

BIBLIOGRAPHY

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ABSTRACT

The study was conducted at the farms of Kapangan and Sablan, Benguet, and at La Trinidad Trading Post and Baguio City market to document the postharvest handling practices on bell pepper grown under protected cultivation and to identify the common postharvest diseases of bell pepper.

Results of the study revealed that majority of the farmers of Kapangan and Sablan, Benguet harvest their bell pepper at matured green stage. Likewise, majority harvest their crop in the morning and mostly with bare hands.

Majority transport their harvest through public utility jeepneys and buses while in Sablan, few have access to refrigerated van. Mostly, farmers sell their produce in Baguio city market than in La Trinidad trading post.

Some traders use electric fan and newspaper to dry the pepper fruit. Some also use gin to preserve and wax their produce. The postharvest diseases in descending order of infection were soft rot (*Pectobacterium carotovorum*), dry rot (*Botrytis cinerea*), anthracnose (*Colletotrichum capsici*) and bacterial spot (*Xanthomonas vesicatoria*).



RESULTS AND DISCUSSION

Varieties of Bell Pepper Planted in Kapangan and Sablan, Benguet

Based on survey results, California wonder is the only variety of bell pepper grown in Kapangan because of its high yielding capacity. This coincides with the report of Domoguen (2012) that California is quite productive. Most of the farmers in Sablan planted the following varieties; red chili like Dongshin (14.52%), Pongok (16.13%), Chinese (22.58%) and Tulis (12.90%). Two farmers planted Gospel (3.23%), Pasarella (3.23%), Norven (3.23%), Inspiration (3.23%), and Chang (3.23%), which are imported varieties while five farmers planted California (8.06%) and two farmers, planted Celica (3.23%) (Table 1).

Table 1. Varieties of bell pepper planted in Kapangan and Sablan, Benguet.

Varieties	KAPANGAN		SABLAN		
	Frequency	Percentage	Frequency	Percentage	
California	<u>19</u>	<u>100</u>	California	5	8.06
			Tulis	8	12.90
			Dongshin	9	14.52
			Pongok	10	16.13
			Chinese	14	22.58
			Compass	2	3.23
			Sondella	2	3.23
			Inspiration	2	3.23
			Gospel	2	3.23
			Pasarella	2	3.23
			Norven	2	3.23
			Chang	2	3.23
			Celica	<u>2</u>	<u>3.23</u>
Total	19	100%	Total	62	100%



Harvesting Practices

California, also called green pepper, were harvested matured green wherein the whole pepper fruit remained green in color until maturity. Other varieties planted in Sablan like Dongshin, Pongok, and Tulis were considered as Red Chili and harvested whole red or the whole pepper fruit are dark red in color. In some cases, especially for the last harvest of old plant, farmers harvest the fruits as mixed red and green. In Kapangan and Sablan, most farmers harvest their produce in the morning (89.47% and 80.77% respectively).

Harvesting is done at this time because of the size of their farm, its distance to the nearest road, to avoid higher respiration rate, to finish their work early and to take advantage of available transportation to market. However, 19.23% of farmers interviewed in Sablan said that they harvest their produce in the afternoon because their farms are located near the road; they transport their products using refrigerated van because they deliver directly to food corporations. In Kapangan, 10.53% of farmers harvest their bell pepper also in the afternoon because of the distance of their farm to the nearest road, and availability of harvesters.

Majority of the Sablan and Kapangan farmer respondents harvest their produce without using harvesting tools or equipment at 73.08% and 94.74% respectively. However, 7.69% of the interviewed Sablan farmers use knives while Kapangan farmers do not any harvesting tool because their pepper was easily separated from the motherplant. The remaining 5.26% of Kapangan farmers and 7.69% Sablan farmers use knives to harvest their produce (Table 2).



Table 2. Harvesting practices of farmer respondents

Harvesting practices	KAPANGAN		SABLAN	
	Frequency	Percentage	Frequency	Percentage
A. Stage at harvest				
Matured green	15	78.95	11	42.31
Half red	1	5.26	3	11.54
Whole red	1	5.26	10	38.46
Mix	<u>2</u>	<u>10.53</u>	<u>2</u>	<u>7.67</u>
Total	19	100%	26	100%
B. Time of harvest				
Morning	17	89.47	21	80.77
Afternoon	<u>2</u>	<u>10.53</u>	5	19.23
Total	19	100%	26	100%
C. Harvesting material				
Scissor	0	0.00	5	19.23
Knife	1	5.26	2	7.69
Bare hands	<u>18</u>	<u>94.74</u>	<u>19</u>	<u>73.08</u>
Total	19	100%	26	100%

Postharvest Practices of Farmer Respondents

Thirteen Kapangan farmers do not practice (68.42%) sorting of their harvested produce; three sorts it according to sizes (15.79%), one sorted it according to color (5.26%) and the remaining two farmers sorted it according to both size and color (10.53%). Farmers package their produce using baskets (78.95%), plastic bag (5.26) and sacks (15.79%). The baskets were lined with cartoons (5.26%), banana leaves (31.58%), sacks (42.11%), and newspapers (5.26%) which serve as protective materials against mechanical injuries while 15.79% did not use any protective material.



