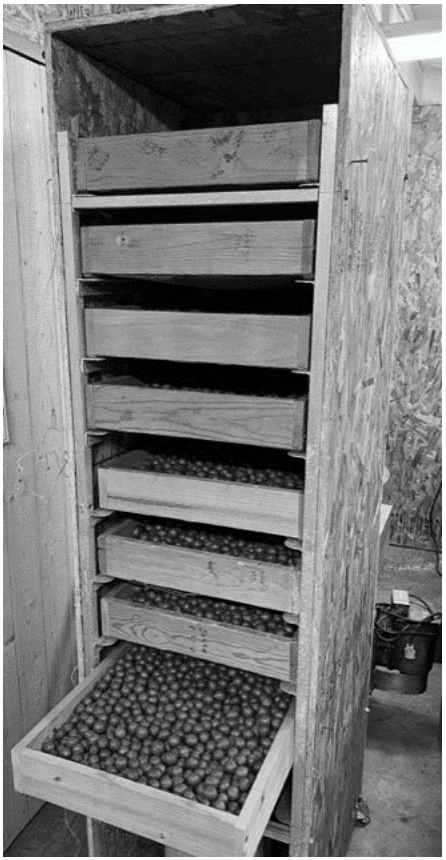
COMMENTARY ON DRYING

Jim Russell

(Reprinted from 2006 Macadamia Nut Society Handbook)

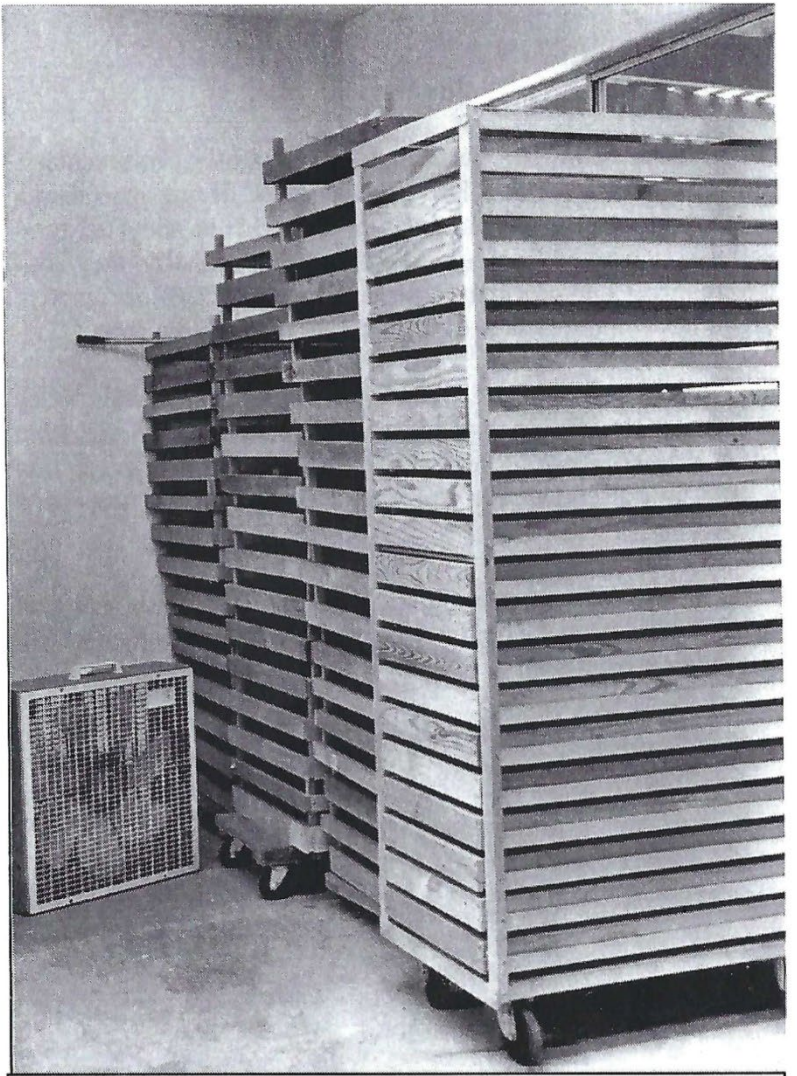
The following section contains photos, commentary, and several articles on "The importance of drying macadamia nuts", both at ambient temperature and with an elevated tem-perature generated from a heat source.

