

Cabbage supply chain mapping and postharvest loss in the domestic and export trade in Lao PDR

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Abstract

Supply chains for cabbage produced in Champasak Province, Lao PDR, for the domestic market (Vientiane City, about 750 km away) and for export (Ubon Lathsathani, Thailand, about 190 km away) and the existing practices and losses were determined. Domestic supply chain involved farmers and collectors in Pakxong District, the main cabbage-growing area in Champasak Province, and wholesalers and retailers in Vientiane. Farmers transported unpacked cabbages to the collectors' house using tractor-driven cart. Cabbages were then trimmed, packed in 20 kg plastic bags, and transported to Vientiane by public bus. The wholesalers brought the cabbages to Nongteng Vegetable Wholesale Market for disposal to retailers. On the other hand, the export supply chain involved farmers and collectors in Pakxong District and Thai collectors who were also wholesalers and retailers. Untrimmed and unpacked cabbages were loaded to collectors' trucks at six tons per load for transport to Songmaek Market, a border trading center at the Lao side of the Lao-Thai border. The Thai collectors bought the cabbages, which were then trimmed, packed in 10-kg plastic bags, and transported in large or mini trucks to their shops at Chaleansy Market in Ubon Lathsathani. Upon arrival, cabbages were re-trimmed before retail or re-packed in 7-kg plastic bags for disposal to other retailers in the market and other provinces. Postharvest loss was about 48.4% in the domestic supply chain and 52.5% in the export supply chain. In both chains, farmers incurred the highest loss of about 32% due to insect damage, rotting and over-maturity. Losses incurred by collectors in the domestic supply chain (3%) were lower than that of wholesalers (9.6%) and retailers (4%). In the export supply chain, Lao collectors had also lower loss (8%) than the Thai collector-wholesaler-retailers (14%). Most common causes of loss were physical damage and bacterial soft rot. Reducing product loss required production and postharvest interventions, including appropriate pest management, proper harvest maturity, proper trimming procedure, improved packaging and transport systems, bacterial soft rot control, and necessary care in product handling. Furthermore, price asymmetry was evident in both domestic and export chains. Farm-gate price was more than four times lower than retail price. To improve the economic opportunities of farmers, a consolidation system that coordinates and directly links production and postharvest operations to consistently meet product volume and quality requirements of markets is a future challenge.

Keywords

Brassica oleracea L. var. capitata
domestic and export supply chains
postharvest loss

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Introduction

Lao PDR's economy relies heavily on agriculture which contributes 34.7% to GDP higher than industry and manufacturing (International Fund for Agricultural Development, 2011). Located at the heart of the Greater Mekong Subregion (GMS) surrounded by the five other GMS countries (China, Vietnam, Cambodia, Thailand and Myanmar), the country plays a strategic role in cross-border trade which is expanding due to the continuing program

on GMS economic corridor development (Asian Development Bank, 2009). Total land area is 230,800 km² and about 80% of the total population of over 6.3 million is engaged in farming, with vegetables as the second most important crop after rice (Department of Agriculture-Lao PDR, 2005).

Cabbage is one of Lao PDR's spearhead agricultural crops which are being targeted for technological and market support to intensify production and marketing and modernize agriculture as a way to achieve food security, alleviate poverty,

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and improve the rural economy (Government of Lao PDR, 2006). Cabbage is a smallholder crop and is mainly produced in Champasak Province, with Vientiane City as the main domestic market and Thailand as the main export market. To improve production and marketing efficiencies and to better position agricultural produce in domestic and export markets at competitive quality and price, a supply chain approach to product quality management is important. It should target smallholders who are the dominant players in supply chains; otherwise, they would become more vulnerable to marginalization in the face of market globalization due to their low productivity, poor quality produce, and limited market access (Chan, 2009). Analysis of supply chains is vital to develop sustainable and reliable supply chain management systems and enable the rural poor to participate gainfully in local, regional and global trade (Batt and Cadilhon, 2007; Mitchell *et al.*, 2009).

Developing market-led supply chains is a priority in agricultural development in Lao PDR (Government of Lao PDR, 2006). Earlier, the country's domestic supply chains for selected vegetables (chili, tomato, cucumber and yardlong bean) have been characterized to be relatively complex involving several collectors, wholesalers and retailers (Genova *et al.*, 2006). Similar situation existed for leafy vegetables (cabbages and mustards) produced in Vientiane Province (Genova *et al.*, 2009). For cabbages produced in Champasak which is the main growing area, the domestic and export supply chains have not been assessed, hence this study was conducted with a view to developing improved supply chain management systems.