In Sablan, twenty farmers practice sorting on their harvested produce according to color (76.92%) because most farmers planted both the green and red chili; three sorts it according to sizes (3.85%), eleven farmers sorted it according to both sizes and color (11.54%) and the remaining seven farmers do not practice sorting (7.69%).

Most Sablan farmers package their produce using baskets (76.92%), plastic bag (3.85), sacks (3.85%) and crates (15.38%). The baskets were lined with cartons (7.69%),

Table 3. Postharvest practices of farmer respondents

Farmers Practices	KAPANGAN		SABLAN	
	Frequency	Percentage	Frequency	Percentage
A. Sorting				
Size	3	15.79	3	3.85
Color	1	5.26	20	76.92
Both size and color	2	10.53	11	11.54
Do not practice	<u>13</u>	<u>68.42</u>	<u>7</u>	<u>7.69</u>
Total	19	100%	26	100%
B. Packaging				
Plastic bag	1	5.26	1	3.85
Basket	15	78.95	20	76.92
Sacks	3	15.79	1	3.85
Crates	<u>0</u>	<u>0.00</u>	<u>4</u>	<u>15.38</u>
Total	19	100%	26	100%
C. Protection practices				
Cartoons	1	5.26	2	7.69
Banana leaves	6	31.58	2	7.69
Sacks	8	42.11	18	69.23
Newspapers	1	5.26	3	11.54
None	3	15.79	1	3.85
Total	19	100%	26	100%



banana leaves (7.69%), sacks (69.23%), and newspapers (11.54%) which serves as protection materials and some do not use any protection materials (3.85%) (Table 3).

Frequency and Percentage of Occurrence of Field Diseases

Some of the diseases observed affecting the bell pepper production in protected cultivation at Kapangan and Sablan, Benguet were caused by both biotic and abiotic factors. Among these diseases were “Tupak” a word coined by the farmers to describe a disease known as soft rot which is caused by *Pectobacterium carotovorum* (18.29%), wilt (15.85%), blight (10%), leaf spot (9.76%), bacterial spot (9.76%) and pepper mild mottle virus (6.10%) were also the top 6 diseases in Kapangan. Physiological diseases were sunscald (9.76%) and deformed fruits.

In Sablan, deformed fruits (21.38%), blossom end rot (3.45%) and sunscald (6.90%) were the physiological diseases reported. Wilt (17.24%), blight (14.94%), bacterial spot (12.64%), “buot” a term to the moldy growth of the fungal pathogen or rot caused by *Botrytis cinerea* (11.34%), black rot (8.05%), powdery mildew (3.45%) and anthracnose (1.15%) were the seven diseases caused by biotic agents (Table 4).

Mode of Transport and Marketing

The owner type jeepney is used in transporting the bell pepper produced in Kapangan (5.26%) and Sablan (7.69%). Most of Kapangan (94.74%) and Sablan (84.62%) farmers transport their produce using jeepneys or buses because it is less expensive compared to refrigerated van. When hired vehicles were used, mixed loading was done to maximize the space. In this case, arrangement was based on weight with the heavier commodity at the bottom. Sometimes handlers load the vegetable in the aisle



Table 5. Frequency and percentage of occurrence of field diseases

KAPANGAN			SABLAN		
	Frequency	Percentage		Frequency	Percentage
Diseases			Diseases		
A. Biotic diseases			A. Biotic diseases		
1. Fungal diseases			1. Fungal diseases		
Root diseases			Root diseases		
Wilt	13	15.85	Wilt	15	17.24
Leaf diseases			Leaf diseases		
Blight	10	12.20	Blight	13	14.94
Leaf spot	8	9.76	Powdery mildew	3	3.45
Powdery mildew	1	1.22			
			Fruit diseases		
			Black rot	7	8.05
			Fruit rot	9	10.34
			Anthracnose	1	1.15
2. Bacterial diseases			2. Bacterial diseases		
Leaf disease			Leaf disease		
Bacterial spot	8	9.76	Bacterial spot	<u>11</u>	<u>12.64</u>
Fruit disease					
Soft rot	15	18.29			
3. Virus disease					
“galigel”/PMMoV	5	6.10			
B. Abiotic agents			B. Abiotic agents		
Fruit diseases			Fruit diseases		
Sunscald	8	9.76	Sunscald	6	6.90
Deformed fruits	<u>14</u>	<u>17.07</u>	Deformed fruits	19	21.84
			Blossom end rot	<u>3</u>	<u>3.45</u>
Total	82	100%	Total	87	100%

