POST-HARVEST STORAGE OF VEGETABLES

At times, it is necessary to store vegetable due to uncertain marketing and shipping conditions. To prolong the shelf-life of the vegetable, certain conditions must be maintained.

Vegetable commodities intended to be stored for 5 to 7 days must be as free of skin breaks, bruises, decay and other deterioration. These conditions not only detract from the appearance of the products, but are the main avenues of entrance for decay organisms. Bacterial soft rot of lettuce often starts on bruised leaves. It is a less serious disease when the storage temperature is kept at 32 degrees F. As the temperature goes above 32 degrees, the bacteria become more active and can cause severe damage.

At times it may be necessary to store different products together. This may or may not be safe. With some products, there is a cross-transfer of odor. Ethylene may be emitted by some products that may be harmful to others. The following combinations should be avoided in a storage room: apple or pear with celery, cabbage, carrots, potatoes or onion; celery with onion or carrot; and citrus fruit with any of the strongly scented vegetables. When stored with potatoes, pears and apples acquire an unpleasant earthly taste and odor. It is highly recommended that onions, nuts, citrus fruit and potatoes each be stored separately.

When stored with apples, pears and other fruits, which emit ethylene, lettuce, carrot and other greens are damaged even at low concentration of ethylene. Tomato, a vegetable, as well as
Cantaloupes and ripe Honey Dew Melon give off ethylene. Ethylene stimulates ripening of many fruits and vegetables. This ripening effect is negligible at low temperature (32 degrees F.), but it may have an effect at higher temperature. This is one reason why products such as cucumber, peppers and acorn squash, in which retention of the green color is desirable and which need to be stored at 45 to 50 degrees F. should not be stored with tomato, apples or other ethylene producing crops.

As mentioned above, proper post-harvest storage can prolong the shelf life of the commodity. The following are some information which will be of great help to you and the wholesalers. For most of the crops below, pre-cooling is a prerequisite for post-harvest storage.

**BROCCOLI**

Broccoli should be held in storage at 32 degrees F. with a relative humidity between 90 and 95 percent. With adequate air circulation and spacing between containers to avoid heating, broccoli should keep satisfactorily 10 to 14 days at 32 degrees F. Broccoli should not be kept beyond 14 days because leaves become discolor, buds may drop off and tissue soften.

**HEAD CABBAGE**

When stored under proper conditions, late cabbage can be kept for 3 to 4 months. Early varieties have a limited storage life of 3 to 6 weeks. To attain these storage conditions of the cabbage, temperature should be uniformly maintained between 32 to 35 degrees F. and relative humidity between 90 to 95 percent.

**CHINESE CABBAGE**

At temperature of 32 degrees F. and relative humidity between 90 to 95 percent, Chinese cabbage can be stored 1 to 2 months. Storage life is
shorter at higher temperature. The heads should be packed loosely in crates with outer diseased or injured leaves removed. Spacing in storage should allow for good air circulation.

**CAULIFLOWER**

Good condition cauliflower can be held satisfactorily, for 2 to 4 weeks at 32 degrees F. with a relative humidity between 90 to 95 percent. Slightly immature heads keep better than more mature ones. Proper storage depends not only on preventing decay, spotting and watersoaking but also on retarding aging. Crates should be stacked with the flower head down to protect the curds from bruising and dirt. Should it be necessary to hold cauliflower temporarily out of cold storage, packing in crushed ice will aid in keeping it fresh.

**CELERY**

Celery, at 32 degrees F. and relative humidity between 90 and 95 percent, can be stored for 2 to 3 months. Current practice is not to store this crop for more than 10 days. Good air circulation is necessary to keep the temperature at the top and bottom of the room as nearly equal as possible.

**CUCUMBER**

At temperature between 45 to 50 degrees F. and relative humidity of 90 to 95 percent, cucumber can be stored 10 to 14 days. When held longer than 2 days at 45 degrees F., cucumber is subject to chilling injury. Cucumber ripens rapidly at 50 degrees F. changing the color from green to yellow which begins about 10 days at this temperature. The ripening process accelerates when cucumbers are stored in the same room with apples, tomatoes or other ethylene producing crops. Symptoms of chilling injury are water soaked spots, pitting or tissue collapse.

