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Postharvest Handling and Losses of Vegetables in the Traditional Public Market of Surigao City, Philippines

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ABSTRACT

This study examines postharvest handling practices and associated losses among retailers and wholesalers of *pinakbet* such as vegetables—ampalaya, eggplant, okra, pole sitao, and squash in Surigao City, Philippines. The research highlights key contributing factors to postharvest losses during transit, storage, and marketing. Findings show that improper transportation using motorcycles with one-sided wheels and open-sided trucks, inadequate packaging materials such as cellophane and sacks, and the absence of proper storage facilities, particularly refrigeration, result in significant physical and mechanical damage to the vegetables. Furthermore, traditional marketing methods and a lack of technical knowledge among traders exacerbate the deterioration of produce quality. Despite these challenges, some adaptive practices were observed, including trimming damaged parts, selling fresh-cut vegetables locally known as *sari-sari*, and utilizing waste for animal feed or compost. A small portion added value by cooking slightly damaged vegetables into ready-to-eat dishes. Additionally, wholesalers established market linkages with island barangays to manage surplus produce. The study concludes that improving postharvest handling through training, better infrastructure, appropriate packaging, and value-adding strategies can significantly reduce losses and improve profitability. Recommendations include the promotion of sustainable waste management, support for cold storage solutions, and stronger policy interventions to address systemic issues in the vegetable marketing chain.

Keywords: *innovative storage solutions, postharvest handling, postharvest losses, sustainable practices, marketing*

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1 Introduction

Vegetables play a vital role in ensuring a healthy diet by providing essential nutrients, and among the most widely consumed in the Philippines are the "pinakbet" vegetables such as ampalaya (*Momordica charantia* L.), eggplant (*Solanum melongena* L.), okra (*Abelmoschus esculentus* L.), pole sitao (*Vigna sesquipedalis* L.), and squash (*Cucurbita maxima* L.). However, like most fresh produce, these vegetables are highly perishable. Once harvested, extending their shelf life becomes challenging because they rapidly deteriorate, lose nutritional value, and spoil when exposed to high temperatures, humidity, and poor handling conditions (Etefa et al. 2022). From harvesting and transport to trimming, cleaning, sorting, packaging, and storage, several days may pass before vegetables reach retail markets, making them highly susceptible to postharvest losses (Gonzales 2021). These losses are evident in "pinakbet" vegetables and can be observed in both their quantity through weight loss and quality through reductions in appearance, nutritional content, and consumer acceptability (Mopera 2016).

Marketing practices further aggravate these losses. The visual appeal of vegetables typically lasts only a day or two due to poor transportation conditions. Manual loading and unloading, where handlers carry multiple bags of produce, lead to mechanical injuries. At the retail level, vegetables are repeatedly resorted and repacked into smaller

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lots, then displayed in traditional wet markets at ambient temperatures of about 30°C. The familiar sight of dropped packages and rough handling contributes additional mechanical damage (Nuevo & Apaga 2010). In the Philippines, postharvest losses across commodities range from 10–50% (PhilMech 2021), meaning a significant proportion of the resources used in production ultimately goes to waste. This highlights a major national issue requiring urgent intervention.

In Surigao del Norte, the Provincial Agriculture Office reports about 25% postharvest losses for rice, fruits, and vegetables. Many vegetables in Surigao City retail stores are discarded due to damage and deterioration, directly affecting food security in the area, especially considering that a large segment of the population relies on vegetables as a staple food source. If unaddressed, these losses could lead to shortage risks and decreased availability of nutritious produce for "Surigaonons".

This implies that improper transport methods, inadequate packaging, limited cold storage, and insufficient waste management highlight the need to improve postharvest handling practices for retailers and wholesalers in Surigao City. The introduction of affordable postharvest technologies (e.g., ventilated crates, low-cost cold storage), capacity-building on handling techniques, value-adding initiatives, and stronger market linkages could substantially reduce economic losses and improve the sustainability of vegetable marketing systems. Reduced postharvest losses would not only stabilize the incomes of farmers, wholesalers, and retailers who rely heavily on vegetable sales but also improve consumer access to affordable, nutritious produce, thereby enhancing food security in Surigao City. Thus, addressing these gaps is crucial for both livelihood protection and ensuring food availability for vulnerable households.

