Reducing Losses of Cabbage in Traditional and Modern Chain in Cebu, Philippines

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***Abstract*—Postharvest losses of cabbages in the traditional and modern chains in Cebu, Philippines have been estimated earlier to range from 26-27% due to poor packaging and lack of handling techniques. Actual measurement of loss based on the sum of weight loss and trimming of damaged, wilted and rotten parts revealed much higher total loss of 33.7% in the traditional chain, with the retail stage (after 3 days holding at ambient) having higher loss of 16.1% than that at the transport stage of 5.4% from the farm to the wholesale-trading center (about 1km) and 12.2% from the trading center to the wholesale-retail market (about 98 km or 3-4 hours travel). Introduction of 3-4 wrapper leaf retention and plastic crate packaging at the farm, 2-3 wrapper leaf retention, 15% alum treatment for bacterial soft rot control and plastic crate packaging prior to transport market, and 15% alum treatment prior to retail reduced losses to 3%, 6.1% and 10.8%, respectively, or a total loss of 19.9%. In the modern chain, total loss was 24.8%, almost similar to the previous estimate, itemized into 3.8% from the farm to the trading center, 12% after transport from the trading center to the wholesale market, and 9% after 3 days in the supermarket. Introduction of 3-4 wrapper leaf retention and plastic crate packaging at the farm, 2-3 wrapper leaf retention, 15% alum treatment and plastic crate packaging prior to transport market, and 15% alum treatment and individual plastic film wrapping prior to supermarket display reduced losses to 2.7%, 7.1% and 6.3%, respectively, or a total loss of 16.1%. With the introduction of the different postharvest techniques, net income and return on investment increased and were highest at retail stage and lowest at the farm level.**

***Index Terms*—alum treatment, *Brassica oleraceae var. capitata*, plastic crate packaging, plastic film wrap, supply chain losses, return on investment, wrapper leaf retention**

I. Introduction

Postharvest losses may occur at any point in the marketing process from the initial harvest through assembly and distribution to the final consumer. The causes of losses includes physical damage during handling and transport, physiological decay, water loss, action of several fruit flies or sometimes simply because there is a surplus in the market place [1], [2]. On other hand, several studies have estimated the loss of fresh produce due to poor post-harvest handling is in the range of 30-40% of production [3]. The overall losses in vegetables can be up to 25% of total production [1], [4], and [5]. Cabbage losses were amongst the highest at 20 to 30% [1]. [6] Stated that the severe losses occur because of poor transportation facilities, lack of know-how, poor management and improper market facilities or due to careless handling of the produce by farmers, market intermediaries and consumers. Marketing through traditional means is characterized by very little attention to grading, sorting and storage, weak institutions and poor handling during loading, unloading and transport [7]. The high percent of post-harvest damage can largely be explained by such poor handling of the produce.

Reducing postharvest losses is one of the strategies for import substitution and a positive step toward vegetable self-sufficiency. A supply chain approach to postharvest loss reduction has become essential to improving marketing efficiency and profitability and creating significant market advantage [8]. Appropriate postharvest technologies would not only increase food availability to the growing world population but also decrease the area needed for production and conserve natural resources [9]. In Cebu, wherein vegetable production areas are usually located at higher elevation (e.g. Mantalongon, Dalaguete, Cebu) where subtropical vegetables such as cabbage are grown. Most vegetable farmers are smallholders; they are poorly educated, the relationship between farm practices and the use of improved techniques for higher yields and quality is not well understood, limiting the development of the sector. Hence, this study was conducted to assess the postharvest loss and evaluate the technical and economic effectiveness of technological interventions in reducing supply chain losses of cabbage.