Additionally, they con-tain much of the information needed on "How To" accomplish the vitally important task of drying your macadamia crop.
We each spend a great deal of time, energy and money to bring our yearly crop to maturity. It takes just a little more of all three of those to keep that crop at the peak of perfection with a proper knowledge and it's application about harvesting and drying.

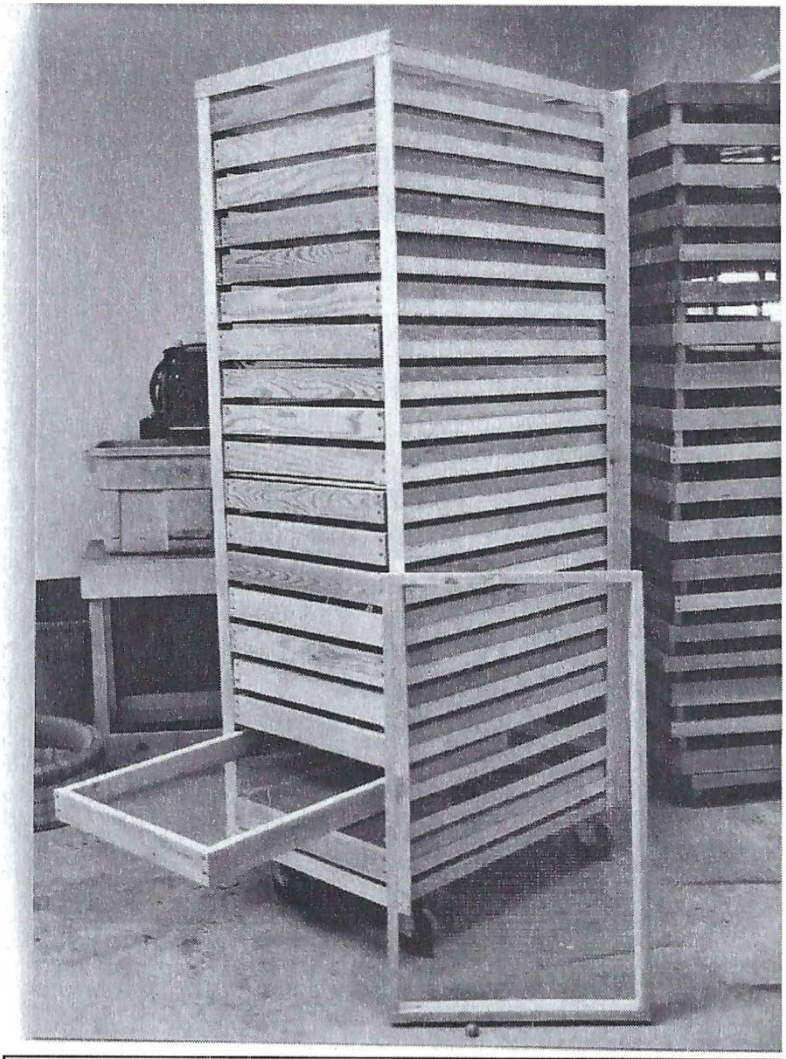


Hopefully, the following pages will supply us with that needed knowledge. The time, energy and money you will have to apply on your own.