This study, therefore, examines postharvest handling practices and losses of key vegetables such as ampalaya, eggplant, okra, pole sitao, and squash to generate insights that can help minimize losses and maintain quality. Additionally, this study seeks to identify innovative ways to use damaged vegetables to increase traders' income, reduce food waste, strengthen food security, and decrease greenhouse gas emissions from decaying produce. By addressing the current gaps in handling and distribution, this research aims to contribute to a more resilient and efficient vegetable supply chain in Surigao City.

2 Materials and Methods

The study respondents

The respondents covered 41 retailers and 15 wholesalers. The retailers sell and display their goods in uniform, regulated stalls, with panels and tables (Kappil 2022), while the wholesalers buy large quantities of the product from farmers and sell it in bulk to retailers (Recio 2013). The sample size for retailers was calculated using Cochran's Formula, while the total enumeration was conducted for the wholesaler. Respondents were selected through random sampling.

Data collection and analysis

Secondary data were collected from the Provincial and City Agriculture Offices. For primary data collection, the survey questionnaire was used as the primary tool, with stakeholder interviews to validate responses. Questions are made simple and easy to understand, with various possible answers provided. Pre-testing of the survey instruments was conducted to ensure the reliability and validity of the questionnaires. The data were analyzed using measures of central tendency, such as mean, frequency, and percentage analyses, and frequency distributions, using the Statistical Package for the Social Sciences (SPSS).

3 Results and Discussion

Causes of the postharvest losses while in transit from the farm gate to the market Transportation

The movement of "pinakbet" vegetables from suppliers to markets in Surigao City is illustrated in Figure 1. A majority of retailers (78%) use single-sided motorcycles to transport vegetables from wholesalers at flea markets, locally known as "Tabo." This method often requires tightly packing the produce onto motorcycles, increasing the risk of physical injuries to the vegetables, such as bruising, breakage, and discoloration. Additionally, the loading and unloading of produce at local markets are frequently done carelessly, further contributing to mechanical damage (Bisht & Singh 2024).

Deliveries occur twice a week, covering distances ranging from 1 to 25 kilometers, as shown in Table 1. Figure 2 further indicates that most retailers (71%) conduct this activity early in the morning. In contrast, 80% of wholesalers use open pick-up trucks to transport vegetables from suppliers located approximately 150 kilometers or

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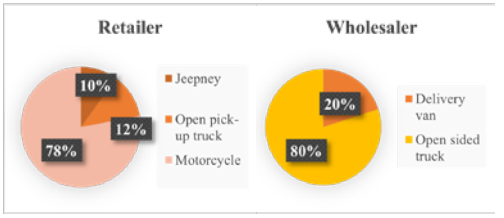

Figure 1. Transportation used of transporting the "Pinakbet" vegetables from the supplier to the traditional public market in Surigao City. Data collected January 2024.

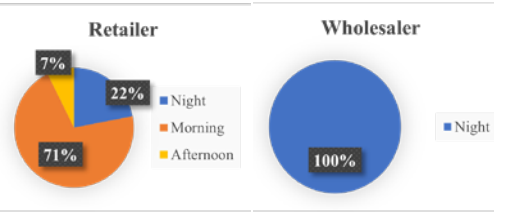

Figure 2. Time of transporting the "pinakbet" vegetables from the supplier to the traditional public market of Surigao City. Data collected January 2024.

more away, mainly from Bayugan City (Agusan del Sur) and Cagayan de Oro City. These trips, usually conducted at night, take around 12 hours. According to Etefa et al. (2022), such transport practices contribute to 5–20% of total postharvest losses. Extended travel time without protective materials, the use of uncovered vehicles, overloading, mixing produce from different sources, and exposure to contaminants are major factors that exacerbate these losses. Sri et al. (2022) suggest that, whenever necessary, the transport vehicle should not be left in the sun, and the produce should be kept safe with a cover and protected from the sun and rain during transport.

Table 1. Distance of the "pinakbet" vegetables of suppliers to the traditional public market in Surigao City. Data collected January2024.

