III. POST-HARVEST TECHNOLOGY FOR EMPLOYMENT GENERATION IN RURAL BANGLADESH

M.A. Mazed [1]

A. Bangladesh economy and agriculture

The economy of Bangladesh is based on agriculture, natural gas, and small industries of jute, textiles, garments, tea, cement, chemical fertilizers, sugar and light engineering. The contribution of agriculture to the country's GDP is about 23 percent while crops account for 13 percent. Agriculture employs 64 percent of labor force in the country. Agriculture is also the largest employer of women. In 1995-96, 79 percent of the total number of employed women (15 years or older) worked in agriculture. Rice and other cereals occupies nearly 80 percent of total crop land giving a production of food grains of more than 26 million tons in 2001 from a net cropped area of more than 10 million hectares. The future growth in agriculture calls agricultural diversification with the intensification of present production trend. The major crops grown are rice, wheat, maize, potato, jute, sugarcane, pulses, oilseeds, vegetables and fruits. Agricultural products account for about 25% of total export value. Per capita income of Bangladesh is estimated at US$ 348 (World Bank,1999). The production and consumption of pulses, oilseeds, vegetables and fruits are in deficit to their recommended levels. Given the present income distribution, cost of production and marketing food must decrease so the poorest half of society can afford healthy diet.

B. Agro-business as linked with post-harvest technology

Private sector perceives the risk of investment in the sector as high, especially in the context of climatic risk. The political environment for agribusiness development needs to be fully supportive of investment in the sector. The small farmers have limited knowledge of the opportunities for domestic as well as profitable export in foreign markets and of the quality standards relevant to those markets as well as correct production and post-harvest practices that result in quality produce. The limited infrastructure to support agro-business (cold storage, transportation etc.) means that high spoilage rates and law quality can erode competitiveness.

Bangladesh produces 4-5 million tons of horticultural produce. There is an estimation that only 0.5% of the horticultural production is processed. Fruits dominate in the processed food products and tomato is the main vegetable that is being processed. The 83 percent of consumers of the processed food are from municipal areas.

[1] Member-Director, Bangladesh Agricultural Research Council, Farmgate, Dhaka 1215, Bangladesh.

The post-harvest losses for crops are huge ranging from 13.5 percent for grain to 40 percent for fruits and vegetables. The losses occur during the operation of handling, transportation, milling, drying, parboiling, harvesting, field stacking, threshing, and storage. About 75% of the tuber crops are stored at home and remaining 25% are stored in the cold storage.

Scientific drying is absent in Bangladesh. Storage facilities for cereals in the public sector are meager. Other crops are stored at home. Food processing is grouped as home based food processing, intermediate and industrial processing. In Bangladesh, jam, jelly and pasted products comprise the largest share (22.4%) of production within fruits and vegetable industry, followed by fruits juice and squash (16.5%) and fruit pickle (12.3%). Packing materials cover on the average 35-40% of the total cost per unit. Tin cans and glass bottles are imported.

Bangladesh has the largest number of NGO activities in the world. There are more then 2000 NGOs operating in Bangladesh, many of them are associated with agricultural mechanization and food processing. The NGOs are promoting agribusiness in providing technical backup, micro credit and managerial skill. Some other NGOs are also initiating post harvest and food processing programmes for rural women.

Research and development of food processing are done by the Bangladesh Council for Scientific and Industrial Research (BCSIR) and several institutes under National Agricultural Research System (NARS). The Bangladesh Standard and Testing Institute (BSTI) is responsible for standardization of processed food which needs to be strengthened.

Research and development agenda of the food processing include solar and natural gas dryer, non-refrigerated cooler for fruits and vegetables, storage structure for different crops, dehydrated product formulation, formulation of fruit leather etc.

Industrial processing of fruits and vegetable is still in a rudimentary stage. As many as 53 industrial fruits and vegetable processing units have been installed so far operating below the installed capacity. Agro-processing products are marketed in local village market, national market and export market by the cottage, small, medium and large-scale industries.

Bangladesh Standard and Testing Institute (BSTI) has so far sanctioned more than 50 processing facilities in the country. The majority is small-scale processing units near urban areas.

