



## Coconut: Postharvest Quality-Maintenance Guidelines

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Coconut is marketed at two stages of development, immature and mature. At an immature stage, the fruit (water coconut) contains mainly juice and a translucent jelly-like meat (endosperm). The immature stage is when the coconut reaches full size, about 6 to 8 months from flowering, the volume of juice in the nut declines, and the sweetness, measured as soluble solids, begins to increase to about 6%. Some varieties have up to 9% soluble solids. Mature coconut (11 to 13 months old) has hard white flesh (meat, endosperm) and a lesser amount of juice, which is still potable but is considered to be of lower quality. Fruit at both stages are available year-round from most tropical countries (Seelig 1970).

A speciality variety of coconut is 'Makapuno'. Due to a recessive mutation in the development of the cell walls, the edible endosperm remains soft and jelly-like at maturity. These nuts are highly prized in Asian markets. "Makapuno" is the Philippine name, while similar fruit are called "kopyor" in Indonesia, "thairu tenga" in India, and "maphrao kathi" in Thailand (Siriphanich et al. 2011).

Young coconuts are hand harvested. Monkeys are trained in some Southeast Asian countries such as southern Thailand to harvest the nuts. Special care is needed with young coconuts to prevent them falling to the ground. When harvested by hand, one worker climbs the palm and lowers the bunch, tied to a rope, to the ground, where it is untied and stacked by another worker. Alternatively, the bunches can be lowered into a canal. Impact injury causes damage that appears as browning of the outer coir.

### Quality Characteristics and Criteria

The major quality characteristics are nut maturity, size, freedom from blemishes and cracking, and freedom from fiber and wet or moldy eyes in husked coconuts. Nuts that are too young, over-mature, undersized, cracked, or misshapen are culled. Oblong-shaped coconuts tend to have smaller nuts and are of lower quality. A sloshing sound from the nut indicates the presence of coconut juice inside. Immature, de-husked coconuts are about 10 cm (4 in) in diameter, weigh about 500 g (1.1 lb), and have 100 g (3.5 oz) endosperm, 120 g (4.2 oz) shell, and 250 g (8.8 oz) juice.



**Fig. 1. Immature coconut showing green skin and jelly-like meat developing inside the husk. (Photograph courtesy Jintair Siriphanich, Kasetsart University).**

## Horticultural Maturity Indices

The most common maturity index is time from flowering, which correlates well with hard white flesh (endosperm) development. Tapping of the nuts is also used: a solid sound is found in just-matured nuts (6 to 8 months) and a hollow sound is found later in nut development as the juice volume declines.

Young coconuts are harvested 6 to 9 months after flowering, as the nut approaches full size and the skin is still green (Consignado et al. 1976, Srivichai 1997). At the same time, the short stem (rachilla) on the top of individual coconuts that originally held the male flowers (in Thai called “rat-tail”) becomes half green and brown (Fig. 1). In immature nuts, the skin surface around the calyx (cap) on the top of coconuts is creamy white or whitish yellow. When the area surrounding the cap is green and the coconut is 10 to 12 months old, it is regarded as mature. At maturity the skin begins to change from green to yellow and then to brown, and the “rat-tail” is entirely brown. A gray skin indicates that the nut is old. ‘Makapuno’ coconuts are harvested at the full-mature stage.

## Grades, Sizes, and Packaging

There are no specific grades; informal grades are usually based on size and weight. Mature U.S. dehusked coconuts are sold in 34 to 36 kg (75 to 80 lb) woven plastic or burlap sacks containing 40 to 50 coconuts, plastic mesh bags of 12 coconuts, or cartons with 20 to 25 coconuts, 17 to 18 kg (37 to 40 lbs).

Immature coconuts (water coconut) require different treatment. In Thailand and other Southeast Asian countries, and now in the U.S., immature green nuts are trimmed and shaped, removing most of the husk (Fig. 2 and 3). The final product has a flat bottom, round body, and pyramidal top, with the eyes showing. Care is needed to avoid over-trimming around the eyes, as the nut at this stage still has internal pressure and the eyes may burst. To prevent browning of the remaining husk, nuts are dipped in 1 to 3% sodium meta-bisulfite for 2 to 5 min and then wrapped in plastic film (Tongdee et al. 1991). Sometimes fungicide is included in the sulfite solution. Sulfite agents, such as sodium bisulfite, cannot be used for cosmetic purposes, and no fungicides are approved for postharvest use on coconuts in the U.S. The nuts are sold in single-piece cartons containing 6 to 16 each.

Husking the nut to remove the outer coir means that the nuts have a shorter postharvest storage life, about three weeks at 12 to 15°C (54 to 59°F) (Siriphanich et al. 2011). However, the lower fruit weight and reduced packing and shipping weight makes the husked nuts more economical to market and more convenient for the consumer.

A new product is roasted (smoked) coconut, which is completely dehusked and then “burnt” slightly in a fire. The juice from these nuts is sweeter and more aromatic. A further development is to cut circular sutures into the nut with a laser and then attach a pull-tab (Fig. 4).