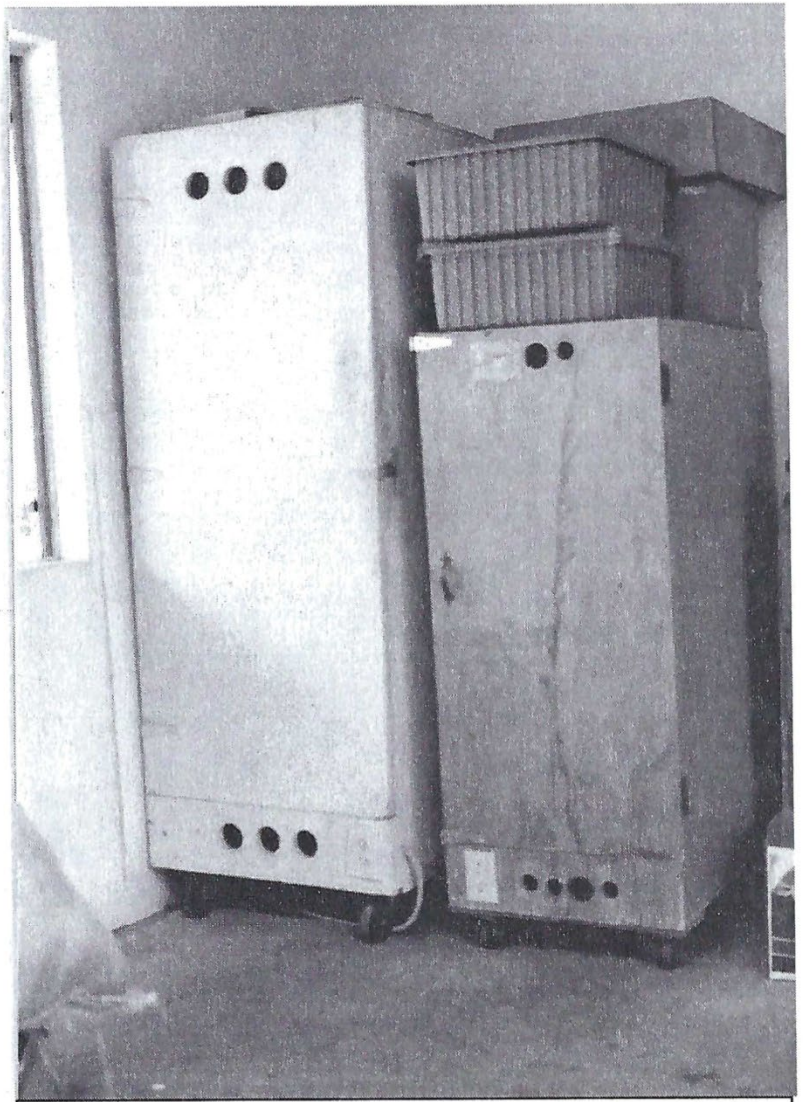
Drying racks and plastic drying trays.



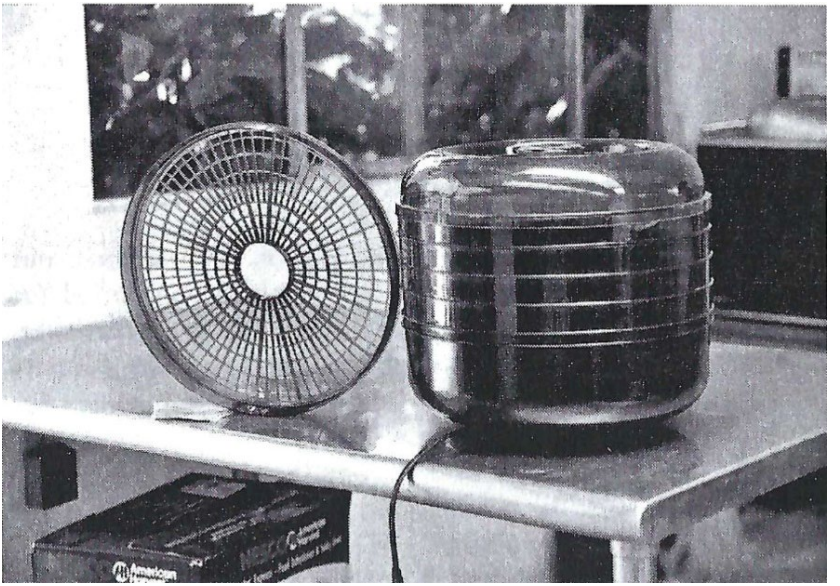
Macadamia nut drying racks at Russell Family Farms for drying nuts at ambient (room) temperature. All are on wheels so they can be moved around as needed. Notice the fan sitting on the floor. When the racks are loaded with wet nuts the fan stirs the air to keep mold from forming on the nuts. The nuts spend at least two weeks in these drying racks, taking the nuts from around 35% moisture to around 5% moisture and an enzyme action eliminates the reducing sugars.



