are also used. This method is especially satisfactory for Danish pastry dough and other doughs with rolled-in shortening, such as pie crust. Chilling to retarded temperatures seems to improve the flakiness of this type of product.

For design calculations the following values are commonly used:

300 Btu per sq ft of box area
10 cfm of air per cu ft of box
10 F deg differential between coil and room temperature.

A relative humidity of approximately 85 percent in the retarding refrigerator is required to prevent drying out of the product. Condensation on the product is undesirable.

This type of operation usually employs complete batch loading, so refrigeration calculations must be based on the introduction of the batch over a short period of time. The capacity of the refrigeration equipment must be sufficient to absorb the product and carrier heat load in from 45 min to 3 hr, depending on cabinet size and handling technique.

The products most commonly handled in this manner are Danish pastry, dough for sweet rolls and coffee cake, cookies, layer cake mixes, pie crust mixes and bun doughs.

The required retarding temperatures are very similar to the temperatures required for storing ingredients, and the refrigerators are usually designed to handle both the ingredient storage and the retarded dough. A common small refrigerator accommodates bun pans on one side, and ingredient containers in another compartment.

CHAPTER 35

BEVERAGE PROCESSES

BREWERIES: Malt, Chemical Aspects, Processing, Storage, Heat Balance; WINE MAKING: Methods and Requirements for Cooling Fermentations, Tartrate Removal, Chill Proofing, Refrigeration Loads; CARBONATED BEVERAGES: Water Coolers, Sanitation, Water Temperatures, Refrigeration Load, Sirup Cooling, Liquid Carbon Dioxide Storage

THIS chapter will discuss the processes and use of refrigeration in: (1) breweries, (2) wineries, and (3) carbonated beverage bottling plants.

PART I: BREWERIES

Beverages made from grains have been recorded by historians as having been in general usage as early as 6000 B.C. in Babylon and Egypt. In the processing of the raw grains, however, the methods and procedures varied widely, as well as did the choice of grains that were used; the choice was dictated by the types that were generally available in a given area or region. Much mystery surrounded the phenomenon of fermentation, and the resulting beverages so produced were necessarily inconsistent, even from batch to batch by the same brewer. Nothing of any consequence was learned until Pasteur discovered that fermentations were brought about by an interaction of living organisms. His further studies disclosed that mixtures of these organisms could be used and would result in a variety of end products, and that an incompatible mixture would be disastrous. The best means of controlling these mixtures was found to be by the maintaining of a high degree of sanitation and the close control of environmental temperature in which these organisms propagate. The fermenting and storing of beer in underground caves was a logical step in the right direction, since the caves provided a relatively constant and depressed temperature. The lager beer type of fermentation, however, could not have been developed, as a lower temperature was required than that provided by underground storage. The addition of ice provided somewhat lower temperatures, and the development of mechanical refrigeration hastened the further development of this type of beer by providing a positive means of controlling temperature.

MALT

Malt is the primary raw ingredient used in the brewing of beer. While adjuncts such as corn grits and rice contribute considerably to the composition of the extract, they do not possess the necessary enzymatic components required for the preparation of the wort. Malting is the initial stage in preparing raw grain so as to make it suitable for mashing. Traditionally this operation was carried out in the brewery, but in the past century, this phase of brewing has become so highly specialized it is now almost entirely the function of a separate industry, the maltster.

Various grains such as wheat, oats, rye and barley can be malted, but because barley-malt has the most desirable characteristics and produces the smoothest performance in the brew-house, it is today used exclusively in the preparation of the mash.

To malt barley, the raw grain is steeped in water of approximately 50 to 60 F for a period of 2 or 3 days, until its moisture content reaches about 45 percent. The kernels by then have begun to germinate and the white tips of rootlets have just appeared at the end of the kernels. When this stage has been reached, the water is drained from the batch which is then spread out on a floor where growing continues. During the growing period, the green malt has to be turned over continually so as to assure uniform growth of the kernels. Upon reaching the desired stage in its growth, the green malt is transferred to the kiln where further growth is checked by reducing the moisture content.

The kilning is usually done in two stages. In the first, the moisture content of the malt is reduced to approximately 8 to 14 percent; in the second, the heat is increased until the moisture is further reduced to 4 percent. By controlling the final degree of heat, the desired color is obtained.

The floor method of malting has in recent years been displaced because of the extensive labor required. Current practice is to use slowly revolving drums which turn over the growing malt, or in the compartment system, slow moving mechanically driven plow-like agitators are used.

From the kiln, the malt is cleaned, so as to separate the dried sprouts from the grain, and is stored for future use. The finished malt differs from the original grain in several significant ways. The hard, flinty endosperm has been modified and is now chalky and friable; the enzymatic power has been greatly increased; the moisture content has been reduced making it more suitable for storing and subsequent grinding; it now has a distinctive flavor and aroma; and the starch and diastase are readily extractable in the brew-house.

CHEMICAL ASPECTS

Two distinct types of chemical reactions are used in the brewing of beer. In the first, which is carried out in the brew-house at temperatures of above 70 F, the starches in the grains are converted into sugar. This reaction is brought about by first crushing the malt and suspending it in water by means of agitation in the mash-tun. A portion of the malt is cooked separately with an adjunct, usually corn or rice. This mixture, after cooking, is then combined with the main malt mash which has been so proportioned that a combining temperature of 160 F results. It is at this temperature that the diastase contained in the malt splits all of the starch ($C_6H_{10}O_5$) present in the grain, converting it into sugar maltose ($C_{12}H_{22}O_{11}$) by