



## Lychee Fruit Bagging for Commercial and Home Growers

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In Hawai'i, lychee (*Litchi chinensis*) is a highly anticipated summer fruit. Harvests begin in May, peak in mid-June and abruptly fade away by late July. It is a common backyard fruit tree, more noticeably planted on the east side of the islands where there is abundant rainfall. There are also approximately 150 commercial growers, producing 230,000 pounds of lychee across the state. In 2011 a pound of fruit had a farm-gate price of \$2.75/lb., bringing the total commercial crop value to \$633,000. These figures do not include any trade occurring between homeowners and consumers.

Lychee fruit are borne on multi-branched flower panicles or inflorescences. These panicles typically arise from the terminal end of branches. In Hawai'i, flowering occurs from November to April. Following pollination and up to color break, fruit drop due to wind or natural attrition is common. Depending on the environment and microclimate, lychee fruit reach maturity approximately 70–80 days after full bloom (Yuan et al. 1988).

### Pests of Lychee

During development, lychee fruit are affected by several major pests including moths (*Cryptophlebia* spp.), fruit



Lychee fruit can be protected from birds and insect pests with bagging, allowing for more delectable fruit for human consumption.

flies, and birds. With heavy populations, erinose mites (*Eriophyes litchii*) can also affect flowering and fruit development, though mite damage is most commonly seen as off-white to purplish-brown velvety lesions that cause the leaves to become curled, gnarled, or dimpled.

Common diseases associated with lychee are *Colletotrichum*, *Phomopsis*, *Lasiodiplodia*, and *Pestalotiopsis*. Many of the symptoms show up as dark brown lesions on the skin of the fruit or as brown spotting on leaves.

Litchi fruit moth (*Cryptophlebia ombrodelta*) and koa seed worm (*C. illepada*) affect fruit from very young, green stages to fully ripe, mature fruit. According to Follet et al. (2003), the adult moth

lays its eggs on the fruit. The larvae then bore through the skin, feed at the skin/pulp interface, and then continue to bore into the seed. Frass can sometimes be seen at the wound surface on the skin or near the pedicel or stem where the fruit attaches to the main flower stalk or inflorescence.

Oriental fruit flies (*Bactrocera dorsalis*) and Mediterranean fruit flies (*Ceratitidis capitata*) cause blemishes to lychee at later stages of ripening. During the process of depositing eggs under the skin of the fruit, the female fruit fly creates a small hole on the fruit with her ovi-



Left: Immature and mature fruit with telltale signs of *Cryptophlebia* spp. caterpillar frass. Middle: Damage on the skin and flesh caused by *Cryptophlebia* spp. Right: Early instar of *Cryptophlebia* spp. Below: Mediterranean fruit fly. Inset photo: fruit fly eggs deposited in lychee fruit flesh.

positor, the pointy tip on her abdomen. This allows for deterioration of the fruit flesh and the introduction of bacteria and fungi into the wound. Fruit fly-stung fruits tend to ooze, bubble, and froth at the puncture site. According to Jones et al. (n.d.), lychee is a poor host for fruit fly, and very few to low numbers of adults are recovered from efforts to rear out larvae in lychee. Nonetheless, fruit flies do cause damage to lychee fruit.

Among birds, the Japanese white-eye (*Zosterops japonicas*) or mejiro and the northern cardinal (*Cardinalis cardinalis*) tend to damage fruit at the start of color break through full maturity. Bulbuls are chronic pests of lychee and many other fruits and ornamentals on O'ahu, the only island known to have established populations. Once wounded, these fruit rot and fall to the ground, resulting in a loss of yield. Damaged fruit also become a food source that attracts more birds to visit and damage additional fruit.

### Why Bag Lychee?

The erratic-bearing nature of the lychee tree is a major obstacle to lychee production, as one year of heavy production can be followed by a year of low or no production (Yokoyama et al. 1991). During low-production years, pest damage can reduce production tremendously.

Bird netting laid over the entire tree, flashy ribbons, hanging CDs, and scarecrows may help to deter birds. Once birds get used to the scare tactic or discover a way



into or under the net, however, fruit damage will resume. And while netting may keep out most birds, it allows moths and fruit flies to continue damaging the lychee. Conversely, trapping and baiting kill only fruit flies and moths. Bagging does not guarantee that all fruit are protected from pests; however, bagging is very effective at deterring all three of these major lychee pests.

