GOVERNMENT OF THE REPUBLIC OF THE UNION OF MYANMAR

Formulation and Operationalization of National Action Plan for Poverty Alleviation and Rural Development through Agriculture (NAPA)

Working Paper - 13

POST-HARVEST AND AGRO-INDUSTRY

Yangon, June 2016
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ACRONYMS

EU European Union
FDA Food and Drug Administration
FAO Food and Agriculture Organization of the United Nations
GAP Good Agricultural Practice
GDP Gross Domestic Product
GMP Good Manufacturing Practice
HACCP Hazard Analysis Critical Control Points
IRRI International Rice Research Institute
LIFT Livelihood and Food Security Trust Fund
MAS Myanma Agricultural Service
MoAI Ministry of Agriculture and Irrigation
NAPA National Action Plan for Agriculture
NGO Non-governmental Organization
NHC National Health Committee
NSPARD National Strategy on Poverty Alleviation and Rural Development
SEARCA South East Asian Regional Centre for Graduate Study and Research in Agriculture
1. INTRODUCTION

The Food and Agriculture Organization of the United Nations (FAO) has been requested by the UNOPS Livelihoods and Food Security Trust Fund (LIFT), to formulate a National Action Plan for Agriculture (NAPA) for Myanmar. The NAPA objective, through the National Strategy on Poverty Alleviation and Rural Development (NSPARD), is poverty alleviation and rural development in Myanmar. The aim of the NAPA project is to give strategic guidance for the effective implementation of the agricultural component of the NSPARD through a comprehensive agricultural and rural development plan consisting of reform proposals for policy and institutions, which are backed by investment plans.

The report justifies the importance of improving the postharvest and agro-industrial sector for income and employment generation among rural people and then identifies the deficiencies in the prevailing practices and technologies that are required for improvement. It subsequently identifies the constraints faced by the farmers and other stakeholders in the postharvest and agro-industrial sector in adopting improved technologies and finally, methods to overcome these constraints to significantly improve postharvest and agro-industrial operations in Myanmar.

2. BACKGROUND

Myanmar is an agrarian country and the agriculture sector is the backbone of its economy. The agriculture sector contributes 34 percent of the GDP and 23 percent of the total export earnings, and employs 63 percent of the labour force. About 75 percent of the total population resides in rural areas and is principally employed in the agriculture, livestock and fishery sectors for livelihoods.

Among the many crops cultivated, rice constitutes the most predominant segment in agriculture and agribusiness. The annual production of rice amounts to 33 million tonnes, of which 536 000 tonnes are exported. Rice being the staple food of the people of Myanmar, rice farming is the livelihood of most of the rural population. The other economically important crops cultivated include maize, pulses, oilseeds, fruits and vegetables.

Due to improper practices during postharvest operations such as harvesting, handling, storage and processing serious quantitative and qualitative losses occur in the crops cultivated. Based on a study conducted by the South East Asian Regional Centre for Graduate Study and Research in Agriculture (SEARCA) postharvest losses in rice have been assessed as 10-37 percent. Discussions with the officials of the Department of Agriculture revealed that the losses occurring during rice postharvest operations amount to, on an average, 15 percent of the total production. The postharvest losses occurring in pulse crops have been estimated to be 5-7 percent and in fruits and vegetables as high as 25-40 percent.

Apart from these quantitative losses, serious deterioration in quality occurs in agricultural commodities due to improper postharvest techniques. For instance, the market demand for good quality paddy is much higher and is around 320 to 340 kyat (US$0.32-0.34) per kilogram whereas poor quality paddy fetches only around 180 to 240 kyat (US$0.18-0.24) per kilogram.
Even though crop production is the main source of income for the local farmer, the income generated from farming is marginal because of low productivity and high production costs. One way of alleviating this problem is to minimize the serious losses occurring during postharvest operations by introducing improved technologies so that farmers will have a greater volume of superior quality produce available for sale at attractive prices and thereby significantly increase their incomes. Further, minimizing postharvest losses would not only lead to a substantial increase in the incomes of the farming population but also appreciably increase the contribution of the agriculture sector to the gross national product of the country which accounts for 34 percent of the total.

Also, as the global demand for rice and other agricultural commodities is projected to continue growing, at least during the next 10 to 15 years, Myanmar has good market prospects to accommodate higher exports. However, the global demand for low-value agricultural commodities, which account for almost 95 percent of Myanmar’s recent exports, is on the decline, necessitating Myanmar to focus on improving quality more than quantity to benefit from the new market opportunities (World Bank 2014). In this context, improving postharvest operations, starting from harvesting up to milling and packaging, assumes importance to ensure quality and safety of agricultural commodities in compliance with international quality standards.

In addition to minimizing postharvest quantitative and qualitative losses occurring in the postharvest chain, another effective way of alleviating the problem of low income from farming is to initiate agri-/food-processing enterprises at the rural level. Farmers currently market their produce in unprocessed forms. It has now been realized that if farmers themselves at the rural level could ‘add value’ to their raw materials through processing, they could significantly increase the market demand for their produce and thereby increase their incomes. It is often argued that the rural sector may not have opportunities to market their processed value-added products. This is not so, because around 75 percent of the population lives in rural areas and there is a big demand for such products in the rural market itself. Currently such products are manufactured in urban areas or sometimes imported to the country and sold in the rural market, where the rural consumers have to bear the added costs. Processing at the rural level has the added advantage that the raw material is readily available on site and the overhead costs are comparatively lower thus enabling farmers to market their products at a competitive price. However, it is emphasized that the quality and safety of the products are maintained to ensure a high market demand. Further, branded products in attractive packages can be supplied to supermarkets and other shops in urban areas at competitive prices.

Improving agricultural productivity and promoting exports are top priorities for the government, which has set determined targets of exporting 2 million tonnes of rice by 2014/2015 and 4 million tonnes by 2019/2020. The state has laid down 12 political, economic and social objectives in its endeavours to establish a peaceful, modern and developed nation. One of the major economic objectives is “building the modern industrialized nation through agricultural development, and all-round development of other sectors of the economy.” The government attaches high priority to alleviating poverty, particularly in rural areas inhabited by the farming population. The Ministry of Agriculture and Irrigation (MoAI) is one of the key institutions charged with achieving this goal. Management of crop production/protection constraints is a key pillar of the MoAI’s development initiatives.
3. SPECIFIC AREAS UNDER REVIEW

3.1. Rice and other cereal crops

Cereal crop production in Myanmar is summarized in Table 1. Rice is the main crop in Myanmar covering some 60 percent of the total cultivated area. There are two main crop cultivation seasons, the monsoon season which extends from June/July to October/November and the summer season extending from January/February to April/May. Cultivation during the summer season is done mainly under irrigation. In the monsoon season, 16-16.5 million acres come under rice cultivation and in the summer season 2.5-3 million acres are cultivated with rice.

Table 1: Cereal crop production in Myanmar

<table>
<thead>
<tr>
<th>Crop</th>
<th>Sown area (ha)</th>
<th>Production area (ha)</th>
<th>Production (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>7 280 000</td>
<td>7 280 000</td>
<td>28 320 000</td>
</tr>
<tr>
<td>Feed maize</td>
<td>362 956</td>
<td>3 629 556</td>
<td>1 626 000</td>
</tr>
<tr>
<td>Sorghum</td>
<td>223 855</td>
<td>223 855</td>
<td>21 334</td>
</tr>
<tr>
<td>Wheat</td>
<td>103 478</td>
<td>103 476</td>
<td>18 211</td>
</tr>
</tbody>
</table>

Source: MoAI (2014).

The serious losses encountered in rice and other cereal crops during postproduction operations are due to adoption improper techniques during harvesting, handling, threshing, cleaning, drying storage and processing. This has resulted in not only high grain losses but also serious reduction in produce quality and safety.

Postharvest losses in rice have been generally assessed as shown in Table 2.

Table 2: Postharvest losses in rice

<table>
<thead>
<tr>
<th>Process</th>
<th>% loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvesting</td>
<td>1-3</td>
</tr>
<tr>
<td>Handling and transportation</td>
<td>2-7</td>
</tr>
<tr>
<td>Threshing</td>
<td>2-6</td>
</tr>
<tr>
<td>Drying</td>
<td>1-5</td>
</tr>
<tr>
<td>Storage</td>
<td>2-6</td>
</tr>
<tr>
<td>Processing (milling)</td>
<td>2-10</td>
</tr>
<tr>
<td>Total</td>
<td>10-37</td>
</tr>
</tbody>
</table>

Source: SEARCA.

Prevailing postharvest practices in cereal grains and technological requirements for improvement

Harvesting and threshing

When harvest and postharvest operations are considered, no uniformity is observed in the stage of maturity of the harvested crop, which leads to serious reduction in quality of the produce, especially due to sun cracking. Further, farmers keep their harvested rice crop stacked in the field for periods ranging from one to four weeks until it is taken for subsequent processing operations.
This is because they concentrate on establishing the pulse crop in the fields soon after harvesting the rice to make maximum use of the residual moisture available in the soil, thus neglecting the harvested paddy crop. Farmers are compelled keep the harvested crop in the field due to shortage of labour and inadequate threshing facilities such as mechanical threshers and combine harvesters. Keeping the harvested crop in the field for long periods leads to serious losses due to grain shattering, bird and rodent damage. Keeping high moisture grain in heaped conditions also leads to grain ‘yellowing’ or discoloration due to temperature build-up (heating) caused by increased rate of respiration in the living grain. Further, the crop is exposed to adverse weather conditions such as sudden rains, which can cause serious damage to grains. Hence, it is important to reduce the time period from harvesting to subsequent threshing and drying. This can be achieved by introducing high-capacity mechanical threshers so that the harvested crop is quickly threshed and removed from the field for subsequent drying. The census on agriculture carried out by the MoAI and FAO reveals that 50-60 percent of the farmers use mechanical threshers while the rest use traditional methods such as buffalo and tractors for threshing of paddy. However, the threshing machines presently used are of inadequate capacity. The threshing machines that should be introduced should have a threshing capacity of at least 2 tonnes per hour. The cost of such a thresher inclusive of a 22 horsepower engine is approximately 3 000 000 kyat (US$30 000).

