



TOGETHER
for a sustainable future

OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.



TOGETHER
for a sustainable future

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as “developed”, “industrialized” and “developing” are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

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



KOHLRABI

POTATO

RADISH

CARROT

This handbook was prepared by PhD Tran Thi Mai, 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

NPK	nitrogen, phosphorus, potassium
CIPC	carbamate - isopropyl N- 3-chlorophenyl
Viben C	benomyl copper oxychloride
RH	relative humidity
Benomyl	Methyl 1- (butylcarbamoyl)-2- benzimidazolecarbamate
EU	European Union
CEFORES CP-07	an edible film, produced by VIAEP
ppm	parts per million
LDPE	low density polyethylene
MAP	modified atmosphere packaging

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 root vegetables: potato, carrot, radish and kohlrabi. These vegetables are called root vegetables because the edible part grows in the earth. They are rich in nutrients such as minerals, vitamins and fibre. Root vegetables’ main causes of spoilage are germination, cotyledon sprout and root strike. Furthermore, root vegetables are commonly affected by dry, wet, black, porous and grey rots. Root vegetables are best stored at low temperatures and at a high relative humidity. When stored in warm and dry conditions they can become hard, withered, tough, soft, bruised and cracked. Root vegetables can also suffer from bitterness and loss of taste when stored in poor conditions. Red radish and red kohlrabi lose their colour when stored at temperatures that are too low.

POTATOES

Pre-harvesting

An NPK fertilizer ratio of 1:2:1 or 1:1:2 is used to give high yields, high dry matter content, low sugar content, rapid healing on scratches and good storage life. When too much nitrogen and water are applied, the yield is high but dry matter content is low and shelf life is poor.

15-20 days before harvesting a mixture of 0.2% CIPC (isopropyl N-(3-chlorophenyl) carbamate) and 0.5% ViBenC is sprayed on the plants at the rate of 1,000-1,400 litres/ha to limit germination and control diseases. Spraying should be done in the morning or late afternoon to allow time for the chemicals to be absorbed.

Harvesting

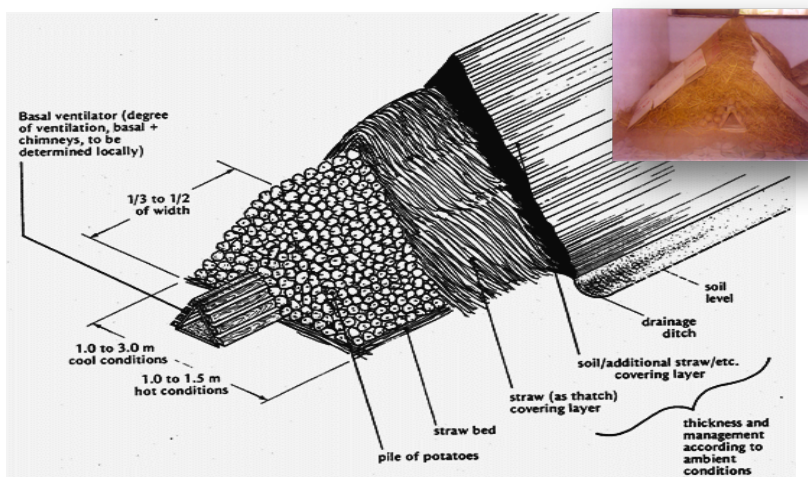
Potatoes are ready for harvest, as shown in the photo to the right, when the plants show shrivelled tops, collapse, yellow leaves at the base and defoliation. By then the tubers are large enough and have high starch content. When potatoes are harvested at good maturity and



in dry conditions they are less likely to get scratched. Potatoes should be harvested gently to avoid bumping, scratches and put in a clean sparse-woven basket or crate. Potatoes should not be held in sacks or tipped from one container to another.

