ALTERNATIVE INSECT CONTROL METHODS FOR DRIED FRUITS AND NUTS

J. F. Thompson

Introduction

The goal of this report is to evaluate possible methods to reduce or perhaps even eliminate the use of chemical fumigants for dried fruits and nuts. High or low temperature disinfestation are two obvious alternatives. These strategies have been proposed by many researchers and are currently being used for a few food products. Subjecting a product to a modified atmosphere (low oxygen or high carbon dioxide) is another nonchemical method of disinfestation that is currently used for some packaged products. This report describes how these alternatives might be used in the current systems for handling, storing, and processing walnuts, prunes and raisins. All of the proposed changes in insect control will need to be thoroughly field tested before they can be recommended to the industry.

Controlled temperature methods:

Managing product temperature can serve two functions in insect control. Disinfestation can be obtained by subjecting the insect life forms to 40° - 50°C (104° - 122°F). Several hours of exposure may be required to kill at 40°C, while only about 10 minutes exposure are required at 50°C. Disinfestation can also be obtained by maintaing products at temperatures near freezing for one to three weeks. For example, navel orangeworm is killed with exposure to 3.5°C (6°F) for 28 days.

In long term storage fumigation is used primarily to prevent product loss. The customer is assured an insect-free product by a disinfestation of the product at the final processing step. Reducing product temperature below a threshold in the range of 10° - 16°C (50 to 60°F) will prevent insect activity and can be as effective as fumigation in stopping product loss.

1. Low temperature disinfestation:

This is most feasible when the product is already under refrigerated storage. Many nut crops are held at 40 to 45°F and disinfestation can be accomplished by dropping the temperature to near freezing for one to three weeks. In many situations, the existing refrigeration equipment is capable of cooling the product to disinfestation temperature and the only cost for disinfestation will be the energy cost for increased operation of the refrigeration equipment. Also, because the product is held at temperatures low enough to stop insect activity, it is possible to postpone disinfestation until the winter months. Outside air temperatures are low during this time and cooling costs are reduced. Preliminary estimates indicate that the additional cooling for product already held at 40°-45° may cost less than $1.00/ton, which is approximately the cost of a single methyl bromide fumigation. After disinfestation the product can be allowed to return to normal storage temperatures, in order to minimize additional refrigeration costs.

Disinfesting products in a commercial cold storage facility is very expensive. Handling the product and storing it for a month costs from $14 to $36 per ton. Prices vary according to the amount of product handled and from one commercial cold storage to another.

Product shipped overseas is usually transported in dry freight containers but occasionally refrigerated containers are used for highly perishable products, like shelled walnuts without a chemical antioxidant. Transit times are two to four weeks. Products could be disinfested during refrigerated transit, if they were cooled to 0°C (32°F) before loading and held at that temperature during shipment. For example, a 40 foot refrigerated container of walnuts, shipped from Oakland to Bremerhaven, Germany will be in transit for 24 days. It holds 17 tons of nuts and costs about $1500 more per trip compared with an unrefrigerated container. In this example, low temperature disinfestation in a container would cost about $90/ton more than shipping in a dry freight container. This is a very high price for disinfestation but since some walnuts are currently shipped in refrigerated containers, apparently there are quality advantages to using refrigeration that also justify this cost.

Rapid disinfestation of product will require that it be dropped to much lower temperatures, perhaps as low as 0°F. This will always involve freezing the product. Walnuts deteriorate rapidly after thawing and would not be suitable for this method. Dried fruit could use this method, although the system must be designed to prevent the cold fruit or packaging materials from gaining moisture through condensation.

2. High temperature disinfestation:

This requires product temperatures above about 40°C (104°F). Paper tarpaulin covered raisin storages have a unique opportunity to use solar energy as a heat source for this. Figure 1 shows that in the summer these storages regularly have 32°-35°C (90°- 95°F) product temperatures. Covering the stacks with clear plastic sheeting instead of white paper would probably allow the fruit to reach killing temperatures. Fruit temperature would need to be monitored carefully in this process and the stack would have to be set up to allow even temperature distribution. Once the disinfestation had been accomplished, the stacks could be painted white (which would preclude further high temperature disinfestations) or covered with an inexpensive white or reflective material. The clear plastic would probably only be required in the south-facing wall and perhaps the top of the stack. Another advantage