Comparative studies on different threshing methods have shown that mechanical threshers have several advantages over traditional threshing methods such as high threshing efficiency, short threshing time, less labour consumption, less threshing cost, less mechanical damage to grain and overall improvement of grain quality. Hence, it is imperative that the use of mechanical threshers is promoted among farmers to significantly improve the postharvest system in Myanmar.

The use of combine harvesters for harvesting and threshing of the paddy crop, instead of manual harvesting using the sickle which is laborious and time consuming, is becoming popular in Myanmar. Use of this machine can considerably reduce the time period from harvesting to subsequent threshing and drying and thereby reduce the serious quantitative and qualitative issues occurring in the rice postharvest system. As the soil in major rice-producing areas is boggy and the access roads to rice fields are narrow the combine harvesters that should be introduced need to be small with a capacity of around 2 ha/day. The introduction and popularization of this machine will greatly assist in overcoming the problem of allowing the harvested crop to remain in the field, causing serious losses in grains. Manual harvesting using sickles is a laborious operation and, on average, a team of 10 to 12 farmers takes two days to harvest 1 ha of grain. On the other hand, combine harvesters can harvest 1 ha in half a day (4 hours), thus appreciably reducing the harvesting time and hence the time period from harvesting to subsequent threshing and drying by almost five to six days. Reducing the time period the crop is kept in the field is critically important to minimize the serious postharvest losses that occur due to shattering, mould, rodent and bird damage and damage due to adverse weather conditions. The combine harvester for paddy and wheat, which also does threshing and cleaning, consumes around 22 litres of fuel per hectare. This fuel cost is more than adequately compensated for by the savings from postharvest loss reduction in the grains and reduction in labour usage for harvesting.

**Drying**

Drying, which involves removal of moisture from the grains, is an important operation prior to storage because high moisture grain will deteriorate rapidly for the following reasons: respiration
and heating, causing grain discolouration and dry matter loss; germination of grains; mould (fungal) growth and subsequent incidence of aflatoxin; and insect activity. The moisture content of cereals has to be brought down to 14 percent or less for safe storage. Sun drying is the normal method adopted for drying of threshed grain by farmers. In this method the grain is spread on plastic sheets or paved floors and allowed to dry for one to three days depending on weather conditions. The advantage of sun drying is its low energy cost; however, several disadvantages are associated with sun drying such as: slow drying rate and hence, longer drying time; dependence of drying time on prevailing weather conditions; interruption in the drying process at night when the crop becomes susceptible to microbial damage and so forth. On the other hand, introduction of mechanical dryers, where heated air is blown through the grain mass has the following advantages: continuous process; drying under controlled conditions; shorter drying time; and drying during adverse weather. Among the different types of mechanical dryers, for introduction at the rural level the flatbed-type batch dryer would be suitable because of its simple design and operation, fast installation and assembly, and uniform low fuel consumption. This dryer has a minimum capacity to dry 2 tonnes of paddy in four hours from an initial moisture content of 20 percent to a final moisture content of 14 percent using paddy husk or any other agricultural waste for thermal energy generation. The only power requirement is to operate the 1 horsepower (0.746 kW) electric motor for the blower. Electricity consumption to dry 1 tonne of grain is only 1.5 kilowatt hours. On the other hand, the labour requirement for sun drying, if good weather conditions prevail, is approximately 16 person hours per tonne. Therefore, the energy cost for mechanical drying is more than adequately compensated by the savings from postharvest loss reduction in the grain and reduction in labour usage. The cost of such a dryer is approximately 400 000 kyat or US$400 (inclusive of fan).

Storage

Discussions with the farmers and stakeholders in the postharvest chain revealed that 50 percent of farmers store around 2 000 to 4 000 kilograms of paddy for their own consumption and future sale and sell the remainder to collectors, traders and rice millers. On the other hand, the remaining 50 percent of the farmers sell their whole quantity of grain soon after harvesting without adopting any on-farm storage. As there is a large difference in the price of grain during ‘glut’ harvesting periods and ‘deficit’ off season periods by almost 50 percent, it is important to encourage farmers to store their grain to be sold during off seasons, when the prices become attractive. At present farmers store their grain in woven bamboo baskets, oil barrels or poly sacks. Due to improper storage techniques serious grain losses are encountered. A suitable storage structure to be introduced for on-farm storage is a properly designed metal bin made out of mild steel (Annex 2). The bin provides adequate protection of the stored grain against rodent attack and moisture migration. The semihermetic conditions prevailing within the bin also control insect multiplication and subsequent damage.

Grain sold by farmers is stored at the commercial level in warehouses belonging to traders, rice millers and specialized rice companies coming under the Myanmar Rice Federation, which represents the private sector of Myanmar’s rice industry. Grain is stored mainly in woven polypropylene sacks and serious losses in grain occur due to unscientific storage practices. Storage losses have been estimated to be around 5 percent. The main causative agents of grain deterioration during storage are inherent metabolic activities of the grain such as respiration and germination and also, external agents such as insects, mould, rodents and birds. Thus, awareness has to be created not only among farmers but also among commercial-level warehouse operators.
on scientific storage practices that would preserve the grain without deterioration. Adoption of scientific storage practices is necessary to minimize losses in quality and quantity. The good manufacturing practices in grain storage include drying of the grain to a moisture content of less than 14 percent before storage, keeping the store and the surroundings clean, use of pallets for stacking to prevent seepage moisture from reaching the grain, use of proper stacking methods to make allowance for inspection and practising insect and rodent control methods.

Studies conducted by the Post-harvest Technology Division of the Department of Agriculture have revealed that using International Rice Research Institute (IRRI) poly sacs where the interior of the poly sac is lined with a low density polyethylene sheet creates hermetic conditions within the sac and thereby significantly enhances the shelf life of the stored grains. Such cost-effective storage techniques have to be conveyed to the farmer and warehouse operator through training and extension.

**Viable rural-level agroprocessing industries in cereal crops**

**Rice milling**

The rice-processing industry is the largest agriculture-based industry in Myanmar creating more value of product than any other industry. According to the Myanmar Census of Agriculture 2010, 71 percent of village tracts in Myanmar possess rice mills. According to the report of the Southeast Asia Sustainable Development Unit East Asia and Pacific Region, World Bank (2014), in Myanmar about 75 percent of mills operate with obsolete processing units, leading to about 15-20 percent quality and quantity losses during milling. The average milling ratio is below 60 percent, much lower than in neighbouring countries. A key factor in upgrading mills is provision of technical and managerial expertise to rice millers operating at the rural level.

Technically, an ideal rice mill should have the following machinery in the process line to produce superior quality rice with a high recovery rate: a paddy precleaner, a rubber-roll type paddy dehusker, a paddy/rice separator, a rice destoner, more than one abrasive/friction type rice polisher, a sieve aspirator (sifter) and a grader. The existing mills already have some of this machinery and hence only a few more machines are required to be introduced to the process line to improve the milling performance. The approximate cost of the rice mill machinery is given in Annex 2.

Assuming that the price of paddy is 300 kyat (US$0.30)/kg and that of milled rice is 600 kyat (US$0.60)/kg with a milling recovery of 65 percent and milling cost 50 kyat (US$0.05)/kg the net income generated by milling 150 tonnes is 13 200 000 kyat (US$13 200) per month.

**Grain flour milling**

There is a high market demand for rice flour because a variety of rice-based products are consumed in large quantities by the people of Myanmar. The market price of rice flour is as high as 1 200 kyat (US$1.2)/kg compared to milled rice which is around 615 kyat (US$0.62)/kg. Presently rice flour is milled in medium to large mills located in urban areas and such flour reaches the rural market where a high demand exists. Hence, rice flour grinding can be promoted as a viable agro-industry for income generation in the rural sector.

The traditional method of making rice flour in rural homes involves destoning the rice manually and then soaking it for two to three hours followed by draining off the water and pounding with mortar and pestle or under a grinding stone until the rice is converted into flour. This traditional method of rice grinding is laborious and time consuming. In the improved technique, the two
most tedious and time-consuming operations namely, manual rice destoning and hand grinding are replaced by two small-scale machines. In this method the rice is first destoned using the small-scale rice destoner, which uses the principle of specific gravity difference to separate stones, followed by grinding of the rice using a small-scale disc-type grinding machine. The cost of a destoner of 500 kg/hr capacity and a flour-grinding mill of 77-100 kg grain/hr capacity is around 600 000 kyat (US$600) and 500 000 kyat (US$500) respectively. Assuming that 250 kilograms of rice flour are produced per day for 300 days per year in a disc mill at the village level, the cost of rice flour production is 720 kyat (US$0.72)/kg and at a recovery rate of 90 percent and rice is bought at 600 kyat (US$0.60) and the milled flour is sold even at a low price of 800 kyat (US$0.80)/kg, a net income of 441 150 kyat (US$441.00)/month can be achieved. Flour produced by the grinding mill has a very fine texture with small particle size (< 200 microns) and it can be used to prepare a variety of traditional popular rice-based products.

**Rice noodle manufacture**

Rice noodles are another popular rice-based product in Myanmar with a high market demand. The price of dry rice noodles is 1 360 kyat (US$1.40)/kg compared to the price of the raw material rice which is around 600 kyat (US$0.60)/kg. Assuming that 6 000 kg of dry rice noodles are produced per month, at a recovery rate of 53 percent and processing and packaging cost of 28 kyat (USD 0.028)/kg the net income would be 1 200 000 kyat (US$1 200)/month. Hence it is a profitable agroprocessing venture that could be promoted for rural income generation. At present rice noodle-processing plants owned by rural community-based entrepreneurs are in operation. However, the following shortcomings that lead to loss in product recovery, quality and safety were observed in the processing plants:

- Outdated machinery;
- Unhygienic production practices leading to physical, chemical and microbial contamination of products;
- Improper waste management: leading to microbial contamination;
- Inadequate cleaning and sanitizing procedures for premises, machinery/equipment (proper sanitizing or disinfection procedures result in a 99.9 percent reduction of representative populations of microbes);
- Worker hygiene procedures such as hand washing and personal hygiene; use of gloves, face masks, head covers etc. not adopted; and
- Worker safety procedures not adopted.

The main reason for adoption of improper production procedures is lack of adequate knowledge by farmers and rural community-based entrepreneurs on good practices that would enhance productivity whilst ensuring product quality and safety. Hence, it is imperative that awareness is created among them.
3.2 Leguminous (pulse) crops

Next to rice, pulse crops constitute the second most important group of crops with respect to income and employment generation in the rural sector. The production of pulses in Myanmar is shown in Table 2. Of the total production around 15 percent is exported.