where passengers tend to lie, sit or put their baggage on top of vegetables packed in sacks and baskets which is not a good practice because the produce will incur injuries like



Table 4. Mode of transport and marketing

Harvesting practices	KAPANGAN		SABLAN	
	Frequency	Percentage	Frequency	Percentage
A. Mode of Transport				
Public Utility Jeepney/bus	18	94.74	22	84.62
Owner	1	5.26	2	7.69
Refrigerated van	<u>0</u>	0.00	2	<u>7.69</u>
Total	19	100%	26	100%
B. Marketing				
La Trinidad Trading Post	2	10.53	4	15.38
Baguio City Market	17	89.47	19	73.08
Direct	<u>0</u>	<u>0.00</u>	<u>3</u>	<u>11.54</u>
Total	19	100%	26	100%

bruises and abrasions that serves an entry point for pathogens. In Sablan, two farmers use refrigerated van (7.69%) and market their product directly to the consumer and food processing company in Baguio and the nearby provinces. Most of the produce of Kapangan and Sablan farmers is marketed by middlemen (Table 5).

Postharvest Practices of Trader Respondents

Survey conducted among traders revealed that La Trinidad traders segregate pepper according to both size and color (60%) while the remaining percentage sorts it according to size only (30%) and color only (10%). They package the produce in plastic or polyethylene bag (70%) and cartons (30%). Baguio traders segregate pepper fruit according to both size and color (78.57%), size only (14.29%) and color only (7.14%). Traders dehorn bell pepper fruits using knives and their bare hands. Traders use knives to remove the infected part of the fruit and sell it at lesser price. Others wash bell



Table 6. Postharvest practices of traders respondents

Practices	Frequency	Percentage
A. Sorting		
Size	4	16.00
Color	1	6.25
Both Size and color	<u>11</u>	<u>68.75</u>
Total	16	100%
B. Packaging		
Plastic bag	13	81.25
Cartoon	<u>3</u>	<u>6.00</u>
Total	26	100%
C. Other practices		
Dethorning		
Wiping		
Using of electric fan, newspaper and gloves for drying		
Washing and removing of the affected pepper fruit and selling it to lesser price		
Applying local alcohol drink (ginebra san miguel) to preserve and wax the product		

pepper fruits with water. In the case where pepper fruits are wet, traders use electric fan and newspaper to remove excess moisture on the fruits surface.

Other traders also apply the local alcohol drink (ginebra san miguel) to preserve and wax the surface of pepper fruits, (Table 6).

Postharvest Diseases

Highest percentage disease was due to bacterial soft rot caused by *Pectobacterium carotovorum* (39.58%) and the other bacterial disease was bacterial spot (4.17%) caused by *Xanthomonas vesicatoria*. Dry rot caused by *Fusarium* sp. (14.58%) and anthracnose caused by *Colletotrichum capsici*. (10.42%) were also the two fungal diseases reported by



Table 7. Postharvest diseases

Diseases	Frequency	Percentage
A. Biotic agents		
Bacterial disease		
Soft rot	19	39.58
Scab	2	4.17
Fungal diseases		
Anthracnose	5	10.42
Dry rot	7	14.58
B. Abiotic agents		
Mechanical damages	14	29.17
Sunscald	<u>1</u>	<u>2.08</u>
Total	48	100%

the traders. Mechanical damages (29.17%) include abrasions and bruises, cracks, splits and punctures during transport contributed to the disease development especially soft rot and other disease like fusarium rot and anthracnose. Physiological disorder like sunscald (2.08%) caused by intense exposure of the harvested pepper fruit to sunlight, likewise observed (Table 7).

Diseases Caused by Fungi:

Many Fungal diseases affecting bell pepper fruits were reported in the Philippines (Domoguen, 2012). Fruit rot was the prevalent disease in the field and in the market especially during wet season and depending on the causal pathogen. Among the fruit rot diseases reported are:



1. Dry rot of pepper- caused by *Fusarium spp.*

Symptoms: Appearance of soft, dark brown or black lesions on the fruits or wound sites. Black water-soaked lesions may also develop around the calyx, eventually spreading down the sides of the fruit. Under conditions of high humidity the fungal mycelium is quite apparent on the lesions (Figure 1a).

