



CASSAVA HANDBOOK



**Supported by: China-Cambodia-UNDP Trilateral
Cooperation Cassava Project Phase II**

Contents

Chapter I: Overall overview of cassava production, processing and exports, and its impacts on the environment.....	4
1. Introduction.....	4
2. Current conditions of the cultivation, processing and exports of Cambodian cassava	6
2.1 Present situation of cassava production in Cambodia.....	6
2.2 Present situation of cassava processing	7
2.3 Local cassava market and its export potential.....	9
3. Constraints in production, processing and exports of Cambodian cassava.....	10
3.1 Constraint in the production of cassava	10
3.2 Constraints in cassava processing.....	12
3.3 Constraints in export of cassava to international market	13
4. Environmental impacts from the production and processing of cassava	13
4.1 Impacts from cassava production.....	13
4.2 Impacts from cassava processing.....	14
Chapter II: Improved management practices for cassava production	18
1. Recommended cassava varieties for Cambodia.....	18
1.1 Introduction.....	18
1.2 Cassava as a crop	18
1.3 Variety recommendation.....	19
2. Production and storage of healthy cassava planting materials.....	21
2.1 Introduction.....	21
2.2 Production	21
2.3 Storage	23
3. Land preparation and soil erosion control.....	23
3.1 Introduction.....	23
3.2 Land preparation	23
3.3 Preparation of planting beds	24
3.4 Soil erosion control	26

4.	Planting, weeding and harvesting of cassava.....	27
4.1	Introduction.....	27
4.2	Planting	27
4.3	Weeding.....	29
4.4	Harvesting and storage.....	30
5.	Integrated nutrient management in cassava production	31
5.1	Introduction.....	31
5.2	Type of fertilizer	31
6.	Cassava intercropping systems	33
6.1	Introduction.....	33
6.2	Type of cassava intercropping systems	34
6.3	Advantage and disadvantage.....	35
6.4	Selection of most appropriate intercropping for cassava	36
6.5	Improvements in Cassava Intercropping Systems	37
7.	Major pests and diseases in cassava production and their controls.....	40
7.1	Introduction.....	40
7.2	Management of major insects	40
7.3	Management of major Diseases	44
8.	Enhancing cassava productivity through farmer participatory research	46
8.1	Introduction.....	46
8.2	Farmer participatory research	47
Chapter III: On-farm cassava utilization, cassava processing and exports		50
1.	Nutritional values of cassava and the use of cassava roots for food and industrialized products ...	50
1.1	Introduction.....	50
1.2	Nutritional values of cassava leaves	50
1.3	Nutritional values of cassava roots	51
1.4	Anti-nutrient in cassava	54
1.5	The use of cassava for food and industry.....	56
2.	Use of cassava leaves and roots for animal production	57
2.1	Introduction.....	57
2.2	The use of cassava leaves.....	58

2.3	The use of cassava roots.....	59
3.	Production chain of noodle and sago	61
3.1	Introduction.....	61
3.2	Noodle processing.....	61
3.3	Sago processing.....	63
4.	Production chain of tapioca wet-starch.....	66
4.1	Introduction.....	66
4.2	Cassava wet starch processing	66
5.	Storage and storing conditions for cassava products	69
5.1	Introduction.....	69
5.2	Factors affecting the quality of cassava products	70
5.3	Storing conditions	71
6.	Waste and waste management in cassava processing (medium and large).....	72
6.1	Introduction.....	72
6.2	Type of wastes	73
6.3	Impacts of cassava processing wastes on the environment.....	75
6.4	Waste utilization and management	76
7.	Cassava market chain assessment and development for producers and processors.....	78
7.1	Introduction.....	78
7.2	Marketing and market chain	78
7.3	Understanding context of cassava producers and processors.....	81
8.	Quality standardization of cassava products to international markets including Chinese markets.	83
8.1	Introduction.....	83
8.2	International standards on cassava and cassava products	84
8.3	Cambodian standards on cassava and cassava products	87
8.4	Chinese standards on cassava and cassava products.....	90
9.	Export regulations for cassava products and quarantine and import regulation required by China	94
9.1	Introduction.....	94
9.2	Plant quarantine inspection procedures.....	94
9.3	Procedures on cassava chip export to China	96

10. Procedures and documentary requirements for the export of cassava products to Chinese markets.....	100
10.1 Introduction.....	100
10.2 Sales contract and trade terms.....	101
10.3 Export procedures	101

Chapter I: Overall overview of cassava production, processing and exports, and its impacts on the environment

1. Introduction

Cassava (*Manihot esculenta* Crantz) is the second largest crop production in Cambodia after rice. It is grown mainly by smallholder farmers for food to supplement the rice diet, for animal feed and for extraction of starch from its roots, but mainly for export as fresh roots to the international markets. Most of the cassava roots produced in the country is exported to the overseas markets through either Thailand or Vietnam and, only a small proportion of that is used in local cassava processing plants in the country. Barriers that prevent a direct trade of Cambodian cassava with the international markets are complex and are less likely to overcome all at once. Nevertheless, Cambodian traders and processors are important to aware about the quality standard required, and ways how to improve the local products before they are in a position to enter the international markets by their own brand.

For the last 10 year cassava production area in Cambodia expanded exponentially from less than 30 thousand hectares in 2004 to a pick in 2011 of more than 400 thousand hectares (MAFF, 2005-2013). However, along with a significant contribution that cassava can have to the household income of the poor farmers and consequently to the country economy, planting to cassava is generally believed to have a negative effect to the environments. It is always assumed that cassava production can cause serious soil degradation due to excessive uptake of nutrients leading to soil nutrient depletion, or by causing serious soil erosion when grown on slopes.

A survey conducted by a team from the Royal University of Agriculture has indicated a tendency of yield decline in cassava production in two major cassava producing provinces, Kampong Cham and Pailin. According to that study, the most influential reasons for yield drop include the decline in soil fertility, invasion of pests and diseases, and the use of poor planting materials. It is quite common that cassava is grown on high fertility upland soils of Kampong Siem, O'Riang Eu and Labansiek soil groups (Men Sarom et al., 2014) with no additional fertilizer application. Due to lack of nutrient replacement especially in the case where cassava is continuously cultivated in the same area for many years, soil fertility declines and thus lower cassava root yield. Therefore reduction in yield that has been reported could be resulted from overexploitation

of land resources without gives it back the nutrients they withdrawn by crop produces as was reported by Howeler (2012).

Soil erosion is also of great concern especially in the course of climate change with high intensity of rains at the region especially on sloping cassava production areas. It has been reported that even though more than fifty percent of cassava production is practiced on sloping land, most farmers do plough the land up-down the slope. This practice can have a very negative impact to the soil as it makes the land a very susceptible to soil erosion especially if it is associated with heavy rainfall (Howeler, 2012). Therefore this poor crop management could accelerate soil erosion in the area if this disturbing situation is not corrected on time.

Cambodian cassava industry is almost exclusively dependent on the border markets of Thailand and Vietnam which act as cassava trade-brokers between Cambodian and International and/or Chinese markets. Therefore any fluctuation in cassava demand in the Chinese markets can have strong influence to the country cassava production through these two border markets. Reasons for a lack of direct trade between Cambodian cassava industry with the international trade dealers including Chinese market, can be several but poor quality standard products, the complexity of exportation procedures and awareness of the local processors to these procedures can be the central ones.

Likewise, cassava processing produces annually big quantity of wastes and if they are not properly managed, they can cause a serious pollution to the environment and human life. There are two types of wastes, solid waste and wastewater. The solid waste which are high in organic matter constituents and cyanide that can be potentially threats to the environment can be unrecoverable starch, the peel and soil/stem debris, while liquid cassava waste can be produced by washing and peeling of cassava roots that generally contains a large amount of inert material and, the second one is produced by draining starch sedimentation tank. It is well accepted that solid waste and waste water (liquid waste) have strong adverse effect to the environment and human health. But if properly managed these wastes can be very useful in many ways. Two main constraints that hinder the proper development of adequate waste management in cassava processing plants are the lack of information on its new developed technologies and, sufficient funding to support its development.

Based on the above described situations, a sustainable production of cassava farming and processing, especially smallholders, can only be possible if all these adverse facts that have been raised can be successfully overcome. Providing that technical knowledge on cassava growing and processing are available, a disseminated approach is to be taken that knowledge across to cassava farmers, processors and exporters.

Due to the above mentioned problems and as recommended by Aye *et al.* (Project Need Assessment Report, 2014), in order to meet sustainable productivity improvement for local cassava production farms, effective and safe cassava processing waste management and to respond to the export requirement to China market, three types of trainings are suggested.

- Training of Trainers (ToT): the participants to the ToT should be the agricultural extension workers with background and experience in the cassava production/processing.
- Training for farmers: the participants of this training should be cassava farmers.
- Training for processors/exporters. This training is for large scale cassava processors and exporters, who require understanding on cassava processing waste management, and on quality standards of cassava products to both international and Chinese markets.

2. Current conditions of the cultivation, processing and exports of Cambodian cassava

2.1 Present situation of cassava production in Cambodia

Traditionally cassava was only a farmstead crop that is grown mainly on the farmer backyard for mainly family consumption. The situation has dramatically changed within the last 5 years as it became the second major crop in the country in term of both cultivated area and production quantity (Table I-2.1). The cultivated area of cassava increased dramatically from less than 26,000 ha in 2003 to nearly 400,000 ha in 2011, slightly declined to around 320,000 ha in 2012, and increased again to about 421,000ha in 2013 (Table I-2.1). Along with a rapid expansion in the production areas, the national average yield for cassava also increased significantly although with some slow decline in the later years. The situation resulted in a vast increase in total cassava production from about 0.33 million tons in 2003 to nearly 8 million tons in 2013 (Table I-2.1).

Expansion of planted areas of cassava is probably due to an increased demand of cassava starch for ethanol production by the international markets, particularly Chinese market (Aye et al, 2014).

Table I-2.1.Crop production (%) in agricultural land in Cambodia from 2010-2013¹⁾

Rank	Crop	2010		2011		2012		2013	
		Ha	%	Ha	%	Ha	%	Ha	%
1	Rice	2,795,892	79.51	2,968,529	77.60	3,007,545	76.71	3,052,420	76.44
2	Maize	205,070	5.83	174,257	4.56	216,330	5.52	239,748	6.00
3	Cassava	190,525	5.42	391,714	10.24	361,854	9.23	421,375	10.55
4	Soybean	101,904	2.90	70,584	1.85	71,337	1.82	80,688	2.02
5	Mungbean	66,265	1.88	68,111	1.78	66,850	1.71	54,312	1.36
6	Vegetables	49,873	1.42	53,757	1.41	76,495	1.95	52,449	1.31
7	Others ²⁾	106,690	3.03	98,354	2.57	120,017	3.06	92,456	2.32
Total production area		3,516,219	100	3,825,306	100	3,920,428	100	3,993,448	100

¹⁾ After MAFF Annual Report 2011, 2012, 2013, 2014.

²⁾ Including peanut, sugar cane, sweet potato, sesame, jute and tobacco.

It was a belief that a dramatic expansion of cassava production from less than 30 thousand hectares in 2004 to more than 400 thousand hectares in 2013 (MAFF, 2005-2013) was a direct link to deforestation. This was not supported by Men Sarom *et al.*(2014) who argued that expansion of cassava production in both Kampong Cham and Pailin was clearly resulted from changing cropping system prioritized by farmers based on market demand and crop productivity outputs. It could be however possible that forest had been earlier cleared for the production of other crops such as maize before it has been transferred to cassava (Men Sarom et al., 2014; Aye et al., 2014).

2.2 Present situation of cassava processing

There are three types of cassava processing plants in Cambodia. Those are dried chip, dried starch and wet starch processing. These processing plants are small-scale with low working capacity and possess poor processing and waste management infrastructures. These processing plants generally produce big quantity of solid and liquid wastes that can have negative impact to the environment and human health.

Through their strong and unpleasant smell wastewater and solid wastes, cause a hostile environment for farming communities living nearby. In addition, the aesthetic and beauty of the environment is also substantially affected by cassava processing if they are not properly managed. Most cassava processing managers recognize the problems arising from their processing wastes and for that reason most of the processing plants have already set up their own waste management structure. However, it appears that most of the structures do not follow technical specification, therefore it still produces significant amount of wastes, solid and liquid, and it is prone to be flooded during the rainy season.

It is recognized that newly developed waste management technologies are available in the country, but they are more suitable for larger scale rather than for small and medium cassava processing plants which are still struggling to keep their business going. Limited access to those new technologies and the lack of financial support are considered the main barrier for developing eco-friendly cassava processing industry in the country.

Good drying floors and storage are considered very important in keeping the right temperatures and relative humidity and also, particularly storage, should be constructed in a way to be preventive from dust, insects and other biological factors that may harmful to the quality of the stored cassava product. However, this requirement has not been accomplished by many local processing plants. It has been observed that most of the cassava processing plants are lack of well-constructed drying floors and storage for cassava processing and it still remains a major issue for cassava industry in the country. For instant, in case of storage facility of dry starch for most of the processors are in open space with high air flow and poor rodent or insect protected wall. In the packaging area, dust and cassava flour maybe mixed that cause high percentage of impurity of the starch (Picture I-2.1). Another example, Picture Plate I-2.2, sago and saray products are packed in polyethylene plastic bag with 10-20 Kg per package, the product was not in good environment before packing that might got contaminated already before it is packed. The plastic bag is kept open or not tightly closed allowing dust and/or foreign matter to enter easily. This situation also raises another concern about the quality, cleanness and shelf life, of packing materials to keep/transport cassava processed product to the market. In addition, there is no label or information about the product.



Picture I-2.1: Packaging and storage facility and practice of dry starch in Cambodia



Picture plate I-2.2: Packaging and storage of sago and saray practice in Kampong Cham province

Attempts to set up new modernized cassava processing plants produced most of the time a negative outcome. In 2008, with Korean investment, Cambodia's first bioethanol plant which is owned by MH Bio-Energy commenced its operations. It has since experienced some difficulties due to a shortfall in supply of cassava, price fluctuations and various pollution problems. Idemitsu Kosan of Japan signed an MOU with the Cambodian Government in 2012 to produce ethanol from cassava. In the same year, there was investment from Banchak Petroleum of Thailand in both Cambodia and Laos. But their operation is either under-capacity or not at all functioning.

2.3 Local cassava market and its export potential

Cassava plays a very important role in household income for farmers. According to Men Sarom *et al.* (2014) there was a significant rise in cassava contribution to farmer household income. In

2013 cassava contributed more than 70% to farmer household economy in Kampong Cham and Pailin while it was only 55 % before 2010.

Due to its rapid production expansion, in 2013 the Cambodian cassava industry is estimated to worth more than USD 500 million annually (Table I-1.2, Men Sarom, 2015). Nevertheless, the official revenue from cassava exports seems to be much lower according to an official data in 2010 (worth US\$10.3 million for the first quarter of the year, Agrocambodia, 2010). Similar report was found in 2013 when Cambodia’s cassava exports reached only 245,438 tones in the first quarter of the year or less than 2% of the total production of about 8 million tones (Table I-1.2, Phnom Penh Post, 2013). This would explain serious business activities that are taken place outside the official parameter and at the borders with Vietnam and Thailand.

Table I-2.2: Estimated cassava contribution to National Economy in 2013¹⁾

Production System Type	National Production Volume (Tonnes)	National production value (Mil USD)
Rainfed Upland (rainy season)	7,632,997	534
Rainfed upland (Dry season)	300,384	22
Total	7,933,381	556

¹⁾ Men Sarom, 2015

Cambodian cassava market depends heavily on Thailand and Vietnam who either use this purchase for their own local market or further export to the international market. Although cassava can help increase household income and improve livelihood opportunities and benefits to smallholder farmers in Cambodia, there are serious concerns about the fluctuation of price. In 2013, Cambodian farmers could sell their cassava at 300 Riel/kg or US\$75/ton for fresh cassava and 700 Riel/kg or US\$175/ton for dried cassava. Although selling dried cassava has higher price, most of the farmer sold it in fresh form due to the lack of drying space facility.

3. Constraints in production, processing and exports of Cambodian cassava

3.1 Constraint in the production of cassava

It appears that for the last 5 years there was a significant reduction in cassava yield. Study conducted in two major cassava production provinces, Kampong Cham and Pailin by a group of researchers from the Royal University of Agriculture has reported for a substantial decline (38 to

42 per cent) in cassava root yield for a period from 2010 to 2013. Yield reduction was more severe in Pailin (42%) than in Kampong Cham (38%). In 2010 cassava root yield was as high as 30.5 tons/ha in Kampong Cham and 50 tones/ha in Pailin. while in 2013, t in one hectare but reduced to less than 20 tons in 2013 for a Kampong Cham case and during the same period, in Pailin, cassava root yield dropped from about 50 tons in 2010 to less than 30 tons in 2013 (Men Sarom et al., 2014).

Causes for yield decline in the two provinces are similar but differ in severity. In Kampong Cham, where more than 50 per cent of the production is on flat land, the main reasons for yield decline include weed problems, soil fertility decline and erosion, damages caused by pests and diseases, the use of poor planting materials and heavy rainfall. In Pailin, where more than 90 per cent of the production is on sloping land, excessive rain, erosion and declining soil fertility and, poor planting materials.

Despite both provinces having different growing conditions, flat land with lower rainfall (Kampong Cham) vs sloping land with high rainfall (Pailin), the major causal factors for yield decline are very similar, soil fertility decline, the use of poor planting materials and damages caused by pests and diseases. This finding is highly parallel to the survey results conducted by Men Sarom et al (2014), which show that majority of farmers (65-95 per cent) in both provinces have never use fertilizer in their cassava production. Therefore due to lack of nutrient replacement especially in the case where cassava is continuously cultivated in the same area for many years, soil fertility certainly decline and consequently lower cassava root yield.

The use of poor quality planting materials is also highly significant and correlated to the lowering cassava root yields. Many farmers in Pailin because of the market opportunities ought to harvest their cassava crop at very early stage, 6- 8 months old, and keep the stems as their planting material for another planting season. As the stems are still young, many of them dies or less vigour hence yield is low. Beside this direct effect, using poor planting materials can host pest and disease outbreak too. In both Kampong Cham and Pailin, most planting materials are purchased from either Thailand and/or Vietnam, therefore weak and infested planting materials are used in the planting.

Emerged pests and diseases are the latest problem for cassava production in the country. Cassava is attacked by a complex of arthropod pests across the country where the crop is grown. Root

yield losses have been recorded. Agronomic characteristics such as vegetative propagation, a long growth cycle, drought tolerance, staggered planting dates and intercropping contribute to the considerable diversity of pests that feed on the crop. More than 60-70 percent of farmers considered yield decline is mainly due to pests and diseases damage that follows by damage caused by drought and flood. Availability of labor is also considered a problem in cassava production in the country where the problem is more severe in Pailin (35 per cent) then only about 8% in Kampong Cham (Men Sarom *et al.*, 2014).

Another constraint for cassava production, particularly if the crop is grown for direct consumption is the content of a substance called *cyanide* that can make the crop toxic if inadequately processed.

3.2 Constraints in cassava processing

In Cambodia, cassava processing is a small scale industry with poor processing technologies, lack of processing facility and low capital for further expansion. Two main constraints that have strongly barrier cassava processing in the country are the lack of adequate funding for setting up appropriate drying, storing and waste management plants and the lack of information on new developed technologies on waste management. More than 50 per cent of cassava processing managers recognize the problems arising from their processing wastes and for that reason most of the processing plants have decided to set up their own waste management structure. However, it appears that most of the structures do not follow technical specification, therefore it produces strong unpleasant smell for the nearby villages and, it is prone to be flooded during the rainy season. In such circumstance, wastewater that is contained in each pond can then be discharged freely into rice fields or other open water sources in the area.

It is recognized that newly developed waste management technologies are available in the country, but they are more suitable for larger scale rather than for small and medium cassava processing plants which are struggling to keep their business going. Limited access to those new technologies and the lack of confident on them are considered the main obstacle for developing eco-friendly cassava processing industry in the country.

Apparently, managers of dried and wet starch processors know well about the impacts of their processing wastes can have on the environment and human health, however due to some reasons, their waste management is still not appropriately developed as it should be.

3.3 Constraints in export of cassava to international market

Although cassava has played a very significant role in increase household income and improve livelihood opportunities and benefits to smallholder farmers in Cambodia, there are serious concerns about the fluctuation of price. In 2013, the price of cassava fresh root was 300 Riel/kg or about US\$75/ton and it was 700 Riel/kg or US\$175/ton for dried cassava chip. It is obvious that even though cassava dried chip has got a higher price, most farmer tend to sell fresh form due to the lack of drying space facility.

Variable and highly unpredictable change in price of cassava root and chip is considered the main problem for cassava farmers who can substantially affect by this fluctuation which can affect to the production intensity as well. Poor quality product and lack of knowledge for quality standard and exporting procedures are considered three main constraints for cassava industry in the country.

4. Environmental impacts from the production and processing of cassava

4.1 Impacts from cassava production

There are contradicted reports about the impacts of cassava growing to the environment, particularly on soil structure and its nutrients. It is widely believed that, cassava is known to cause serious soil degradation due to excessive uptake of nutrients leading to soil nutrient depletion, or by causing serious soil erosion when grown on slopes.

In contrary, it has been shown that cassava extracts less nutrients from the soil than most other food crops which makes cassava to be grown in areas with low soil fertility where other crops cannot be grown productively.

It is true for all crops, not just cassava, if the crop is grown continuously on the same land without inputs of manure or fertilizers, soil nutrients will eventually be depleted and productivity will decline. This is undeniable as even without growing any crop, the soil fertility will naturally decline by nutrient leaching and erosion, particularly in the case of sandy soil texture. Finding has suggested that, soils planted to cassava are particularly susceptible to erosion during the initial stage of the crop before the canopy closes and rain impacts directly on the soil (Putthacharoen *et al.*, 1998). Based on soil nutrient analysis, when comparing soil nutrients of N, P and K between soil samples, at both top-soil layer and sub-soil layer, taken from cassava growing areas and those samples taken from land areas under the production of other crops and

wild habitat, Men Sarom et al. (2014) have rejected the hypothesis that cassava production leads to the depletion of soil nutrients.