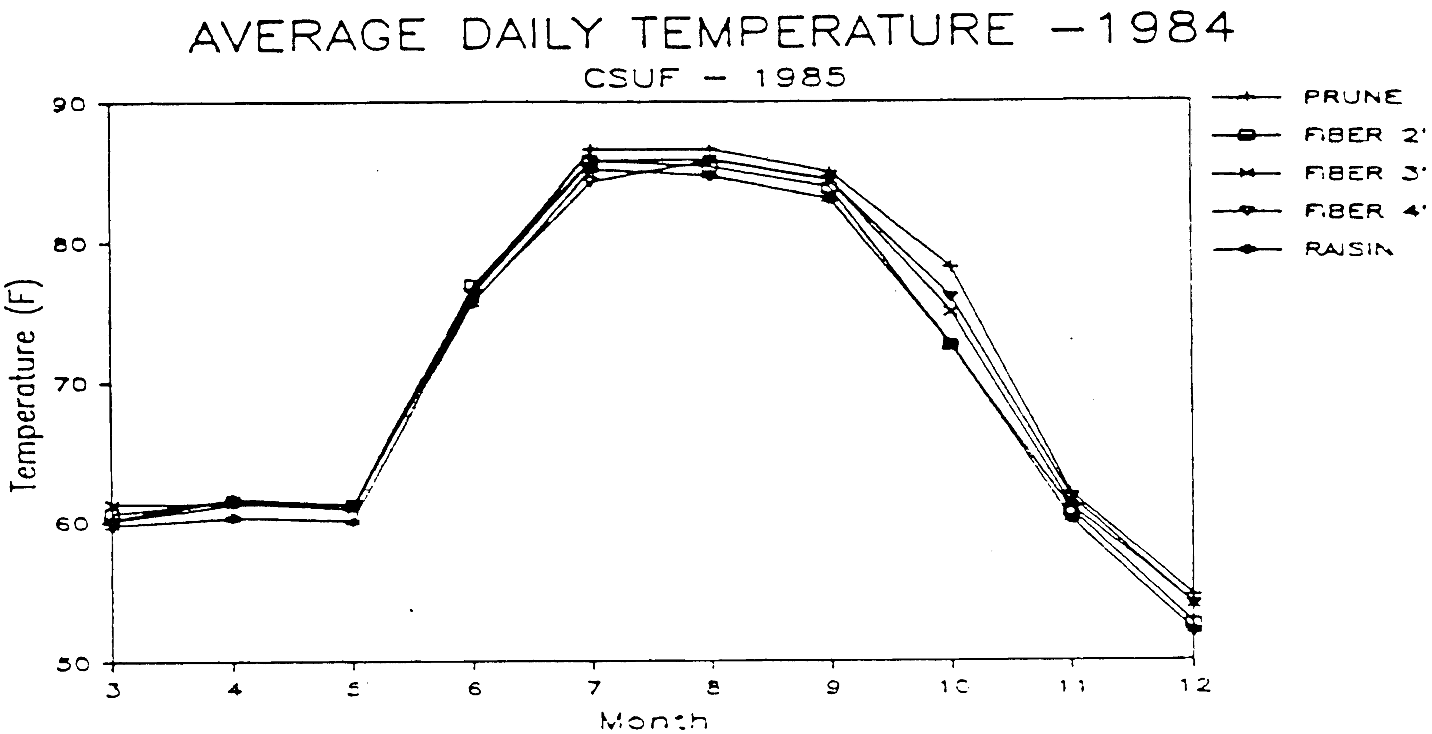

Figure 1. Average daily temperature of raisins stored in a paper-covered stack located near Fresno, CA. Raisins were stored in five types of pallet bins.

of heat treatment is that high temperatures have been shown to soften raisins and reduce the incidence of sugaring (formation of a white crystalline coating on the fruit's surface).

High temperature disinfestation can be fast enough to allow the use of a continuous flow disinfestation system. This has been designed for grains and would probably be adaptable to raisins. This system would be best suited for use in the processing line, where a relatively small capacity would be required and the equipment could be used year around. Disinfesting the incoming harvest would require a very high capacity that would be used for only a month per year and would be far more expensive to operate compared with a unit in the processing line.