This set of drying racks is made from the frame of a bread truck, used originally to deliver baked goods from the bakery to grocery stores. The trays are made from ash wood and 1/4 inch hardware cloth. The wheels on the bottom make it easy to move the drying racks where needed.



Two dryers at Russell Family Farms that heat the air to around 96% and circulate the worm air to facilitate drying of the nuts. The holes at the bottom take in cool dry air while warm moist air is expelled at the top of the dryers. These dryers take around four days to dry the nuts from around 5% moisture to around 1% moisture content.



Standard food dehydrator for drying macadamia nuts.

IMPORTANCE OF DRYING PROPERLY

Joe Harvey

Reprinted from the 1988 California Macadamia Society Year-book.

The next few weeks in the life of a Macadamia nut grower should be the most exciting and rewarding period for the entire year. Why? Harvest time is almost upon us. However, too many growers simply do not know what to do with the nuts after they start falling, or don't do it right. Here are some sug-gestions for your help.

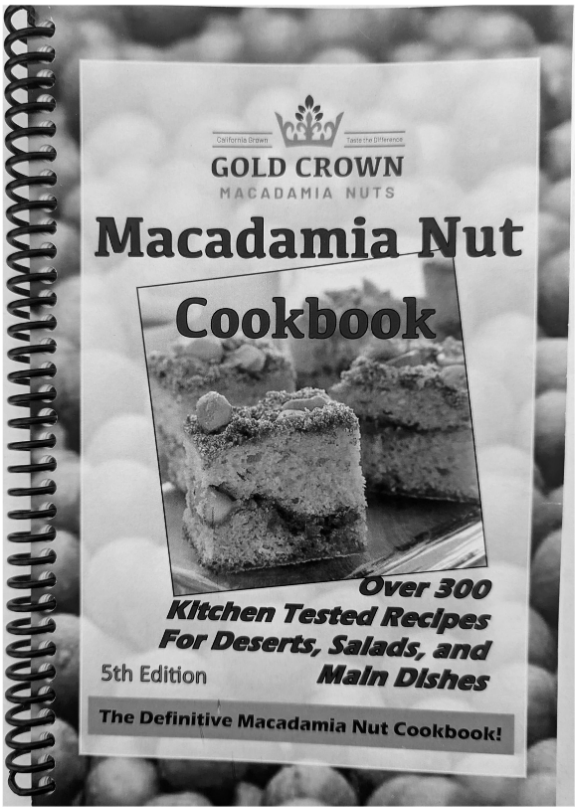
(1) Harvest the nuts as soon as they fall from the trees. 2 or 3 times per week would be perfect.
(2) Remove the husk from the nut immediately. How? If you have many nuts, how about using the Co-op' s equip-ment. The charge is 10¢ per pound if you do your own work, or 20¢ per pound if you leave the nuts for the Co-op to husk.
(3) Place the nuts on drying trays. If you don't have any, why not build them? Probably a 3" side x 24" length x 36" width might be a good size to start with. The bottom should be rabbit wire, or a heavy type wire cloth. White pine or any of the hard woods could be used. All materials are available at: a do-it-yourself store or a lumber yard.
(4) The tray full of nuts should then be put into your patio or garage. DO NOT PUT THE TRAYS IN THE DI-RECT SUNLIGHT. The trays can be stacked one on top of the other, but you would probably want a cleat under each comer. The free movement of air is what you are trying to ac-complish. Keep the nuts drying for at least 2 weeks.

(5) If you are holding the nuts for your own use place them in either corrugated cartons or burlap bags until you can give them the final drying. Do not store in poly bags or plastic buckets because they trap moisture, and often re-introduce moisture back into the nuts.

(6) Final drying. We recommend drying the nuts at 105 degrees F in your kitchen oven. Then run a test on a couple of nuts to see how

they taste, and that they are thoroughly dried. If they still seem a little soft, put them back into the oven and give them another 24 hours. Repeat the testing.

