and drying (*Proceedings, 2nd International Congress Microbiology*, 1937, p. 40).

Tentative methods for the microbiological examination of frozen foods (American Public Health Association, *American Journal Public Health*, Vol. 36, 1946, p. 332).

D. K. Tressler and C. F. Evers: *Freezing Preservation of Foods* (Avi Publishing Co., Westport, Conn., 1947, 2nd ed.).

J. A. Ulrich and H. O. Halverson: *Changes in Foods During Storage in Frozen Conditions* (University of Minnesota, Hormel Institute, *Annual Report* 48, 1947, p. 48).

W. P. Van Eseltine, L. F. Nellis, F. A. Lee, and G. J. Hucker: Effect of rate of freezing on bacterial content of frozen vegetables (*Food Research*, Vol. 13, 1948, p. 271).

G. S. Wilson: *The Bacteriological Grading of Milk* (His Majesty's Stationery Office, London, 1935).

CHAPTER 38

FROZEN FRUITS AND VEGETABLES

Raw Material Problems, Basic Principles, Processing Operations, Freezing Methods, Quality Control, Storage, Dehydrofreezing, Process Operations, Drying Procedures and Equipment

COMMERCIAL freezing of fruits and vegetables is a more recent development than freezing of fish, poultry and meat. Several factors combined to delay the rapid growth of the frozen fruit and vegetable industry. Technological information regarding the preparation and storage of these products was lacking. Fruits and vegetables required certain special treatments which were not needed with meat, fish or poultry. Other problems included the lack of adequate refrigerated storage space, shipping facilities and equipment for retail sales. The technological problems involved in the freezing of fruits and vegetables will be discussed in detail.

RAW MATERIAL PROBLEMS

The quality of raw material is one of utmost importance in the frozen fruit and vegetable industry. Freezing does not improve the quality of the product. At best it merely arrests the development of undesirable changes and holds the product under conditions which prevents deterioration of the fruit or vegetable. Therefore, the raw material quality as affected by maturity and handling practices is directly correlated with the acceptability of the final product.

Contract purchase agreements for raw materials are usually made several months in advance of planting the crop. The price may be fixed or adjustable but is usually based on general economic conditions, previous contract price and general demand for the processed product. Generally the processor pays for the product on a sliding scale. This gives the grower a greater total income for raw material of highest quality.

Suitability for Freezing

Selection of the proper variety for freezing is very important. Some varieties of fruits and vegetables are not suitable for freezing. The undesirable characteristics may include unsatisfactory color, flavor and texture. Much effort has been expended on the development of new varieties and the improvement of accepted varieties for freezing. This work has been carried out by state and federal experiment stations and research groups in industry. This type of work is very important and should receive united support from the frozen food industry.

In different processing areas across the country the same variety may not be suitable. Local state experiment stations can usually offer sound counsel on varieties for the specific area. The text *Freezing Preservation of Foods* by Tressler and Evers offers a complete discussion of suitable varieties of fruits and vegetables for freezing.

Maturity

The maturity or stage of development of the fruit or vegetable at the time of harvest directly affects the quality of the frozen product. These products develop or mature while on the living plant. As the fruits or vegetables develop, they pass from an under-mature to a mature and finally to an over-mature condition. Under-mature produce may be too hard or too soft in texture and lacking in flavor or color while the over-mature product will also exhibit undesirable quality characteristics. Produce of optimum maturity rates high in every quality characteristic and almost invariably results in a superior product with satisfactory field and factory yields. Obtaining produce of suitable quality is the responsibility of the raw products or field department.

Harvesting Methods and Equipment

Harvesting methods and equipment used for fruits and vegetables are in a state of change and development. This is especially true for many vegetable crops. The trend towards mechanical harvesting is being encouraged by the high cost of manual labor required in hand harvesting.

Some of the most interesting of the mechanical equipment in use or under development for harvesting vegetables is that for peas and lima beans, sweet corn, snap beans, spinach and asparagus.

Green peas and lima beans have been vined or threshed in stationary viners for years. These viners were installed in a permanent or semi-permanent location and the pea or lima bean vines were transported to the viner station for threshing. This is not ideal in that a delay occurs between cutting the vines and transporting to the viner station as well as while waiting for the threshing operation. A combination harvester-viner which can be operated in the field is being developed. This machine is designed to pick up vines which have just been cut, thresh the vines, return the vines to the field and clean and collect the shelled peas in lug boxes.

The sweet corn harvester has been widely employed. Use of this equipment has allowed the industry to continue operation in certain areas where manual labor costs incurred during harvesting were discouraging the production of sweet corn for processing. In a sweet corn harvester, the corn stalk is drawn through the revolving knives and chopped into short segments. When the shank or base of the ear is cut, the ear, with husks intact, drops into a conveyer which deposits the ear in a wagon. The remaining portion or top of the stalk is drawn through the chopping knives. With this method the stalks are completely disintegrated during harvest.

The snap bean harvester is also in commercial use and its operation substantially reduces raw material costs. With this machine two rows are harvested simultaneously. During operation the plants are stripped of pods and leaves and the pods are separated from the refuse and filled into mesh bags for transportation to the processing plant.

Less progress has been made in the development of fruit harvesting equipment. This has been due to the fact that fruit generally requires very gentle handling and the trees or shrubs cannot be destroyed or damaged during the harvesting operation. Most of the successful vegetable harvesters destroy or