Table 3: Pulse crop production in Myanmar

<table>
<thead>
<tr>
<th>Crop</th>
<th>Sown area (ha)</th>
<th>Production area (ha)</th>
<th>Production (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black gram</td>
<td>1 076 525</td>
<td>1 023 099</td>
<td>1 485 351</td>
</tr>
<tr>
<td>Green gram</td>
<td>1 076 525</td>
<td>1 076 461</td>
<td>1 314 718</td>
</tr>
<tr>
<td>Winged bean</td>
<td>181 332</td>
<td>181 331</td>
<td>211 338</td>
</tr>
<tr>
<td>Soybean</td>
<td>170 893</td>
<td>170 893</td>
<td>253 671</td>
</tr>
<tr>
<td>Chickpea</td>
<td>327 538</td>
<td>327 538</td>
<td>434 397</td>
</tr>
<tr>
<td>Cowpea</td>
<td>155 508</td>
<td>155 508</td>
<td>185 706</td>
</tr>
<tr>
<td>Pigeon pea</td>
<td>616 161</td>
<td>616 161</td>
<td>760 578</td>
</tr>
<tr>
<td>Lab lab bean</td>
<td>114 239</td>
<td>114 239</td>
<td>126 838</td>
</tr>
</tbody>
</table>

Source: MoAI (2010).

Pulse crops are cultivated mainly in the regions of Sagaing, Magwe, Ayeyarwaddy, Mandalay, Bago and Yangon. Globally Myanmar is one of the major exporters of pulses and 1.3 million tonnes were exported in 2014 (MoAI 2014).

Owing to the improper postharvest practices cited already serious deterioration in the quality and quantity of pulses occurs. The quantitative losses in pulses have been estimated to be around 5-7 percent by the Department of Agriculture. Minimizing these losses by adopting improved techniques will significantly increase the income of the rural population. Also, deterioration in quality has hindered Myanmar in entering lucrative foreign markets where there is a high demand for superior quality pulses. The factors considered in evaluating the quality of pulse seeds are: moisture content, which should be less than 12 percent; presence of foreign matter; presence of seeds damaged by insects, mould and mechanical causes; seeds discoloured due to ‘heating’ and other causes; and presence of immature seeds.

**Prevailing postharvest practices in pulses and technological requirements for improvement**

**Harvesting**

The prevailing method of harvesting the pulse crop manually is a highly labour-intensive operation requiring 20 workers to harvest 1 acre in one day (80-100 person hours per hectare). The severe labour shortage prevailing during harvesting periods is a major problem confronting the pulse growers. This predicament can be alleviated by introducing combine harvesters for rice, adapted for pulse crops, which could harvest 3-4 acres per day. However, for mechanized harvesting it is important that determinate varieties that mature at the same time are cultivated. Also, as the maturity stage of the crop for harvesting is determined by subjective methods it is best to introduce moisture meters so that the best moisture content for harvesting (15-20 percent) is determined objectively to ensure high yields while preserving the quality of the seeds.

**Threshing**

Threshing or removal of seeds from pods is currently done manually by drying the harvested crop in the field for one to two days and then beating the crop spread on the threshing floor with
sticks or using animal draught power. High seed losses are encountered with these methods due to mechanical damage, spillage and admixture with foreign matter. Further, this method is highly labour-intensive and only about 15-40 kilograms of seed can be obtained per person hour. On the other hand, a drum and concave axial flow-type mechanical thresher can thresh 1 000 kilograms of seeds per hour and promoting such a machine among pulse growers will greatly assist in overcoming the problems confronted by farmers in threshing of pulse crops (Annex 2). It was heartening to note that rural artisans have already initiated the fabrication of mechanical threshers for pulse crops and the price of a locally manufactured thresher of capacity 1 tonne/hr (30 baskets/hr) inclusive of the 10 horsepower engine is around 2.2 million kyat (US$2 200). In this context, it is important to upgrade technology in rural workshops, provide credit plus other support services to encourage local manufacture of these machines.

Drying

Sun drying is the usual method of drying pulse seeds. However, a high percentage of discoloured or heat-damaged seeds occur in pulses produced in Myanmar. This is mainly due to inadequate drying of the crop prior to storage. It is imperative that pulse grains are dried down to a moisture content of less than 12 percent prior to storage. In this context, promoting the use of moisture meters among farmers for accurate determination of moisture assumes importance.

At present drying of pulse crops is achieved by spreading the seeds on paved drying floors or on tarpaulin sheets and exposing them to sunlight for two to three days with frequent stirring. However, sun drying has the following disadvantages: a slow drying process; dependence on weather conditions; high risk of contamination; shattering losses; rodent and bird damage; high labour input. These disadvantages can be overcome by the use of mechanical dryers. The flat bed batch-type dryer used for paddy and other cereals can be used for drying of pulse seeds too.

Storage

Farmers store about 5 to 15 tonnes of their pulse production for seed purposes and for future sale and the remainder is sold to traders. The market price of pulses during the harvesting season is around 30 000 kyat per basket (US$0.92/kg) whereas during the off season the price escalates to around 40 000 kyat per basket (US$1.22/kg). Farmers could take advantage of this significant price variation by storing their harvest to be sold during off seasons.

The losses in quality and quantity of pulse seeds during storage are more serious than in cereal grains. Losses occur mainly due to pulse beetle attack, mould damage, heating and discolouration, and rodent damage. In this context, it is important to create awareness among farmers on scientific storage practices that would minimize both quantitative and qualitative losses. It is also important to promote the use of well-designed storage containers such as a metal bin made out of mild steel that is recommended for storage of cereal grains to preserve the stored seeds without deterioration (Annex 2).

The pulse crop sold by farmers to traders is stored in poly sacs inside buildings and again due to adoption of improper storage techniques serious losses are encountered. Hence awareness has to be created among farmers and other stakeholders in the postharvest chain on best practices that would preserve the stored seeds with minimum losses. In this regard, the use of IRRI super-bags for air-tight storage of pulse seeds should be encouraged. The cost of an IRRI super-bag is 400 kyat and a similar bag is available in the market for 800-1 000 kyat thus making the technology cost effective.
Viable rural-level agroprocessing industries in pulse crops

Pulse processing

Dehusking and splitting into *dhal* form (dried and split) makes the pulse seeds more acceptable to consumers, improves texture, product quality, palatability and digestibility, reduces cooking time and gets rid of the seed coat which contains antinutritional factors. Hence it is necessary to process the pulse seed to make it suitable for human consumption. Except for home consumption, the farmers sell their pulse crop in unprocessed form and processing is done mainly in urban mills. The large quantities of pulses exported by Myanmar are also in unprocessed form.

The market price of processed pulse seed, on average, is around 1 700 kyat (US$1.70) whereas the unprocessed seed fetches only about 1 200 kyat (US$1.20). A cost/benefit analysis of pulse processing indicates that at a recovery rate of 76 percent the cost of processing and packaging is 40.00 kyat (US$0.04)/kg. The total production cost is 1 611 kyat (US$1.61)/kg and the net income is 80.00 kyat (US$0.08)/kg. If 16 tonnes of seed are processed per month the net income generated is 1 280 000 kyat (US$1 280)/month.

The pulse-processing plants presently in operation which are owned by rural community-based entrepreneurs have outdated machines and in these mills the recovery level is low and is around 70 percent. Only two main machines are required for small-scale pulse processing, the emery roll mill for pealing and splitting of pulse seeds and sifter for removal of unprocessed seed. The capacity of such a process line is around 100-150 kg/hr and a recovery level of 78 - 80 percent could be achieved. Operating with a single phase 2-horsepower motor such an emery stone mill is ideal for initiation of a small-scale pulse-processing enterprise in the rural sector.

Manufacture of tofu crackers

Another popular pulse-based food product which has a high market demand in Myanmar is the tofu cracker and its small-scale manufacture needs to be promoted as a viable rural sector agro-industry. The price of chickpea from which tofu crackers are produced is around 1 000 kyat/viss\(^1\) (US$0.63/kg). On the other hand, the price of tofu crackers in the market is around 2 250 kyats/viss (US$1.40/kg) showing a significant value addition to the pulse seeds. At a recovery rate of 80 percent and a processing cost of 250 kyat/viss (US$0.15/kg) the net income that can be generated by manufacture of tofu is 750 kyat/viss (US$0.46/kg). Assuming that 25 viss (41 kilograms) of tofu crackers are produced per day, the net income is 18 750 kyat (US$19.00)/day.

Small-scale production of tofu crackers is currently carried out by rural community-based entrepreneurs. However, due to use of improper machinery/equipment and production procedures the productivity of these processing plants is low. Also, production is carried out under unhygienic conditions and good manufacturing practices (GMP) to ensure product safety and quality are not adopted. It was observed that solid and liquid waste materials are not disposed properly and they are collected close to the processing facility, harbouring flies and emitting antisocial odours. Also, cleaning and sanitizing the processing plant and equipment using appropriate detergents and sanitizers to prevent physical, chemical and microbial contamination of the product are not carried out. The use of a cheap sanitizer like chlorine water at 100-200 ppm (1-2 grams in 10 litres) of water can prevent microbial contamination to a great extent. Chlorination can be achieved by using household bleach or swimming pool chlorine.

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\(^1\) 1 viss = 1.632 kg.
was also observed that workers’ hygienic practices such as hand washing, personal hygiene, use of gloves and face masks etc. are not adopted. The rural sector workers engaged in processing activities are unaware of even these simple techniques and this emphasizes the need to train and create awareness among the target groups on GMPs to ensure product safety and quality. It was also observed that some workers perform laborious unsafe operations like stirring the hot bean slurry while sitting close to the open fire. Such an operation can easily be mechanized by installing a stirring device using a 0.5-horsepower motor. This shows that worker safety procedures are not adopted in rural processing facilities.

3.3 Oilseed crops

Myanmar cultivates large areas of oilseed crops especially in the CDZ. This is summarized in Table 3.

