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HARVESTING, PACKING HOUSE OPERATIONS, STORAGE AND TRANSPORT OF LEAFY VEGETABLES



MUSTARD GREENS

(NAPA) CABBAGE

LETTUCE

CAULIFLOWER

This handbook was prepared by PhD Le Duc Thong, with the support of B Food Tech. David Pooch, under the supervision of PhD Karl Schebesta of UNIDO Vienna, Project Manager, assisted by Hoang Mai Van Anh of UNIDO Hanoi, Program Officer and MSc Nguyen Thai Duong, Technical Advisor.

Cover design: Lisanne Brummelhuis.

ABBREVIATIONS

ppm	Parts per million
RH	Relative humidity
LDPE	Low density polyethylene
PE	Polyethylene
CO ₂	Carbon dioxide
VietGAP	Vietnam Good Agriculture Practice
1-MCP	1-methylcyclopropylene
NaOCl	Sodium hypochlorite

PREFACE

Under the framework of the Joint Program for Vietnam “UN Support to National Target Programme on New Rural Development” funded by One Plan Fund, the United Nations Industrial Development Organization (UNIDO) aims to support the strengthening of the supply capacity of the fruit and vegetable sector by applying proper technologies along the value chain.

UNIDO and the Vietnam Institute of Agricultural Engineering and Post-harvest Technology (VIAEP) collaborated in the development of a set of four handbooks on Harvesting, Packing House Operations, Storage and Transport of Leafy, Root, Spicy and Fruit Vegetables. The four handbooks give practical information and describe simple low-cost and practical post-harvest technologies.

This handbook covers four leafy vegetables: mustard greens, cabbage and napa cabbage, lettuce and cauliflower.

Leafy vegetables are a good source of vitamins, minerals and dietary fibre. However, they are perishable due to their high water content and soft cell structure. Leafy vegetables are also sensitive to ethylene, which causes them to develop an undesirable yellow colour. Common diseases in leafy vegetables are soft rot, grey mould and black rot, which all appear on the leaves.

MUSTARD GREENS

Harvesting

Harvest maturity: Mustard greens are best harvested when their stems and leaves have fully developed, but before flowering. The plants become plump when they reach their mature height of 35-40 cm.

Sweet brassica (*Brassica integrifolia*) and green brassica (*Brassica juncea*), are the most common mustard greens and are harvested at around 25-30 days and 40-45 days after sowing, respectively.

Harvest time: Mustard greens should be harvested in the early mornings or in the late afternoons when it is dry and cool. If they must be harvested on a sunny day, they should be kept shaded.

Harvest method: vegetables are manually harvested using sharp sickles, knives or scissors as shown in the photos.



Trimming: Roots and leaves that are stale, yellowish, affected by insects or diseased are rejected immediately.

The greens should be placed in bamboo or plastic crates holding 10-15 kg each or plastic bags holding 5-10 kg each. They should

be handled with care to avoid bruising. The trimmed greens must be rapidly transported to the packing house because they wilt quickly in a hot field.

Packing house operations

Sorting/Grading: All leaves suffering from insect damage, disease, decay and serious mechanical injury are removed. Mustard greens are graded by the length and colour of the leaves.

Hand washing: If the greens are dirty they should be washed manually in three plastic, stainless steel or cement basins that are 25-30 liters in size. In the first basin all the dirt is washed off. In the second one the greens are soaked in 75-150 ppm chlorine solution for 2 minutes to kill any



harmful bacteria on the surface. In the third basin the greens are rinsed with clean water. This removes residual chlorine. Water in each basin should be replaced after washing 20-30 kg of vegetables.

Note: 1 teaspoon of commercial 5.25% hypochlorite solution in 1 liter of water gives 75-150 ppm chlorine.

Ozone treatment: This is an alternative to chlorine treatment. Ozone is generated by a machine, then evenly sprayed into a

basin of water at pH 6.5-8.5 and 25°C. Vegetables are soaked in the basin for 10-15 minutes, rinsed in clean water then drained.

