000	300,000
• Oil expellers	225,000	410,000
Total	958,000	1,950,000

Source: Ali, 1998

D. Agricultural processing

All the raw food materials are processed to improve their palatability, nutritional value and shelf life. Processing is carried out at household, micro, small and large scales either for home consumption and/or for trade. Conventional post-harvest operations, which can be improved, take better advantage of raw materials and modern technology (Table. 5.6).

In crop production and utilization system, the post-production loss occurs at all stages of operations. Right in the field with standing crops; in transport, threshing, cleaning, drying, storage, milling, packaging, preparation and utilization. But these losses can be avoided by adopting improved post-harvest practices and equipment evolved through R&D. Post-harvest processing of some of the major food commodities are described here.

Table 5. 6. Some of the conventional and improved post-harvest and agro-processing operations

Operation/activity	Conventional Technology	Improved Technology
• Threshing	Manual beating and animal/tractor treading	Mechanical threshing with improved design of threshers.
• Winnowing	Manually with ordinary baskets	Mechanical winnowing with manual mechanical power.
• Cleaning	Manually operated SUPA, a simple device but of low capacity.	Manual/power operated cleaner-cum-graders.
• Drying	Open yard sun drying	Solar dryers or heated air dryers using mechanical power.
• Storage	Earthen pitchers, mud bins or bag storage	Metal bins, brick structures and concrete silos of improved designs.
• Milling	Hand and foot pounding, rice hullers, stone grinders, oil ghanis, etc.	Modern rice, dal and flourmills of different capacities, oil expellers, solvent extraction plants.
• Byproduct utilization	Direct feed and fuel uses	Solvent extraction of rice bran and oil cakes, pelleted animal feed, etc.
• Marketing	Selling raw materials to middlemen of trade at low prices	Selling of cleaned and graded produces, value added products directly to super/cooperative markets for better profitability.
• Preparation & Utilization	Open vessel cooking and traditional food preparations	Pressure and microwave cooking. Nutritionally balanced diet/recipes. Use of refrigerators, grinders/mixtures.
• Social responses	Rigidity in food habits and preparations	Flexible & fast changing food habits and varieties, out of home eating, packed foods, etc.

Source: Ali, 1999.

1. Paddy/rice processing

Paddy production in India is about 125 million tons. The cleaned paddy, on an average, yields 22% husk, 6% bran and 72% rice. Paddy is milled into raw or parboiled rice and flaked rice. Puffed rice is also produced as snack food. Milling is generally done in hullers, shellers and modern rice mills. The design parameters for a paddy-rice milling system are capacity, mill type and economics. In the conventional paddy-rice system of harvesting at low moisture content, parboiling in masonry tanks, drying in sun and milling by hullers, the total yield of

rice seldom exceeds 65 per cent with 20-30 per cent broken when milled as raw and 68 per cent with 15-20 per cent broken as parboiled paddy (Table 5.7). Moreover, the by-products cannot be used economically. Excessive breakage during milling in the conventional system reduces the total recovery of rice.

Table 5.7. Average output of raw and parboiled rice in various milling units/system

Milling Unit	Rice output, %					
	Raw			Parboiled		
	Total	Head	Broken	Total	Head	Broken
Huller	65.00	50.00	23.00	68.00	61.00	10.00
Sheller	68.00	60.00	12.00	70.00	65.00	7.00
Modern	71.00	65.00	8.00	72.00	68.00	5.00

The recent investigations have shown that it is possible to increase the total out turn of better quality rice by 10 per cent with improved harvesting, parboiling, drying and milling technologies. The increase in rice out turn will be about 8 million tons assuming 125 million tons of annual paddy production. Its economic value would be approximately Rs. 80,000 million at the rate of Rs. 10,000/ton.

2. Wheat

Wheat is harvested, transported and stored in the form of grain. Average weight of 1000-grain of wheat ranges between 35-45 g. Wheat grain consists of 12% bran, 3% embryo and 85% flour. It is processed for flour, maida, Suji and Dalia. There are 3,00,000 wheat milling units consisting of hand grinders and flour mills (one and 10 hp units). Roller flourmills are 426 with a milling capacity of 8-10 million tons.

The proximate nutritional composition of wheat is 10% protein, 2% fat, 5% crude fiber, 3% minerals and 80% carbohydrates. The pattern of distribution of nutrients within wheat grain has been reported that starch is present only in the endosperm, crude fiber is restricted almost entirely to the bran, but protein occurs throughout the grain. About 50% of total lipid is in the endosperm, 20% in the germ and 30% in the bran, but more in aleurone than pericarp and testa. Over 50% of the total mineral is present in the pericarp, testa and aleurone.

Wheat is cleaned to remove impurities, conditioned primarily to improve the physical state of the grain for milling, and sometimes to improve the baking quality of the milled flour milled in burr or roller flourmills. The burr mill consists of two discs of hard and abrasive stone, arranged on a vertical/horizontal axis. The stone surfaces facing each other are patterned with a series of grooves leading from the center to periphery. In operation, one stone is stationary while the other rotates. Grain is fed from the center and the ground product

discharges at the periphery. The flour extraction rates vary from 75-100% depending upon the extent of bran removal and degree of whiteness for fine flour.

White flour is obtained using modern roller-mill, exploiting the differences in mechanical properties between the endosperm, bran and germ. It is essential to minimize the production of fine particles of bran and this basic requirement is responsible for the complex arrangement of the modern flour-milling system and for the particular design of the specialized machinery used in it, and also for the conditioning process. There are three basic processes, grinding, sieving and purifying. Whole-wheat flour is better for health and need to be advocated.

3. Pulse processing

The production of pulses in India is 13-15 million tons and these are the major protein source in Indian diets. Protein content is 220-250 g/kg. It makes 15-30% of protein requirement. Dal yield (split pulse) potential is 83-85%, but at present, it is 65-70% in conventional mills and 70-75% in modern dal mills. There are 10,000 modern dal mills in India. Such dal mill should be multiplied and promoted.

Dal milling is the 3rd largest processing industry in India after rice and wheat milling. Dal milling is done by means of both, traditional and modern mills in different parts of the country. At the household level, hand stone grinder (Chakkis) is used to dehusk and split pulses. Whereas, the mechanized rollers and shellers are used by the organized industry to prepare dal from pulses. Dal milling basically consists of removal of husk without loosing any edible portion, i.e., the cotyledons and the germ, if possible. The husk of most pulses is attached to cotyledons through a layer of gums. The husk may be thin or thick; rough or smooth; sometimes with oil/wax coating. Moisture has opposite influence on the adherence of husk to the cotyledons and the bonding between the two cotyledons. The maximum possible recovery and dal yields in respect of few selected pulses are given in Table 5.8. Dal milling is generally done in two steps: Loosening of husk by wet or dry methods; Dehusking and splitting into two cotyledons using appropriate machines.

Table 5．8． Husk content, the maximum possible dal yield from some of the selected pulses grown in India

Pulse (Grain legume)	Husk content, %	Gota yield[1], %	Dal yield, %	Germ yield, %
Chickpea	12	88	84	4
Pigeonpea	13	87	83	4
Mugbean.	11	89	84	5
Black gram	13	87	83	4
Cowpea	12	88	83	5
Kidney bean	11	89	84	5
Horsegram	12	88	83	5
Soybean	11	89	84	5
Average	12	88	84	4

1 Gota = Dehusked pulse; Source: Ali and Srivastava, 1993.

The amount of oil mixed with pulses varies from place to place. It is 50-400g/100kg of pulse. Similarly, addition of water also varies from 4-20kg/100kg of pulse grain. For loosening of husk and its complete removal, 3-7 passes through the roller in case of pigeon pea are given to the conditioned grains. A process flow chart along with mass balance for making pegionpea dal is given in Fig. 5.2. There is a need to develop new dal milling technology to achieve higher dal recovery, less energy consumption and pollution free dal mill surroundings. Protein rich products from dal brokens may also be developed and promoted.

PIGEONPEA (100 KG)		
	Cleaning (99 kg)	Impurities (1 kg)
	Milling – 1 (94 kg)	By-products (5 kg)
	Cleaning & grading (86)	By-products (8 kg)
Water	Soaking (20 min)	Loss (1 kg)
	Sun drying (12 h)	Moisture (10% wb)
	Milling –2 (79 kg)	By-products (6 kg)
	Cleaning & grading broken (6 kg)	DAL (73 kg)

Fig. 5.2. Process flow-chart and mass balance for making pigeonpea dal (improved process)

4. Oilseed processing

The oilseeds production is about 18-20 million tons. On an average, oilseeds contain 40% oil and 20% protein. Present utilization of total oilseed production in India is 7% as seed, 8% direct food uses and 85% for oil extraction. Meal/cake export is worth Rs. 25000 million. Nutritionally, the edible oil is the richest source of energy (9 kcal/g) and provides essential fatty acids and transports fat-soluble vitamins in human body. There is a shortage of edible oil in the country. One of the ways of augmenting edible oil supply is to reduce post-harvest losses of oilseeds and enhance oil extraction efficiency.