Table 4: Oilseed crop production in Myanmar

<table>
<thead>
<tr>
<th>Crop</th>
<th>Sown area (ha)</th>
<th>Production area (ha)</th>
<th>Production ('000 tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundnut</td>
<td>866 420</td>
<td>866 420</td>
<td>1 341</td>
</tr>
<tr>
<td>Sesame</td>
<td>1 634 100</td>
<td>1 632 070</td>
<td>854</td>
</tr>
<tr>
<td>Sunflower</td>
<td>883 010</td>
<td>883 010</td>
<td>770</td>
</tr>
<tr>
<td>Mustard</td>
<td>99 960</td>
<td>99 960</td>
<td>85</td>
</tr>
<tr>
<td>Niger</td>
<td>155 800</td>
<td>155 800</td>
<td>97</td>
</tr>
</tbody>
</table>

Source: Myanmar Agriculture Service (2010).

Oilseed crops also play a vital role in Myanmar due to high consumption of cooking oil compared to other neighbouring countries. As the amount of edible produced is not enough for consumption, approximately 200 000 tonnes of palm oil are being imported annually to fulfil the local requirement (MoAI 2014). However, a major portion of the good quality oil crop seeds such as groundnut and sesame are exported and the remaining substandard oilseed enters the domestic oil extraction industry giving poor quality edible oil with low recovery levels. This is because the export market prices for oilseeds are more attractive than the prices offered locally. The serious loss in quality and safety that occur in oilseeds, in addition to quantitative losses, is mainly due to adoption of improper postharvest technologies. This leads to incidence of damaged, discoloured, shriveled and malodourous kernels in the product. Hence there is an urgent need to improve the prevailing postharvest operations.

Prevailing postharvest practices in oilseed crops and technological requirements for improvement

Harvesting

Harvesting, which is presently done manually, is a highly labour-intensive operation. Assuming that the average yield of groundnut is 25 baskets (800 kilograms) per acre, the labour requirement for harvesting is 20 people per acre; at a labour wage rate of 1 500 kyat/basket the labour cost for harvesting comes to about 3 7500 kyat (US$37.50/acre. This serious problem of labour shortage and high labour cost faced by farmers can be overcome by introducing appropriate mechanical harvesting devices which could harvest 1 acre of the crop in one day utilizing two people. Such simple digging devices attached to two- or four-wheeled tractors can significantly reduce the scarce labour requirement for harvesting of groundnut. These devices can be fabricated cost effectively and easily in workshops of rural artisans.
**Threshing**

Threshing or stripping of the harvested crop is another labour-intensive operation in oilseed crops. Manually, about 20 to 30 women are required for stripping an acre of oilseed. This serious problem confronted by the farmers can be alleviated by introduction of mechanical threshers of appropriate capacity. The drum and concave-type axial flow threshers used for paddy can be used after slight modifications for threshing of oilseed (Annex 2).

It is encouraging to note that rural artisans are already fabricating threshers for oilseed in their workshops because of the high demand for the machine. However, there is an urgent need to upgrade the facilities available in these rural workshops and at the same time provide knowledge to the artisans on improved designs of machinery and equipment, through training.

**Drying**

The moisture content of oil crops has to be reduced to less than 8 percent for safe storage. Proper drying of oilseed crops is extremely important because high moisture seed is highly susceptible to mould growth and subsequent development of aflatoxins. Incidence of mould and aflatoxin seriously hamper export businesses especially to EU countries where strict standards are maintained for aflatoxin levels. For example, in the German quality standards the maximum residue limits for aflatoxin is 2µg/kg.

At present drying is accomplished by spreading the crop in the field or on drying floors or tarpaulin sheets and exposing to the sun for two to three days. As mentioned previously, several disadvantages are associated with sun drying such as dependence on weather conditions, interruption of drying at night, grain contamination with dust and foreign matter, labour intensiveness of the operation and prolonged drying periods. These disadvantages could be overcome by the use of a flat-bed batch-type dryer which utilizes agricultural waste such as groundnut husk, paddy husk etc. for heat energy generation for drying. A suitable dryer to be introduced would have a capacity of 2 tonnes per batch where drying is accomplished in four hours. The only power requirement in this type of dryer is to operate the 1-horsepower (0.746 kW) electric motor for the blower. Electricity consumption to dry 1 tonne of grain is only 1.5 kilowatt hours. The labour requirement for sun drying, if good weather conditions prevail, is approximately 16 person hours per tonne. Therefore, the energy cost for mechanical drying is more than adequately compensated by the savings from postharvest loss reduction in the seeds and reduction in labour usage. In this context it is important to popularize the use of mechanical drying in the rural farming sector. Flat-bed batch dryers currently fabricated in Myanmar cost around 400 000 kyat (US$400)/4 tonne dryer.

**Storage**

Oilseeds are semiperishable in nature and, if not correctly stored, are subject to serious quality losses during storage due to microbial proliferation; insect and rodent infestation; biochemical changes such as flavour change, rancidity and viability loss; and physical changes such as shrinkage, weight loss and absorption of odours and chemicals. Hence it is important to adopt GMPs during both on-farm and warehouse-level storage to preserve the quality of the product whilst minimizing losses.

Adoption of GMPs such as adequate drying of seeds before storage, cleaning and sanitation of the storage and surroundings to prevent cross-contamination, exercise insect and rodent control, and use of well-designed storage containers and warehouses should be encouraged among
farmers and other stakeholders in the postharvest chain of oilseed crops. In the case of warehouse storage in bags it is important to stack the bags on pallets to prevent seepage moisture from reaching the stored seed and popularize the use of IRRI super-bag package types to minimize damage (Annex 2).

For on-farm storage the metal bin made out mild steel previously described for cereals and pulses can be successfully used for oil seeds too (Annex 2).

**Viable rural-level agroprocessing industries in oilseed crops**

**Shelling of groundnuts**

Groundnut pods have to be shelled to extract the seeds prior to marketing for oil extraction or for use in food items. Farmers take their harvested crop to rural-level shelling mills owned by medium- to large-scale farmers and rural community-based entrepreneurs. The market price of seed is around 1 300 kyat/viss (US$0.79/kg) whereas the price of unshelled pods is only around 400 kyat/viss (US$0.24/kg). Normally the cost of shelling is around 25 kyat/viss (US$0.02/kg). Hence there is an appreciable value addition to the product by converting groundnut pods into seed form. Each village has about two to three shelling mills and the capacity of a mill is around 6-7 baskets (200 kg) of seed per hour. Not only is the shelling capacity presently available in the rural sector inadequate but also due to the use of outdated machines, milling recovery and efficiency are quite low. Ideally, a milling recovery and a milling efficiency of over 75 and 90 percent, respectively should be obtained. Improved designs of groundnut-shelling machines are available in the market where the pods are crushed by pressing them by rubber pads mounted on a rotating drum. The price of such a machine of capacity 200 kg/hr and operating with a 3-horsepower single phase motor is around 1 200 000 kyat (US$1 200). In this context, promotion of groundnut processing as a viable enterprise in the rural sector through provision of training and concessionary credit facilities to farmers and village community-based entrepreneurs to acquire improved technologies assumes importance.

Another step in processing of oilseeds is grading of the seeds after milling to enhance market demand for the product by separating damaged, discoloured and shrivelled seeds. Currently, grading is performed manually by visual examination. This method is laborious and time consuming and hence should be replaced by introducing sifters which can be operated by a 1-horsepower single phase motor, resulting in increased profits from this agro-industrial venture.

**Oil extraction**

Extraction of oil from oil crop seed is another highly profitable venture which should be established as an agro-industry in the rural sector. As the edible oil produced in Myanmar is not adequate to meet domestic requirements, large quantities of palm oil are imported. Hence, development of the rural oil extraction industry will not only benefit the rural farming sector but also be of benefit to the national economy. The current market price of sesame oil and groundnut oil is 5 800 and 3 800 kyat/viss (US$3.54 and 2.32/kg) respectively. When compared to the price of sesame and groundnut seed at 2 100 and 1 300 kyat/viss (US$1.28 and 0.79/kg) respectively there is an appreciable value addition to oilseed by extracting edible oil. At an oil recovery level of 65 percent and a processing cost of 246 kyat per viss (0.15 kyat/kg) and if 150 kilograms of groundnut oil are produced per day the net income would be 127 500 kyat (US$127)/day or 2 550 000 kyat (US$2 550/month).
The small-scale oil extraction plants currently in operation owned by rural community-based entrepreneurs have outdated expellers and filters giving low recovery levels of 40-48 percent and poor quality oil. It is necessary to upgrade this machinery and equipment by introducing improved extraction techniques such as the cold press technique where the oil does not become heated during extraction that leads to chemical changes causing reduction in quality of the oil. An oil recovery level of at least 65 percent should be obtained. The cost of an improved expeller-type oil extraction machine of capacity 15-20 litres/hr operating with a 5-horsepower single phase motor would be around 1 200 000 kyat (US$1 200) and an oil filtering machine with oil pump of capacity 200 litres/hr operating with a 1-horsepower single phase motor would be around 1 250 000 kyat (US$1 250). The main problem confronting the owners of the small-scale oil mills is lack of capital to upgrade the existing machinery and also lack of knowledge on improved oil-extraction techniques. Other deficiencies observed in rural oil-extraction plants are use of low-quality seeds; non-adoption of oil-refining techniques; and improper utilization of groundnut cake, which is a valuable by-product of oil extraction.

3.4 Horticultural crops

Fruits and vegetables are very important to the Myanmar economy and diet, in that they are a source of income for rural farmers and nutrition for the general populace. They are also used as a source of raw material for the agroprocessing industry. Developing the fruit and vegetable industry is essential in guaranteeing a reliable supply of fresh produce for the local and international markets. Next to paddy, the vegetable subsector is the most prominent in the agriculture sector as vegetables are grown throughout the country and many farmers are involved in vegetable cultivation (Table 5).

<table>
<thead>
<tr>
<th>Table 5: Vegetable production in Myanmar</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crop</strong></td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>Tomato</td>
</tr>
<tr>
<td>Lettuce</td>
</tr>
<tr>
<td>Bottle gourd</td>
</tr>
<tr>
<td>Carrot</td>
</tr>
<tr>
<td>Cabbage</td>
</tr>
<tr>
<td>Mustard</td>
</tr>
<tr>
<td>Cauliflower</td>
</tr>
<tr>
<td>Radish</td>
</tr>
<tr>
<td>Watermelon</td>
</tr>
<tr>
<td>Asparagus</td>
</tr>
<tr>
<td>Others</td>
</tr>
</tbody>
</table>

Source: Myanmar Agriculture Service (2010).