Morphological characteristics: conidia are slightly curved sickle shaped in appearance, hyaline and with 4-5 septations(Figure 2b).

2. Dry rot of pepper caused by *Botrytis cinerea*

Symptoms: Fruit symptoms begin as water-soaked spots that rapidly expand into large yellowish-green or grayish-brown, irregular lesions that are soft and spongy in texture. Velvet-like fungus mycelium and spores are produced on the lesion under cool, humid conditions (Figure 2a).

Morphological characteristics: gray long mycelium and long branched conidiophores bearing clusters of hyaline oblong conidia (Figure 2b).

3. Anthracnose caused by *Colletotrichumcapsici*

Symptoms: Fruit has water-soaked lesions that are soft, slightly sunken, and become tan. The lesions cover most of the fruit surface and multiple lesions occur after 3 days (Figure a).

Morphological characteristics: conidia are hyaline, curved and fusiform (Figure 3b).

4. Phytophthora rot

Symptom: Infected fruit appears as moist, cream-colored oppressed growth. The decay develops (Figure 4a).



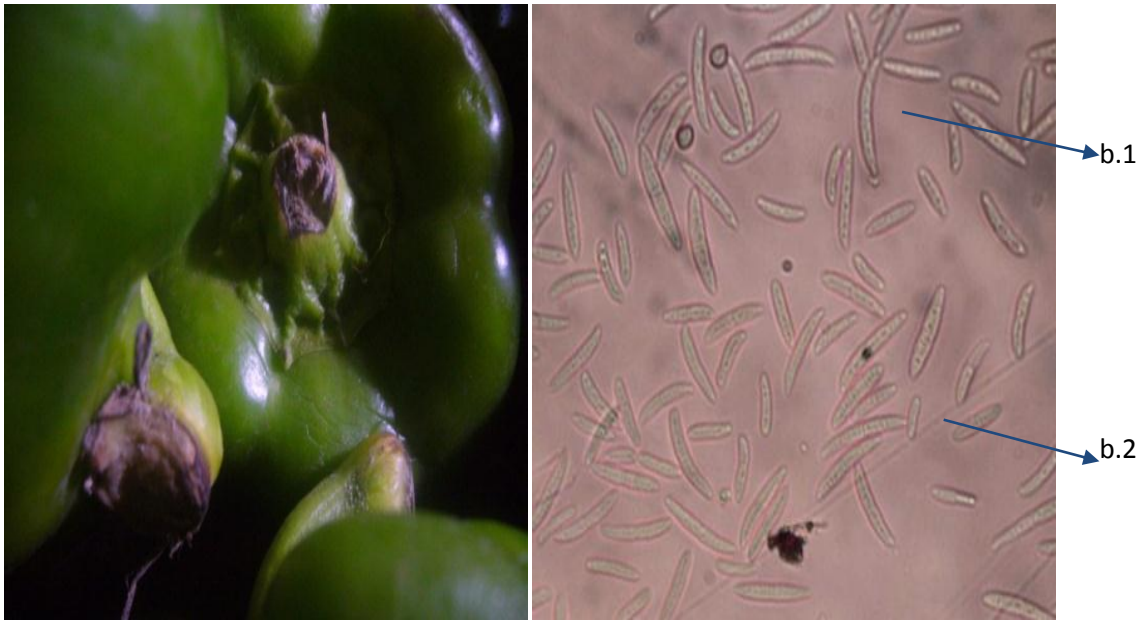


Figure 1. Fruit rot on pepper (a) and macroconidia (b.1) and microconidia (b.2) of *Fusarium* sp. (400x)