### Benefits of Bagging Lychee

- Deterrence of birds, *Cryptophlebia* moths, and fruit flies
- Reduction or elimination of pesticide use
- Improvement of overall fruit color
- Reduced culling time of damaged fruit
- Reduced amount of damaged fruit and seconds
- Increased yield (fruit retention and pack-out)
- Uniform ripening
- No need to individually harvest ripe fruit
- Consumers prefer appearance of bagged over un-bagged fruit
- Potential for higher selling price
- Potential for higher net return

### *Negatives of Bagging Lychee*

- Cost of bags
- Time and cost of bag preparation and supplies
- Labor to bag fruit panicles
- Creates rubbish
- Potentially hazardous if using a ladder for bagging

### **How to Bag Lychee Fruit**

Many household products such as brown or white paper bags, wax paper, newspaper, etc. can be used to cover fruits. Attaching and securing the coverings around the fruit can be as simple as stapling one end of the bag, stapling the paper into a cone shape, or twist-tying the bag to the stem. Different-colored coverings have different effects on the ripening of fruit. For example, brown paper bags have been recognized as a tool for delaying fruit maturation, thereby extending the harvest season of some fruits (Debnath and Mitra 2006).

### *Supplies for bagging lychee fruit*

- Waxy paper or fruit bags – one per panicle or fruit cluster
- Ladder
- Desktop stapler
- Standard staples
- Scissors or paper cutter to modify bags

This publication looks at the effects of bagging lychee with waxy paper bags purchased from Shibataya Kakohshi Co., Ltd. in Niigata, Japan. Fruit bags are com-

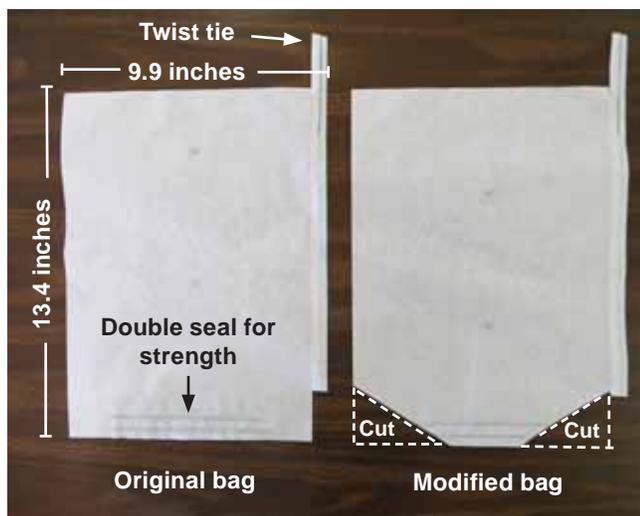
monly used in Japan and Okinawa to cover fig, loquat, apple, pear, peach, and mango. The bags chosen to cover 'Kaimana' lychee were SGS-10 (252mm by 340mm) white bags with a single wire, light waxy coating, and 73% light transmission. These were the largest fruit bags obtainable.

Modifications (photo below) to the bag allowed for aborted fruit to exit from all four corners of the bag to keep fruit from decaying within the bag and attracting disease and/or insect pests. Stapling was used instead of the twist-tie so larger panicles could be bagged. The bags used in this study endured wind, rain, and sun. In addition, the staples lasted through to harvest and did not rust off.

Bagging can be done selectively, randomly, or for every panicle on the tree. More than likely, growers will want to bag panicles with the greatest number of fruits to provide the greatest return on investment. Most panicles start off with hundreds of little fruit, many of which naturally abort for 6–7 weeks after full bloom (Yuan and Huang). To avoid collecting abscised and decaying fruit at the bottom of the bags or bagging panicles of highly aborted fruit, lychee panicles were bagged 6 weeks after full bloom at all farm locations. The average fruit size was approximately 2 cm x 1.3 cm at the time of bagging.