C. Human nutritional status in Bangladesh

The nutritional status of an average Bangladeshi national can be taken as a good indicator of quality of life enjoyed by peoples of the country. The human nutritional situation of this country is quite deplorable owing to lack of access to adequate food intake and partly due to lack of adequate knowledge on preservation of nutritional qualities of products. Majority of the population, especially children and mothers suffer from severe form of malnutrition. The incidence of poverty has been decreasing at a rate of one percent per annum and still nationally 44.33 percent of the population lives below poverty line having daily calorie intake of less then 2,122 kcal per day. A survey in 1994-1996 conducted by the Dhaka University showed that the average intake of caloric was 1868 kcal against the average requirement of 2,300 kcal for the surveyed population. The actual dietary pattern compared with the desired pattern and suggested calorie intake of 2,310 kcal/person/day to be obtained through a balanced diet (Table 3.1). Major nutrients to keep bodies fit are carbohydrates proteins, fats, minerals and vitamins.

D. Poverty alleviation: A national priority agendum

Poverty alleviation of the increasing population through income generation has been the national goal of top priority during the recent decades. Although the rate of population growth has brought down to 1.48 percent, the supply of labor force continues to increase at over 3 percent per annum without further access to land for agriculture, the only way out for getting rid of poverty circle is to engage in rural non-farm activities. Agriculture is presently and will remain the largest employer of labor in years to come. Increasing pro-poor economic growth will be one of the important elements in achieving poverty alleviation. The national aim would be to increase GDP growth to more than 7 percent (presently 5.33 percent) on average during the next decades.

Table 3. 1. Dietary pattern in Bangladesh compared to the desirable dietary pattern

	Actual dietary pattern				Desirable dietary pattern			
Food	Intake (gm)	Energy (kcal)	% Of total kcal	Protein (g)	Intake (gm)	Energy (kcal)	% Of total kcal	Protein (g)
Cereal	465	1,607	82.4	33	372	1,281	55	27.7
Rice	423	1,464	75.1	28	312	1,076	46	20.6
Wheat	42	143	7.3	5	60	205	9	7.1
Potato	42	37	1.9	0.9	130	115	5	2.6
Pulses	14	49	2.5	3.5	66	231	10	16.5
Animal food	60	55	2.8	8.4	126	115	5	18.7
Fish	24	24	1.2	4.8	50	5	2.2	10
Meat	10	11	0.6	2.6	22	24	1.0	6.2
Egg	3	5	0.3	0.3	7	11	0.5	1.1
Milk	23	15	0.7	0.7	47	30	1.3	1.4

Fruits	34	34	1.7	0.8	57	57	2.5	1.3
Vegetables	57	25	1.3	1.1	132	57	2.5	2.5
Additive oil	7	63	3.2	-	38	342	15	-
Sweeteners	20	80	4.1	-	28	112	5	-
Sugar	6	24	1.2	-	8	32	1.4	-
Gur	12	38	2.5	-	17	68	2.9	-
Molasses	2	8	0.4	-	3	12	0.7	-
Total	699	1,950	100	47.7	949	2,310	100	69.3

For desired growth in all sectors, the country has already taken up pro-poor incentive structures. Better support to the backward linkages i.e., agricultural equipment, repair services, marketing of inputs; and forward linkages i.e., post-harvest technologies and marketing of produces has been considered one of the key factors to increase national income and poverty reduction.

E. Post-harvest technology of major crops

1. Post-harvest operations and technologies

(a) Handling and transportation

In Bangladesh local/improved sickles or knives are generally used for harvesting of field and horticultural crops. The use of tractor drawn combine harvester or reaper is not possible because the procurement of these machineries is not within economic reach of the common farmers community. Therefore, handling of harvested materials is mostly done manually in bundles (crops) and baskets (fruits and vegetables) transported to threshing yard and/or home or local markets as head loads, on shoulder-slings, bicycles, bullock carts and power-tiller and tractor trollies. An appropriate package of practices, suitable for each crop, is followed to minimize losses during harvesting, handling and transportation, as well as to maintain the quality of the harvested biomass. These practices are mostly traditional age-old and though have drawbacks and inadequacies still serve the purpose more or less satisfactorily.