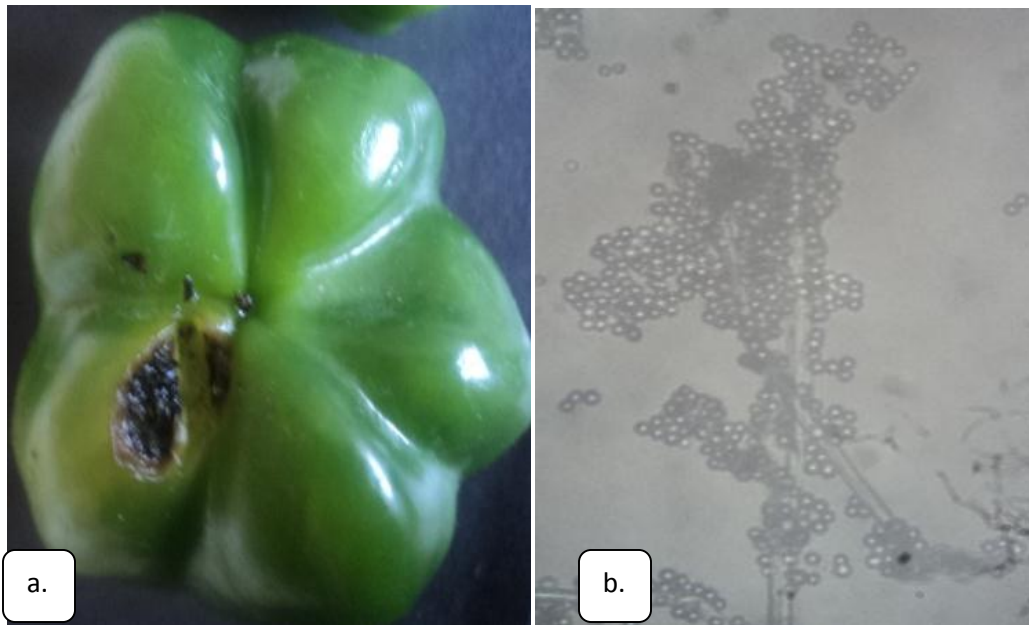


Figure 2. Dry rot of pepper (a) photomicrograph structure of *Botrytis cinerea* (400x)

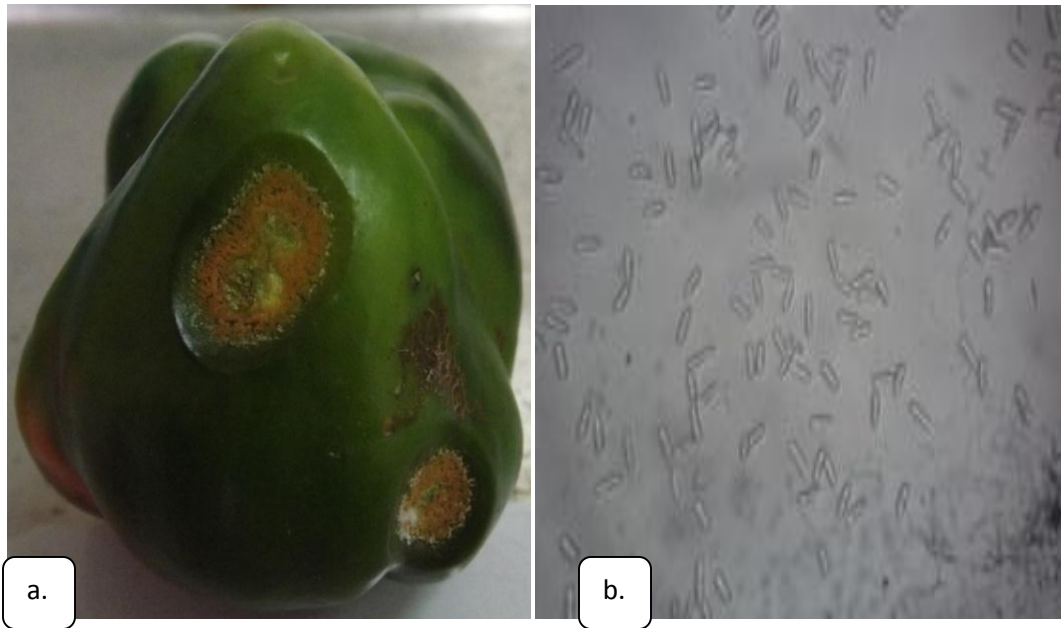


Figure 3. Anthracnose on pepper fruit (a) and conidia of *Colletotrichum*(b) (400x)

