Fermentation of Philippine Vegetable Blends

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Seven blends of Philippine vegetables, two of which contained soybeans and one mango bean sprouts, were prepared for fermentation and study of microbiological and chemical changes. The fermentations were typical lactic acid bacterial fermentations, initiated by Leuconostoc mesenteroides and continued by Lactobacillus brevis, Pediococcus cerevisiae, and L. plantarum. The combination of high acidity and low pH resembled other vegetable fermentations, such as sauerkraut. The procedure offers a method of preserving surplus vegetables, and, in addition, a method for incorporating and preserving the high-protein-containing soybeans.

Preservation of vegetables by fermentation probably originated in Asia with methods that have been in use for centuries. Yen tsai, paw tsay, kimchi, sajur asin, mostasa, and nukamiso pickles are among the better known preserved foods of the Far East. In recent years, the Filipinos have become increasingly aware of the value of vegetables to their diets. Although recently cucumber pickling has become an important industry, the Filipinos have not utilized fermentation as a method of preserving other vegetables. They are accustomed to eating sweet-sour foods, such as "Atchara," a vegetable blend sweetened with sugar and acidified with vinegar. The increase in vegetable production, particularly in the mountain province, has resulted in seasonal overproduction which could be alleviated by preserving vegetables by fermentation for later use.

Palo and Lapuz (2) isolated strains of bacteria from fermenting mustard leaves, "mostasa," which were presumably strains of Leuconostoc mesenteroides. Kim and Whang (1) reported that this species played an important role in the fermentation of kimchi. In view of the importance of L. mesenteroides, Lactobacillus plantarum, and other species in the production of sauerkraut of superior quality (4) and the necessity for establishing optimal environmental conditions for growth of these species, it seemed desirable to determine whether they also played a major role in all of the major vegetable blends that could be made in the Far East.

MATERIALS AND METHODS

The vegetables used were purchased on the open market. The vegetables of higher sugar content, such as cabbage and singkamas, were included in the blends. The edible roots of singkamas, a yam bean grown in the Philippines, resemble small white turnips in appearance, but are white, crisp, and sweet. The blends contained the percentages of trimmed vegetables given in Table 1. The vegetables were washed, peeled when necessary, cleaned, sliced or shredded, and then mixed with 1.75 to 2.25% salt. The mixtures were packed into jars of 1 to 3-gal-capacity. A bag-like plastic cover was placed on the surface of the vegetable, and sufficient water was placed in the bag to contact the entire surface and to bring the vegetable brine to a height level with the surface.

During fermentation, samples of brine were removed at regular intervals for determination of pH, total acidity, and salt content. With four blends, samples of brine were plated for estimation of numbers of bacteria, isolation of colonies, and study of the flora. Plates were incubated for 2 days at room temperature, which usually approximated 30 C. Colonies were counted, and usually 25 colonies were isolated from each plating. Later the cultures isolated were identified by the method of Pederson and Albury (3). Representative cultures were commonly studied further to assure the validity of identification.

RESULTS AND DISCUSSION

With the uniform and comparatively high temperatures of the Philippines, fermentations were initiated rapidly and continued at a rapid rate. Acidities (as lactic) were attained as follows: no. I, 1.34% in 7 days; no. II, 1.72% in 11 days; no. III, 1.60% in 8 days; no. IV, 1.75% with a pH of 3.70 in 12 days; no. V, 1.83% with a pH of 3.78 in 7 days; no. VI, 1.75% with a pH of 3.70
in 5 days; and no. VII, 1.74% with a pH of 353. in 7 days.

Blends no. I and III resembled sauerkraut in both appearance and flavor. The varying shades of green of mustard leaves, beans, and peppers, combined with the white of the other vegetables, cabbage, singkamas, and radish, in blend no. II presented the least attractive appearance of all blends and also had the least appealing flavor. In contrast, blend no. IV was most attractive in color and flavor. The red and green colors of the peppers and with the carrot-red hue of the carrots blended well with the white vegetables. These vegetables were included also in blends V, VI, and VII. Although the soybeans in blends V and VI were very noticeable, the mango bean sprouts in blend VII were barely discernible.

After fermentation was completed, the blends were diluted with one-half their volume of water to reduce the acidity to about 1.2%. They were then heated to 165°F (74°C), packed into heated glass jars at this temperature, sealed, and cooled.

Microbiological and chemical changes. The microbiological and chemical changes that occurred during fermentation were quite similar to those that occur in the sauerkraut fermentation (3). The detailed microbiological and chemical changes that occurred in blend no. V (Table 2) show the rapid rise in acidity with a corresponding reduction of pH. *L. mesenteroides* was entirely responsible for the early stages of this fermentation as it was in the other blends studied. A maximal count of $3,700 \times 10^4$ was attained in 21 hr. The count dropped to $2,700 \times 10^4$ during the next 6 hr, and a marked change in flora occurred during the next 7 hr, when an acidity of 0.77% was attained. This change in flora occurred at a
lower acidity than that which occurs in sauerkraut fermentation. Lactobacillus plantarum became the predominant florum. L. brevis and Pediococcus cerevisae played predominant florum. than in blend with fermentation L. but 0.26%, tococci and soybeans, e.g., 3), V. In one of the vegetable fermentations without soybeans, e.g., blend no. IV, and the second fermentation with soybeans, blend no. VI (Table 3), P. cerevisae was never isolated at any stage; Lactobacillus brevis played a less important role than in blend V. In blend no. IV, strains of streptococci and micrococci were isolated from the second plating when the acidity was low, e.g., 0.26%, but they were entirely absent thereafter.

The soybeans were added to vegetable blends no. V and IV to increase the protein content. Protein analysis of the heat-processed sample of blend no. IV yielded 8.80% protein (N × 6.25) calculated on the dry basis. The soybean sample, blend no. V, yielded 34.44% protein on the dry basis. Although this may seem abnormally high when only 32% by weight of soybean had been added, soybeans even after cooking contain a high percentage of total solids, whereas the other vegetables are low in total solids. Blend no. VI, in which only 18% soybeans were added, contained 23.0% protein.

Because of the high-protein content of blend V, it was assumed that the buffer content of the brine may have increased to such an extent that insufficient acid would be produced to lower the pH for effective preservation. Actually equilibrium between the soybean and the other vegetable was not attained rapidly, and the soybean protein apparently remained within the bean. Therefore, the buffering effect of the fermenting brine was not affected greatly. A pH below 4.00 was attained at an acidity level of 1.0 to 1.2%.

The blend of carrots and red peppers contrasted well to the white cabbages, singkamas, and radishes, providing an attractive and acceptable appearance. In general, the Americans who were accustomed to eating sauerkraut found the flavor of the blends acceptable. The processed blends were too sour for the majority of the Filipinos; however, when they were sweetened with 10 to 15% sugar or blended with crushed pineapple, the products were relished by them. They compared them to their “Atchara.” The soybeans acquired a somewhat chewy, peanut-like flavor. There may be a chemical change responsible for development of this character. The mongo beans in blend VII were barely discernible.

Technically, the low oxidation-reduction potential attained in lactic acid fermentation systems is effectual in retaining the light color and bright appearance of the vegetables. Low pH or high acidity delays enzyme action and inhibits growth of other microorganisms.

Preservation of mixed vegetables, such as those seasonally available, can be readily adapted to small-scale operations using almost any blend of vegetables as is done in other Asian countries.

After fermentation, the vegetable blends may be preserved by heating the blend to 165 F (74 C), filling into containers, and hermetically sealing the containers at a temperature of 165 F.
LITERATURE CITED