(b) Drying, threshing and winnowing

Field curing or drying is done to bring the moisture down sufficiently so that the operation of threshing can be done efficiently. In general, harvesting is delayed to lower moisture contents. Threshing is separation of grains from stalks or the portion of the plant that holds them. The separation is done either by hand or by machine. In Bangladesh, threshing of cereals (rice, wheat, maize), pulses, oilseeds is done by foot trampling, hand beating, animal and tractor treading or mechanical threshers depending upon farm size, availability of threshers and type of crops grown. The Agricultural Research Institutes have developed threshers (both manual

and power-operated) for rice, wheat, maize, pulses and oilseed of different capacities. They are made of indigenous materials (wood, iron, bamboo, etc.) and can be fabricated by the local engineering workshops. The Regional Network for Agricultural Machinery (RNAM) also supplied a design of winnower, which is being manufactured by local engineering workshops, and it is gradually becoming a popular machine. The rice-dryer using heat supplied by natural gas, electricity, rice husk, cow-dung briquette has not been popular. The sun and natural air-drying is normally done in Bangkok.

Power thresher for wheat and paddy

The machine can thresh wheat and paddy plant up to 18% moisture content. Operating mechanism is very simple, capacity for wheat and paddy is about 195 kg/hr and 300 kg/hr respectively and price is less then US$ 200 without power.

The thresher is made of M.S. sheet, bearings, bar, M.S. angle bar, nut and bolts etc. This can be manufactured (as per drawing and prototype) in any rural mechanical workshop having facilities of welding, drilling and cutting machinery.

Pedal wheat and paddy thresher

Both wheat and paddy can be threshed manually by incorporating wire loop or concave in the same machine. Expected life is over five years, the capacity is 110-120 kg and 40 kg/hr for paddy and wheat respectively. The cost of the machine is US$ 50 only. Threshing cost is 30 cents per 100 kg of wheat. The thresher is made of M.S. Sheet, M.S. angle bearings, and nut and bolts. This can be manufactured (as per drawing and prototype) in any rural mechanical workshop having facilities of welding, drilling and cutting machinery.

Improved manual maize sheller

The main features are:

- De-shelling cost is lower than that of traditional (manual method)
- The machine can be manufactured with locally available materials
- The machine is cheap and small maize growers can buy the machine
- Capacity of the machine is 35 kg/hr (grain)
- The price is US$ 7-8 only

The thresher is made of M.S. pipe and angle, M.S. rod bush bearings, nut and bolts, wooden planks etc. This can be manufactured (as drawing) in rural mechanical workshops having facilities of cutting, welding, drilling machines, etc.

Power maize sheller

It can shell maize cob up to 26 per cent moisture content. The Sheller is made of locally available iron material, Operating mechanism is simple. The capacity of the Sheller is 2.5 to 23.5 ton/hr. The price is US$ 350 without power; total operating cost (variable and fixed cost) is 25 cents.

The thresher is made of M.S. sheet, M.S. angle, bearings, and nut and bolts. This can be manufactured (as per drawing and prototype) in any rural mechanical workshops having facilities of welding, drilling and cutting machinery.

Bud chip cutting machine for sugarcane

Cutting rate is 1,045 bud-chip per hour and required cutting time for one-hectare seed material (30,250 bud-chip) is 30 hours. It is a machine, which is manual, pedal operated semi-circular cutter (60 mm long and 30 mm diameter).

Brri power winnower

Clean grain crops, increased winnowing capacity compared to manual one. Can be made in small workshop with locally available iron materials. Suitable for seed production farm. Two operators can clean about 750 kgs of paddy per hour, reduce human drudgery for manual winnowing. This winnower can serve farms with electricity facilities.

All parts are made of sheet metal, metal screen and mild steel. Blower size and RPM: 67 cm dia and 730, Capacity: 700-800 kg/hr, Power: Two persons and 0.4 kw electric motor price: US$ 200.

Solar drying of fruits and fish

All the areas in Bangladesh receive abundant solar radiation and natural convection. Solar drier appears to have potential for adoption and application in Bangladesh. The high weather risk and drying limitations due to extremely low buoyancy induced airflow of natural convection; solar driers simulated the development of efficient technologies for production of quality dried fruits.