Draining and drying: A thin layer of vegetables is spread on the table and the water allowed to drain and dry. A centrifugal blower can be used for faster drying.



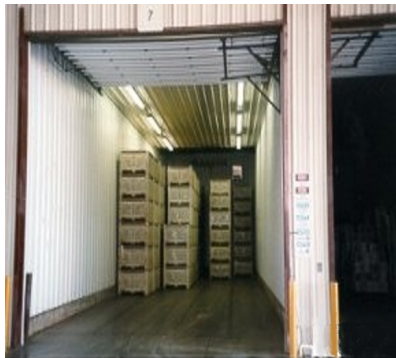
Chilling: If mustard greens are intended to be kept in cool storage, they should be chilled in 0-2°C air for 2-4 hours.

Packaging: Mustard greens are packed in hygienic and perforated 0.03-0.05 mm thick LDPE film bag. The film should be perforated to prevent condensation (dew) during storage. The film can be printed with a net weight label and other information. The bag should be sealed after filling.

Storage

Ambient storage: The mustard greens are put in a dry, cool, airy place. Shelf-life is 1-2 days.

Cool storage: Bags of mustard greens are placed in plastic crates holding 10-15 kg each then put in a cool store. At a stable temperature of 2-5°C, mustard greens can be stored for 5-7 days and have a spoilage rate of less than 10%.



Transport to market place

Normal precautions should be taken. Avoid overloading, ensure ventilation and avoid bumps. A temperature of 2-5°C is recommended for long distance transport.



CABBAGE AND NAPA CABBAGE

Pre-harvesting

Watering should be restricted at least 15 days before harvest to prevent the cabbage from cracking.

Harvesting

Harvest maturity: Cabbage and napa cabbage take 75-90 days and 90-100 days, respectively to mature. Cabbages are ready for harvest when they feel moderately hard to fingers pressed on the surface. See photo on the right.



Harvest time: Cabbages should be harvested in dry, cool weather.

Harvest method: Cabbages are tilted to one side then cut off, using a sharp knife to make a clean and smooth cut and leaving a residual 1-2 cm stem below the outermost leaves.



Trimming in the field: Too old, diseased and damaged leaves are removed, but 2-4 old inner leaves may be kept to protect the cabbages during transport to the packing house. Cabbages are then carefully placed in soft padded bamboo or plastic containers.

Packing house operations

Trimming: The 2- 4 outermost old leaves are removed.

Sorting/Grading: Cabbages are graded by weight into three classes: big - 2.5 kg, medium - 1.0 to 2.5 kg and small - less than 1 kg.

Treatment: The cut on the stalk is smeared or sprayed with a thin layer of lime or 2% acetic acid solution to control bacterial disease then left to dry naturally.



Chilling: Cabbages may be chilled at 0-2°C in a cold store for 8-10 hours before being packed ready for cool storage.

Packaging: Cabbages are wrapped in kraft paper to protect them from withering and mechanical injury during transport to the market place. Alternatively perforated 0.01 mm thick PE and 0.03 mm thick LDPE films with 4-8 mm



diameter holes can be used. Cabbages are also packed into 10-15 kg plastic crates or netting bags.



Storage

Ambient storage: Cabbages are kept in a dry, cool and airy place, away from direct sunlight.

Cool storage: When held at 0-2°C, and 90-95% RH, both cabbage and napa cabbage can be kept for 3-6 months and 1-2 months, respectively, but lose about 10% of their weight over that time.



Transport to market place

Normal precautions should be taken. Avoid overloading, ensure ventilation and avoid bumps. A temperature of 2-5°C is recommended for long distance transport.

LETTUCE

Harvesting

Harvest maturity: Lettuce can be harvested 40-60 days after sowing seeds or 25-30 days after planting seedlings. Lettuce is harvested when the leaves are tightly packed, and before the flower buds appear.

Harvest time: Lettuce should be harvested in the cool, dry mornings or afternoons.

Harvest method: Lettuce is cut close to the ground or pulled from the soil then the root is cut with a sharp knife or sickle. Roots, outermost and spoiled leaves are rejected. They are carefully placed in soft padded bamboo, wooden or plastic containers, or put in PE bags with 5 kg in each.