In conclusion, we find that too many people do not dry their nuts and too often place the nuts with husk still on in plas-tic bags or buckets immediately upon picking the crop. The combination of moisture trapped by the poly bag or bucket can often mildew the meats and ruin the nuts. All your hard work for the past year is a loss, simply because you didn't know how to dry your nuts. We urge you to properly dry your nut crop for your personal use, or to save you from a rejection slip from the Co-op. It is a simple procedure and will increase your pay check at the end of the year.



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REVIEW OF THE LITERATURE ON FARM DRYING AND STORAGE REQUIREMENTS1

Mrs. Bev Atkinson2

This article is reprinted from the 1991
California Macadamia Society Yearbook

DRYING AND STORAGE OF NUT-IN-SHELL

As growers face the present situation in the macadamia industry and contemplate the necessity of holding nut-in-shell on their fanns for much longer periods, review of the recom-mended conditions for drying and storing nuts, so that quality is not compromised, is timely.
Below is a summary of some of those recommenda-tions that have been published in the macadamia literature in recent years.

HARVESTING

"Storing" your nuts by leaving them on the ground until your present silo has been emptied is NOT an option!
Exposure to direct sunlight is the most likely factor in quality deterioration nuts left on the ground before harvest (Manson, Apr 1982) but germination thin-shelled varieties and growth of mold may also be a problem in shad wet conditions. It is, therefore, recommended that you harvest at least every 4 weeks where leaf cover is insufficient to shade nuts or in wet weather at least every 6 weeks in older, well-shaded orchards. Do not leave nuts on the ground longer than 6 weeks under any circumstances. Nuts should be dehydrated as soon as possible after harvesting but certainly within 24 hours. Nuts when harvested may have a moisture content of 10-25%, but a moisture content of 10% is needed for transport to the factory without kernel damage, and storage of "wet" nut-in-shell without drying will lead to rapid deterioration. Under no circumstances should nuts at greater than 12 % moisture content be stored in any container through which air cam1ot circulate.

1- From Australian Macadamia Society limited News Bulletin, Volume 17, Number 2, July 1990.
2- Using the Australian Macadamia Society computer bibliog-raphy.

DRYING RACKS

De-husked nuts can be stored in drying racks. Such racks may be 10-25 cm deep, with pine or hardwood frames and a wire mesh base. They should be stored in a covered well ventilated position NOT in sunlight. On-farm drying must have good air circulation, racks may be stacked but with a spacer between each one to ensure air movement. Rake over racks at least weekly to assist moisture removal and reduce drying times. Drying in racks is slow and limited in capacity and it may take up to 6 weeks to reach 10% moisture content.

A do-it-yourself drying room holding approximately 6 tons of nut-in-shell, with drying racks, a propane furnace and thermostat and fan is described by Tom Cooper (Cooper, 1982).

DRYING SILOS

Nuts may also be dried in containers. Suitable contain-ers include bulk bins (foil lined), silos, steel drums and water tanks. They may also be fabricated to your design. Containers should be sealed so that air flow (from the bottom upwards) into and out of the container is restricted to inlet and outlet ports and provision should be made for heater (if used) and fan, to provide air movement, at the base. Design should ensure even air distribution, correct air quantity and efficiency. Short cuts in silo design and construction will only result in lower quality and, therefore, lower returns, (Smith, undated). For dia-grams of silo design and specifications see Smith, undated; McConachie 1984. For large scale silo construction, it would be wise to consult ventilation, structural and combustion engi-neers. Two smaller silos may be preferable to one big one for continuous operation (Wilkie, 1988).

Air in silos must circulate evenly or pockets of un aer-ated nuts will heat and may even go up in flames! (Wilkie, 1988)Check air flow with a tissue or feather. Ensure that nuts are dried to 10% moisture content before fans are turned off or high day temperature with low night temperature will cause condensation inside the silo. Use fan continuously until 14% and then perhaps only 50-100% of the time until 10% moisture content is reached. Although high atmospheric humidity may not result in moisture content reduction, air flow will ensure there is no deterioration.

