

PRINCIPLES OF POSTHARVEST
HORTICULTURE

Midterm Exam I

100 points possible

NAME: _____ ANSWER KEY _____

EXAM I

POSTHARVEST HORTICULTURE

POSTHARVEST DETERIORATION & LOSSES (10 points-MAR)

(2 points) What is the most important factor than can be managed to reduce losses of fresh fruits and vegetables?

TEMPERATURE!

(2 points) What historical movement(s)/event(s) really drove the need for improved postharvest handling practices?

Urbanization, especially spurred on by the industrial revolution. In addition, increased globalization and demand for produce year-round has driven movement of produce to population centers from around the world, not just from the nearby country side production areas.

(6 points) For 2 points each, list what you think are three of the **most important consequences of fresh fruits and vegetables being alive** after harvest and why you think each should be included (think of things that occur in fresh fruits and vegetables that don't occur in processed fruits and vegetables)

Any of the following:

- Respiration – Living products respire and the rate of respiration is tied to shelf life, compositional, nutritional, and other changes.
- Heat production – Heat of respiration must be removed during storage/transport or metabolism with increase leading to shorter shelf life.
- Ethylene production – Produced as part of wounding or ripening and causes important physiological responses (e.g., ripening, loss of green color, stimulates some physiological disorders, etc.).
- Other, numerous, metabolic processes leading to **compositional changes** – Living products can still develop after harvest leading to often negative (e.g., senescent) or positive (e.g., ripening) compositional changes.
- Growth and other morphological changes – Being alive, some change morphologically, e.g., curving and/or elongating of asparagus and gladiolus spears)
- Transpiration (**water loss**) – While even non-living, processed products can lose water (i.e., frozen vegetables), fresh horticultural commodities developed as part of a plant body where transportation was an important way to transport nutrients from the roots to areal portions of the plant. After harvest, that water loss continue with often detrimental results.
- Physiological disorders – To extend shelf life, we alter the environmental condition usually experienced by the commodities during storage and marketing (e.g., lower temperature, ethylene exposure, etc.), but these conditions, and other metabolic imbalances in the tissues, can result in the development of physiological disorders.

EXAM I

POSTHARVEST HORTICULTURE

- General senescence – Over time, the plant tissues break down in often a genetically programmed series of metabolic events.

EXAM I

POSTHARVEST HORTICULTURE

MORPHOLOGY, STRUCTURE, GROWTH AND DEVELOPMENT (10 points-JKB)

(5 points) Give an example of a horticultural crop for which each of the following parts of an ideal plant is the part that is harvested and consumed:

Root: Carrot (taproot), Turnip, Cassava, Beet, Sweetpotato (adventitious root), Cassava

Underground Stem (Tuber): Potato (tuber), Yam, Ginger (ok; rhizome)

Petiole: Celery, Rhubarb

Leaf Blade: Spinach, Leaf lettuce, etc.

Stem/Sprouts: Asparagus, Kohlrabi, Sprouts

Axillary Buds: Brussels sprouts,

Flower Buds: Broccoli, Cauliflower, Artichoke,

Fruit: Pepper, Tomato, Cucumber, Apples, Grapes, Citrus, Sweetcorn, Okra, Green beans, etc., etc.

(5 points) Define the following two terms (2 pts each) and give an example of a crop that is typically harvested when it is horticulturally mature but physiologically immature (1 pt).

Horticultural maturity: The stage of development when a plant or plant part possesses the prerequisites for utilization by consumers for a particular purpose.

Physiological maturity: The stage of development when a plant or plant part will continue ontogeny even if detached.

Crop: sprouts, any immature fruit, floral or root vegetable, leafy and stem vegetables.

EXAM I

POSTHARVEST HORTICULTURE

RESPIRATION (20 points - MAR)

GIVEN:

$$\text{mg CO}_2/\text{kg hr} \times 61 = \text{kcal/MT/day}$$

$$Q_{10} = (R_2/R_1) \exp (10/T_2-T_1)$$

$$\text{mg CO}_2 \text{ produced} \times 0.68 = \text{mg sugar consumed}$$

$$\text{ml CO}_2 \times 1.78 = \text{mg CO}_2$$

(2 points) Briefly explain how a plant tissue's requirement for energy to carry out metabolic processes controls the tissue's rate of respiration.

