

CHEMICAL AND BACTERIOLOGICAL CHANGES IN DILL-PICKLE BRINES DURING FERMENTATION¹

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The manufacture and storage of genuine dill pickles under climatic conditions typical of the southern states is generally unsatisfactory, and few southern pickle packers attempt to manufacture genuine or fermented dills.

In other sections of the United States several investigators have studied different phases of dill-pickle manufacture. Lesley and Cruess (1928) studied the relationship between brine acidity and soft pickles. Joslyn (1929), in extensive experiments, investigated the influence of numerous commercial practices on the quality of the finished product. Fabian and Wickerham (1935) have reported some chemical and bacteriological changes which take place in dill manufacture.

During the past few years a study of the manufacture of genuine dills under climatic conditions of eastern North Carolina has been undertaken. This paper is a report of a chemical and bacteriological study in regard to the types of microorganisms predominating, the utilization of sugar, and the production of acid during the fermentation. The data presented were obtained during the 1938 curing season.

EXPERIMENTAL PROCEDURE

In outlining the program followed in 1938 one treatment was considered standard; other treatments deviated somewhat from the standard with respect to brine salinity, added acid, or addition of sugar.

The cucumbers used were uniform in size and carefully selected. They were of 600-count size,² which would ordinarily be considered too large for marketable dills, but were entirely suitable for making comparisons of different treatments. Duplicate barrels of each treatment were put down.

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² Number per 45-gallon cask.

Brine samples were taken at frequent intervals for chemical and bacteriological analyses. These samples were taken by inserting a short piece of stainless steel tubing through the bung of the barrel and withdrawing the brine through an attached piece of rubber tubing. Two 12-ounce bottles full were withdrawn before the bacteriological sample was taken.

Chemical samples were preserved with sodium 2, 4, 5 trichlorophenolate in a concentration of 1-10,000 as described by Veldhuis (1938). The titratable acidity of the brine samples was determined by diluting a 10-c.c. sample with 50 c.c. of water, boiling about 20 seconds to expel carbon dioxide, cooling, and titrating with one-tenth normal sodium hydroxide using phenolphthalein as the indicator. The pH of the brine was determined by means of a glass electrode. Reducing sugars were estimated by the Shaffer-Hartmann (1921) micro method, standardized to the conditions under which it was used. Chemical studies were made on all lots.

For bacteriological analysis, the brine was examined by the plating technic with respect to total number of bacteria, acid-forming bacteria, peptonizing bacteria, and yeasts. Bacteriological findings showed the acid-formers and yeasts to be the predominating organisms and they alone are considered in this study.

The media used for plating of the brine samples were nutritive caseinate agar (Difco) for the bacterial counts and tartaric acid agar for yeast counts. The routine platings of the brine samples on the nutritive caseinate agar were counted and classified according to physiological growth reactions of the predominating organisms. On this medium the acid-formers showed definite zones of precipitated casein about the colony, owing to their acid production. The addition of eight c.c. of .4-per cent brom-cresol-purple indicator to the agar during preparation was a further aid in identification of the acid-forming bacteria. It was found that with the routine use of this media for brine platings, during the active phase of the dill fermentation substantially all of the colonies present on the plates were acid-formers. The yeast counts were obtained by plating dilutions of the brine on tartaric acid agar, which was prepared by adding five c.c. of sterile five-per cent tartaric acid to each 100 c.c. of melted dextrose agar.³ All plates were incubated at 35°C. (95°F.) for three days and then counted. Occasionally, when yeast colonies were not well developed the incubation period was extended to five days. The treatments followed bacteriologically are outlined (Table 1, Nos. 2, 3, 5, and 11).

³Laboratory Manual (*Methods of Analysis of Milk and Its Products*), International Association of Milk Dealers, 1933. p. 81.

