capacity of the storage room and subtracting the space occupied by the grapes, allowing ½ cu ft per lug. The space occupied by 1 lb of sulfur dioxide at 32 F is 5.5 cu ft.

Other methods of applying sulfur dioxide that are sometimes used are the placing of pads of sodium bisulfiite powder in the packages of grapes, or mixing sodium bisulfite with the sawdust. About 5 grams of the chemical are used for a lug of 20 lb of grapes.

Sulfur dioxide fumigation must be done with caution to avoid injury to workers, fruit and equipment. Even a concentration of 0.25 percent can cause respiratory spasms and death from asphyxiation if the victim cannot escape from the fumes. Concentrations as low as 0.04 percent are irritating and can injure the mucous membranes. A gas mask with cannister for acid gases or goggles should be worn when working even in weak concentrations. On exposure to irritating concentrations, washing the mouth, eyes, and nose with water and applying a few drops of ephedrine sulfate in the nose gives relief. Because of the corrosive action of sulfur dioxide exposed metal surfaces in the storage rooms and brine spray chambers should be coated with acid-resistant paints.

Fumigation with sulfur dioxide is suitable for California grapes only. American grape varieties and most other fruits and vegetables are seriously injured even by weak concentrations of this gas. Care must be taken to prevent leakage of sulfur dioxide from grape rooms into rooms containing other fruits, vegetables, eggs, meat and poultry.[62]

Nitrogen Trichloride Gas

Nitrogen trichloride fumigation of citrus to control decay has been practiced extensively in California. This gas is effective against blue and green mold and stem-end rot caused by *Diplodia natalensis*.

Nitrogen trichloride cannot be stored in cylinders because it is very unstable and is explosive in concentrated form. Therefore it must be generated where used by means of special equipment. The fruit may be treated in the storage room, coloring room, or refrigerator car. Oranges are treated with 6 to 14 mg per cu ft of air for 3 to 6 hr and lemons and grapefruit with 1 to 2 mg per cu ft for 4 hr once or twice weekly. Overtreatment may cause etching, pitting, and browning of the skin and should be avoided.

Fumigation with nitrogen trichloride has also been used with cantaloupes, tomatoes, and peppers but not as extensively as with citrus. Cantaloupes are treated with 11 to 25 mg per cu ft for 3 to 5 hr to reduce spoilage. Post harvest losses of tomatoes may be reduced by fumigating for 4 hr on two consecutive days with 5 to 12 mg per cu ft. Overtreatment causes sinking of the stem scar. Treatment of peppers is similar to that of tomatoes except that only 4 mg of nitrogen trichloride per cu ft is used. Higher concentrations causes bleaching of the stem.[63]

Ethylene Oxide Gas

Ethylene oxide is used to reduce spoilage of high moisture content dried fruits such as figs, prunes and dates and to reduce the microbial content of dried spices. Dried fruit is treated by putting a mixture of liquid ethylene oxide and isopropyl formate in the center of the master carton and then sealing the package. This mixture vaporizes readily and penetrates the smaller packages.[63] A vacuum process is used in fumigating spices.[64]

ANTISEPTIC WASHES

Many fruits and vegetables are washed before packing to remove dirt and improve appearance. In some cases ice water baths are used to remove the field heat. If the water is recirculated and used repeatedly, as is often done when water is scarce or when it is refrigerated for hydrocooling, it may become heavily contaminated with decay producing bacteria and fungi. Antiseptic materials that are nontoxic to human beings in concentrations used are added to the water to destroy these germs and also to kill fungi and bacteria that are on the surface of the fruits and vegetables.

