United States Patent Office 3,403,032 Patented Sept. 24, 1968

3,403,032

PURE CULTURE FERMENTATION PROCESS FOR PICKLED CUCUMBERS

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No Drawing. Continuation of application Ser. No. 493,936, Oct. 7, 1965, which is a continuation-in-part of application Ser. No. 324,898, Nov. 19, 1963. This application Oct. 4, 1967, Ser. No. 672,722

10 Claims. (Cl. 99—156)

ABSTRACT OF THE DISCLOSURE

A process for pickling cucumbers to produce a firm-textured, essentially acetic-acid free, fermented cucumber material containing lactic acid. The process involves heat-shocking cucumbers to destroy asporogenous micro-organism on the surface of the cucumbers as well as to inactivate deleterious heat-labile enzyme systems of plant or microbial origin, packing the heat-shocked cucumbers in aseptic containers and covering them with brine of a strength to give en equilibrated salt concentration of about 1.6% to 10% by weight, inoculating the containers with a selected species of pure culture lactic acid fermentation-inducing micro-organisms, sealing the containers, and incubating them at a temperature favorable for growth of the introduced pure culture micro-organisms until the fermentation has progressed to completion.

This application is a continuation of application bearing Ser. No. 493,936, filed Oct. 7, 1965, now abandoned which, in turn, is a continuation-in-part of application bearing Ser. No. 324,898, filed Nov. 19, 1963, now abandoned.

A non-exclusive, irrevocable, royalty-free license in the invention herein described, throughout the world for all purposes of the United States Government, with the power to grant sublicenses for such purposes, is hereby granted to the Government of the United States of America.

This invention relates to a process for the pure culture fermentation of vegetables, particularly cucumbers, by selected pure cultures of lactic acid producing bacteria.

As used herein, the term "vegetables" includes cucumbers, carrots, green tomatoes, peppers, onions, okra, snap beans, West Indian gherkins, and the like. Because of their wide use in the food field, "cucumbers" or "cucumbers for pickles" will frequently be used below as "the vegetable."

It is well known that the conventional centuries old process for the brine curing of vegetables, such as cucumbers for pickles, involved brining of the cucumbers and subsequent fermentation induced by micro-organisms normally extant on the cucumbers or other vegetables and transient micro-organisms introduced by virtue of processing operations; the type and number of micro-organisms present in the brine being limited only by the ability of each to survive the conditions of brining. The success of this natural, mixed microbial flora fermentation process depends completely upon chance and the skills of those practicing the art of brine curing in establishing environmental conditions favorable for the growth of the lactic acid producing bacteria. A major and costly difficulty in the natural fermentation process is the frequent ascendency of non-lactic acid producing bacteria, yeasts, molds and other fungi. This ascendency results in a fermentation which is abnormal to the one desired, and usually gives rise to such kinds of deteriorative conditions as softening, hollow cucumbers, bleaching, putrefaction, and to other unpalatable and unappetizing changes.

Herein is reported the invention of a new, novel, and practical process for the brine fermentation and curing of vegetables, such as cucumbers, which enables scientific control of the fermentation thereby decreasing the chances of brine-stock loss and giving rise to finished products of unusually high quality and controlled characteristics.

It is accordingly an object of this invention to provide a vegetable brine curing process in which the frequency of abnormal fermentations is reduced or eliminated by the attenuation, destruction, or removal of the natural and introduced mixed flora which give rise to abnormal fermentations, and by supplanting these undesirable microbial species with pure cultures of one or more bacterial species of strains selected from the genera Lactobacillus, Pediococcus, and Leuconostoc.

Another object of this invention is to provide a vegetable brine curing process in which the desirable characteristics of the processed product may be predicted. This is accomplished by knowing the biochemical properties and fermentative behavior of a selected strain or a mixture of selected strains of lactic acid producing bacteria employed in the pure culture process. Our selection studies first revealed that specific fermentation differences affecting brine-stock vegetable quality were obtained not only between individual species of lactic acid bacteria but also between strains of the same species. For example, a decided difference in color and odor of brine-stock was obtained with certain strains of the species *Pediococcus cerevisiae*. Some gave the brine a stale, hay-like odor and the vegetables revealed an off-color, with evidence of bleaching. As the result of the above important findings, screening tests involving several hundred pure culture fermentations were carried out using over 50 individual cultures of lactic acid bacteria representing 10 species in 3 genera, namely: *Lactobacillus bulgaricus, L. brevis, L. delbrueckii, L. fermenti, L. helveticus, L. lactis, L. plantarum, L. thermophilus; Pediococcus cerevisiae;* and *Leuconostoc mesenteroides*.

By virtue of these extensive screening tests, final selection of the most desirable strains of lactic acid bacterial species for use in vegetable fermentations was accomplished. Criteria used in the selection of a given strain included: color, odor, flavor and texture of the fermented vegetable, such as, pickles; absence of bloaters; utilization of brine sugars, rate of development of brine acidity; final brine acidity and pH; salt and acid tolerance of the culture; temperature range and tolerance of the culture; and viability and longevity of the culture. The cultures selected in their approximate rank order of desirability were: *Lactobacillus plantarum* (4 strains); *Pediococcus cerevisiae* (2 strains); *Lactobacillus delbrueckii* (3 strains); *Lactobacillus lactis* (1 strain); *Lactobacillus thermophilus* (1 strain); and *Leuconostoc mesenteroides* (2 strains).