Solar tunnel drier

The drier consists of a flat plate air heating collector, a tunnel-drying unit and a small fan to provide the required airflow over the product to be dried. These are connected in series. Both the collector and the drying unit are covered with plastic sheets. Black paint is used as an absorber in the collector. The products to be dried are placed in a thin layer on a plastic net in the tunnel drier. Glass wool is used as insulation material to reduce the heat loss from the drier. The whole system is placed horizontally on a raised platform. Two dc fans operated by one photovoltaic

module provide the air at required flow rate. As the air is passed over the product rather than through the product in the drier, the power requirement to drive a fan is low. To prevent the entry of water inside drier unit during rain, the cover is fixed like a sloping roof. Solar radiation passes through the transparent cover of the collector and heats the absorber. Ambient air is forced through the collector. Heat is transferred from absorber to air in the collector and heated air from collector while passing over the products absorbs moisture from the products. Solar radiation also passes through the transparent cover of the drier and heats the products in the drier. This enhances the drying rate and the temperature in the drier.

The design of solar tunnel drier developed at the University of Hohenheim, Germany has been modified to make it economical and simple in construction using locally available materials. The standard size of the drier is 2m x 20m with $20m^2$ drying area. All parts of the drier including back insulation and metal frames are designed using modular concepts, which facilitates easy transport and installation.

The drier is simple in construction and can be constructed by local craftsmen by using locally available materials. The solar tunnel drier can be operated by one/two solar module independent of electrical grid. The solar module has the advantage that the drying air temperature is automatically controlled by solar radiation. The drier has been optimized for efficient operation and it is suitable for small-scale industrial production of quality dried pineapple, mango and fish.

The salient features are: Capacity: 120-150 kg of fresh fruits and fish, drying time: 3-4 days; cost of the drier: US$ 1,200; operating cost: none; product quality: high.

(c) Cleaning and grading

Cleaning and grading of threshed and winnowed grain masses, tubers, harvested fruits and vegetables are done before these produces are sent for subsequent operations in marketing, storage or processing in order to enhance the quality of the produce and thereby market price and consequently more return to the farmers. The operation of cleaning and grading is done manually. A machine called “Potato Grader” does the grading of potato.

(d) Storage

Production of almost all crops in this country is seasonal while the demand is more or less uniform throughout the year. Moreover, all the raw materials for food are to be processed before use to make them edible, wholesome, and palatable. Since the capacity of the processing equipment in Bangladesh is generally limited, storage of harvested biomass for varying periods becomes necessary. In addition to these, food grains, oilseeds, tubers etc. are also stored as seed for the next crop.

Optimum moisture content of the stored commodities becomes congenial for them. Therefore drying becomes essential. Drying yards, which are, cemented floor at farmers' premises or traders' places are used for spreading of the crops in thin layers and exposed to the sunrays. In Bangladesh several types of storage structures are used. Storage of cereals is mostly done in a heap form in one of the corners of the farmers house, mud bins, gunny/jute bags, plastic lined hessian/jute sacks, plastic bags and containers, metal bins, brick/masonry structure, RCC/metal silos, cold stores, etc depending on the type/perishability of the commodity and cash value. Potato is stored in naturally ventilated store houses and cold storages located throughout the country.

Improved storage structure for pulses

The improved storage structures were polythene lined jute bag; polythene lined/coal tar coated earthen Matka (container) and improved tin containers. The improved earthen Matka and tin container have a good sealing system at the top. Earthen Matka with inside polythene lining or outside coating with coal tar prevents moisture absorption. The containers are low cost and easily available and suitable for storage of pulses at 8-9% moisture level for more than a year without any physical loss/damage with retention of their qualities (physiochemical and nutritional). It does not require any intermittent drying of pulses.

Improved storage containers for maize and groundnut seeds

Simple improvement in the traditional storage structure for keeping groundnut and maize seeds could maintain their viability and meet the long felt need of the farmers. Drying of maize and unshelled groundnut, pods, to 11-12% and 6.65% moisture content respectively is, however, a pre-condition for safe storage of the seeds. The polythene lined jute bag and metallic containers with good sealing system to make it air tight were found efficient for groundnut seeds while traditional jute bag internally lined with polythene sheet and polythene lined Matka were found efficient in respect of protection of maize seed against moisture pick-up and fungal infestation. These devices could maintain seed viability for about a year.

(e) Food processing technologies

Home consumption and commercial trade are the two major areas where processed food commodities are utilized. In case of commercial trades, processing is done either at big or at small scale. In this country mostly small scale food processing technologies and equipment are used because they are less expensive and labor-intensive. There is loss in productivity because of manual operations is insignificant compared to the underutilized and high investment costs of larger automated equipment. The gain in employment and sparing use of resources make these small-scale technologies more sustainable and therefore, more valuable to the

national economy. If comparatively higher values are added by processing, the processed products become more suited for small-scale production. For example cereals fruits and vegetables, root crops. have low-price in their raw state, but when processed into a range of baked foods, snacks, dried foods, juices, pickles, chutney ,etc, they have considerably higher value.