Packing house operations

Curing: Potatoes that are uniform size and without scratches are piled in a heap inside a triangular cross-section wooden frame as shown in the illustration below. The frame is open at both ends and the bars of the frame should be wide enough apart to get natural ventilation. A 50-cm layer of straw and then a layer of jute sacks or cartons is spread over the potatoes.



The potato has a 1-3-month period of “physiological sleep” right after harvest and scratches in the skin can self-heal during that time. Good conditions for curing are 15-20°C and 85-90% RH for 15-20 days.

Preventing diseases: Potatoes can suffer from several post harvest diseases:

- Wet rot may occur any time after harvesting. The disease is highly contagious so it must be quickly detected and the problem

isolated. One diseased tuber can infect others nearby after 24 hours. Large volumes of potatoes can be spoiled after 3-4 days.

- Dry rot is caused by *Fusarium spp.* Tubers become withered, the skin becomes wrinkled and turns dark brown. Dry rot spreads fast, but not as fast as wet rot does.

To prevent these diseases, potatoes are loaded onto bamboo netting trays and sprayed with enough 0.2% Benomyl fungicide solution to make the surfaces evenly wet. The potatoes are then allowed to drain and dry.

Preventing germination: This can be done following anti-disease treatment or after 2 to 3 months in storage. Potatoes should be treated sooner if they are going to be kept in a cool place.



Potatoes are spread on sparse woven trays and then sprayed with 0.2% CIPC solution (isopropyl N-(3-chlorophenyl) carbamate). The compulsory withholding period after spraying CIPC is 3 weeks. The maximum allowed residue is 10 mg/kg for the EU and 30 mg/kg for USA.

Storage

Containers used for potato storage must be sprayed with disinfectant. Blend 2-2.5 litres of lime in 10 litres of 3% copper sulphate solution then spray at a rate of 5-7 liters/100m² for good disinfection.

Ambient storage: Potatoes can be loaded on shelves in a dark place then checked after 15-20 days to remove rotten and sprouting tubers. Alternatively they can be buried in clean dry sand. Anti-rot and anti-sprouting treatment can be repeated after 2-3 months storage.



Chilled storage: Suitable conditions to extend the shelf life of both seed and commercial potatoes are 4-5⁰C and 75-80% RH. To avoid chilling injury, potatoes should not be stored below 2⁰C.

Too high relative humidity can lead to potato rot. At too low humidity, potatoes dehydrate and shrivel.

After being stored at low temperatures, potatoes should be allowed to warm slowly to avoid condensation when they are taken out from the store.



Transport to market place

Normal precautions should be taken. Overloading and bumps should be avoided. Good ventilation is also necessary. Optimal temperature for long distance transport is about 7⁰C.

CARROT

Pre-harvesting

Lack of potassium causes carrots to be less sweet, less crispy and lack their typical flavour. Too much nitrogen causes cracks in the carrot flesh. Lack of calcium causes cavity spot. Carrots are also prone to germination and tip burn.

Three weeks before harvest, to reduce germination, root strike and bitterness, a spray of 0.2% CIPC (isopropyl N-(3-chlorophenyl) carbamate) is recommended.

Harvesting

Carrots are ready for harvest when leaves turn yellowish and the shoulder is evenly rounded. Carrots are harvested on dry days, placed in the shade and carefully covered by soft material.



Carrots are gently placed into containers or baskets lined with soft materials and not loaded too full to minimize mechanical injury. Harvesting containers need regular cleaning.

Packing house operations

Sorting/Grading: Spoiled, rotten, poor quality carrots are removed then the good carrots are graded according to size, weight and colour.

Washing: Carrots are washed to remove inorganic and organic impurities and improve storage life. Washing can be done manually with clean water under a running tap. A washing tank with built-in aerator can be used for larger scale production. The use of a 100-150 ppm chlorine solution at a pH of 6.5 to 7.5 is recommended to ensure food safety.