High temperature disinfestation may be useful only for raisins. Previous research indicates that the temperatures needed for disinfestation will probably reduce the walnut quality and this method will likely not be useful with walnuts. Prunes could use this method, but they are already dried with air temperatures of 88°C (190°F) for 16-18 hours and much of the fruit is processed with temperatures high enough to disinfest the product.

3. Low temperature for preventing product loss:

Insects become inactive at temperatures below 10°-16°C (50°-60°F). The specific temperature depends on the insect species, life stage of the insect, and the insect's previous temperature exposure. Maintaining storage temperatures below a critical threshold will stop product loss and allow disinfestation to be postponed until a later time such as the final processing operation. Low temperatures also tend to preserve other quality characteristics of stored products.

Preliminary calculations indicate that night air ventilation may be effective in keeping insects inactive in storages. Figure 2 is a graph of the air temperature in two prune storage rooms located in the Yuba City area. Under the existing method of operating the rooms, they were never below 16°C (60°F) between the end of April and the first of January. The bottom line on the graph is an estimate of storage air temperature that night air ventilation might produce in the same two storages. It is based on a rule of thumb calculation method used in potato storages. The graph shows that temperatures could be below 50°F from November through March and below 60°F from October through May. Night air ventilation would probably require that the storage roof be insulated and a thermostatically controlled fan system installed. The ventilation would need to be controlled so that the cold night air, which may also have a high humidity, does not cause the product to gain moisture. This should be a very inexpensive system, certainly less expensive than installing mechanical refrigeration.