Materials and Methods

Supply chain mapping

Domestic and export supply chains for cabbage produced in Champasak Province, Lao PDR, were identified and mapped between July-September 2009. Pakxong District was the focus production site being the main cabbage-growing area in the province. The supply chains were identified through key informants from provincial and district agriculture, commerce and trade offices which also provided key contact points in each supply chain. These contact persons were interviewed to determine the key farmers, collectors, wholesalers and retailers in the domestic and export supply chains as reliable reference points. On-site visits were then conducted to interview the key supply chain actors, map the supply chains, and gather initial information on existing practices and constraints.

Postharvest practices and loss assessment

After the supply chains were mapped, an in-depth survey was conducted between October 2009 to February 2010 to document the postharvest practices and obtain postharvest loss estimate at different stages in the domestic and export supply chains. A questionnaire was formulated, pre-tested, and refined before conducting the survey. Following the sample size principle in determining the appropriate number of respondents (Van der Vorst, 2000), 30 respondents were randomly selected from the domestic supply chain (from Champasak to Vientiane City) comprising of 15 farmers, 5 collectors, 5 wholesalers and 10 retailers. For the export supply chain (from Champasak to Thailand), 25 respondents comprising of 15 Lao farmers, 5 Lao collectors and 5 Thai collector-wholesaler-retailers were covered in the survey. In addition, practices in each supply chain were documented by observing on-site the activities from the farm to final market destination.

Analysis of results

The results were analyzed using the SPSS program at 95% confidence level and reported here as frequencies and averages. From the results, implications were drawn for improving supply chain management.

Results and Discussion

Supply chain maps

Figure 1 illustrates the domestic and export supply chain maps for cabbages produced in Pakxong District, Champasak Province, Lao PDR, and transported to and retailed at Vientiane City, Lao PDR, and Ubon Lathsathani, Thailand, respectively. The domestic supply chain involved four players; farmers and collectors in Pakxong, wholesalers in Nongteng Vegetable Wholesale Market in Vientiane, and retailers in Vientiane. Farmers brought the harvested cabbages to the collectors' house, about 4 km away on average. After confirming order from the Vientiane wholesaler, the collectors arranged transport of packed cabbages usually by public bus from Pakxong to the wholesale market in Vientiane, about 750 km away or 14 hours travel. Upon arrival at Vientiane wholesale market, the cabbages were distributed to retailers in the same market and nearby wet markets in the city.

On the other hand, the export supply chain had three main players; farmers and collectors from the Lao PDR side and Thai collectors who were also wholesalers and retailers. As in the domestic supply chain, farmers delivered the cabbages to

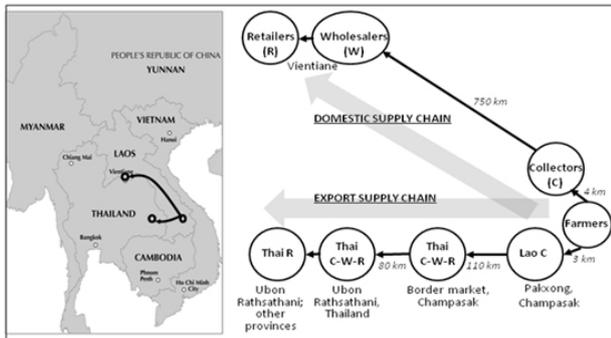


Figure 1. Location map of the main cabbage-growing district (Pakxong) in Champasak Province, Lao PDR, destination markets (Vientiane, Lao PDR and Ubon Lathsathani, Thailand), and the domestic and export supply chain maps

Table 1. Demographic characteristics of domestic and export supply chain actors for cabbage in Lao PDR

Supply chain actor	Male: Female ratio	Age, years	Years in farming/business	Farm size, hectare	Yield/traded volume
Domestic supply chain					
Farmers	87:13	44.7	12.4	1.3	24.9 tons
Collectors	40:60	36.5	9.5		6.0 tons/day
Wholesalers	0:100	36.5	12.5		0.7 ton/day
Retailers	10:90	37.4	10.8		100 kg/day
Export supply chain					
Lao farmers	87:13	38.3	9.9	1.5	21.7 tons
Lao collectors	80:20	38.8	7.4		4.0 tons/day
Thai collector-wholesaler-retailers	0:100	50.8	16.2		27.8 tons/day

