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MICROORGANISMS AND SANITATION IN THE CARBONATED BEVERAGE INDUSTRY

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Microorganisms play important roles in many industries, and often their importance varies directly with the size of the industry. They are vital in the preparation, storage, and sale of carbonated beverages. The size of the industry indicates their importance. The following facts and figures are from the United States Department of Commerce bulletin, *Census of Manufactures 1947*. There were 5,618 syrup and bottling plants in the United States which employed 79,397 people. These plants produced merchandise valued at $837,662,750. The soft drink industry is the largest user of sugar--in 1949 it used 1.4 billion pounds. The industry also uses large amounts of water, approximately 6.25 billion gallons annually.

Since the keeping properties of the product are dependent in large part upon its freedom from spoilage organisms, high bacteriological standards are necessary in the carbonated beverage industry. This is especially important because the final product is not heated.

There are two significant ways in which microorganisms can affect the carbonated beverage industry. Unless proper sanitation measures are employed there is a remote chance of disease organisms as well as spoilage organisms entering the product itself. However, the nature of the product--that is, the presence of large amounts of carbon dioxide with the resulting acidity (pH 2.2 - 3.2) and high sugar content (11 - 14 per cent)--provides such an environment that disease organisms do not survive to reach the consumer even if they were present at the time of bottling. There has been no known instance of a communicable disease outbreak being traced to carbonated beverages. This is an exceptional record when compared to other food products.

Despite this excellent record, microorganisms cause several types of spoilage: formation of sediments, short shelf life, separation of essential oils, foaming at the filling machine which results in low carbonation and low fill, loss of carbonation on opening, fermentation, and off tastes. The true fruit and artificial flavors are especially susceptible to spoilage because of their low carbonation and high pH value. The cola beverages are the least susceptible because of their low pH value (2.4 - 2.7) and higher carbonation (3-4 volumes).

Carbon Dioxide in the concentration found in the beverages is valuable as a preservative. The effects of CO_2 on microorganisms is worthy of note, because it seems to exert a selective effect on bacteria. Some are killed while others are not harmed, and these will even increase in number in its presence. The presence of CO_2 in the beverage is especially detrimental to the growth of some molds. Some species are not able to grow in relatively large amounts of CO_2. Others, however, sometimes appear in beverages with little or no CO_2 or when abnormal amounts of air have been introduced into the bottle in the process of filling.

In order to establish the effects of sugar, acid, and CO_2 on the survival of *E. coli*, W. A. Nolte of the University of Maryland introduced 4,500,000 *E. coli* in each of the following media: (1) tap water, (2) tap water and .085 per cent citric acid, (3) tap water, .085 per cent citric acid, and 10 per cent sucrose, (4) tap water, .085 per cent citric acid, 10 per cent sucrose, and 3.5 volumes of CO_2. The results obtained are shown in Figure 1. Another ingredient that sometimes is found in carbonated beverages is sodium benzoate. This preservative is used chiefly in flavor type beverages. The strength generally employed, 1/20 of 1 per cent, is, however, of little value in heavy contaminations.

There are several sources of spoilage in a beverage plant--airborne organisms, water, sugar, machinery, and bottles. The greater amount of spoilage seems to be caused by the air-borne species of microorganisms; of these, yeast is particularly noteworthy. Statistics by the *American Bottlers of Carbonated Beverages* indicate that in the plants inspected, 46 per cent had yeast contamination of empty washed bottles or simple or finished syrup. Forty per cent of these plants

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with yeast contamination had contaminated syrup or syrup handling equipment. Investigation showed that the presence of yeast in the finished product was caused by the following conditions: (1) holding simple syrup for excessive periods of time, (2) excessive periods of storage of improperly agitated finished syrup, (3) infrequent or improper sterilization of syrup handling equipment, (4) using valves and fittings that were not of sanitary construction, (5) dead end syrup lines, and (6) possible air contamination of syrup, bottles, or equipment.