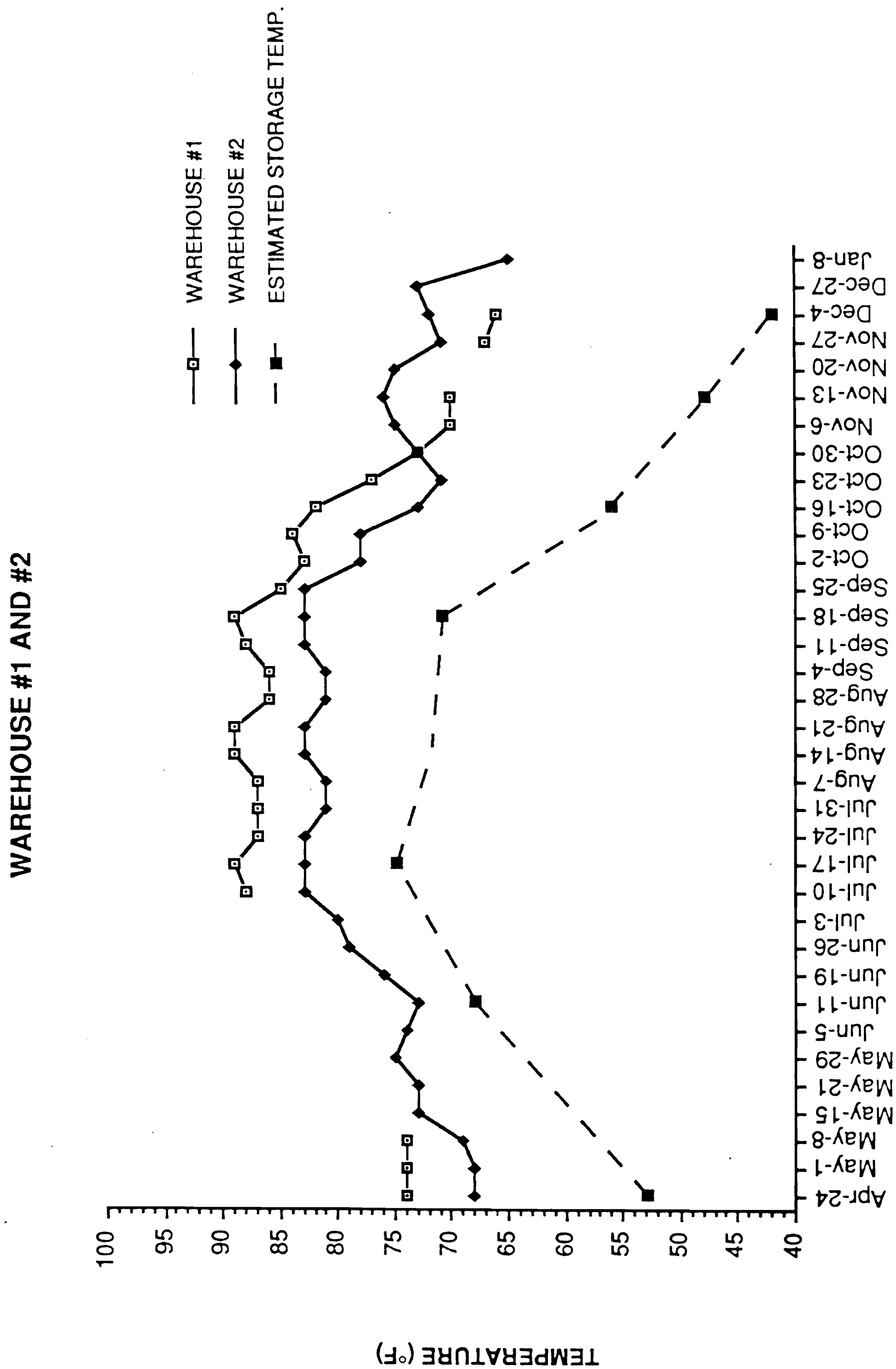

Figure 2. Average air temperature in two prune storage rooms located near Yuba City, CA and predicted air temperature in the storage rooms if they had been set up to utilize night ventilation.

Modified Atmosphere Methods:

Oxygen concentrations below 1 - 3% have been proven effective in insect disinfestation. Low oxygen packaging is in wide commercial use to protect product from oxydation and disinfestation. Increased use of gas-tight packaging would reduce the need for final product fumigation. The Australians have perfected the use of low oxygen disinfestation in grain storages. Many of our existing storages can be sealed tightly enough to allow MA fumigation although the cost of this may be fairly high. Other investigators have estimated a cost of $2 to $7 per ton for making the storage gas tight and operating the gas generating equipment.

Application to Existing Operations:

Prunes
A minimum amount of chemical fumigation is used in the current prune handling, storage and processing practices as figure 3 shows. High temperature dehydration immediately after harvest is very effective in disinfesting the fruit. There is a possibility of fruit reinfestation in temporary storage at the dehydration facility, but the level of reinfestation is usually not great. Most processors can delay the first fumigation until the end of November with little fruit loss. Some processors are even experimenting with eliminating the fall fumigation. Fruit that remains in storage during the spring is often fumigated again.

Night air ventilation of the storage may have the potential of eliminating the fall fumigation. Based on our estimates it should bring fruit to below 16°C (60°) by the first week in October and below 10°C (50°F) by the first part of November. Night air ventilation may also postpone the spring fumigation until May and reduce the amount of fruit that must receive this fumigation.

Prune juice and all pitted fruit (which includes fruit used as an ingredient) is processed at temperatures high enough to disinfest the product. Natural condition fruit is rehydrated at temperatures that may be high enough to kill insects. This process needs to be studied more carefully and if the temperature exposure is not great enough, it may be possible to slightly modify the process to increase the temperature exposure. There is the potential then to use the high temperatures in processing to provide disinfestation for all prune products.

Walnuts
Figure 4 indicates that walnuts leave the dehydration process with relatively low levels of infestation. It may be possible to eliminate the initial fumigation of shelling stock by placing the nuts immediately in refrigerated storage and stopping insect activity. Disinfestation could be achieved with low temperatures later in the storage season. Nuts kept in unrefrigerated