Traditional oil extraction equipment of India is the bullock-drawn ghani, which leaves 10-15 per cent oil with cake. The mechanical power ghanis have now been introduced in the country but they also leave 8-12% oil with cake. The ghanis are phasing out is favor of power operated oil expellers. The single and the double chamber expellers of this type are capable of extracting most of the oil except 6-8%, which is left with the cake. There are about 225,000 oil extraction units in India, which consist of 160,000 expellers and 65,000 ghanis. In addition, there are about 400 solvent extraction plants. Oil left in the solvent extracted meal is less than 1%.

Refinement of meal/cake for food product development is desirable. Oil expeller with lightweight, energy efficient and capable of extracting up to 90% oil and above is to be developed for decentralized oil milling. Hydraulic press, batch solvent extraction, extrusion expelling and physical refining of oil, need to be attempted.

5. Soybean

Soybean packed with 40% good quality protein, 20% oil and other nutrients has a great potential to combat protein-calorie malnutrition in India at an affordable cost. Soy foods are nutritious, economical and provide many health benefits. Use of 5-25% of soybean along with cereals gives maximum nutritional advantages. However, due to the presence of some ant nutritional factors in soybeans, it requires careful processing to make it fit for human and animal consumption.

The annual soybean production in India is 5-6 million tons. Soybean is generally processed for its oil (20%), protein (40%) and lecithin (0.4%). Whole beans or partially/fully defatted cake/meal are used for making various soy based food and feed products. Soybean fortification enhances the nutritive value and functionality of foods and feeds. As of now, in India, soy products like oil, textures soy protein (TSP), soymilk, soypaneer (Tofu), soy-yogurt, soy flour, soy fortified bakery products, and health and snack foods are gaining good acceptability among the people because of economic and health benefits. Also, the use of soy meal as protein source in poultry, piggery and aquaculture feeds are increasing.

Soybean has gained importance for its contribution to foreign exchanges to the extent of Rs. 20,000 million annually and for augmenting edible oil resources of India by 0.4 to 0.6 million tons per year. It has brought socio-economic prosperity to soybean farmers. Today soybean occupies a vital place in agriculture and oil economy of India. It has emerged as third important oilseed crop after groundnut and rape/mustard contributing about 12% to the total edible oil pool of India (Anonymous, 1998).

Soybean as a rich source of protein has tremendous diversified food and feed values. This would call for great care in processing, keeping in view the ultimate products, which one is aiming at viz, oil, protein or lecithin. The primary interest in soybean in India has been oil, although increasing attention is currently being paid to the potential that soybean offers as a major protein source. About 15% of total soybean production goes for direct food and feed uses, 10% for seed uses and 75% is processed for oil and protein. Crop residue like leaves, fine straw are used as fodder and the hard and woody stem for fuel in rural areas. The present day soybean industry has about 330 units, which may be grouped as under:

-	Oil extraction plants:	154
-	Food manufacturing units:	125
-	Equipment manufacturers:	30
-	Trading houses:	15
-	Government and other agencies:	6
-	Total:	330

Creation of domestic market for soy meal through its utilization in food, feed and pharmaceutical industry is essential for delinking foreign dependence of Indian soybean industry. This requires need-based and high quality R&D in the area of soybean processing and utilization. Some of the suggested strategies for value addition and diversified uses of soy meal in domestic and export market are:

- Protein rich defatted edible soy flour to be used in wheat and chickpea flours for higher protein content and better nutritional quality.

- Soy based high quality and cost-effective poultry, aqua and cattle feeds.

- Soy protein concentrates, isolates and hydrolysates to be used in food formulations for infants, children, adult and aged persons.

- Soy based specialty foods for diabetics, lactose intolerants and cancer and CVD patients.

- Export of value added soy meal for food, feed and industrial applications.

- For biodegradable plastics and packaging.

Soybean has bright future in India. Low-price and high nutritive soy based food and feed products are gaining consumer acceptance and the demand for these products is increasing. It, therefore, ensures economic viability of soybean industry and promises household nutritional security and better health in the near future.

6. Animal products

Livestock husbandry and dairying is an integral part of cultural ethos of India. Success of Amul Pattern has imparted great impetus to decentralised milk production and organised processing and marketing through network of co-operatives. Amul Pattern is harbinger of White Revolution in the country. 'Primary Milk Producers Societies' are affiliated to a District Union, which own and operate a feeder/balancing dairy plant; cattle feed plant and facilities for production of semes and its distribution. Milk production at 83 Mt is being efficiently handled; milk products are readily available, marketed in distant markets. Solid and liquid wastes, skin and hydes, caracass of dead animals need to be handled more efficiently. Popularity of biogas plants as quality cooking fuel to rural homes and orgnic manure have created good avenue for livestock solid and liquid wastes. Skin and hydes have their network, essentially rural, though not very satisfactory.

Meat and poultry production is at 5 Mt with goats and sheeps contributing 54%, buffalo and cattle 26%, poultry 13% and pig 7%. It is used mostly fresh. But infrastructure is developing to export meat and poultry. Production is essentially decentralized and rural, stall-feeding of buffaloes for meat purpose is suggested. Poultry has done well remaining rural and developing network of marketing in remunerative distant markets. Hygiene in slaughterhouses, 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.

Egg production, about 2 Mt, and its market has increased a great deal. Eggs are being moved to distant markets for better price. Due to lack of refrigeration and efficient transport, large quantitative of eggs perish. Egg albumin flakes, pickled eggs are some of the possibilities that have been tried.

7. Fish and fish products

India, with its 7,500 km long coastline and an exclusive economic zone of 2.02 million km^2; 28,000 km of rivers and 3 million hectares of reservoirs and fresh water lakes, has an enormous potential for fisheries. The country has an estimated 1,42,450 traditional fishing craft; 34,000 mechanized fishing vessels and 180 deep-sea vessels in operation, at present. The present fish production is about 6 million tons.

Fish processing in India is done almost entirely for export purposes through 223 freezing units with a capacity of 2,170 tons; 25 canning units with a capacity of 84.5 tons; 129 ice-making units with a capacity of 1,820 tons; 24 fish meal units with a capacity of 419 tons and 297 cold storage units with a capacity of 20.35 tons. The existing capacities are very small compared to the potential. Due to lack of handling and storage facilities fair percentage decays and disintegrates before reaching markets and processing factories. Chilling the fish after catch can reduce it. Inland fisheries need cheap palletized feeds, special containers to transport fingerlings and fish. Fish hatcheries, fingerlings rearing ponds/structures, brooder and fish rearing ponds and control of seepage loss need special attention. The fishing gears are age old. Refrigerated handling, transport, storage and retail counter, better fish waste and byproduct use need to be developed.

E. Rural-based agro-processing

There is a convergence of thought at all levels that development and application of appropriate post-harvest technologies leading to the establishment of Agro-Processing Centers (APCs) in the production catchments and owned & operated by targeted beneficiaries, individually or collectively, are must. It has greater capacity for employment and income generation than production agriculture. It can help stabilizing market prices through removing vulnerabilities of perishables by transforming them into semi-perishables or durables or through appropriate post-harvest infrastructure hold safely the perishable agricultural commodities for table use. De-urbanization has come to be a development goal in order to improve lot of the rural people.

The present scenario of declining public funding and emphasis on privatization, weak public-private linkages and lack of confidence between them, adjustments in public funding and audit procedures impede the development processes towards agro-processing more so on-farm agro-processing that can directly increase income and employment to the rural people for their socio-economic development. There are production and productivity related constraints too that impede acceleration in agro-processing. Many of our crop varieties are tailored for table grade use, when sued for processing the product recoveries tend to be low, much lower than the strains and varieties available with the world leaders. The major goals of post-harvest technology at rural threshold should be:

- Minimization of harvest and post-harvest losses, improving net availability and net returns to the growers.
- Capacity to handle and hold the produce without excessive losses at affordable cost to negotiate with the forces of marketing avoiding distress sales.
- Transform the perishables in to semi-perishables or durables for better marketing and also value addition.
- Creation of rural agro-processing enterprises that meet needs of the rural people at the least cost and market surpluses alter value addition for additional income and employment.
- Improve livelihood base of rural people through entrepreneurship development and up gradation of skills.
- Provide consumers fresh and processed products at reasonable rates.
- Make better use of crop residues, processing of by-products and wastes in eco-friendly and economically rewarding fashion.
- Meet hygiene and quality standard specified for domestic and export markets for fresh and processed products.
- Appropriate packaging and marketing of minimally processed and value added products through cooperative super market and other retail outlets.