The respiration rates of all commodities are continuously regulated based on the metabolic demands of the cells. For example, higher temperatures cause faster metabolism (i.e., faster cell maintenance processes), or after being wounded, there is a greater energy demand to supply the wound-healing metabolic processes. Greater metabolic demand => lower cellular ATP levels => stimulates respiration to replenish the pool of ATP. One key enzyme in glycolysis, phosphofructokinase (PFK), is inhibited by high levels of ATP in the cytosol. Thus, lower energy (ATP) demand within the cell results in higher concentrations of ATP that inhibit PFK and slow respiration (as measured by CO₂ production or O₂ consumption).

(3 points) What is the Q₁₀ of a commodity between 5 and 15°C if its rate of respiration is:

10 mg CO₂/kg hr at 5°C, and

40 mg CO₂/kg hr at 15°C. (circle correct answer)

A) 1

B) 2

C) 3

D) 4

$$Q_{10} = (R_2/R_1) \exp (10/T_2-T_1)$$

$$Q_{10} = (40/10) \exp (10/20-10)$$

$$Q_{10} = 4 \exp (1) = 4$$

(5 points) Explain why CO₂ production increases when plant tissues transition from aerobic respiration to anaerobic respiration.

The cells need to supply sufficient ATP to support their metabolic needs, but anaerobic respiration produces much less ATP per CO₂ released (& per glucose molecule) than aerobic respiration. Therefore, much more CO₂ is produced during anaerobic respiration compared with aerobic respiration if equal ATP production is to be maintained to support cellular metabolism.

EXAM I

POSTHARVEST HORTICULTURE

(10 points) Onions held at 30°C respire at a rate of 16 ml CO₂/kg-h. Estimate the rate of heat production and the rate of dry weight loss of those onions at 30°C. State your assumptions and show your work.

- a. Heat production: answer using the formula **mg CO₂/kg-h × 61 = kcal/MT/day**

Given: respiration rate at 30°C is 16 ml CO₂/kg-h

Convert the respiration rate from ml CO₂/kg-h to mg CO₂/kg-h using the conversion equation given above (1.78 mg/ml CO₂)

$$16 \text{ ml CO}_2/\text{kg-h} \times 1.78 \text{ mg/ml CO}_2 = \mathbf{28.48 \text{ mg CO}_2/\text{kg-h}}$$

$$\mathbf{28.48 \text{ mg CO}_2/\text{kg-h}} \times 61 = 1,737 \text{ kcal/MT/day}$$

- b. Dry weight loss:

Convert the respiration rate from ml CO₂/kg-h to mg CO₂/kg-h using the conversion factor 1.78 mg/ml CO₂

$$16 \text{ ml CO}_2/\text{kg-h} \times 1.78 \text{ mg/ml CO}_2 = \mathbf{28.48 \text{ mg CO}_2/\text{kg-h}}$$

Then use the formula: mg CO₂ produced × 0.68 = mg sugar consumed

$$\mathbf{28.48 \text{ mg CO}_2/\text{kg-h produced}} \times 0.68 = 19.37 \text{ mg sugar/kg-h consumed (the rate of dry weight loss)}$$

EXAM I

POSTHARVEST HORTICULTURE

COMPOSITION & COMPOSITIONAL CHANGES (20 points-JKB)

Match the statements with the correct chemical constituent(s). More than one statement can match a constituent/more than one constituent can match a statement. **Hint:** there are >20 correct matches.

(+1 point for each correct match; -1/2 point for each incorrect or missing match)

Carotenoids d, e

Phenolics e, j, l [f (lignin) and n (bitterness) are ok, too]

Polysaccharides a, f, m [k (storage carbs) is ok, too]

Lipids b, i, l (k and n are ok, too)

Proteins c, g, i

Organic acids h, j, k, n

Soluble sugars h, k, n

Vitamins e, g [h is ok, too]

- | | |
|--|--|
| a) This is the most abundant type of chemical constituent in plants on a dry weight basis. | h) Content may continue to increase on the plant, but not always postharvest. |
| b) Compounds in this group protect fruits and vegetables from water loss. | i) Compounds in this group are thought to play an important role in chilling injury. |
| c) The highest levels of this constituent are found in legumes. | j) Unripe fruits contain high levels of this group, and that makes them less likely to support the growth of some types of microbes. |
| d) These are mostly red, orange and yellow pigments. | k) These are important respiratory substrates |
| e) Fruits & vegetables are important sources of the compounds in this group, which are vital for human health. | l) Compounds in this group protect fruits and vegetables from decay organisms. |
| f) Enzymatic effects on compounds within this group are primarily responsible for changes in fruit and vegetable texture. | m) A compound in this group is the most important storage compound in plants. |
| g) Members of this group play a vital role in every aspect of metabolism. | n) Important contributors to fruit and vegetable flavor. |

EXAM I

POSTHARVEST HORTICULTURE

ETHYLENE & PLANT HORMONES (20 points-JKB)

(10 points) Explain the general mechanism by which hormones exert their effects on plants, including how this relates to the changing ‘sensitivity’ of plants and plant organs to a hormone during development.