While high relative humidity at the time of drying will mean longer drying times, heating to increase the drying rate is not recommended (McConachie, 1984). Incorrect heating procedures can permanently damage kernel quality so if heat is used it should only be to increase the air temperature by ap-proximately 5 degrees C and it must be strictly controlled. Moisture content of nut-in-shell is sufficiently high at 10% for damage to kernel from high temperature d1ying (Buckle, 1988) so a thermostat and a thermometer to control and monitor tem-perature are essential if heating is to be used. Do not use heat to lower moisture content to below 10 % and never use heat on field moisture content nut-in-shell. Dry with ambient air only first.
A report of a controlled humidity dryer (for processors use), giving a reduction of drying time from 240 hours to as little as 31 hours with no loss of quality it makes interesting reading (Van Blarcom, 1988). While further studies are needed to determine drying times for commercial quantities, determina-tion capital and operating costs of present and this system, a system such as this could significantly reduce processing times at the factory.

STORAGE

10 % moisture content can be tested by rattling (25 % rattlers = 10 %), by cracking and tasting or by moisture meter. Once that 10% level has been reached, nuts can be stored in silos for up to 3 months (McConachie, 1984) so long as temperature fluctuations are not sufficient to cause condensation inside the silo - if stored for long periods, turn on fans periodi-cally (say one day per week) to maintain the low moisture con-tent. Nuts stored for any period of time at ambient temperature should not be dried to less than 4 % moisture content. Other storage recommendations include hessian bags (2-4 weeks) in covered well-ventilated position (Mason, Apr 1982), and, for storage longer that one month, reduction of the moisture con-tent to 1-1.5 % and the use of sealed, tight container, (Mason Apr 1982) (in ambient air, up to six months; in an inert atmos-phere at 1-4 degrees C., up to twelve months) (Mason, Mar 1982).

AIR DRYING MACADAMIA NUTS

Jim and Barbara Russel

This article is reprinted from the 1991
California Macadamia Society Yearbook

You can you tell when a macadamia nut is ripe? That's easy; when a macadamia nut is ripe it falls from the tree, and that is the only thing that is easy about growing, harvesting, and processing the king of the nut world. In the spring, a macadamia tree sets a multitude of ra-cemes, 6 to 15 inches in length that are then covered with blos-soms. After pollination, those racemes turn into strings of up to 50 macadamia nuts. With the exception of one variety, the Beaumont, most of the nuts fall to the ground when they are ripe, and then the fun begins for the macadamia fa1mer.

The first joy is in retrieving those delectable nuggets from the ground and transporting them to the Nut House. For that task, all kinds of equipment has been devised, from a rake and dustpan to large tractor-like equipment that costs in excess of $30,000. For our farm, we use a small hand-held device that was originally developed for the task of picking up golf balls on a driving range. That device, the Little Davie, is manufactured and sold for less than $10, by the Davebilt Company located in Lakeport, Calif. From the Little Davie, we place the nuts into five gallon buckets and then into a trailer pulled by our garden tractor for transportation to our Nut House.

Each macadamia nut is covered with a tough, leathery husk that must be removed, within a week, after the nut falls to the ground. On the tetraphylla variety, called self-husking, the husk splits open and can be easily removed by hand. Other varieties require a machine to accomplish the task.

Fortunately, most of our trees are Cates, of the tetraphylla vari-ety, so we are able to remove the husks without the aid of ex-pensive equipment. The nuts at that point contain close to 35 percent mois-ture content and must be dried, at ambient temperature, out of the sun, for at least 2 weeks. During that time the moisture con-tent will be reduced to around 5 percent. Additionally, almost as important, that two-week period will also facilitate

an en-zyme that will completely eliminate the reducing sugars in each nut. If this action is not allowed to occur, the reducing sugars will turn brown, inside and out when the nuts are roasted. This two week air drying process is extremely important for the quality of your nut crop. A slip up here can render all of your other efforts to produce your crop worthless. If those nuts are placed in storage at the end pf those two weeks, without further drying, this perishable commodity will last from 4 months to 1 year, depending on the variety and the storage facility.