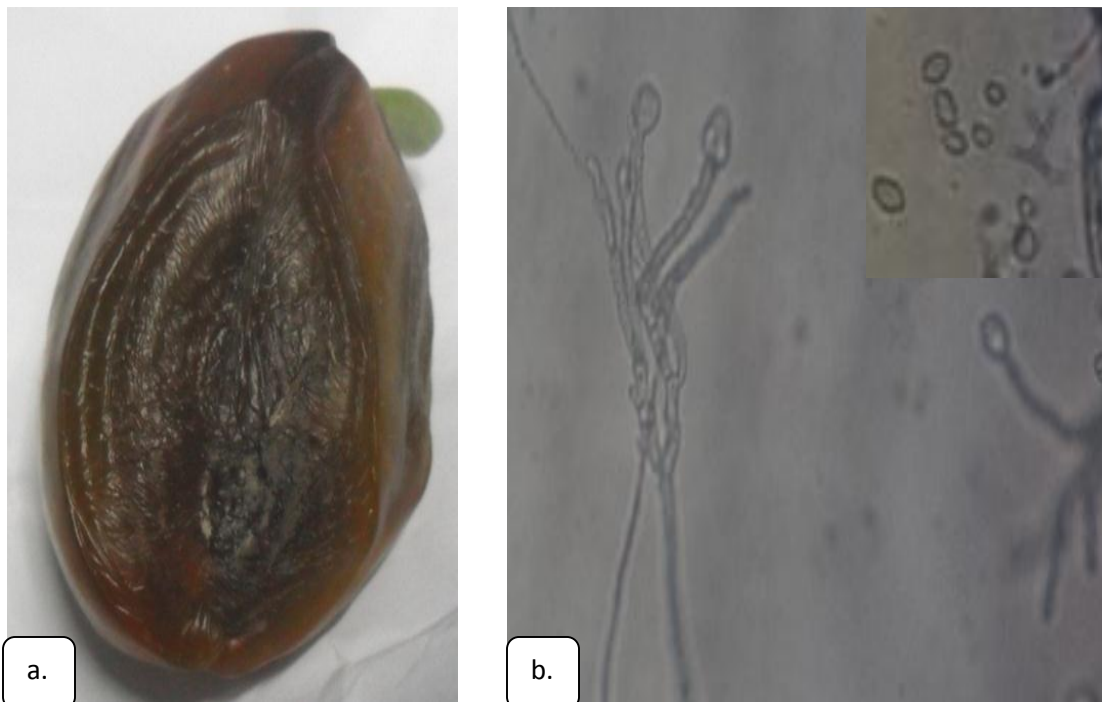


Figure 4. Symptom of *Phytophthora* (a) and, micrograph structure of *Phytophthora* sp (b) (400x)

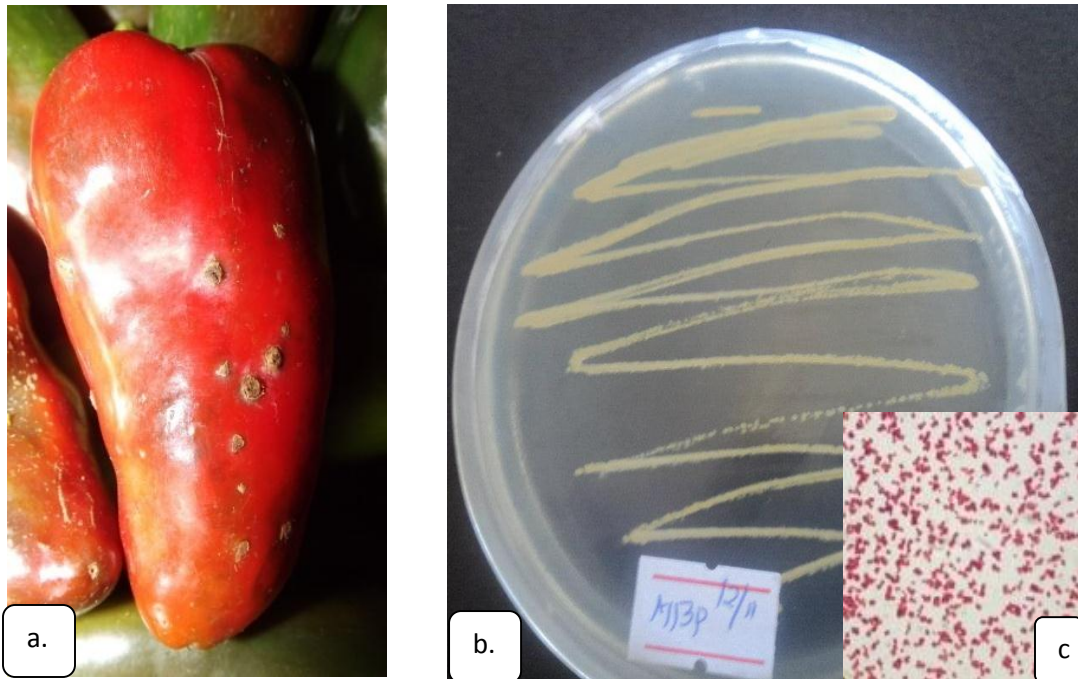


Figure 5. Symptom of bacterial spot (a) and 2-days old culture of *Xanthomonas vesicatoria* (b), and gram negative stained *Xanthomonas* cells (c)