### *Step 1*

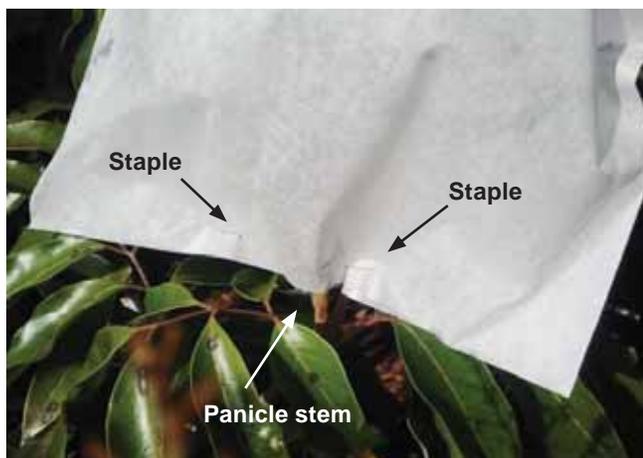
Gather the branches of the panicle with one hand and slide the entire panicle into the bag. Lychee panicles and fruit are relatively hardy and steadfast. Unless ag-



gressively bagged, fruit should not fall off with handling and bagging. If fruit do fall off, it is likely that they would have fallen prematurely or would not have matured properly, but you also may need to be a little gentler when bagging.

### Step 2

Staple the bag closely on both sides of the stem below the panicle. Check that the staples are secure. If not, staple again. Allow for enough space between the staple and bag corner for aborted fruit and panicle rubbish to exit.



### Harvesting the Fruits of Your Labor: Is Bagging Worth the Cost, Time, and Effort?

Tables 1 and 2 show that the resulting quality, yield, and dollar returns far outweigh the costs, time, and effort of bagging. The biggest differences were seen in fruit retention, yield of marketable fruit, and culling time. Culling is necessary to remove and discard fruit that are immature or infested with insect and bird damage, fungal disease, and blemishes that could reduce the shelf life of lychee fruit.

Conventional harvesting of lychee requires a picker to scour trees for the ripest individual fruits or clusters



Examples of culled fruit.

Table 1. Yields of 270 each bagged and unbagged lychee panicles from 10 trees at 4 test sites

	BAGGED				UNBAGGED				
	Fruit weight (lbs.)			Average no. of fruit/lb.	Fruit weight (lbs.)			Average no. of fruit/lb.	
	Total	Marketable	Unmarketable		Total	Marketable	Unmarketable		
Site A (970 ft*)	38.0	32.5	5.3	20.9	Site A	11.8	7.0	4.8	22.6
Site B (1,084 ft)	56.0	47.5	8.5	18.8	Site B	21.1	10.0	10.9	19.1
Site C (900 ft)	11.5	10.0	1.8	19.0	Site C	7.3	3.6	3.7	18.5
Site D (550 ft)	18.5	14.3	4.2	18.1	Site D	12.6	9.7	2.9	18.3
Average	31.0	26.1	5.0	19.2	Average	13.2	7.6	5.6	19.6

\*Elevation above sea level

to harvest, especially at the beginning of the season. This is a very time-consuming process. One of the benefits of bagging was the ability to harvest entire panicles with one snip. There was no need for individual fruit harvesting. A majority of fruit in the bags was completely ripe and at full maturity, whereas unbagged fruit had noticeably less uniform ripening.

Labor costs were based on wages of \$10/hr and assumed that a typical farmer would already have basic tools such as stapler, scissors, ladder, harvesting buckets or baskets, and shears for panicle and fruit removal. The estimated cost for bagging was \$141 per tree, which included the bags, staples, and labor for bagging, harvesting, and culling, compared to \$23 per tree for harvesting and culling labor of unbagged fruits.

The recommended planting distance for lychee is 24' x 24' or 8m x 8m (Zee et al. 1999). At this rate, 49 trees can be planted in one acre. With optimum management, a mature lychee tree can yield over 100 pounds of (unbagged) marketable fruit, according to Matsumoto et al. (2007).

Table 1 presents the harvest data from this study. These are based on approximately 270 each of bagged and unbagged panicles that were harvested from a total of 10 trees on 4 farms. Three farms were located in West Hawai'i and one in East Hawai'i. Entire panicles of both bagged and unbagged fruits were harvested on the same day, between 15 and 18 weeks after full bloom. 'Kaimana' lychee should be harvested after the skin turns

red. Harvesting and culling of unbagged fruit would be more time consuming if harvests are done normally, by picking individual fruit or clusters.

Bagged panicles had 55.6% fruit retention compared to 28.3% on unbagged panicles. Of the surviving fruit, 84% from bagged panicles were marketable and 57% from unbagged. Any damaged or misshapen fruit and fruit with a brown mark resembling a sting were culled. Overall, approximately 3.4 times more marketable lychee were harvested when fruit were protected. On average, bagged fruit were also slightly larger in size, resulting in fewer fruit required per pound.