**LETTUCE**
Lettuce can be expected to keep for 2 to 3 weeks under storage at 32 degrees F. and relative humidity of 95 percent. Lettuce is known to keep about twice as long at 32 degrees F. as at 38 degrees. Lettuce is easily damaged by freezing so it important to keep the storage room above the lettuce freezing point of 31.7 degrees F. Lettuce should not be stored in the same room with produce emitting ethylene. Russet spotting, which cause serious loss in storage, is known to be caused by ethylene. Bacterial soft rot, often starts on bruised leaves, is one of the most serious disease of lettuce in storage. This disease is less serious at temperature at 32 degrees F.

BELL PEPPER

Recommendation for storage of bell pepper is at 45 to 50 degrees F. with relative humidity of 90 to 95 percent. Peppers are subject to chilling injury when stored below 45 degrees F. and temperature above 50 degrees promote ripening. Under the most favorable conditions, peppers should not be stored more than 2 to 3 weeks. Pitting of the peppers occurs in a few days when stored at temperatures of 32 to 36 degrees. Chilling injury occurs when peppers are held at temperature below 45 degrees.

ZUCCHINI

Zucchini and other soft-skin squashes are harvested at the immature stage for best quality. They are very perishable as the skin is tender and easily wounded in handling. Because of their perishability, they normally should not be stored except for a short time to accommodate marketing conditions. Zucchini should be stored for a few days at 32 to 40 degrees F. with a relative humidity of 90 percent. When held longer than 4 to 5 days, chilling injury causes deterioration. When held 10 to 14 days at 32 degrees F., deterioration after removal is rapid (increased yellow color, pitting and wilting). Should storage extends beyond a week and distribution is
involved after removal, storage at temperatures of 45 to 50 degrees F. is best. This period at 45 to 50 degrees should be limited to 2 weeks or less.

**TOMATO**

The most desirable temperature for slowing ripening of mature-green tomatoes without increasing decay problems is between 57 to 60 degrees F. and relative humidity from 85 to 90 percent. At this temperature, the more mature fruit will ripen enough to package for retailing in 7 to 14 days. Mature-green tomatoes held for 2 weeks or longer at 55 degrees F. may develop an abnormal amount of decay and fail to reach an intense red color as tomatoes ripened at 65 to 70 degrees F. Temperatures commonly used for ripening mature-green tomatoes are 65 to 70 degrees F.

Ripe tomatoes can be held at 45 to 50 degrees F. for several days. Tomatoes with 50 to 75 percent color can be held up to a week at 50 degrees. If held longer, they will probably not have a normal shelf life during retailing. Holding ripe tomatoes for a long period of time at low temperature (40 degrees or less) results in loss of color, shelf life and firmness. The more advance in ripeness, the lower the temperature tomatoes will tolerate.

For pink-red to firm-red greenhouse-grown tomatoes, it is recommended that they be stored at 50 to 55 degrees F. Ripening of less mature tomatoes at 70 degrees is recommended before storage at 50 to 55 degrees F.

**MAUI ONION**

Proper curing of the Maui Onions will assure longer storage. The onion is considered cured when the neck is tight and the outer scales are dried until they rustle. This condition is reached when onions have lost 3 to 5 percent of their weight. Onions decay readily in storage when not properly cured. Because of its poor keeping
quality, Maui Onions can be stored for about 1 to 2 months under temperature of 32 degrees F. and relative humidity between 65 to 70 percent. Bagged onions should be stacked to allow proper air circulation. Onion should not be stored with other produce that tend to absorb odors.

**SWEET CORN**

Should it be necessary to be stored, sweet corn will keep best at 32 degrees F. with a relative humidity of 90 to 95 percent. Serious deterioration begins to develop when corn is stored more than a few days. At regular temperature, the sugar content decreases rapidly, but the rate is lessen when stored at 32 degrees F. The loss of sugar is about four times as rapid at 50 degrees F. as at 32 degrees. Sweet corn should be cooled immediately after harvesting.

