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[54] CONTROLLED BULK VEGETABLE FERMENTATION

[75] Inventors: John L. Etchells; Thomas A. Bell; Henry P. Fleming; Roger L. Thompson, all of Raleigh, N.C.

[73] Assignee: The United States of America, Washington, D.C.

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[58] Field of Search 426/49, 52

[56] References Cited

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Binsted et al., Pickle & Sauce Making, 1962, p. 211.

Etchells et al, Applied Microbiology, Vol. 12, No. 6, (1964) pp. 523–535.

Primary Examiner—A. Louis Monacell

Assistant Examiner—Esther L. Massung

Attorney, Agent, or Firm—Irons & Sears

[57] ABSTRACT

Bulk fermentation of brined vegetables comprising controlled sanitizing, acidifying, buffering, and inoculating while continually purging CO_2 from the fermenting vegetable/brine mass.

10 Claims, No Drawings

CONTROLLED BULK VEGETABLE FERMENTATION

BACKGROUND

For many, many years research scientists have struggled with the time-honored methods of naturally fermenting vegetables in an ardent endeavor to minimize or eliminate the serious element of chance attending such fermentation. By that is meant that a host of factors come into play which all too often deleteriously affect the quality of the fermented product. Typically, the varied nature and quality of the stock to be fermented, the multiple and likewise varied microorganisms found associated with such stock, the difficulties attending control of, say, salt and acid concentrations during a 6–12 month fermentation period, etc., all come into play and any of them can adversely affect the quality of the fermented product, as reflected by odor, taste, bloating, and the like.

On the whole, the efforts made over the years have been very rewarding in that significantly improved controls have been instituted, waste has been reduced and the risk factor reduced. Nevertheless, the art of naturally fermenting vegetables, such as cucumbers, is still plagued by the element of chance; it is still very dependent upon the human factor, i.e., the skill of the artisan; and it is still crippled by inordinate losses and waste.

The following references clearly attest to the great strides that have been made and provide an excellent insight into the pitfalls attending the art of fermenting vegetables:

U.S. Pat. No. 3,374,099, Mar. 19, 1968, for Enzyme Inhibitor for Preventing Softening in Brined Foods, Bell, T.A., Etchells, J. L., and Smart, W. W. G., Jr.

U.S. Pat. No. 3,403,032, Sept. 24, 1968, for Pure Culture Fermentation Process for Pickled Cucumbers, Etchells, J. L., Bell, T. A., and Costilow, R. N.

U.S. Pat. No. 3,410,755, Nov. 12, 1968, for Process and Media for Producing Cells of Lactic Acid Bacteria, Etchells, J. L., and Costilow, R. N.

U.S. Pat. No. 3,480,448, Nov. 25, 1969, for Pure Culture Fermentation of Green Olives, Etchells, J. L., Bell, T. A., and Kittel, I. D.

J. L. Etchells, A. F. Borg, I. D. Kittel, T. A. Bell, and H. P. Fleming, Pure Culture Fermentation of Green Olives, Applied Microbiology, Vol. 14, No. 6, (1966) pp. 1027 – 1041.

J. L. Etchells, R. N. Costilow, T. E. Anderson, and T. A. Bell, Pure Culture Fermentation of Brined Cucumbers, Applied Microbiology, Vol. 12, No. 6, (November 1964) pp. 523 – 535.

J. L. Etchells, A. F. Borg, and T. A. Bell, Bloater Formation by Gas-forming Lactic Acid Bacteria in Cucumber Fermentations, Applied Microbiology, Vol. 16, No. 7, (July 1968) pp. 1029 – 1035.

J. L. Etchells, T. A. Bell, H. P. Fleming, R. E. Kelling, and R. L. Thompson, Suggested Procedure for the Controlled Fermentation of Commercially Brined Pickling Cucumbers-the Use of Starter Cultures and Reduction of Carbon Dioxide Accumulation, Pickle Pak SCIENCE, Vol. III (December 1973), pp. 4 – 14.

H. P. Fleming, F. L. Thompson, J. L. Etchells, R. E. Kelling and T. A. Bell, Bloater Formation in Brined Cucumbers Fermented by *Lactobacillus plantarum*, Journal of Food Science. Vol. 38 (1973), pp. 499 – 503.