Yeast that falls into finished syrup and survives the high concentration of sugar may grow after it has been diluted in the finished product. To keep at a minimum the air-borne microorganisms, some plants have found it feasible to install ultra-violet ray lamps in their syrup rooms. If properly installed, the lamps can be very effective. In plants that store large amounts of simple or finished syrup, ultra-violet lamps are installed at the top of the tank to reduce the number of organisms coming in contact with the syrup. Any organisms in the syrup itself will not be effected to any extent as ultra-violet has low penetration power in organic media. Even a thin film provides a high degree of protection to organisms contained in them. Syrup that has splashed on the walls, floors, and ceilings of mixing rooms may become sufficiently diluted to allow the growth of molds and yeast. Spores from these sources can be carried by air currents to all parts of the plant, contaminating material coming in contact with the finished product or its ingredients, thereby causing spoilage. Bottles stored over long periods of time--such as through the winter months--frequently are the source of airborne mold spores that contaminate syrup, crowns, and other material, converting them into unsuitable materials for use.

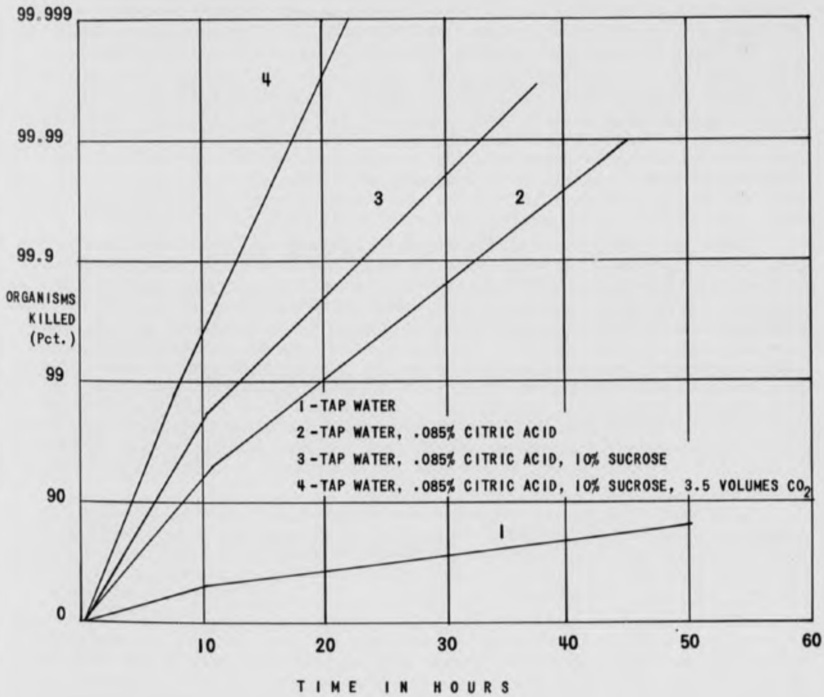

Fig. 1. The Effect of Sugar, Acid, and CO_2 on the Survival of Organisms.

Since water makes up at least 85 per cent of the finished product, a good source of pure water is important. Some spoilage has been traced to contaminated water mains. The bottler's efforts in sanitation can be defeated if water containing spoilage organisms is allowed to pass through his equipment. The solution of this problem has been found in lime coagulation and a super chlorination water treating system along with sand filtration and carbon purification. In this type of system the residual chlorine content after two to four hours retention is kept at from six to eight parts per million at the sand filter. The equipment through which the water passes on its way to the finished product also contributes to spoilage. The main trouble in plants lacking water treating equipment lies in poorly maintained sand filters and carbon purifiers. Certain types of coolers and parts of fillers also have been a serious source of trouble.

The most abundant organic ingredient in carbonated beverages is sugar. Most parent companies in the beverage industry have set up rigid standards for the micro-flora content of sugar. Storing sugar properly is important if it is to be kept sanitary. It should be stored on pallets off the floor and away from walls in enclosed, properly ventilated rooms. Paper bags are better than cloth for keeping sugar free from contamination during storage. Cloth bags absorb moisture, forming a dilute sugar solution around the outside edge, offering a good environment for certain microorganisms.

The problem of preventing sugar from becoming a source of contamination is complicated by a frequent practice in the industry--shaking the bags over the mixing tanks to remove all of the sugar. Tests by the *American Bottlers of Carbonated Beverages* to find out how much contamination results from this practice, show the following results when the bags were properly stored: 1,208 bacteria from each bag, 35 yeast, 82 mold. In the second series of tests the bags were brushed with a fine hair brush. This time the count was 320 bacteria, 1 yeast, 29 mold. The third series of tests was run with the outside layer of paper torn off the bags. The count was reduced to 60 bacteria, no yeast, and 6 mold.