II. Materials and Methods

A. Assessment of Postharvest Losses

The postharvest losses of cabbage in traditional and modern supply chains were assessed in May 2013 – July 2013. The traditional supply chain covered major

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growing areas in Mantalongon, Dalaguete, Cebu up to the retail markets in Carbon Market, Cebu City. This was compared with modern supply chains for cabbage produced in Mantalongon, Dalaguete, Cebu for supermarkets within Cebu City. Fig. 1 shows the country location of the study areas. To obtain postharvest loss estimates and their causes, on-site interviews were conducted following the sample size principle in determining the appropriate number of respondents [10], 35 respondents (15 farmers, 5 traders/collectors, 5 wholesalers and 10 retailers) were randomly selected for the traditional supply chain (from Mantalongon, Dalaguete, Cebu to Carbon Market, Cebu City) and 28 respondents (15 farmers, 5 traders/collectors, 5 wholesalers and 3 supermarkets) for the modern supply chain (from Mantalongon, Dalaguete, Cebu to supermarket). The results were analysed using the SPSS program at 95% confidence level. Product losses were estimated at each stage in the supply chain. For farmers, loss was quantified as percentage of total harvest. For traders, wholesalers and retailers, loss was estimated as the difference between quantity purchased and quantity sold. Problems and constraints contributing to postharvest losses and inefficiencies of the supply chain were identified. This information served as basis in identifying and testing technological interventions.

B. Introduction of Postharvest Techniques in Cabbage Supply Chains

Critical stages in the supply chains where postharvest losses were serious were targeted for technological interventions. Available techniques developed at the Postharvest Technology Division of the Department of Horticulture, VSU, and those at the Postharvest Horticulture Training and Research Center, UPLB were used, in particular retention of wrapper leaves, use of plastic crates as packaging material, application of 15% alum solution to control bacterial soft rot, and modified atmosphere packaging using plastic film. The techniques were integrated at the different stages in both traditional and modern supply chains and evaluated for technical and economic effectiveness. For each transport load of cabbages from the production site (Mantalongon, Dalaguete Cebu) to destination markets (Carbon Market and supermarkets), 6 packs of cabbages or their equivalent if not bagged (each pack representing a replicate) were used as sampling units at each supply chain stage involving the introduced postharvest technique/s. Another set of 6 bags of cabbages were used for the existing practices as control.

Technical effectiveness was evaluated based on the magnitude of postharvest loss reduction (magnitude of reduction in weight loss, soft rot incidence and trimming loss). Economic effectiveness was assessed by performing cost and return analysis to determine profitability (e.g. increased market volume/share due to reduced postharvest loss; increased sales due to improved product quality). Results and treatment differences were analysed by performing T-test using the SPSS program.

III. Results and Discussion

A. Postharvest Loss

The total loss of cabbage was almost similar in both traditional and modern supply chains (26.4-26.5%) (Table I). However, farmers in modern supply chain incurred higher loss of 13.2% than traditional chain farmers of about 10.1 % loss. Losses were primarily due to pre-harvest origin, including insect damage and rotting/decay due to rain. No loss was recorded at the commission agent's level where no postharvest operation was performed since the cabbages were merely transferred from the farmers to the wholesalers at the trading post. Losses at the wholesalers to retailer's level differed with supply chain. In traditional chain, wholesalers incurred 6.8% loss due to weight loss and mechanical damage as a result of improper handling of fresh produce and poor packaging during transportation. Retailers incurred 9.6% loss on average, much higher compared to wholesaler's level due to physical damage and weight loss resulting from improper handling of fresh produce and poor temperature and humidity control. Loss may be in the form of trimmings or whole cabbage rejection at the farmer's level while at the wholesaler and retailer levels, trimming contributed more to losses.

In the modern chain, wholesalers and retailers incurred an average loss of 6% and 7.2% respectively (Table I). Poor transport was the main contributory factor to loss in both chains. Losses in wholesaler level were due to weight loss and mechanical damage as a result of improper handling of fresh produce and poor packaging during transportation. Physical damage and soft rot incidence were among the causes of loss at retailer's levels as a result of improper handling and lack of techniques. A large volume of cabbages discarded per day basis in Mantalongon Trading Center was due to trimming.

