International Journal of Scientific Research and Management (IJSRM)
||Volume||12||Issue||9||Pages||7339-7350||2024||
Website: https://ijsrm.net ISSN: 2321-3418
DOI: 10.18535/ijsrm/v12i09.em01

Assessment on the Postproduction Systems and Losses of Calamansi in the Philippines: Oriental Mindoro to Manila Market Chain

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Abstract
Calamansi (Citrofortunella microcarpa) also known as calamondin, or Philippine Lime is considered one of the high value crops indigenously and commercially grown in the Philippines. A steady decline in the volume of production was recorded from 2016 to 2022 wherein postproduction losses was as one of the factors identified. Using the chain of Oriental Mindoro to Manila market, this study was conducted to assess the present situation compared to the 2009 postproduction systems and perceived loss figure.
Results showed that there was a shift in the harvesting time, more careful harvesting using the metal clip to minimize plugging, incorporating washing and curing and more market outlets identified in the present postproduction system. It was evident that total perceived losses by the different stakeholders were reduced at 17.07% from 30% of 2009. Farm losses contributed the highest and sources of losses were due to insect damage, yellowing, and browning. Majority of the calamansi produced in Oriental Mindoro were supplied to Divisoria, Manila and Tanauan, Batangas markets. Among the chain actors, farmers incurred the highest costs while wholesaler received the highest net income. Farm activities were predominantly done by males while females for the marketing and processing. Processing the marketable rejects and the volume during peak seasons' glut is recommended through farmer's cooperative/associations as value adding activities.

Keywords: browning, calamansi, curing, insect damaged, postproduction losses, washing, yellowing

Introduction

Calamansi (*Citrofortunella microcarpa*) also known as calamondin, lemonsito, or Philippine Lime is considered one of the high value crops indigenously and commercially grown in the Philippines. It is a fruit crop with diverse uses such as food or drinks (juices, tea, syrups, concentrates, and purees) and for medical purposes (treatment for cough asthma, high blood pressure, etc.) (Pabuayon, 2000; Cheong et al 2012). It is well-known for its health benefits due to its high phosphorus, calcium, iron, and most notably, vitamin C or ascorbic acid content (Morton, 1987; Singh et al, 2020; Husni et al 2021; Siner et al 2020). Also, it ranks fourth as the most produce fruit in the country and a significant source of revenue for many small farmers (Ochasan et al 2014).

In the last five years (2017-2021), the Philippines registered an average annual production of 112,130 metric tons harvested from 19,710 hectares with an average yield of 5.69 mt/ha. The highest producer of calamansi in the country is MIMAROPA region sharing around 35.9% to the total country's production. On the other hand, Oriental Mindoro is one of the provinces of MIMAROPA and the top producer of calamansi in the region contributing almost 97.2% of the total regional production (PSA, 2022).

From 2016 to 2019, the Philippines exported an average of 727 mt (PhP 72.9 M) of fresh. Juice and dried calamansi. Among these, calamansi juice has the highest volume with an average of 645 mt annually

to United States and Korea markets. However, in 2019, more than 32% of calamansi juice was exported to China and none to Korea. On the other hand, the Philippines imported calamansi juice from Korea, United Kingdom of Great Britain, Northern Ireland, Taiwan, Singapore and the United States (PSA, 2019 and 2020).

Though with economic value this product still lacks support in terms of marketing management and postharvest handling, which could redound to extra benefit in the form of additional revenue if given proper attention by the government (Masagca and Ines, 2021). Consequently, in spite of the international market demand, calamansi production in the Philippines is declining due to aging trees, poor farming techniques, and widespread farm conversion. Farmers said that they convert the calamansi trees with rice or other fruit trees due to the low price during peak season (P2.50 – P4.00/kg) compared to lean season (P28.00 – P45.00/kg) (PRDP, 2014).

Increasing production is often the focus of efforts to feed a growing population. However, reducing postharvest losses also increases food availability. When production increases, loss reduction is necessary to maintain certain levels of food supply thus postharvest losses are another area that leads to increased food availability. According to PRDP (2014), postharvest handling is just as critical as maintaining the fruit's quality at the farm level. Duman (2010) stressed the importance and urgency of reducing supply chain losses in developing nations, and that increasing production without considering postharvest systems risks compounding the situation.

In 2009, a study was conducted on the perceived postharvest losses in Mindoro and this undertaking was to determine the changes in the postharvest systems and losses after more than a decade.