## Pre-Cooling Conditions

Room-cooling is generally used for mature husked nuts. Forced-air and hydro-cooling are acceptable. A rapid temperature change of 8°C (14.4°F) can cause cracking.

## Optimum Storage Conditions

Mature coconuts with their husks intact can be kept at ambient conditions for 3 to 5 months before the liquid endosperm has evaporated, the shell has cracked because of desiccation, or sprouting has occurred. Storage at 0 to 1.5°C (32 to 35°F) and 75 to 85% RH is possible for up to 60 days for mature, dehusked coconuts (Maliyar and Marar 1963) and 13 to 16°C (55 to 60°F) and 80 to 85% RH for 2 weeks or less. Low RH and high temperature should be avoided.



**Fig. 2. Film-wrapped shaped coconut packed for shipping. (Photograph courtesy Jingtair Siriphanich, Kasetsart University).**

Young coconuts are normally held at 3 to 6°C (37 to 43°F) with 90 to 95% RH, while wrapped shaped fruit can be held for 3 to 4 weeks. Shaped young coconuts treated with 0.5 to 1.0% sodium meta-bisulfite can be held at ambient temperature for 2 days before browning occurs, while those treated with 2% sodium meta-bisulfite can be held at ambient temperature for 2 to 7 days (Tongdee et al. 1992). Young coconuts that have not been dehusked can be stored for a longer period than dehusked or shaped young coconuts. In dehusked or shaped coconut, SSC declines and TA increases more rapidly than in non-dehusked coconut. These changes in taste characteristics mean that the taste of de-husked or shaped coconuts sours earlier than that of non-dehusked nuts (Somboonsup 1985). The husk possibly acts as insulator and may increase the storage life of young coconuts.

### Controlled Atmospheres (CA) Consideration

No data are available on CA storage. Mature dehusked coconuts are waxed or film-wrapped to reduce water loss, the major cause of loss in quality. Wrapping in high-oxygen-transfer plastic film significantly improves postharvest life (Siriphanich et al. 2011). Immature de-husked nuts can also be film-wrapped or waxed; however, the outside color changes rapidly from white to brown unless they are dipped into sodium bisulfite (Tongdee et al. 1992).

### Retail Outlet Display Considerations

Display at ambient temperature and do not mist. Non-wrapped or individually wrapped shaped coconuts are displayed at ambient temperature or 10°C (50°F). Sometimes, 5 to 10 shaped coconuts are placed in perforated polyethylene bags and sold in Thai retail markets.

### Chilling Sensitivity

When stored at 0°C (32°F), the green skins of immature nuts turn brown after 7 days; few other changes occur in other quality characteristics at this temperature (Consignado et al. 1976). Chilling injury is not seen when coconuts are stored at 5°C (41°F) for 6 weeks, though the juice sours with long storage times.

### Ethylene Production and Sensitivity

Ethylene production is very low to near zero for mature husked coconut. 'Makapuno' ethylene production is 0.6 to 0.8 uL C<sub>2</sub>H<sub>4</sub> kg<sup>-1</sup> hr<sup>-1</sup>. Ethylene production for normal fruit is lower at 0.24 uL C<sub>2</sub>H<sub>4</sub> kg<sup>-1</sup> hr<sup>-1</sup> but increases with storage (Siriphanich et al. 2011). Husked nuts produce more ethylene. There are no reports of sensitivity to ethylene.

### Physiological Disorders

Mechanical damage to immature coconut due to impact will cause the white coir to turn brown and can cause the



Fig. 3. Shaped coconut being delivered to market (A) and in the supermarket (B). (Photographs courtesy Jingtair Siriphanich, Kasetsart University.)



**Fig. 4. Coconut with all the husk removed, roasted, and showing the laser-burnt suture and pull tab. (Photograph by Saichol Ketsa, Kasetsart University.)**

nut to crack. Younger nuts have a lower rupture force than mature nuts (Tongdee 1991). Careful handling is crucial. A rapid temperature change of 8°C (15°F) during storage of mature husked coconut can lead to cracking (Burton 1982). Nut freezing occurs at -3°C (26.6°F). Water loss by the nut can be reduced by RH control, film wrapping, or waxing mature nuts.

### Postharvest Pathology

Superficial mold growth occurs on wet coconuts. For trimmed young coconut, mold due to various fungi occurs, often turning black, orange, and pink. Over-mature nuts in the rainy season often show various types of mold growth, including *Colletotrichum*.

### Quarantine Issues

None, if nuts are mature and free of surface insects and soil, and the husks are dry. Some restrictions exist on the importation into certain tropical and subtropical areas from countries having diseases that may impact local palms.