(f) Processing of food grains

The food grains (cereals and pulses) are the major staple food in the country and are eaten regularly as part of the daily diet. Wheat has recently grown in popularity and demand for wheat based products such as bread and pasta has increased all over the country. Processing techniques of food grains include milling, puffing and flaking. Rice, wheat, maize and millets are milled to produce flours, which are used to prepare many types of foods. Dough and butters are made from a combination of flowers and other ingredient like fats, milk solids etc. Noodles, pasta products and other snack foods are extruded foods undergoing a series of process such as frying, boiling and drying. Backed products like bread, biscuits, cakes and pastries are widely available and are consumed by people from almost all income groups. A range of wood, charcoal, gas or electric oven is available for the baking purpose.

(g) Puffed products

Puffed products are made from cereals and pulses. During puffing, grains are exposed to a very high steam pressure, when rapidly released causes the grains to burst open. Flaked products are also widely consumed. Both flaked and puffed grains are eaten crisp and need to be packed in moisture proof containers.

2. Processing of oilseeds

The major oilseed and oil-bearing materials are: rape, mustard, sunflower, groundnut, sesames linseed, coconut etc. Oil content in these materials vary (15-65%) and expressed/extracted oil is used for cooking and in making soap, detergents lubricants, paints, varnishes, hair oil, cream etc. The cake/meal obtained from oil industry is used for making protein foods, feed and manures. Oilseeds are processed using mechanical expellers, solvent extraction plants or a combination of both. Traditional oil expelling devices like "Ghani" are time consuming and strenuous and are being rapidly replaced by mill. Groundnut, coconut are also used in snack foods and used in biscuits, cookies, confectionary, etc.

3. Processing of fruits and vegetables

(a) Status of commercial processing of fruits

The existing fruits and vegetables processing industries in the country mainly produce jam, jelly, and squash, ready to serve fruit drinks, ketchup and pickles. Present situations of the industries are as follows:

- They produce food items mainly from mango, pineapple, orange and some other exotic fruit commodities. In some cases the products are prepared using only flavors and emulsions instead of original fruits. From the under-utilized groups, olive is processed into oil pickles and chutneys, bar and tamarind is processed into chutneys.

- A small number of fruits and vegetables processing industries uses a very few numbers of indigenous fruit commodities for processing into jam, jelly, fruit drinks and pickles. Vegetables, except potatoes, are not at all processed in the existing industries, although there is a good prospect for processing these commodities. A small number of seasonal fruits is not sufficient for efficient running of the industry. As a result, considerable amount of time of the year is spent idly in these factories.

- Most of the industries are located only in and around big cities especially in the capital city where fruit and vegetable reach through different channels of marketing. The freshness of the commodities deteriorates and post harvest loss occurs to a great extent due to excessive handling and transportation in the marketing process. Also the producers of fruit and vegetables are not in direct contact to the processing industries and hence, they do not get the profitable price for their produce.

- The quality of processed products produced by majority of fruit processing industries is not improved in comparison to the foreign products. As a result, foreign products predominate in the local market.

(b) Processing technologies of fruits and vegetables

Presently the processed products of fruits, vegetables include jam, jelly, fruit cheese, fruit leather, chutney preserves and candies, fruit drink and pickle. The fruits are mainly jackfruit, pineapple, papaya, palmyra palm, golden apple, muskmelon, watermelon and guava. Pineapple juice is prepared with help of low cost solar dryer. The technology has been transferred to home and industry level. Proper dehydration of cabbage retaining more Vitamin C has been developed. The dehydration technology of cauliflower has been standardized both in mechanical and solar dryer method. The procedure for preparation of formulated products from cabbage has been standardized. The technology is very efficient, inexpensive and

simple, and hence there is ample scope for wide adoption by the growers and the housewives.

Sun dried chips from potato

1.0- 1.5 mm slices are kept in saline water (normal salt) for 10 minutes. After washing in running water, slices are boiled in water for 1-2 minutes, and then these are dried in the sun for 3- 4 days. After cooling chips are packed in polyethylene bags.