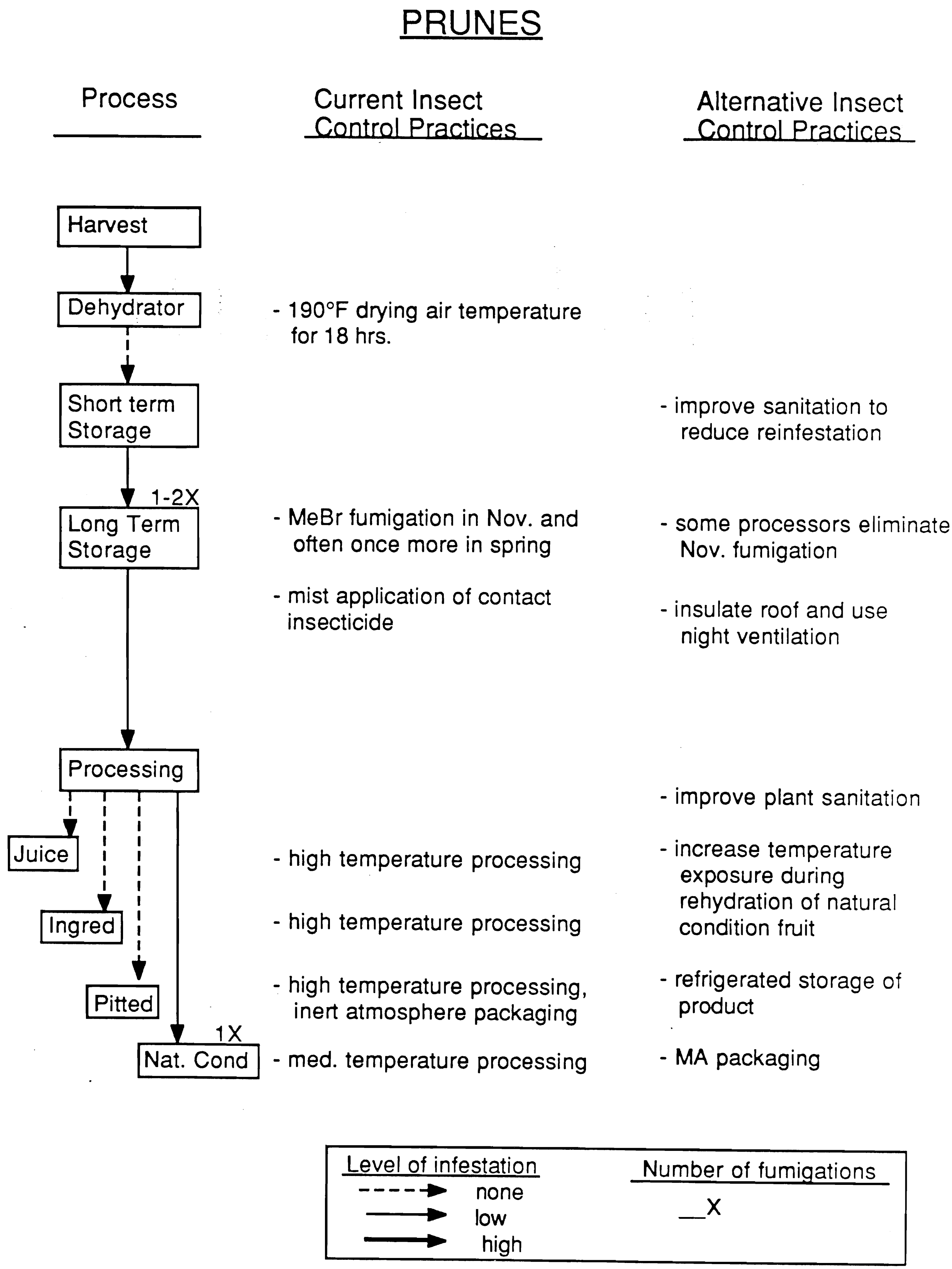

Figure 3. Current and proposed insect control practices for prunes.