Table 2. Harvesting practices of farmers in the domestic and export supply chains (frequency, %)¹

Harvesting practice	Domestic supply chain	Export supply chain
Harvest maturity index		
Firmness	60	47
Days from planting	53	33
Combination of the above	40	53
Time to harvest when mature		
Immediately	33	33
After certain period (days)	60 (3.3 days)	60 (4.1 days)
Based on collectors' order	40	13
Method of harvesting		
Use knife to cut the base of cabbage	100	100

¹multiple responses

the collectors' house over an average distance of 3 km and directly loaded to the collectors' mini-truck. After consolidating about 6 tons produce per truck load, the collectors transported the cabbages unpacked to Songmaek Market, a border trading center in Champasak District, Champasak Province, Lao PDR, near the Lao-Thai border, about 110 km away or 2 hours travel on average. The Thai collectors transported the packed cabbages using their own vehicle (10-wheeler truck, mini-truck or pick-up car) to their shops at Chaleansy Market in Ubon Lathsathani Province, Thailand, about 80 km

away or another two-hour trip including delays due to documentary processing at the Lao-Thai border. Upon arrival, the cabbages were re-packed for retail or distribution to other retailers within and outside the province.

Demographics of supply chain actors

Farmers in both domestic and export supply chains were male-dominated and had an average farm size of 1.3-1.5 hectares producing more than 20 tons of cabbages per cropping (Table 1). Farmers in the domestic supply chain were older and had more farming experience than those in the export supply chain. On the other hand, collectors, wholesalers and retailers in the domestic supply chain were female-dominated, relatively younger, and had been in the business for about 9.5-12.5 years. Collectors traded the biggest volume of produce while retailers the smallest as expected because collectors dealt with a number of wholesalers before transport of produce from Pakxong to Vientiane. In the export supply chain, Lao collectors were male-dominated since they performed transport to and sale of produce at the border trading center (Songmaek Market). The Thai collector-wholesaler-retailers were all women and had much longer business experience than the Lao collectors and farmers. They consolidated the cabbages from different collectors before cross-border transport to Thailand; as a result, the traded volume was about seven times higher than that of individual Lao collectors.

Postharvest practices

In both domestic and export supply chains, farmers harvested the cabbages based on firmness, number of days elapsed from planting, or their combination (Table 2). When mature, cabbages were not harvested right away; instead, majority of the farmers waited for 3-4 days before harvesting was done. Delaying harvest could lead to head cracking, which is a typical symptom of over-maturity, and consequently, loss of quality. A significant number of farmers (40%) in the domestic supply chain harvested the cabbages after receiving the order from the collectors. This would not cause maturity problem if the collectors' order is timed when cabbages reach their proper maturity stage. Otherwise, problems with over-maturity or immaturity (e.g. puffy heads, low saleable weight) would arise. Harvesting was usually done by cutting the base of the cabbage head using an ordinary knife, which is a good practice compared to the old practice of uprooting the whole plant or breaking the head by hand.

Trimming, sorting, packaging, storage and

Table 3. Postharvest operations of domestic supply chain actors (frequency, %)¹ and description of operation

Operation	Farmers	Collectors	Wholesalers	Retailers
	73	100	80	100
Trimming	Trim butt, remove all outer leaves	Trim butt, remove all outer leaves	Trim butt, remove damaged leaves	Trim butt, remove damaged leaves
Sorting, its basis, and place of activity	13 Size, free of insect pest and physical damage; done on covered ground or floor	100 Size (80%), no pest damage (100%), no harvest injury (80%); done on covered ground	80 Size (40%), no pest damage (60%), no harvest injury (40%); done on covered ground (20%) or table (60%)	90 Size (40%), no pest damage (50%), no harvest injury (50%); done on covered ground (40%) or table (50%)
Special treatments	0	0	0	0
Packaging	13 Bamboo basket, plastic bags	100 Plastic bag	40 Plastic bag	10 Plastic bag
Storage	6 Keep under shade	0 No store room	60 Ambient storage	30 Ambient storage
Transport	100 Hand tractor	100 Public bus	60 Mini-truck	100 ‘Tuktuk’ (80%), mini-truck (10%), public car (10%)

¹multiple responses

Table 4. Postharvest operations of export supply chain actors (frequency, %) and description of operation