But, how does one go about drying for two weeks, at ambient temperature, and out of the sun, a large quantity of macadamia nuts? We have answered that question, on our farm, by con-structing stackable trays that are just over 2 feet square. As we remove the husks the nuts are placed in a tray. When that tray is full it is placed on top of the stack of trays. Each tray is identi-cal in size so they can be stacked and restacked in any se-quence. In addition to the nuts, each tray receives a piece of paper containing the date it was filled, so we will know when the 2 week period has passed. Of course, when those two weeks are up, the trays containing the oldest nuts are located on the bottom of the stack. However, due to their small size, each tray's weight is minimal and therefore they are easy to move around.

To construct a tray we use our radial arm saw and cut a piece of¾" -inch Alder board into 23 ¾" -inch lengths. When we have cut enough of them for our current project, we reset the saw to rip, (cut lengthwise with the grain), two inch widths. Then we rip the 23 ¾ -inch lengths into 2 inch widths. It takes four of those 23 ¾ by 2-inch pieces to make one tray. When we have ripped enough 2-inch pieces, we reset the saw for a¾ inch rip cut and rip enough pieces for upright spacers. With the saw still set for rip we put on a Dado blade and rip a groove ½ inch by¼ inch along one side of each of our 23 ¾ by 2 inch pieces. This will provide a recess to receive the hardware cloth when each tray is assembled. That will protect our hands from some rather nasty cuts as we handle those trays.

Finally, we reset the saw for crosscut and cut the ¾-inch pieces to 4 inch lengths. Each tray needs four of the 4-inch upright spacers. Next, we use tin snips, and a good pair of leather gloves for protection, to cut a 2-foot length from a 2- foot wide roll of hardware cloth.

To assemble the tray, first we drill holes for two wall-board screws near one end of each of the long pieces. Drilling prevents the wood from splitting. Then using wood glue and two of the long wallboard screws in each piece, the four long pieces of wood are joined into a square frame. Before they are glued and screwed we make sure that the ½ inch by ¼inch groove is on the bottom and facing in, on each piece of wood. Next, the hardware cloth is placed in that groove and attached with the staples. Finally, one of the upright spacers is glued and nailed, using two of the short finishing nails, into each comer of the tray.

When finished, each tray takes up four inches in height, and to allow for air circulation under the bottom of the stack of trays, we place the first tray on two, 2-foot lengths of 4x4. Thus, in a room with 8-foot ceilings, 20 such trays can be stacked, one on top of the other, taking up just 2 square feet of floor space.

Since our trees will be dropping their nuts over a 6- month period we estimate that 40 such trays will be sufficient to handle the needs of our trees.

If you just have a few trees and don't want to go to the trouble to construct drying trays, you can use those plastic nurs-ery trays that have the openings in the bottom. They will allow the air to circulate around your nuts and facilitate the drying process. They are a bit cumbersome if you have a large quantity of nuts, but for one or a few trees they will work fine.

At this point in the processing of macadamia nuts, the nuts are ready to go into dehumidifiers that will further reduce the moisture content to 1.5 percent. Then those delicious mor-sels will be ready to be cracked, sorted, packaged, and finally, marketed to the consuming public.

POSTHARVEST HANDLING OF MACADAMIA NUTS

CATHERINE G. CA VALETT

This article is reprinted from the 1990
California Macadamia Society Yearbook

Many factors prior to harvesting affect the quality of macadamia nuts. Among these are the selection of cultivars environmental conditions, plant nutrition, diseases, and pests. Let us assume, however, that all of these things have gone well and that the perfect nut has been produced. This is not the time to relax because there are still many ways left to ruin this "perfect" nut. Proper harvesting and handling practices are criti-cal in maintaining quality.

HARVESTING

How often should nuts be harvested? Since there is no simple answer, it may be best to consider what happens when certain practices are followed. Weather conditions and orchard conditions vary widely and so do harvesting and handling prac-tices.

In the past two years, we have looked at practices that might be responsible for reduced shelf life in macadamia nuts. Dr. Harry Yamamoto is the co-principal investigator on this research and we have been assisted by Mr. Tsuyoshi Tsumara, Ms. Sumonrut Kanchanatawan and Ms. Natalie Nagai on a grant funded by the U.S. Department of Agriculture. Our first study looked at nuts left in the field for periods of 0, 1, 3, and 6 months. We found that spoilage, mainly mold, increased to about 20% with increased harvest interval and color changes occurred in the kernel. Fresh kernels were nearly white and kernels from nuts left on the ground for six months were discolored to the extent that they appeared to be roasted. Only slight decrease in shelf life (development of ran-cid flavor) could be attributed to a long harvest interval. The relatively dry field conditions in this test did not represent con-ditions common in a large part of the producing areas. For this reason we chose to create the conditions of in-field and/or bulk storage on in-husk nuts in bags or bins.