Hormones act by binding to specific receptors that may differ for different hormone effects. Binding of the hormone by the receptor initiates a cascade of reactions, which ultimately results in changes in gene expression.

Changing “sensitivity” of plants and plant organs to a hormone during development relates to synthesis of the hormone’s receptors along with the downstream transporters and transcription factors, etc., which allow the plant or plant organ to respond to the hormone.

(5 points) Explain how and why ethylene is used to ripen climacteric fruits.

How: Ethylene is applied to unripe climacteric fruit in air-tight ripening rooms using a saturating dose/concentration. The ripening temperature is chosen to promote the most desirable ripening changes; humidity is kept high to reduce water loss; aeration is used to prevent excessive CO₂ buildup, because CO₂ is a competitive inhibitor of ethylene action.

Why: Ethylene both initiates and coordinates ripening. The concentration of ethylene used is a saturating dose so that all the fruit respond maximally; less developed fruit will respond more than more developed fruit because the latter are likely to be producing ethylene on their own – this is why the resulting population ripens more uniformly than if allowed to ripen on their own.

(5 points) Indicate for each of the following whether it describes ‘climacteric’ or ‘nonclimacteric’ behavior or is true for ‘both’ types.

1. Ripening is triggered in mature specimens upon exposure to ethylene. **Climacteric**
2. Produces ethylene in response to wounding. **Both**
3. a. Respiration rate elevated upon exposure to ethylene. **Both**
b. Respiration rate returns to pre-exposure level when ethylene is removed. **Nonclimac.**
4. Ethylene synthesis is induced upon exposure to ethylene. **Climacteric**