F. Status of post-harvest technology and agro-processing industry

The size of India's food industry is estimated at Rs. 250,000 crore and expected to double by 2005. Of this, value added processed food are forecast to rise three times form the present Rs. 80,000 crore to 225,000 crore during the same period. Indian food agro-products industry is predominantly related to conservation and simple processed food. However, there is a trend towards value added, easy to use convenient products. Some of the major post-harvest technology and equipments developed in India are given in Table 5.9.

Table 5. 9. Some of the major post-harvest technologies and equipments developed in India

Name of the Technology/ Equipment	Description
Optimum Stage of Harvesting	For higher grain yield and better milling characteristics, optimum stage of harvesting was studied and recommended for different high yield varieties of rice, sorghum, groundnut, pigeon-pea, green gram, Bengal gram, red gram and finger millers in different agro-climatic regions (work done by all the Centers).
Status of Traditional Post Harvest Activities	To identify the field level problems, surveys were conducted in different regions on status of post harvest activities. Also losses at different stages after harvesting were assessed (work done by all Centers).
Effect of Chemicals on Yield	To hasten the process of grain maturity with higher yield, 15% salt spray on physiologically matured crop was found to reduce time for harvest by 3-5 days for rice (TNAU Coimbatore, CRRI Cuttack, and IIT Kharagpur).

Name of the Technology/ Equipment	Description
Groundnut Stripper	Drum and comb type manually operated groundnut strippers were developed for minimizing drudgery. These increase the output by 2-2.5 times as compared to manual method (8.5 kg/ha) and costs Rs. 1000-3000. A motorized machine for this purpose has also been developed at TNAU Coimbatore.
Maize Dehusker Sheller	Pedal operated machine of 200-250 cobs/ha, costing rs. 5,000 and an electric motor operated unit of 400-500 cobs/ha costing Rs. 25,000 have been developed to remove sheath from the cobs, and grain from hearth. The shellers require 2-3 operators (RAU Udaipur). It has been under commercial manufacturing.
Crop covering structures	For protection of heaped harvested crop from untimely rain, collapsible structures made form conduit pipes and tarpaulin/polyethylene have been developed to cover 50-100 m^3 of crop volume (PKV Akola).
Storage structures	For minimization of storage losses to food grains at farm level, improved structures were developed. These included (i) PKV Bin (raised platform, rodents protected cylindrical shaped bin made from locally available materials of 5 q capacity at PKV Akola), (ii) Chittore Stone Bin (made of stone slabs and cement mortar, 5-10 q capacity developed at RAU Udaipur), (iii) Metal Bin (made of GI sheet, capacity 1.0-10.0 q, developed at CIAE Bhopal and PAU Ludhiana), (iv) Nanda Bin (made of bricks and polyethylene shee4t, capacity 3-5 q, developed at CRRI, Cuttack), and (v) Plywood Bin (made of plywood with wooden frame, developed at PAU Ludhiana). Storage losses in these were less than 1% in 6 months as compared to 6-7% in local bins.
Crop Driers	Agricultural waste fired batch drier of 250 kg capacity with air blowing system was developed at PKV Akola to bring down the moisture content of freshly harvested crops; rice, sorghum chillies etc. to safe levels to minimize losses. It costs Rs. 15,000 and needs 8-15 kg/ha of agricultural waste as fuel. A trolley-cum-batch drier was developed at PAU Ludhiana utilizing crop waste as fuel, as well as engine heat of tractor/diesel engine. It can dry 500 kg of paddy form 20 to 15% moisture content in 8 hours. Metal bin batch drier with kerosene burner was developed at TNAU Coimbatore of 500-1000 kg batch capacity for different crops. It requires 2 hp electric motor and 1.0-1.5 lph of kerosene and costs Rs. 200,000. Also, an agricultural waste fired batch drier was developed at Coimbatore costing Rs. 25,000. A paddy husk fired direr with forced air system has been developed at Pantnagar that is suitable for small rice mills. It costs Rs. 20,000.
Cleaners and Graders	Paddy winnowers, with and without scalper of 500-540 kg/h capacity were developed at TNAU Coimbatore. These cost Rs. 10,000. Rotary screen grain pre-cleaner of 5 t/h capacity for cereals and pulses was developed at Ludhiana costing Rs. 25,000. Groundnut grader (oscillating screen type), of 400 kg/h capacity costing Rs. 5,000 was developed Coimbatore.
Decorticators and Threshers	Coriander thresher of 25 kg/h capacity was developed at Coimbatore. TI operates on 0.5p electric motor, and costs Rs. 7,000. A manually operated groundnut decorticator of 50 kg pods/ha was developed at Coimbatore. It is easily portable and cost Rs. 1,500.
Storage structures for	Forced air ventilated onion storage structure having air duct at the centre and wire

Name of the Technology/ Equipment	Description
Onion	mesh wall with storage capacity of 1.5 cubic m was developed at CIAE Bhopal costing about Rs. 10,000. It was able to reduce losses to 5% as compared to 10% as compared to 10% in traditional methods over a period of 3 months. At Akola, Onion Storage Structure (concentric perforated cylindrical shaped cages) with raised plinth was developed for 25 cubic m capacity.
Solar Drier and Seed Treater	A solar cabinet drier with wooden frame, glass top and wire mesh screen cabinets/drawers was developed at Bhopal. It reduces drying time by 66% over open surface sun drying for chillies, cut-cauliflower, green vegetables etc. and cost Rs. 10,000. A multi seed treater with parabolic reflector, and grain conveyor at the focal axis, has been developed at Udaipur for removing insect infestation through heating.
Milling equipment for small scale operations	A multipurpose grain mill operated by 2.o hp electric motor was developed at CIAE bhopal. It is used for grinding/milling of cereals to grit (for feed and food), and fine powder (flour). It can also grind spices. The mill gives 8-30 kg/h capacity for different materials and costs Rs. 8,000 with motor. A concentric abrasive cylinder dhal mill of 100 kg/h capacity for small entrepreneurs was developed at Bhopal for Pigeon pea, green gram and black gram. It operates on 2.0 hp electric motor and costs Rs. 15,000. The entire plant based on this mill costs Rs. 25,000.
Leaf Grinder and Pyrolyser	A leaf grinder for grinding 60 kg/h of dried leaves has been developed at Jabalpur. It costs Rs. 1000. Also, a Pyrolyser has been developed that converts powdered leaves to charcoal powder using a cylindrical drum and produces 10 kg/h of product. The Pyrolyser costs Rs. 2500. A briquetting machine for agricultural waste and charcoal has been developed at PAU Ludhiana for small scale operation.
Decorticators	The TNAU model of groundnut decorticator was modified at CIAE Bhopal from ergonomic consideration to decorticate 50-70 kg pods/h. The unit costs Rs. 1500 and has been under commercial manufacturing by a number of companies.
Grain Infestation Detector	A manually operated infestation detector for showing hidden infestation in grains has been developed at CIAE Bhopal. It consists of two grooved and pinned circular metal plates. It costs Rs. 500 and uses Ninhydrin soaked blotting paper for obtaining stains of the body fluid of insects. The gadget is ideally suited for fast detection of insect infestation.
Straw Baler and Feed Treatment structure	Straw baler, capacity 40-50 bales/day of 20 kg each using 3 hp electric motor was developed at Bhopal. It costs Rs. 25,000. A feed treatment structure of 9 cubic m capacity was also developed for gaseous (ammonia) treatment to straw and costs Rs. 12,000.
Pedal-cum-power Operated Cleaner	A pedal-cum-power operated cleaner suitable for a variety of agricultural grains having oscillating screens, and blower mechanism was developed at Bhopal. Its capacity is 300-500 kg/h of different grains, and costs Rs. 12,000. / It can be operated either through pedaling or by 0.5hp electric motor.
Seed Treater	An infrared radiation based seed treater of 40-50 kg/h capacity (10-30s of exposure for complete mortality) has been developed at Coimbatore. It costs Rs. 4,000.
Use of Biogas in	Biogas was found effective for safe storage of food grains by Coimbatore and