Based on results from a study conducted by a research team of the Royal University of Agriculture have indicated that majority of cassava farmers in both Kampong Cham and Pailin have never use fertilizer in their cassava production (Men Sarom et al., 2014). It is understandable that upland soils in both provinces where cassava is cultivated, classified as Kampong Siem, O'Riang Eu and Labansiek soil group which are considered rich in soil nutrients. Nevertheless, due to lack of nutrient replacement especially in the case where cassava is continuously cultivated in the same area for many years, soil fertility certainly decline and consequently lower cassava root yield. According to Howeler (2012), continuously planting crops without fertilizer resulted in yield decline in all crops as nutrients are removed from the field in all plant parts.

Soil erosion is a function of rainfall, soil structure, length and gradient of the slope, crop and management factors. Therefore this poor crop management could accelerate soil erosion in the area if this disturbing situation is not corrected on time.

There are reports which confirm a strong association between cassava production practices in sloping land on soil erosion. Both, cassava cultivation as monoculture and farmers practice up-and-down ridging have been reported to produce a high level of erosion as compare with other cultural practice in cassava-based cropping systems. Study by Men Sarom et al. (2014) also suggested that inappropriate practice by farmers in growing cassava on sloping land could potentially contribute to soil erosion. According to their study, up to 80 per cent of cassava production is on sloping land but most farmers do plough the land up-down the slope. This practice has certainly a very negative impact to the soil as it makes the land very susceptible to soil erosion especially if it is associated with heavy rainfall. Reports from many cassava farmers who have come across with the problem of soil erosion on their cassava plantation has confirmed the situation.

4.2 Impacts from cassava processing

It is known that cassava processing produces a big quantity of wastes that can have negative impact to the environment and human health. Through their strong and unpleasant smell these cassava processing wastes cause a hostile environment for farming communities living nearby.

In the addition, if these wastes are not properly treated, they constitute potent toxicant to the soil, soil organisms, water and plants. During the process of cassava processing (dried chip, dried starch, and wet starch) it resulted particularly in large volume of wastes. The quality and quantity of these wastes vary greatly due to plant age, varieties, time after harvesting, kind of industrial equipment used in processing and its adjustment (Oliveira *et al.*, 2001). Furthermore, if they are not properly managed, the aesthetic and beauty of the environment in the processing areas can also substantially be affected.

Cassava processing produces large amount of wastes including solid and liquid which are high in organic matter constituents and cyanide. Solid wastes are mainly derived from cassava chip processing, if properly managed, can be utilized in many ways in crop and animal productions. Liquid (water) waste on the other hand has the potential to pollute ground water or lakes, rivers or streams into which it flows. Cassava processing can also produce unpleasant smell and unattractive pictures. Due to all these problems, cassava processing has always been regarded with a reputation of a major environment pollutant.

Cassava processing generates two types of liquid waste, the first one is produced by washing and peeling of cassava roots that generally contains a large amount of inert material and, the second one is produced by draining starch sedimentation tank. Wastewater from cassava processing is odorous with unpleasant smell. Due to its high microbial content, it is subject to a relatively rapid breakdown. This wastewater is normally rich in cyanogens content therefore it causes a general concern of their possible effect on health and the environment. However, even with such possible harmful effect, this water is discharged directly by the factory onto soils and nearby rivers and streams. It is therefore presenting a strong risk for the environment through reducing quality of the stream and makes its water less suitable for other downstream users. Polluted water can cause unpleasant odours and flies infested environment and eventually affect the health of the inhabitants adversely.

Nevertheless, other than all these negative impacts that the wastewater from cassava processing can have on the environment and human health, there are also positive impacts of this wastewater. It is known that wastewater contains both organic material and a rich source of nitrogen, therefore if appropriately managed; this wastewater can certainly be utilized as liquid fertilizer for rice production. Reports from farmers who have their rice field adjacent to the

cassava processing plants confirm this efficacy of cassava wastewater in boosting their rice yield. In addition, due to its high contents of cellulose, hemi-cellulose and starch, cassava processing wastewater can as well be effectively utilized for the production of ethanol (Vo *et al.*, unpublished).

The other type of waste that produced by cassava processing plants is solid waste. Cassava solid waste can be unrecoverable starch, the peel and soil/stem debris. This type of waste can also have a significant hazard to the environment and human health of those communities living nearby the processing plants. Nevertheless, as compared to wastewater, the solid waste is less hazardous to the farming communities other than its strong and unpleasant smell. During the process of its breaking down, the solid waste is reported to produce strong and unpleasant smell that can attract houseflies which causes nuisance and health threaten to people in the area. In some occasions this unpleasant odour can reach up to 200-300 m and provide good ground for a complaint and/or attacked by people who live around the processing areas.

Annually, cassava processing in the country produces big quantity of solid waste and if this is not managed properly, it can cause a serious pollution to the environment and human life. Results of this study suggested that for the dried chip processing, one metric ton of fresh cassava root produces about 20 Kg of solid waste (Men Sarom *et al.*, 2014). Therefore based on this calculation and the exporting quantity of dried chip of 1,269,653 tons in 2013 (MAFF, 2014) and, with a conversion ratio of fresh root to dried chip is 0.463Kg, presumably at least 54,844 tons of solid waste was produced by local cassava dried chip processing plants in that year. This is quite a big amount of solid waste produced by cassava dry chip which without appropriate management it can be not only a wasteful resource but also a source of environmental pollution.

Nonetheless, solid waste of cassava processing can be a good feed for animal and aquaculture production. Cassava peel can be utilized as a medium for mushroom cultivation or is used to produce compost, and for the production of ethanol and maltose (Henry and Howeler, 1996). Currently, most of the cassava solid waste is dried in the sun for 3-7 days, and then sold to the manufacturing of animal feed at a low price.

Chapter II: Improved management practices for cassava production

1. Recommended cassava varieties for Cambodia

1.1 Introduction

There are two type of cassava planted in Cambodia, sweet and bitter varieties. Sweet varieties or it is called in local language Damlong Kor or Damlong Mi content low hydrogen cyanide (HCN) concentration and therefore are appropriate for direct consumption, while “bitter varieties” are for industrial purposes. According to a survey conducted by Tin *et al*, 2014, more than 85% of farmers in Kampong Cham cultivated KU 90 (also called KM94 or Malay variety) while more than 80% of farmers in Pailin grew Kartoil variety (Tin et al., 2014). These two varieties are high yielding, high starch content and also high HCN concentrations. Therefore they are mainly used for industrial purposes despite they can also be processed for food.

1.2 Cassava as a crop

Cassava is a tropical crop, growing between 30°N and 30°S in areas where annual rainfall is greater than 500 mm and mean temperature is greater than 20 °C. However, some cassava varieties grow well at 2000 m altitude or in sub-tropical areas with annual mean temperatures as low as 16 °C.

Cassava is a perennial woody shrub, although farmers usually harvest the tuberous roots and leaves during the first or second year. Cassava is commonly propagated by stem cuttings although it can also be propagated by seed particularly in plant breeding.

The cassava plant propagated from stem cuttings produces adventitious roots at the base of the cuttings. Some adventitious roots also develop from axillary buds on the cuttings, or at the nodes (nodal roots). These adventitious roots develop into a fibrous root system. The fibrous root system may grow to a depth of 2 m or more. Cassava plants propagated from seeds first develop a tap root system. The radicle grows vertically downward and develops into a tap root. Within 30-60 days, some fibrous roots increase in diameter and become tuberous roots. As tuberization proceeds, tuberous roots swell as a result of starch accumulation. Tuberous roots do not absorb water or nutrients; they are physiologically inactive and cannot be used as planting material.

Only a few fibrous roots develop into tuberous roots; the rest remain fibrous and continue to function as water- and nutrient-absorbing roots. The actual number of fibrous roots which form tuberous roots depends on several factors genotype, assimilate supply, photoperiod and, temperature. Cassava roots vary in shape, depending on the soil conditions under which plants grow.

Cassava is monoecious that means male and female flowers are located on the same plant. Some varieties flower frequently and regularly, while others flower rarely or not at all. Flower production is important for breeding. Environmental factors, such as photoperiod and temperature, influence flowering. Female flowers open 1-2 weeks before male flowers (protogyny). Insects carry out cross-pollination. Self-pollination occurs when female and male flowers, located on different branches of the same plant, open at the same time.

After pollination and subsequent fertilization, the ovary develops into a fruit. The fruit matures in 70-90 days. Seeds can be light gray, brownish or dark gray, with darker blotches.

1.3 Variety recommendation

At the present no cassava breeding program has been either established or carried out in the country besides some testing of introduced varieties from cassava breeding centers located in countries like Thailand, Vietnam and China. Results of such testing have confirmed the suitability of some varieties such as KU 50 and Huay Bong 60, the two varieties from Thailand, and varieties SC8 and SC9 from China. Selected varieties particularly for industrial purposes must have good root yield potential and high starch content, whereas for direct consumption low concentration of cyanide is the main priority.

Some of the most common varieties cultivated by farmers are shown below:

Kasetsatr 50 (KU50)

KU 50 was released in 1992 in Thailand and is the most popular variety there. In Vietnam they call it KM 94, while most cassava farmers in Cambodia call it Malay variety. KU50 is a high yielding variety, the average yield ranges from 26t/ha to 30t/ha with about 25.8% of starch content and 37.4% of dry matter content. KU 50



leaves are simple with green to pink petiole. The root skin color is light brown and the root flesh color is white.

Rayong 1

Rayong 1 was released in 1975 in Thailand, the average yield is 22t/ha with about 18-24% of starch content. Rayong 1 leaves are simple with green to pink petiole and shoot is purple. Stem color is grey, root skin color is light brown and the root flesh color is white.



Hauy Bong 60

Hauy Bong 60 was released in 2003 in Thailand, the average yield is 30 t/ha with about 25-30% of starch content. Hauy Bong 60 leaves are normal with green to pink petiole and shoot is purple. Stem color is grey, root skin color is brown and the root flesh color is white.



Rayong 72

Rayong72 was released in 2000 in Thailand, the average yield 31.6 t/ha with about 20-25% of starch content. Rayong72 leaves are normal with red to purple petiole and shoot is purple. Stem color is grey, root skin color is brown and the root flesh color is white



2. Production and storage of healthy cassava planting materials

2.1 Introduction

Cassava is a vegetative propagated crop which is commonly propagated by stem cuttings. Cassava stems are cylindrical, with a diameter ranging from 2 to 6 cm. Cassava stems can grow up to 4 m, though in some genotypes they grow to only 1 m. Stems vary considerably in color from whitish gray to brown or dark brown and are usually woody with a large pith. Each stem produces an average of one node per day during early growth stages, and one node per week later. Each nodal unit consists of a node which subtends a leaf, and an internode. Internodes vary in length according to genotype, plant age, and environmental factors such as soil moisture, temperature and light. Internodes are short under drought stress, long under favorable conditions and, abnormally long under insufficient light.

The shoot develops from buds located at the nodes of the cutting. The number of shoots which develop from a stem cutting depends on several factors such as length of cutting, planting orientation, stem diameter, genotype, mother plant effect and, apical dominance.

The use of a previous crop stem to plant a new crop is very convenient, but it also provides an easy way for disease-causing pathogens, particularly viruses, to pass directly from one plant generation to another.

2.2 Production

To get good cassava planting materials, mother plants must be cultivated on fertile soils or well-fertilised soils. Cassava planting materials derived from this planting condition of the mother plants will have better food for the new plants - good germination, grow better and produce

higher root yields and, may have better resistance to pests and diseases, such as mealybugs and CWB.

Planting materials must be produced using stems that are selected from vigorous plants with no nutritional deficiencies, are of suitable age and are free of diseases and pests. It can be noticed that cassava plants of the same varieties on the same land do not show similar vigor and there may be large differences in root yield between cassava plants. At the time of harvest, plants can have significant variation in stem maturity and some roots may be rotten. The cause of these problems could be certain soil or climatic factors, but they may also be related to the quality of the original planting material. Therefore, two important things must be considered to get healthy and high-quality planting materials.

1. Disease and pest free (healthy) planting material
2. Good quality of planting material

Best quality planting material is usually taken from the middle two thirds of the stems of plants that are 10-12 months old. The length of the planting stakes should be about 20-25 cm long.

Farmers practice different spacing with the distance between plants in the row varying from 50 to 150 cm. A plant density of 10,000-15,000 plants per ha in general results in good yields. The optimum plant spacing varies from uplands to lowlands, and depends on whether cassava is a sole crop or is intercropped with other crops. In upland areas farmers traditionally grow cassava together with other crops such as maize, peanuts, banana, etc. The distance between cassava plants will differ depending on the type of intercrops, but generally ranges from 100 to 400 cm. In monocropping, the spacing of cassava is usually between 80 and 100 cm within and between rows. In Thailand, the plant spacing in monocropped cassava will vary from 1 x 1 m to 1 x 0.5 m. The plant spacing depends mainly on: variety, climatic conditions, soil fertility of specific locations and cultural practices. There is no universal recommendation for the plant spacing of cassava. Branching and vigorous cassava varieties will need wider spacing compared to less branching and less vigorous varieties. Cassava grown on very fertile soils will need wider spacing compared to cassava grown on infertile soils.

2.3 Storage

The stems should be stored under shade and preferably in a standing position with the lower part of the stem in contact with the soil. Placing mulching material around the base of the bundles or keeping the soil slightly moist may help prevent the stems from drying out. Storing of stems should be for as short a time as possible and under optimum conditions. Depending on the varieties, longer storage time may reduce the germination and rooting of the planting stakes. Generally, the stems should not be stored for more than two months after harvest.

3. Land preparation and soil erosion control

3.1 Introduction

Land preparation is an important part of crop establishment with the aim of achieving high survival and rapid growth of the crops. Good cassava production requires a good land preparation. The land should be well prepared with tillage the land in order to remove the weeds, loosen up the soil, improve soil drainage and make it easy for root development. Cassava succumbs easily to weed competition, excessive soil moisture and root rot. However, the level of tillage required for the cassava field mainly depends on the soil type and the drainage, which the field may be prepared as mounds, ridges, flat-tilled or zero-tilled. For tillage system, the soil is ploughed and exposed to the sun for 2 weeks to a month. This helps to kill deeply embedded weed seeds. Second plowing is then done in preparation for planting associated with seedbed pattern. Land preparation for growing cassava can be done by manual, animal drawn and machine

Land preparation technique is always necessary in order to achieve successful cassava plantation establishment. Although cassava can also grow well on poor soils with limited inputs fertilizer, a well prepared field, weed control, recycles plant nutrients and provides a soft soil mass are basic components for cassava growing. Understanding of nutrient management technique is important to maintain the soil nutrients and obtain a high yield. So, cassava and soil productivity can be sustained with proper land preparation and applying an appropriate integrated nutrient management techniques in local context.

3.2 Land preparation

One or two times of plowing and once harrowing are usually implemented by cassava grower. Land is ploughed or dug properly for loosening soil to a depth of 20 to 25 cm. Cassava is grown

mostly on gently slopes or steeper slopes, especially in mountain areas, ridges are taken across the slope. Thus, land preparation should be made according to the slope gradient.

a. On steeper slopes

The land is recommended to plant cassava without land preparation or prepared only by making individual planting holes of 10 x 20 cm with a hoe, after clearing the weeds or bush vegetation.

b. On gently slope

The soil should be well-prepared using animal-drawn or tractor followed by contour ridging, usually 1-2 plowing followed by 1-2 rakings. Contour ridges, sometimes call contour furrows or micro watershed, prepare before planting. Ridges are made follow the contour at spacing of usually 1 to 2 m.

On gently sloping land is prepared for cassava in many different ways and at different intensities:

- Plough the fields with oxen or water buffaloes, usually one or two passes with a simple reversible plough.
- Plough the fields with oxen, and then create planting ridges by hand, using a short-handle hoe.
- Hoe the soil, and then make individual mounds for each cassava plant.

Plough the fields with tractors one or two passes with reversible plough and create planting ridge across the contour.

3.3 Preparation of planting beds

a. *Preparation of mounds or ridge*

Cassava is planted on mounds or ridges to enhance soil aeration if the soil is poorly drained soils. In the planted areas with shallow soils or poorly drainage clayey soils, it is important to make mounds or ridges onto which the cassava is planted to encourage better root development and yields. The soil ploughs to depth of 30 cm than harrow, so that the root can get well down. After tilling, at the beginning of the rainy season, create mounds or ridges. The size of the mounds or ridges varies with respect to soil drainage condition. In well drained soils, ridges should be made at 75 to 90 cm apart and 30 cm high. In low-lying area, where get flooded during rainy season, ridges should be made at 100 to 120 cm apart and 50 to 60 cm high. The space between mounds varies from 0.6 to 2 m and 30 to 60 cm high; on average. Big ridges and mounds enable the plant

to grow above water in saturated soils. In hilly areas and in valley, plough across the contour and make mounds or ridges to limit prolonged contact between root and stagnant water.

b. Preparation for flat beds

At planted areas with well drained, good physical properties (e.g. texture), cassava is normally grown on flat beds. The soil is ploughed to remove weeds and grasses. In the mean time, harrowing 1 to 2 times is done after 3rd plowing to break the soil clods into small mass and incorporate plant residues. In sandy soils, minimum tillage and planting of cassava on flat beds are more appropriate, as the soil is sufficiently loose to allow root development (Figure 4).

The physical property, especially soil texture, is an important factor in determining the level of tillage and type of seedbeds required for cassava cultivation. Not only soil texture but also the drainage condition and topographical of cassava fields can change the level of tillage and type of seedbeds. For example, in sandy soils, minimum tillage and planting cassava on flat are appropriate because the soil is sufficiently loose to allow for faster drainage and normal storage root development. In contrast, at site where sandy soil gets waterlogged, it is however better to make ridges or mounds than to plant on the flat beds.

c. No-till or zero-tillage

No-till is one type of conservation system, in which the crop is sown directly into an untilled seedbed without any primary or secondary tillage. Previous crop residue is left on the surface and weeds are generally controlled by herbicides. Cassava can also planted and produced good yields in soil that has not been tilled, which may not require a thorough manual or mechanized soil preparation because it needs a sufficiently loosed-textured soil for root development. This system is considered most appropriate in sloping areas where soil topography is relatively even, moisture infiltration and soil structure are enhanced and excess water drains freely out to maintain a friable soil condition. Growing cassava without tillage may produce lower yields in the initial years. In long term, however, by reducing mineralization, erosion and water loss, helping to build up organic matter and maintaining soil aggregate stability and internal drainage, no-tillage promotes root functioning to the maximum possible extent.

3.4 Soil erosion control

Soil erosion is a process of removal soil particles of topsoil by various agent, including rain, water flowing over through the soil profile, wind etc, from one place and transport elsewhere.

Cassava is often blamed for causing severe erosion when grown on slope. It causes more run-off and erosion than leaving the land in forest, in natural pasture or under perennial trees. This is mainly due to the frequent loosening of soil during land preparation and weeding, as well as due to the lack of canopy and soil cover during the early stage of crop development. Figure 5 shows the cause and result of soil erosion.

Impact of erosion

- Degrades soil resource
- Reduces soil productivity
- Reduces soil organic matter
- Reduces plant nutrient
- Causes downstream sedimentation
- Produces sedimentation which is a pollutant

Soil erosion control

There are various agronomic and soil conservation practices are very effective in reducing soil erosion and maintain soil fertility as well as increase cassava yields, including:

- Use of good quality planting material, vigorous varieties and adequate applications of fertilizers will enhance plant growth and formation of soil cover.
- Making ridges across the contour, and planting contour hedgerows of grasses or legume or lemon grasses.
- Mulching cassava, especially after planting is help when growing cassava on the slope.
- Intercropping with legumes such as peanut or mungbean is very effective in increasing nutrients and helping to reduce erosion.
- Returning cassava leaves and stems to the soil after harvest and maintaining a continuous vegetative cover on the soil
- Use minimum tillage and at rather close plant spacing can reduce the soil exposing.

- Apply organic and inorganic fertilizer can improve canopy development and is therefore one of the most effective ways to reduce runoff and erosion

4. Planting, weeding and harvesting of cassava

4.1 Introduction

Cassava is cultivated in all agro-ecological zones in Cambodia as it can grow under both upland and rainfed lowland conditions and in the conditions with low soil fertility as compared with other field crops. However it grows poorly in clayey and stony while perform well in deep loamy soils with medium fertility and good drainage conditions.

4.2 Planting

a. Planting time

Planting time should fit with local farming calendars as this will help to ensure:

- Healthy sprouting
- Good crop establishment

Generally, planting time varies between locations depending on the availability of water (rain). In some locations, cassava is planted in the early rainy season from March to June while in the other places is planted in late rainy season from October to November.

b. Preparation of planting materials

Planting materials should be taken from plants that are between 8 and 18 months old. Best quality planting material is usually taken from the middle two thirds of the stems of plants that are 10-12 months old. As a general rule, the diameter of the stems should be not less than one-half the diameter of the thickest part of the stem for the variety being used. The length of the planting stakes should be about 20-25 cm long. Generally stakes should have between five or seven nodes.

A sharp knife or a saw should be used for cutting the stems into planting stakes, taking care to avoid bruising of tissues, tearing the bark, splintering the wood and damaging the planting material. Under favorable conditions, planting materials with either transverse cuts or bevelled cuts may give good yields. Stakes that have been transversely cut are able to root uniformly around the whole stem perimeter, resulting in better root distribution.

c. Method of planting

Depending on the growing conditions such as rainfall, flatness and soil types of the production field, there are three planting methods used in cassava production. Those are:

- **Horizontal method.** The entire stake is placed horizontally and buried at a depth of 5 to 20 cm (usually about 10 cm) in the ground. This method produces shallower roots than slanted and vertical planting.
- **Inclined method:** The stake is placed 2/3 of its length in the ground and at an angle ranging from about 45° to 60°.
- **Vertical method:** The stake is pushed vertically and about 1/2 of its length into the ground. With this method the stake sprouts quicker than with the other two methods, but it produces deeper roots than the horizontal or inclined planting methods.