Sweet potato processing

Technologies of processing Kamalasundari a high yielding, high beta carotene variety of sweet potato released by BARI have been developed for as many as 22 food and feed products. They include, inter alia, unleavened bread, jelly, jams, pickles, sauce, biscuits, cakes, dehydrated peel (feed) etc. These inexpensive and simple technologies are expected to increase production of this nutritious variety, which is not so palatable for consumption in the traditional way of boiled sweet potato. Jelly, jam, chips and sauce are prepared using the technology. Ingredients used are; S.P. Pulp 1 kg, black pepper 10g, onion 40kg, salt 70kg, garlic 5g, cunin powder 8g, ginger 25g, vinegars 250 ml, sugar 200g, clove, chinamon 6g, each, chilli powder 10g, KMS 600 ppm.

Preservation of shelf-stable mango nectar

Shelf stable nectars in glass bottles for ready use have been formulated from pulp of major mango cultivars e.g. Langra, Gopalbhog, Khirshapat and Surjapuri. Major mango cultivars may be utilized to prepare this ready-to-serve beverage. Pulp from these fruits are separated, blended and sieved through a fine cloth. Then total soluble solids are determined with a hand refract meter and pH with a pH meter. Adjust TSS to 16-17% and pH to 3.2 to 3.4 by adding required quantities of sugar and citric acid respectively. Then the mixture is stirred well to dissolve sugar and acid and heated to 900C for 3 minutes. Then 500 ppm Potassium Metabisulphite is added and dissolved in the pulp. Nectar is then poured in previously sterilized bottle, sealed, processed in boiling water for 25 minutes, cooled and stored in cool, dry place.

Formulation of multi fruit leather

Addition of jackfruit and pineapple pulp to mango pulp (75% mango pulp, 28% pineapple pulp, 25% jackfruit pulp) produce leather of better colour, eating quality and Vitamin-C contents and has excellent shelf life in package. Ripe mangoes are washed and peeled. The peeled mangoes are hand pressed on bamboo-made strainer and the stones are separated. The separated pulp is rugged on

the strainer; the pure pulp is passed into a bowel kept under the strainer leaving fiber on the strainer. Similarly jackfruit pulp is separated, seeds removed and pulped using the strainer. After washing, peeling and removal of eyes, pineapples are cut into small pieces and pulped in the same manner.

Pulp mixtures are prepared as per the following proportions. 75% mango pulp with 20% pineapple pulp and 25% jackfruit pulp. The mixture is spread on oiled stainless steel tray in thin layer (1-1.5 mm) and is dried in the mechanical dryer (60 C). Upon drying the fist layer, another layer is spread and dried. This practice is continued until the leather is thick (3-4 mm). The prepared leathers are cooled and packed in polythene (0.06 mm thickness) packets and stored under ambient condition.

Preservation of vegetables in brine solution

Preservation of vegetables in 4% brine solution in glass containers is made by sterilizing the contents in an auto clave. The method is simple and can be easily adopted by the rural community.

Vegetables are washed, peeled and blanched in hot water (90-94^{0}C) for 3-5 minutes. Blanched vegetables are then filled into sterilized glass bottles. These glass bottles are kept dipped in boiling water (100^{0}C) for at least 15 minutes for sterilization. Care should be taken so that the glass bottles remain filled with water during the whole process of sterilization. After filling with vegetables, the bottles are covered with 2% salt solution. Then they are exhausted in boiling water for 7 mts. followed by heat processing at 116^{0}C for 35 minutes then they are rapidly cooled and placed in cool, dry place.

There is an ample scope for exporting the fruit products in the Middle East, USA, UK, Australia and European countries. However, due to lack of improved formulations of fruit, the country is being deprived of earning valuable foreign currencies.

F. Post-harvest technology in food production and employment generation

The diversification and modernization of the present agricultural and other related activities supported by efficient on and off farm processing of the commodities for the purpose of value-added is expected to increase food production and create employment and income generation. Adding value to food commodities after harvest is also aimed at minimizing the losses during storage and to maintain the quality of product. Efficient post-production practices, particularly the preservation and processing of agricultural and allied produces may bring a wide range of benefits to the people in this country, generating job opportunities by opening up village-level processing units. The goals of post-harvest and food

processing technology are loss prevention as well as adding value to the harvested biomass, which result in more income to the farmers/processors and better quality produce provided to the consumers. Post-harvest and food processing technology are commodity-and location-specific and it is done at home, village and/or cottage levels at small and large industrial scale. On-farm post-harvest storage and primary processing integrated with production technology help to generate more employment opportunities and additional income for rural people.