Packing house operations

Sorting/Grading: Plants that are damaged by transport or not up to standard are rejected. Lettuce is graded by size or weight of each plant.

Treatment: Each lettuce stem is smeared on its cut with 2% acetic acid solution to prevent bacterial disease then left to dry naturally.

Chilling: If lettuce is to be kept in a cool store it should be chilled to 0-2°C within 2-4 hours.

Packaging: Lettuce is wrapped in 0.01mm PE film or bag and then packed one layer high in a carton with ventilation holes.



Storage

Ambient storage: Lettuces that are picked early in the morning are sent to the market on the same day. Lettuces that are picked later in the day are kept only one day in a dry, airy, cool place, away from direct sunlight before being sent to the market place.

Cool storage: At 0-2°C and 90-95% RH, lettuce can be stored for 5-7 days. With modified atmosphere packaging, they can be kept for 10-20 days.

Transport to market place

Normal precautions should be taken. Avoid overloading, ensure ventilation and avoid bumps. A temperature of 2-5°C is recommended for long distance transport.

CAULIFLOWER

Harvesting

Harvest maturity: Cauliflower can be harvested 15-20 days after its tassel appears. By then it is big enough and its surface is typically lumpy. They should be harvested before the outer layer becomes soft.

Harvest time: Cauliflower should be harvested in the early morning or cool, dry afternoon.

Harvest method: Cauliflower heads are cut at the level of the lowest leaves with a sharp knife to make a smooth, flat cut.



Trimming in the field: All leaves on the stem are trimmed except for the 2-3 innermost leaves to give protection from mechanical damage. Cauliflowers are packed vertically and tightly then transported immediately to the packing house.

Packing house operations

Sorting/Grading: Cauliflowers are graded by their shape, colour and degree of defects.

Treatment: The cauliflower stem is smeared with a 2% acetic acid solution to prevent rot, then left to dry naturally. To improve the shelf life, cauliflower can also be treated with 1-MCP (1-Methylcyclopropylene) at 10-12 ppm before storage. This chemical binds with ethylene receptors to stop harmful effects of ethylene.

Chilling: If the cauliflower is to be kept in a cool store, it is chilled in ice-water for 20 minutes or covered with a thin layer of flaked ice. Alternatively, it can be kept in a cool room at 0-2°C for 2-4 hours.

Packaging: Each cauliflower is individually packed in 0.05mm LDPE or 0.01mm PE film, then carefully placed upright in a carton that has ventilation holes. Cauliflower can also be packed in bulk in ventilated cartons that are lined with perforated LDPE.



Storage

Ambient storage: Cauliflower is kept in a dry, airy and cool place, away from direct sunlight.

Cool storage: Cauliflower can be stored for 3-6 weeks at 0-1°C and 85-90% RH. At 4-6°C cauliflower can be stored for 7-8 days.



Transport to market place

Normal precautions should be taken. Avoid overloading, ensure ventilation and avoid bumps. A temperature of 2-5°C is recommended for long distance transport. Cauliflower should be kept away from sources of ethylene.

REFERENCES

1. Thompson A. K., *Fruit and Vegetables Harvesting, Handling and Storage*, the 2nd edition, Blackwell Publishing Ltd, 2003.
2. Antonio L. Acedo, Jr., *Post-harvest Technology for Leafy Vegetables*, the AVRDC - The World Vegetable Center, 2010.

For more information, contact:

1. Dept. of Technology for Food Preservation,

Vietnam Institute of Agricultural Engineering and Post-Harvest Technology

No. 60, Trung Kinh Str., Cau Giay Dist., Hanoi

Phone No. +84.4.37823032

2. Dr. Le Duc Thong

Phone No. +84.01692713466

E-mail: leducthongbq@gmail.com



**UNITED NATIONS INDUSTRIAL
DEVELOPMENT ORGANISATION**



**VIETNAM INSTITUTE OF AGRICULTURAL
AND POST-HARVEST TECHNOLOGY**