Distance (km)	Retailer	%	Wholesaler	%
1-25	36	87.80	-	-
26-50	-	-	-	-
51-75	-	-	-	-
76-100	-	-	-	-
101-125	-	-	1	6.67
126-150	-	-	-	-
151-175	1	2.43	6	40.00
175- above	4	9.75	8	53.33
1 day	41	100	15	100

Damages observed in vegetables during transit to market stalls are summarized in Table 2. For ampalaya, yellowing due to maturity is the most common defect reported by both retailers (8 cases) and wholesalers (12 cases). Postharvest losses and product quality are influenced by maturity criteria, of which setting an ideal fruit and vegetable maturity date is critical (Sri 2022). Sellers explain that this occurs when fruits are harvested beyond their optimal stage. Ideally, harvest should occur at physiological or horticultural maturity, as determined by attributes such as color, size, taste, and total soluble solids (Kumar & Meena 2023).

For eggplant, rotting is the most frequently reported issue among both wholesalers and retailers, while compression and bruising are less common. Okra generally sustains minimal damage. Pole sitao, however, often exhibits broken pods due to its fragile and tender nature. In squash, internal rot is the most commonly observed problem for both groups of respondents.

The preservation of perishable foods is further challenged by inadequate transportation, poor road conditions, and inefficient logistics management. In many cases, loading and unloading tasks are handled by individuals lacking proper training, leading to careless handling and mechanical damage to agricultural products. Proper packaging is therefore essential. Bisht and Singh (2024) highlight that careful handling and appropriate packaging reduce mechanical injuries, while Etefa et al. (2022) emphasize that well-designed packaging systems are crucial for minimizing damage to horticultural products, particularly highly perishable commodities such as fruits and vegetables.

During transportation, produce must be maintained in optimal condition to preserve quality and minimize losses. The most significant ways to ensure the preservation of perishables are adequate temperature control and air circulation systems. The cold chain is a logistics system that protects the quality of perishable goods from the point of origin to the point of consumption. Temperature variations during transport and storage are the key determinants of shelf life (Sri et.al 2022).

Improper Packaging Materials

Packaging plays a crucial role in protecting fresh produce by shielding it from dust, minimizing microbial contamination from the environment and consumers, and helping preserve freshness. For food items, packaging must be non-toxic, compatible with the type of produce, and suitable for its physiological needs (Junghu et al. 2024).

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Table 2. Kinds of damage of "pinakbet" vegetables during transport from the supplier to the traditional public market in Surigao City. Data collected January 2024.

Vegetables	Kinds of Losses/ Damage	Retailer	Wholesaler
Ampalaya	Bruises	2	1
	Cracked	4	5
	Yellowing (Physiological change due to maturity)	8	12
	Compression damage	1	1
Eggplant	Bruises	2	1
	Cracked	5	2
	Rot	8	10
	Compression damage	1	2
	Fruit borer	4	5
Okra	Bruises	1	-
	Cracked	2	5
	Rot	2	2
	Broken pods	2	3
	Compression damage	-	4
Pole sitao	Cracked	-	3
	Rot	1	1
	Broken pods	3	5
	Compression damage	-	2
	Insect (pod borer)	3	4
Squash	Bruises	2	-
	Cracked	1	6
	Rot	7	8

For "pinakbet" vegetables, retailers commonly use polyethylene bags (cellophane) for packaging during transport to market stalls. Cellophane is typically used because the quantity of vegetables purchased fits conveniently in such bags, as shown in Table 3. Squash, on the other hand, is usually packed in sacks by both wholesalers and retailers. In the case of ampalaya, 11 out of 15 wholesalers use corrugated boxes, while eggplant is packed in sacks, and okra and pole sitao are placed in cellophane by nine and ten out of 15 wholesalers, respectively.

In many developing countries, typical packaging materials include nylon sacks, plastic or wooden crates, woven palm baskets, cardboard boxes, and polyethylene bags. However, these materials often fail to fully protect the produce. For instance, nylon sacks lack ventilation, which prevents air circulation, raises the internal temperature, and traps heat caused by respiration. Additionally, containers with rough surfaces or sharp edges can inflict mechanical damage on the vegetables (Kumar & Meena 2023).

Using inappropriate packaging increases the risk of spoilage, as it fails to shield fresh produce from external harm (Bisht & Singh 2024). Proper packaging should be sturdy, free from harmful chemicals, allow for efficient cooling, and support both handling and marketing demands (Kumar & Meena 2023). Effective packaging is essential for safeguarding fruits and vegetables, reducing losses, and extending shelf life. However, the continued use of low-quality packaging mainly due to its affordability remains a leading cause of postharvest losses in many parts of the world, particularly in developing and underdeveloped regions (Junghu et al. 2024). Sri et.al (2022) added the packaging necessities for fresh fruit and vegetables can be summarized as follows: (1) protection against bacterial contamination and degradation, (2) safety against bruising and physical injury, (3) protection against moisture / losing the weight, (4) providing air circulation for respiration and gas exchange, (5) slowing respiration rate, (6) delaying ripening, and increasing storage life.