H. P. Fleming, R. L. Thompson, J. L. Etchells, R. E. Kelling and T. A. Bell, Carbon Dioxide Production in the Fermentation of Brined Cucumbers, Journal of Food Science, Vol. 38 (1973) pp. 504 – 506.

Henry P. Fleming, Roger L. Thompson and John L. Etchells, Determination of Carbon Dioxide in Cucumber Brines, Journal of the AOAC, Vol. 57, No. 1, 1974, pp. 130 – 133.

F. W. Fabian and R. C. Fulde, The Rate of Salt Penetration Into Pickles Charted, Size By Size, Food Packer, Vol. 31, No. 9, pp. 23, 38, 41; and No. 10 (1950), pp. 28–29, 38–40, 51.

Still left to chance, however, are any number of hidden factors which, over the conventional extended period of fermentation of 6 to 12 months, account for heretofore high rates of product losses and, as a result, serious economic handicaps.

Typically, the present uncontrolled commercial brine-stock pickling procedures admit of any or all of the following drawbacks in any given tank of fermented pickles: soft or inferior textured pickles; bloaters (hollow stock) or gassy deterioration; shriveled or flat stock; poor color (external and internal bleaching); unclean odor and taste; and poor keeping quality (storability, shelf-life).

The present invention, on the other hand, provides the following very important advantages: new pickled vegetable products with improved flavor, odor, color, texture, savor, stability, and general appearance; a more scientifically controlled vegetable fermentation industry; reduction of losses due to bloaters, softening, shriveling, and poor color; reduced processing time and costs with opportunities for increased automation; reduced waste disposal problems; diversification and readycash for small farmers; increased opportunities for food processing in rural areas; simple and inexpensive means for preserving vegetables in developing countries; reduced waste disposal problems reducing the quantity of salt needed; use of significantly lower salt concentrations during fermentation and bulk storage; and other like advantages which will be apparent from the description, infra.

INVENTION

The present invention relates to controlled lactic acid fermentation of vegetables, in bulk. More particularly, the instant discovery involves careful sanitizing, acidifying and buffering of brined vegetables preliminary to inoculating same with a viable culture, all the while purging autogenously-generated dissolved CO_2 from the vegetable/brine mass.

According to the present invention, a revolutionary method has been found for controlled lactic acid fermentation of cucumbers and other vegetables brined in bulk. Whereas heretofore at least 60 days, usually 6–12 months, was involved in the conventional or natural fermentation of vegetables, the instant discovery accomplishes the job in 7–12 days.

In addition, as indicated hereinbefore, the defects of brinestock pickles are very significantly minimized or

eliminated pursuant to the present invention. Typically and more specifically, not only have bloaters — which heretofore constituted about one-third of conventionally-fermented large size cucumbers — been essentially eliminated, but the texture, color, appearance, odor, and taste of the pickles produced by the fermentation process of the present invention are all immeasurably enhanced.

Briefly, it has been found that cucumbers, for example, may be rapidly fermented into brine-stock pickles by, stepwise, thoroughly washing the cucumber green stock, sanitizing by incorporating active chlorine into a brine for the stock and acidifying same with acetic acid or vinegar, uniformly buffering, and inoculating with acid-tolerant cultures, e.g., special strains of *Lactobacillus plantarum*, *Pediococcus cerevisiae*, or a combination of both, all the while sweeping fermentation gases, particularly CO_2, from the fermenting medium using an inert gas, such as nitrogen.

While the prior art alluded to above has shown that rapid pure culture fermentation, employing the so-called heat-shock (170°F., 5 minutes) method, could be successfully accomplished on small quantities of vegetables, i.e., one- to five-quart quantities, the heat-shock process is entirely impractical for bulk brining in commercial tanks. Further, controlled culture fermentation, in bulk, of large size cucumbers, sans heat-shock treatment, creates severe bloating problems, even with careful sanitizing, acidification and buffering. The heat-shock treatment used in small quantity pure culture fermentation destroys contaminating microbes found on green stock, which microbes adversely affect the quality of the fermented product.

Needless to say, present conventional brine-stock bulk pickling procedures (natural fermentation methods) do not employ the just-mentioned heat-shock method and the hereinabove-described serious disadvantages persist. Likewise, the present invention is not directed to heat-shock treatment but rather to controlled fermentation, in bulk, using acid-tolerant cultures.