If the soil is loose and friable, stakes can be planted vertically (slanted) by pushing the lower part of the stake about 5-10 cm into the soil. Stakes can also be planted horizontally at 5-7 cm depth by digging individual holes, or by making a long furrow, laying the stakes down and covering with soil. Planting vertically or slanted generally produces higher yields than planting horizontally, especially during periods of drought and the vertical method is suitable in sandy soils and under erratic rainfall.

Studies show that vertical planting resulted in the highest germination percentage, but that slanted planting produced the highest yields. Planting one stake per hill significantly increased yields as compared to the traditional practice of planting two stakes per hill, slanted in opposite directions. Planting stakes horizontally is common in heavy clay soils or with zero- or minimum-tillage methods of land preparation. When the soil is well prepared and friable, planting vertically or slanted is faster than planting horizontally, but care should be taken that the eyes or buds on the stakes face upward; with horizontal planting this is of no concern.

d. Planting space

Farmers plant cassava at different spacings with the distance between plants in the row varying from 50 to 150 cm. A plant density of 10,000-15,000 plants per ha in general results in good yields. The optimum plant spacing varies from uplands to lowlands, and depends on whether cassava is a sole crop or is intercropped with other crops. In upland areas farmers traditionally

grow cassava together with other crops such as maize, peanuts, banana, etc. The distance between cassava plants will differ depending on the type of intercrops, but generally ranges from 100 to 400 cm. In monocropping, the spacing of cassava is usually between 80 and 100 cm within and between rows. Branching and vigorous cassava varieties will need wider spacing compared to less branching and less vigorous varieties. Cassava grown on very fertile soils will need wider spacing compared to cassava grown on infertile soils.

4.3 Weeding

The crop should be weeded when cassava plants are about 20 to 25 centimeters high, that is 3 or 4 weeks after planting. A second weeding should be at about 1 to 2 months later after the first weeding. During weeding the crop can also be mounded up to support the formation of tuber roots, and to prevent the wind from blowing the plants down. After this, the cassava plants are big enough to prevent weeds from growing. If rain spoils the mounds, they must be remade. When the soil of the mounds gets too hard, break it up with a hoe, so that water and air can get in to nourish the roots. Early weeding prevents weeds from competing with the crop for nutrients, water, light and space. Hand weeding is recommended if labor is available and economical. Combine different cultural practices to control weeds. Those can be:

- Manual weed control (hand weeding).
- Use cover crops (Melon, legumes or pumpkin) to suppress weeds.
- Use inter-row weeders (mechanical).
- Use chemicals to control weeds. Herbicide can be used if labor becomes a limiting factor.

The recommendation for herbicide application as follows:

- ▶ First Application: Apply a pre-emergence herbicide, for example, 1,500-2,250 g ai/ha of metholachlor 40 % EC or 750-1,500 g ai/ha of diuron 80 % WP directly after planting and before germination occurs. This will then control weeds for 30-45 days.
- ▶ Second and third Application: Apply a post- emergence herbicide such as 500-750 g ai/ha of paraquate 27.6 % AS or 1,500 g ai/ha of glyphosate 48% AS, when and where it might be necessary.

4.4 Harvesting and storage

Depending on the variety, harvesting of cassava for food may begin from the seventh month after planting for early varieties, or after the tenth month for late varieties. Before this, the roots are too small. At the harvesting time, that is, between the sixth and the twelfth month, each fully grown cassava root may weigh 1 or 2 kilograms, depending on the variety. In small family plantations, without cutting the stems, roots can be harvested at any time depending on the need of the farmers.

For industrial purposes, the crop is harvested at once at around 10-12 months after planting despite it can be harvested as early as 8 months and as late as 24 months. Generally, high starch cultivars are harvested late.

After harvesting, the roots must be transported to the factory within 4 days before they become rotten and the stem must be stored until they are required for the next planting season.

Cassava can be harvested by hand, levellers and machine.

a. Hand harvesting

Hand harvesting of cassava can be simple if cassava stakes are planted horizontally in the soil at a depth of 5–10 cm. In case they are planted vertically or slanted, a garden fork can be used to loosen the soil around the tubers before they are pulled by hand. In this system, it is always better to plant the stem cut slanted, since most of the tubers will be produced at the distal end, away from the stem. Thus root damage can be minimized by sticking the fork in the ground at the proximal end of the plant where the stem emerges from the ground.

- Cut the plant about 20 to 50 cm from the soil before pull out of cassava.
- Or cut some part of plant about 7 to 14 days before pull out of cassava.
- Shake the cassava plant before pull out, because to avoid the tuber broken and bark tuber broken.

b. Levers

Harvesting the cassava can be done by using levers. Through this practice, a pole about 3 m long is securely attached to the stem, with one end on the ground and the other serving as a lever to pull up the plant and tubers.

c. Machine harvesting

Farmers can adapt mold board ploughs and even chisel ploughs to penetrate and lift the soil so that the roots can be easily extracted. A cassava harvester, which can literally unearth the roots and separate them from the soil, has been developed and successfully used in South America.

5. Integrated nutrient management in cassava production

5.1 Introduction

Cassava is known for its ability to grow in poor soils and to produce good yields where other crops fail. However, it is important to improve the nutrient availability of the soil, particularly at the early growth stage as the root system of cassava develops slowly and has limited uptake.

Integrated nutrient management (INM) is the maintenance of soil fertility with combination of old and new methods of nutrient management into ecologically sound and economically viable family systems that utilize available organic and inorganic sources of nutrients in a judicious and efficient way. Similarly, sustainable soil nutrient enhancing strategies involved the wise use and management of inorganic and organic nutrient sources in ecologically sound production system.

5.2 Type of fertilizer

Cassava removes much less nitrogen (N), phosphorus (P) and potassium (K) than most other crops. This is because most nutrients, except K, are mainly present in cassava leaves and stems. Therefore, if the leaves and stems are returned to the soil, nutrient removal will be minimal. In contrast, in the areas where leaves and stems are also utilized and removed from the field, nutrient removal will increase. In this case, nutrient depletion can become a serious concern if soil fertility is not maintained properly. Returning leaves and stems to the soil is an essential first step in preventing nutrient depletion and maintaining soil fertility. It is, therefore, important to avoid burning of cassava and other crop residues.

a. Organic materials

Animal manure contains plant nutrients and improves the physical condition of the soil. The integration of farm animals can, therefore, contribute to better recycling of nutrients within the farm, if the animals are fed on farm-own forage legumes and the manure is returned to the field. Cassava plants will get benefit from the valuable manure of cattle, goats, pigs or chicken

offering. In order to minimize nutrient losses from manures, special attention must be paid to their collection, storage and application.

Organic wastes such as kitchen wastes, animal manure and plant materials can also be collected, composted and applied to the cassava field to replenish the nutrients taken away through harvest. These materials improve the amount of nutrients as well as the soil organic matter content, and thus the soil's physical conditions and water-holding capacity will be improved. It is advisable to avoid using weed residues containing seeds, or roots as mulch because these can increase weed problems on the farm. Also, straws of maize are bad mulch materials, as they take too long to rot and temporarily reduce soil nitrogen before they are decomposed.

b. Green manure

Planting of green manures and their subsequent mulching or incorporation into the soil before planting cassava is an agronomic technique to improve soil fertility. Grain legumes, such as groundnuts, mungbeans, cowpeas and soybeans, which fix atmospheric nitrogen and make it available to the successive cassava crop. Sequential cropping of cassava and cowpeas improves soil fertility to the point where applications of mineral fertilizer can be reduced, with no loss of yield. However, in many systems, cowpea has proved to be more promising. It can provide 80 kg of nitrogen per hectare to a subsequent crop in 8 to 10 weeks of growth. It is tolerant of drought and well-adapted to sandy and poor soils. For example, the 35 days (flowering) broad bean will be cut and mixed with the soils before planting cassava.



b. Chemical fertilizer

Under continuous cropping, recycling and reusing of nutrients from organic sources many not be sufficient to sustain crop yields. Nutrients exported from the soil through harvested biomass and lost from the soil through various processes must be replaced with nutrients from the external sources. Decline in soil productivity can be attributed in part of negative nutrient budgets (or the amount of nutrient removed compared to the amount of nutrient being put into the system). Thus the judicious use of chemical fertilizers is essential to maintain soil fertility. Fertilizer use is

closely associated with the growth phases of cassava. Fertilization is critical during the first phase at 4 to 6 weeks after planting as the thin and thick roots are being rapidly produced and can absorb nutrients from the soil. Fertilization is also important during the second phase, at 8-10 weeks after planting, when the roots begin to bulk up and there is a high demand for sucrose, which is stored in the root. Potassium (K) fertilizer is the most important fertilizer to apply at this time because it helps to produce the starch. However, the fertilizer decision should be made according to the following guidelines:

- a) Determine the nutrient content and pH of the soil by having a soil test conducted because cassava plant can grow best at a pH of 5 to 6.5. At this pH level, most of nutrients become available for plant growth. If the soil pH is lower than 5, liming should be applied. In the contrary, if the soil pH is higher than 6.5, organic matter is to be considered. The application of ammonium fertilizers such as urea, ammonium nitrate and ammonium sulfate can also lower the soil pH.
- b) Based on the recommendation rate, if any, determine the amount of nutrients that cassava crop can produce high yield.
- c) Calculate the amount and type of fertilizer to be used to the soil.

In conclusion, during land preparation, organic fertilizers and inorganic fertilizers can be added into the soil to increase soil nutrients, improve soil structure and water holding capacity. For organic fertilizer, for example animal manure will be incorporated into soil during land preparation as basal fertilizer. As for chemical fertilizers, it can be placed 15 to 20 cm from the stem base in 10 to 15 cm deep at about 4 to 6 weeks and 8-10 weeks after planting. On the soils that are moderately deficient in P and K, a general recommendation would be to use fertilizer with an N:P:K ratio of roughly 1:1:2, e.g. 40-80 kg N, 40-80 kg P and 80 -160 kg K per ha.

6. Cassava intercropping systems

6.1 Introduction

Cassava is considered as a long-season crop. Due to its slow growth at the initial stages, it does not efficiently use the availability of light, water and nutrients during these early growth stages. Thus short-duration crops may be inter-planted to make more efficient use of these growing

factors. Among all, legumes can be considered for use in intercropping systems with cassava because of their fast growing and the ability to improve soil fertility through nitrogen fixation.

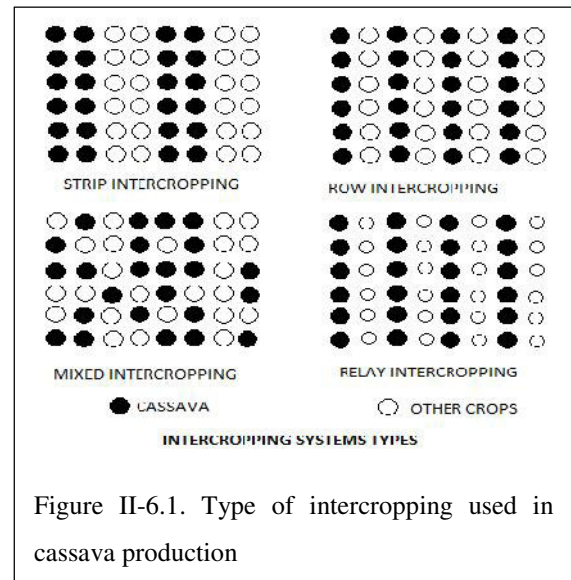
Intercropping cassava with short-duration crops is a common practice among smallholder farmers in many tropical countries. These intercrops are useful because they supply either food or additional income, especially at times when the cassava crop cannot yet be harvested; they may fix N and supply other nutrients to the topsoil; they may protect the soil from the direct impact of rainfall, and may reduce the speed of runoff water when the cassava canopy is not yet closed, thus reducing soil erosion; and they may reduce weed growth during the early stages of cassava development. However, intercrops need to be carefully managed in order to reduce the competition with cassava, for light, water and nutrients. This is usually done through modifications of the plant spacing or planting pattern of both crops, by adjusting the relative time of planting and by fertilizing each crop adequately to maximize yields.

6.2 Type of cassava intercropping systems (See Fig.II-6.1)

Growing two or more crops at the same time in the same field is usually described as an “*intercropping system*”. However, these can still be subdivided into four different subsystems:

1. ***Mixed Intercropping***: in which usually several crops are grown mixed and randomly distributed in the same space, and these crops may be planted and harvested at different times according to their specific characteristics.
2. ***Row Intercropping***: in which two or more crops are grown simultaneously in a regular arrangement with a well-defined planting pattern, consisting usually of one or more rows of a short-duration crop in parallel rows between rows of the long-duration crop.
3. ***Relay Intercropping***: is a kind of intercropping in which two or more crops grow simultaneously during part of the life cycle of each. A second crop is planted before the first crop matures; or, the second crop is planted in the same field as the first crop after the first has achieved reproductive maturity but before it has reached physiological maturity. This allows farmers to grow two crops in one season in places where the growing season is not long enough to accommodate two crops.

4. **Strip Cropping:** in which two or more crops are grown simultaneously in the same field, but in separate and alternating strips that are wide enough to allow independent cultivation but narrow enough to obtain some crop interaction.



6.3 Advantage and disadvantage

Intercropping is usually practiced by small-holder farmers who have only small areas of land from which to feed or sustain a family. In this case, land and capital are the major constraints while labor may be rather abundant. These farmers have to maximize the total productivity of the land by optimizing the growth factors such as light, water and nutrients. Growing two or more crops together could have the following advantages:

- The different crops provide a greater food variability such as carbohydrates from grain and root or tuber crops; protein from grain legumes; and vitamins and fiber from vegetables
- Increase yield stability or income and reduced risk of total crop failure
- Reduced incidence of pests and diseases
- Reduced weed competition
- Reduced soil loss by erosion by providing an early ground cover between the rows of the slow-growing long-duration crop
- More efficient use of land and labor, the latter being needed for different operations throughout the year
- Increased yield and total net income per unit area of land.

However, intercropping also has certain disadvantages:

- It reduces the possibility of using mechanization for planting, weeding and harvesting, as well as the use of certain herbicides to control weeds and the application of fertilizers
- It may complicate the management of each crop individually
- It requires more labor per unit area
- Intercrop competition is likely to reduce the yield of each individual crop, although this is generally compensated for by an increase of the total value of all crops included in the system.

Intercropping systems must be designed to maximize the total net income of the system, to increase the various advantages and decrease the disadvantages mentioned above. This will require the careful selection of the various crops to be planted, the most suitable varieties of each crop, the most effective plant densities and planting arrangements, the relative time of planting each crop, the most effective fertilization, amounts and balance of nutrients and times of application, as well as their distribution among the various crops.

6.4 Selection of most appropriate intercropping for cassava

The selection is highly site-specific, depending on the soil and climatic conditions, as well as on local tastes and traditions. Farmers tend to select crops on the basis of differences in growth habits and growth duration. Having a slow initial growth, cassava can best be intercropped with crops having a rapid growth and early to medium growth duration, such as cowpea (*Vigna unguiculata*), peanut (*Arachis hypogaea*), mungbean (*Vigna radiata*), and maize. Crops with different rooting pattern and growth cycle improve the use of water stored in different soil layers. The various crops should also have different times of maximum water and nutrient usage and different nutritional requirements. Thus, cassava tends to need mainly K for root formation while cereal crops require mainly N and grain legumes mainly P and K.

Intercropping cassava with short-duration grain legumes has the advantage of providing both carbohydrates from the cassava roots and protein from the grain legumes. The latter may also fix N, and cassava may benefit from this symbiosis. The selection of early maturing grain legumes, such as mungbean, peanut, bush-type common beans (*Phaseolus vulgaris*) and cowpea (*Vigna unguiculata*), has the advantage that the grain legumes are harvested before the cassava closes its

canopy and neither crop suffers too much from interspecific competition. In this case, the association of a long-duration crop (cassava) with a short-duration crop results in a higher total yield due to better utilization of both space and time.

Cassava can also be inter-planted between the rows of recently planted tree crops, such as rubber, coconut and cashew nut. As the trees grow and produce more and more shade, the number of cassava rows growing between the rows of trees is generally reduced until the shading of trees does not justify the further planting of intercrops. When cassava is planted under mature coconut trees, the yield of cassava tends to be greatly reduced, mainly due to excessive shading.

6.5 Improvements in Cassava Intercropping Systems

Several factors should be considered in the selection of crops and management practices to maximize the outputs of intercropping systems.

Plant type and/or growth habit: Cassava varieties may differ in their growth habits, some having vigorous early growth and early branching, while others are more erect with medium to late branching. This may also vary with fertility of the soil; in soils low in K plants tend to be short and highly branched, showing a prostrate growth habit, while plants growing in soils high in N are tall and show vigorous early growth. To minimize the shading of low growing grain legumes by cassava, the latter should have an erect and late-branching growth habit, but to avoid the shading of cassava by fast growing intercropped maize, the former should have a vigorous early growth with medium to late-branching.

Relative time of planting: The intercrops can be planted at the same time as cassava, or one or more weeks before or after planting cassava, depending on the vigor of each crop, as well as on the relative income expected from each crop. When the income from the intercrop is expected to be high, these crops may be favored by planting before the planting of cassava, and *vice versa*. However, in general, the greatest total yields are obtained when both crops are planted at the same time, or with a difference in planting date of only 1-2 weeks.

Planting density: In general, the optimum monocrop planting density can also be used when cassava is grown in association with other crops without causing a serious yield reduction of the associated crop. However, if the cassava variety is very vigorous, it may be necessary to reduce its plant density in order to maximize total yields. With late-branching and less vigorous cassava

varieties the best yield were achieved with an intermediate plant density of about 10,000 plants per hectare.

Planting pattern: The choice of spatial arrangement of each crop is important in reducing competition and maximizing total yield, as different arrangements affect the efficiency of utilization of light and space. In many cases, a normal square planting arrangement of cassava with one row of grain legume or maize between cassava rows gives the maximum yield and income from both crops. However, to favor the growth of intercrops, a wider interrow spacing of cassava and shorter interplant spacing within the row is often preferred. This arrangement may allow the planting of two or more rows of intercrops between cassava rows. In Indonesia, cassava is often planted with an interrow spacing of 1.8-2.0 m and interplant spacing of 0.5 m, which allows the planting of 4-5 rows of upland rice or peanut planted between rows in addition to one hill of maize between cassava plants in the row. After the harvest of upland rice and maize, there is still enough light between rows for planting a second intercrop of a short-duration grain legume between cassava rows. Alternatively, cassava can be planted in double rows spaced at 0.8 x 0.8 m in each double row, with 1.9-2.0 m between double rows. This will allow the planting of several rows of intercrops between each double row of cassava. By varying the interrow and interplant spacing, a cassava plant density of about 10,000 plants/ha can be maintained. Within limits, whether cassava is planted in a square or rectangular planting pattern has little effect on cassava yields.

The spacing of the intercrops planted between the cassava rows depends on the growth habit of the crop. Most grain legumes should be planted at least 50-70 cm from the nearest cassava row to prevent excessive competition from cassava. Within the remaining interrow space, 2-3 rows of legumes can be grown at 30-50 cm between rows. Intercropping cassava with common beans at CIAT, the arrangement of three rows of beans (spaced a 30 cm between rows) planted between cassava rows (spaced at 1.8 m between rows) produced the highest total yield and income. However, in North Vietnam the planting of two rows of peanut between cassava rows, spaced at 1 m between rows, was most profitable.

Fertilization: Crops grown in association tend to reduce soil erosion and nutrient leaching but some more nutrients are likely to be removed in the harvested products. Intercropping represents and intensification of the demand for nutrients, particularly when each associated crop is planted

at its normal density. In this case, the removal of nutrients from the soil is higher than when cassava is grown in monoculture.

There is little or no information about the optimum rates and balance of N, P and K fertilization for each crop in an intercropping system, because this is highly dependent on the fertility of the soil, on the nutritional requirements of each crop, their competitive interaction and growth duration. Whether most fertilizers should be applied to cassava or to the intercrop also depends on the expected income to be derived from each crop. In general, cassava should be fertilized as if it were planted in monoculture, generally requiring relatively high levels of N and K, while cereal crops require mostly N and P, and grain legumes P and K.

Weed control: Intercropping cassava tends to reduce the growth of weeds between cassava rows, but it also makes weeding by mechanical means more difficult. On hand weeding with a hoe at 3-4 weeks after planting is often practiced, after which the canopy cover from both cassava and the intercrops will generally prevent further weed growth. Weed competition can also be reduced by application of pre-emergence herbicides. However, some herbicides that are selective for cassava may not be selective for the intercrop. Thus, care should be taken in the selection and dosage of the appropriated herbicides.

Reducing Soil Erosion: The effectiveness of intercrops in reducing soil erosion depends on whether they have been able to produce enough foliage in time to protect the soil surface from rainfall. More consistent results in reducing soil erosion have been achieved by planting cassava with protective hedgerows, or “live barriers”, a low-cost alternative to engineered soil conservation options such as contour bunds or bench terraces. Hedgerows filter and slow the rate of runoff and can be created using various recommended grasses, perennial legumes and other plants, or established naturally from native grasses and other species left as unhoed or unploughed strips in the field. An added advantage of planting hedgerows is that, when pruned regularly, they provide *in situ* mulch, which makes these systems particularly effective in reducing erosion and less laborious than carrying mulch from elsewhere.

7. Major pests and diseases in cassava production and their controls

7.1 Introduction

Most cassava is grown by small-scale farmers in traditional farming systems, often on marginal or fragile soils under rainfed conditions. As yields are low in these systems, pest control is of low priority due to the high costs and the long crop cycle, which may require various pesticide applications. The dynamics of cassava production are changing, however, as trends in the food; feed and industrial sectors are leading to an increased demand for high-quality cassava starch. There are indications of a shift toward larger scale production units, where cassava is grown as a plantation crop, and it is advantageous for farmers to employ a multiple planting and harvesting production system in order to meet the constant market demands of the processing industries.

In the past cassava growing areas have been relatively free of pests and diseases. Evidence now indicates that pest problems will be compounded in these overlapping production systems. Populations of certain pests such as whiteflies and mealy bugs tend to increase when a constant

The cassava plant is well adapted to long periods of limited water and responds to water shortage by reducing its evaporative (leaf) surface rapidly and efficiently and by partially closing the stomata, thereby increasing water-use efficiency. Younger leaves play a key role in plant carbon nutrition. Most pests prefer the younger canopy leaves; thus, dry-season feeding tends to cause the greatest yield losses in cassava.