The annual production of major fruit crops cultivated in Myanmar and the export data are given in Tables 6 and 7. Among the many fruits cultivated in Myanmar, mango forms an important crop where 7.5 percent of the production is exported to neighbouring countries. Of the annual fruit production, about 50 percent is locally consumed, 30-40 percent is wasted and about 10-15 percent is exported.
Table 6: Fruit production in Myanmar

<table>
<thead>
<tr>
<th>Crop</th>
<th>Sown area (ha)</th>
<th>Production area (ha)</th>
<th>Production (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mango</td>
<td>79 228</td>
<td>71 534</td>
<td>482 235</td>
</tr>
<tr>
<td>Pineapple</td>
<td>21 054</td>
<td>20 628</td>
<td>242 523</td>
</tr>
<tr>
<td>Lime</td>
<td>17 582</td>
<td>16 489</td>
<td>50 052</td>
</tr>
<tr>
<td>Jujube</td>
<td>22 338</td>
<td>20 821</td>
<td>314 272</td>
</tr>
<tr>
<td>Tamarind</td>
<td>18 458</td>
<td>17 747</td>
<td>123 080</td>
</tr>
<tr>
<td>Orange</td>
<td>14 156</td>
<td>10 892</td>
<td>297 815</td>
</tr>
<tr>
<td>Durian</td>
<td>8 420</td>
<td>7 966</td>
<td>39 726</td>
</tr>
<tr>
<td>Pumelo</td>
<td>6 111</td>
<td>5 520</td>
<td>19 911</td>
</tr>
<tr>
<td>Custard apple</td>
<td>4 091</td>
<td>3 870</td>
<td>14 471</td>
</tr>
<tr>
<td>Litchi</td>
<td>5 391</td>
<td>4 425</td>
<td>29 738</td>
</tr>
<tr>
<td>Apple</td>
<td>1 703</td>
<td>930</td>
<td>4 648</td>
</tr>
</tbody>
</table>

Myanmar Agriculture Service (2010).

Table 7: Data on export of major fruits (tonnes)

<table>
<thead>
<tr>
<th>Fruit</th>
<th>2008-09</th>
<th>2009-10</th>
<th>2010-11 (25-2-11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mango</td>
<td>21 760</td>
<td>44 360</td>
<td>34 276</td>
</tr>
<tr>
<td>Watermelon</td>
<td>150 365</td>
<td>152 468</td>
<td>126 870</td>
</tr>
<tr>
<td>Muskmelon</td>
<td>28 421</td>
<td>27 357</td>
<td>13 750</td>
</tr>
<tr>
<td>Jujube</td>
<td>39 310</td>
<td>30 247</td>
<td>36 106</td>
</tr>
</tbody>
</table>

Source: Myanmar Agriculture Service (2010).

**Prevailing postharvest practices in fruits and vegetables and technological requirements for improvement**

As in the case of many other developing countries, a major portion of all the fruits and vegetables is produced in smallholdings and home gardens and is usually intended for local domestic markets. As such, these commodities pass through long and complex marketing chains prior to reaching the consumer. At present, there are different categories of people such as the farmer, collector, wholesaler and retailer involved in the vegetable and fruit marketing chain, who perform various postharvest activities such as harvesting, sorting and grading, collecting, storing, transporting and selling. Farmers sell most of their produce through intermediaries and add little value to the primary product supplied.

Due to improper practices during postharvest operations, serious quantitative and qualitative losses are encountered in fruit and vegetable crops along the supply chain. Even though scientifically-designed loss assessment studies have not been conducted in the country, based on losses that can be expected in the postharvest techniques currently being adopted and data gathered through interviews with producers and others involved in the fresh produce supply chain, as in most other developing countries, the quantitative loss of fresh produce during postharvest operations in Myanmar can be estimated to be around 30-35 percent of the total annual production. This value agrees with the estimated value for losses of the Department of Agriculture. Qualitative and quantitative losses occur due to use of improper techniques during harvesting, packinghouse operations, storage, handling and transportation. The main loss, amounting to approximately 18-20 percent of the production, occurs due to use of improper...
packages, rough handling and overloading of vehicles during transportation from production to consumption areas. Minimizing these losses by adopting improved postharvest techniques will not only increase the income of the rural farming population but also ensure availability of superior quality produce to the consumer at a reasonable price.

Harvesting

Harvesting of tree fruits such as mango, which is a highly labour-intensive operation, is usually done manually either by hand plucking or, if unreachable, with the help of wooden poles. The fruits thus detached from the trees are often allowed to fall on to the ground. This practice leads to serious mechanical/physical damage to the produce. Due to shortage and high cost of labour, harvesting is often performed in bulk, without any selection of fruits that are at the correct stage of maturity for harvesting in order to ensure high produce yield and quality. Another factor contributing to harvesting at incorrect stages of maturity is that the crop is often reaped based on market demand prevailing at a particular time and not based on stage of maturity. These problems can be alleviated to a great extent by introducing properly-designed harvesting tools and nets not only to prevent undue mechanical damage caused to produce but also to reduce the requirement of scarce labor for harvesting, thus leading to an appreciable reduction in the cost of production and improvement in the quality of tree fruit crops produced in Myanmar.

Packaging for handling and transportation

In Myanmar fruits and vegetables have to be transported, often over considerable distances from areas of production to areas of consumption. The commonly-used packages for transportation are woven polypropylene sacks. As mentioned previously, the highest postharvest loss in fresh produce (18-20 percent) occurs due to use of improper packages, rough handling and overloading in vehicles during transportation. The losses occur due to physical/mechanical damage such as bruising and wounding, and subsequent rotting of the produce. Fruits and vegetables are often packed tightly by being forced into polypropylene sacks. These sacks do not provide sufficient ventilation for the produce and this results in temperature build-up which accelerates both toughening and senescence. The fruits and vegetables packed in poly sacs by farmers are usually kept near the roadside until the collectors come to pick them up. This can expose the fresh produce to sun or rain. Rough handling and loading take place during transportation. Because of the high transportation cost the collector or wholesaler generally tends to transport the maximum amount possible. Packaging used by traders does not accommodate or compensate for high ambient temperature and humidity conditions that prevail during extended periods of transportation, which can last for two to eight hours, resulting in rapid deterioration of quality. Thus the fresh produce is often bruised, infested by postharvest pathogens and is not of optimum quality on reaching distribution points. Use of plastic crates (containers) for handling and transportation can minimize this serious postharvest loss occurring in fruits and vegetables. Previous studies carried out have shown that the loss occurring during handling and transportation of fruits and vegetables in poly sacs which amounts to approximately 20 percent can be reduced to less than 3 percent by using plastic crates. Plastic crates are available in different sizes to suit the product that is being transported. Ideal plastic crates should have the following characteristics: they should be stackable (can be placed one on top of the other) and nestable —empty containers can be placed one inside the other to reduce storage space requirements when empty crates are being transported; the bottom and sides of the crate should be perforated so as to allow for proper ventilation; size uniformity is important to allow for the exchange of containers between stakeholders along the supply chain; crates should be made of
food-grade recyclable plastic (heavy metals such as cadmium should not be incorporated to achieve colour etc.); the plastic should be of UV-resistant quality; crates should be environmental stress resistant, that is, tough and long lasting with sufficient impact resistance and compression strength; and crates should withstand temperatures ranging from -18° to 75°C (Annex 2).

**Wholesale market facilities**

Another weakness observed in the fresh produce supply chain in Myanmar is lack of properly designed wholesale markets with adequate space and facilities for temporary storage and to perform packinghouse operations such as cleaning, sorting and grading. Often the fresh produce is exposed to the sun causing serious deterioration in quality due to enhanced metabolic activities such as respiration and transpiration. There is inadequate space for storing empty containers and for proper loading and unloading from transportation vehicles. Proper waste disposal facilities are not always available in the prevailing wholesale markets resulting in microbial contamination of the produce. In this context, it is important to upgrade the wholesale markets through provision of scientifically-designed wholesale markets with adequate space, clean water, electricity and solid and liquid waste disposal facilities.

**Viable rural-level agroprocessing industries in horticultural crops**

Due to increases in the cost of agricultural inputs, including labour, the returns to farmers from horticultural crop cultivation have become marginal. An effective way of alleviating this problem of low income from farming is to initiate agro-/food-processing microenterprises at the farm level. At present, farmers market their produce in unprocessed forms. Now it is realized that if farmers themselves at the rural level could do the processing they could ‘add value’ and increase the market demand for their produce; and thereby significantly increase their incomes. Also, the production of most fruits and vegetables is seasonal in nature and, during harvesting periods due to a glut in production, the prices of these commodities tend to slump to unprecedented levels. The farmers are compelled to dispose of their produce soon after harvest at prevailing low prices because they lack facilities to preserve their crop for future sale. Further, large quantities of these fruits and vegetables go to waste during glut periods. Therefore, improvement of processing and preservation facilities, which is an important component of the postharvest system, would enable the farmers to sell their commodities during off seasons at attractive prices, thus increasing their incomes. It is often argued that farmers lack access to urban markets where a demand exists for such value-added processed products. But it has to be emphasized that in Myanmar, like in most developing countries, the rural sector constitutes the majority of the population and hence, there is a ready demand for such commodities in the local rural markets themselves. However, any technology that is introduced for processing and value addition should be affordable and manageable by the rural sector, especially by rural women, and at the same time, should bring about a significant increase in their incomes. Women contribute an enormous labour force for agroprocessing, starting from harvesting, handling, drying, cleaning and processing, while attending to laborious operations at the household level such as family care and food preparation. Hence, selection of appropriate technology that would eliminate the drudgery of the rural woman assumes importance. In this context, some viable value-adding techniques that can be introduced for fruits and vegetables at the rural level in Myanmar are manufacture of dried/dehydrated products, sauces, pickles and jams.
**Manufacture of dried/dehydrated products from fruits and vegetables**

Manufacture of dried mango is a popular rural agro-industrial venture. The product has a moisture content of 10-15 percent and a shelf life of 12 months. The product is packed in polyethylene packages. Nearly 40 percent of the production is exported to neighbouring countries. The cost of raw material is about 300 kyat (US$0.30)/kg whereas the market price of dried mango is around 1 750 kyat (US$1.75)/kg. With a drying and packaging cost of around 50 kyat (US$0.05/kg) and a recovery level of 25 percent the net income generated by drying of mango is 500 kyat (US$0.50)/kg. If 400 kilograms of dried fruit is produced per month the net income of an enterprise is 200 000 kyat (US$200) per month.