Chlorine washes containing 50 to 100 ppm of chlorine are in extensive commercial use for fruits and vegetables, but there are very few actual data to show how effective they are in reducing decay. In some cases, the chlorine is used in the form of hypochlorite solutions and in other cases as chloramines. This treatment is probably beneficial in reducing contamination of the wash water, but much more research will be required to determine its actual value and to perfect it.[64-66]

Borax. Borax washes have been used for many years to control green mold and stem-end rot of critus fruits. The fruit is dipped in a solution containing 5 to 8 percent borax held at a temperature of 100 to 110 F for 3 to 5 min and then rinsed to remove the excess borax. The treatment should be applied as soon as possible after harvest to obtain maximum benefit.[67]

Sodium ortho-phenylphenate. Sodium ortho-phenylphenate has been substituted to a large extent for borax in treating Florida citrus fruit. It is quicker acting than borax, but is more apt to cause rind injury. The likelihood of injury can be reduced to a large extent by adding hexamine to the solution. The concentration of sodium ortho-phenylphenate should not exceed 1 to 1¼ percent or be less than ¾ percent. Hexamine at the rate of one part to two parts should be added to prevent rind injury. Sodium ortho-phenylphenate also may be mixed with the wax emulsion and applied as a flood spray to the fruit.[67] Sodium ortho-phenylphenate is also used in the Pacific Northwest as an antiseptic wash for apples and pears. A concentration of 0.6 percent in a buffered solution containing enough alkali to maintain a reaction of about pH 12 is used. The fruit is sprayed with the solution and then rinsed with fresh water.[68]

Chlortetracycline. Chlortetracycline, an antibiotic, is added to the cooling water in some poultry processing plants to reduce bacterial contamination and extend the shelf life. When used at a concentration of 10 ppm the poultry remains in good condition for 14 to 21 days in commercial refrigeration. For best results it is important that high sanitary standards be maintained in the processing plants.[69]

TREATED FRUIT WRAPPERS, BOX LINERS, PAPER BAGS AND CARTONS

Treated fruit wrappers of various kinds are used for the control of apple scald and decays of several kinds of fruits.

Oil-impregnated paper wrappers are used for apple scald control. The wrappers contain about 15 percent (by weight) of tasteless odorless mineral oil. Shredded oiled paper distributed through the package at the rate of about ½ lb for each bushel of apples is nearly as effective as wrapping the fruits individually. Oiled paper does not entirely prevent scald. Some extremely susceptible varieties develop scald in spite of the oiled paper but to a lesser degree than when the paper is not used. Also susceptible varieties that are picked too immature or held in poorly ventilated common or cold storage during the critical 6 to 8 week period after harvest are benefited very little by oiled paper.[68]

Copper resinate-oil impregnated wrappers, containing about 1.5 percent basic copper and 17 percent mineral oil, are used to control both gray mold decay and scald on Anjou pears. The oil controls scald and the copper prevents the gray mold fungus growing from infected fruit to adjacent sound fruit.[69]

Diphenyl impregnated paper wrappers, box liners, paper bags and cartons are used to control the blue and green molds and stem-end rot of citrus fruits. Diphenyl volatilizes slowly and inhibits the development of decay. It does not kill the causal fungus, and the decay is apt to develop after the wrappers are removed or the fruit is taken from the treated packages. Diphenyl evaporates rapidly after fruit is unpacked and does not affect the odor or taste of citrus fruit. Since diphenyl may cause undesirable flavors in other fruits and food products, packages of citrus fruit treated with it should be stored by themselves.[67]

SULFUR DUST

Dusting peaches with sulfur during the grading process aids in reducing losses from brown rot. The dust is frequently applied before defuzzing, but results of recent experiments indicate that the treatment would be more effective if the dust were applied after defuzzing.[70]

IRRADIATION

There has been much research in recent years on preservation of food by irradiation with cathode and gamma rays. This means of preservation of both canned and fresh foods has considerable promise but it is still in the experimental stage. Preservation by this means has not been entirely acceptable because treatments that are sufficient to kill microorganisms do not stop enzymatic activity and more intense treatments often injure the product. Also, undesirable flavors and odors are caused in some foods by irradiation treatments. There is a possibility of prolonging the storage life of foods in storage by using radiation exposures that only partially sterilize the food and would not cause undesirable changes in appearance, taste and odor.[71,72,73]

MISCELLANEOUS TREATMENTS

New treatments are continually being introduced, some of which have enough merit to become adopted commercially. Ices containing varous antiseptics such as benzoic acid and chloramine have been tried for different commodities, but have not been generally adopted. A large number of antiseptic washes and fumigants in addition to those already discussed have been tested and used for a limited time, but have been discarded because of injury to the food product, toxicity to human beings, or ineffectiveness in preventing spoilage.

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