Materials And Methods

The secondary data is gathered through desk research while the primary data is collected through the conduct of a survey, focus group discussion (FGD), and key informant interview (KII). The primary respondents were the farmers, traders, processors, and government and private employees who have knowledge on calamansi. Phone call interview was also considered to save time and budget. Among the key informants were the leaders of calamansi associations, Philippine Calamansi Association, Inc.

Market flow was done to characterize the different actors involved in the different identified chains. To fully understand the chain system, the roles of the different actors, its operations, and practices were documented and described.

Using a structured questionnaire, primary data on the perceived losses of calamansi, were gathered through surveys. Starting from harvesting, sorting, washing/cleaning, packaging, transporting, and marketing including key players involved was noted. The quantitative loss estimates were gathered according to the sequence of the postproduction practices done by each involved stakeholder. Losses incurred were determined in each channel as well as the factors that contribute to the losses such as the technology, infrastructure used, and the environmental condition. Postproduction losses of processed products were excluded in this study.

The main outputs were description of the existing performance of the major supply chain in terms of losses, identification, and quantification of losses, technology gaps and inefficiencies of existing postproduction, identification of available technologies, and recommended measures to reduce losses.

Data Gathering and Analysis

One-on-one interviews, focus group discussions (FGD) and key informant interviews (KII), and phone call interviews and tracing method was adopted. A total of 249 farmer-respondents of fresh calamansi were interviewed. Wholesalers, retailers, and processors identified by farmers or other actors in the chain are also interviewed. Individual interviews with the respondents were conducted in the top-producing barangay/municipalities of calamansi.

Top producing municipalities of calamansi and farmer respondents were identified through the office of the agriculturist. Based on the experiences of the actors involved in the calamansi for local markets in

Oriental Mindoro to Manila chain, data were gathered covering the last two harvest seasons before the COVID-19 pandemic. For the loss assessment, data were gathered through individual interviews with the farmers, traders, and other stakeholders based on their experiences and perceptions.

RESULTS AND DISCUSSION

Postproduction System of Calamansi in Oriental Mindoro to Manila market

Harvesting

Calamansi trees in Oriental Mindoro were tall, reaching approximately 3 – 4 meters with wide canopy. Trimming or pruning of trees was not being practiced by calamansi farm owners in the area (Figure 1). More so, most of them believed that not applying fertilizer and pesticides would produce organic calamansi fruits.

Figure 1. Calamansi trees in Oriental Mindoro, 2022

Maturity indexes for calamansi fruits are appearance, size, and colors. Matured calamansi fruits are green and shiny. Harvesting was done with a metal thumb harvesting clip to minimize rejects due to plugging. Plugging and bruising as well as rough handling of the fruit results to browning and yellowing. Harvesters were trained to be more careful when picking the fruits to avoid bruising, plugging and other forms of damages. Ladders were used for old and tall calamansi trees and a bamboo basket tied around the waist of the harvester to collect the fruits and packed in a 30-kilo red bag (Figure 2). In 2009, the fruits were packed in larger containers such as 35kg for red bags and 50 kg for the bamboo baskets.

Peak harvest months were from September to October while lean harvest months were from December to January. During good weather conditions, manual harvesting was usually done from 8:00 in the morning until 1:00 in the afternoon, a total of five hours a day depending on the volume of calamansi fruits. This change in time from the previous practice (9:00am to 3pm) allowed farmers to pick the fruits during the cooler part of the day and thereby maintaining its freshness and reducing the likelihood of postharvest damage. Harvesting fruits was not advisable when raining or foggy as well as early harvesting and immediate transporting can cause oil spotting which causes injury to surrounding living cells resulting to olleocellosis (Sawamura et 1988). The number of harvesters in peak months range from 1 to 10 persons while 1 to 3 persons only in lean months. During harvesting season, the labor cost for the harvesters, sorters, washers, and packers ranges from P1.00 – P3.50 per kilo of calamansi fruits.

It was noted that in 2009 peak months were longer (July to October) than to date which was September to October. This was perhaps due to farmers were not practicing trimming and pruning of trees so fruiting was delayed and with low harvest.

Figure 2. Metal thumb clip, ladder and bamboo basket as harvesting tools used in Oriental Mindoro, 2022

Sorting/Trimming

Harvested calamansi fruits packed in a red bag or plastic pail were hauled manually by the harvesters/pickers to a packing shed near the farm or the farmer's house for the sorting activity (Figure 3). Sorting was practiced to classify/grade the calamansi fruits based on its sizes. Quality fruits get better prices.