Name of the Technology/ Equipment	Description
Grain Storage	Ludhiana Centers. 100% mortality of insects was observed in 10 days of gas exposure inside airtight containers. The cost of treatment was Rs. 20/t of grain.
Bottling of Sugarcane Juice	A process has been developed at TNAU Coimbatore to preserve sugarcane juice upto 120 days in glass bottles using potassium met-bi-sulphite, and sterilization of bottles. The process costs less than Rs. 1.00 per 180 ml bottle.
Rice Puffing Machine	A manually operated, agricultural waste fired rice puffing machine of 10-15 kg/h capacity costing Rs. 1,000 has been developed by IIT, Kharagpur. It also puffs/roasts sorghum, Bengal gram and popcorn. More than 250 units have been sold int eh market.
Pantnagar Dhal Mill	A dhal mill of 250-300 kg/h capacity was developed at Pantnagar. The mill uses Carborundum rollers rotating inside perforated metal screen to dehusk the pre-treated grain and yields 75-76% recovery for pigeon-pea (as compared to 71-72%) in case of traditional dhal mills). The mill combines dehusker, dhal cleaner, and grader. The entire plant costs about Rs. 75,000.
Pearler for Coarse Grains	A sorghum pearler of 25 kg/h capacity consisting series of abrasive stons operated by 1.0 hp electric motor has been developed at Coimbatore with 80-85% dehulling efficiency and costs Rs. 7,500.
Sago Roaster	A sago roaster-cum-drier operated by 1.0 hp electric motor and 12 kW electric heaters has been developed at Coimbatore for 100 kg/h capacity. It costs Rs. 12,000.
Ginger and Turmeric Polisher	Hand operated 10-15 kg/h capacity ginger-cum-turmeric polisher units costing Rs. 2,000 with 95-98% polishing efficiency has been developed at RAU Udaipur. It suits the requirement of a small entrepreneur.
PKV Dal Mill	A compact mini dal mill with all essential operations integrated has been developed at Akola. It yields 100 kg/ha of dhal from a variety of pulse grains and uses an electric motor of 2.0 hp. The mill costs Rs. 40,000. By the end of the year 2000, 25 units have been sold. It is advantageous to small-scale processors due to less cost and space economy.
Pea Peeling and Punching	As green pea peeling machine of 50-60 kg/h capacity has been developed at JNKVV Jabalpur. It is operated by 0.25 hp electric motor and costs approximately Rs. 10,000. Besides, a manually operated pea-punching machine has been developed that uses two circular disks (one with circular grooves to hold 200-250 g of peas, and another on the top with sharp pins welded at 6 mm spacing. The machine costs Rs. 2,000.
Extraction of Chillies Seed	To minimize drudgery to the seed extraction workers due to high pungency, at TNAU Coimbatore, and Akola Centres, electric motor driven chilli seed extractors have been developed. Capacity of these machines ranges from 50-70 kg/h or red chillies and yield about 95% extraction efficiency. The unit developed at PKV Akola has been under commercial production. It is coupled with a bucket elevator.
Agro-processing	Agro-processing centers as multi-product small scale processing enterprises were

Name of the Technology/ Equipment	Description
Center	designed and established by Bhopal, Ludhiana, Coimbatore, Junagadh, Pantnagar, Akola, Udaipur and Bangalore Centres. The cost of all the equipment per center varies between rs. 1.00-3.00 lakhs and these provide employment to 4-5 persons all through the year. These are designed to serve as multi-product processing facilities to augment income to producer/farmers through production and sale of value added products, generation f rural employment all through the year, and help consumers to get processed products at minimal cost.
Garlic Bulb Breaker	A hand operated 40-50 kg/h capacity, 92-93% breaking efficiency, and garlic bulb breaker, costing Rs. 2,000 has been developed at Udaipur centre. It is ideally suited for small entrepreneurs. Another machine using 0.5 hp electric motor can break 100-120 kg/h garlic bulbs, costs @ Rs. 5,000.
Use of Waste Kagzi Lime for Citric Acid	A process has been developed at PKV Akola to use waste kagzi lime for the production of citric acid granules (2.5% recovery by weight), and gypsum (2.7 recovery). A pilot plant for this technology has also been developed.
Enhancement of Shelf Life of Fruits and Vegetables	Shelf life of banana could be enhanced to 40 days when packed in 300 gauge LDPE bag, with treatment. Shelf life of tomato could also be enhanced to 40 days when packed under above conditions with suitable treatment (TNAU Coimbatore).
Cashewnut Sheller	A continuous type cashewnut sheller of 18 kg/h capacity and 70% shelling efficiency for roasted nuts has been developed at IIT Kharagpur. The unit is ready for multi-location trials.
Water Chestnut Decorticator	A 1.5-q/h capacity machine with 95% decortication efficiency operated on 2 hp electric motor has been developed at Jabalpur for Water chestnut grading-cum-decortication. The machine is likely to get commercialized soon.
Mango Grader	Mango grader of 0.5 t/h capacity has been developed at Pantnagar for obtaining 4 grades. The machine costs about Rs. 20,000. It is being adopted for other fruits also.
Bengal Gram Stripping-cum-Shelli ng Machine	A machine designed at Jabalpur yields 50-60 kg/h of stripped and shelled Bengal gram with 74% efficiency and costs about Rs. 10,000.
Magnetic Treater for Seeder	A 700 gauss electro-magnetic field applied on soybean and groundnut seeds of r5-11 min. was found to increase seed viability and vigour significantly, A magnet seed treater of 5 kg/h capacity is being fabricated at PKV Akola.
Microwave for Disinfestations	Using microwave, an exposure of 20-25 s produced 100% mortality of adult insects in rice. In case of gamma radiation, an exposure of 25-30 rad. Produced 100% mortality in 21 days at IIT Kharagpur.
Honey Bee Smoker	For ease in honey extraction, to subdue honey bees, a 9 V.D.C. Battery operated; the farmers at PAU Ludhiana have developed burlap cloth burning/smoking type unit for use. It has been under commercial production.
Radial Honey	A radial honey extractor using manually operated centrifugal type

Name of the Technology/ Equipment	Description
Extractor	concentric.cylinder system has been developed at PAU Ludhiana for farmers' use. Also, an electricity motor operated unit has been developed. These are under commercial production.
Effluent Treatment System	A rice mill effluent treatment system using digestion of organic wastes by anaerobic bacteria suitable for 4 t/h capacity rice mill has been developed at PAU Ludhiana, adopting the concept which was developed earlier at IIT Kharagpur. The system has been installed and evaluate din a rice mill.
Blended Leather Boards	At Coimbatore, leather dust (waste) combined with cellulose fibres of bagasse and banana pseudo stems were used to produce blended boards upto 70 kg/cm2 of tensile strength.

Source: Illyas, 2003.

Post-harvest characteristics of an agricultural produce is affected by pre-harvest treatments-seed rates, level of fertilizer use, nutritional balance, irrigation and drainage, diseases and pests, growth hormones an pesticides used an d their residual toxicity, mechanical and environmental injuries during harvesting, handling, transport and storage. A strong awareness drive is needed to provide pre-harvest inputs for scientific post-harvest management of agricultural produce and by-products.

For scientific storage of agricultural produce cleaning, grading, shelling, decortications, drying to safe moisture levels -10-12% in case of cereals, 8-10% in case of pulses and 6-8% in case of oilseeds, are important. A number of useful equipments- for such unit operations are available that need to be commercialized and extended to targeted beneficiaries. Scientific storage-room, warehouses storage bins, or even CAP storage capacity to the growers to negotiate with the forces of marketing enabling them to earn 25-50% more net returns.

The utilization pattern of produce and their by-products governs the Use of process and machinery. By improved harvesting, parboiling, drying and milling technologies the total out-turn of rice can be increased by 10%. There is an increasing trend towards the use of roller mills for milling wheat that give quality products. Maize is a very versatile grain having food, feed, and industrial raw material value. It yields numerous products employing dry milling, wet milling, fermentation and other processes. Sorghum and minor millets have excessive fiber causing anti-nutritional effect, to overcome this defect there are pearlers.

India is second largest producer of fruits and vegetables (F&V) next only to china. It is growing at a rate of 6-8% annually. In the absence of awareness, skills and proper PH-infrastructure post-harvest losses in F&V are excessive 20-40%. Not only that every bumper harvest is faced with slump in the market price creating disincentives to the growers. The major reasons for these losses are:

- Untimely harvest and mechanical injuries during the process
- Growth of micro-organisms (yeasts, molds and bacteria)
- Life processes of these biologically active materials/post-harvest physiological factors

- Enzymatic activities, browning, discolouration
- Physical changes like desiccation, shriveling, loss of turgidity
- Chemical changes such as oxidation
- Spoilage and mechanical damage during harvest handling, packaging transport and storage

Chilling of perishable produce like fruits and vegetables, immediately after harvest and keeping them cool during transport, storage and retailing pays dividends in many ways. Cold storages and cool chain are requirements for scientific handling and management of fruits and vegetables and other perishables. However, these are costly and cold stores are not often located in production catchments. A number of equipments and practices have been developed which can be helpful in reducing post harvest losses, improving handling and storage process of fruits and vegetables.