Improper Storage

Data shows that both retailers and wholesalers

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typically store vegetables in open areas or at room temperature once they arrive at their respective market stalls. Most of them lack access to refrigeration facilities. The produce is usually displayed openly in trays, on raised platforms, in open boxes, or inside wooden and plastic crates. In some cases, vegetables are sold in their original packaging, such as sacks. This traditional and inadequate storage method negatively impacts the quality of the vegetables. Temperature plays a critical role in determining how quickly produce deteriorates (Junghu et al. 2024). A lack of understanding about proper temperature requirements often leads to spoilage during storage (Budhathoki et al. 2022). Cold storage, combined with postharvest technologies such as controlled environments, can significantly extend the shelf life of perishable goods (Sri et al. 2022). Janghu et al. (2024) emphasized that temperature regulation is vital for vegetables, as optimal conditions can delay ripening, softening, respiration, and spoilage. Conversely, higher temperatures accelerate deterioration. Heat from the surrounding environment increases respiration rates, which in turn speeds up the breakdown of fresh produce (Kumar & Meena 2023). Sri (2022) added that storage is the skill of preserving the quality of agricultural products and preventing them from deteriorating beyond their typical shelf life for a specified period.

Postharvest Handling and Practices to Minimize Losses in Wholesale and Retail Vegetable Markets

Marketing is the final step in the postharvest system, encompassing the movement of produce from producers to consumers. However, the marketing of vegetables poses significant challenges due to their perishable nature, which often leads to losses (Budhathoki et al. 2022). Effective postharvest handling by retailers and wholesalers of "pinakbet" vegetables is essential to reduce damage and waste at this stage.

a. Prompt unloading and display of vegetables

Upon arrival at the market, 90.24% of retailers personally handle vegetable unloading, as shown in Table 4. They unload the produce carefully and gently to minimize bruising and abrasions. Bisht and Singh (2024) emphasize that gentle handling is crucial to prevent physical injuries, such as cuts and bruises, which can accelerate tissue decay. Junghu (2024) further notes that mechanical damage enables pathogens to enter plant tissues, triggering rapid deterioration.

In contrast, 73.33% of wholesalers hire laborers to unload vegetables. Sri et al. (2022) caution that untrained workers often mishandle produce, leading to mechanical damage. Sri et.al. (2022) advise that care should be taken when loading and unloading. The product should be effectively protected from physical harm.

After unloading, most retailers (92.26%) and wholesalers (86.67%) immediately display the vegetables to prevent moisture buildup, which can accelerate spoilage.

b. Washing and cleaning

Washing and cleaning are practiced by 68.29% of retailers and 66.67% of wholesalers, according to Table 4. This process is crucial for removing dust, dirt, and microbial contaminants from the produce (Junghu et al. 2024). Proper cleaning ensures that the vegetables are sanitized before packaging or storage. Dry cleaning (dusting) and wet cleaning (washing) are both used, depending on the type of produce (Budhathoki et al., 2022). Acedo et al. (2016) also reported that cleaning reduces microbial contamination. Washing using clean water to remove adhering soil and other debris. After washing, the produce should be air-dried before packing. While cleaning, sorting can be done. Avoid contact between produce and soil, which is a rich source of spoilage and human pathogens.

c. Purchasing vegetables for 3-4 days of marketing

To reduce spoilage, sellers purchase quantities of "pinakbet" vegetables sufficient for only three to four days of sales. This strategy helps maintain the produce's freshness, visual appeal, and marketability. As shown in Table 5, 95.12% of retailers and 73.33% of wholesalers follow this practice.

d. Selecting High-Quality Vegetables at Purchase

Retailers prioritize selecting vegetables in good condition, free of defects such as rot, yellowing, cracking, bruising, insect damage, or broken pods. This quality selection is practiced by 90.24% of retailers (Table 5). They also prefer freshly harvested vegetables, which have longer shelf lives and are more appealing to customers who purchase in small quantities.

Wholesalers, however, generally do not have the opportunity to select individual items due to the large volumes they handle. Only three wholesalers reported being able to assess the quality of the

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Table 3. Packaging materials of "pinakbet" vegetables used during transportation from supplier to the traditional public market of Surigao City. Data collected January 2024.