Operation	Lao farmers	Lao collectors	Thai collector-wholesaler-retailers
	0	0	100
Trimming			Trim butt and remove outer leaves with knife; done at trading center in the Lao-Thai border (Lao side) and after arrival in Chaleansy Market, Ubon Lathsathani, Thailand
Sorting, its basis, and place of activity	0	0	100 Size; on covered ground
Special treatments	0	0	0
Packaging	0	0	100 Plastic bag (10 kg/bag)
Storage	0	0	100 Ambient storage for 2-3 days
Transport	100 Hand tractor	100 Mini-truck	100 large truck (40%), mini-truck (60%)

transport were the usual operations following harvesting and practices differed with supply chain (Tables 3-4). In the domestic supply chain, farmers brought the cabbages usually unpacked (loose handling) to the collectors' house using a tractor-driven cart where both farmers and collectors trimmed the cabbages of their butt and all outer leaves (wrapper leaves) with sharp knife (Table 3). The trimmed cabbages were then placed in a container (plastic crate or bamboo basket) for weighing as basis of payment to farmers. After weighing, the cabbages were removed from the container and placed on a slatted floor or table upside down to drain water from the outer and internal parts of the head and allowed to air-dry. After 4-6 hours of air-drying, the cabbages were sorted based on size and freedom from insect pest damage and physical injury on the ground covered with plastic or tarpaulin sheet or on the table before packing in 20 kg-capacity plastic bags (0.05 mm-thick high density polyethylene or HDPE film). The plastic packaging practice is a form of modified atmosphere packaging (MAP) that could minimize excessive weight loss during subsequent transport to Vientiane. However, drawbacks of its use include inadequate protection against physical damage and the likelihood of creating warm and moist conditions inside the package during prolonged holding which could promote bacterial soft rot development. This is

a serious concern considering that the cabbages were devoid of wrapper leaves as protective outer layer. The bags of cabbages were transported to Vientiane by public bus by stacking the bags on top of the bus and covering them with tarpaulin or plastic sheet. Upon arrival in Vientiane, the cabbages were again trimmed of damaged leaves and protruding butt by both wholesalers and retailers and sorted based on the same criteria as that of collectors. Wholesalers then distributed the cabbages mostly unpacked to retailers using mini-truck. Retailers transported the cabbages to the market by public transport using mostly ‘Tuktuk’ which is like a cabin compartment attached to a motorcycle. In retail markets, cabbages were usually displayed unpacked.

In the export supply chain, the Thai collector-wholesaler-retailers performed value addition activities, including trimming the butt and all outer leaves, sorting based on size, and packing in 0.05 mm-thick HDPE plastic bags with 10-kg capacity before cross-border transport to their shops in Chaleansy Market, Ubon Lathsathani (Table 4). Upon arrival, cabbages were re-trimmed for retail unpacked or individually wrapped with plastic bag, or packed in 7-kg plastic bags for distribution to other retailers within and outside the province. In contrast, only transport was performed by Lao farmers and collectors using tractor-driven cart and mini-truck, respectively, and the cabbages were unpacked or loosely handled. However, all wrapper leaves were retained for protection and cabbages were arranged in the cargo load upside down to allow water to drain from the internal part of the heads.

In both domestic and export supply chains, no special storage facility was employed at all chain stages (Tables 3-4). When practiced, storage was done only at ambient to wait for transport or retail. Similarly, no special treatment, such as washing or bacterial soft rot control treatment was practiced. Washing was believed to favor rotting while bacterial soft rot control was not known.

Postharvest losses

In both domestic and export supply chains, farmers incurred the highest loss of slightly over 30% (Table 5). Main causes were insect pest damage, rotting and over-maturity (i.e. cracked heads) which were primarily of preharvest origin. From the collector to retailer level, losses differed with supply chain. In the domestic supply chain, the collectors incurred about 3% loss due to physical damage as a result of careless handling during pre-packing and packing operations. Wholesalers incurred much higher loss of 9.6% on average as a result of bacterial

Table 5. Postharvest loss and price changes of cabbage in the domestic and export supply chains in Lao PDR