EXAM I

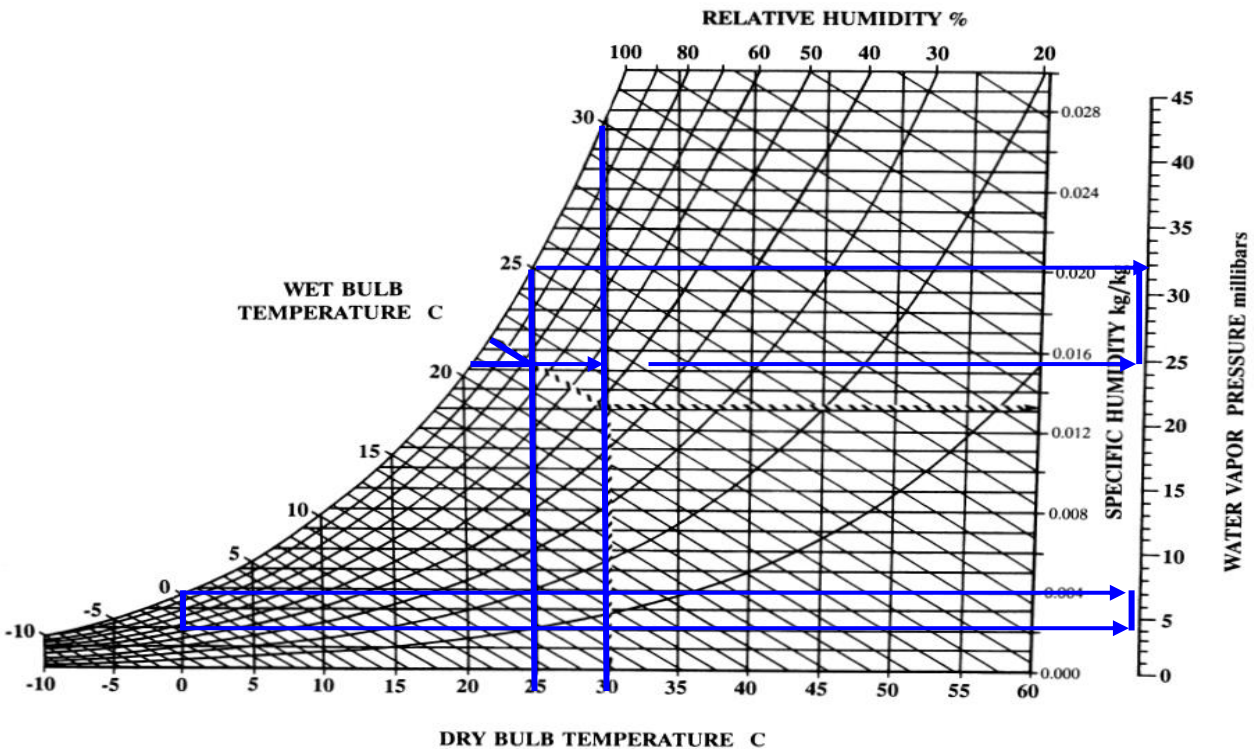
POSTHARVEST HORTICULTURE

TRANSPIRATION & WATER LOSS (10 points - MAR)

Using the equations and psychrometric chart below, answer the following questions.

$$VPD = SVP_{\text{tissue}} - VP_{\text{air}}$$

$$J = VPD * k$$



- A. (1 point) What is the relative humidity of air with a dry-bulb temperature of 25°C and a wet bulb temperature of 22°C? ~77%
- B. (1 point) What is the dew point of the air in question “A”? ~21 °C
- C. (1 point) If the air in question “A” was warmed to 30°C and water was neither added nor removed, what would be the new relative humidity of the air? RH would decrease to ~57%.
- D. (1 point) Would a commodity lose water faster if stored in the air in question “A” or if stored in air at 0°C (32°F) with 50% relative humidity? Why? Note: The commodity is at the same temperature as the air in both environments?
The commodity would **lose water faster** if stored in question “A” air than at 0°C with 50% RH. The VPD between 100% (saturation) and 77% RH is greater at 25°C (question A) than 50% RH at 0°C.

EXAM I

POSTHARVEST HORTICULTURE

- E. (2 point) If a pallet of leeks at 25C and weighing 500 kg is left in a room with conditions “A” above overnight (14 hours). During this time period, the pallet of leeks loses 2% of its original weight. What is the VPD experienced in conditions “A”.

Calculate the vapor pressure deficit (VPD) using the psychrometric chart

SVP at 25C = ~32 milibars

VP at 25C with ~77% RH = ~25 milibars

VPD = SVPtissue – VPair; VPD = 32-25 = **7 milibars** (or 700 pascals or 0.7 kPa)

(Note: it's ok if your VP numbers are not exactly the same as these).

We usually use kPa, but this psychrometric chart happens to be in milibars. You can either convert to kPa, or continue the calculations as milibars

- F. (2 point) From the previous question, calculate “k” (proportionality constant) for these leeks.

Now calculate k

Using $J = k \times \text{VPD}$

$0.14\%/h = k \times 7 \text{ milibars}$

$(0.14\%/h)/(7 \text{ milibars}) = k$

0.02 (%/h)/milibars = k

- (2 point) Product arriving at a distant market is found to have bruising, especially on fruit above the wheel axels. What likely happened to cause this bruising?