Table 2 provides an estimate of net returns according to recovery rates determined by this project and based on a bagging speed of 90 bags per hour or 40 seconds per bag and starting with 150 pounds of unbagged and uncultured lychee per tree. Culling damaged and unmarketable fruit from unbagged panicles took less than a third of the time because there were fewer fruit per panicle. However, to obtain the same amount of marketable fruit, it took nearly twice as long to cull damaged fruit from unbagged versus bagged panicles.

With proper field management and a purchase price of \$2.50/lb, there is potential to earn \$173 per tree or \$8,484 per acre with bagging compared to \$69 per tree and \$3,372 per acre for unbagged lychee. At \$6.00/lb, growers can achieve upwards of \$613 per tree or \$30,026 an acre. By bagging their lychee fruit, growers can gain an estimated 2.5 to over 3 times more in returns at the stated



Unbagged (left) panicle and bagged (right) panicle of similar age just before harvesting.



These buckets contain harvests from thirty unbagged (left) panicles and thirty bagged (right) panicles. A much greater amount of fruit was harvested from bagged panicles.

farm gate prices. At farm gate prices at or above \$1.34 per pound, bagging lychee becomes worthwhile compared to harvesting entire panicles of unbagged lychee.

A refractometer was used to measure brix, or the percent of soluble solids or sugars within the fruit flesh. No significant difference was found between brix readings of bagged and unbagged fruit.

Surveys showed that consumers preferred bagged fruit over unbagged fruit because of size, color uniformity, and other visual appeal. Although 86% of those surveyed preferred bagged fruit visually, approximately equal percentages of participants preferred the taste of bagged (44%) and unbagged (40%) fruit, while 16% responded that there was no obvious taste difference. Some consumers preferred “slightly tart lychee fruit” or “fruit with a good balance of sweetness and tartness.”

Survey participants were also provided with the average wholesale price of lychee from 2006 to 2008 (NASS 2009) of \$2.84 per pound and were asked to select the highest price per pound that they would pay for bagged and for unbagged lychee following the visual and taste section of the survey. On average, participants stated that they would pay \$3.47 per pound for bagged fruit and slightly less (\$3.39 per pound) for unbagged fruit. According to previous research conducted by Ken Love (2008), bagged lychee fetched \$3.50/lb. and unbagged fruit received \$2.75/lb.



Various creatures living in or on or visiting bagged lychee fruit.

**Table 2. Comparative returns from bagged and unbagged lychee**

NET PROFIT OF BAGGED LYCHEE*								
Price per Pound	\$2.50	\$3.00	\$3.50	\$4.00	\$4.50	\$5.00	\$5.50	\$6.00
Profit per Tree	\$173.15	\$235.95	\$298.76	\$361.56	\$424.37	\$487.17	\$549.98	\$612.78
Profit per Acre	\$8,484	\$11,562	\$14,639	\$17,717	\$20,794	\$23,871	\$26,949	\$30,026

NET PROFIT OF UNBAGGED LYCHEE*								
Price per Pound	\$2.50	\$3.00	\$3.50	\$4.00	\$4.50	\$5.00	\$5.50	\$6.00
Profit per Tree	\$69.84	\$88.44	\$107.03	\$125.63	\$144.23	\$162.83	\$181.43	\$200.02
Profit per Acre	\$3,422	\$4,333	\$5,245	\$6,156	\$7,067	\$7,979	\$8,890	\$9,801

\*Net profit reflects gross income minus the cost of supplies and labor.

## Considerations for Bagging

Although major pests like birds, *Cryptophlebia* moths, and fruit flies were discouraged from damaging bagged fruit, other minor insects, invertebrates, and vertebrates found the bags inviting, including geckos, frogs, ants, slugs, cockroaches, earwigs, and various scale insects.

Bagged panicles on lower branches had a tendency to droop particularly low to the ground under the weight of the maturing fruit, with some bags resting on the soil or grass. These bags attracted a greater variety of uninvited guests, and some were torn by passing lawn mowers.

Slugs and amphibians may carry diseases such as *Salmonella*, *Leptospirosis*, and Rat Lungworm. Wash all produce thoroughly prior to consumption. Avoid bagging panicles near the ground, or prune low branches to prevent heavy, fruit-laden panicles from contacting the soil.