Cabbage prices along the chain varied greatly (Table I). Farm-gate price was slightly higher in the modern chain (27.3 Php/kg) than in the traditional chain (26.7 Php/kg). Commission agents in both chains got 1 Php/kg commission for produce dealt from growers to wholesalers without any postharvest operation. Wholesalers in both chain added about 11 Php/kg to the price given to commission agents; however, they shouldered the costs of postharvest operation and transport to retailers. Big discrepancy in price was obtained at retailer's level as the price in the traditional chain (42.7 Php/kg) was almost twice lower than that in the modern chain (78.3 Php/kg).

From the above results, it appeared that farmers got the lowest profit in both chains while the intermediaries received higher financial return.

Postharvest losses of cabbages were about one-fourth of the total volume and these were usually passed on to farmers as low farm-gate price and to consumers as high retail price. Appropriate technological interventions reduce losses which should translate to high farm-gate price to increase the financial returns of farmers.

TABLE I. POSTHARVEST LOSS OF CABBAGE IN THE TRADITIONAL AND MODERN SUPPLY CHAIN IN CEBU, PHILIPPINES

Supply chain actor	Postharvest loss, %	Causes of loss*	Reason for loss*	Nature of loss*	Price of cabbage, Php
Traditional supply chain					
Farmers	10.1	Insect damage Rotting/ decay	Lack of reliable maturity indices Unsuitable used of pesticides	Trimming/ cleaning Whole- cabbage rejection	26.7
Commission Agent	0	0	0	0	27.7
Wholesalers	6.8	Weight loss Mechanical damage	Improper handling of fresh produce Poor packaging during transportation	Trimming/ cleaning	37.7
Retailers	9.6	Weight loss Physical damage	Improper handling of fresh produce Poor temperature and humidity control around the produce	Trimming/ cleaning	42.7
Total loss	26.5				
Modern supply chain					
Farmers	13.2	Insect damage Rotting/ decay	Unsuitable used of pesticides	Trimming/ cleaning Whole- cabbage rejection	27.3
Commission Agents	0	0	0	0	28.3
Wholesalers	6	Weight loss Mechanical damage	Improper handling of fresh produce Poor packaging during transportation	Trimming/ cleaning	38.3
Retailers	7.2	Physical damage Soft rot	Improper handling of fresh produce No techniques	Trimming/ cleaning	78.3
Total loss	26.4				

*with ≥ 30% frequency

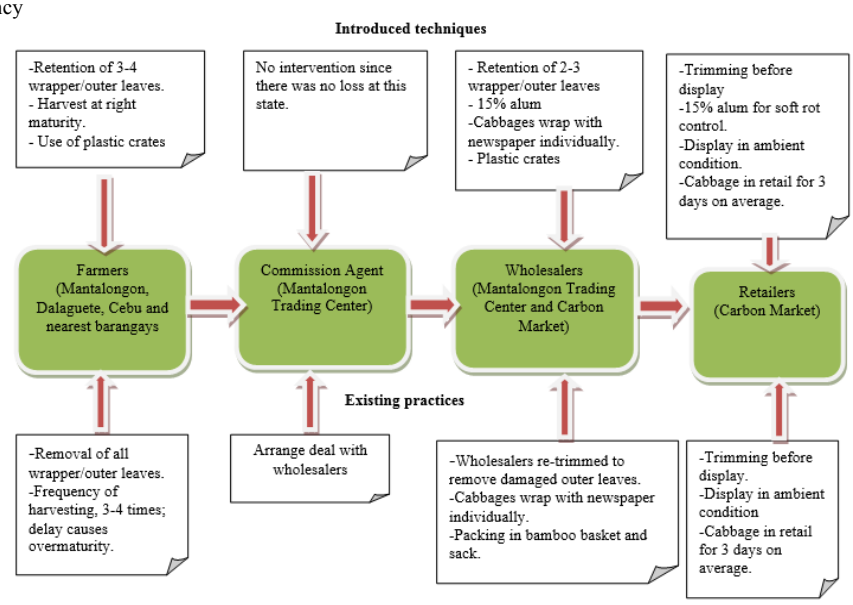


Figure 1. Cabbage introduced quality management techniques (top) relative the existing management system (bottom) for the traditional supply chain