Usually corn is hydrocooled, but vacuum cooling is also satisfactory if the corn is prewet and top-iced after cooling. Unless copiously iced, sweet corn should not be handled in bulk because of its tendency to heat throughout the pile. Top icing during transit and storage is recommended to keep husks fresh and prevent denting of kernels. Upon arrival at the market place, corn should not be expected to keep in marketable condition in cold storage for more than 4 to 8 days. (The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stock, Agriculture Handbook No. 66, USDA)

Should you be interested in other vegetable crops for post-harvest storage, please call me.

***************************************************************
**************

**CHINESE CABBAGE**

Many research on Chinese cabbage production has been done in Japan because it is one of the major vegetable crops grown there. The following
is the fertilizer recommendation in Japan for Chinese cabbage production:

Pre-plant application based on 1 acre:

550 to 660 lbs. of N
300 to 440 lbs. of P
550 to 600 lbs. of K

1st side dressing (at thinning which is not done here):

66 lbs. of N
66 lbs. of K

2nd side dressing (40 to 45 days after planting):

66 lbs. of N 66 lbs. of K (Proceedings of the First International Symposium of Chinese Cabbage)

Since we transplant all of the Chinese cabbage here, I believe that only one side dressing of fertilizer is necessary. The time of application should be made between 20 to 25 days after transplanting.

Please have your soil analyzed first should you decide the above.

******************************************************************************

AGRICULTURAL BOOK SOURCE

AgAccess is a catalog for many books on agriculture which may be of interest to you. You can receive a free catalog by writing to AgAccess, P.O. Box 2008, Davis, CA 95617.

******************************************************************************

1989 STATE LAWS & RESOLUTIONS AFFECTING AGRICULTURE IN HAWAII
This publication is a summary of the major acts and resolution passed in the 1989 Legislature which affect the Hawaii agriculture industry. This publication is now available at the Cooperative Extension Service offices.

MILLION DOLLAR ROUNDTABLE OF MAUI COUNTY VEGETABLE PRODUCTION

According to the Statistics of Hawaiian Agriculture 1988, head cabbage was first with a value of $2,100,000. Number 2 was watermelon with a value of $2,014,000. Third in value was onion ($1,069,00). Tomato follows with a value of $1,368,00.

Crops with less than a million dollar of value were lettuce ($517,000), Chinese cabbage ($348,000), Romaine (S331,000) and Zucchine ($250,000), respectively.

CALCUM

High calcium level in the plant tissue may increase the plant resistance to bacterial diseases, such as, the bacteria soft rot of Chinese cabbage and potato. (Management of Diseases with Macro- and Microelements.)

THE GREENER THE GREENS. THE BETTER
"The greener the vegetable is, the higher its level of chlorophyll, and that means higher levels of carotenoids," said Frederick Khanchik of the USDA's Agricultural Research Service. Carotenoids are the red and yellow pigments, including beta carotene, thought by some to protect against cancer. (The Packer, Oct. 14, 1989.)

VEGETABLE INDUSTRY ANALYSIS

It has been quite a while since a vegetable industry analysis was made. This year a different approach will be tried by the grouping of the vegetable crops. This approach will be more equitable for both emphasis and funding. I will be sending out meeting notices to determine Maui's priorities in the near future. The following are the groupings:

<table>
<thead>
<tr>
<th>Crucifers</th>
<th>Lettuce</th>
<th>Legume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head cabbage</td>
<td>Head lettuce</td>
<td>Pitted peas</td>
</tr>
<tr>
<td>Mustard cabbage</td>
<td>Semi-head lettuce</td>
<td>Soybeans</td>
</tr>
<tr>
<td>Chinese cabbage</td>
<td>Romaine</td>
<td>Green beans</td>
</tr>
<tr>
<td>Broccoli</td>
<td>Celery</td>
<td></td>
</tr>
<tr>
<td>Cauliflower</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Roots</th>
<th>Cucurbits</th>
<th>Water/Paddy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulb Onion</td>
<td>Bittermelon</td>
<td>Lotus root</td>
</tr>
<tr>
<td>Daikon (radishes)</td>
<td>Cucumber</td>
<td>Waterchestnut</td>
</tr>
<tr>
<td>Burdock</td>
<td>Squashes (summer, winter, Oriental)</td>
<td>Watercess</td>
</tr>
<tr>
<td>Sweet potato</td>
<td></td>
<td>Ung choy</td>
</tr>
<tr>
<td>Yams</td>
<td>Watermelon, etc.</td>
<td>Others</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Solanaceous</th>
<th>Others</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Eggplant</td>
<td>Green onions</td>
<td></td>
</tr>
<tr>
<td>Pepper</td>
<td>Sweet Corn</td>
<td></td>
</tr>
<tr>
<td>Poha</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potato</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomato</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
REPORT OF ACCOMPLISHMENTS OR PROGRESS REPORT