Vegetables	Kinds of Losses/ Damage	Retailer	Wholesaler
Ampalaya	Sack	1	2
	Corrugated box	4	11
	Woven basket	2	-
	Polypropylene bag (cellophane)	34	2
Eggplant	Sack	9	14
	Wooden Crates	-	1
	Polypropylene bag (cellophane)	32	-
Okra	Sack	4	5
	Corrugated box	-	1
	Polypropylene bag (cellophane)	37	9
Pole sitao	Banana leaves/	3	-
	Sack (cut in rectangular)	6	2
	Corrugated box	-	3
	Polypropylene bag (cellophane)	32	10
Squash	Sack	41	15

vegetables they purchase.

There is a growing demand for higher-quality, both external and internal. External factors (presentation, appearance, uniformity, ripeness, and freshness) are the main components in the decision to purchase, which is usually made when the consumer sees the product displayed. This is particularly important in the self-service systems where the product must "self-sell," and if it is not chosen, it represents a loss for the retailer. Internal quality (flavor, aroma, texture, nutritional value, and the absence of biotic and non-biotic contaminants) is linked to aspects not generally perceived externally but that are equally important to many consumers (FAO 2022).

e. Selling fresh-cut or "sari-sari" vegetables

To minimize waste, 87.89% of retailers and 60% of wholesalers process vegetables showing signs of wilting or deterioration by peeling, slicing, and combining them with other vegetables to create ready-to-cook packages, commonly called "sari-sari" in Surigao City. This method is widely accepted by consumers who prefer the convenience of pre-cut vegetables.

"Fresh-cut" refers to raw vegetables and fruits that have been cut, shredded, peeled, abraded, or otherwise prepared to produce convenient ready-to-eat or ready-to-cook portions. The preparation of vegetables (peeling, shredding, cutting, washing, etc.). They feel a fresh-cut vegetable item is very helpful because it requires less time, is easy to cook, minimizes waste, and makes life easier (Salam 2022). Raffo and Paoletti (2022) noted that the fresh-cut industry supplies the food market with healthy, fresh fruits and vegetables and, in doing so, may help improve the nutritional status of the general population. This is composed of fresh-cut fruits and ready-to-cook vegetables.

f. Trimming damaged portions

About 85.36% of retailers and 60% of wholesalers trim damaged parts of vegetables to reduce further spoilage during the selling process. While damage is often unavoidable, removing only the affected sections helps preserve the rest of the produce and maintain its market value. These practices are detailed in Table 5. They trim the decayed and diseased parts of the vegetables to maintain quality and prevent spoilage. This improves the appearance and marketability of the vegetables, as well as extending the shelf life until they are marketed.

g. Selling within a short marketing period

Retailers typically market pinakbet vegetables within a limited time to maintain freshness. For instance, 92.68% sell ampalaya, 90.24% sell eggplant, 68.29% sell okra, 58.53% sell pole sitao, and 63.41% sell squash within 3–4 days. Similarly, 73.33% of wholesalers sell ampalaya, and 66.66% sell eggplant within the same timeframe. Okra is sold

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Table 4. Postharvest handling of vegetables upon arrival in the traditional public market in Surigao City. Data collected January 2024.

Activities upon Arrival in the Market	Specific practices	Retailer	%	Wholesaler	%
Unloading the Vegetables upon arrival	Supplier's labor	-	-	1	6.67
	Hired labor	4	9.75	11	73.33
	Owner	37	90.24	3	20.00
Time of unloading the vegetables upon arrival	Less than 1 hour	41	100	14	93.33
	More than 1 hours	-	-	1	6.67
Activities after unloading the vegetables	Display the vegetables immediately	38	92.26	13	86.67
	Wash and clean	28	68.29	10	66.67
	Sorting	2	4.87	7	46.67

Table 5. Practices to minimize losses during marketing of the "pinakbet" vegetables in the traditional public market in Surigao City. Data collected January 2024.