Supply chain actor	Postharvest loss, %	Major causes of loss*	Price of cabbage, USD
Domestic supply chain			
Farmers	31.8	Insect damage Rotting Overmaturity	0.08
Collectors	3.0	Physical damage	0.21
Wholesalers	9.6	Soft rot	0.30
Retailers	4.0	Weight loss Wilting Soft rot	0.38
Total loss	48.4		
Export supply chain			
Lao farmers	32.5	Insect damage Rotting Overmaturity Leaf crushing	0.072
Lao collectors	8.0	Head bursting Soft rot	0.09
Thai collector-wholesaler-retailers	14.0	Physical damage Soft rot	0.32
Total loss	54.5		

*with > 50% frequency

soft rot that usually developed on the cut butt end and damaged parts of the cabbage heads. The warm and moist conditions inside the plastic bags during the 14-hour journey from Pakxong to Vientiane probably provided favorable conditions to rot development. At the retailers' level, estimated loss was about 4% due to weight loss and trimming of wilted outer leaves and rotten parts caused by bacterial soft rot. In total, cabbage losses from farmers to retailers were about 48.4%.

In the export supply chain, the Lao collectors had a postharvest loss of about 8% due to physical damage (leaf crushing and head bursting) consequent to loose handling of cabbages from Pakxong to the border trading center. Rotting due to bacterial soft rot caused additional losses when there were delays in disposing the produce to the Thai collectors. Losses incurred by Thai collectors of about 14% were realized only on arrival of cabbages at Chalaensy market where they also performed wholesaling and retailing activities. Major causes of loss were physical damage and bacterial soft rot. In total, the export supply chain had a total product loss of 52.5%.

Product losses contributed to price disparity along the chain (Table 5). In the domestic supply chain, the farm-gate price (0.08 USD/kg) was almost three times lower than the collectors' price (0.21 USD/kg) offered to wholesalers. Transport cost was the main contributor since it was shouldered by the collectors. Other contributors to the collectors' price were the costs of pre-packing and packing operations. The wholesale and retail prices were 0.08-0.09 USD/kg higher than the collectors' price. In the export supply chain, farmers received a price of about 0.072 USD/kg, lower than that in the domestic supply chain. However, the farm-gate price was for whole cabbages with wrapper leaves intact (i.e. untrimmed

heads) unlike that in the domestic supply chain. Some farmers also revealed that the export market provided more assurance of high-volume orders. The Lao collector's selling price was about 0.018 USD/kg higher than the farm-gate price while the selling price of the Thai collector-wholesaler-retailer was much higher, about 0.32 USD/kg, due to the costs of value addition (e.g. trimming and packing) and transport, in addition to product losses incurred.

Implications for development

Cabbage loss reduction along the domestic and export supply chains apparently required both production and postharvest interventions. At the farm level, appropriate pest management strategies and harvesting techniques should be introduced. Proper production programming should be practiced also in order to time production and harvesting with market requirements. During the postharvest period, the transport stage seems to be the main bottleneck where physical damage and rotting originated. Factors contributing to losses include loose handling from Pakxong to Songmaek Market (export supply chain), removal of all wrapper leaves, use of plastic bags as packaging container, and poor handling and transport conditions. Technological innovations that could minimize these problems include retention of 3-4 wrapper leaves, use of plastic crates to supplement or replace the use of plastic bags, and application of safe antibacterial treatments (e.g. alum, lime, chlorine and botanical extracts as biocides) (Acedo, 2009). These techniques are applied before, during, and/or after transport but need to be examined to suit local conditions and resources.

Asymmetry in economic opportunities was evident in both domestic and export supply chains, with the farmers who were all smallholders receiving the least as shown by the great disparity in farm-gate, wholesale and retail prices. Strategies to expand the economic opportunities necessitates collective action by small farmers to gain economies of scale and bargaining power, do value addition activities, and engage directly with market (Shepherd, 2007; Kanlayanarat, 2009). This can be done by assisting small farmers to develop and manage a consolidation center with packinghouse facilities. The consolidation center can serve as a direct link of farmers to market providing such market with steady supply of produce that meets quality and volume requirements. If properly managed, the consolidation center could enable participation of small farmers in coordinated supply chains which are principal commercial tools for competitive strategies (e.g. labeling, branding), assuring product quality and better logistics, and

expanding market and income opportunities (Van der Meer, 2006).

Conclusion

Cabbage supply chains for domestic and export markets differed but shared common constraints contributing to product losses. Improving current supply chains for better control of product quality and for more equitable distribution of benefits among chain actors requires technological and non-technological interventions. A consolidation system that coordinates production and postharvest operations linked directly to serving market requirements is a future challenge to better the economic well-being of small farmers.

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