Osmotically dehydrated fruits such as damson are also produced. The price of the processed product is around 2 000 kyat/viss (US$1.22/kg) whereas the price of raw material is around 1 000 kyat/viss (US$0.61/kg). The production cost is around 44 kyat/viss (US$0.03) and hence there is significant value addition and an attractive income for farmers via the manufacture of this product. Similarly, osmotically dehydrated mango and tomato are produced as viable rural agro-industries.

Currently drying/dehydration of fresh produce is accomplished by spreading it on trays kept on racks above ground level and drying in the sun for two to three days depending on weather conditions until the moisture content of the product reaches 10 percent or less. Several disadvantages are associated with sun drying of fresh produce such as dependence of the drying time on weather conditions, uncontrolled drying conditions, prolonged drying time, intermittent drying during day and night and contamination of the product with dust and dirt. Insufficient and prolonged drying lead to microbial proliferation, especially mould growth, in the product with storage. These disadvantages can be overcome by using a tray-type dryer. A dryer with capacity of 150 kg/batch operating at 55-600°C, where heat is generated by electrical heating coils, can accomplish drying in six to eight hours. It costs between 1 000 000 to 3 000 000 kyat (US$1 000-3 000). Use of tray-type dryers guarantees a product with high quality and safety, having a high market demand both locally and abroad. In the absence of adequate capital, another alternative is to use solar dryers which can reduce the drying time appreciably while protecting the drying material from physical and microbial contamination. In this context, a solar tunnel type of dryer would be suitable for drying of fresh produce. A solar dryer with capacity of 25 kilograms per batch could be constructed at approximately 200 000 kyat (US$200) (Annex 2). The drying time in a solar dryer is around eight to 10 hours.

Apart from not using improved drying techniques, other limitations observed in rural-level fresh produce drying facilities are production under unhygienic conditions and not adopting GMPs to ensure product safety and quality. Solid and liquid waste materials are not disposed of properly and amass near the processing facility harbouring flies and emitting foul odours. Also, cleaning and sanitizing the processing plant and equipment using appropriate detergents and sanitizers to prevent physical, chemical and microbial contamination of the product are not carried out. As mentioned previously, the use of a cheap sanitizer like chlorine can prevent microbial contamination to a great extent. Chlorination can be achieved by using household bleach or swimming pool chlorine. It was also observed that workers’ hygienic practices such as hand washing, personal hygiene, use of gloves and face masks etc. are not carried out. The rural sector workers engaged in processing activities are unaware of these simple techniques and this emphasizes the need to train and create awareness among the target groups on GMPs to ensure product safety and quality.
Further, most of the processors indicated the necessity to have easy access to a product inspection and certification scheme of an accredited institution for product safety and quality, with respect to adoption of GAPs, GMPs and Hazard Analysis and Critical Control Points (HACCP) etc. which will enable them to enter attractive export as well as domestic markets.

Manufacture of sauces, pickles and jams

Small-scale manufacture of sauces, pickles and jams can be identified as economically as well as technically viable microenterprises that could be promoted in the rural sector, especially among rural women. For example, during field visits, it was observed that in a remote village in Mandalay Region where tomato is grown over a large area, the tomato sauce consumed by rural people comes from urban areas like Yangon. The market price of bottled tomato sauce manufactured in Yangon is around 6 000 kyat (US$6.00)/kg whereas the price of raw tomato is only around 500 kyat (US$0.50)/kg. At a recovery level of 40 percent and processing and bottling cost of 850 kyat US$0.85)/kg, the net income from tomato sauce manufacture even if sauce is sold at 3 000 kyat (US$3.00) per kilogram is 1 275 kyat (US$1.27)/kg. Even if 200 kilograms of bottled sauce are manufactured per month the net income per enterprise is 255 000 kyat (US$255) per month. A high capital investment is not required to initiate a microenterprise of this nature and the simple equipment required is manually operated bottling devices, stainless steel pans/vessels, chopping/cutting, mixing/blending, heating and packing equipment.

Rural people are enthusiastic in initiating viable agroprocessing enterprises provided they are given knowledge, by way of training, in appropriate processing techniques and also capital, by way of concessionary credit, to acquire the technologies. It is also important to create awareness among the processors on GMPs to ensure hygienic production whilst maintaining safety and quality of the products.

3.5 Fisheries sector

The fishery sector follows the agriculture sector in importance for fulfilling the protein requirements of the people of Myanmar and to provide food security as well as opportunities for the employment.

In the 2013-2014 fiscal year, the total production of fish in Myanmar was 5.05 million tonnes. During this period, the production of freshwater fish was 2.35 million tonnes (46 percent of the total fish production) and the production of marine fish was 2.70 million tonnes (54 percent of the total production of fish in Myanmar). The exported amount of fish and fishery products was 0.345 million tonnes, the value of which was US$536.274 million. Fish was exported to 32 different countries. The exported amount was 7 percent of the total production of fish in Myanmar in this period (Myanmar Fishery Statistics 2014).

Postharvest practices in fresh fish: present status and technological requirements for improvement

The Inspection and Certification Section and the Inspection and Quality Control Section of the Research and Development Division, Department of Fisheries, Ministry of Livestock, Fisheries & Rural Development governs fish and fishery products according to the following food safety management protocols:

- Improve wholesomeness (quality) and safety of fishery products for human consumption and minimize postharvest losses;
- Develop and apply quality and safety management systems that ensure food safety through the implementation, validation and verification of an HACCP-based system;

- Improve inspection practices and harmonize them with international inspection systems; adapt quality and safety management systems as appropriate to the fishery sector; and

- Develop and implement GMP guidelines and compliance standards.

The Department of Fisheries has been operating these protocols through the supply chain in fishing vessels, landing sites, ice plants and processing establishments to respond to the ASEAN Free Trade Area agreement. Hence quality and safety issues in fresh fish production are well addressed in Myanmar.

However, there are some deficiencies in handling and transportation of fresh fish. In Myanmar fish has to be transported over long distances from areas of production to areas of consumption. At present wooden boxes are the main type of container used for packing of fresh fish for transportation. Several disadvantages are associated with wooden boxes related to difficulties in cleaning and sanitization, re-use, possible damage to packed fish due to rough surfaces and overpacking. These disadvantages could be overcome by using plastic fish boxes of suitable design with the following specifications:

- Should be made of food-grade recyclable plastic (heavy metals such as cadmium should not be incorporated to achieve colour etc.) The plastic should be of UV-resistant quality;

- Can be closed with a lid and have vents in the lower section for dissolved ice and slime to exit;

- Should be stackable, that is, they can be placed one on top of the other and be nestable;

- Should be environmental stress resistant, that is, tough and long lasting with sufficient impact resistance and compression strength. They should be crack, chip and corrosion resistant. Boxes should withstand temperatures ranging from -18° to 75° C;

- Easy to clean and sanitize;

- Size uniformity is important to allow for the exchange of boxes;

- They should be of hygienic design, made of non-toxic material and resistant to bacterial and fungal growth; and

- Boxes should be well lodged and stable when stacked and leave no room for movement. This is important, as it will help reduce damage due to vibration and abrasion damage.

Postharvest practices in dry fish production: present status and technological requirements for improvement

Dry fish is a popular component in the diet of Myanmar people and a large quantity of caught fish goes for dry fish production. Dry fish processing is carried out by rural community-based
entrepreneurs. Dry fish production involves salting and drying of the fish and at present drying is accomplished by spreading fish on the ground, on rocks or on beaches to dry in the sun. Some fish processors use mats or reeds laid on the ground to prevent contamination by dirt, mud and sand. Sun drying lasts for about three to five days.

The prevailing market prices for dried fish and dried prawn are 1 400 and 17 000 kyat/viss (US$0.85 and 10.37/kg) respectively whereas the price of fresh fish and prawns that go for processing is 350 and 6 000 kyat/viss (US$0.21 and 3.66/kg).

In dry fish production it is important to dry the fish to a moisture content of less than 15 percent. If the moisture content of fresh fish is reduced during drying to around 25 percent, spoilage bacteria cannot survive and autolytic activity will be greatly reduced, but to prevent mould growth, the moisture content must be reduced to 15 percent or less. It was observed that the fish processors use subjective methods such as hardness of the product to determine whether the fish has been dried adequately. Sometimes these methods are inaccurate and it is best to use moisture meters for accurate determination of moisture to ensure a long shelf life without spoilage. A moisture meter will cost around 200 000 kyat (US$200) and it would be a useful item for fish-processing sites.

Traditionally, in tropical countries, many fishers spread fish on the ground, on rocks or on beaches to dry in the sun. Some fish processors use mats or reeds laid on the ground to prevent contamination of the fish by dirt, mud and sand. Drying fish in this manner has many disadvantages and, hence, it is important to use raised sloping drying racks as a simple but often effective improvement. A cleaner product is obtained from rack drying because the fish do not come into contact with the ground; also they are less accessible to domestic animals and pests, such as mice, rats and crawling insects, which contaminate or consume them. Protection from rain is simply accomplished by covering the rack with a sheet of waterproof material (e.g. plastic); if fish on the ground are covered, they are protected from falling rain but not from water on the ground itself. Drying rates are higher because air currents are stronger at a metre or so above the ground and air can pass under the fish as well as over them. The use of a sloping rack allows any exudates to drain away. The sun-drying racks could be made of nylon netting or woven reed mats mounted on poles erected on the ground.

Processing is carried under unhygienic conditions and good manufacturing practices (GMP) to ensure product safety and quality by eliminating physical, chemical and microbiological contamination are not adequately practised in the dry fish-processing sites. Solid and liquid waste materials are not disposed of properly and pile up close to the processing facility harbouring flies and emitting foul odours. Also, cleaning and sanitizing the processing plant and equipment using appropriate detergents and sanitizers to prevent physical, chemical and microbial contamination of the product are not carried out. The use of a cheap sanitizer like chlorine at 100-200 ppm (1-2 grams in 10 litres) of water can prevent microbial contamination to a great extent. Chlorination can be achieved by using household bleach or swimming pool chlorine. It was also observed that worker hygienic practices such as hand washing, personal hygiene, use of gloves and face masks etc. are also not carried out. The rural sector workers engaged in processing activities are unaware of these simple techniques and this emphasizes the need to train and create awareness among the target groups on GMPs to ensure product safety and quality.
Another deficiency observed in dry fish processing in Myanmar is that the rural sector processors do not do any packing, into convenient sizes, but sell their product in bulk form to wholesalers and retailers who pack into convenient sizes and carry out labelling in order to add value to the product. Proper packaging would not only ensure product safety and quality but also bring additional income to the rural sector processors by selling at an attractive price. In this regard, the two equipment items required for packaging are an electrical (digital) weighing scale and a poly-sealer costing about 70,000 and 170,000 kyats (US$70 and 170) respectively.