Project Title   Edible Crops of Maui

Project Leader    Ted M. Hori

Department/Unit       Maui  
Project No.    041

Part I. Description of Project Activities.
Introduction of disease resistant and/or improved varieties is a continuous project of the agent. For head cabbage, the introduction of black rot resistant and improved varieties has been an on-going project for over 16 years. The high incidence of the viruses on cucurbits in Kula prompted the agent to initiate a cucumber trail at the Kula Agricultural Park Station with 5 cultivars. With export of Chinese cabbage increasing throughout the year, 30 cultivars were evaluated for resistance/tolerance to the virus and the bacterial butt rot. The cause of the decline of tomato production was due to the Tomato Spotted Wilt Virus (TSWV). Seven cultivars were evaluated at three different sights on Maui to determine the commercial marketability and yields of the cultivars.

Past works for the control of the cabbage black rot and the lettuce bacterial spot resulted without any success. Through literature search, the agent found that copper, as a nutrient, can reduce the bacterial disorder in wheat. The agent initiated a trial to control the bacterial disorders of cabbage, lettuce, Chinese Cabbage and onion with the use of copper as a nutrient.

One of the major disorders of Chinese Cabbage in certain cultivars is "Gomasho". The symptom, large numbers of black spots, which appears after head formation. The disorder is caused by the plant's inability to metabolize the nitrate nitrogen in the foliage. The disorder can be
created with the heavy application of nitrogen fertilizer. The agent informed the growers of this disorder through the Maui Vegetable Notes, June 1989 (Appendix 1). Through literature search, the agent found that Molybdenum assist the plant to metabolize nitrate nitrogen. The agent initiated a trial control "Gomasho" with the use of Molybdenum.

Effective measures needed to be developed for the control of insect pests on the various vegetable produced on Maui. One of the major pests of tomato and cucurbit is the greenhouse whitefly. This pest appeared to have resistance to several of the chemical pesticides which used to control it. With the information obtained by the agent from Agent R. Hamasaki, the agent tried an ultrafine oil product for the control of the whitefly.

Obtaining and using timely publications on vegetable production is an on-going project of the agent. The contents of the publication~ were either generated by the agent from field demonstration/ trials or from excerpts from professional journals and work conducted by county agents and researchers of HITAHR.

Alternative crops have become a focus for Hawaiian agriculture. Crops to be considered are the spices and endemic trees. The agent collaborated with a researcher to develop a project on endemic trees. They were assisted by a federal forester and a researcher of HITAHR. The project was submitted for a grant to the RREA-Agriculture Project.

The primary objective of the agent in the Herb project was to have a state-wide herb growers' association. The second objective was to develop a newsletter for the growers. With the assistance of the other county agents, efforts were initiated and the library of insect and disease pests of herbs was developed.

Requests for the relationships of plant nutrients in the soil were received by the agent.
The requests prompted the agent to develop a program on soil fertility. The agent invited the other horticultural and livestock agents to participate in the program. The agents agreed to participate in the program, thereby, developing a county wide program. The result was the Soil Fertility Shortcourse.

The agent was asked to determine the decrease in yield of basil of its members by Maui Economic Opportunity, Inc. Through individual consultations, the agent found that the causal agent of the decline was due to the root knot nematode.

Water quality is a national initiative of CES. The agent wrote a proposal for a program to be conducted in the County of Maui. The proposal was submitted for a grant to conducted the program on Maui.

Due to the inclement weather during the first two months of 1990, the agent received numerous complaints from growers on post-harvest losses during storage. The complaints prompted the agent to do literature search on post-harvest storage on vegetables.