B. Postharvest Techniques in Cabbage Supply Chains

In the traditional and modern chains, highest loss was incurred at the farm level caused by preharvest (pest problems), harvest (maturity problem) and postharvest (removal of protective wrapper leaves, poor packaging) factors. Losses at the wholesaler and retailer levels were also significant and were caused by poor handling, packaging and transport practices; some of these losses can be traced to the farm level since the removal of wrapper leaves made the cabbages more susceptible to damage and loss at subsequent stages in the chain. Addressing the pest problem during production is beyond the scope of this study while maturity-related problem can be minimized by following established harvest maturity recommendation, i.e. combining phonological index (number of days elapsed from field planting) with firmness or solidity of the cabbage head. Thus, the following sections focus on postharvest techniques introduced to reduce losses. These postharvest techniques

have been optimized in earlier works and included the retention of 3-4 wrapper leaves, use of plastic crates to supplement or replace the use of sack and bamboo basket, and 15% alum for bacterial.

Fig. 1 and Fig. 2 show the techniques introduced at the different stages in the traditional and modern supply chains, respectively, in comparison to the existing practices. At the farm level, retention of 3-4 wrapper/outer leaves and use of plastic crates were introduced while at the wholesaler's level at Mantalongon Trading Center, removal of damaged wrapper leaves to retain 2-3 leaves, application of 15% alum and use of plastic crates. The application of 15% alum was again introduced at the retailer's level. The use of MAP (use of plastic film cling wrap) is an existing practice in the modern chain and is included being a suitable technique.

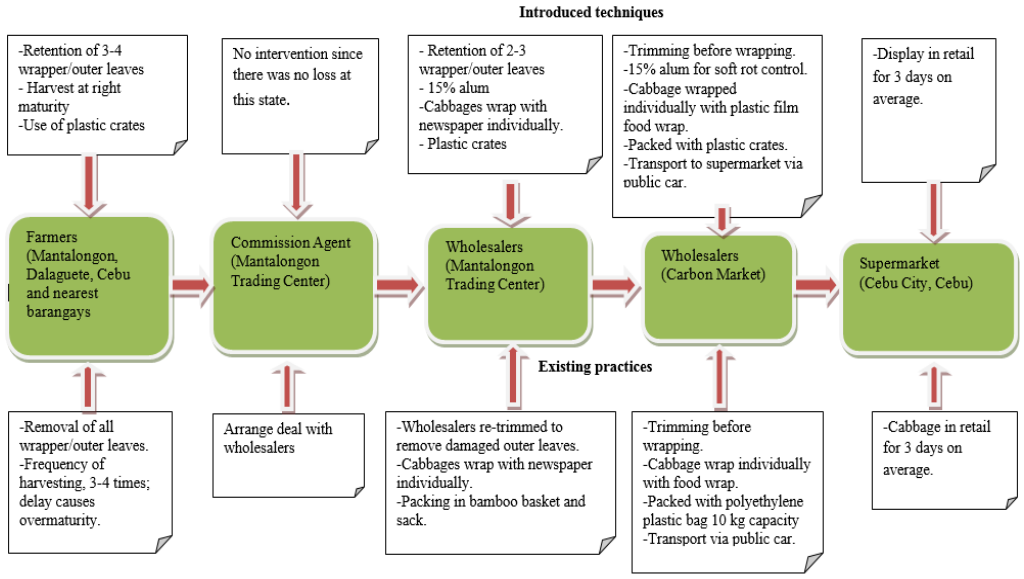
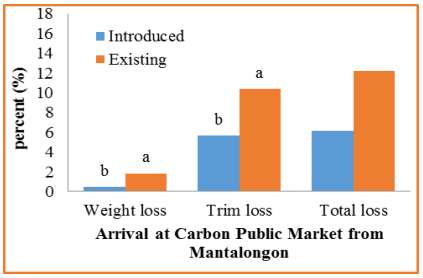