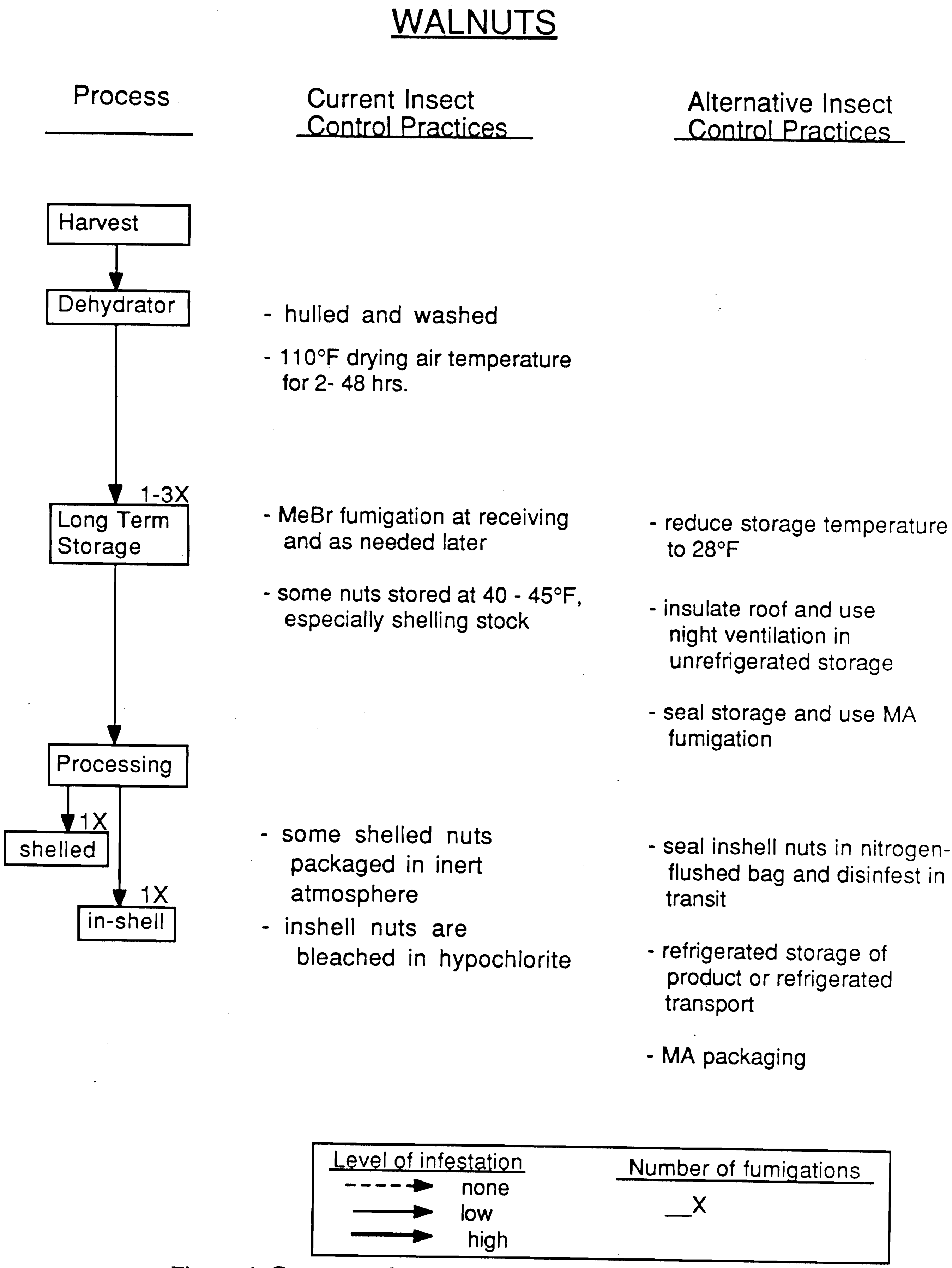

Figure 4. Current and proposed insect control practices for walnuts.

storage might be cooled using night air ventilation to stop insect activity and fumigated as needed based on insect activity.

Fumigation of shelled nuts could be reduced by increasing the use of modified atmosphere packaging. In-shell nuts (often shipped in 50 lb. bags) may be suited to modified atmosphere fumigation by covering them with a gas-tight plastic, flushing the package with nitrogen or carbon dioxide and placing an oxygen absorber in the package to remove excess oxygen. This may also help to maintain the quality of the nuts since reduced exposure to oxygen will slow rancidification.

Finished product might also be disinfested with low temperature methods. However, walnuts must not be allowed to drop below -2°C (28°F) or they will freeze and their shelf life will be reduced dramatically. Product shipped overseas is in transit long enough to allow disinfestation at temperatures near 0°C (32°F). Shipping nuts in refrigerated containers may be a very feasible disinfestation method, especially since some nuts are already shipped this way for other reasons.

Raisins

Sundried raisins are fumigated up to 20 times in storage and processing. They arrive from the field heavily infested and may be stored in the open for more than two years in paper covered stacks. As figure 5 indicates most of the fumigation is done while the fruit is in storage. During the summer it may be possible to use the solar heating technique mentioned earlier to disinfest the fruit. During the colder part of the year, night air ventilation could be used to prevent insect activity, although the lack of insulation may limit the use of this. Careful insect monitoring and judicious use of chemical fumigation will probably be needed in long term storage.