Increased interest in taro (wet and dry land) production created a problem on the availability of planting materials on Maui. A state-wide project is being developed to evaluate taro cultivars.

The agent is aware of the county, state, national and international implications for himself as well as for the Cooperative Extension Serv~co and HITAHR. He thus pursued programs that involved such implications.

Part II. Resources Involved.

Resources from HITAHR, Hawaii State Department of Agriculture, Hawaii State Forestry and a federal forester were involved in the agent's projects.
Part III. Accomplishments or Progress Made Toward Achieving Project Objectives.

In a cabbage variety trial conducted in FY 88, Exp YR 25 one of the cultivars that gave good yield. With the shortage of Tastie seeds, Exp. YR 25 became commercially available under the name of Pacifica. About 60% of the growers are planting Pacifica until Tastie seeds becomes available.

The original cucumber trial which was conducted in FY 88 did not show any symptom of the cucurbit viruses, another trail was conducted in May 1989 to determine the resistance or tolerance of the 5 cultivars to the Watermelon Mosaic Virus 1 (WMV-1), Watermelon Mosaic Virus 2 (WMV-2), Cucumber Mosaic Virus (CMV), and the Zucchine Yellow Mosaic Virus (ZYMV). Of the 5 cultivars, only Dasher II did not have any resistance to the above viruses. Lani and Milo are resistant to WMV-2 and CMV. Sweet Slice is resistant to CMV, WMV-1 & 2, and Sweet Salad is known to possess resistance to all of the viruses. The trial resulted with Lani, Milo and Dasher II came down with the ZYMV. Both Sweet Slice and Garden Salad were not affected by the viruses. The WMV-1 was not present in this trial. Results of this trial was sent to the growers via the Maui Vegetable Notes, October 1989 (Appendix 3).

With the damage caused by the viruses of cucurbits and the interest by the growers for the control of the diseases, a workshop was held on this subject. Drs. Diane Ullman and John Cho were the principal speakers. Eight growers attended this workshop which was held on June 1, 1989.

The summer Chinese cabbage variety trial was conducted to determine the resistance of the cultivars to the bacterial butt-rot. Also included in this trial were the incidence of "Gomasho" and tip-burn. It was difficult to recommend which cultivar was best for summer planting in Kula because of the results of the trial. Results of this trial were sent to the
growers via the Maui Vegetable Notes, July 1989 (Appendix 2).

**County, State, National and International Implications.**

County: The agent coordinated the Soil Fertility Shortcourse on the island of Maui with the horticultural and livestock agents. He initiating and submitted a proposal for funds to conduct a water quality project for Maui County.

State: The agent disseminated information on vegetable production on Maui to other vegetable county agent via the Maui Vegetable Notes. He worked with HITAHR researchers to develop the Endemic Tree Pro~ect and participated in state wide association conference (Herb). He co-authored a Research/Extension publication: Diseases and Pests of Carnation.

National: He attended the conference sponsored by the Agricultural Development of the American Pacific and had the opportunity to talked to some of the researchers from the American Pacific on my projects in vegetable production on Maui.

International: He assisted in the mainland tour for the Japan Agricultural Exchange Council (JAEC) trainees and also conduct the Maui farm tour for JAEC trainees. Conducted classes on insect and disease control for the Maui Agriculture Training Council trainees from the Philippines. Assisting a researcher from Argentina to evaluate several cultivars of tomato for resistance to the Tomato Spotted Wilt Virus.

**Part IV. Future Implications.**

Introduction of new improved and disease resistant varieties of vegetables will always be a continuous program for the agent. More work will be done for an effective and economical control of the insect vectors of plant diseases and insect pests. Work will be continued with Molybdenum for the eradication of "Gomasho" in Chinese Cabbage.
production on Maui. The control of bacterial diseases with copper as a nutrient will be continued. Workshops on water quality will be conducted as an island-wide program. Integrated pest management workshops will be conducted for the vegetable growers on Maui. A workshop will be held for the herb growers on nematodes and nematodes control. Control of the above disorders in vegetable production will automatically expand the markets of Maui's vegetable industry. Conduct the vegetable industry analyses to determine the program priorities.