Of the 300 Mt of sugarcane produced, 53% is processed into white sugar, 36% into jaggery and khandsari, 3% for chewing an cane juice, and 8% as seedcane. Jaggery and khandsari have withstood competition protecting farmers' interests besides meeting ethnic demands. Processes and equipments have been developed for quality solid, liquid and powder jaggery. Liquid jaggery has been commercialized. The organic clarificants developed help to retain jaggery as organic food.

Jute ushered India into industrialization. India is still the largest producer/processor/ consumer of jute and allied fibers, which are being marketed as eco-friendly products. R&D efforts are directed towards diversified uses of jute and allied fibers. There is an increasing demand for ramie, which is a fabric grade best fiber and currently being imported. PHET support should be provided for indigenous production of ramie fiber and it's degumming.

India has 9.10 Mha area under cotton, largest in the world. Productivity has gone up from 88 kg/ha in 1947 to presently 308 kg/ha. But it is still too low, possibly because if largely rained. Though India cotton is 1000% handpicked yet cotton bales carry 6-8% trash. Its competitors are able to market bales with less than 2% trash; therefore attention is being paid towards having clean cotton for which development of a number of equipments and practices is being undertaken. Under technology mission, cotton sector is being modernized. R&D efforts are being made of diversified uses of cotton, its by-products and wastes.

India is largest producer of milk with annual production of 80 Mt, 55% of which comes form buffaloes. As a result of the White Revolution in the country milk availability has improved to 212 g/caput/day against recommended dietary need of 220 g/caput/day. About 45% milk is consumed as liquid milk, rest is processed into products like ghee (28%), dahi (7.0%), khoa (6.5%), Butter (6.5%), Milk powder (2.6%), Channa, cheese and paneer (2.0%), cram (0.5%), icecream (0.2%), and others (1.7%). The organized diary sector handles about 15% of total milk produced in India through about 575 dairy factories in cooperative, public and private sector. During last two decades, efforts have been made towards mechanized manufacture of ghee, khoa, paneer, channa, shrikhand, gulabjamun and peda. Milk being highly perishable requires special hygiene levels that need to be addressed.

Meat production in India has reached to 4.46 mt ranking 7th in the World, 60% of which comes form beef and buffalo (spent). However, it is largely used as fresh. Value added products have been developed form spent buffalo meat such as sausages, nuggets, meat blocks, etc. Similarly, value added meat products have been developed from spent poultry, sheep and goat meat. DFRL and CFTRI have developed technologies for spent chicken curry in retort able pouches. Efforts are on for instant pulav and biryani. With annual egg production of 28.56 billion, per capita availability has increased to 30 eggs/annum. India is exporting egg powder. Egg yoke and albumen find a few industrial uses.

Fish production has steadily increased. It is at 5.39 mt (1997-98)-2.95 mt marine and 2.44 mt inland. With catches form marine and capture fisheries declining, role of aquaculture has increased tremendously. A number of post-harvest technologies have been developed and commercialized by Fisheries Division of ICAR.

G. Post-harvest technology research and infrastructure - SWOT analysis

Strengths, Weaknesses, Opportunities and Threats (SWOT) of post-harvest management; research and infrastructure have been analyzed. Stringent demand on quality and economic competitiveness in the wake of globalization of world market, shrinking public funds for R&D making it unmatched to the challenges, movement of trained manpower to industry, fast obsolescence of technologies, competition from foreign organization made the socio-economic cost of failure in post harvest management too heavy.

Post-harvest technology especially appropriate at rural threshold tends to be crop, commodity and situation specific. As a result a broad strategy is adopted to have a lead or nodal institution which undertakes leads researches of wider applicability at the same time plans, promotes, and coordinates R&D programme in PHE&T and acts as national repository. AICRP networks have been created utilizing strengths and resources available at selected SAUs and ICAR institutes addressing to crop, commodity and location specificity. It is also expected that Division or Section of PHET/PHT evolve linkages with the nodal institutes and adopt technologies relevant to their needs. Division of Agricultural Engineering, Horticulture, Animal Science and Fisheries of ICAR have institutes/Directorates/AICRPs/networks addressing to post harvest management of agro-produce and by-products under the aegis of ICAR. The ongoing R&D programmes and future priorities have been examined. The cognigence is taken to some of the successful agro-processing models that exist in the country for adaption.

Lead Researches of wider applicability is undertaken at nodal institutes of the country and the commodity specific technologies are at commodity institutes/centres. However, there cannot be hard and fast rule, the strengths and creativity that exists are allowed to express. Focus is laid at post-harvest loss prevention, value addition and rural agro-entrepreneurship development that lead to additional income and employment to rural sector. Human resource should be developed at different levels in Post-Harvest Engineering and Technology (PHET), Food Science and Technology, Research-Extension-Industry Linkages be developed that promote on-farm/rural agro-processing enterprises. Research efforts be stepped up to monitor status specifically quality and economic competitiveness to develop scientific base for produce management, pre-harvest and post-harvest aspects. Capacity should be created for development of HACCP and food safety measures for

different commodities and products. Modern scientific methods and practices like biotechnology, irradiation, ultra filtration/membrane technology, energy conservation, computer aided design, manufacturing f on-line quality control, information technology, modern packaging, handling and transport need to be harnessed for post harvest management of agriculture produce and by-products.

Prototype and pilot plant development units for commercialization of modern equipment for food processing need to be created at nodal institution. The PHET/PHT programs are facing constraints of human resource; there are very high vacancies in scientific and technical cadre. There is need to have additional scientific and technical manpower and generous funds for research and development as well as pilot introduction and transfer of technologies.

H. Priority in post-harvest technology research and development

Post harvest technology is commodity and location specific. However, the present requirement is to develop need-based and market driven PHT and equipment for loss prevention and value addition to raw food materials of plant, animal and aquatic origin for internal and international markets. Diversification in the present uses of rainfed and other crops may be considered (Table 5.10). The technology so developed must lead to rural industrialization and thereby creating employment and income generation opportunities. Appropriate PHT would help in enhancing per capita food and fiber availability from the limited and dwindling land and water resources. To achieve these goals, following programs and plan of action are suggested:

- Refinement and adaptation of the presently available PHT for loss prevention and value addition to agricultural produces and other allied commodities.
- Establishment of pilot plant and production of the desired product on a limited scale and market search.
- Preparation of project reports including manufacturing drawings of equipment and operation manual.
- Consultancy and contract research in the priority areas identified by the State Agricultural Universities/ICAR/GOI at regional, national and international levels.

Table 5.10. Present use and suggested diversification of field crops for better domestic utilization and export promotion

Field Crop	Present Value-added Products	Suggested Product Diversification
Paddy (Rice)	Milled raw and parboiled rice, flour and flakes and puffed rice.	Quick cooking rice, Sela Basmati rice and rice based extruded snack/breakfast cereals.
Wheat	Flour, Maida, Suji, Dalia and Noodels.	Puffed & flaked breakfast foods.
Maize	Flour and flakes, starch and dextrins and puffed corns.	Degermed maize flour and corn oil.
Sorghum	Flour, flakes and puffed sorghum.	Food and feed uses.
Millets	Flour and pearled millets.	Food and feed uses.
Oilseeds	Oil and cake.	Protein rich soybean flour, protein isolates and concentrates, dal anologs, soy-lecithin, fatty acids and derivatives, direct food uses of oilseeds.
Pulses	Dal, Besan, feed (husk and brokens) and roasted snack foods.	Quick cooking dal, mixed and speciality dal.
Cotton	Cotton and cotton yarn, cottonseed oil and cake.	Colour cotton, byproduct utilization and refinement of cottonseed oil and cake for food and feed.
Jute and Mesta	Gunny bags, carpets, ropes and bags.	For interior decortications, blended yarn, soft luggage, shoe uppers and disposable sleeper, non-woven fabric and geotextile.

Source : Ali, 1999.

- Transfer of technology to farmers, SMS, NGOs, etc.
- Need based R&D activity for cereals, pulses and oilseeds to develop marketable products and technology achieving highest recovery and top quality of the desired constituents/parts of the raw materials processed with minimum energy spent and no pollution created.
- National and international training and human resource development in specialized and priority areas.
- Linkages with national and international R&D Institutions and Universities to cut-dow n gestation period on a particular R&D and avoid duplication and unnecessary spending and to come-out with high quality R&D results in minimum possible time.