**Table 1. Respiration Rates of Coconut**

	Temperature	mg CO <sub>2</sub> kg <sup>-1</sup> hr <sup>-1</sup>
Immature	10°C (50°F)	6.5–7.5
Mature	10°C (50°F)	6.2–7.2
Immature	20°C (68°F)	13–24
Mature	20°C (68°F)	13–26
‘Makapuno’	5°C (41°F)	20
‘Makapuno’	30°C (86°F)	50

### Respiration Rates

See Table 1 for respiration rates of coconuts. To calculate heat production, multiply mg CO<sub>2</sub> kg<sup>-1</sup> h<sup>-1</sup> by 220 to get BTU per ton per day or by 61 to get kcal per metric ton per day.

### Suitability as Fresh-Cut Product

Meat from both immature (jelly-like) and mature (hard) coconuts is sold in trays with an over-wrap or in plastic bags for use in desserts. Immature coconut’s jelly-like meat and coconut juice have to be held at 3 to 5°C (37 to 41°F) to avoid spoilage. Small plastic bags with the jelly-like meat and juice are frequently seen held on ice in Southeast Asian markets and at roadside stalls. For mature coconuts, non-shredded and shredded meat is packed in plastic bags for cooking and desserts. In Thailand, nuts between the immature and mature stages are harvested, and the meat, which is slightly firm and not jellylike, is used in a Thai dessert called maproaw (coconut balls). Coconut milk is obtained by removing and grating the hard white flesh and squeezing out the milky juice. Sometimes water is added to the juice. This product quickly spoils and needs to be kept on ice.

### References

- Burton, B.D. 1982. Prevention of postharvest studies cracks in husked coconuts during transit. *J. Amer. Soc. Hort. Sci.* 107:905–907.

**Table 2. Nutrient Composition of Coconut per 100g Edible Portion<sup>1</sup>**

	Immature	Mature	Juice
<b>Proximate (g)</b>			
Water	81.4	55	94
Calories (kCal)	122	296	22
Protein	1.9	35	0.2
Fat	11.9	27.2	0.4
Carbohydrate	4	13.7	4.5
Fiber	0.7	3.8	-
Ash	0.8	1	0.5
<b>Minerals</b>			
Calcium (mg/100g)	11	13	24
Phosphorus (mg/100g)	42	83	18
Iron (mg/100g)	1.1	1.8	0.3
Sodium (mg/100g)	51	16	5
Potassium (mg/100g)	257	340	130
<b>Vitamins</b>			
Ascorbic Acid (mg/100g)	7	4	3
Carotene (mg/100g)	Trace	0	0
Thiamine (mg/100g)	0.05	0.04	Trace
Niacin (mg/100g)	0.8	0.6	0.1
Riboflavin (mg/100g)	0.03	0.03	Trace

<sup>1</sup>(Leung et al., 1972).

- Consignado, T.O., P.C. Tabora, and R.P. Creencia. 1976. Physio-chemical changes in stored young coconut. *The Phillipine Agriculturist* 60:256–270.
- Leung, W.T.W, R.R. Bitrum, and F.H. Chang. 1972. Proximate composition of mineral and vitamin content of East Asian foods, Part 1. *In: Food Composition Table for Use in East Asia*. UN-FAO and USDHEW.
- Luengwilai, K., D.M. Beckles, O. Pluemjit, and J. Siriphanich. 2014. Postharvest quality and storage life of ‘Makapuno’ coconut (*Cocos nucifera* L.). *Scientia Horticulturae* 175:105–110.
- Marar, M.M.K. and C.A. Kurhiraman. 1957. Studies on the keeping quality of ripe coconut in storage. *Coconut J.* 10(4):37–51.
- Muliyar, M.K. and M.M.K. Marar. 1963. Studies on the keeping quality of ripe coconuts in storage. *Indian Coconut J.* 17:13–18.
- Seelig, R.A. 1970. Coconuts: Fruit and vegetable facts and pointers. United Fresh Fruit and Vegetable Assoc., Washington, D.C.
- Shivashankar, S. 1991. Biochemical changes during fruit maturation in coconut. *Journal of Plantation Crops* 19:102–119.
- Somboonsup, S. 1985. Effect of some postharvest handling on quality of fresh coconuts. Undergraduate Special Project. Dept. Hort., Kasetsart Univ., Bangkok. 18 pp. (In Thai)
- Siriphanich, J., P. Saradhulthat, T. Romphophak, K. Krisanapook, S. Pathaveerat, and S. Tongchitpakdee. 2011. Coconut (*Cocos nucifera* L.). *In: E. Yahia (Ed.), Postharvest Biology and Technology of Tropical and Subtropical Fruits, Vol 3: Cocona to Mango*. Woodhead Publishing in Food Science Technology and Nutrition, Cambridge, UK (2011), pp. 8–33.
- Srivichai, S. 1997. Planting Coconut Palm. *Agric. Com. Pub.*, Bangkok, Thailand, 95 pp. (In Thai)
- Tongdee, S.C. 1991. Postharvest handling of tender coconut. *ASEAN Food J.* 6:74–75.
- Tongdee, S.C., A. Suwanagul, and S. Neamprem. 1992. Control of browning in trimmed green coconuts. *In: ACIAR Project 8844, Wkshp. Postharv. Hand. Trop. Fruit*. Bangkok, Thailand, pp. 15.

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