Minimization of the post-harvest losses is an important means to increase per capita food availability. It also helps to generate more employment and income. Investment in post-harvest measures is more economical and time saving than in production activity to obtain the same amount of a particular commodity. Furthermore, post-harvest measures automatically add value to the raw commodities as they pass on their marketing channels. Adoption of post-harvest technologies and value additive measures are very strong tools for rural and social development through employment and income generation. Development and adoption of efficient value addition practices will enhance national food supply and sustain food security even at the household level. Fruits and vegetables processing industries have a good deal of potential in serving the rural economy. First, it helps in generating more employment for rural people. It will also check mobility of rural masses towards urban areas in search of employment. Employment opportunities offered by agro-processing industries are plenty to the farm population and entrepreneur seeking self-employment. Cottage scale units particularly offer self-employment opportunities. Traditionally women handle food and are familiar with skills of food processing. In order to improve the status of living of woman and rural food processing, low cost appropriate fruit and vegetable processing technologies offer excellent opportunities for production of processed foods. The improvement of status of socially backward and landless labor classes will be possible only through providing non-farm employment at their doorsteps. This will generate a sense of security and confidence amongst rural people for overcoming uncertainty in agricultural income and providing self-employment to the land-less labor. The locally available untapped resources should be used effectively.

G. Conclusions

Bangladesh has a comparative advantage in labor-intensive agricultural production and processing and could potentially be producing a wider variety of horticultural and agro-processing products. In Bangladesh, post-harvest technology activities are likely to expand at a much faster rate than what can be stipulated at the present scenario with the dramatic increase in the production of commodity items as required by the future demand. Therefore, research and extension capabilities must be built in order to undertake dynamic endeavor to keep pace with the production. Successes in development of post-harvest processing technology and industries are hindered by a growing number of constraints. The main constraints are:

- Lack of readily available modern machinery, equipment, and technologies suited to local condition;
- Absence of reliable supply of raw materials;
- Poor managerial skills;
- Increased reliance on the part of many producers on imported raw materials (preservatives, color, flavor, emulsifier, etc.) which results in increased cost of production;
- Most of the modern and special processing equipment have to be imported which are expensive and difficult to maintain;
- For cottage and small-scale industries, promotional activities are limited due to high cost of publicity in mass media;
- Uncertainty of processed product market in the domestic market, there is stiff competition from multinational companies;
- Low and fluctuating nature of demand, high taxation and absence of transport make serious bottlenecks in marketing products;
- Lack of forward and backward linkage industries storage facilities; and
- Lack of standard packaging facilities.

H. Recommendations

Agriculture continues to be the mainstay of the economy of Bangladesh. It remains as the major source of rural employment and the driving force behind its economic growth. The entry of this country into the World Trade Organization has opened up opportunities for new markets of its products and on the other hand exposed the country to greater competition. In the markets of the world, consumers demand products, which are perceived to be of higher quality than those grown in this country. There is, therefore, an urgent need to grow agricultural products of higher qualities for marketing, distribution and trade.

The policy issues for a sustainable and reliable development of post-harvest technologies in the country to increase food production, generate employment and income can be summarized as:

- Srong urban-rural linkage should be developed to ensure sustainable development of agro-industrial base in the villages;
- Development of alliances between large enterprises usually urban based and small and medium scale enterprises (SMEs) to be created at the rural level for creating dynamic agribusiness sector in rural areas;
- Establishment of SMEs should be at the forefront of the agribusiness sector, adding value to domestic raw materials, generating employment;
- Agricultural education has to be modified with incorporation of modern concepts and technologies. Selected faculty members from agricultural research and educational institutes should be trained in agro-business and curricula

development;

- Upgrading of quality for better competition and marketing is needed;
- For successful implementation and management of a value addition enterprise women participants should be empowered and gender issue should be properly dealt;
- Extending existing policy of providing more financial assistance to processing industries;
- Providing financial and technical support for the development of packaging industries;
- Providing custom relief or tax rebates for importing specialized transport vehicles with cooling system for carrying fresh commodities to urban areas or to the processing industries; and
- Supporting specialized research programmes for the development of the suitable processing technologies as well as producing quality raw commodities.

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