3.6 Dairy sector

The dairy sector is dominated by smallholder systems, with local indigenous breeds of cattle and buffalo. However, there is also some commercial dairy cattle production. Generally, a rural family owns four to six cows and the milk production level is 4-5 viss (8 litres) of milk/cow/day. The milk is sold to rural tea shops or to commercial milk-processing plants if the plant is in close proximity to the farming community. Milk is sold to tea shops at 2,000 kyats/viss (US$1.22/litre) and at a production cost of 1,700 kyats/viss (US$1.04/litre) the net income from a single cow is around 1,500 kyats (US$1.50) per day and for a family owning six cows the net income would be 9,000 kyats (US$9.00)/day.

Postharvest handling of fresh milk and technological requirements for improvement

Milk is a highly perishable item and it cannot be kept for more than three to four hours after milking before it gets spoiled due to microbial activity. Bad milk will be rejected at the dairy plant. The farmer will lose money; the milk transporter may lose money if the fault is personal. The nation will suffer because its people will not have high-quality food. To avoid these disadvantages, hygienic milk handling is essential at each stage; at the farm, cooling centre and during transport.

Fresh milk production by farmers is often carried out under unhygienic conditions and GMPs to ensure product safety and quality are not adopted. Waste materials are not disposed of properly and they collect close to the production facility harbouring flies and emitting foul odors. Also, cleaning and sanitizing of the plant, milk-handling equipment and cans used for milk transportation using appropriate detergents and sanitizers to prevent physical, chemical and microbial contamination of the product are not carried out. Workers’ hygienic practices such as hand washing, personal hygiene, use of gloves and face masks etc. are also not carried out. The rural sector farmers engaged in dairy production activities are unaware of these practices and this emphasizes the need to train and create awareness among them on GMPs to ensure product safety and quality.

It is important that immediately after milking, the milk is cooled preferably to 4°C to enhance its shelf life and keeping qualities. This requires mechanical refrigeration or milk cooling tanks. These are expensive and can usually be afforded by large-scale commercial farms. For small-scale dairy farmers, setting up a milk-cooling centre centrally on a cooperative basis may be the ideal solution. Where farmers bring their milk to a cooling centre through a cooperative, they should do so as soon as milking is completed. A milk-cooling centre with a bulk (direct expansion) milk-cooling tank with capacity of 1,000-3,000 litres will serve up to 300 smallholder farmers, ensuring that the quality of their milk when produced under hygienic conditions, is well preserved and accepted at the processing plant.
Viable agro-industries for rural dairy farmers

Manufacture of yoghurt

Manufacture of yoghurt is a technically and economically viable agro-industry that can be established in the rural sector especially among rural women engaged in dairy farming. Yoghurt is produced by the controlled fermentation of milk by two species of bacteria (*Lactobacillus* sp. and *Streptococcus* sp.). The sugar in milk (called lactose) is fermented to acid (lactic acid) and it is this that causes the characteristic curd to form. The acid also restricts the growth of food-poisoning bacteria and some spoilage bacteria. So, whereas milk is a potential source of food poisoning and only has a short shelf life, yoghurt is safer and can be kept for up to 10 days, under proper storage conditions. It is a popular food item in Myanmar and in the market it is available as 80 ml of yoghurt enclosed in polystyrene cups. The market price of yoghurt is around 300 kyat (US$0.30) per cup or 3 750 kyat (US$3.75) per litre, in comparison to fresh milk which is only around 600 kyat (US$0.60) per litre. At a recovery level of 88 percent the production cost of yoghurt, inclusive of processing and packaging cost, is around 150 kyat (US$0.15)/80 ml cup or 1 875 kyat (US$1.88) per litre. If the product is sold to retailers at 200 kyat (US$0.20)/cup or 2 500 kyat (US$2.50)/litre and if 1 000 cups (80 litres) of yoghurt are produced in one day, the net income per family is 50 000 kyat (US$50)/day.

Yoghurt can be easily produced on a small scale and the required equipment for a processing plant is: milk churns or similar containers; a water bath with a thermostat for pasteurizing the milk at 80-85°C for 15-20 minutes; a gas ring or other source of heat; a thermometer (0-100°C); an incubator with capacity of 200 cups/batch to maintain a temperature of 40-450°C for 4 hours; a refrigerator (optional) and stainless steel vessels, spoons etc. The initial capital investment would be around 680 000 kyat (US$680), exclusive of the refrigerator.

Spoilage of yoghurt by bacteria or mould can occur due to unclean equipment, contaminated milk or poor hygiene of the production staff. Awareness has to be created among processors to ensure that all equipment is thoroughly scrubbed, sterilized with diluted bleach (two tablespoons of bleach per gallon of water) and thoroughly rinsed in clean water before production starts. Pasteurization should ensure that fresh milk is not contaminated, but old milk is not used. Also it is important to make sure operators wash their hands before starting work and do not allow anyone with stomach complaints, coughs or skin infections (e.g. boils) to work with the milk.
4 KEY CONSTRAINTS

The main constraints in developing the postharvest and agro-industrial sector for income and employment generation among rural people in Myanmar are as follows:

Farmers and other stakeholders in the supply chain lack basic knowledge and awareness of the factors that could compromise productivity, quality and safety during postharvest handling, and processing operations. They are reluctant to adopt scientific harvesting, postharvest handling, agroprocessing and packaging practices due to inadequate knowledge of improved techniques and the benefits that could be achieved by adopting such technologies.

Capital

Inadequate capital for adoption of improved postharvest and agroprocessing technologies is another constraint confronted by the rural sector. At present concessionary credit facilities are not available for postharvest and agroprocessing activities. For instance, the Agriculture Development Bank provides seasonal low interest (0.5 percent) loans for cultivation amounting to 100,000 kyat (US$100) per acre but no such loan schemes are available for improvement of postharvest operations and agroprocessing industries. The Rural Development Fund provided by the Department of Rural Development amounting to 1 billion kyat per region is currently utilized for other sectors but not for improvement of postharvest operations and agroprocessing industries.

Market information

Lack of adequate knowledge in the rural sector of the prevailing market situation for agricultural/food products is another drawback in developing postharvest and agroprocessing activities in the rural sector. Farmers rely upon the collectors (traders) to learn about the prevailing market demand and prices for their products which sometimes can be inaccurate and misleading.

Also, farmers and processors have inadequate awareness about the importance of product certification for GAP, GMP, HACCP, by an accredited agency, such as the Food and Drug Administration, to enter attractive markets.

Infrastructure facilities

Insufficient electricity supply in rural areas for implementing improved postharvest and agroprocessing technologies is another constraint faced by the rural sector in Myanmar.
5. RECOMMENDED AREAS OF INTERVENTION AND INVESTMENT

5.1 Training

It is important to create awareness among farmers and other stakeholders in the postharvest and agroprocessing sector about improved technologies that would significantly increase their incomes by minimizing the serious quantitative and qualitative losses occurring in the postharvest system and, at the same time, by initiating viable agroprocessing enterprises.

Training should be extended to:

- Farmers;
- Rural community-based entrepreneurs (processors, service providers);
- Collectors (traders);
- Transporters; and
- Wholesalers and retailers

An effective training curriculum should include improved postharvest and agroprocessing technologies as well as GAPs and GMPs to ensure food hygiene and safety.

A suitable training module should initially build the capacity of core groups of trainers comprising extension personnel of the Department of Agriculture and Department of Agricultural Mechanization of the MoAI; Department of Fisheries and Department of Livestock of the Ministry of Livestock, Fisheries and Rural Development operating at national, regional, district, township, village tract and village levels. The core group of trainers will serve as key national implementing partners for training of farmers and other stakeholders in the postharvest system and will be equipped with relevant tools, information and materials to organize and implement training programmes designed to upgrade stakeholder capacity to adopt improved postharvest and agroprocessing technologies.

The resource persons for training of trainers can be drawn from the following institutions:

- Yezin Agricultural University;
- Department of Agricultural Research, MoAI;
- Department of Agriculture, Post-harvest Technology Division, MoAI;
- Department of Agricultural Mechanization, MoAI;
- Research and Development Division, Department of Fisheries, Ministry of Livestock, Fisheries and Rural Development;
- Livestock Breeding and Veterinary Department, Ministry of Livestock, Fisheries and Rural Development;
- Agriculture Development Bank, MoAI;
- Commodity Testing and Quality Management Branch (formerly Post-harvest Technology Application Centre) and Department of Trade Promotion, Ministry of Commerce;
The farmers and other stakeholders engaged in postharvest and agroprocessing activities should be trained effectively via farmer field schools (FFS). The FFS model is based on ecological principles, participatory training and non-formal educational methods. It emphasizes learning through experience and dealing with real field problems and giving farmers the opportunity to experiment, hone their observation and research skills and take the initiative, as well as adapting alternative technologies to local conditions. FFS also enhance the existing knowledge and skills that the farmers have gained through years of experience.

Also, establishment of field demonstration sites in the 15 regions would enhance the effectiveness of technology transfer to farmers and other stakeholders in the postharvest chain.

5.2 Capital generation

Rural people lack sufficient capital to acquire improved postharvest and agroprocessing technologies so there is an urgent need to strengthen microfinance systems. In this context, it necessary to ensure that concessionary credit is given by the Agriculture Development Bank to postharvest and agroprocessing activities. Also, it is essential that concessionary credit is extended not only to farmers but also to rural community-based entrepreneurs who are processors or service providers.

It is also recommended that the Rural Development Fund provided by the Department of Rural Development to regions is extended to develop rural sector postharvest and agroprocessing activities.