In-husk nuts were stored in barrels under the following conditions:
1. Air Flush - Ambient air was constantly circulated through the nuts.
2. Cycled - Wet (saturated) and ambient air were alternately cycled through the nuts. This procedure was similar to wet and dry periods in the field.
3. Continuous - Wet air (saturated) was continuously circulated through the nut.
4. Closed System-the system was sealed; no air circulation. This condition was similar to large bins or stacks of bags where no air reaches the inner portions of the mass.

Nuts were sampled after 1 and 3 months of storage, processed and their quality evaluated. The following observa-tions were made:

1. One month in-husk storage:
Nuts stored in a continuous air flow dried to about 11 % kernel moisture and were not moldy. Those stored under the other conditions had mostly moldy husks. Then nuts were husked, dried, cracked, and roasted before taste tests were conducted. Because those nuts stored in the closed system had a foul odor, they were not included in the taste test.

2. Three month in-husk storage:
The same general observations regarding mold devel-opment were made but drying continued in the continuous air flow system with kernel moisture reaching 3%. In the continu-ous wet air system, a large number of nuts germinated. None germinated in any of the other treatments. Thus, only the con-tinuous air and the cycled wet air treatments were used for the taste panel. Results of these tests are not yet complete.

Several conclusions can be made from this study to date:

A. In-husk nuts d1y slowly, but continuously, if air flow through them is sufficient.
B. Wet conditions are undesirable for in-husk nuts; mold develops quickly and off-flavors result.
C. Low oxygen levels, as might be present in bins, appears to be especially bad resulting in foul odors.

This study is continuing to determine the effect of the storage conditions on shelf life.
Current recommendation is to harvest as often as possi-ble, particularly in wet weather. Once nuts have been harvested, do not store wet nuts in bags or bins, but husk immediately and begin the drying process.

HANDLING WET NUTS
Nuts coming from the field can vary a great deal in moisture content depending on the harvest interval and environ-mental conditions. In wet areas, nuts commonly are harvested at about 25% kernel moisture while those in dry areas have of-ten dried to 10 to 15% kernel moisture before harvest. At times, a defect known as bruised browning is observed in nuts coming from d1y areas. This defect does not show up until after roasting, but is then seen as dark brown spots, rings, or in some cases, an almost completely dark kernel. It is thought that these bruised areas result from impacts that the nut receives during handling when wet. A certain amount of impact is inevitable in the normal course of handling nuts from the field to the proc-essing plant.

A study was conducted to determine the effect of im-pact on in-shell nuts of varying moisture content ranging from 27% to 1.5% kernel moisture. Impact was kept uniform by dropping individual nuts onto a steel plate from a height of 6 m (19 ft.), after which they were dried to 1.5%, cracked, and roasted.

It is apparent that in this case, nuts in the intermediate moisture range are most sensitive to brnised browning and extra care should be taken to reduce impact to those nuts. Tests are continuing to determine if this sensitivity is variety related.

HANDLING DRY NUTS
Once nuts have been dried, certain kinds of impact damage such as brnised browning do not occur. However, in the dry state, kernels are brittle and prone to splitting and chip-ping. This damage can occur both when· the kernel is in the shell and after the nut has been cracked. Typically, in-shell nuts and kernels are moved into bins, down chutes, across conveyors and into containers. Ample opp01tunity exists for the nut to re-ceive impacts. The extent of damage is dependent on the extent of the impact. Splitting and

chipping of the kernel can reduce its value; small chips are a total loss since they cannot be recovered.

SUMMARY

Harvesting of macadamia nuts should be done as fre-quently as possible, particularly in wet environments, and husk-ing and drying should begin immediately following harvest. Kernels can be damaged by mold in wet conditions, by bruising at intermediate moisture conditions, and by chipping and splitting when they are dry.