7.2 Management of major insects

Cassava mealybugs

Mealybugs are economically important species that has caused substantial yield reductions in cassava production. Mealybugs may be placed into two groups: the short-tailed mealybugs and the long-tailed mealybugs. Mealybugs can be effectively controlled through the



proper employment of biological control agents, especially parasitoids. The biological control such as mealybug parasitoid, *Anagyrus lopezi* became well established in Thailand.

The use of chemical pesticides for mealybug control can be both difficult and costly. The employment of a chemical pesticide can be disruptive to the natural biological control that exists, or is introduced into a cassava field. Most natural enemies, especially parasitoids, are very sensitive to pesticides, even when they are applied at low doses. In contrast to biological control methods, the use of chemical pesticides does not require as much knowledge of the ecological origins of the pest.

Mealybugs are oval, flattened, soft-bodied insects, distinctly segmented but without a clear definition between the head, thorax and abdomen. They are covered with a white, powdery, or mealy wax and feed by inserting their slender mouth parts into the plant tissues and sucking cell contents.

Strategies for prevention

- 1) Selection and treatment of planting material (eg. with Thaimethoxam) in areas of high pest pressure;
- 2) Minimize movements from infested to non-infested fields (Enforce quarantine regulations),
- 3) Avoid use of chemical pesticides (conserve mealybug natural enemies-parasitoids),
- 4) Constant monitoring of plantations (every 2-4 weeks),
- 5) detect focal point of infestation (hot spots),
- 6) Remove infested growing areas of plant (apical buds) and destroy (burn),
- 7) Application of a systemic pesticide in area of infestation and surrounding area,
- 8) Release and establishment of natural enemies (depending on mealybug species), and
- 9) Avoid movement of planting material (stem cuttings) from one region to another.

Cassava mites

Mites are dry-season pests that can cause yield losses where there is a seasonally dry period of at least three months. At the onset of the rainy season, mite population decrease and cassava plants

produce new foliage. Leaves develop a mottled whitish-to-yellow appearance and may become deformed or reduced in size. Heavy infestations will cause defoliations, beginning at the top of the plant, often killing apical and lateral buds and shoots.



Mites attack from 3-6 months of cassava crop resulted in yield losses of 21 to 53%. Mite attacks will reduce the quality and quantity of planting material (cuttings) as well as decrease the root yields.

Pesticide applications for controlling mites on a long-cycle crop such as cassava are not a feasible or economic option for low-income farmers. Moreover, even low doses of pesticides have adverse effects on natural enemies. Cultural control methods have not been explored, and there is little mention of their use in the literature. For controlling cassava mites some measures are recommended.

1. Stake treatment (eg. with Thaimethoxam) in endemic areas.
2. Plant at the beginning of the rainy season (to guarantee good establishment).
3. Appropriate fertilization to improve plant vigor.
4. Use resistant or tolerant cultivars where available.
5. Water sprayed under pressure will reduce mite populations.
6. Only use selective insecticides to protect natural biological control.
7. Phytoseiid mite predators are very sensitive to pesticides (even low dose applications).
8. Quarantine measures (prevent invasive species).

Whiteflies

Considered one of the world's most damaging agricultural pest groups, as both direct feeders and virus vectors, whiteflies attack cassava-based agro-ecosystems in the Americas, Africa and Asia. Currently, they may be causing more crop damage and yield loss on cassava than any other pest attacking the crop.

Whiteflies can cause direct damage to cassava by feeding on the phloem of leaves, inducing leaf curling, chlorosis and defoliation. High populations, combined with prolonged feeding, result in considerable reduction in root yield.



Integrated management of cassava whiteflies depends on having effective, low cost, environmentally-sound technologies available for farmers. A successful whitefly control program requires continual research input to acquire the basic knowledge needed to develop the technologies and strategies for appropriate implementation. Four methods of whitefly control in cassava are presented in below: host plant resistance, biological, cultural and chemical.

Scale insects

Several species of scales are reported attacking cassava stems and leaves in the Americas, Africa and Asia. Although reductions in yield due to scale attack have been reported, they are not considered to be serious pests of cassava. The species *Parasaissetia nigra* is reported from Asia.

The most effective means of control is through the use of clean, uninfested planting material and destroying infested plants to prevent the spread of infestation. Stem cuttings for vegetative propagation should be carefully selected from uninfested plants. Treating stem cuttings that have originated from fields with scale attack is highly recommended. Heavily infested cuttings should not be sown as they will germinate poorly even if treated with a pesticide.

7.3 Management of major Diseases

Witches Broom

Cassava plant affected by Witches Broom can have the symptoms as below:

- a. Plants exhibit dwarfism and an exaggerated proliferation of buds; shoot proliferation and/or unusually rachitic branches growing from a single stake. Sprouts have short internodes and small leaves, but do not show deformation or chlorosis.
- b. Production of weak spindly sprouts on the stakes.
- c. Stakes produce only a few dwarf and weak spindly sprouts that never reach normal size.
- d. When the affected cassava is uprooted, the roots are thinner and smaller, with rough textured skins, and drastically reduced starch content.



For disease prevention, using healthy planting materials and eliminating diseased plants in the field are recommended. The disease is reduced by selecting stakes from healthy plants. Restrict the movement of cassava planting stakes, especially from infected areas and restrict the movement of related species such as jatropha.

Cassava bacterial blight

Cassava bacterial blight is one of the most widespread of the cassava diseases. It is transmitted by infected planting material and farm tools. It can be controlled by using varieties with good tolerance, soaking stakes in hot water before planting, sterilizing tools with disinfectant, and intercropping to reduce plant-to-plant dissemination

Symptoms characteristic of CBB are small, angular, aqueous-looking leaf spots found on the lower surface of the leaf blade. Or symptoms may be leaf blight or brown leaf



burn, wilt, dieback, and a gummy exudation in infected young stems, petioles, and leaf spots. The vascular bundles of infected petioles and stems are also necrotic, appearing as bands of brown or black color. Symptoms occur 11 to 13 days after infection. Some susceptible varieties present dry and putrid spots around necrotic vascular bundles.

Management

- a) Use CBB disease free planting materials
- b) Planting at the end of rainy periods,
- c) Crop rotation with grasses,
- d) Planting barriers (for example maize) to prevent dissemination by wind,
- e) Improving soil drainage,
- f) Weed control,
- g) Fertilizers application, mainly sources of potassium,
- h) Eradicating diseased plants,
- i) Preventing the movement of people, machines or animals from infected to healthy lots,
- j) Eliminating infected materials after harvest by burning branches and stems,
- k) Incorporating harvest residues into the soil.

Brown leaf spot

Symptoms in cassava leaves are characterized by leaf spots visible on both sides. On the leaves' upper surface, uniform brown spots appear, with defined and dark margins. On the leaves' undersurface, the lesions have less-defined margins, and, towards the center, the brown spots have a gray-olive background because of the presence of the fungus' conidiophores and conidia. As these circular lesions grow, from 3 to 12 mm in diameter, they take up an irregular angular form, their expansion being limited by the leaves' major veins.



The veins found within the necrotic area are black.

Sometimes, depending on how susceptible the variety is, an undefined yellow halo or discolored

area can be observed around the lesions. As the disease progresses, infected leaves become yellow and dry before falling off, possibly because of toxic substances secreted by the pathogen. Susceptible varieties may undergo severe, or even total, defoliation during the hot rainy season.

Phytophthora root rots

Root rot occurs mainly in poorly drained soils during intense rainy periods. It can be eliminated by planting stakes taken from healthy mother plants, using ashes and dry leaves as a soil amendment and fertilizer, and intercropping with cowpeas. An effective biological control is immersion of stakes in a suspension of *Trichoderma viride*, a soil fungus that parasitizes other soil-borne fungi.



Viral diseases

Viral diseases are usually transmitted through infected planting material. In addition, whiteflies are vectors for viruses that cause cassava mosaic disease (CMD) and cassava brown streak disease (CBSD), which can cause total crop failure. Key recommendations for control of CMD and CBSD are strict enforcement of quarantine procedures during international exchange of germplasm, and cultural practices, especially the use of resistant or tolerant cultivars and virus-free planting material.



8. Enhancing cassava productivity through farmer participatory research

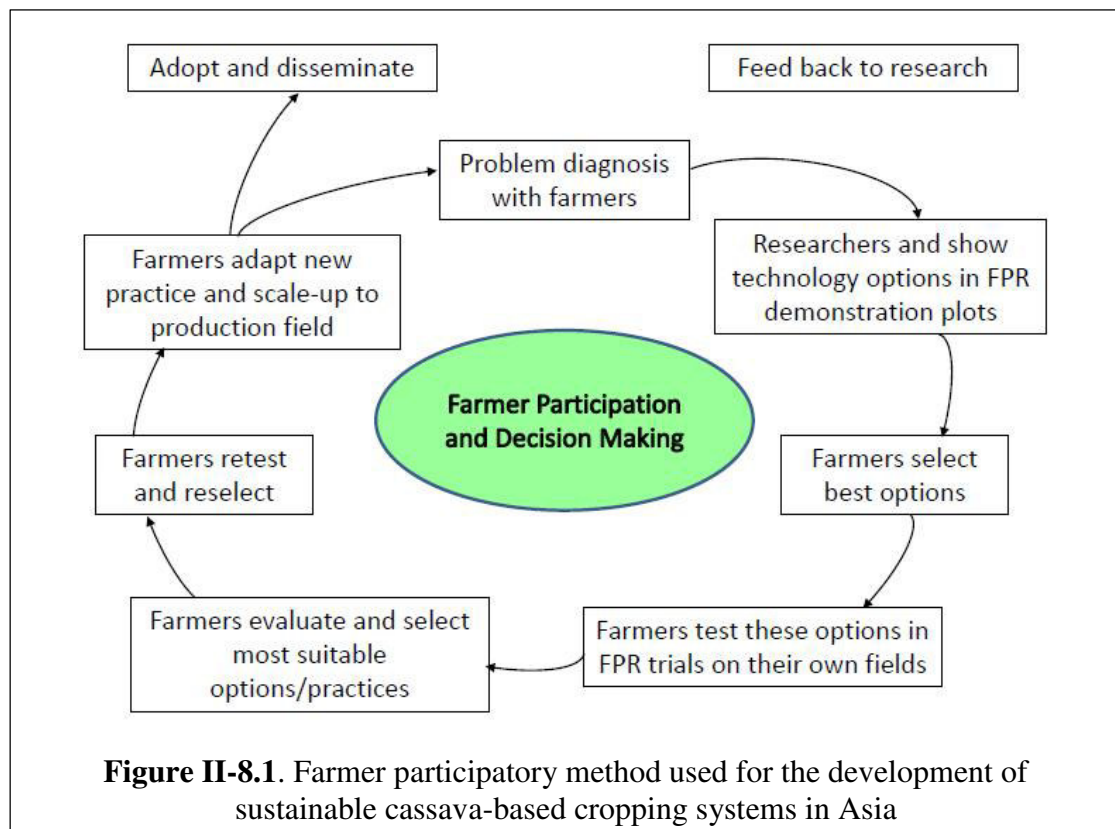
8.1 Introduction

Farmer participatory research (FPR) is a participatory approach, which involves encouraging farmers to engage in experiments in their own fields so that they can learn, adopt new technologies and spread them to other farmers. This is a new approach that encourage farmer to

directly involve in decision making and in the development of suitable practices that can increase yields or income for the farmers.

8.2 Farmer participatory research (Fig.II-8.1)

The basic idea behind the FPR approach is quite simple: to involve farmers directly in the development and testing of new technologies, and to let them make their own decisions about what they consider useful without making our own recommendations. The role of the researcher and extensionists changes from selecting and then recommending or transferring our selected technologies to being an equal partner with farmers in the quest for new technologies that are most useful in particular area. Government officials become facilitators in the process of helping farmers diagnose their own problems, select some promising technologies that might solve those problems, and then help them test those technologies on their own fields in simple FPR trials. From these trials farmers select the best treatment; they may test those again before selecting the very best ones to be tried in larger area of their production field, make some adaptations if necessary, and then adopt those practices considered most useful.



Steps in conducting FPR:

a) *Planning Meeting*

- The researchers as the facilitator conduct group meetings with farmer to discuss about cassava growing, related problems, and shows technology options.
- Discussions should focus on the topic of relevance to both farmer and researchers on enhancing cassava productivity such as cassava varieties, land preparation, planting materials and methods, weed and pest management, fertilizer application, multiple cropping, harvesting, storage, and processing.
- Encourage farmers to discuss which factors they need to improve for enhancing the productivity in order to select best options.
- Researchers, local extension groups and farmers meet to discuss and plan activities.

b) *Laying out the experiment*

- Each participating farmer would mark out a small area in his/ her field that can conduct the experiment plot to improve the productivity.
- During the cropping season, the researchers will make at least one follow-up visit to each participant.

c) *Support materials*

Provide participating farmers with some materials such as follows:

- A signboard with the farmer's name, collaborating agencies and experimental title for display in each participant's field.
- Book note and pen for recording farming activities and input costs.
- A set of instructions to conduct farmer participatory research.

d) *Monitoring*

- Before the experiments begin, conduct a short pre-FPR or baseline survey primarily to allow subsequent comparison of yields and costs of the practice of interest from the experimental plots. Determine their practices, and knowledge and attitude towards the problem.
- The second survey could focus on farmer practices, costs, perception of yield differences and benefits derived from applying the “new” treatment.

e) Farmer experience sharing workshop

- Organize a workshop where farmers will report their experimental results. Invite neighboring farmers and local extension technicians to participate in the workshop.
- Before the workshop, help each participating farmer to prepare his report on the results. Have a one-page cost and yield comparison between before- and after learning new techniques plots.
- During the workshop encourage farmers to discuss possible reasons for yield differences and their plans for future.

As a token of appreciation, give each participant a t-shirt or a cap, a certificate of participation or picture with their experimental plots.

f) Farmer to farmer

- To monitor diffusion, ask farmers in a monitoring survey for names and addresses of other farmers with whom they had directly shared the results of their experiment.
- Track down the farmers who heard about the experiment from the first group and had followed the simple rule that was tried out in FPR. If most of them are neighbors and relative, it could suggest that the spread may be through kinship and close proximity of their neighbors.

Chapter III: On-farm cassava utilization, cassava processing and exports

1. Nutritional values of cassava and the use of cassava roots for food and industrialized products

1.1 Introduction

Cassava is classified as sweet or bitter. Like other roots and tubers, cassava contains antinutritional factors and toxins. It must be properly prepared before consumption. Improper preparation of cassava can leave enough residual cyanide to cause acute cyanide intoxication and goiters, and may even cause ataxia or partial paralysis.

1.2 Nutritional values of cassava leaves

The nutrient composition of cassava leaves varies in both quality and quantity depending on the variety of cassava, the age of the plant, and the proportional size of the leaves and stems. Cassava leaves are rich sources of protein, minerals, vitamins B1, B2, and C, and carotenoids. Cassava leaf protein ranges from 14% to 40% of DM in different varieties. The carbohydrates in cassava leaves are mainly starch, with amylose content varying from 19% to 24% (Gil and Buitrago 2002).

Cassava leaves are rich in iron, zinc, manganese, magnesium, and calcium. Iron and zinc content in cassava leaf meal (CLM) are comparable to those reported for sweet potato leaves and peanut leaves (Table III-1.1).

The vitamin content of cassava leaves (Table III-1.3) is richer in thiamin than legumes and leafy legumes, except for soybeans (0.435 mg/100 g). The riboflavin (vitamin B2) content of cassava leaves surpasses that of legumes, leafy legumes, soybean, cereal, egg, milk, and cheese. The vitamin A content of cassava leaves is comparable with that of carrots and surpasses those reported for legumes and leafy legumes. The vitamin C content of cassava leaves is high compared to values reported for other vegetables. Thus, the overall vitamin content of the leaves is comparable and in certain cases better than those reported for most legumes, leafy legumes, cereals, egg, milk, and cheese.

Table III-1.1: Comparison of sweet potato leaf and peanut leaf nutrients with cassava leaf meal

Nutrient (100g dry weight)	CLM	Sweet potato	Peanut
Protein (g)	28.1	30.6	26.6
β-carotene (mg)	88.0	75	113.3
Vitamin C (mg)	90.2	141.7	293.3
Iron (mg)	16.7	14.7	16
Zinc (mg)	5.08	3.33	5.33
Manganese (mg)	14.1	–	–
Magnesium (mg)	229.3	493.3	676.7
Calcium (mg)	1509.4	623.3	1236.7

Source: Wobeto et al., 2006

The fiber content of cassava leaves is high (Table III-1.3). Dietary fiber is considered part of a healthy diet and can reduce problems of constipation. Although recent evidence is mixed, fiber may help prevent colon cancer. The rich fiber of cassava may assist intestinal peristalsis and bolus progression, but if fiber content from any source is too high, it will have negative effects in humans. Fiber can be a nutritional concern because it can decrease nutrient absorption in the body. Excess fiber will increase fecal nitrogen, cause intestinal irritation, and reduce nutrient digestibility, in particular protein digestibility. It is important to optimize the utilization of nutrients from cassava because nutrient deficiencies are more prevalent in regions where cassava is used as a staple food

1.3 Nutritional values of cassava roots

Cassava roots are rich in carbohydrates, mainly starch, and are a major source of energy. Cassava leaves contain more protein than the roots but they lack the essential amino acid, methionine. The leaves are used for human consumption and animal feed. The composition of cassava depends on the specific parts (root or leaf) and on several factors, such as geographic location, variety, age of the plant, and environmental conditions. The roots and leaves, which constitute 50% and 6% of the mature cassava plant, respectively, are the nutritionally valuable parts of cassava. The nutritional value of cassava roots (Table III-1.2) is important because they are the main part of

the plant consumed in developing countries. In Table III-1.1, the proximate, mineral, and vitamin compositions of cassava roots and leaves are reported.

Cassava is a good source of minerals such as calcium, phosphorus, manganese, iron and potassium. These minerals are necessary for proper development, growth and function of human body's tissues. For example, calcium is necessary for strong bones and teeth; iron helps in the formation of two proteins hemoglobin and myoglobin which carry oxygen to your body tissues; and manganese helps in the formation of bones, connective tissue and sex hormones. Potassium is necessary for synthesis of proteins and helps in the breakdown of carbohydrates.

Cassava contains high amounts of dietary fiber, which can help prevent constipation. According to the Mayo Clinic website, fiber also helps you lose weight as it promotes lasting satiety. It may also help reduce your unhealthy cholesterol levels, which lowers the risk of cardiovascular diseases. If you are suffering from diabetes, eating fiber-rich cassava may help lower your blood sugar levels. This is because fiber slows the absorption of sugar into the bloodstream.

Cassava contains 38 grams of carbohydrates per 100-gram serving. This makes it a good energy source for individuals who engage in strenuous physical activities. Such activities deplete glycogen, which is the form in which glucose is stored in the muscles. When you eat cassava, the carbohydrates present in it are converted to glucose in your body, which is then converted to glycogen and stored in the muscles.

Absence of the allergenic protein gluten makes cassava flour a good substitute for rye, oats, barley and wheat. Persons diagnosed with celiac disease and other gluten-based allergies can find relief in consuming foods made using tapioca or cassava flour. Although baking cakes, bread and other foods requires gluten to enable them to swell in size, it can be substituted with guar and xanthan gum.

Cassava is a good source of saponins. These phytochemicals may help lower unhealthy cholesterol levels in your bloodstream. They do so by binding to the bile acids and cholesterol, thus preventing them from being absorbed through the small intestines. The antioxidant effects of saponins may help protect your cells from damage by free radicals.

Table III-1.2: Nutritional value of cassava root (*Manihot esculenta* (L.) Crantz), per 100 g,

Principle	Nutrient Value	Percentage of RDA (Recommended Dietary Allowance)
Energy	160 Kcal	8%
Carbohydrates	38.06 g	29%
Protein	1.36 g	2.5%
Total Fat	0.28 g	1%
Cholesterol	0 mg	0%
Dietary Fiber	1.8 g	4%
Vitamins		
Folates	27 µg	7%
Niacin	0.854 mg	5%
Pyridoxine	0.088 mg	7%
Riboflavin	0.048 mg	4%
Thiamin	0.087 mg	7%
Vitamin A	13 IU	<1%
Vitamin C	20.6 mg	34%
Vitamin E	0.19 mg	1%
Vitamin K	1.9 µg	1.5%
Electrolytes		
Sodium	14 mg	1%
Potassium	271 mg	6%
Minerals		
Calcium	16 mg	1.6%
Iron	0.27 mg	3%
Magnesium	21 mg	5%
Manganese	0.383 mg	1.5%
Phosphorus	27 mg	4%
Zinc	0.34 mg	3%

Source: USDA National Nutrient data base

Table III-1.3: Proximate, vitamin, and mineral composition of cassava roots and leaves

Proximate composition (100g)	Raw cassava	Cassava roots	Cassava leaves
Food energy (kcal)	160	110 – 149	91
Moisture (g)	59.68	45.9 – 85.3	64.8 – 88.6
Dry weight (g)	40.32	29.8 – 39.3	19 – 28.3
Protein (g)	1.36	0.3 – 3.5	1.0 – 10.0
Lipid (g)	0.28	0.03 – 0.5	0.2 – 2.9
Total carbohydrate (g)	38.06	25.3 – 35.7	7 – 18.3
Dietary fiber (g)	1.8	0.1 – 3.7	0.5 – 10.0
Ash (g)	0.62	0.4 – 1.7	0.7 – 4.5
Vitamins			
Thiamin (mg)	0.087	0.03 – 0.28	0.06 – 0.31
Riboflavin (mg)	0.048	0.03 – 0.06	0.21 – 0.74
Niacin (mg)	0.854	0.6 – 1.09	1.3 – 2.8
Ascorbic acid (mg)	20.6	14.9 – 50	60 – 370
Vitamin A (µg)	–	5.0 – 35.0	8300 – 11800
Minerals			
Calcium (mg)	16	19 – 176	34 – 708
Phosphorus (mg)	27	6 – 152	27 – 211
Iron (mg)	0.27	0.3 – 14.0	0.4 – 8.3
Potassium (%)	–	0.25	0.35
Magnesium (%)	–	0.03	0.12
Copper (ppm)	–	2.00	3.00
Zinc (ppm)	–	14.00	71.00
Sodium (ppm)	–	76.00	51.00
Manganese (ppm)	–	3.00	72.00

Source: Julie A. et al., 2009

1.4 Anti-nutrient in cassava

Analyzing the nutritional value of cassava, it appears that cassava roots are a good carbohydrate source and cassava leaves are good mineral, vitamin, and fiber sources for humans. However, cassava contains anti-nutrients and toxic substances that interfere with the digestibility and the

uptake of some nutrients. Nevertheless, depending on the amount consumed, these substances can also bring benefits to humans.