TABLE 1

Salting Schedule Followed in Experimental Dill Pack(Treatment for all lots was the same as for the standard¹ except as otherwise indicated in this table)

Lot No.	Treatment description	Quantities of materials added per barrel		
		Salt	Acid	Sugar
1	Standard Acid series Vinegar—at starting	19 lbs.	.5 gal. 110-grain vinegar	None
2	No acid added	19	None	None
3	Medium acidity	19	1.0 gal. 110-grain vinegar	None
4	High acidity Lactic acid— (vinegar omitted)	19 19	1.5 gal. 110-grain vinegar	None
5	At starting	19	1700 c.c. 50%	None
6	10 days after starting Salt series	19	1700 c.c. 50%	None
7	Low salt	15	.5 gal. 110-grain vinegar	None
8	High salt Sugar series	23	.5 gal. 110-grain vinegar	None
9	Dextrose at starting	19	.5 gal. 110-grain vinegar	3.5 lbs.
10	Dextrose 7 days after starting	19	.5 gal. 110-grain vinegar	3.5 lbs.
11	Sucrose at starting	19	.5 gal. 110-grain vinegar	3.5 lbs.

¹ Standard treatment—19 lbs. NaCl, .5 gal. 110-grain vinegar; barrel filled with water, stored inside shelter, rolled at frequent intervals early. All barrels were of 42-gallon capacity.

DATA AND DISCUSSION

Typical curves of chemical changes which occurred during fermentation in a lot receiving the standard treatment are shown (Fig. 1). Progressive changes in acidity and pH and sugar concentrations of the brine are indicated. From the acidity curve it is evident that the changes in this constituent were small during the first three days. The acid content of .4 gram per 100 c.c. at the end of the first day was due to the vinegar added. During the second and third days the brine acidity decreased somewhat as a result of brine dilution and vinegar absorption by the cucumbers.

A rapid increase in acid content began on the fourth and continued until about the 18th day, followed by a slight decrease, after which there were but small fluctuations in brine acidity.

The sugar curve (Fig. 1) indicates a rapid increase in brine-sugar concentration during the first three days and a correspondingly rapid reduction in this sugar concentration after an active fermentation had started, as indicated by the development of brine acidity.

The pH curve shows the effect of the added acid and acid produced by fermentation. The variations found with this treatment

are not very large. The added vinegar lowered the pH to about 3.6 on the first day. During the second and third day the pH rose slightly as the vinegar in the brine was diluted. When the formation of acid by fermentation began, the pH decreased again and continued to decrease slightly as long as acid was formed. A constant value was approached on about the 18th day.

A more or less average dill fermentation is shown (Fig. 2) with respect to predominating microorganisms and their effect upon the sugar present and the production of brine acidity. The upper part shows the differential plate counts of the brine in regard to the acid-forming bacteria and yeasts. Owing to the great difference in the number of the two types, the counts are plotted logarithmically so that both may be shown on the same graph. The acid-forming bacteria show a growth curve of moderate activity, reaching a peak of 38 millions per c.c. on the third day and then subsiding. The yeast fermentation did not begin actively until the acid-forming bacteria had changed the acidity of the brine to more optimal conditions. The yeast population, after starting on the fourth day, reached a peak on the 10th day and then dropped sharply although remaining in the brine for approximately 30 days.

The lower part of Fig. 2 shows the reducing sugar content and titratable acidity of the brine during the fermentation. The acid-forming bacteria brought about the first part of the downward trend of the sugar curve, then the advent of the yeast fermentation aided in bringing about the further decline to approximately .1 per cent on the 10th day. The acidity curve, starting on the first day, shows a gradual rise to approximately .75 per cent on the 21st day, this period comparing favorably with that of the active growth phase of the acid-forming bacteria.

The influence of the addition of lactic acid and different quantities of 110-grain vinegar at the outset of the experiment on subsequent changes in acidity, pH, and sugar concentration of the brine during the fermentation is evident (Figs. 3 to 5). The details of these treatments are shown (Table 1, Treatments 1 to 5).

The quantity of lactic acid added for treatment No. 5 was equivalent to approximately one and three-fourths gallons of 110-grain vinegar. Since the dillweed used in these treatments had been packed in vinegar, a small amount of acid was introduced into all barrels including those designated as "no acid added." The amount of vinegar thus added was equal to about one pint of 110-grain vinegar.

For the vinegar-treatment series the curves (Fig. 3) show that there was a decrease in the acid content of the brines during the first few days as the vinegar became diluted. This condition was