To achieve the results herein alluded to, it is important to grade out stock that is diseased, broken or moldy; to carefully wash the remaining selected stock; to control the vegetable/brine volume ratio; to properly chlorinate the vegetable/brine mixture; to carefully acidify; to uniformly buffer the vegetable/brine mass; having achieved the desired controlled conditions, to add a viable culture of lactic acid bacteria; and, all the while, to continually control the vegetable/brine strength and purge CO_2 from the fermenting vegetable/brine material. Fermentation is completed when the sugar content of the vegetable/brine mass is near zero.

As will also be seen hereinafter, the controlled bulk fermentation process of the instant discovery is far simpler than the age-old conventional uncontrolled natural fermentation process. Of course, the revolutionary rapidity, the economy and the superior reproducible results achieved are unprecedented.

After grading out stock that is diseased, broken or moldy, and according to a preferred embodiment, the graded stock is washed thoroughly with a brush- or reel-type washer. Preferably, also, stock which has been refrigerated is tempered to 65° – 70°F. with a warm water pre-soak before or during the washing step.

Conventional techniques may be used to achieve the desired packout ratio (i.e., the vegetable/brine ratio, by volume) in likewise conventional bulk fermentation tanks. As the knowledgeable artisan knows, for instance, the pack-out ratio takes into consideration in-tank shrinking of the vegetable and the volume of cover brine.

The pack-out ratio herein contemplated is in range of 40 to 75 percent vegetable to 60 to 25 percent brine, preferably 55 – 70 to 45 – 30 percent.

Generally, from about 15° to about 32° salometer brine, preferably from about 20° to about 28° salometer brine, is used to initiate fermentation and sufficient salt added throughout fermentation to maintain the salt concentration in that range. As a point of reference, 25° salometer is about 6.6% NaCl concentration, weight by volume.

The active chlorine concentration in the brine, upon sanitizing, is usually in the range of about 50 to about 100 parts active chlorine (Cl_2) per million parts brine, preferably from about 70 to about 90 ppm. The active chlorine may be added as liquid chlorine, sodium hypochlorite, or the like. In practice, the initial brine generally contains the active chlorine and additional active chlorine is introduced about 12 to 14 hours after the initial chlorination, i.e., generally about 10 to 12 hours before inoculation.

In other words, the initial chlorination, in the concentration given, destroys substantially all the microbial flora in the brine, thus guarding against uncontrolled growth of interfering, vegetative microorganisms.

Similarly, for the purpose of controlling acid-sensitive microorganisms and to inhibit the germination of microbial spores, the vegetable/brine mass is acidified with sufficient weak organic acid to reduce the pH of the brine to between about 2.7 to about 3.2. According to a preferred embodiment, the acid is added after about 45 to about 180 minutes of sanitizing with the chlorinated brine, preferably from about 60 to about 120 minutes. Again, as in the case of the chlorination treatment, competitive contaminants are being controlled to substantially eliminate or minimize interference with the culture of choice, i.e., the lactic acid bacteria herein contemplated.

The weak organic acid of choice is glacial acetic acid or its equivalent amount of 100–200 grain vinegar. In practice, when fermenting cucumbers, for example, the just-mentioned pH desideratum is generally achieved by adding acetic acid at the rate of about 6.0 milliliters (ml) per gallon of total cucumbers and brine.

Following acid addition to achieve the desired pH, the vegetable/brine mass is allowed to ferment and salt is added incrementally to maintain the aforementioned initial brine strength (15°–32° salometer) until the point of near equilibration. The brine, at equilibration, usually contains from about 0.2 to about 0.6 percent sugar, by volume, preferably about 0.4 to about 0.6 percent. In practice, the desired brine strength is generally achieved by salt addition at the rate of 6 pounds of salt for every hundred pounds of cucumbers.

By near equilibration is intended the condition in the vegetable/brine mass in which the moisture content of the vegetable has substantially all diffused and the salt concentrations of the brine outside and inside the vegetable are about the same or the same.

The chlorine sanitizing step hereinabove disclosed is repeated at least once — depending upon the rapidity of equilibration — about midway intermediate the original chlorination and equilibration. In this way, and at the concentrations heretofore recited, microbial flora