Cyanide is the most toxic factor restricting the consumption of cassava roots and leaves. Cassava-eating populations ingesting cyanide and high amounts of nitrates and nitrites have the risk of developing stomach cancer. Phytate (inositol hexakisphosphate) is another compound found in high abundance in cassava, with approximately 624 mg/100 g in roots. Phytic acid is able to bind cations such as magnesium, calcium, iron, zinc, and molybdenum and can, therefore, interfere with mineral absorption and utilization which may affect requirements. It may also bind proteins preventing their complete enzymatic digestion (Singh and Krikorian 1982). However, phytic acids also have antioxidant and anti-carcinogenic properties. Indeed, phytic acids can reduce free ion radical generation and thus peroxidation of membranes by complexing iron, and phytate may protect against colon cancer. Phytate was able to reduce serum cholesterol and triglycerides in an animal model fed a cholesterol-enriched diet. Oxalates are anti-nutrients affecting calcium and magnesium bioavailability and form complexes with proteins, which inhibit peptic digestion. The negative effect of oxalates on humans depends on the level of both oxalate and calcium in the cassava leaves.

Is Cassava toxic?

Cassava should never be eaten raw as the root composes small quantities of cyanogenic glycosides, especially hydroxycyanic acid. Cyanide compounds interfere with cellular metabolism by inhibiting the cytochrome-oxidase enzyme in the human body. The amount of these toxic compounds varies according to cultivars and growing conditions. There are many types of cassava based on the amount of cyanide content of the tubers: sweet cassava contains 40 - 130 ppm (parts per million) cyanide; non-bitter cassava, 30 - 180 ppm; bitter cassava, 80 - 412 ppm; and very bitter cassava, 280-490 ppm. At concentrations less than 50 ppm, the cassava products are considered harmless. The cyanide content of the sweet cassava tubers is mainly located in the skin, therefore, sweet cassava only require peeling and boiling to reduce the cyanide content to non-toxic levels. The bitter varieties are usually grated or chopped finely and allowed to soak in water where fermentation occurs, converting the cyanogenic glucosides into cyanide which is released in the environment. Drying (for storage purpose) and boiling will further detoxify the tubers. Only young leaves of the cassava plant are eaten and they require boiling prior to consumption. Peeling followed by cooking ensures them safe for consumption by

removing these compounds. Therefore, cassava is known to contain levels of cyanide so the leaves and skin of the root should be avoided. Cooking or soaking the cassava root makes it safe for consumption.

1.5 The use of cassava for food and industry

Culinary Uses of Cassava

Cassava can be consumed in different ways. In many countries, cassava is handled similarly to potatoes, meaning they are eaten as mash, fried or boiled.

In Africa, cassava “mash”, fufu, is widely consumed by pounding and sieving cassava to make flour which is then put into hot water. This is a particularly popular food in Nigeria, Ghana and the Democratic Republic of Congo. Cassava is also used to make gari, a kind of cassava porridge, which is a white flour made from fermented cassava tubers. The flour can be added to cold water and milk and seasoned to taste.

In Latin America, cassava is mostly fried and offered as “yuca frita” as a side dish. In Panama, yuca is used in Sancocho, a chicken soup. **Carimañola** is a Panamanian dish that is a stuffed cassava fritter. It is normally stuffed with cheese, meat or chicken and then fried.

In the west, cassava is widely used in the form of tapioca which is a flavorless, starchy ingredient used as a thickening agent in foods. It is gluten-free and therefore used in many gluten-free foods. Tapioca is also used to make tapioca pudding and used to make gluten-free bread. Tapioca is also a main ingredient in the popular Bubble Tea, a Taiwanese Drink that is has a tea base and includes tapioca pearls.

In Asia, cassava utilization patterns vary from country to country. In Thailand, the world’s largest producer, cassava is used for production of starch and pellets for exports, and is not directly used as a staple food, although small quantities are consumed in snack form. Cassava produced in the Philippines is used predominantly for starch production and as a domestic food. In Malaysia, cassava is mainly processed into starch, while some is used as a traditional food. Cassava utilization in Indonesia differs throughout the country. In java, cassava is used as food, whereas in south Sumatra it is used for production of starch and animal fee, the latter mainly for export. In India, cassava is used as human food and for starch production. Some poorer districts of China and Vietnam, nearly all cassava for food is first processed; direct consumption of baked

or boiled fresh roots is minor. This form of consumption is largely a rural practice, and often by households having cassava in their own backyard garden.

Industrial Use

- **Animal Feed:** There is rapidly growing demand for **cassava pellets** for the use of animal feed as it provides many a lot of calories to animals. **Cassava pellets** are easier to transport and pack and easier for animals to consume than whole cassavas.
- **Ethanol:** Ethanol is produced by fermenting and distilling cassava. **Ethanol** has various industrial uses: It can be mixed with petrol or used on its own as a transport fuel. It can also be used as a base for alcoholic beverages. Lastly, ethanol can be utilized as industrial alcohol which is important in the pharmaceutical and cosmetic industry.
- **Flour:** Cassava Flour offers several benefits: It is completely gluten-free and can be used as a substitute for wheat flour in bakery and other products.
- **Starch:** **Cassava starch** can be extracted from cassava roots to form which are used by the food industry, but is also used by the paper and textile industry, as well as an adhesive in glass, mineral wool and clay. Starch for industry is classified as native or modified. The technology for modifying starches with physical, chemical and biological processes is highly advanced and evolving rapidly. These modified starches are absorbing an increasing market share. At the same time, there is pressure in some industries, especially foods, to move away from modification based on chemicals.

2. Use of cassava leaves and roots for animal production

2.1 Introduction

The use of cassava leaves and roots in animal production is either not known or not practiced by many farmers. In particular for smallholder pig producers, using cassava leaves and roots can substantially reduce cost of production as these resources can be obtained locally through various ways. The limitation of the use of cassava leaves and roots is due to the level of toxicity and fiber content. Younger leaves have lower fiber content but higher protein and toxicity while older leaves have lower toxicity and protein but higher fiber.

Fiber content and toxicity might be the limiting factors for pig feeding. However toxicity can be reduced through several processing methods such as sun-drying, cooking, ensiling and wilting. Cassava leaf has high protein content varied between 20-30% and has also good amino acid

profile. Cassava roots can be good source of energy for pigs kept by medium and small scale farmers when the price of by-products from grain especially rice increase. Cassava roots have been using successfully in pig feeding.

2.2 The use of cassava leaves

Top cassava leaves are used as vegetables for human consumption in many countries in Asia and Africa. There is a conflict however between the use of cassava leaves and roots. It has been reported that if farmers harvest cassava leaves 2-3 times before harvesting, roots production can be decreased by 20-30%.

On a small scale, farmers can grow cassava in their backyard, green fence or in a combination with other crops. They can then harvest regularly and prepare a cassava leaf meal or silage for their pigs. Cassava leaves contain toxic compounds (cyanogenetic glycosides) but the toxicity can be reduced to minimal levels after boiling, ensiling or sun-drying and can then be used in animal feed. The most common methods recommended for smallholder farmers in using cassava leaves to feed their pigs are ensiling and sun-drying.

Amongst the two, using sun drying is cheap and easy for smallholder animal production farmers. However this method can have serious problem in particular during the wet season when there is not enough sun light for drying and rain can be at any day or every day. In contrary, as it does not required sun light for cassava leaves preparation, ensiling method can be used any time of the year. Cassava leaves preparation steps using ensiling method are shown below:

Step 1:

- Harvest cassava leaves - preferably the top 30-40 cm.
- Remove leaves from stems and petioles.
- Wilting 3-5 hours.
- Chop 3-5 cm

Step 2:

- Mix 5kg of molasses with 5 kg of water in a basket

Step 3:

- Place a plastic sheet on the ground under the shade
- Put 20kg of chopped cassava leaves on the plastic sheet
- Spray 1/5 of the mixed water and molasses over 20kg chopped cassava leaves

- Mix cassava leaves thoroughly with the solution.

Step 4:

- Place the plastic bag inside the container or polyethylene bag
- Put the mixture into the plastic bag
- Press it strongly to get the air out
- Repeat Step 3 and 4 until getting silage done.
- Seal the plastic bag with motorcycle inner tube
- Keep the container with silage in the place out of children, dogs, cats and rats.

Ingredients:

- Cassava leaves: 100kg
- Molasses: 5kg
- Water: 5kg

- The silage can be used after 30 days.
- Be careful to feed cassava leave silage to the recent weaning pigs because their digestive tract is not yet adapted to the diet with high fiber content.
- Pigs generally do not have problem with fermented feed but make sure the silage is in good quality with green yellowish colour. The good silage smell nice lactic acid but bad silage has the butyric acid odor. Should not use, if the silage becomes brown
- Preferably feed about 1/3 of the total pigs diet with the weight around 20-25 kg.

2.3 The use of cassava roots

Cassava root is a good source of energy particularly for pig production. It is known to have been successfully used in pig feeding for many years by local farmers. Similar to its leaves, cassava root is also content some toxicities for pig especially the peels of the root. Therefore to use it for pig feeding, cassava roots need to be processed to reduce the quantity of the content toxicity. There are several techniques such as boiling, sun-drying and ensiling that can serve the purpose.

Boiling is time consuming and not very practical because farmers have to cook the roots more often. Cassava roots after taking out from the soil are not last longer without processing them. In addition boiling needs firewood which is at present not easy to collect it for free.

Sun-drying is cheap and practical for smallholder farmers. Normally in order to dry faster, roots are chopped into small pieces. Other than to dry faster, this practice can have another implication through the release of the toxic chemical compound cyanide from cassava chips faster. Nevertheless, one difficult part in this method is to keep the chips under the country hot-humid climate.

Cassava roots have been successfully made into silage for smallholder farmer conditions. The root silage is likely to be the most convenience technique for the farmers. Followings are steps to produce cassava root silage.

Step 1:

- Harvest cassava roots
- Clean roots with water to remove soil and brown shell
- Wilting for 3-5 hours.
- Chop the roots for a size of 2-3 cm in an open space

Step 2:

- Place a plastic sheet on the ground
- Put 20kg of chopped cassava roots on the plastic sheet
- Put 0.1kg of salt over the chopped cassava roots
- Mix it very well with salt.

Step 3:

- Place the plastic bag inside the container or polyethylene bag
- Put the mixture into the plastic bag
- Press it strongly to get the air out
- Repeat Step 2 and 3 until getting silage done.
- Seal the plastic bag with motorcycle inner tube
- Keep the container with silage in the place out of children, dogs, cats and rats.

Ingredients:

- Cassava leaves: 100kg
- Molasses: 0.5kg

- The silage can be used after 30 days.
- Good cassava root silage has a yellowish color with attractive odor for pigs.
- Feeding large quantity might impact on the color of the pig meat.
- Pigs between 2-4 months are fed with 1-1.5kg of cassava roots silage while after these ages they can be fed 3-6 kg.

3. Production chain of noodle and sago

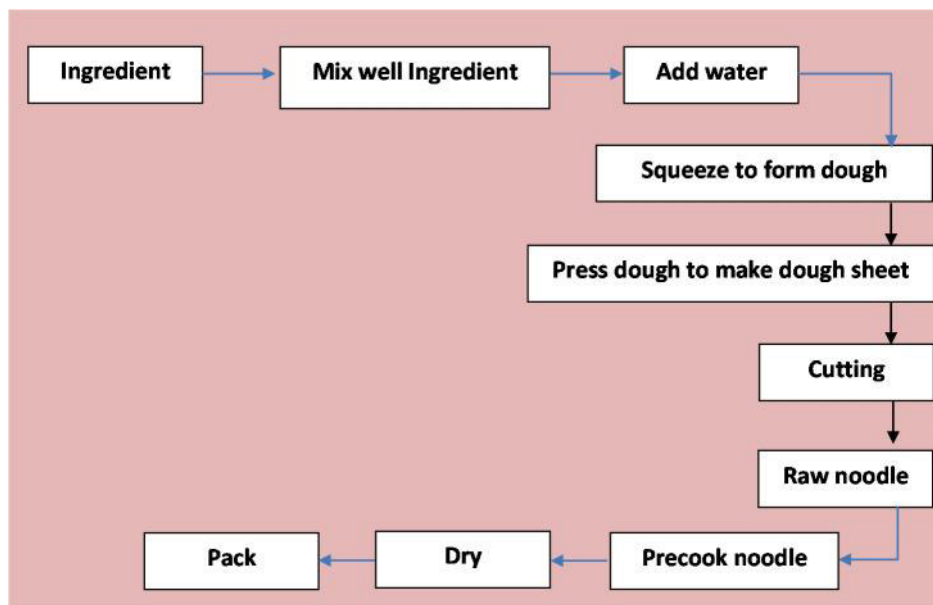
3.1 Introduction

Similar to most countries in Asia, except for the production of instant noodle, noodle production in Cambodia is in small to medium size. At the present, the most popular forms of noodle that are used for everyday consumption in the country are Kuy Teav, Mee, and vermicelli.

Noodle can be made from rice, cassava (tapioca) and wheat powder. Generally, the way to produce noodle varies from one processor to the others and there is no common formula for its production. Nevertheless, general steps in its production can be prescribed.

3.2 Noodle processing

Cassava noodle processing in Cambodia is still dominated by small-scale industry. Other than variation in specific ingredients for different type of noodles, the process of their manufacturing, up to the cutting stage, is common for all types of noodles and is shown below.



1) Ingredients



Cassava starch: 1000g

Salt: 10-15g

Water: 300-350g

2) Dough making



Mix well the dried ingredient together. Add water to the mixed ingredient and squeeze by hand or mix by machine 5- 20 minute. Dough is formed

3) Dough sheet



The dough is pressed into the dough sheet prior to cut or press into different shape of noodle. In the case of large amount of dough, the used of machine is essential.



4) Cutting noodles



Dough sheet noodle can be cut by hand or machine and can be direct used by cook it immediately and mix with soup, and can make it small bowl and dry it.

5) Precook



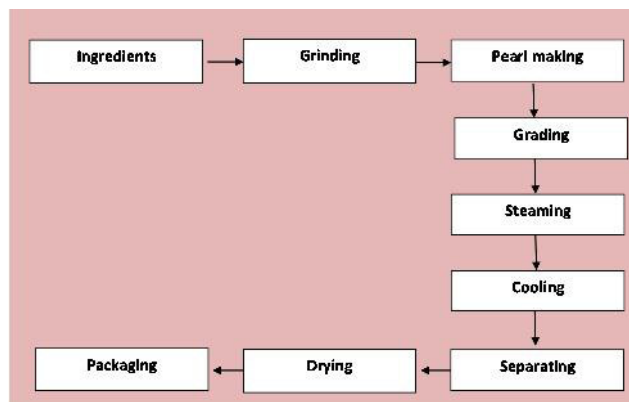
After cutting, the noodle can be precook and coat with oil to keep the strands from sticking together or can dry by sun or in room by air

6) Packaging

After drying properly, the raw or precook noodle has to be packed properly in the clean package to protect it from the contamination prior to access in the market.

3.3 Sago processing

In Cambodia, processing industry for tapioca sago is still small and medium scale. The initial stages of tapioca sago processing up to the packaging stage are common to all sago production as indicated in the diagram below.



1) Ingredients



- Wet starch
- Dry starch
- Water
- Food color (option)

2) Grinding



After mixing well the ingredient (dry starch 60 % and water 40%) in case dry starch is used, or even if the wet starch is used it needs to be grinded to small pieces by using the powder making machine.

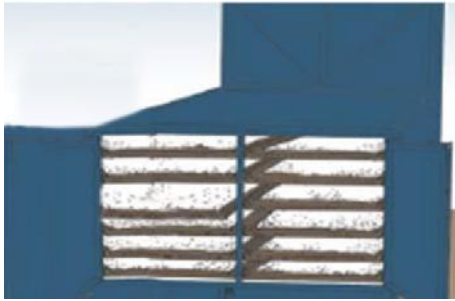
3) Pearl making

Making pearl is the very important stage in Sago making. After wet starch is ground, the smooth powder is shaken by using clothes or sieve.

4) Grading

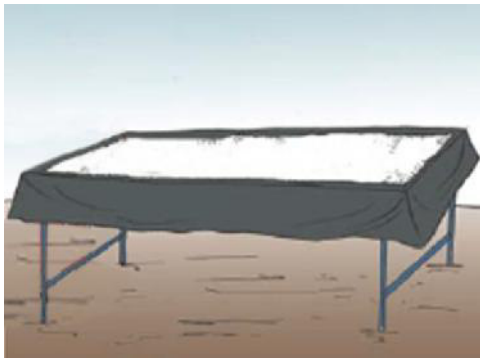
After the pearl is made, the next stage is to grade the pearl by size that the market needs. In Cambodia, the size of pearl should cross the sieve number 30 that has 5 holes in 1 inch but should not cross the sieve number 22.

5) Steaming



After grading, the pearl of sago should be transferred to the next stage which is steaming. The pearl sago is put in the steam tray and put into the steam chamber. It takes about 2.5 to 3 hours.

6) Cooling



Cooling is the stage that to reduce temperature of sago pearl after steaming. After the pearl Sago is well cooled it can be transferred to the cool dry area to cool the pearl before continuing for another process.

7) Separating

After the sago pearl is cool enough it should be transferred to separating stage. This stage is important because generally after steaming the pearl tends to stick with one another so we need to separate them by using the sieve number 35 that has 4 holes in 1 inch.

8) Drying



After separating, the sago pearl will be transferred to drying floor to be dried to moisture content about 12-14 %. It can be dried under sun or by using dry chamber.

9) Packaging



After appropriately dried, the sago pearl can be packed for long time storage and as well as to avoid from contamination. Depending on the market demand the pack can be 1kg, 5kg, and 20kg in one package.

4. Production chain of tapioca wet-starch

4.1 Introduction

Cassava starch is used for the production of many kinds of products such as noodle and bread. Cassava starch can be classified as dry and wet. Wet starch is used as the main ingredient for the production of maltose, dessert, sago, and noodle.

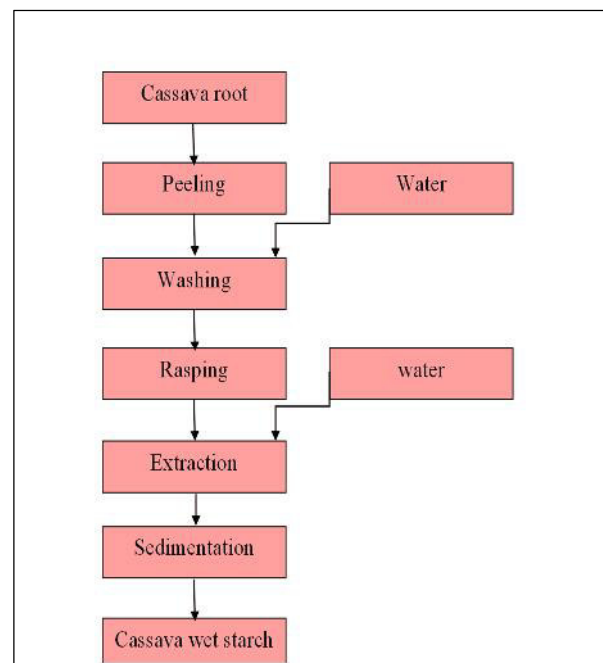
Regardless of what happened in the other countries, wet starch production in Cambodia is still at the infancy state and many improvements are required. The industry is still either a family business or small scale processing and for that reason the existing processing facilities are still traditional.

4.2 Cassava wet starch processing

The processing of cassava root into wet starch involves washing, rasping, extraction, sedimentation, and storage as shown in a general diagram below:

a. Cassava root

Generally age of harvested cassava plants and quality of roots are the critical factors in cassava starch production. There are varieties of cassava that are known to produce good quality of starch, it



is important to use these varieties to obtain the highest quality. Freshly harvested roots must be processed immediately for good starch quality. Use fresh cassava root harvested 10-12 months after planting. The fresh root must be clean without rot and well handle from farm. The cassava roots have to sorting by select clean roots for processing and discard the unwholesome roots.

b. Peeling and Washing

In small and medium-size mills the general practice is to remove the peel (skin and cortex) and to process only the central part of the root, which is of much softer texture. With the relatively primitive apparatus available and limited power, the processing of the whole root would entail difficulties in rasping and in removing dirt, crude fiber and cork particles, whereas comparatively little extra starch would be gained. Wash peeled root in clean water at least twice is important for the removal of pieces of peel, all sand particles and other dirt, which could – reduce the quality of the final product. It has many methods to wash the cassava root event by manual and mechanical.

c. Rasping

Grate root properly in clean stainless steel grater to obtain uniformly smooth mash. The grated mash must be uniformly smooth without lumps. In case of non-uniform mash, grate again until smooth mash is obtained. The smoothness of the mash determines the quality, yield and market value of the finished wet starch. Engine-driven rasps are more economical when production rises above a certain level - say,



for the handling of 10 tons of fresh roots a day. The machine has a rotor of hardwood or drawn steel tube, 50 cm in diameter, with a number of grooves milled longitudinally to take the rasping blades or saws. The number of saw teeth on the blades varies from 10 to 12 per centimeter according to need. The blades are spaced 6-7 mm apart on the rotor.

d. Extraction

After rasping the fresh pulp were received. In this stage the milk will separate from the slurry. The pulp was stirred by hand or motor with water prior to being sieved through a cotton filter cloth. Other extraction method consider of a vertical stirring axle placed in an aluminum tank flanked by two baffles which were fixed 10 cm from the bottom of the tank and a cotton filter cloth was placed on the bottom screen of the extractor (Fig. III-4.1).