Producing a clean sanitary bottle in which to package the finished product is a major problem facing the manufacturers of carbonated beverages. Unless this is overcome, serious spoilage can result. It is fortunate that the concentration of caustic necessary to produce a clean bottle is more than the concentration necessary to kill microorganisms. The present requirements for washing compounds include exposing the bottle to a three per cent alkali solution, of which not less than 60 per cent is caustic, for at least five minutes at a temperature of not less than 130°F or to an equivalent cleaning and sterilizing compound.

Tests by a well known manufacturer of washing compounds show that vegetative cells and spores of yeast normally encountered in carbonated beverages are killed when exposed to 130°F and as little as .19 per cent caustic for five minutes. At the same temperature it takes only two minutes and .75 per cent caustic to kill *Staphlococcus aureus* (F. D. A. Phenol Coefficient Technique was used in these tests). Tests by the American Bottlers of Carbonated Beverage's laboratories on the resistance of yeast to caustic soda showed these results: In a one per cent caustic solution 5,600 swimming yeast were introduced. At the end of five minutes at 104°F, 230 survived, and at 122°F none survived. At the end of 10 minutes at 104°F, 130 survived. In two per cent caustic 5,600 swimming yeast were introduced. At the end of five minutes at 104°F, 20 survived, and at 122°F none. At the end of 10 minutes at 104°F, there were no survivors.

Water softening agents sometimes are employed with caustic to aid in obtaining a clean bottle. It has been found that in general the action of Alkyl arly sulphonates weakens microorganisms for attack by other germicides such as caustic. Mold, for instance, is killed in half the time if as little as .15 per cent of the wetting agent is used.

Mobile laboratories of the Pepsi-Cola Company have found that the sterilizing action of the caustic solution can be nullified if care is not taken in sanitizing the rinse tank of the bottle washing machine. Spoilage has been traced to this compartment. Dirt particles that have not been removed from some of the bottles drop off in the rinse compartment, carrying with them organisms that have not been reached by the caustic solution. The warm damp walls of this section offer an excellent environment for these organisms to thrive.

The sanitation problem can be reduced by a carefully chosen site. Locations near bakeries, laundries, or breweries should be avoided because of airborne yeast. Excessively dusty or smoky sites or poorly drained areas also should be avoided.

The building itself should be designed properly for sanitary maintenance. For example, the bottling room should be enclosed. Tests have shown that there is more yeast, bacteria, and mold in the air inside beverage plants, particularly the receiving end of the soaker, than in outside air. Therefore, it is advisable to separate the receiving end of the bottle washer from the bottling area. The bottling and syrup rooms also should have walls and floors of hard, glazed material which is water and acid proof. This will enable easier cleaning.

It is often difficult to sell sanitation to plant managers and personnel because the results are not always tangible. However, it has been proved that a plant that practices adequate cleaning will produce a superior product. To help the bottler with spoilage problems in prevention as well as elimination, parent companies have set up laboratories to deal with them. The *American Bottlers of Carbonated Beverages* and some parent companies, including the Pepsi-Cola Company, have established mobile laboratories to aid the bottler in his own plant. These laboratories are able in many instances to spot spoilage-producing conditions before they have progressed for enough to cause loss of merchandise. The personnel on these mobile units are able to advise the bottler on the latest methods in sanitation and aid him in setting up programs that suit his plant's needs. The parent companies realize that uniform high quality throughout the nation is of prime importance and that good sanitation is a leading factor in maintaining that quality.

Some conclusions may be drawn from this study: (1) Sanitation in the beverage industry must be thorough, since neglect of one phase can cause trouble. (2) Counts obtained in finished products taken from the trade will not necessarily give a true picture of the sanitary condition of the plant in which they were bottled. (3) More study is needed on how various organisms affect a carbonated beverage. (4) More study is needed on effects of CO_2, sugar, and acid in the concentrations found in carbonated beverages on spore forming bacteria which are found in water and soil.

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