Figure 3. Packing shed used in Oriental Mindoro, 2022

Trimming of the peduncle was done by leaving 1 – 1.5" stem length and one to two leaves in each calamansi fruit (Figure 4). In the market, the green leaves indicate freshness. In the area, calamansi fruit produced for the market were with classifications or grading of good large, good rumble, marketable rejects, and unmarketable rejects (Figure 5).

Figure 4. Sorting and trimming of calamansi using packing shed and scissors in Oriental Mindoro, 2022

Good Large | Good Rumble | Marketable Rejects | Unmarketable Rejects

Figure 5. Picture guide in the classification of calamansi in the Philippines, 2022

Good large or >3cm in diameter calamansi was preferred by the markets and commands a higher price. Good rumble is a mixture of medium and small size. The color of good large and rumble calamansi fruit was green and shiny in appearance. Marketable rejects were calamansi fruits with some defects such as scab and punctured sold at a lower price. However, these defects did not affect the taste of the extract. Based on the 2009 results, sorting and trimming practices were done the same.

Washing and Curing

Farmers in Oriental Mindoro practiced dipping of calamansi into a water solution with shampoo to clean, removed the acid rain during harvesting and other contaminants that could contribute to spoilage during transport. After washing them, farmers used an electric fan to dry the fruits at the packing shed for curing. As explained by Ashebre (2015) curing is a pre-treatment and conditioning of the fruit before packaging. It removes moisture from the peel so that it becomes suitable for mechanical handling and to minimizes physiological disorders. Actually, this can also be done by just holding them under the shade in ambient conditions but requires longer time. This practice was not done in 2009.

Packaging
In Oriental Mindoro, good quality calamansi was packed in a 30 kg red bag for Tanauan Market in Batangas and 30 kg bamboo basket for Divisoria Market. For the bamboo basket, the top and the bottom portions were lined with dried banana leaves or newspaper. A wooden cap was placed on top and tied it with straw string to be secured (Figure 6). For easy identification of cargoes, wholesalers painted their names on it while for red bags putting name tags were being practiced.

In 2009, calamansi was packed in larger capacities such as 35 kg for red bag and 50 kg for the bamboo baskets which also contributed to the high postharvest losses due to punctured and bruises.

Figure 6. Packaging of calamansi in Oriental Mindoro, 2022

Transporting
Red bags and bamboo baskets from Oriental Mindoro were loaded in an oversized jeepney along with other products of the province such as lanzones, rambutan, banana, coconut, and taro (Figure 7). The Jeep was loaded to a Roll on - Roll off (Ro-Ro) vessel traversing Calapan to Batangas Port with travel time of 2-3 hours. Upon arrival at Batangas Port, the jeep transported and delivered the calamansi in red bags to Tanauan Market which was around 1-2 hours away. On the other hand, the volume of calamansi packed in bamboo baskets were brought to Divisoria Market that took around 2-4 hours. Transportation cost for Tanauan market ranges from P100.00 to P120.00 per red bag and P150.00 to P200.00 per bamboo basket for Divisoria. No changes from 2009 transport of calamansi practices were observed.

Marketing
In Oriental Mindoro, farmers sold their harvested calamansi on a consignment basis to wholesalers to be paid in cash after two to three days of delivery. Markets were in Oriental Mindoro, Tanauan, Batangas, and Divisoria (Figure 8). A discount of 2-3 kg of calamansi fruits per bag or basket was usually imposed by traders when buying the product. This is on top of the total weight to be paid by the trader. Actually, this serves as allowance of the traders for the possible rejects upon delivery in the wholesale level.

Calamansi fruits from Oriental Mindoro were bought by retailers from the assembler-wholesalers and truckers (Figure 9). Upon the arrival of the truckers in Tanauan or Divisoria Markets, retailers checked their orders if it's good or if there were any rejects. Retailers paid in cash to the wholesalers upon pick-up of orders.

The marketing systems of 2009 were still being practiced as of to date.

Figure 7. Transport system in Oriental Mindoro, 2022

Figure 8. Wholesalers in Tanauan Market (left) and Divisoria Market (right), 2022

Figure 9. Retailers in Tanauan Market (left) and Divisoria Market (right), 2022

Actors involved in the Calamansi from Oriental Mindoro to Manila Chain

Farmers. Owns a calamansi farm and responsible for the land preparation, transplanting, and farm maintenance activities such as irrigation, fertilization, pruning, cleaning, and pest control. Land preparation can be done manually. There were two kinds of farmers: small farmers and commercial farmers. Small farmers sold their newly harvested calamansi fruit to traders operating in their barangay or municipalities. Commercial farmers delivered directly to buyers in the public markets of Tanauan in Batangas and Divisoria in Manila.