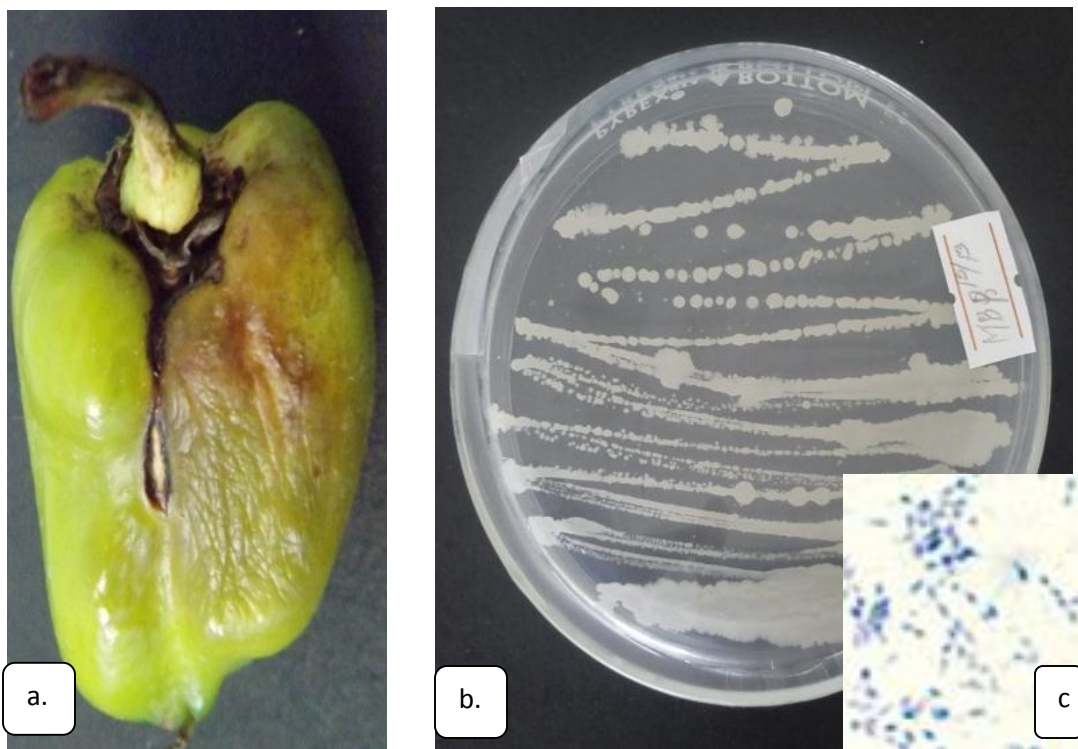


Figure 6. Fruit rot symptom (a), 5 days old pure culture of *Bacillus sp* (b) and stained gram positive *Bacillus* cells (c)

Morphological characteristics: lemon- shaped sporangia with long pedicels. Upper row, umbellate (Figure 4b).

Diseases Caused by Bacteria:

5. Fruit rot- *Xanthomonas campestris pv vesicatoria*

Symptoms: fruits have raised brown spots that are wart-like in appearance (Figure 5a).

Cultural characteristics: colonies are large, smooth-domed, mucoid-fluidal and yellow with entire edges (Plate 5b). Stained bacterial cells appear as rod shaped and gram negative, stained pink (c).

6. Fruit rot- *Pectobacterium carotovorum*

Symptoms: water-soaked lesion. The affected area was soft and mushy. The surface was discolored and depressed. Tissues were colored cream and slimy. Outer surface remained intact and the entire contents have changed to a turbid liquid (Plate 6a).

Morphological characteristics: gray-white, glossy, convex, translucent, and round colonies (Figure 6b). Stained bacterial cells appear as rod shape and gram negative and stained pink (c).

7. Fruit rot by *Bacillus sp.*

Symptoms: Water-soaked lesion that usually at the side of the fruit. The surface were discolored and depressed. Affected fruits were cream colored and slimy. Outer surface remained intact although contents were liquefied.

Cultural characteristics: Cream colored, circular with undulate margins (b). Stained bacterial cells were blue in color and gram positive (c).



Physiological disorder

8. Sunscald caused by too much exposure to sunlight

Symptoms: Fruit affected is discolored or light colored, water-soaked in appearance, soft and slightly wrinkled, blistering and desiccation of the tissues beneath the skin and areas on the fruit surface are sunken (Figure 8).