Beside insect, "Gomasho" was the second major problem for the exportation of Chinese Cabbage to the mainland and Guam. The cabbage arrived with the black "pot" throughout the head. Applications of Molybdenum at the rate of 1 to 4 oz. Mo per acre were on the seedlings of the Chinese Cabbage prior to transplanting. At the higher rate of application, the intensity of "Gomasho" was reduced but not eliminated. More work will done to control this disorder with the use of Molybdenum. The alternative for the control of this disorder is to plant resistant cultivars but limitations of each cultivars must be considered (see above).

After a period of 5 years, Peto Seed Company with the cooperation of HITAHR, developed several tomato cultivars with resistance to the Tomato Spotted Wilt Virus (TSWV). On November 7, 1989, a field day was called to evaluate these cultivars. Of the 5, 2 cultivars appeared to be satisfactory for commercial production. A larger field trial will be conducted in October of 1990.

The control of bacterial diseases is most difficult in vegetable production because of the lack of good chemical agents. The agent had introduced Copper-Count-N for the control of the bacterial disorders in cabbage, lettuce and onion. Growers using this product commented that they were satisfied with the performance of the product to control/suppress the bacterial diseases. An alternative to chemical control of these disorders, the agent initiated the use of copper,
as a nutrient, for the control of the bacterial
diseases of head cabbage, Chinese Cabbage, lettuce
and onion. Rate of application of copper varies
with the crop tried. Soil samples were taken to
determine the amount of copper in the soil. Each
treatment of the crops will have the tissue
analyzed to determine the amount of copper in the
tissue. Results of this trials will be sent to
the growers via the Maui Vegetable Notes.

Complaints from the producers of tomato and
cucurbits were received by the agent on the
explosion of the greenhouse whitefly. Information
received by the agent from Agent Hamasaki that an
ultra-fine oil gave excellent knockdown of the
whitefly. The agent tried the product on tomato
and found the oil to be an excellent source of
control. Being an oil, there appears to be no
problem of a built up of resistance by this pest.
The growers on Maui were informed of the result of
this trial via the Maui Vegetable Notes, December
1989 (Appendix 4).

The agent has continued to send out timely
information. vegetable production to the growers
through the Maui Vegetable Notes. Six issues were
sent to the growers varies information pertaining
to vegetable production (Appendix 1, 2, 3, 4, 5 & 6).
DISEASES AND INSECT PESTS OF HERBS
Ted M. Hori
County Extension Agent

Herbs, like any horticultural plants, are subjected to diseases and insect damages. Unfortunately, there is only a few pesticides available to combat the insect pests but none for disease control.

Because of its recent economic venture, only a few disease and insect pests have been identified. For Basil, 13 insect pests have been identified to be of economic value. The most common insect pests of Basil are the following:

1. Rose beetle
2. Leafhopper
3. Broad mite
4. Grasshopper
5. Flea beetle
6. Mealybug
7. Leafminer

Some unusual insect pests are the Formosan Subterranean Termite and the Longhorn beetle. Two insect pests had been identified on Terragon. They a mealybug and the Chrysanthemum thrips.

On Rosemary, only a thrips had been identified to cause some damage.

On Sage, the lace bug and a mite were identified to cause damage.

Only the Red Spider Mite was recorded on Chiso.

There has been very little recording of diseases of herbs in Hawaii. So far, only 8 diseases were recorded for Basil and they are:

1. Stem die-back (Fusarium roseum 'Graminearum')
2. Anthracnose Leafspot (Colletotrichum sp)
3. Damping Off (Rhizoctonia solani)
4. Leafspot (Phytophthora sp)
5. Stem canker (*Sclerotinia sclerotiorum*)
6. Plant wilt (*Tomato Spotted Wilt*)
7. Plant die back (*Root Knot Nematode*)
8. Damping Off (*Pythium sp.*)

On Coriander, only a Damping -off disease had been identified which is caused by *Pythium ultimum*.

Only Foliar nematode was recorded on Sage to be of an economic importance.

We would like to have a good catalog of all the diseases and insect pests of herbs. To establish the catalog, we (Extension Service) need your help. Please call the county agent whenever you have a problem so that he can identify the causal agent of the disorder.