5.3 Farmer groups

The adoption of improved postharvest and processing activities among registered farmer groups is recommended because, as a group, they have easy access to credit and sharing of information on good practices in postharvest and agroprocessing management. Such farmer groups include:

- Agriculture cooperatives in villages and village tracts. At present there are about 7350 such cooperatives;
- Village-level women’s organizations which are prominent in more than 60 percent of the village tracts (Census of Ministry of Agriculture in collaboration with FAO);
- Farmer organizations; and
- NGOs.

5.4 Market information

Since farmers rely mostly on collectors and traders to get information on prevailing and future market demands and prices for agricultural commodities, which can be inaccurate, it is important to impart knowledge to them on the current and future market situations for agricultural/food products through mass media such as TV and radio. In this context, making further use of the Farmer TV channel run by the Department of Agriculture to cover the postharvest and agro-industries sector is important.
5.5 Product inspection and certification for quality and safety

Inspection and certification of agricultural and food commodities produced by the rural sector by an accredited institution is an essential requirement to enter attractive domestic as well as export markets. In this context, the Food and Drugs Administration of the Ministry of Health needs to extend services to the rural sector to provide certification for GAP, GMP and HACCP. Further, it is important that private sector accredited institutions are established for product inspection and certification.

5.6 Training of rural artisans

Upgrading of technology in rural workshops through provision of training, credit and other support services will encourage local manufacture of necessary machinery and equipment for improvement of rural-level postharvest and agroprocessing industries.

5.7 Infrastructure facilities

It is necessary to upgrade the wholesale markets through provision of scientifically-designed premises with adequate space and facilities for temporary storage and to perform packinghouse operations such as cleaning, sorting and grading. There should be adequate space for storing empty containers and for proper loading and unloading from transportation vehicles. Proper waste disposal facilities should be made available in the markets to minimize contamination of the produce.

Public retail markets too should be improved to minimize physical, chemical and microbial contamination of the commodities and to perform marketing under hygienic conditions.

As viable postharvest and agroprocessing industries require electricity, it is necessary to provide adequate electricity supply to rural areas.

5.8 Strengthening of research activities

Even though adequate research is being carried out in agricultural production and preharvest operations, sufficient research is not carried out to address technological problems confronting the postharvest and agroprocessing sector. Hence there is an urgent need to strengthen the human and material resources of the present research and development organizations to undertake both pure and applied research in postharvest and agroprocessing technology.
ANNEX 1: BIBLIOGRAPHY


FAO. 2009. The use of warehouse receipt finance in agriculture in transition countries. Rome, FAO.


Ministry of Agriculture and Irrigation (MoAI). 2012. Seed industry development in Myanmar.


MAS. 2009b. MAS and current situation of some major crops. MoAI.


ANNEX 2: SPECIFICATIONS OF SOME TECHNOLOGIES REQUIRED FOR IMPROVEMENT OF POSTHARVEST AND AGROPROCESSING OPERATIONS IN MYANMAR

Establishment of maturity indices for harvesting at correct stage of maturity
For cereals, pulses, oil seed crops, fruits and vegetables

Mechanical thresher for cereals, pulses and oil seed crops

- Function: With adjustments to thresh paddy, corn (maize) and wheat
- Type: Drum and concave, axial flow type mobile thresher with peg tooth drum
- Mounted on wheels
- Capacity: 2 tons per hour of threshed grain (minimum)
- Power source: Ability to couple either to the PTO shaft of tractor of 40 hp or greater or diesel engine of 27/28 hp
- Approximate cost inclusive of 22 hp engine 3000000 Kyats (USD 30000).

Typical threshing speed and drum-concave clearance in a mechanical thresher for different crops:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Peripheral speed of drum (m/min)</th>
<th>Drum-concave clearance (mm) (Inlet four times greater than outlet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy</td>
<td>1300 - 1700</td>
<td>5-10</td>
</tr>
<tr>
<td>Corn (maize)</td>
<td>800 - 1200</td>
<td>20-25</td>
</tr>
<tr>
<td>Wheat</td>
<td>1600 - 2000</td>
<td>5-15</td>
</tr>
<tr>
<td>Soya bean</td>
<td>800 - 1200</td>
<td>8 -20</td>
</tr>
<tr>
<td>Cowpea</td>
<td>500 - 800</td>
<td>8-20</td>
</tr>
<tr>
<td>Ground nut</td>
<td>1000- 1500</td>
<td>8-20</td>
</tr>
<tr>
<td>Barley</td>
<td>1500- 1800</td>
<td>6-12</td>
</tr>
</tbody>
</table>

Combine harvester
For harvesting of rice, wheat, maize
Ideal capacity for Myanmar: around 2ha/day

Flat-bed batch type mechanical dryer
For drying of paddy and other cereal grains, pulses, oil seed crops
Specifications:
- Type: Flatbed type batch dryer for drying of paddy, wheat, corn (maize), pulses and oil crops
- Capacity: To dry 2 tons of paddy in 4 hours from an initial moisture content of 20% to a final moisture content of 14%
- A heater (paddy husk/biomass fired furnace) with an output of 38.8 kW; consuming 56 kg of paddy husk / batch
A blower which delivers air at a volume flow rate of 1.5 m³/s and at a pressure of 90.0 N/m² and consumes 486 watts (a one horsepower motor recommended)

**IRRI super bag:**
- For storage of cereal grains, pulse and oil crop seeds in sacs under hermetic conditions
- Laminated plastic bag inside poly-sac
- Prolong storage life of Cereals, pulses and oil seeds
- Cost: IRRI super bag - 4000 Kyats/bag
- Similar bag available in Myanmar market - 800 -1000 Kyats
**Metal bin for indoor storage**

Improved indoor storage bin for cereals, pulses and oil seeds of capacity 375 kg, for farm household level storage
**Scientific storage of cereals, pulses and oil seed in warehouse**

- Moisture meters: MC <14% for cereals, < 12% for pulse seeds and < 8% for oil seed
- Use of pallets
- Stacking methods
- Insect control
- Rodent control
- Cleanliness of stored commodity, empty bags, warehouse and surroundings
Rice milling

Process line of an improved rice mill:

Approximate cost of machinery for improved rice mill: capacity 1 ton per hr (Kyats):

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Quantity</th>
<th>Cost 1</th>
<th>Cost 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy pre-cleaner with motor</td>
<td>01</td>
<td>295,000.00</td>
<td>295,000.00</td>
</tr>
<tr>
<td>Rubbersroll sheller MLGT 25</td>
<td>01</td>
<td>250,000.00</td>
<td>250,000.00</td>
</tr>
<tr>
<td>Paddy separator with motor MGCZ</td>
<td>01</td>
<td>2,550,000.00</td>
<td>2,550,000.00</td>
</tr>
<tr>
<td>Destoner with motor DAZZ</td>
<td>01</td>
<td>180,000.00</td>
<td>180,000.00</td>
</tr>
<tr>
<td>Friction polisher (N 120)</td>
<td>01</td>
<td>120,000.00</td>
<td>120,000.00</td>
</tr>
<tr>
<td>Jet polisher</td>
<td>01</td>
<td>160,000.00</td>
<td>160,000.00</td>
</tr>
<tr>
<td>Sifter and Fan box</td>
<td>02</td>
<td>125,000.00</td>
<td></td>
</tr>
<tr>
<td>Elevator (18 feet) (with motor)</td>
<td>10</td>
<td>105,000.00</td>
<td>105,000.00</td>
</tr>
</tbody>
</table>
**Grain flour milling**

Specifications of small scale rice de-stoner with single phase motor

- Capacity: 500 kg per hour
- Motor: Single phase, 01 hp 230 V 50 Hz
- Price: De-stoner 55,000 Kyats

**Specifications of grain flour grinding mill with single phase motor**

- Type: FFC 23 Disc Mill (also called FFC 23 Pin Mill)
- Capacity: 75-100 kg of grain per hour
- Motor: Single phase, 5 hp (minimum), 230 V and 50 Hz
- Price: 450000 Kyats

**Pulse processing**

Pealing and splitting of legume seeds into dhal form

Emery roll mill:

- Pealing and splitting capacity: 100 – 150 kg/hr
- Motor: 2 hp single phase
- Recovery: 78-80%

Sifter: for separation of unhulled grains:

- Motor: 0.5 hp

**Shelling of groundnut**

Ideally, a milling recovery and a milling efficiency of over 75 and 90% respectively should be obtained.

Pods are crushed by pressing them by rubber pads mounted on a rotating drum.

Approximate price of machine of capacity 200 kg/hr and operating with a 3 hp single phase motor: 1200000 Kyats.

**Oil extraction from oilseed crops**

Expeller:

- Oil recovery level of at least 65% should be obtained.
- Capacity 15-20 liters/hr
- operating with a 5 hp single phase motor
- Approximate price would be around 1200000 Kyats

**Oil filtering machine with oil pump:**

- Capacity 200 liters/hr operating with a 1 hp single phase motor
- Approximate price: 1250000 Kyats.
Specifications for plastic crates for handling and transportation of fruits and vegetables

The containers should be stackable, that is, containers could be placed one on top of the other (Figure 45) and nestable, that is, empty containers could be placed one inside the other to reduce storage space requirements when empty crates are transported.

The bottom and sides of the container should be perforated so as to allow for proper ventilation.

Size uniformity is important to allow for the exchange of containers:

Jumbo sized containers: close to 700 mm x 500 mm x 400 mm

(For breadfruit, banana, papaya, banana, sour sop)

Large containers: close to 600 mm x 400 mm x 300 mm

(mango, citrus, ackee, June plum, avocado, guava, naseberry, sweet sop, tamarind)

Medium sized containers - close to 600 mm x 400 mm x 230 mm

(For ripe fruit; to avoid damage of the bottom layers due to fruit weight of top layers)

The crates should be made of food grade recyclable plastic (heavy metals such as cadmium should not be incorporated to achieve colour etc.) The plastic should be of UV resistant quality.

Crates should be environmental stress resistant, i.e. tough and long lasting with sufficient impact resistance and compression strength. They should be crack, chip and corrosion resistant. Crates should withstand temperature ranging from -18 to 75 C.

They should be of hygienic design, made of non-toxic material and resistant to bacterial and fungal growth.

Crates should be well lodged and stable when stacked and leave no room for movement. This is important, as it will help reduce damage due to vibration and abrasion damage.
Solar tunnel dryer for dehydration of fruits and vegetables