- Transfer of technology and entrepreneurship development in collabo-rations with Central and/or State Government Agencies, NGOs and Private Sectors.
- Periodical meetings/seminars/conferences/study tours etc. at national and international levels to have up-to-date information and technology generated in the area of PHT and to have better interaction between the Scientists of different disciplines.

I. Post-harvest technology for employment and income generation

The food processing industry in India is labor intensive and offers a major employment opportunity. The industry employs 18 to 20 percent of country's labor force and contributes around 50 per cent to the industrial production. Processing activities in the production catchments can help improve the raw material quality and enhance shelf life. Also, these units can take-up the activities of supplying primarily processed raw material to large-scale industries. Some of the examples of such PHT based enterprises are as under.

1. Full fat soyflour

Full fat soy flour is one of the simplest soy based food products to be used in combination with cereals and pulses. Ten percent addition of soy flour is recommended to start with and can be increased up to 20%. Preparation and use of recipes form soy cereal/pulse blended flour does not demand any change in the traditional food habits of the people. It contains 40% protein and 20% oil besides carbohydrates, minerals and vitamins. Production of medium fat soy flour involves expelling of about 70% oil from the beans. It, therefore, contains less fat (4-6%) and more protein (45-50%). It can be used in food products in the same manner as that of the full fat soy flour.

Technical and financial details for the production of 100 kg full fat day/day (8 h)

Parameters	Details
• Assumptions	300 working days in a year (25 days in a month) and one shift of eight hours/day. 18% interest on capital investment.
• Capacity	100kg of full fat day per day of 8 working hours.
• Space requirement	15 m x 4 m shed. It can be hired @ Rs. 2,000 per month in rural areas.

• Cost of machinery and other non-recurring items	Rs. 85,000
• Cost of raw materials for a month	Rs. 25,500
• Salaries/wages of workers per month	Rs. 4,200
• Cost of utilities per month	Rs. 7,600
• Other contingent expenses per month	Rs. 3,725
• Sale price of full fat day	Rs. 20/kg

? Fixed capital: Rs. 85,000

? Working capital for 3 month: Rs. 123,150

Total investment	: Rs. 208,105
Say	: Rs. 210,000

Total turnover per year	: Rs. 600,000
Cost of production per year	: Rs. 537,717
Net profit per year	: Rs. 62,283

2. Soy fortified biscuits

Soy fortified biscuits are made by adding 12-15% soy flour to refined wheat flour (Maida). About 1.8 kg biscuits can be prepared form one kg media and other ingredients in suitable proportions. Protein content of soy-fortified biscuits is 11-12% against 7-8% in commercially available equivalent product. Soy fortified muffins; bread and buns can also be prepared. These bakery products have a great potential for combating protein calorie malnutrition at low cost. Process for making soy-fortified biscuits has been standardized for adoption at home and industry levels. It consists of creaming, mixing, sheeting, cutting and baking.

Technical and financial details for the production of 50 kg soy fortified biscuits per day (8 h)

Parameters	Details
• Assumptions	300 working days in a year (25 days in a month) and one shift of eight hours/day. 18% interest on capital investment.
• Capacity	50 kg of soy fortified biscuits/day (8 h)
• Space requirement	5 m x 4 m shed. It can be hired @ Rs. 2000 per month in rural areas
• Cost of machinery and other non-recurring items	Rs. 68,000
• Cost of raw materials for a month	Rs. 29,485
• Salaries/wages of workers per month	Rs. 4,200
• Cost of utilities per month	Rs. 5,500
• Other contingent expenses per month	Rs. 3,725
• Sale price of soy fortified biscuits	Rs. 50/kg

? Fixed capital : Rs. 68,000

? Working capital for 3 month : Rs. 128,730

Total investment : Rs. 196,730

Say : Rs. 128,730

Total turnover per year : Rs. 750,000

Cost of production per year : Rs. 557,131

Net profit per year : Rs. 192,869

Say : Rs. 193,000

3. Soypaneer (TOFU)

Soymilk is a water extract of soybean and it is the base material for making soypaneer, soy-yogurt and other dairy analogs. One kilogram of dry soybean yields 6-8 liters of milk. Special features of soymilk are low cost, good nutrition and suitability of lactose intolerant people. Soymilk contains about 90% water, 2.5% fat and 3.5 proteins, and other nutrients. Soypaneer, popularly known as TOFU in the orient is a coagulated and pressed soy-protein. At 72% moisture, it contains about 14% protein and 9% fat. The production cost of soypaneer is Rs. 20-25/kg. Soypaneer is used in vegetable curry, paneer pakoda and paneer -paratha. Soy-yogurt is a cultured dairy analog produced by fermenting soymilk. It is nutritious and easily digestible food.

Technical and financial details for the production of 50 kg soypaneer/day (8h)

Parameters	Details
• Assumptions	300 working days in a year (25 days in a month) and one shift of eight hours/day. 18% interest on capital investment.
• Capacity	50 kg of soypaneer/day (8 h).
• Space requirement	5 m x 4 m shed. It can be hired @ Rs. 2,000 per month in rural areas.
• Cost of machinery and other non-recurring items	Rs. 215,000
• Cost of raw materials for a month	Rs. 8,940
• Salaries/wages of workers per month	Rs. 4,200
• Cost of utilities per month	Rs. 7,625
• Other contingent expenses per month	Rs. 3,725
• Sale price of fullfat soyflour	Rs. 30-40 / kg

?	Fixed capital	: Rs. 215,000
?	Working capital for 3 month	: Rs. 73,470
	Total investment	: Rs. 288,470
	Say	: Rs. 290,000

Total turnover per year	: Rs. 600,000
Cost of production per year	: Rs. 365,154
Net profit per year	: Rs. 234,846

4. Agro-processing center

The concept of processing and value addition to agricultural produces in the production catchments itself started in 1980s by the All India Coordinated Research Project on PHT under the aegis of the Indian Council of Agricultural Research (ICAR), Government of India, New Delhi. It has been field tested and evaluated for its techno-economic feasibility at a number of centers of the project. It has been a success. One such Agro Processing Center (APC) established at Aradeshahalli in Bangalore rural district of Karnataka, India is meeting the need of processed products of farmers of 10-village and also providing employment to some of them. The total investment is about Rs. 2.0 lakhs (US$ 4,000).

Processing activities such as flour making, production of potato chips, spice grinding, cleaning and grading of grains were successfully performed involving men and women. Now the concept of Aradeshahalli APC has been accepted by the Government of Karnataka for multiplying it into 620 more units under Watershed Programme funded by the World Bank. During 2001-2002, the Bangalore Center of AICRP on PHT has established nine such APCs. It is progressing well.

5. Rural go-down and other rural employment schemes/projects

It is well known that small farmers do not have the economic strength to retain produce with them till the market prices are favorable. Therefore, there is a need to provide farming community with facilities for scientific storage so that wastage and produce deterioration are avoided and also to enable them to meet their credit requirement without being compelled to sell the produce at a time when the prices are low. A network of rural go down will enable small farmers to enhance their holding capacity in order to sell their produce at remunerative prices and avoid distress sales. Accordingly, the Government of India has introduced Rural go-down Project, a capital investment subsidy scheme for construction/renovation/expansion of rural go

down. The main objective of the scheme is creation of scientific storage capacity to meet the requirements of farmers for storing farm produce, processed farm produce, consumer articles and agricultural inputs; promotion of grading, standardization and quality control of agricultural produce to improve their marketability; prevention of distress sale immediately after harvest by providing the facility of pledge financing and marketing credit; to strengthen agricultural marketing infrastructures in India by paving the way for the introduction of a national system of warehouse receipts in respect of agricultural commodities stored in such god owns (Anonymous, 2001 (a)). Government of India has launched a number of other rural employment programmes (Table 5.11).