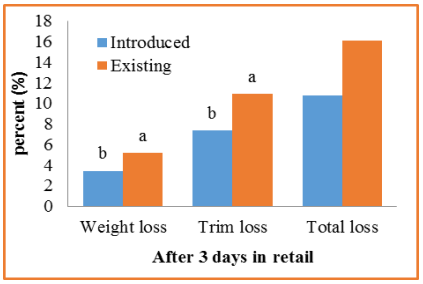
Figure 2. Cabbage introduced quality management techniques (top) relative to the existing management system (bottom) for the modern supply chain

C. Technical Effectiveness of Postharvest Techniques

In the traditional chain, the existing practice was found to incurred a total loss of 33.7% broken down to 5.4% at the farmer's level (after transport from the farm to the trading post), 12.2% at the wholesaler's level (after transport from the trading post to the Carbon market) and 16.1% at the retailer's level (after 3 days holding at retail) (Fig. 3). This was higher than that estimated by survey respondents during the supply chain assessment; underreporting of loss estimates by chain actors may lead to inaccuracies in determining loss interventions. The introduction of 3-4 wrapper leaf retention and plastic crate packaging at the farm, 2-3 wrapper leaf retention, 15% alum treatment for bacterial soft rot control and plastic crate packaging prior to transport to Carbon market, and 15% alum treatment prior to retail reduced losses to 3%, 6.1% and 10.8%, respectively, for a total loss of 19.9% or about 41% lower than that incurred from the existing practice (Fig. 3).

In the modern chain, the total loss was 24.8%, almost similar to the estimate by supply chain actors, but losses were lowest at the farmer's level (3.8%) and highest at the wholesaler's level (12%); at retail, 9% loss was incurred (Fig. 4). Introduction of 3-4 wrapper leaf retention and plastic crate packaging at the farm, 2-3 wrapper leaf retention, 15% alum treatment and plastic crate packaging prior to transport to market, and 15% alum treatment and individual plastic film wrapping prior to supermarket display (Fig. 4) reduced losses to 2.7%, 7.1% and 6.3%, respectively, for a total loss of 16.1% or about 35% lower than that from the existing practice.





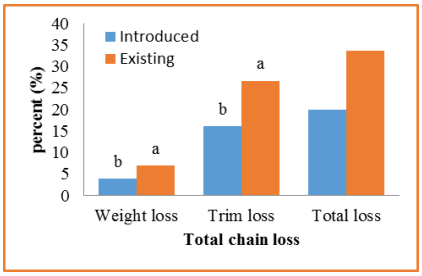


Figure 3. Cabbage loss in the existing and improved Quality Management (QM) in traditional chain for cabbage

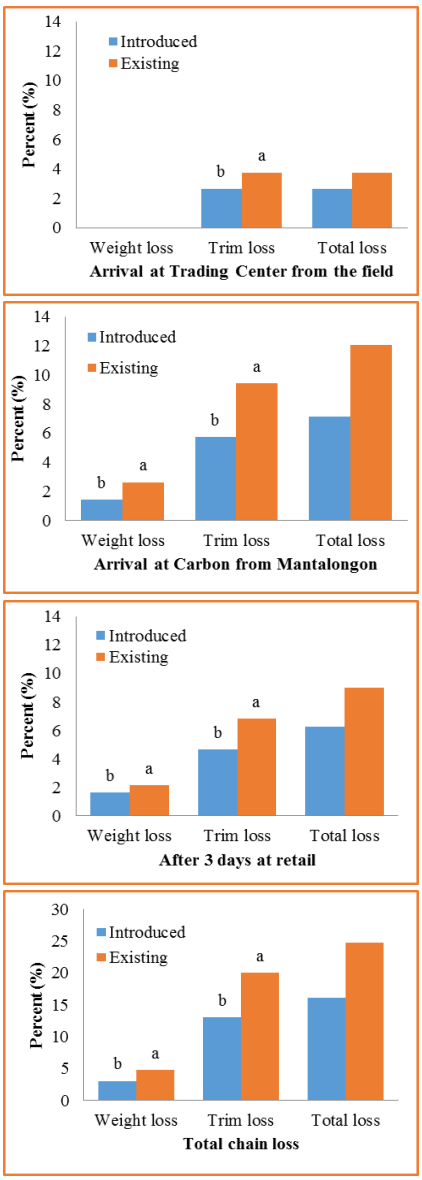


Figure 4. Cabbage loss in the existing and improved quality management in modern chain