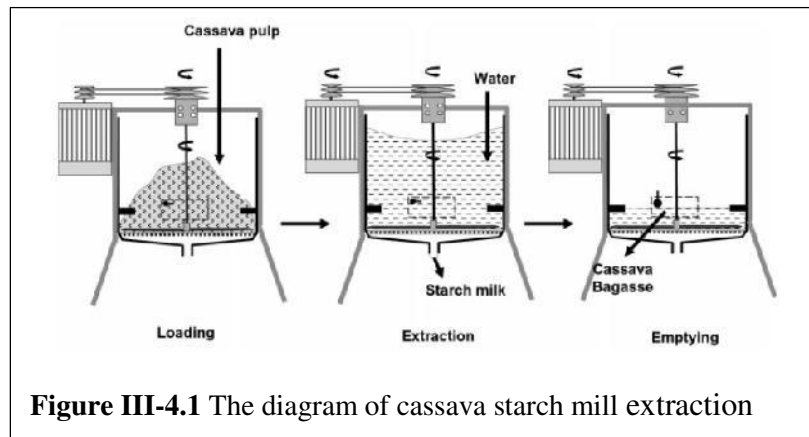


Figure III-4.1 The diagram of cassava starch mill extraction

e. Sedimentation

Sedimentation on one flour table is not usually sufficient to effect a complete separation of pure starch from slurry. One obvious defect of both tables and sedimentation tanks is that they do not separate contaminating particles heavier than starch (sand, clay). In the large factories, when producing a high-grade flour the product is collected, after a first tabling, in containers with conical bottoms, where it is stirred moderately with fresh water. Heavy particles settle in the lower part of these stirring tanks and can be discharged from time to time from a tap in the bottom. The flour milk obtained is then pumped to a second table or set of parallel tables, where settling takes place. To prevent any reaction between the flour milk and the wall material, these channels may be coated with a resistant material such as aluminum.

f. Packaging

The wet starch can be pack in the sac or can be make as block after dewater from the sedimentation stage. Or the wet starch can be delivery to continue processing in other food, sugar and/or ethanol factory.

5. Storage and storing conditions for cassava products

5.1 Introduction

Cassava is used as raw material for food and non-food products. The quality of these final products depends on several factors. One of the most important factor is storage conditions and control measures. These conditions, depending on how proper management is taken into account, can have significant effect to the quality and quantity of the final product. Therefore, this chapter is mainly to describe about (i) quality of semi products to be storage, (ii) condition of storage, and (iii) controls measure during storage. These three main concepts will provide the basic knowledge and practical skill to maintain the original quality (Table III-5.1), to prolong self-life and decrease deterioration rate of the cassava product (dried chip, dried starch, wet starch and sago and saray).

Packaging and storage technology is important for cassava processed product. The proper storage technique will help maintaining the quality and shelf life of cassava product after processing. The good packaging and storage facility can decrease of risk and contamination of final product. In addition, well organized packaging and storage will provide the confident to the consumer and reduce the cost of traceability.

Table III-5.1: General specification of cassava starch

Attribute	Specification
Moisture content (% maximum)	13
Starch content (%minimum)	85
Ash (%maximum)	0.2
pH	5.0 to 7.0
Whiteness (Kett scale, minimum)	90
Viscosity Barbender unit, BU, minimum at 6% dry weight concentration	600
Sulfur dioxide content (ppm, maximum)	30
Cyanide content	Nil
Appearance	White, no speck, fresh odor

Source: James, N. B and Roy L.W, 2009, Starch: Chemistry and technology

5.2 Factors affecting the quality of cassava products

Major factors affecting the storage of cassava products include:

- Micro-organisms
- Insects, mite and pests
- Rodents
- Environmental factors

Major micro-organism associated with storage includes fungi, bacteria and yeast. Through the activities of micro-organism can result in color degradation, off flavor, moisture upgrading, wet spot & moldiness, and loss of viability, etc.

Insects, mites and pests attack both the stored material and wooden components of the storage structure. They can attack dried chips, starch, sago and saray and bore through them, and lay eggs in the storage facilities/structures. They reduce product weight, quality, nutritional value and viability.

Rodents are mammals that parasite on stored materials and attack storage structures. They eat cassava products and waste the remaining parts. They are vectors and can contaminate stored products with their faeces, urine and carcasses.

The environmental factors that mostly associated with cassava stored products include temperature, relative humidity, and storage time. When stored in areas of high relative humidity, the chips and starch or sago and saray product absorb greater amount of moisture. As a result, the bulk swelling power of the chips and starch or sago and saray decreases. Conversely, chips and starch or sago and saray stored in areas of low relative humidity have lower moisture content. As a result, it has a greater water uptake and a higher bulk swelling power. Besides, storage in high relative humidity areas for a long period of time causes the chips and starch or sago and saray to deteriorate due to microorganisms and biochemical reactions. It was reported that swelling power and percentage of solubility of cassava chips and starch or sago and saray decreased as the degree of microbial contamination increased. The amount of sulfur dioxide also greatly affects the quality of cassava starch during storage. It has been shown that viscosity of starch with high amount of sulfur dioxide decreases faster than that of starch with lower amount of sulfur dioxide

It is noted that for small scale processing of cassava product in Cambodia, the packaging and storage practice is very poor in term of hygiene which may lead to the contamination and high risk of product deterioration. Generally, the storage facility is rarely clean or washed that result in very dusty or wet condition within the storage. This problem may deteriorate of cassava product through moldy and other insect contamination (Picture III-5.1).

Picture plate III-5.1. Storage facility and practice of wet starch processor and wet starch as raw material for sago & saray processing

5.3 Storing conditions

Storage is the art of keeping the quality of cassava product and preventing them from deterioration for specific period of time, beyond their normal shelf life. Inappropriate storage conditions may result in many disadvantages of products and adding to the cost of production because of quality and quantity losses during this period. There are several reasons for cassava product to be stored such as:

- Provision of food materials all year round
- Pilling/ provision for large scale processing
- Preservation of viability for multiplication
- Preservation of nutritional quality
- Weapon for national stability
- Price control and regulation
- Optimization of farmers' gain / financial empowerment of farmers, and
- Opportunity for export market, etc

To ensure the storage quality of cassava products, storing condition should meet the following appropriate conditions:

- Proper temperature.
- Proper relative humidity
- Free from insect and other biological factor
- Good ventilation in storage structure

In addition, controlled measures of cassava product quality should be also taken into account both before and during storage. Pre-storage quality is very important to deliver the good quality

of stored product and prolong the storage life. This refers to the initial quality of processed cassava products prior to storing includes moisture content, no contamination from biological factors and other physicochemical properties. The technologies applied to produce cassava product will also affect the storage life and quality change of the stored product.

Cassava chips, cassava starch and sago and saray are hygroscopic and tend to draw moisture which promotes the formation of mold and thus early deterioration. Generally, cassava product contains low moisture content of 9-11 percent and low density, therefore, a lot of dust may be generated during packaging and storage. If the storage of cassava product is available prior to packaging, its moisture content will come close to equilibrium with the atmosphere and there will be less dust generated during packaging. The packages bags are placed on pallets, with stacks of more than four or five meters being avoided. The packaged starch is stored and distributed based on a first-in, first-out system.

Controlled measure is to ensure the quality of processed cassava products can be maintained or prolonged. That mean several measure techniques are needed to maintain the original quality of cassava products by avoiding from insects, weight loss, and other physicochemical properties. The measures techniques depends on each type of processed products as their physical and chemical characteristic are different during the processing.

Good storage depends on the moisture content of the products and temperature and relative humidity of the storage environment. The structure of the storage should be preventive from insect and other biological factors that may harmful to the quality and quality of the stored cassava product. The moisture content of most of cassava processed product for safe storage is about 12.7% with storage temperature at around 27°C and relative humidity 65-75%.

6. Waste and waste management in cassava processing (medium and large)

6.1 Introduction

Cassava processing is generally considered to contribute significantly to environmental pollution through its production of large amount of wastes. The wastes produced by cassava processing can be solid and liquid. The wastes can have strong and unpleasant odor. Most of the case, wastewater (liquid waste) from the processing plant is the major concern to the public. This is become more constraint of the business if proper management was not take into account. Depending on the processing methods and technologies applied in cassava processing plant.

In Cambodia, various form of processing such as dried starch, wet starch, methanol production, animal feed and many other processing forms of cassava are greatly increasing which contribute and play an important role in the economic growth of Cambodia. However, this production sector is also challenging to the environmental problems as in above mentioned due to lack of investment, technologies constraint and lack of human resource to adapt the proper techniques in managing the waste and prevention environmental pollution. This is become true that some cassava processor feel hesitate or not ready to applied the technology that available due to less confident with those technologies along with their limited investment.

Proper waste management is very important for cassava processors in providing the sound environment and its legality under the environment law. One of the keys success techniques in manage of the waste from the cassava processing is to educate the processors to understand those impacts and how to recycle, reuse and manage the waste effectively. Therefore, training cassava processors on waste and waste management is the key success of sustainable development in cassava processing sector.

6.2 Type of wastes

Waste, also known as rubbish, trash, refuses, garbage, junk, litter, and ort, is unwanted or useless materials. In biology, waste is any of the many unwanted substances or toxins that are expelled from living organisms, metabolic waste; such as urea and sweat. According to Basel Convention's definition wastes are "substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of the law", while disposal means "any operation which may lead to resource recovery, recycling, reclamation, direct re-use or alternative uses".

Cassava processing generates two types of wastes, solid and liquid wastes. In addition it also produces two types of liquid waste, the first one is produced by washing and peeling of cassava roots that generally contains a large amount of inert material and, the second one is produced by draining starch sedimentation tank.

In the process of producing dried starch, a big quantity of fresh roots and big amount of water are used. Left over parts of the fresh root such as peel, some soil debris and used water for cleaning become both solid and liquid wastes. These wastes are produced at different processing stages as indicates in Table III-5.1. Most people considered unpleasant smell produced by cassava dried

starch processing is the major disturbing waste as it can reach up to 500 meters in diameter in addition to many waste products derived from dried starch processing which can have strong negative impact to the environment, especially if no proper management has been taken.

Table III-6.1: Types of wastes and their environmental impact of various unit operation used in cassava processing

Unit operation	Type of waste generated	Expected environmental impact
1. Washing	Organic matter, soil.	Little impact.
2. Retting	Cyanide diffused into rivers, ponds or back-water. Organic matter.	High HCN concentration in the waste water can be a problem if used directly on land. Dissipation is rapid if passed to waterways. Organic matter is a problem, causing high BOD and COD, and eutrophication of waterways and foul odors.
3. Peeling	Peels with high fibre and high cyanide content.	Can contaminate ground water supply during rain. Foul odor. Cyanide is a problem if used as a feed.
4. Squeezing	Effluent with high content of cyanide and organic matter (mainly starch).	High HCN may kill plants if effluent is allowed to run out on land. Dissipation should be rapid if released into waterways. Organic content may contaminate ground water supply and cause eutrophication of surface water and foul odor.
5. Drying and cooking	Cyanide vapors, ash (from firewood).	Cyanide vapor is not likely to be a problem unless processing is done in an enclosed space.
6. Sieving	Fibrous waste.	If exposed to rain, the seepage of organic material from stored waste could contaminate the ground water
7. Sedimenting	Starch residue. Waste water.	Foul odor, Organic matter is a problem, causing high BOD and COD, and eutrophication of water ways.

Most of wet starch processing in Cambodia is considered as small scale processor, with the capacity of producing wet starch of 30 tons of fresh root per day. However, their waste produce has also adverse impact to the environment if no proper managed.

In the process of wet starch production, several forms of wastes are also produced. Those include waste water, solid waste, and oil spillage (Table III-6.2). Solid and water wastes through their strong and unpleasant smell is considered to have a negative impact to health and daily lives of people.

Table III-6.2: Types of waste from wet starch processing

Unit Operation	Type of waste generated
Cleaning, grating, washing	Peel, soil debris waste
Filtrating for starch solution	Waste water
	Pulp
Washing and Dewatering of for wet starch	Waste water
	Remaining solid waste starch
-outside operation using machine	Oil
-Machine operation	Noise
water treatment plant	Dust
	Odor

6.3 Impacts of cassava processing wastes on the environment

It is known that during the production of cassava processing, it also produces a big quantity of wastes that can have negative impact to the environment and human health. Through their strong and unpleasant smell cassava processing wastes, wastewater and solid waste, cause a hostile environment for farming communities living nearby. In addition, the aesthetic and beauty of the environment is also substantially affected by cassava processing if these wastes are not properly managed.

One of the major threats to the environment by starch processing industry is the content of *hydrocyanic acid* and the unbroken down *cyanogenic glycoside - linamarin* and *lotaustralin* which produces toxic and acidic effect in their processing wastes. If these products are not properly treated, they constitute potent toxicant to the soil, soil organisms, water and plants. During the process of cassava processing (dried chip, dried starch, and wet starch), it resulted particularly in large volume of wastewater and solid waste. The quality and quantity of this waste vary greatly due to plant age, varieties, time after harvesting, kind of industrial equipment used in processing and its adjustment.

As the factory is usually located close to the village, people frequently complain about unpleasant smell coming from the factory, and especially during the transportation of solid waste through the village. Similarly to the solid waste and apart from the bad smell that it contains, the produced waste water by wet starch processing can have strong impact to the populations of fishes and other aquacultures.

In general the effect of wastes if not manage wisely, they will affects to human health, socio economic conditions, water resources and aquatic life and finally to the climate.

6.4 Waste utilization and management

Waste utilization and management is activities that deal with waste before and after it is produced, including its minimization, transfer, storage, separation, recovery, recycling, and final disposal. All wastes materials, whether they are solid, semi-solid, liquid, gaseous or radioactive fall within the remit of waste utilization and management. Typically, there are different levels of waste management that can be applied. In Figure III-6.1 shows the waste management hierarchy that has been applied globally. In this figure, the steeper the pyramid becomes the better management.

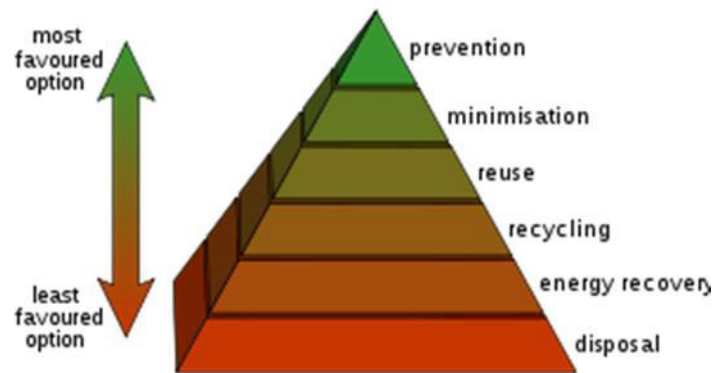


Figure III-6.1 Waste management hierarchy

Cassava processing generates two types of wastes, solid waste and wastewater. The solid waste produced by cassava processing can be unrecoverable starch, the peel and soil/stem debris, while liquid cassava waste can be produced by washing and peeling of cassava roots that generally contains a large amount of inert material and, the second one is produced by draining starch sedimentation tank. It is well accepted that solid waste and waste water (liquid waste) have strong adverse effect to the environment and human health. But if properly managed these wastes can be very useful in many ways.

Solid waste

Solid waste derived from cassava peel can be used as feed in animal and aquaculture production. This is widely practiced, but does have limitations due to its low digestibility and toxicity of the

peel and, on the availability of supplement protein to the feed. These limitations of solid waste for animal and aquaculture feed can be overcome through several techniques. One effective way to increase digestibility and to reduce toxicity of the peel is through fermentation. After the fermentation cassava peel can be converted into a more digestible substrate and can provide even to pig and poultry. On the other hand, in order to overcome protein deficiency in animal feed by using cassava peel, one effective way is to establish fully integrated crop-animal and aquaculture farming system or Model Farming as it is called by CARDI (2006). Currently, a common practice applied by many cassava processing plants is to let the produced solid waste be dried in the sun for 3-7 days before it is sold to animal feed manufactory. Other than its use for animal feed, solid waste can also be used as a medium for mushroom cultivation, can be used to produce compost for other crop production, and also can be used for the production of ethanol and maltose.

Liquid waste or wastewater

Ideally waste water should only be used after it has been properly treated. Cassava waste products can be treated by different ways. One way is to build anaerobic and aerobic lagoons (ponds) to treat the waste before its disposal. In the condition of anaerobic digestion of cassava waste, cyanide is released in the form of liquor and then liberated by enzymatic and non-enzymatic reactions. This system is very effective and environmental sound but requires a large area of land and large capital investment and therefore is suitable only for the large processing plant. In case cassava processing is of small to medium scale, waste water can be treated through channelling the waste into shallow seepage areas. The areas however should be situated away from natural water sources. Cassava processing wastewater can also be effectively utilized as a liquid fertilizer, if it is well treated. However if the waste is not properly treated and due to its high HCN content that can have a negative effect on plant growth, the use of waste water for irrigation or as a source of fertilizer should be restricted. The other problem in using wastewater as a liquid fertilizer is to have an appropriate concentration of wastewater to be used. There is a need therefore to establish this level through a research study. Failure to determine this may cause serious damage to the crops as high concentration of dilution can cause a total death of the plants.

Other than just using as liquid fertilizer, wastewater can also be used to produce biogas and to generate electricity. This technology is well known and has been adopted in many cassava producing countries.

7. Cassava market chain assessment and development for producers and processors

7.1 Introduction

Product marketing is important for cassava farming and processing since understanding the marketing process and using that knowledge in marketing produce can have a major impact on the profitability (or net farm income) of a farm. Cassava farming with a poor knowledge of the marketing process can lack power or influence in the marketing process. They are price takers. Knowledge about the marketing process and marketing strategies can strengthen the farmer's position.

7.2 Marketing and market chain

The role of the marketing group is not only to capture our “hearts and minds” today, but also to identify what we will need tomorrow. Marketing is an ever more pervasive element of our daily lives and marketing, more than other business function, is focused on people, which makes it compelling. Marketing in a more scientific context, can be defined as “a social and managerial process by which individuals and groups obtain what they need and want through creating and exchanging products and value with others”. The process of marketing is therefore finding ways to provide people with products and services that they need to either function normally or desire to improve their well-being.

There are three distinct categories of need that marketing aims to service:

- 1) The first area includes (a) basic physical requirements, such as food, clothing, shelter and safety; (b) social needs, related to belonging and affection; and (c) individual needs for knowledge and self-expression.
- 2) The second area includes wants or desires, which go way beyond immediate basic requirements for basic human operations and social interactions. Desires are a seemingly unlimited set of ideas, products, services that people seek in order to satisfy any perceived need. The main limitations to satisfying perceived needs are the

resources to pay for them. Whichever category, the consequences are similar in the market place, in that, when wants are supported by the ability to pay, these wants can be translated into demands.

- 3) The third areas consider products and services as benefits; consumers will choose those products and services that provide them with the best value for money. As value is based on an individual's estimation of satisfaction, there are many degrees of fulfillment when making a purchase, decisions are based on a multitude of cultural, ethical, moral, climatic, and wealth related dimensions. Therefore, for many situations, producers and marketing agents have developed a mesmerizing range of quality, price and emotionally loaded options.

Given this introduction, the first rule of marketing for small-scale farmers is to "produce what you can sell, rather than trying to sell what you have produced". To achieve this, in the cassava context means that producers and processors need to know what consumers are demanding at the marketplace and how the laws of demand (the quantity of products that the consumers can buy) and supply (the quantity of products that producers can offer for sale) affect prices, price trends, volumes being sold and market opportunities. The market place generally operates on the laws of demand and supply with the basic principle that as supply increases prices fall and vice-versa. To make informed decisions, clients (producers, processors and traders) need to know how their production fits within this law in the marketplace.

The market chain refers to the system that consists of actors and organizations, relations, functions, and product, cash and value flows that make possible the transfer of a goods or service from the producer to the final consumer (Fig. III-7.1). A production chain is made up of inter-related links, which are generally production, post-harvest and processing, marketing and consumption. The rapid evolution in marketing of cassava has been driven by the need to remain competitive in the marketplace and this is based on the ability to attract new customers (e.g. local, national, international) with the promise of better value and retain existing customers, by delivering satisfaction.

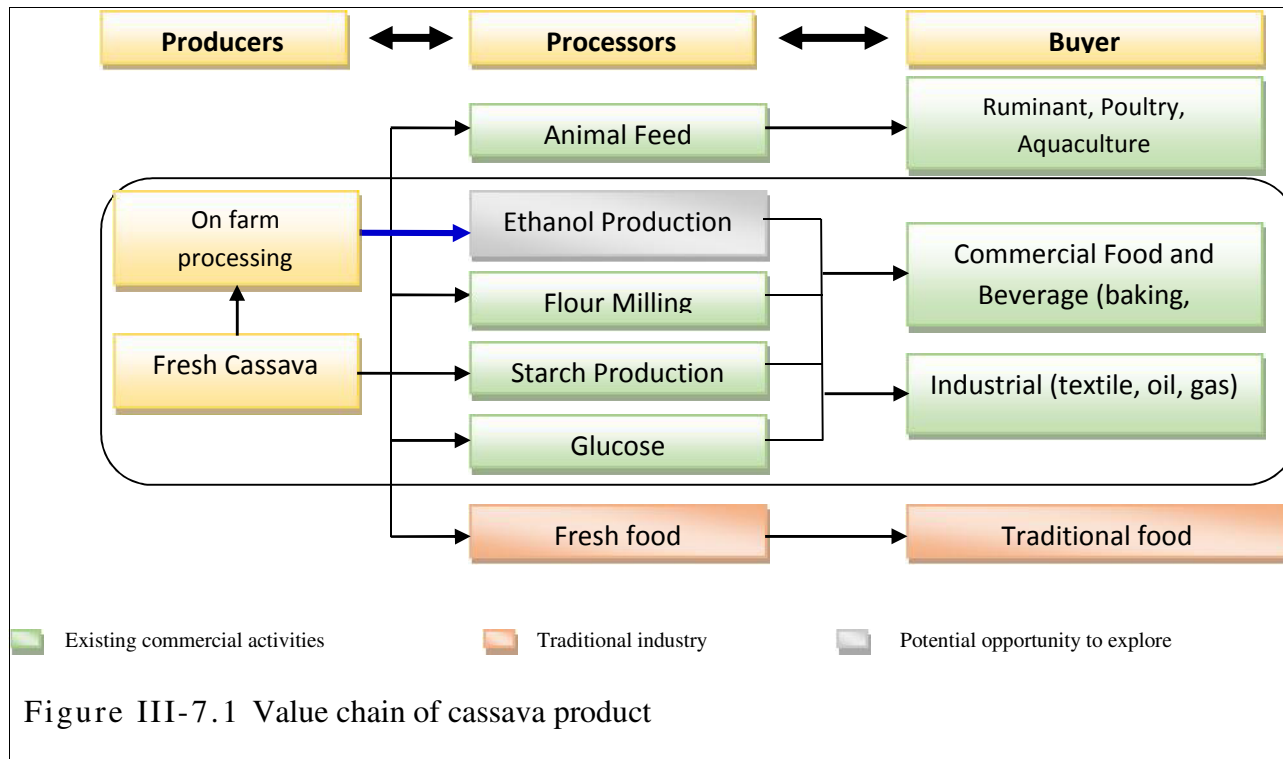


Figure III-7.1 Value chain of cassava product

Market Actors

Market collector – small and mobile traders who visit villages and rural markets. They buy from village bulking directly from farmers. Collectors operate over short distances; they trade small volumes at a time, using limited amounts of money and use simple means of transport, such as donkeys, bicycles, motorbikes and carts. They are most common in areas where farmers are poorly organized.