Table 5.11. Government (Central/State) and NGO-sponsored schemes/projects for employment generation in India

Scheme/Projects	Description
• Training of rural youth for self employment (TRYSEM)	• It was launched in 1979 and is run by Central and State Rural Employment Departments. This has helped in skill development. 40% benefits are reserved for women.
• Integrated rural development programme (IRDP)	• Launched in 1978-1979, basically aims to eradicate poverty from rural areas by providing income generating assets. Under this scheme also 40% of total assistance is reserved for rural women.
• District Supply and Marketing Society of Women Producers (DSMSWP)	• Introduced in some districts of India to facilitate marketing of products produced by women groups.
• Development of Women and Children in Rural Areas(DWCRA)	• Launched in 1982, meant specially for mobilising rural women through group formation for skills development training, employment generation and marketing.
• Jawahar Rojgar Yojna (JRY)	• Started in 1989 under wage employment programme, 50% benefits are earmarked for women.
• Prime Ministers Rojgar Yojna (PMRY), and Support to Training and Empowerment	• Administered by the Department of Women and Child Development, this programme enables voluntary organizations, other autonomous bodies and government corporations to give skill development training as well as marketing facilities to women, training-cum-employment-cum-production centres with aim to empower women through training and employment in

Scheme/Projects	Description
Projects (STEP)	non-traditional sector.
• Agri-clinic and Agri-business Enterprises (AC&ABE)	• It was launched in 2002 for agricultural graduates to set-up their own AC&ABE, provide services to farmers and get self-employment.
• Rashtriya Mahila Kosh (RMK) (National Women Fund)	• Set up in 1993 to provide credit to poor women in the informal sector for income generating activities through NGOs and institutions engaged in thrift and credit promotion. This scheme is gaining popularity since it combines in it elements of the technical profits of the banks and sensitivity and commitment of the Deptt. Of Women and Child Development. RMK is implementing its schemes through the cooperation of voluntary organizations. The number of such organizations is far better in southern states of country. The NGOs have formed Women's self-help groups for this purpose. RMK also provides support for marketing to some NGOs and it plans to fund Indira Mahila Block Societies (IMBSs) through Women Development Corporations for mobilisation of rural women in the much-needed realm of active economic participation.
• Science and Technology Projects	• National Institute of Science, Technology and Development Studies, New Delhi has conducted a study in 1994 on behalf of National Commission for Women to assess the impact of new technologies on women's participation in agriculture. The technologies documented in this study are: Agriculture, dairy and animal rearing, sericulture, aquaculture, food processing, mushroom cultivation, composting technology and medicinal plants.

J. Role of women in post-harvest technology and income generation

Women comprise about half of the world and that of Indian population and many of them are involved in agriculture in addition to their daily household chores. Their role in agriculture is very significant as they contribute 50–75% of the total labor required for various agricultural operations in the developing countries. Most of the production and post-production agricultural activities in which women participate are done manually using traditional hand tools. It causes a lot of drudgery to them and low-productivity. Moreover, the substantial contribution made by women in agriculture and other domestic activities is not duly acknowledged and recognized by the society and as a result, women remain economically poor and socially the most exploited group by male-population. Now, therefore, there is a strong and genuine need to free the women from under-productive tasks and augment the productivity of their work as a means of accelerating the development process. One of the options is

to promote micro and small-scale enterprises for women to increase their productivity and family income. One such option is PHT-based enterprise for women. It would not only augment their income but also help in achieving household food and nutritional security at an affordable cost.

1. Employment opportunities

Adding value to the farm products through one or more steps in village-processing systems will generate employment opportunities, most of which are suitable for women. In developing countries, there exist various agro-industrial enterprises for such purposes and some are managed and operated by women themselves. If the technology for such processes are initially identified and listed, and then exchanged or transferred from one area to another, and better yet, improved to enhance product quality, the opportunities for female farm workers would be indeed large. These exchanges would be further multiplied and enriched if done on an inter-country basis.

2. Efforts of ESCAP

Consequent to agricultural mechanization, the rural women who might be displaced need to be provided an alternative employment for their livelihood. To work out a suitable strategy for rural poverty alleviation and employment creation for rural women, the activities of the RNAM (Regional Network for Agricultural Engineering and Machinery) were expanded in 1992 to include a network subprogramme on Integration of Women in Agricultural Mechanization Activities. Consequently, a project on Enhancement of Employment Opportunities for Rural Women (EEORW) was formulated and approved by ESCAP, with funds provided jointly by the governments of Japan and the Netherlands. The participating countries in the project were Bangladesh, China, India, Indonesia, the Islamic Republic of Iran, Pakistan, Philippines and Thailand. As a result of this Network, women friendly PHT and products have been identified in the participating countries (ESCAP, 1997) and some of these are listed in Tables 5.12 and 5.13, respectively.

Table 5.12. Women-friendly food products and technology in Asia and the Pacific countries identified /developed under the aegis of RNAM/ESCAP

Commodity	Products
Cereals and Pulses	Whole grain foods, flour based foods, baked products, pasta and noodles, Fermented drinks, snack foods, weaning foods, pulse products.
Fruits, Nuts and Vegetables	Canned fruits and vegetables, dehydrated fruits, jams and jellies, squashes, pickles, ketchups, banana chips, fruit and nut candies, stuff fruits, strawberry wine.
Root Crops and Spices	Potato chips, arrow root flour, sweet potato bar, cassava cake, turmeric powder, coriander powder, black pepper powder, dried ginger, ginger tea.
Oilseeds-based food products	
Soybean	Full fat Soy flour, soymilk, soy-yogurt, roasted snacks, bakery products, spray dried soymilk powder, soy-sauce, defatted soy flour, texturized soy-protein (TSP), de-fatted bakery products, soy-lecithin.
Groundnut	Roasted nuts/kernel confectionery items, peanut butter, protein concentrate, composite flour and grain, protein isolate, infant and weaning foods.
Sesame	In confectionery and other food items, garnish on bread and rolls, protein concentrate from dehulled sesame cake/meal.
Rapeseed-mustard	As seasoning material for flavor and pungency, chutney (paste) like product form mustard, ginger and salt; mustard powder/dehulled seed in pickles, meat and salad dressing.
Animal Products	
Milk	Cheese, butter and ghee, fermented milks, miscellaneous milk-based products (Khoa, kulfi, leche flan (Philippines), Mukaghar monda (Bangladesh), Peda/gundpak).
Meat	Salted and dehydrated meat, sausage meat.
Fish	Smoked/dried fish, Salted/dried fish, fermented fish.

Source: ESCAP, 1997.

Table 5. 13. List of some of post-harvest machines and food-processing tools and equipments identified under the aegis of RNAM/ESCAP

Tools, machines or equipments	Type	Purposes/Uses
Blanchers	Scladers Steam blanchers	For blanching of fruits and vegetables to inactivate enzymes that cause deterioration in color and flavor during drying and subsequent storage. It also improves the texture of the product. Blanching may be carried out using water or steam.
Bottle washing machine	Manual and power	For cleaning and washing of bottles. Bottle washers may be of bristle, hydro or soaker type or a combination of these.
Brew equipment	Fermentation bins Fermenters	For brewing of beverages.
Butter churns	Manual and powered churns	Use for butter production.
Butter pats	Wooden pats, plastic trays, butter scoops	Used to knead and form butter. It also removes excess moisture and produces a uniform texture.
Canning equipment	Retorts, sterilizers and pressure, seamers, hot lifting tongs	Aid in canning process which involves filling the food into can, fitting the lid and heating the can in a retort to sterilizer the food.
Carbonating equipment	Manual and powered	Makes carbonated drinks using high-pressure carbon dioxide.
Centrifuges	Dairy, honey, juice and filter centrifuges	Separation of substances like cream, honey and juices using the principle of centrifugal force.
Cheese moulds, presses and kits	Moulds, presses, kits, vats	For making cheese.
Chopper	Fruits, vegetable and bowl chopper	For chopping fruits and vegetables.

Tools, machines or equipments	Type	Purposes/Uses
Cleaners	Fruits and vegetables, grain, seed cleaners	To wash and clean fruits and vegetables, remove chaff and other impurities from grain.
Curd making equipment	Cutters, tubs, curd-making set	For making and storing curds. Specially designed for curd to avoid whey corrosion.
Cutting, slicing and dicing equipment	Cutters, slicers, dicing equipment	For cutting, slicing and dicing various food products.
Decorticators (shellers)	Manual and power operated	For decortications/shelling of maize, groundnuts, cashew nuts, peas, walnuts, cocoa, coffee, sunflower, etc.
Dryers	Solar, fuel-fired, electric, vacuum and spray dryers	For drying and dehydration.
Enrobers	Low cost	Used to coat foods in chocolate, butter or other coating materials.
Evaporators	Electrical	For evaporation of water.
Expellers	Mechanical	For expression of oil from oilseed sand nuts.
Extruding machines	Hot, and cold extruders	Used for making extruded products such as snack foods from cereals.
Filling machines	Liquid, solid, paste, powder fillers	Filling of liquid and solid materials into containers and pouches.
Fillers, sieves and strainers	Filters, filter presses, sieves, strainers	Used for filtration, sieving and straining of oils, juices, powders/flours etc.
Flaking and splitting machine	Rice flaking equipment, dal splitter	For making rice flakes and dal splits.
Fryers	Gas fryers, electric fryers	For frying.