As a result of the heavier fruit load and retention caused by bagging, fertilizer requirements may vary from normal applications. On a well-maintained tree, if bagging increases fruit production and retention by 51%, then at least 51% more fertilizer would need to be applied to the field to replenish what is removed at harvest.

An acre of lychee trees with an average of 150 pounds of bagged fruit per tree would remove 12.5 lbs. N, 3.7 lbs. P<sub>2</sub>O<sub>5</sub>, 19.8 lbs. K<sub>2</sub>O, 2.2 lbs. Ca, and 2.9 lbs. Mg during a growing season. Uptake efficiency of fertilizers, soil type, rainfall, and additional nutrients needed for branch removal should be considered to sustain tree health. Consult your local extension agent or specialist about tissue and soil analyses and fertilization recommendations.

## Summary

The results of this trial demonstrate that, as with many other fruit, bagging of lychee results in higher harvestable yields and better fruit quality than for conventional, unbagged lychee, in turn leading to higher pack-out rates. The higher sales at historical market prices more than compensate growers for the additional costs of bagging, such that grower returns are 2.5 to over 3 times greater than with unbagged fruit.

While the results look very promising, it should be noted that the data are relatively limited and were obtained in a very productive lychee season. Further research could test bagging under broader, likely less favorable, conditions and would validate the current findings, including the magnitude of net benefits.

## References

- Debnath, S.; Mitra, S.K. 2008. Panicle bagging for maturity regulation, quality improvement and fruit management in litchi (*Litchi chinensis*). *Acta Hort.* 773:201–208.
- Follett, P.A.; DeLuz, S.; Lower, R.A.; Price, D.K. 2003. Suitability of lychee fruits on and off the tree for *Cryptophlebia* spp. *Proc. Hawaiian Entomol. Soc.* 36:89–94.
- Jones, V., Tome, C., and Robb, C. (n.d.). Progress towards pest management in litchi. Retrieved 4/2/2012 from [http://www.extento.hawaii.edu/kbase/reports/litchi\\_pest.htm](http://www.extento.hawaii.edu/kbase/reports/litchi_pest.htm).
- Love, K., 2008. Increasing marketable production of exotic tropical fruit with protective wrapping. [www.sare.org/content/download/1417/10549/FW02\\_008.pdf](http://www.sare.org/content/download/1417/10549/FW02_008.pdf).
- Matsumoto, T.K.; Zee, F.; Nagao, M.; Nishina, M.; Easton-Smith, V.. 2007. Management of flowering and fruiting of ‘Kaimana’ lychee in Hawaii. 17th International Tropical Fruit Conference Proceedings (CD-ROM). Hilo, HI pp. 67–78.
- National Agricultural Statistics Service. 2011. Tropical specialty fruits. Retrieved 3/8/13 from [http://www.nass.usda.gov/Statistics\\_by\\_State/Hawaii/Publications/Annual\\_Statistical\\_Bulletin/stat11-39.pdf](http://www.nass.usda.gov/Statistics_by_State/Hawaii/Publications/Annual_Statistical_Bulletin/stat11-39.pdf)
- National Agricultural Statistics Service. 2009. Statistics of Hawaii Agriculture 2009. Retrieved 4/2/12 from [http://www.nass.usda.gov/Statistics\\_by\\_State/Hawaii/Publications/Annual\\_Statistical\\_Bulletin/2009.pdf](http://www.nass.usda.gov/Statistics_by_State/Hawaii/Publications/Annual_Statistical_Bulletin/2009.pdf).
- Yokoyama, K.M.; Nakamoto, S.T.; Wanitprapha, K.; Chia, C.L. February 1991. Lychee. CTAHR Economic Fact Sheet No. 12. CTAHR, UH-Manoa. 4 pp.
- Yuan, R.; Huang, H., 1988. Litchi fruit abscission: its patterns, effect of shading and relation to endogenous abscisic acid. *Scientia Hort.* 36: 281–292.
- Zee, F., Nagao, M., Nishina, M., Kawabata, A. 1999. Growing lychee in Hawaii. UH CTAHR F&N-2, [http://www.ctahr.hawaii.edu/oc/freepubs/pdf/F\\_N-2.pdf](http://www.ctahr.hawaii.edu/oc/freepubs/pdf/F_N-2.pdf).

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