Assembly traders: These traders normally buy from producers and collectors, and sell to larger wholesalers. Their main function is to gather produce for sale to large traders who do not have the time to carry out small purchases from scattered producers and collectors. Assembly traders are normally based in rural markets or towns. They may own or rent small, motorized transport vehicles and small storage facilities.

Wholesalers: Wholesalers vary in size, but deal with larger volumes than collectors and assemblers and often store goods. They normally own or rent medium to large vehicles for transporting products, and own or rent medium to large size storage premises which allows them to postpone sales in anticipation of price rises, i.e., to *speculate* on the market. These traders depend on the needs of larger markets with many other wholesalers, retailers and consumers, i.e.

large towns and cities. They sometimes buy produce from producers and collectors, but tend to rely on assembly traders and other wholesalers as the main source of supplies. Wholesalers sell in bulk to other wholesalers, processors, industries, institutional buyers and retailers.

Retailers: The main role of retailers is the distribution of products to consumers. Their function is to obtain supplies and display them in forms and at times convenient to consumers. Retailers are very diverse in size and operation from small kiosks and hawkers or roadside sellers that sell small volumes of a limited number of goods, to shops, and supermarket chains that deal with a vast range of agricultural products. Some retailers specialise in specific products, whereas others sell a range of fresh, processed and frozen products.

Processors/commercial buyers: Processors are individuals and firms involved in the transformation of agricultural commodities. Rice and maize millers, bakeries, fruit juice makers and cassava starch manufacturers are examples. Processors can be small household enterprises or large formal firms. Large processors tend to have significant stocks of raw material to ensure continuous processing activity and high utilization of installed equipment during the offseason.

7.3 Understanding context of cassava producers and processors

Despite their production, potential, cassava producers and processors confront serious constraints in profiting from their resources due to lack of investment in basic infrastructure, limited access to services and unfavorable policies. Major global trends, see below, are rapidly changing the producing environment and communities need to devise ever more innovative ways of using their labor, resources and skills to take advantage of new business opportunities for cassava. In many cases, current trends will continue to marginalize increasing numbers of cassava producers and processors with particularly negative effects on those that are least organized and distant from markets. To address these changes producers and processors are adopting various strategies, including agricultural extension, intensification, diversification, mixed on / off-farm income streams and increasingly urban migration.

Global trends and local market development: There is growing consensus among development economists that growth is positively linked to export oriented trade and that a robust private sector is the means to long-run prosperity. For many development institutions related to cassava crop, this has led to the conclusion that even the basic tenets of social support

are no longer considered a supply problem, but the result of underdeveloped markets. As such, these market problems should be addressed through market solutions. The changing socio-economic environment has triggered many trends that offer both new opportunities and threats to the many cassava producers and processors in regard to market access. These trends include:

- **Market integration:** The effects of market liberalization, globalization, market concentration and innovations in finance, communications and transport are having profound effects on how business is being conducted within the cassava markets. To remain competitive within this new environment actors along the market chain are adopting strategies to increase economies of scale, through collective action, concentration of ownership and vertical integration.
- **Value addition:** Although, value addition to primary cassava post-harvest and processing offers a major income opportunity for many rural communities in Cambodia, lack of progress in the multi-lateral trade negotiations has meant that tariff barriers prevent exports of processed cassava. Consequently, in the export trade most value to cassava products takes place in the importing country. Even within Cambodia, (80%) of value addition is generated off-farm, due to lack of knowledge, infrastructure and market access.
- **A strategy for cassava market development:** The analysis of macro-trends and policy in the agricultural and food sectors suggests two major challenges for cassava business development:
 - o Developing competitive cassava enterprises at the micro level.
 - o Creating an enabling policy environment at the macro and micro levels

To address these business challenges, the following strategies are recommended:

- (a) Promote participatory methods that directly involve local chain actors in decision-making and develop local capacity for business development;
- (b) Stimulate collective action and organization of rural economic organizations with a solid business and market orientation;
- (c) Promote intensification, diversification and value adding for cassava in rural areas;

(d) Strengthen the market for rural business development services and its coordination;

The emphasis of identifying market opportunities is linked with growth and emerging markets. The methods will enable service providers and producers to evaluate market options for existing products and to identify new products. It should however, be recognized that any change in a marketing system tends to increase risk and therefore it is important to understand the relationship between the potential gains by investing in an identified market against the potential risks.

8. Quality standardization of cassava products to international markets including Chinese markets

8.1 Introduction

Food standards can be defined as documents or rules that concern food from raw material to finished products or retail presentation. They are an integral component of food laws.

Food standards seek to:

- Promote safety and protect consumer
- Limit the sale of unwholesome products
- Simplify the marketing of food products

There is a growing awareness of the importance of quality and the need for standardization of cassava and cassava products whether they are used for domestic consumption or intended for international trade.

Traditional cassava-based foods of producer countries have not generally been standardized and their quality is very variable, although a few specifications have been suggested or adopted. Some countries, for example, Brazil, India, Malaysia, Paraguay, Thailand, and the United States have laid down official standards for various commercial cassava products including chips, flour, pellets, starch, tapioca (flakes, pearls). Although there are variations between standards for the different products and different countries, the main quality parameters are moisture, fiber, ash, and starch contents.

8.2 International standards on cassava and cassava products (CODEX STAN 176-1995: Codex Standard for edible cassava flour)

Scope

This standard applies to cassava flour intended for direct human consumption and which is obtained from the processing of edible cassava (*Manihot esculenta Crantz*).

Definitions of the product

Edible cassava (*Manihot esculenta Crantz*) flour is the product prepared from dried cassava chips or paste by a pounding, grinding, or milling process, followed by sifting to separate the fiber from the flour. In case of edible cassava flour prepared from bitter cassava (*Manihot utilisima Pohl*), detoxification is carried out by soaking the roots in water for a few days, before, they undergo drying in the form of whole, pounded root (paste) or in small pieces.

Essential composition and quality factors

- *Quality factors-general*

Edible cassava flour shall be:

- Safe and suitable for human consumption
- Free from abnormal flavors, odors, living insects, and mites.
- Free from filth (impurities of animal origin, including dead insects) in amounts which may represent a hazard to human health.
- *Quality factors – specific*
 - **Moisture content 13% m/m max**

Lower moisture limits should be required for certain destinations in relation to the climate, duration of transport and storage. Governments accepting the Standards are requested to indicate and justify the requirements in force in their country.

- **Hydrocyanic acid content**

The total hydrocyanic acid content of edible cassava flour shall not exceed 10mg/kg.

Contaminants

- *Heavy metals*

Edible cassava flour shall be free from heavy metals in amounts which may represent a hazard to human health.

- *Pesticide residues*

Edible cassava flour shall comply with those maximum residue limits established by the Codex Committee on Pesticide Residues for this commodity.

- *Mycotoxins*

Edible cassava flour shall comply with those maximum residue limits established by the Codex Committee on Food Additives and Contaminants for this commodity.

Hygiene

It is recommended that the product covered by the provision of this standard be prepared and handled in accordance with the appropriate sections of the Recommended International Code of Practice – General Principles of Food Hygiene (CAC/RCP 1-1969, Rev. 2-1985), and other Codes of Practice recommended by the Codex Alimentarius Commission which are relevant to this product.

To the extent possible in good manufacturing practice, the product shall be free from objectionable matter.

When tested by appropriate methods of sampling and examination, the product:

- shall be free from micro-organisms in amounts which may represent a hazard to health;
- shall be free from parasites which may represent a hazard to health; and
- shall not contain any substance originating from micro-organisms in amounts which may represent a hazard to health.

Packaging

- Cassava flour shall be packaged in containers which will safeguard the hygienic, nutritional, technological, and organoleptic qualities of the product.

- The containers, including packaging material, shall be made of substances which are safe and suitable for their intended use. They should not impart any toxic substance or undesirable odor or flavor to the product.
- When the product is packaged in sacks, these must be clean, sturdy and strongly sewn or sealed.

Labeling

In addition to the requirements of the Codex General Standard for the Labeling of Prepackaged Foods (CODEX STAN 1-1985), the following specific provisions apply:

- *Name of the product*

The name of the product to be shown on the label shall be “edible cassava flour.”

- *Labeling of non-retail containers*

Information for non-retail containers shall either be given on the container or in accompanying documents, except that the name of the product, lot identification and the name and address of the manufacturer or packer shall appear on the container. However, lot identification and the name and address of the manufacturer or packer may be replaced by an identification mark, provided that such a mark is clearly identifiable with the accompanying documents.

Analysis

- *Determination of moisture*

According to ISO 712-1985 Cereals and Cereal Products – Determination of Moisture (routine reference method).

- *Determination of total hydrocyanic acid*

Method to be selected.

Annex

The following provisions are of an advisory nature reflecting quality factors and criteria typically used by commerce to define or describe the quality of product purchased. Individual merchandise should independently determine their product quality needs. These guidelines are intended to assist users of the Codex standard when asking international purchases and are, therefore, not subject to formal acceptance by users of the standard. In those instances where more than one factor limit and/or method of analysis is given we strongly recommend that users specify the appropriate limit and method of analysis (Table III-8.1).

Table III-8.1. Appropriate limit and method of analysis

Factor/Description	Limit	Method of analysis
Crude fiber	Max: 2.0%	ISO 5498 (1981) - Determination of Crude Fiber Content. Separation by filtration through filter paper - General Method
Ash	Max: 3.0%	ISO 2171 (1980) – Cereals, Pulses and Derived Products – Pulses and Derived Products – Determination of Ash (Type I Method)
Food additives	Conform with legislation of the country in which the product is sold	Not Defined
Particle size		
- Fine flour	Min: 90% shall pass through a 0.60 mm sieve	Not Defined
- Coarse flour	Min: 90% shall pass through a 1.20 mm sieve	

8.3 Cambodian standards on cassava and cassava products (CS 0056:2007. Cambodian Standard for Tapioca Flour)

Scope

This standard prescribes requirements, hygiene, packaging, and marking; methods of sampling; and analysis for tapioca flour.

Definition

Tapioca flour is the product prepared from dried roots by a pounding, grinding, or milling process, followed by sifting to separate the fiber from the flour.

Tapioca flour preparation is different from starch cassava which is grinded or pounded to get starch from fresh cassava roots.

- ***Tapioca flour identification***

This product is cooked with water in 15 times of its weight and then cooling, a gelatine was received and mostly starch. When it mixed with iodine solution, it become dark blue and it disappeared when heating, it will appar a same color when it was cooled.

Requirements

- ***General requirements***

This matter shall be flour forms with light color without dark spot and no purification. There is no insect or mould infected.

- ***Actual requirements***

This matter shall be followed on requirements stated in Table III-8.4 when samples tested.

Hygiene

It is recommended that the product must follow Cambodian Standard on “General Principles of Food Hygiene”.

When tested by appropriate methods of sampling and examination, the product shall not contain any substance originating from tapioca flour.

Table III-8.4. The requirements for tapioca flour

No	Characteristic	Limit
1	Particle size on sieve 150 m	1%
2	Moisture	14.0% of weight, max
3	Starch	82.0% of dried weight, min
4	Ash	2.0% of dried weight, max
5	Ether extract, per cent by mass, (on oven-dry basis)	0.4% of weight, max
6	Free acid, NaOH 0.1N/100g flour	100ml, max
7	pH	4.8-7.0
8	Viscosity, 2% solution at 60°C, m ² /s	5.5 x 10 ⁻⁶ dried weight, min
9	Crude fiber	2.5% of dried weight, max

Labeling

Labeling of product shall be follow on Cambodian Standards, CS 001:2000, on Food Labeling.

All packaging shall be marked with the following information:

1. Name of product “Tapioca Flour”
2. Name and address of manufacturer and/or logo if have
3. Net weight in gram or kilogram
4. Date of producing and expiring
5. Lot or code number
6. Product of origin

Packaging

Tapioca flour shall be packed with clean material and not effect to flour quality and prevent the product from any hazard.

Method of sampling

- Lot: when delivery, all packed products shall have same quality and group process.
- To identify this standard, the sample shall be collected to represent its lots.
- Number of sampling shall be followed Table III-8.5. All selected samples shall be randomized.

Table III-8.5. Number of sampling size

Lot size	Number of sampling size
2 up to 8	2
9 up to 27	3
28 up to 64	4
65 up to 125	5
126 up to 216	6
217 up to 343	7
344 up to 512	8
513 up to 729	9
730 up to 1000	10

8.4 Chinese standards on cassava and cassava products

China's growing demand for chips as bioethanol feedstock is the outcome of a combination of factors. First, the Chinese government's policy on grain self-sufficiency discourages the use of domestic grain for non-food purposes e.g. bioethanol. Secondly, the shift towards protein rich diet as income grows increases demand for feed. Thirdly, China's growing industrial and consumers' energy need increases demand for bio-fuels. China imports chips instead of pellets, and is concerned generally with the high starch content in chips, while standard certification seems to be less of an issue.

Standards governing product entry into China

There is no official standards govern cassava chips' entry into China. However, since chips are used as bioethanol feedstock, customarily 67% starch content is required.

8.5 Thai standards on cassava and cassava products (TIS 52-2516 (1973). Thai industrial standard for tapioca products)

Scope

This standard prescribes requirements, packaging, and marking; methods of sampling; and analysis for tapioca products

Definition

For the purpose of this standard, the following definitions shall apply:

- ***Tapioca product***

Tapioca has been processed from tapioca roots and dried may be in meal or piece, chip, sheet, pellet, bar, granule or other form excluding tapioca starch and dregs.

- ***Foreign materials***

Materials that are not the composition in nature of tapioca roots.

- ***Ash***

Residue obtained after igniting tapioca product to constant weight.

- ***Sand***

Acid-insoluble ash.

- ***Crude fiber***

Residue remaining after digesting tapioca product with acid and alkaline and which can be burnt.

Requirements

Tapioca products shall conform to the following requirements

- Starch shall comply with Table 2.
- Sand or silica shall comply with Table 2.
- Crude fiber shall comply with Table III-8.2.
- Moisture shall comply with Table III-8.2, except that is in product intended for further processing into pellets, bars, or granules, the moisture shall not be more than 16.0% of weight during October to May and not more than 17.0% of weight during June to September.

Table III-8.2. Thai requirements for tapioca

Characteristic	Limit
Starch	To be developed
Sand	3.0% of weight, max
Crude fiber	5.0% of weight, max
Moisture	14.0% of weight, max

Note: in case the ash content obtained during the determination of sand content is more than 4.5% of weight, this ash content shall also be reported.

1. Packaging and marketing

- Where product is packaged, the material used for the purpose shall be free from tears, leaks, or abnormal odor, be of adequate rigidity and workmanship, and marked with the following information.
 - Name and nature of the product
 - Name of manufacturer
 - Net weight

Any person who manufactures products complying with this standard may use the standards mark in connection with his products only after having received a license from the Industrial Product Standards Council.

Method of sampling

The sample collected shall be thoroughly mixed (Table III-8.3). Where the sample collected is less than 3kg, more samples shall be taken to obtain a total sample weight of 3kg. Where the

total sample weight is more than 3kg, the sample shall be quarterly subdivided until 3kg is obtained. The sample so obtained shall be divided into 3 parts, each kept in a clean container sealed with the information indicating the date of sampling and signature of sampler. One part shall be retained by the manufacturer, one by the purchaser, and the other used for testing.

Table III-8.3. Sampling

Lot size metric tons	Number of sampling points min.
Up to 50	10
51 up to 200	20
201 up to 500	30
501 up to 5000	50
Over 5000	80

Standards governing production in the Thai dried cassava value chain

Minimum export standards required by the Thai Ministry of Commerce

The Thai Ministry of Commerce introduced a number of technical export standards for dried cassava in 2002. The main ones are minimum starch content of 65%, maximum crude fiber of 5%, maximum moisture of 14%, maximum sand of 3%, and free from foreign materials. However, some exports (i.e. residue pellets to Korea) are shipped to a lower starch content (see below).

Standards governing product entry into the EU

EU “farm to fork” policy, introduced in 2000 requires the traceability of products used in food and feed production. Compliance to this is obtained through HACCP and GMP certifications on the pellet plants.

- HACCP (Hazard Analysis Critical Control Point) certification is required as pellets are part of the feed-food chain.
- GMP (Good Manufacturing Practice) relates to the sanitary and processing requirements in food production.

The required starch content for pellets exported to the EU is 65%.

Standards governing product entry into China

No official standards govern cassava chips’ entry into China. However, since chips are used as bioethanol feedstock, customarily 67% starch content is required, 2% higher than the Thai MoC minimum export standards. This is also higher than the requirements of the EU and Korean pellets buyers.

Standards governing product entry into Korea

No standard certification is required for entry into Korea. Korean buyers prefer residue pellets which are made wholly out of starch waste, rather than chips, and have lower starch content of just 55%.

9. Export regulations for cassava products and quarantine and import regulation required by China

9.1 Introduction

With a view of effectively preventing the entry and spread of pests and epidemic diseases of plants into one contracting party from the other, protecting the production of agriculture and forestry as well as the ecological environment and human health, and encouraged by the common will to promote and strengthen bilateral exchange and cooperation in the field of plant inspection and quarantine, the Ministry of Agriculture, Forestry and Fisheries (MAFF) of the Kingdom of Cambodia and the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) agreed to have a technical protocol on exporting cassava chips to China as in order to advance the exports of that commodity.

For better captures and understanding, the contexts of the protocol will be shown in the following texts including key concepts of Plant Quarantine Inspection Procedures:

9.2 Plant quarantine inspection procedures

Plant Quarantine Inspection (PQI) aims to protect plant resources in the Kingdom of Cambodia through preventing the introduction or spread of quarantine and other regulated pests, to facilitate trade in plants and plant products and to regulate other related matters.

MAFF shall be responsible for any activities related to PQI although MAFF provides a powerful delegation to GDA (PPSPD) to implement PQI activities as he/she deems appropriate.

Plant Quarantine Inspection Materials (PQIM) or Regulated Materials (RM):

The regulated articles for plant quarantine inspection are:

- Plants, plant parts, plant products, products originated from plants which can be host and transmitted of plant pests.
- Wood Packing Materials, pallets, boxes, transportation and warehouses.
- Soils or any parts of soil carried by plant roots or parts.
- Pests or living or death of any organism.
- The products which not originated from plants but can be host of pests.

Plant Quarantine Procedures on Exporting Commodities (PQPEC):

Plant Quarantine Inspection on exporting goods shall follow to the SPS WTO agreements and complies with others agreements, convention and other agreement documents of importing countries:

Export Company or Good Owner or representative should apply for PQI to the General Directorate of Agriculture (GDA) get the PQI services.

The application forms and PQI procedures have the following steps:

Step1: PQI application

At 10 working days before exporting, applicant shall apply for PQI to the nearest Plant Quarantine Officer and provide all necessary facilities for inspection procedures.

Step2: Inspection

Once received application documents for PQI, Department of Plant Protection Sanitary and Phytosanitary assign Plant Quarantine Inspection Officers (PQIOs) to inspect and evaluate the risk of inspected commodities including the source of those goods.

Step3: sample testing at lab facilities

In case observed there is suspicious or found of any harmful of pest or any symptoms, PQIOs collects the commodity samples for conducting analysis/testing at the Department of PPSPS's Lab.

Step4: Recommendation Response

In case testing lab results found in high risk, inspected commodity must be treated by using fumigation.

Step5: Fumigation

The fumigation process will spend 96 hrs. The fumigation activities will be directly conducted by Department of PPSPS of GDA.

Step6: Exporting

After passed the above PQPEC's 05 steps, the Phytosanitary Certificate (PC) is issued and overhands to the exporter. The issued PC is indicated source of goods, inspected date, issued date and kind & used dosage of fumigant applied and free of pests.

Receiving the issued PC, it means exporter is able to export his/her inspected commodities.

For those commodities, which are not complied with the Phytosanitary requirements, exporter/good's owner shall follow to the Phytosanitary measures of the exporting country. All expenses related to the Phytosanitary measures are covered by exporter/owner's good.

9.3 Procedures on cassava chip export to China

In order to safely export tapioca from Cambodia into China, ensure the security of agriculture and ecology, and protect the health of human being in China, based on results of the Pest Risk Analysis results and the principles of Agreement on the Application of Sanitary and Phytosanitary Measures of WTO (SPS Agreement), the Ministry of Agriculture, Forestry and Fisheries of the Kingdom of Cambodia (MAFF) and the General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China (AQSI), have reached agreements on the Phytosanitary requirements of Cambodia tapioca as follows.

Species and Source:

The tapioca including Cassava chips and Cassava pallet to be exported to the People's Republic of China, should specify scientific name of the crop such as *Manihot esculenta* Crantz, and should also indicate the origin of the product such as "originated from Cambodia".