Treatment: Carrots need to be treated to prevent germination and root strike with a 0.2% solution of CIPC (isopropyl N-(3-chlorophenyl) carbamate) and coated with CEFORES CP-07 film. (This is an edible film, produced by VIAEP). The chemical solution can be applied by spraying, dipping or wiping depending on the scale of production.

Spraying is the best way. It is fast and efficient and helps the chemical to be evenly spread over the entire surface and penetrate into cavities.

Soaking ensures the whole surface is covered but a large amount of the solution is needed. Further, concentration of the chemical weakens with subsequent batches.

Wiping involves dipping a clean cotton towel into the chemical solution then wiping it all over the carrot. The labourer should wear gloves. This method takes a lot of time and labour.

Chilling: Carrots should be chilled immediately after harvest by putting them in a forced air chiller or ice water tank. This maintains their quality, limits diseases, increases shelf-life, reduces weight loss, sustains colour and enhances the carrot's self-healing process.

Storage

Carrots should not be stored with fruit that produce ethylene, as it will cause bitterness and poor smell/taste. Carrots should not be stored at over 50C and low relative humidity as this is the cause of early spoilage, germination and root strike.

Ambient storage: When packed with a 0.03 mm thick LDPE film or coated with an edible film such as CEFORES CP-07, carrots keep their quality for 1-2 weeks.

Chilled storage: Carrots can keep for 3 months when stored at 0-1⁰C, above 95% relative humidity and packed in a 0.03 mm thick LDPE film or coated with an edible film.

Storage below the freezing point (-1.2⁰C) must be avoided as cracks and a thin icy crystalline layer appears on the carrot surface, making it become dark brown to black and dripping with water.

Transport to market place

Normal precautions should be taken. Overloading and bumps should be avoided. Good ventilation is also necessary. Optimal temperature for long distance transport is 0-1⁰C.

RADISH

Pre harvesting

To reduce germination and root strike, it is recommended a 0.2% solution of CIPC (isopropyl N-(3-chlorophenyl) carbamate) be sprayed 10 days before harvesting.

Harvesting

Main crop is sown from August to September then harvested 60-70 days later.

Late crop is sown from October to November then harvested 80-100 days later.

Summer-spring crop is sown from February to April then harvested 25-35 days later.

The actual harvest time varies depending on the variety and the season. Harvesting should be done in dry weather. The radishes are gently placed into containers or baskets lined with soft materials. Overloading should be avoided to minimize mechanical injury. Containers used for harvesting need regular cleaning.

Packing house operations

Sorting/Grading: Soil, immature and damaged, rotten, crushed, diseased radishes are removed. Radishes are graded by size or weight to meet standards as required.



Washing: Radishes are washed by hand under clean running water or pressure spray as shown in the photo to the right. Specialized equipment can also be used. Soaking in a 60-70 ppm chlorine solution for 5 minutes will help to ensure food safety.



Treatment: Radishes that have not already been treated for germination and root strike need soaking in 0.2% solution CIPC at (isopropyl N-(3-chlorophenyl) carbamate) for 3 minutes and then dried in the air.

Chilling: To increase shelf life and sustain crispness, radishes should be chilled using ice or cold airflow at temperatures over 50C and then moved to the cool store.

Storage

Ambient storage: Radishes are kept in a dry, cool, airy place, away from direct sunlight and can keep up to 7 days.

Chilled storage: Radishes can keep for 2-4 months when packed in 0.05 mm thick LDPE bag, and stored at -20C to 1.50C and relative humidity of 90-95%.

Transport to market place

Normal precautions should be taken. Overloading and bumps should be avoided. Good ventilation is also necessary. Optimal temperature for long distance transport is 0-1°C.

KOHLRABI

Harvesting

Kohlrabi has two main crops. The spring crop is harvested 25-35 days after planting and the winter crop is harvested 50-70 days after planting. The actual harvest time varies depending on the variety and the season. Harvesting should be done in dry weather.