Agents/Dicers. They approached the calamansi farmers during harvesting to negotiate with them in buying their harvest on behalf of the assemblers/traders and get commissions.

Assemblers-wholesalers. They were single proprietors who bought most of the fresh calamansi from small farmers. They played an important role in moving the products from the point of production to the final consumers. Moreover, they performed distribution and financing and provide other intermediaries with greater access to agricultural products in the supply chain. They often had verbal contracts with the farmers to ensure that there would be no disruption in the calamansi supply throughout the year.

Truckers. They delivered calamansi fruits from the assembler-wholesaler going to the public markets where wholesalers were located.

Wholesalers. They were called *bodegeros* because they had warehouses to temporarily store the fresh calamansi before selling it to retailers. They played an important role in maintaining the supply of fresh calamansi in the market. Wholesalers-retailers got their calamansi from several traders to manage risks associated with seasonality and competition with other buyers.

Retailers. Bought calamansi fruits from wholesalers based within the same public market they were operating. Retailers from other smaller public markets may also buy their stocks from wholesalers located in major market centers.

Processors. Engaged in processing calamansi fruits into juices, concentrates, and purees.

Consumers. Use the calamansi fruits or products for their own consumption.

Supply Chain/Market flow of Calamansi from Oriental Mindoro to Manila Chain

For the loss assessment study farm to the market chain was traced as well as the different actors involved and their roles through the perceptions of the respondents during the survey/interviews.

From the farmer, around 89 percent of calamansi fruits went directly to assemblers within the province and 11 percent were bought by the processors situated within and outside the Province of Oriental Mindoro. Processors placed their orders to the farmers before the delivery. For the assembler-traders, sometimes agents negotiated with the farmers on their behalf for a commission. The calamansi fruits were transported to Calapan by the truckers wherein 4 percent were distributed at the Calapan market while the rest would be brought to Calapan port and loaded in a ferry going to Batangas port. From the port, calamansi fruits would be delivered to wholesalers of markets in Tanauan (33%), Divisoria (49%) and other parts of Luzon (3%). On the other hand, retailers upon the arrival of the shipment, checked and picked up the fruits from the wholesalers' stall and displayed it in their own stalls. Further, wholesalers delivered calamansi fruits to the processors of National Capital Region (NCR) and Cavite (3.5%) (Figure 10).

Cost and Return of Calamansi Production and Postproduction

Table 1 shows the expenses and net income of the different actors involved in the postproduction system of calamansi in Oriental Mindoro to Manila chain. The costs incurred by the farmers were mostly for the production costs (85.28%) while hauling (100%), transport (38.58%) and warehouse (60%) costs for the assembler-wholesaler, wholesaler and retailer, respectively. Among the actors, the wholesaler received the highest income at P11.39 per kg while the retailer got the lowest income at P7.50 per kg.