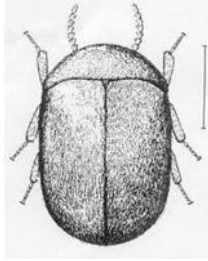
Requirements and Prohibitions:

The tapioca prepared for export to China shall comply with the relevant Phytosanitary laws and regulations on import of China and be free of live insects and quarantine pests concerned by China (listed in below), and shall not be comingled or contaminated with other grain or extraneous impurity.

The pesticide residue and heavy metal pollutants on the tapioca exported to China shall comply with the relevant requirements of Chinese laws, regulations and standards.

The quarantine pests for cassava chips being exported to China as appeared in the following:

- *Lasioderma serricorne*



- *Pharaxonotha kirschii*



- *Sinoxylon* spp (non-chinese)



- *Trogoderma granarium*



- *Heterobostrychu aequalis*



- *Prostephanus truncates*



- *Sitophilus granaries*



- *Oryzaephilus surinamensis*



- *Cenchrus echinatus*



Registration for cassava chip exporter to China:

MAFF through its agent GDA shall register the companies for processing and/or storing to ensure that they meet the relevant quarantine conditions and implement such measures as disinfecting and cleaning. MAFF shall notify in advance to AQSIQ the list of those registered companies.

Packaging:

Tapioca that needs to be exported to China shall be properly packed for transportation as much as possible. Packaging materials shall meet the requirements of Chinese plant quarantine, be clean and new. Each package of Cambodian tapioca shall have the obvious Chinese words “本产品输往中华人民共和国” (This consignment of tapioca will be exported to the People’s Republic of China) as well as the name and address of the registered companies in English.

Transporting:

The tapioca designated to be exported to China should be sealed during the transportation. The means of transportation should meet the requirement of safety and sanitation. The overland transport vehicles should maintain including when pass through a third country and the consignment should not be unloaded and the transport vehicles should not be changed.

Fumigating:

Before exporting, if live insects are found, the tapioca designated for export to China should be fumigated with hydrogen phosphide under the supervision of Cambodia official Department of Plant Protection Sanitary and Phytosanitary, General Directorate of Agriculture (GDA) of MAFF. The specific technique data as follows:

Hydrogen phosphide 3.8g/m ³ 72h ≥21°C

Before Exporting:

An Import Permit issued by AQSIQ should be acquired by tapioca importers in advance of the importation.

10. Procedures and documentary requirements for the export of cassava products to Chinese markets

10.1 Introduction

Trading goods across borders requires vast number of transactions to meet the rules and regulations of exporting and importing countries. Failure to comply with any of these requirements and/or submit wrong or incomplete set of documents often results in unnecessary delays in time and tax-on additional costs.

High trade facilitation and internal transportation costs are acting likes headwind, which have significant impact on trader's ability to earn profits on a thin margin. Not all costs, however, are attributable to the public sector purview, e.g., certification and/or licensing, customs clearance, cargo inspections, etc. Business-to-business transactions can also be the domains of enormous non value-added costs, e.g., inefficient use of transportation mode, truck fuel inefficiency, lack of commodity warehouse at strategic export hub, etc.

For better captures and understanding, the contexts of the procedures and documents required for cassava exportation will be shown in this training module.

10.2 Sales contract and trade terms

The process starts with exporter identified two main types of clients: 1) prospective new client who ask for quotation and trade terms by email; and 2) existing clients with whom the company has previous dealing on a regular basis. For illustrative purposes it's assumed the exporter is conducting the business with a prospective new client in China (Table III-10.1).

Table III-10.1: Processing Sales with New Importer

Step 1	An importer expresses an interest to import cassava or maize from Cambodia sends a query via email to an exporter. The exporter then sends the quotation along with the trade terms to the importer. In some cases the importer may asks for sample, where it would be sent via overnight courier.
Step 2	The prospective importer verifies the quotation and trade terms, agreeing the price and the payment terms are acceptable to both parties, if not the importer may requests exporter to revise new price and/or trade terms.
Step 3	The importer confirms the intent to proceed with the transaction by issuing a Purchase Order (PO), then sent it to exporter by email or by fax.
Step 4	Upon the receipt of the PO, the exporter issues and sent to the importer a Proforma Invoice (PI) coupled with Sales Contract for countersignature.
Step 5	The exporter prepares the shipment for export.
Step 6	The importer receives PI and Sales Contract.

10.3 Export procedures

Export procedures and documentation are divided into 3 categories:

- 1) Standardize international trade practices by defining the rights and obligations of the parties;
- 2) To comply with governmental rules and regulations (exporting and importing countries); and
- 3) To comply with Conventions and Multinational Agreements (WTO, ASEAN, GSP, etc.).

The so called limitations to freedom of contract are quite extensive and include items like; export and import regulations, consumer protection, technical norms and standards, customs clearance, taxation, foreign exchange control, restrictive trade policies, public health and safety, laws of transit countries, and dangerous and prohibited goods.

To meet importer orders requirement, in a timely manner as specified in the sales contract, the exporter must master the intricacy and timeline required to secure all of the appropriate certifications and inspections and clearances before the cargo can be exported. For instance, some key certificate such as Certificate of Origin (CO) from the MoC could take longer than 2 or 3-day to obtain and can only be applied after all other requirements are completed.

New exporter must first register with the Automated System for Customs Data (ASYCUDA) before it can process the export documents through the system for Customs clearance, *a one-time process*. Documents needs for the ASYCUDA registration at the Customs headquarter are: Proposal Letter; Company Registration; Company Memorandum; Certificate of Corporation, VAT, Patent, and ID/passport.

Certificate from and inspection by the Ministries/Agencies

- **Register with MAFF**

Due to the General Administrative of Quality Supervision, Inspection and Quarantine (AQSIQ) and China Inspection Quarantine Services (CIQ) stringent requirements and MAFF wants only legit companies are authorized to export to China. MAFF/GDA requires exporter to be qualified, registered with GDA, and be on the lists it sent to CIQ, pre-export inspection and certification.

Notwithstanding that the qualification and registration is a *one time event*, but may subject to review and reconfirm every 2 or 3-year to stay qualified, the vetting processes institute by GDA is vigorous and all the expenses incurred are to be borne by the aspire exporter. There are *no official fees* for the registration.

The process begins with the aspire exporter submitted to GDA the owner(s) bios and company registration logged at the MoC and other relevant data, i.e., locations of the office, silo, warehouse, factory, and/or geographical areas of the commodities. Once the documents received by the GDA and they are all in order, an inspector or surveyor is assigned to conduct an actual on-site inspections of the exporter's premises, as listed on the documents.

When the inspection is completed and where there are no irregularities are found, then GDA issues a certificate to the exporter and the company name is added onto the approved lists of qualified companies, which GDA send the said lists to CIQ on an annual basis.

- **Certificate of Origin**

Issues by either Bilateral or Multilateral Trade Department at the MoC the Certificate of Origin (CO), which certifying where a product originated from, is an important piece of document for the buyer and seller and Customs authorities, for it affects tariffs and quotas applied between countries for specific product.

Product classification, origin and original status determine eligibility for preferential treatment and the specific duty rate assessed by the importing country. The CO are often required by both importing and exporting countries because of the established trade arrangements and generally allow exporters to take advantage of the preference system of the importing countries, such as GSP or MFN schemes.

Before applying for the CO, exporter must register with the Trade Preferences Department (“TPD”) at the MoC, *a one-time process*. And documents needs to register are similar to those used in the ASYCUDA registration.

- **Phytosanitary Certificate**

The Phytosanitary Certificate (PC) and the Fumigation Certificate are required when exporting agriculture commodities to most countries. Depending on the risk factor whereby plants are classified into low and high risks categories. Grains are usually identified as low risk, whereas fruits are high risks due to high moisture content. Soil where the commodity is originated constitutes an important factor in the risk assessment.

The GDA is responsible for import/export inspections of plants, plant products, and other regulated articles, and for issuing permits and phytosanitary certificates in compliance with the International Plant Protection Convention. Sub-Decree No. 15 (2003) on Phytosanitary Inspection relates to preventing entry of plant pest and diseases through Department of Plant Health inspection and quarantine facilities, and the issuance of phytosanitary certificates, transit arrangements plant health inspectors’ powers and enforcement penalties.

It is the exporter’s responsibility to ensure that the product is free from quarantine pests and significantly free from injurious pests that could damage crops. For this, the exporter submits an application to the GDA in Phnom Penh, which then issue the PC, once all the conditions are met.

- **Inspection and fumigation Certificate**

The GDA makes a risk assessment based on the risk for pests, the grains' source of origin, the testing and inspection requirements of the importing country, and then determines the export requirements and guidelines in Cambodia.

Authorized private company must do the inspection and fumigation sanctions by MAFF, at the exporter's warehouse or the Port of exit. The control process may take up to 72 hours to complete. A Fumigation Certificate is then issued, which states the product, date, and dosage used for the treatment.

In addition, although it is *not mandatory* like ACSIQ/CIQ, some Chinese buyer/importer may, sometimes, asks for Fumigation Certificate issues by CCIC, which is very costly up to US\$700 per shipment.

- **Customs declaration**

To complete the Customs Declaration formality the exporter or freight forwarder submits the Letter for Customs along with the completed documents for export to the Customs and Excise Office Chief for approval and requests for inspection, and pays declaration charges and export duties, if any.

The Deputy Customs Chief then assigns an inspector to inspect the cargo at the exporter's warehouse or the Dry Port, if one is used.

Exporter may also use the ASYCUDA for Customs Declaration, if and where such system is available, for more accurate and streamline customs clearance process.

- **Cargo inspections (Customs and Camcontrol)**

According to export (and import) procedures, which are laid out in Sub-Decree 131 (2006). All goods to be exported must be reported at a customs office or other location as determined by the DGCE.

The Law on the Management of Quality and Safety of Products and Services provides the legal mandate for Camcontrol to conduct official inspection of goods in international trade and on the domestic (retail) market. Under Sub-Decree No. 59 (2008), the Department has the following

duty and responsibility, among other duties and responsibilities, to conduct inspection of imports and exports, jointly with Customs.

Camcontrol also undertakes non-regulatory inspections for exporters, primarily in relation to export shipments of rice and other agricultural products. Customs and Camcontrol must examine all exports where goods are released when documents are approved, the container is sealed, the export tax (if any) is paid, and the examination completed.

Customs charges a fee of Riels 15,000 for each export declaration and the Camcontrol fee is 0.1% of the f.o.b. value of exports and 0.1% of the c.i.f. value of imports.

- **Customs clearance at the Port**

Customs at the Port of exit does not reopen the containers; the officer only checks the related documents and verified the authenticity of the seal on the container. The container may undergo scanning, depending on the type of goods and the risk management assessment. A private company (concessionaire) is charged with scanning the container using TX Scan, located within the Port zone. The company levied a scanning fees based on the size of the container, US\$25 and US\$40, for 20-foot and 40-foot containers, respectively.

Once all the documents and container seal are checked by General Department of Customs and Excise (GDCE), container is ready to be stowed onto the vessels for export.

In-house paperwork and processes with private parties

To process internal paperwork to facilitate the physical movement of goods including establishing title or ownership during transportation and documentation required by consignee for Customs clearance, payment, etc., can be time consuming, if not carefully choreographed.

- **Commercial invoice**

Commercial invoice vary according to destination; special invoice forms, certificate of origin or consular documents, certificate of value, may be specified and care must be taken in fulfilling these destination requirements.

- **Packing list**

Packing list is an essential document, as it is needed in particular for Customs purposes when goods are exported or imported. Most Incoterms stipulate that the exporter must provide at his

own expense the customary packing of the goods, unless it is the custom of the trade to dispatch the goods unpacked.

Many countries have specific label requirements, such as the requirement that imported goods (or containers) be marked with the country of origin. If the cargo is not properly marked when exported, a penalty can be assessed. This is called a marking duty. Marking duties are imposed in addition to any other duties, even if the cargo is exempt from ordinary duties.

- **Arrange for transport**

Exporter considers 4 major factors when selecting which mode of transportation to be used in the shipment to the importer's country: the-urgency of the delivery; the size and weight of the cargo to be moved; the location and accessibility of the point of delivery; and transit time.

Product characteristics dictate the different modes of transportation to be used and its relative costs. Sea freight is the most widely used form of transportation for commodity trade. Today, SAP is Cambodia only deep-sea port and accounts for approximately 70-80% of cargo traffic for the country's international trade.

With limited capacity, maximum allowable vessels' load and docking in the port is 10,000 tons, sending cargo via SAP, however, is more costly compared to exports via Vietnam's new deep-sea port in Cai Mep.

- **Freight forwarder**

Freight Forwarders are service companies that handle all aspects of import and export shipping for a fee. They're seasoned operator with in-depth knowledgeable about the different modes of transport and how they can best be used for a particular cargo.

To improve delivery time and customer service some exporter employs freight forwarder to handle all the shipping transactions, i.e., trucking cargo to port, cargo insurance, sea freight and routing, and Customs clearance.

- **Bills of lading**

For ocean shipments this is the supreme document. In legal terms it is "a receipt for goods shipped, a document of title and evidence of the contract of affreightment". In commercial terms,

the Bill of Lading has an accepted special identity, and may be regarded as a combined “ticket for the journey” and “title deeds” of the goods. Possession of a negotiable Bill of Lading, properly completed, constitutes effective control of the goods.

- **Cargo insurance**

Merchandise transports within Cambodia are fully insured with the inland part of the insurance premium is borne by the exporter, while marine insurance depends on the importer requirements and/or negotiated agreement between exporter and importer.

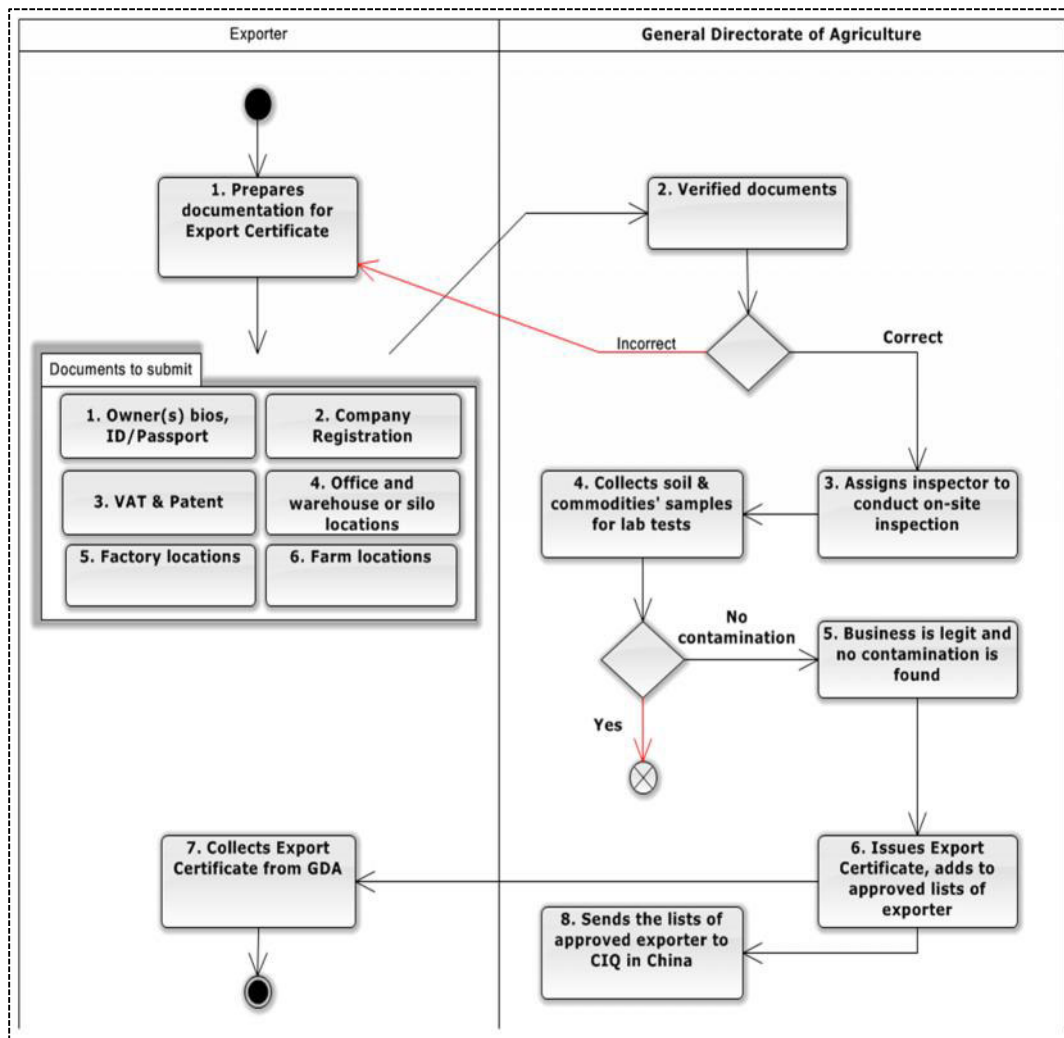


Figure III-10.1: Register with MAFF/GDA, Pre-export Inspection and Certification (General Directorate of Agriculture, 2013).

Note: Exporter does not need to process this task for each transaction. The registration is a one-time event, but may subject to review and reconfirm every 2 or 3-year to stay qualified. There are no official fees for the registration.

10.4 Application for Certificate of Origin (CO) for exportation to China

a. Certificate of Origin (CO) form

It is important to obtain the right CO for exporting goods from Cambodia. Depending on the destination of the export, the CO form can be different.

1. Certificate Form N
2. Certificate Form A
3. Certificate B255
4. Certificate Form D (Export to Asean Countries)
5. Certificate Form E (Asean-China)
6. Certificate Form AJ (Asean-Japan)
7. Certificate Form AK (Asean-Korea)
8. Certificate Form ANZ (Asean-Australia, Netherland)

Therefore the certificate of Origin (CO) to be used for exportation to China is the Form E which is shown in Figures III-10.1 & III-10.2.

b. Application procedures

- Manual Application; and
- Online Application

Manual application

Applicants must be ready with the following documents

- Application Form;
- Copy of Receipt and Cheque of Administration Fees and EMF Fees;
- Receipt of Public Service Fees;
- Invoice/Packing List;
- Letter of Attorney.
- Airway Bill (by Air)
- Joint Inspection Report of Garment and Textile Export
- Cambodia Out Ward Declaration;
- Bill of Lading;
- Certificate of Quantity;
- Custom Declaration;

- Any supporting documents to identify the origin of goods;
- Export License (if need be of the rule of law);
- Letter of Attorney.

Online Application

Applicants can look on the following website: www.ico.moc.gov.kh

Original

1. Products consigned from (Exporter's business name, address, country)		Reference No.			
2. Products consigned to (Consignee's name, address, country)		ASEAN-CHINA FREE TRADE AREA PREFERENTIAL TARIFF CERTIFICATE OF ORIGIN (Combined Declaration and Certificate) FORM E			
3. Means of transport and route (as far as known)		Issued in <u>CAMBODIA</u> (Country)			
Departure date Vessel's name / Aircraft etc. Port of Discharge		See Overleaf Notes 4. For Official Use <input type="checkbox"/> Preferential Treatment Given <input type="checkbox"/> Preferential Treatment Not Given (Please state reason/s) Signature of Authorised Signatory of the Importing Party			
5. Item number	6. Marks and numbers on packages	7. Number and type of packages, description of products (including quantity where appropriate and HS number of the importing Party)	8. Origin criteria (see Overleaf Notes)	9. Gross weight or other quantity and value (FOB)	10. Number and date of invoices
11. Declaration by the exporter		12. Certification			
The undersigned hereby declares that the above details and statement are correct; that all the products were produced in (Country) and that they comply with the origin requirements specified for these products in the Rules of Origin for the ACFTA for the products exported to (Importing Country) Place and date, signature of authorised signatory		It is hereby certified, on the basis of control carried out, that the declaration by the exporter is correct. Place and date, signature and stamp of certifying authority			
13.					
<input type="checkbox"/> Issued Retroactively <input type="checkbox"/> Exhibition <input type="checkbox"/> Movement Certificate <input type="checkbox"/> Third Party Invoicing					

Figure III-10.1 Certificate of Origin (CO) Form E (Original)

Duplicate

1. Products consigned from (Exporter's business name, address, country)		Reference No.			
2. Products consigned to (Consignee's name, address, country)		ASEAN-CHINA FREE TRADE AREA PREFERENTIAL TARIFF CERTIFICATE OF ORIGIN (Combined Declaration and Certificate) FORM E Issued in <u> CAMBODIA </u> (Country)			
3. Means of transport and route (as far as known)		4. For Official Use			
Departure date		<input type="checkbox"/> Preferential Treatment Given			
Vessel's name / Aircraft etc.		<input type="checkbox"/> Preferential Treatment Not Given (Please state reason/s).			
Port of Discharge	 Signature of Authorised Signatory of the Importing Party			
5. Item number	6. Marks and numbers on packages	7. Number and type of packages, description of products (including quantity where appropriate and HS number of the importing Party)	8. Origin criteria (see Overleaf Notes)	9. Gross weight or other quantity and value (FOB)	10. Number and date of invoices
11. Declaration by the exporter		12. Certification			
The undersigned hereby declares that the above details and statement are correct; that all the products were produced in (Country) and that they comply with the origin requirements specified for these products in the Rules of Origin for the ACFTA for the products exported to (Importing Country) Place and date, signature of authorised signatory		It is hereby certified, on the basis of control carried out, that the declaration by the exporter is correct. Place and date, signature and stamp of certifying authority			
13.					
<input type="checkbox"/> Issued Retroactively <input type="checkbox"/> Exhibition <input type="checkbox"/> Movement Certificate <input type="checkbox"/> Third Party Invoicing					

Figure III-10.2 Certificate of Origin (CO) Form E (Duplicate)



Ministry of Agriculture, Forestry, and Fisheries

Department of International Cooperation

Address: No. 200 Preah Norodom Blvd, Sangkat Tonle Basak, Khan Chamkarmon, Phnom Penh, Cambodia

Email: prumsomany35@gmail.com

HP: (855) 016 811 827

Fax: (855) 23 217 320

Website: <http://www.maff.gov.kh>