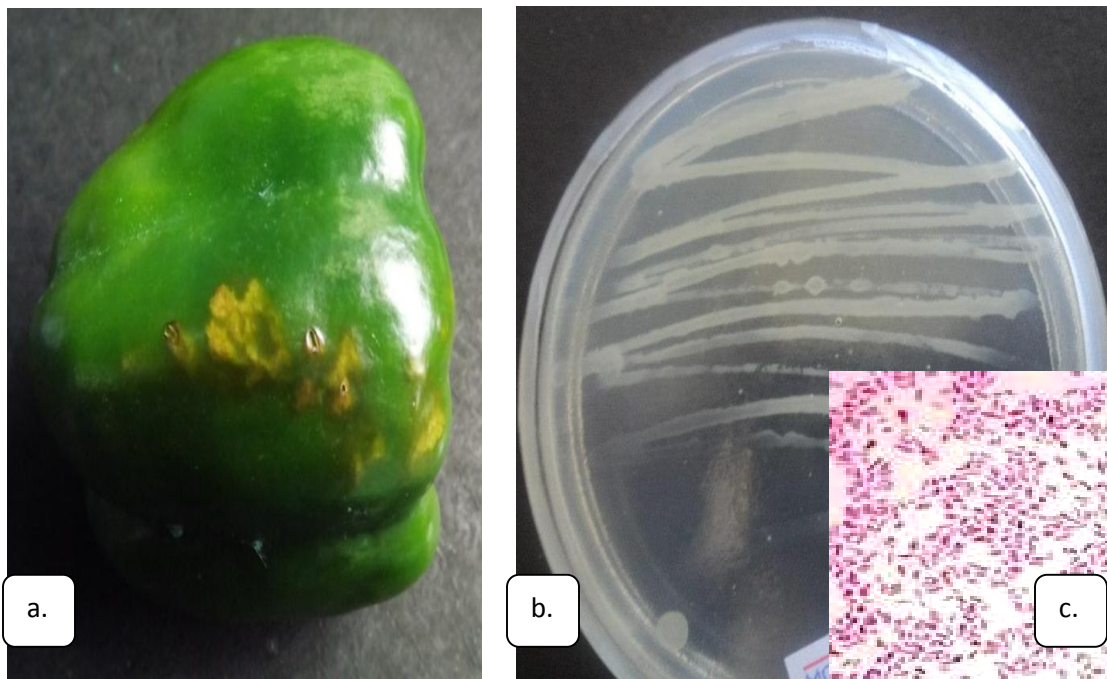


Figure 7. Soft rot on pepper fruit (a) and 2 days old pure culture of *Pectobacterium carotovorum*, and stained gram negative *Pectobacterium* cells (c).



Figure 8. Sunscald on pepper fruit
Mottle Virus (PMMoV)



Figure 9. Pepper plant affected with Pepper Mild

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The study was conducted to survey and document the postharvest handling practices on bell pepper grown in protected cultivation in Kapangan and Sablan, Benguet and at La Trinidad trading post and Baguio city market and to identify the common postharvest diseases of bell pepper. Personal interview was done using a prepared questionnaire.

Result of the survey regarding the practices of farmers in Kapangan and Sablan, and traders in Baguio city market and La Trinidad trading post revealed each farmer and trader had their own way in controlling postharvest disease and preserving their pepper produce. Majority harvest their produce in the morning without using any harvesting tools. Farmers do not practice sorting and they package their produce in baskets lined with sacks as protective material and transport it using public utility vehicles and buses.

Traders practice drying of produce using electric fan to remove excess moisture and apply local alcohol drink (Ginebra san Miguel) to wax and preserve it. Some of the diseases isolated were fruit rots caused by *Xanthomonas vesicatoria*, *Pectobacterium carotovorum*, *Botrytis sp*, *Fusarium sp*, *Colletotrichum spp.* and *Bacillus sp*.

Conclusions

The practices of farmers and traders affect the development of postharvest diseases. If not properly handled, harvested produce will be injured during harvesting, sorting, packing and transporting (during loading and unloading). The injuries incurred will serve



as entry points for pathogens and thus disease will develop that will affect greatly the quality and quantity of pepper fruits.

Recommendations

It is recommended that farmers should practice cleanliness and proper handling procedures when harvesting and plastic crates should be used as containers to avoid mechanical injuries. Plastic crates are reusable and has soft edges that will reduce mechanical injuries.

Further study should be done to evaluate materials used by farmers and traders to preserve or prolong shelf life of bell pepper.



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