When harvested, a 3-5cm root stem should remain on the bulb as demonstrated in the photo below. Then kohlrabi is gently placed into containers or baskets lined with soft materials. Containers should not be loaded too full to minimize mechanical injury. Harvesting containers need regular cleaning.



Packing house operations

Sorting/Grading: Kohlrabi with signs of damage, rot, crush or disease, as shown in the photos on the next page, is rejected. There are no grade standards for kohlrabi. However, it is graded by size or weight depending on the variety and market requirements.



Damaged by rodents



Crushed



Bacterial black rot



Diseased

Chilling: Kohlrabi can be placed in a cool room, soaked in cool water, iced or a combination of these ways can be used.

Storage

Shelf-life of kohlrabi depends on whether the leaves are kept on or not. It is shorter when kohlrabi is stored with its leaves on because when the leaves turn yellow, they produce ethylene, which reduces the storage life. It is better to cut off all leaves further than 1-3 cm from the bulb and disinfect the cuts with saturated lime solution. Cutters should be kept sharp to give a clean cut. Kohlrabi should be packed in a 0.05 mm thick LDPE bag.

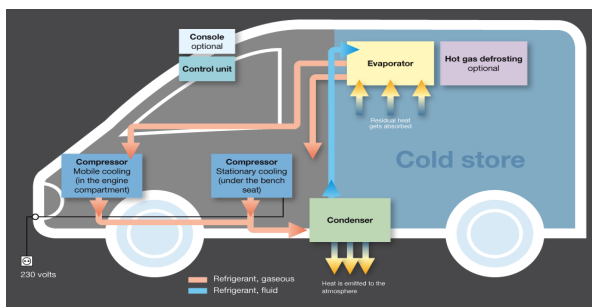
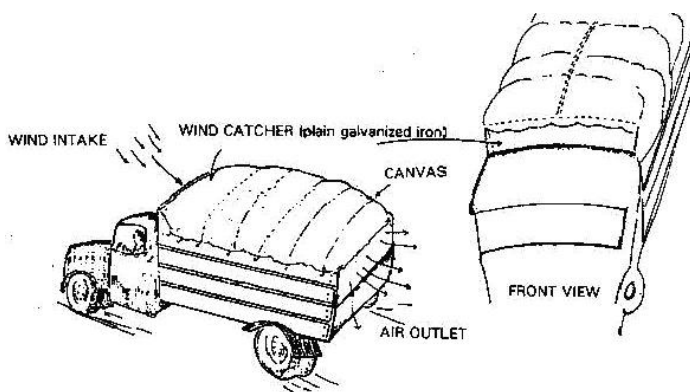
Ambient storage: Kohlrabi without leaves can be stored for 4-7 days.

Chilled storage: At suitable low temperatures near 0°C, high relative humidity of 90-95% and without leaves, kohlrabi can be stored for 1-2 months. However, with leaves the storage time is only 1-2 weeks.

When kohlrabi is stored in dry conditions (less than 60% RH) it becomes hard, tough and porous.

Transport to market place

Normal precautions should be taken. Overloading and bumps should be avoided. Good ventilation is also necessary. Optimal temperature for long distance transport is 0-1°C.



REFERENCES

1. Escalona, V.H., *Extending the shelf life of kohlrabi stems by MAP*, Journal of Food and Science, Jun 72(5): S308-13, 2007.
2. Keith Thompson. A., *Controlled atmosphere storage of fruits and vegetables*, 2010.
3. Salunkhe, D. K., Kadam, S.S., *Handbook of vegetable science and technology*, Marcel Dekker. INC, 270 Madison Avenue, New York 10016, 1998.
4. Michael Eskin, *Quality and preservation of vegetables*, 1989.
5. Navrre, R. & Pavek, M.J., *Potato: Botany, production and users*, 2014.

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. PhD Tran Thi Mai

Phone No. +84.904732223

E-mail: tranthimai05@yahoo.com



**UNITED NATIONS INDUSTRIAL
DEVELOPMENT ORGANISATION**



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