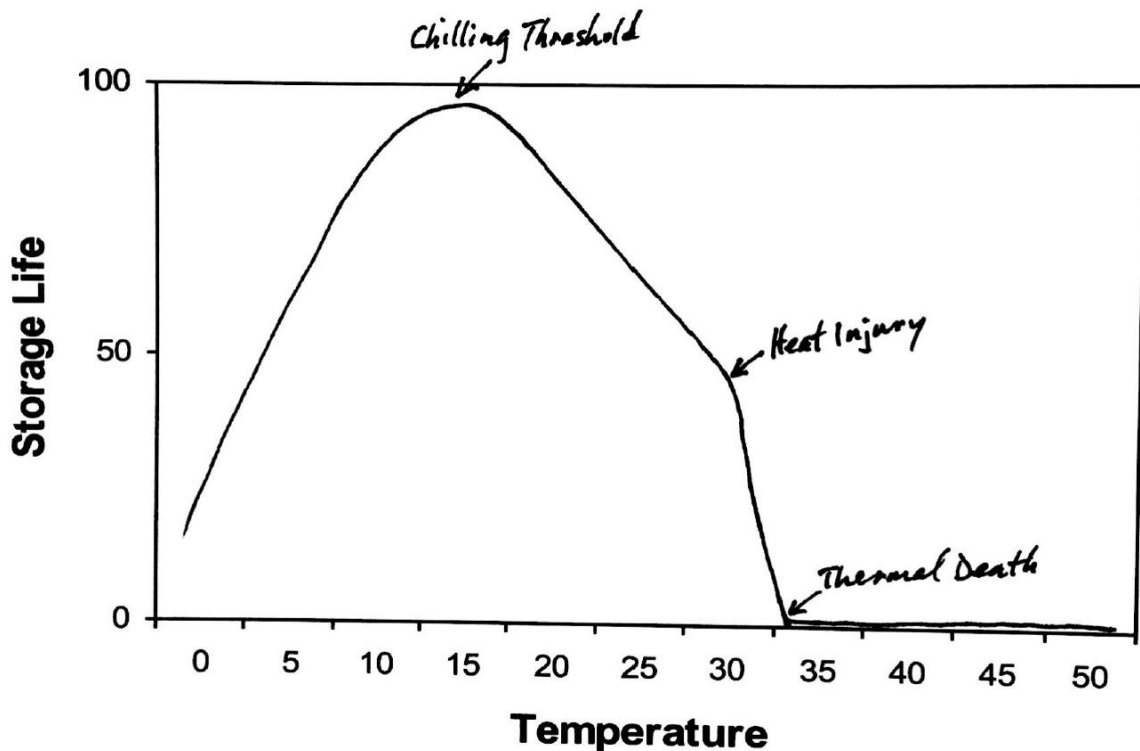
Vibration injury transmission up through the road/wheels (worst in product stacked directly over the wheels). Product is usually packaged to prevent movement, but water loss could cause product to shrink and allow jostling within each package causing vibration injury.

EXAM I

POSTHARVEST HORTICULTURE

PHYSIOLOGICAL DISORDERS (10 points-JKB)

(5 points) Draw a generalized figure showing the effects of temperature in the range of 0°C to 50°C on the storage life of a crop of **tropical** origin and label the points where the direction of the curve changes (Hint: there are three such points).



Label these:

- 1) chilling threshold temperature
- 2) when heat injury begins
- 3) thermal death point

The chilling threshold should be around 10-15°C with storage life at or near 100%

The slope from the chilling threshold to the start of heat injury should be roughly representative of a Q10 of around 2.

Storage life drops more quickly above the heat injury temperature

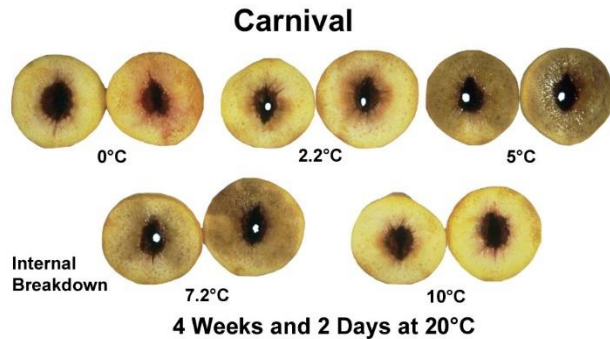
No storage life at or above the thermal death point

4) Labeling the freezing point is ok, too (no points off)

EXAM I

POSTHARVEST HORTICULTURE

(5 points) Define the term, “chilling threshold temperature” for horticultural crops, then explain the unusual case of stone fruits (see below), which have a chilling threshold of about 10°C, but for which storage at 0°C is recommended.



Definition:

The chilling threshold temperature is the lowest temperature, characteristic of a commodity, at which no chilling injury is seen, regardless of the length of storage. (Below the chilling threshold temperature, chilling injury occurs.)

Stone fruit case:

Stone fruits can be stored without chilling injury at their chilling threshold temperature of around 10°C, but the storage potential at that temperature is quite short because the fruit ripen at 10°C.

Temperatures below 10°C cause chilling injury, but those low temperatures can also inhibit the chemical reactions that are involved in chilling injury symptom development. The worst temperature is around 5°C – low enough to cause severe chilling injury and high enough to also allow severe chilling injury symptom development.

The recommended storage temperature for stone fruits is 0°C because it is low enough to almost completely inhibit chilling injury symptom development for quite long storage durations. However, for the typical times that stone fruits are in the distribution system (<1 week), the chilling injury at 0°C is not too severe and the fruit actually can recover when warmed for ripening.