Practices	Retailer	%	Wholesaler	%
Purchase goods for 3-4 days in marketing	39	95.12	11	73.33
Selecting good quality vegetables upon purchase	37	90.24	3	20.00
Sprinkling with water	2	4.87	6	40.00
Cover with cloth during strong winds to prevent shrinkage	1	2.43	-	-
Fresh cut vegetables locally known as "sari-sari"	36	87.80	9	60.00
Trimming of the damage parts	35	85.36	9	60.00

more quickly, with 53.33% of wholesalers marketing it within 1–2 days after arrival. Meanwhile, pole sitao is sold within 3–4 days by 80% of wholesalers. Squash, which is less perishable, is sold for over 5–6 days. Table 6 presents these findings. This practice helps ensure that vegetables are sold before they lose their freshness or become visually unappealing, thereby reducing losses.

Table 6. Valorize the utilization of damage of "pinakbet" vegetable in public traditional market of Surigao City. Data collected January2024

Variable	Specific practice	Retailer	Wholesaler
Utilization of not sold pinakbet vegetables	Use as animal feed	12	9
	Collect to make it compost	3	2
Value adding of the losses/ damage pinakbet vegetables	Cook as menu	15	-
	Improved packaging to market the product	1	-
Valorize activities to reduce losses	Improved labelling	1	-
	Market linkage	-	9

To minimize losses of fruits and vegetables during marketing, sellers perform regular inspections and sorting to distinguish good-quality produce from damaged or unsellable produce. Defective items are separated from healthy batches to prevent contamination. During sorting, some products are wiped to remove mud, dirt, and other contaminants that may accelerate spoilage. Time is allocated for regular cleaning to maintain a well-organized marketplace and ensure a safe, pleasant environment for both consumers and vendors (Buhion et al. 2024).

Vegetables that require hydration are sprinkled with water to prevent wilting, while washing and drying help delay product deterioration. To maximize freshness and minimize waste, sellers also follow the "First-In, First-Out" (FIFO) principle, organizing products by purchase date (Buhion et al., 2024).

Maximizing the Use of Damaged Vegetables to Minimize Economic Loss

a. Utilizing damaged and unsold "pinakbet" vegetables

Instead of letting damaged produce go to waste, some retailers and wholesalers repurpose it through alternative methods. This is evident in 12 retailers and nine wholesalers that feed non-edible vegetables to livestock such as pigs, chickens, and ducks, as shown in Table 6. This practice not

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only reduces waste but also offers a low-cost feed solution. A few retailers and wholesalers convert spoiled vegetables into compost by transporting the waste to composting sites, where it is turned into organic fertilizer. However, most 38 retailers and 13 wholesalers still dispose of damaged vegetables by throwing them away, indicating room for improvement in sustainable waste management and opportunities for environmentally and economically beneficial alternatives.

Buhion et al. (2024) found that damaged or discarded fruits and vegetables were used by consumers to feed their animals, while others were given away for use as fresh-cut leafy vegetables, serving as a potential alternative feed source for livestock. This approach supports the concept of a circular economy in animal production and strengthens sustainability.

Several studies have investigated converting fruit and vegetable waste into alternative products by utilizing the bioactive chemicals in waste as pharmaceutical excipients and food additives, and using them in pharmaceutical formulations or food matrices to create nutraceutical and functional foods. This indicated that agricultural by-products, mainly vegetables and fruit, can be used to enhance the nutritional content of functional foods such as biscuits, cakes, and bread.

b. Adding value through cooking slightly damages vegetables

Fifteen retailers creatively add value to slightly damaged or wilted vegetables by cooking them into dishes like the local pinakbet stew, as reflected in Table 6. Instead of being discarded, vegetables such as ampalaya, eggplant, okra, pole sitao, and squash are prepared into budget-friendly, ready-to-eat meals. This strategy not only reduces waste but also supports food security by using produce that would otherwise be thrown away.

Buhion et al. (2024) suggest creating alternative products such as fermented goods through innovative strategies to address fruit and vegetable waste in the public market. They transformed inedible waste into fermented juice, which was then marketed as fertilizer for backyard vegetable gardens and ornamental plants. This initiative not only reduced waste but also generated additional income.

Given the success of this value-adding process, it is suggested that market administrators conduct workshops or livelihood programs to train vendors on preserving the quality and safety of their products. Through these programs, vendors can acquire sustainable methods and technologies to maintain product quality, prevent losses, and promote environmental sustainability.

c. Reducing losses through market linkages

Market linkages" is a physical connection between the producer and the ultimate consumer. Linkages also involve financial transactions - the selling and buying of goods. It means to facilitate the flow of produce between the different levels of the marketing system. The input to the process is agricultural production (the supply), and the output is the consumption of that produce by consumers (the demand) (FAO 2022). This situation requires wholesalers to minimize losses by expanding their market reach beyond their usual locations. Ten wholesalers have built ties with Island Barangays and nearby municipalities. When they have a surplus of vegetables, they utilize communication tools and technology to coordinate deliveries, often using motorized boats to transport produce to these remote areas. This helps widen their market reach and ensures that excess vegetables are distributed efficiently rather than wasted.