The results demonstrate the effectiveness of the postharvest techniques in reducing cabbage losses along the chain. Earlier, it was reported that retaining 2-3 wrapper leaves in cabbage reduced losses by 6.3% from 28.5% with all wrapper leaves removed [11]. The use of plastic crates has also been shown to reduce losses of vegetables from 30% with the use of poly sacks to 5% with the use of plastic crates [12] and [13]. The rigidity of plastic crates and their smooth internal surfaces allow maximum protection of fresh produce [14]. On the other hand, the application of 15% alum to control cabbage soft rot has been optimized and commercial tested at the Postharvest Horticulture Training and Research Center, UPLB. This technique has also been reported to be effective against cabbage soft rot by [11] and [15].

D. Economic Effectiveness of Postharvest Techniques

In the traditional chain, farmers, wholesaler and retailers traded 6600kg/cropping, 175kg/day and 145kg/day, respectively (Table II). With the existing practice, the net saleable volume traded after postharvest losses were 5,933.4kg, 153.6kg, and 121.37kg, respectively, giving a gross income of Php 158,421.78, Php 5,836.8, and Php 5,825.76, respectively. With the introduction of postharvest techniques, the net saleable volume and gross income increased to 6399.36kg, 164.29kg, and 129.37kg, respectively, and Php 172,782.22, Php 6243.02, and Php 6209.76, respectively.

The techniques correspondingly increased the cost to a total of Php 44,384.53, Php 4885.31, and Php 3550.51 at the farmer, wholesaler and retailer levels, respectively, while that in the existing practice was Php 41,369.22, Php 4923.06, and Php 3600.51, respectively. However, the added cost of the techniques more than offset by the increased saleable volume due to loss reduction. Thus, the net income and Return on Investment (ROI) with the use of postharvest techniques increased to Php 128,398.19, Php 1357.71, and Php 2659.25, and 289%, 27.79%, and 74.90% at the farmer, wholesaler and retailer levels, respectively, from Php 117,052.56, Php 913.74, and Php 2225.25, and 283%, 18.56%, and 61.80%, respectively, in the existing practice.

Similar trend was obtained in the modern chain. Farmers, wholesaler and retailers traded 5200kg, 185kg and 60kg cabbages per day, respectively (Table II and Table III). With the existing practice, the net saleable volume traded after postharvest losses was 4513.6kg, 162.71kg, and 54.61kg, respectively, giving a gross income of Php 123,221.14, Php 6182.98, and Php 4259.58, respectively.

With the introduction of postharvest techniques, the net saleable volume and gross income increased to 5061.68kg, 171.78kg, and 56.24kg, respectively, and Php 138,183.36, Php 6527.64, and Php 4386.72, respectively. With the introduction of postharvest techniques as a result of the reduction of losses. The techniques correspondingly increased the cost to a total of Php 30,959.99, Php 5400.31, and Php 1570.51, at the farmer, wholesaler and retailer levels, respectively, while that in the existing practice was Php 27,944.68, Php 5418.06, and Php 1560.51, respectively. However, the added cost of the techniques was more than offset by the increased saleable volume due to loss reduction. Thus, the net income and Return on Investment (ROI) with the use of postharvest techniques increased to Php 107,223.87, Php 1127.33, and Php 2816.21, and 346%, 20.87%, and 179.32% at the farmer, wholesaler and retailer levels, respectively, from Php 95,276.46, Php 764.92 and Php

2699.07, and 341%, 14.12% and 172.96%, respectively, in the existing practice.

The results indicate that the introduced postharvest techniques were economically and technically feasible. However, large scale trials are needed to firm up the findings and establish solid recommendations to improve the traditional and modern supply chains.