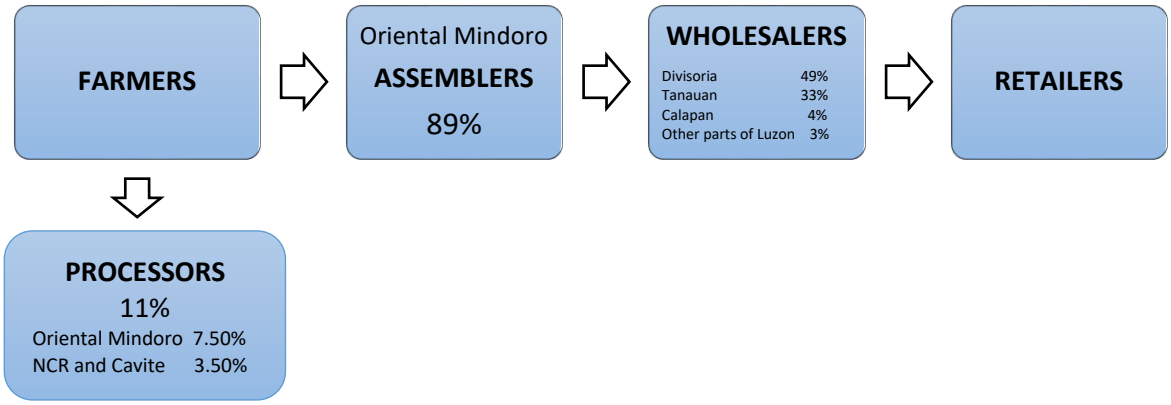

Figure 10. Supply chain of calamansi from Oriental Mindoro to Manila, 2022

Cost and Income Share Analysis

The cost and income sharing of the different actors involved particularly in the calamansi chain from Oriental Mindoro to Manila was analyzed. Out of the total expenses of the whole chain totaled to P23.92/kg, the calamansi farmers had the highest contribution at 46.57 percent, followed by wholesalers at 36.00 percent, retailers at 10.45 percent, and assembler-wholesalers at 6.98 percent. Note that farmers spent more than the other actors and expenses were mostly on the production costs of the product. While the wholesalers expended more on the packaging, transporting and the warehousing of the product to ensure the supply in the market. Further, the assemblers and the retailers had minimal expenses on the handling costs. On the other hand, the entire chain received a net income of P36.08/kg and the wholesalers had the highest share at 31.57 percent, followed by the farmers at 24.56 percent, assembler-wholesalers at 23.08 percent, and retailers at 20.79 percent. Based on the net income sharing, data showed that it was more or less spread out equitably among the actors (Table 2).

Table 1. Cost and return of calamansi from Oriental Mindoro to Manila Chain, 2022

Actors/Particulars	**Php per kilogram**	**Percentage**
Farmers		
Production Cost	9.50	85.28
- Seedling		
- Farm Maintenance (Labor Cost – Cleaning,		
Postproduction Cost	1.64	14.72
- Harvesting, Sorting, Cleaning, Packaging		
Sub-total Expenses	11.14	100.00
Selling Price	20.00	
Net Income	**8.86**	
Assembler-Wholesaler		
Hauling (Farm going to the nearest road)	1.67	100.00
Sub-total Expenses	1.67	100.00
Buying Price	20.00	
Selling Price	30.00	
Net Income	**8.33**	
Wholesaler		
Packaging Cost	2.33	27.06
Transportation Cost (Jeepney and Roro)	3.33	38.68
Labor Cost	1.00	11.61
Warehouse (Inclusion of Water and Electricity)	1.95	22.65
Sub-total Expenses	8.61	100.00
Buying Price	30.00	
Selling Price	50.00	
Net Income	**11.39**	
Retailer		
Warehouse (Inclusion of Water and Electricity)	1.50	60.00
Labor Cost	1.00	40.00
Sub-total Expenses	2.50	100.00
Buying Price	50.00	
Selling Price	60.00	
Net Income	**7.50**	

Table 2. Cost and income share analysis of calamansi from Oriental Mindoro to Manila chain, 2022

Particulars	**Farmer**	**Assembler-Wholesaler**	**Wholesaler**	**Retailer**	**TOTAL**
Total Expenses, Php per Kg	11.14	1.67	8.61	2.50	23.92
Net Income, Php per Kg	8.86	8.33	11.39	7.50	36.08
Cost Share, %	46.57	6.98	36.00	10.45	100.00
Net Income share, %	24.56	23.08	31.57	20.79	100.00

Gender Roles of the Different Actors Involved in the Postproduction System of Calamansi from Oriental Mindoro to Manila Chain

Pandey et al., 2010 studied the gender role in rice farming in the Philippines and stated that gender roles and gender relations within households are strongly influenced by social, cultural, economic circumstances, family structure, and the degree of labor participation in the marketplace.

According to Quisumbing et al., 2014, women comprised about 43 percent of the agricultural labor force in developing countries, ranging from 20 percent in Latin America to 50 percent in sub-Saharan Africa and East Asia. Pandey et al., 2010 estimated a 32 percent female: male ratio in the agricultural labor force in the Philippines.

In Oriental Mindoro, calamansi farmers were mostly male at 57.32 percent while female was at 42.68 percent. For the assembler-wholesaler, male and female in Oriental Mindoro shares at 50 percent. Processors in Oriental Mindoro were mostly female at 80 percent as compared to male at 20 percent. Meanwhile, in the markets of both Tanauan and Divisoria, female wholesalers were dominant at 80 percent. But for the retailers, it was female dominated in Tanauan market at 70 percent while male in Divisoria market at 60 percent (Table 3).