Tools, machines or equipments	Type	Purposes/Uses
Grating equipment	Manual and powered	For grating various food materials.
Grills	Low cost	For grilling of meat, fish and other products.
Heater and hotplates	Low cost	For heating water and other items.
Homogenizers	Low-capacity	To form a stable emulsion form two immiscible liquids.
Ice-cream making equipment	Manual, powered, ice-cream scoop	For ice-cream making.
Incubators	Electrical	To hold food items at a preset temperature.
Mills and grinders	Pate, roller, hammer, colloidal mills	Fro grinding cereals, pulses, spices, sugar etc. Will also reduce liquid suspensions to a finer particle size.
Mincers	Low capacity	For grinding met for sausages and patties.
Mixers	Liquid and solid mixers	For mixing various ingredients into a homogeneous mixture.
Moulds and baking units	Confectionery and dairy moulds, dough and pastry moulds, baking tins	Used in bakery production.
Ovens		For cooking, roasting and baking.
Packaging equipment	Sealing, capping, wrapping, vacuum packaging	Packaging of different food materials.
Pans and kettles	Small cooking, commercial, commercial steam jacketed pans and kettles	For cooking, coating, etc. of food items.
Pasta machines	Manual, powered, pasta	For making pasta foods.

Tools, machines or equipments	Type	Purposes/Uses
	dryer	
Peeling equipment	Manual and powered	Used for peeling and coring of fruits and vegetables.
Presses	Fruits and vegetable presses, oil presses, meat presses	For extraction of oil, juices, pulp, etc.
Puffing machines	Low capacity	For puffing grains like cereals and pulses.
Pulpers and juicers	Steam, mincing juicers/pulpers, coffee pulpers	Used for the extraction of pulp and juices especially fruits and vegetables. Manual as well as power operated coffee pulpers are also available.
Roasting equipment	Small scale	For roasting coffee, cocoa, cashew nut, peanut, soybean, etc.
Rolling equipment	Small scale	To roll pastry and pasta. Papad is also made.
Sorting equipment	Low capacity	Used for grading food items on the basis of size, density or shape, Color sorters are also available.
Testing, weighing and measuring equipment	Weighing, measuring cylinders/jugs, lactometers, hydrometers, butyrometers, testing equipment	For weighing, measuring and testing of quality of raw and finish food products.
Threshers	Manual and power	For threshing grain and oilseed crops.
Winnowers	Manual and powered	
Miscellaneous equipment	Soymilk equipment, manual can opener, popcorn maker, corn popper, sugar cotton machine, mobile cooling rack, ice-cream making equipment, ice-flakers	For miscellaneous jobs in the food industry.

Source: ESCAP, 1997.

3. Food enterprise for rural women

Agro-based Industries in Asia and the Pacific region account for 36% of the total manufacturing value-added products. Majority of producers, processors and sellers of food in Asia are women. Food is processed either for home consumption or for commercial purposes, the latter providing a source of income for women who generally have limited access to cash. The development of food processing activity as a cottage industry or home industry results in increased value of raw materials decreased post-harvest losses and increased income for farmers. Therefore, there is a need to support rural based food processing activities through the provision of the required equipment for preservation and processing.

Small-scale food enterprise often starts by working from home using domestic equipment because such entrepreneurs, to begin with, have little money to invest in equipment and little access to credit. However, they must be able to produce uniform quality food under hygienic conditions to get success. Some people will see food processing as their main source of income, go for a loan to buy specialized equipment and secure working capital and if successful, they will develop business and marketing skill to expand and diversify their enterprise.

(a) Food product selection

The selection of suitable products for small-scale manufacture and then the process by which to make them, require very careful consideration. It is not sufficient to assume that simply because there is a surplus of raw material each year that a viable food processing venture can be created to use up the excess. There must be a demand for the processed food, which has been clearly identified before a process is set-up. Otherwise, the most likely result is to produce a processed commodity that no one wants to buy and substantial losses to those involved. The product selected should have minimum inherent risk of food poisoning. Acidic foods and most type of dried foods have a low-risk of transmitting food poisoning microorganisms. In contrast, low acid foods are much more susceptible to transmitting food-borne illness through poor hygiene of workers or incorrect processing conditions. Some types of processes have a large inherent risk of causing food poisoning than others. In addition some processes are much more expensive to set-up and operate than others.

An individual producer should not base a decision to produce a food on availability of raw materials, cost of equipment and risk of food poisoning alone. He or she should conduct local surveys to find out which processed foods are in demand and how much will pay for them throughout the year. The scale of production is then set to meet a pro-determined proportion of this demand. From this scale of

production, together with technical advice on the best way to process the food, it can be decided what size and type of equipment is required and thereby the approximate cost required.

(b) Appropriate technology

Appropriate food technology implies, affordable, locally produced, locally repaired, reliable technology that has a suitable scale and complexity of operation for the people who will operate it. It would help increase income and improve income distribution. However, the knowledge of the appropriate technology alone will not ensure its adoption. Proven prototypes may be needed for demonstration and those who are convinced of the effectiveness of a technology may need financial support to acquire and promote it. This in turn may require the collaboration of national food research institute and/or university food science and technology department for development and testing of technology for local needs.

(c) Criteria to recommend technology

The consequences of introducing a new technology are largely unpredictable. It is true that potentially adverse effects of a new technology on poor produces can be predicted to some extent and therefore avoided by careful studies before a project is implemented. But the larger number of factors that in play during a technological change prevent an accurate prediction of the final outcome and of who will benefit. There is, therefore, a need for sensitivity and understanding of the social and cultural content in which the introduction is planned. The criteria that will help to decide whether to recommend a technology are complex and inter-related but are likely to include the following:

- Technical effectiveness
- Relative cost of equipment and any ancillary services required
- Operating cost and overall financial profitability
- Heal0th and safety features
- Conformity with existing administrative or production conditions
- Social effects such as displacement of a work force
- Training and skill levels required for operation, maintenance and repairs
- Environmental impact such as pollution of air or local waterways
- Flexibility to perform more than one function
- Compatibility with other parts of a process

However, it must be stressed that each of these factors is an aid to judgment by staff on the spot and not simply a checklist. Each will have a different weightage in different circumstances and there can be no simple solution tot he difficult takes of weighing up all factors in a particular situation and making the best-fit from the available technologies.

(d) Problems and constraints

Raw material are seasonal and some of the highly perishables, making food business difficult. Foods are biological materials whose composition varies as a result of the action of whether, pests and diseases. This means unpredictable supply and cost of raw materials. Even after processing, foods do not keep indefinitely. The shelf life of processed foods can vary form a few days to several months or years. The distribution and sales methods used by the entrepreneur must be suited to the expected shelf life of the food and carefully organized so that customers receive the food before it spoils.

Packaging is an important means of controlling shelf life of food but there are problems in finding suitable packaging materials in rural areas of the developing countries. This is one of the most important constraints on small scale food processing. The technically advanced plastic films, Cartons and cans usually have to be imported and are very expensive. Traditionally packaged foods do not perform well technically and are often perceived by customers as inferior. This put the small-scale entrepreneur at a marketing disadvantage compared to equivalent imported products.

Food is the only commodity that people buy every day and eat. Hence, in all food processing activities there is an over-riding concern to avoid food poisoning. Processors and processing methods must meet strict standards of cleanliness and production control to avoid the risk of harming or even killing their customers by allowing the growth of food poisoning organisms in their products. Thus, the small-scale food processors have to operate under such multiple complex technical constraints.

In the majority of the developing countries, the bulk of food processing enterprises are on a small scale and are located in the informal sector. They are rarely formed into associations and have little economic power or ability to seek such assistance as may be available. They often need intermediaries, such as extension agents, to guide them to appropriate solutions for their own individual problems. The larger, formal food-processing sector may receive government support in the form of subsidies, foreign exchange allowances, price stabilization, or guarantees and accesa to specialist advice. In contrast, the small-scale informal sector has no political influence; despite it combined volting power, and is therefore subject to the vagaries of the national and/or international economic climate.

K. Recommendations

Post-harvest technology is commodity and location specific. The present requirement is to adapt/develop/refine the need based and market driven PHT and

Equipment for loss prevention, processing and value addition to raw food/feed materials of plant and animal origin for household consumption and national and international markets. To achieve this; the specific recommendations are:

- Establish and operate agro-processing centers in the production catchments to minimize losses and transform the raw food materials into palatable and nutritive edible products at an affordable price by one and all.

- Make better use of crop residues, processing by-products and wastes in eco-friendly and economically rewarding mode.

- Meet hygiene and quality standard specified for domestic and export markets for fresh and processed products.

Farmers may go for Integrated Intensive Farming System (IIFS) including rural-based Processing for better return and quality produces/products. It will enhance their total income and thereby the living standards.

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