TABLE II. COST AND RETURN ANALYSIS OF EXISTING AND IMPROVED QUALITY MANAGEMENT (QM) OF CABBAGE AT THE FARM, WHOLESALE AND RETAIL LEVEL IN TRADITIONAL CHAIN

Item	Farmer level, Php /Cropping		Wholesale level, Php /Operation		Retail level, Php /Day	
	Improved QM	Existing QM	Improved QM	Existing QM	Improved QM	Existing QM
A. Revenue (A.4)(A.5)	**170,862.9**	**158, 421.78**	**6243. 02**	**5836.8**	**6209.76**	**5825.76**
A.1 Traded volume/day, kg	6600	6600	175	175	145	145
A.2 % Loss	3.04	10.1	6.12	12.23	10.78	16. 05
A.3 Loss volume, kg	200.64	666.6	10.71	21.40	15.63	23.27
A.4 Saleable volume, kg	6399.36	5933.4	164.29	153.6	129.37	121.37
A.5 Selling price, Php	26.7	26.7	38	38	48	48
B. Cost			**4885.31**	**4923. 06**	**3550.51**	**3600.51**
BI. Existing QM[2]		**41,369.2**				
B2. Model QM, B.1+trt. Cost	**44,384.5**					
B1	41,369.2					
Cabbage (A.1 x buying price)[1]			4200	4200	3480	3480
Packaging cost	3000		60	60	*	*
Transport cost			200	180	*	*
Labor cost (trimming, sorting, packaging and hauling)			400	480	60	120
Depreciation Expenses**	15.31		15.31	3. 06	0.51	0.51
Alum trt cost, Php10/50g			10		10	
C. Net income (A-B)	**126,47838**	**117,052.56**	**1357.71**	**913.74**	**2659.25**	**2225.25**
D. ROI, (C/B)100, %	**285**	**283**	**27.79**	**18.56**	**74.90**	**61.80**

*Packaging cost and transport cost not provided as wholesalers handled the cost of operation.
[1]buying price = Php 24

TABLE III. COST AND RETURN ANALYSIS FOR THE IMPROVED AND EXISTING QUALITY MANAGEMENT (QM) SYSTEM FOR CABBAGE AT THE FARM, WHOLESALE AND RETAIL LEVEL FOR MODERN CHAIN

Item	Farmer level, Php /Cropping		Wholesale level, Php /Operation		Retail level, Php /Day	
	Improved QM	Existing QM	Improved QM	Existing QM	Improved QM	Existing QM
A. Revenue (A.4)(A.5)	**138,183.86**	**123,221.14**	**6527.64**	**6182.98**	**4386.72**	**4259.58**
A.1 Traded volume/day, kg	5200	5200	185	185	60	60
A.2 % Loss	2.66	13.2	7.15	12.05	6.26	8.98
A.3 Loss volume, kg	138.32	686.4	13.22	22.29	3.76	5.39
A.4 Saleable volume, kg	5061.68	4513.6	171.78	162.71	56.24	54.61
A.5 Selling price, Php	27.3	27.3	38	38	78	78
B. Cost			**5400.31**	**5418. 06**	**1570.51**	**1560.51**
BI. Existing QM		**27,944.68**				
B2. Model QM, B.1+trt. Cost	**30,959.99**					
B1	27,944.68					
Cabbage (A.1 x buying price)[1]			4440	4440	1440	1440
Packaging cost	3000		135	135	*	*
Transport cost			300	240	*	*
Labor cost (trimming, sorting, packaging and hauling)			500	600	120	120
Depreciation Expenses**	15.31		15.31	3. 06	0.51	0.51
Alum trt cost, Php10/50g			10		10	
C. Net income (A-B)	**107,223.9**	**95,276.46**	**1127.33**	**764.92**	**2816.21**	**2699.07**
D. ROI, (C/B)100, %	**346**	**341**	**20.87**	**14.12**	**179.32**	**172.96**

*Packaging cost and transport cost not provided as wholesalers handled the cost of operation.
[1]Buying price= Php 24

IV. Conclusion

Postharvest losses of cabbages in the traditional chain were higher than in the modern chain. Removal of all protective wrapper leaves together with poor handling, packaging and transport practices were the main causes of loss. Introduction of postharvest techniques proved to be technically and economically feasible.

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