As per the different postproduction activities, male roles were very evident in the farm postproduction and transport undertakings. However, in the marketing and processing endeavors it was female dominated (Table 4).

Table 3. Gender roles of different actors in postproduction and marketing of calamansi in Oriental Mindoro to Manila chain, 2022 in percent

Location/Actors	No. of respondents	Male	Female
Oriental Mindoro			
Farmer	82	57.32	42.68
Assembler-wholesaler	20	50.00	50.00
Processor	5	20.00	80.00
Tanauan, Batangas			
Wholesaler	10	20.00	80.00
Retailer	10	30.00	70.00
Divisoria, Manila			
Wholesaler	5	20.00	80.00
Retailer	5	60.00	40.00

Source: Survey/interview on Loss Assessment, 2022

Table 4. Gender roles in different activities in postproduction of calamansi in Oriental Mindoro, 2022 in percent

Postproduction Activities	Male	Female
Harvesting	76.33	23.67
Sorting	77.84	22.16
Washing and Cleaning	72.41	27.59
Packaging	78.16	21.84
Transporting	93.41	6.59
Marketing	45.00	55.00

Source: Survey/interview on Loss Assessment, 2022

Perceived and Sources of Postproduction Losses of Calamansi from Oriental Mindoro to Manila Chain

In the year 2009, perceived postproduction losses of calamansi in Oriental Mindoro ranged from 1 – 30 percent due to plugging, glut in major markets, inappropriate harvest containers resulting in

bruises/punctures, and punctures/yellowing. Plugging is a mechanical damage wherein part of the rind at the stem-end is torn and pulls loose from the fruit. Also, it favored the growth of *Penicillium digitatum*, leading to high decay rates and postharvest losses in calamansi (Agravante et al, 2013).

In 2022, total perceived postproduction losses in Oriental Mindoro was 17.07 percent. In the different postproduction activities in the area, perceived losses in harvesting contributed the highest percentage and it was due to insect damage. The stakeholders declared that the major sources of postharvest losses of calamansi were because of insect damage, yellowing, and browning (Table 5 and Figure 12). When calamansi were packed in a bamboo basket or red bag without proper sorting and curing high moisture and temperature developed resulting to browning.

Compared to the previous study in 2009, plugging was minimized because farmers were now aware of its causes so that they required cautious and careful harvesters using metal thumb clip to avoid its high incidence in calamansi.

Figure 11. Defects in calamansi, Oriental Mindoro, 2022

Table 5. Perceived losses and causes of calamansi postproduction losses in Oriental Mindoro to Manila chain, 2022

ACTORS	ACTIVITIES	PERCEIVED LOSSES (%)	SOURCES OF LOSSES
Farmers		**7.11**	
	Harvesting	5.43	Insect damage/plugging
	Sorting	0.63	Unintentionally included rejects due to unskilled sorters
	Washing/curing	0.02	Partial browning due to moisture of the undried fruit
	Packaging	0.19	Rapid browning due to compression in packaging
	Transporting	0.24	Delays in shipment
	Marketing	0.60	Browning
Assembler - wholesaler		**3.85**	
	Acquiring from source	1.35	Bruised
	Disposal	0.50	Yellowing
	Transporting going to the wholesaler	2.00	Browning
Wholesaler		**4.15**	
	Delivery from Assembler-wholesaler	4.15	Browning
Retailers		**1.96**	
	Delivery from wholesaler	1.96	Browning
TOTAL		**17.07**	

Source: Survey/interview on Loss Assessment, 2022

Conclusion

The shifting in the harvesting time as well as improving its handling technique and incorporating a washing and curing process played a vital role in reducing the perceived postharvest losses of calamansi from 1-30% in 2009 to 17.07% in 2022. Majority of the calamansi production supplied the Divisoria, Manila and Tanauan, Batangas markets and minimal to the processors. Among the actors in the chain, farmers incurred higher costs than the rest while wholesalers received highest net income. Postproduction activities as well as transport endeavors were male dominated while female for the marketing and processing. Processing marketable rejects and volume during glut through farmers' cooperatives/associations would be of great help to the calamansi industry. Also, actual postharvest loss measurement is recommended.

Acknowledgment

The authors would like to thank Ms. Kristine Soliven, Ms Ria Mae Gualon, and Paula Mae Domingo who helped us gather data. Our gratitude to the calamansi farmers, wholesalers, traders and processors for sharing your time and knowledge and PHilMech for funding the study.

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