Implication of the Study

The findings of this study highlight the urgent need to improve postharvest handling, packaging, transportation, and storage practices among retailers and wholesalers of pinakbet vegetables in Surigao City. The significant losses observed due to improper transport methods, inadequate packaging materials, lack of cold storage, and insufficient waste management practices reflect broader systemic challenges faced by small-scale vegetable traders in developing regions.

The study suggests that targeted interventions, such as the introduction of affordable and appropriate postharvest technologies (e.g., ventilated crates, cold storage), capacity-building programs on proper handling techniques, and the promotion of value-adding practices, can significantly reduce economic losses and enhance the sustainability of vegetable marketing systems. Furthermore, strengthening market linkages and improving infrastructure support for rural-urban vegetable distribution can help minimize waste while increasing income opportunities for farmers, wholesalers, and retailers.

For farmers, wholesalers, and retailers, vegetables form a primary source of income.

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Postharvest losses mean lost revenue, threatening their financial stability and livelihoods. Likewise, consumers, particularly those from low-income backgrounds, face higher prices and reduced access to fresh, nutritious produce. These price increases worsen food insecurity, making it harder for vulnerable populations to maintain a balanced diet. Therefore, improving postharvest practices and reducing losses could not only support the economic well-being of farmers and traders but also enhance access to affordable, nutritious food for local consumers, thereby fostering greater food security in the City of Surigao.

Overall, this research underscores the importance of integrating practical, low-cost innovations and policy support into the local agricultural value chain to ensure food security, reduce postharvest losses, and enhance the livelihoods of stakeholders involved in the vegetable marketing system. This is to enhance the adaptation to climate change among vegetable farmers and vendors. Varela et.al (2022) mentioned that farmers can confront adverse climate change impacts with their ingenuity.

4 Conclusion and Recommendations

Postharvest losses of *"pinakbet"* vegetables such as ampalaya, eggplant, okra, pole sitao, and squash are primarily caused by transportation, improper packaging, and improper storage. The vegetables are transported from suppliers in Bayugan, Agusan del Sur, and Cagayan de Oro to Surigao City using open-sided trucks, such as Bongo and Forward vehicles, by wholesalers, and by retailers on motorcycles. Packaging is typically done using polyethylene bags, and during marketing, the vegetables are stored in open-air, temperature-uncontrolled environments. Despite retailers' and wholesalers' efforts to reduce losses by reducing the purchase of vegetables, selling fresh-cut vegetables, trimming damaged parts, and limiting the number of days vegetables are kept for sale, these measures are insufficient to prevent damage completely. As a result, a significant portion of the vegetables is discarded. However, the practice of selling pre-cut vegetables, known locally as "sari-sari," has been shown to mitigate some losses by offering slightly damaged vegetables to consumers in a ready-to-cook form.

Furthermore, improved packaging, storage technologies, and transportation practices are essential to reducing postharvest losses. Future studies should also examine gas emissions resulting from physiological changes during spoilage to understand the environmental impacts of spoilage-related losses better. It is recommended that local agriculture offices and cooperatives conduct regular training on proper postharvest handling, packaging, and storage techniques for farmers, wholesalers, and retailers. The use of ventilated, stackable crates should be encouraged to minimize bruising and overheating during transport. Investments in communal cold storage facilities or affordable cooling systems are necessary to extend shelf life and preserve quality. Moreover, supporting value-adding initiatives such as processing slightly damaged vegetables into cooked dishes, animal feed, or compost can reduce waste and create alternative income sources. Strengthening market linkages through transport cooperatives and digital platforms can improve the efficient distribution of surplus produce. At the same time, local government units should develop policies that promote sustainable waste management practices, including composting and donating edible but unsellable produce.

5 Declaration of AI Use

The authors declare that AI-assisted tools were used to aid in language editing and formatting of the manuscript. All content, ideas, and interpretations presented in this study were developed and verified by the authors.

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