Raisins are not processed with high temperatures and the final product needs to be disinfested. A combination of methods may be useful for this. High-temperature, continuous-flow equipment, like that developed for grain might be feasible. Modified atmosphere packaging and low temperature storage, like that described for walnuts, may also be suitable for some products.

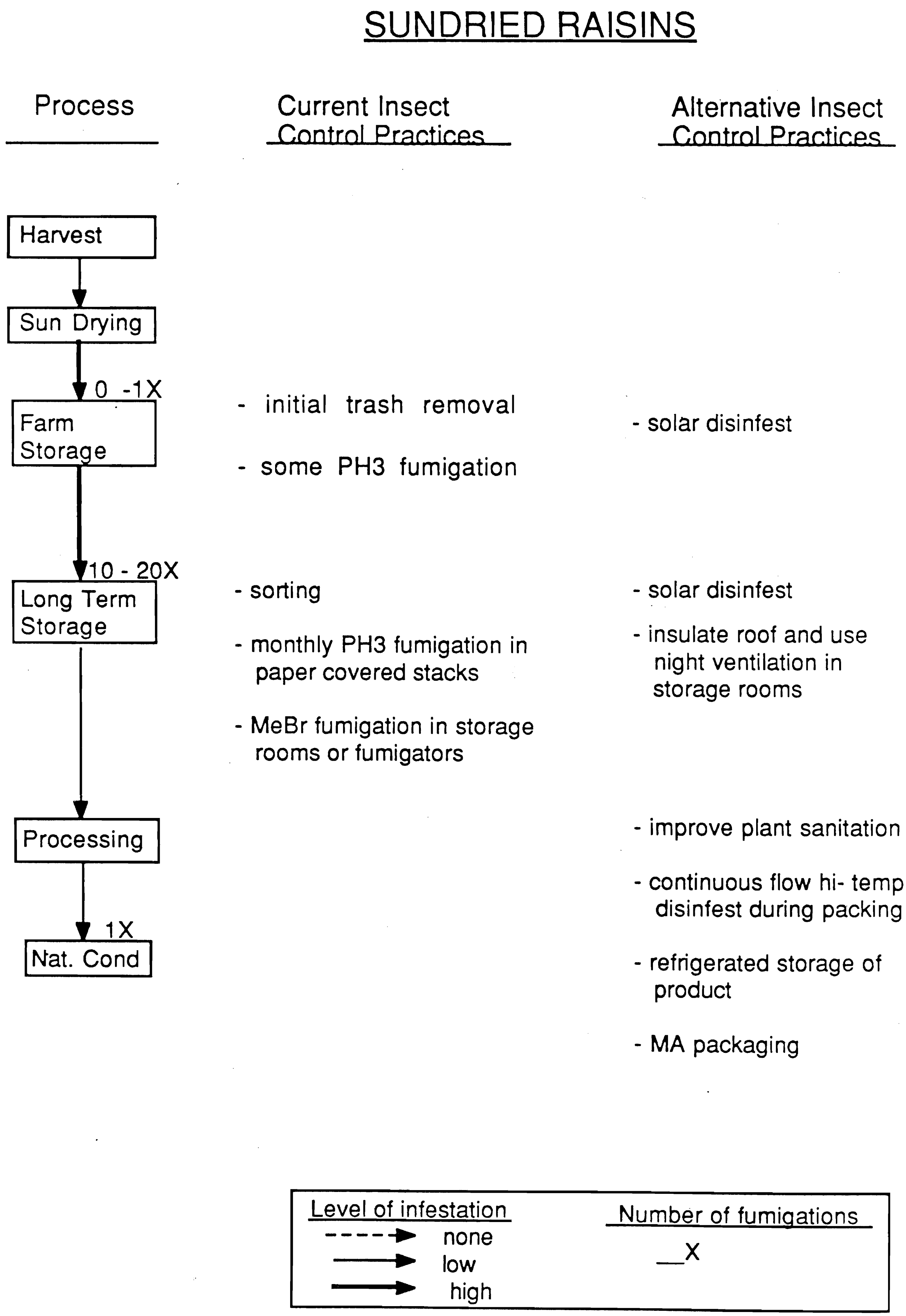

Figure 5. Current and proposed insect control practices for raisins.