All 10 strains of the species *Lactobacillus brevis* produced bloaters in pickles, even in combination with one or more cultures of non-gas-forming species and with but 1/10 of their inoculum. This undesirable property of *L. brevis* would probably preclude its use in pure culture pickle fermentation even in bulk unless pierced or pricked cucumbers were used. Essentially the same would be true for the species *L. fermenti*. The two remaining species of the 10 tested, *L. bulgaricus* and *L. helveticus*, failed to grow in vegetables, such as cucumbers, brined at 4% to 5% salt.

A still further object of this invention is to provide a new and novel process for manufacturing pickled vegetable products in the retail and wholesale containers as

well as in bulk for reprocessing as pasteurized vegetable products and for use as brine-stock pickles in the manufacture of conventional processed pickled products.

A still further object of this invention is to provide new and novel types of fermented vegetable products in which the firmness (texture) remains substantially that of the starting vegetable material, and which is essentially acetic acid-free and contains lactic acid.

The new process as applied to the manufacture of pure culture pickled vegetables such as cucumber pickles involves:

(1) Harvesting, sizing, and washing the vegetables.

(2) Subjecting the vegetables to a heat shocking or continuous blanching operation which step amounts to a surface sanitization. The vegetables are subjected to the heat shocking treatment by completely immersing them, in bulk, in a water bath, or putting them through a suitably-modified continuous hot water blancher until the internal temperature reaches 145° to 150° F. For cucumbers of commercial grade size 1B (⅞ to 1 1/16 inch diameter) or other vegetables of similar size, the temperature and time requirements are in the order of 170° F. for 3 to 5 minutes. The temperature and time factors will, of course, vary for the different size vegetables to avoid excessive heating (see Table I). This is particularly true for the continuous heating operation using a rotary hot water blancher. Here the rate of travel of the cucumbers or other vegetables through the machine and the temperature of the blanching water during operation must be calibrated for each vegetable size used and necessary adjustments made to insure that the internal temperature of the heated vegetables reaches the recommended range (145° to 150° F.). Furthermore, the vegetable material must be kept completely submerged during the heat-shocking treatment. For vegetable sizes exceeding 1½ inches in diameter, the calculated immersion time given in Table I can be reduced by preheating such material to about 110° F. For example, preheated size 3 cucumbers, or carrots, and green tomatoes of this diameter (1½–2 inches), would then receive the immersion time given in Table I for 2B size. This is particularly important in mixed vegetable packs where certain of the vegetables used may be of a larger diameter than others. The heat-shocking treatment is highly effective in substantially destroying vegetative micro-organisms, particularly the asporogenous species normally found on the untreated vegetables in great numbers (i.e., about 200 million present on a 1 inch diameter cucumber) and considered as interfering and competitive contaminants in the pure culture fermentation process. Also, the heat-shocking-treatment inactivates or attenuates certain deleterious heat-labile enzyme systems of plant or microbial origin associated with cucumbers and other vegetables which, if present in sufficient concentrations, could otherwise cause deterioration of the texture, color, flavor, and odor of the fermented product.

TABLE I

Size of Cucumber (Commercial Designation)	Size of Cucumber (Diameter, inches)	Water Temp., degrees F.	Time of Immersion, minutes
1A	Up to ⅞	170–172	3.
1B	⅞–1 1/16	170–172	3–5.
2A	1 1/16–1 5/16	170–172	5–7.
2B	1 5/16–1½	170–172	7–10.
3 [1]	1½–2	170–172	10–15.
4 [1]	Over 2	170–172	15–20.

[1] Preheat to about 110° F. and use the immersion time given for size 2B

(3) Draining and packing the heat-shocked vegetables in sanitized containers with sanitized closures. The term "sanitized" is employed as being descriptive of a container and its closure that have received conventional washing and then rinsing with a chlorine solution of sufficient strength to destroy the asporogenous microbes, plus the normal careful handling that is exercised in the care of food containers intended for human use.

(4) Covering the packed vegetables in the sanitized containers with a concentration of salt (sodium chloride) brine which will equilibrate to approximately 1.6% to 10% by weight and which brine has been previously heated to 175° to 180° F. to destroy asporogenous microorganisms and then cooled to such a temperature level (about 40–45° F.) that the total pack (i.e., heat-shocked vegetables, plus brine and container) will equilibrate out within the desired temperature range of the particular strain or species of lactic acid organisms chosen for the fermentation. For pure culture brine stock vegetables that are to be used for manufacture of various processed pickled products, cover brines equilibrating in the range of 5% to 8% by weight are used.

(5) Adding an inoculum of selected pure culture lactic acid producing bacteria in the form of either dried pellets, dried granules, dried powder, or broth to each of the containers, the micro-organisms being introduced in a quantity the order of magnitude of which is about 1,000,000,000 viable cells per quart of the packed and brined vegetables.

It is advantageous in the case of slow growing species and strains to add, prior to inoculation, a sufficient quantity of food grade, edible lactic or acetic acids or vinegars to reduce the equilibrated brine pH to within the 4.6 to 4.2 range to favor the growth of the introduced lactic acid producing bacteria and greatly retard or completely inhibit the growth of the spore-forming types that survive the heat-shocking treatment. A brine pH of about 4.5 is a good practice.

(6) Adding dill weed, oil of dill, garlic (either fresh or as the essential oil), and/or other pickling spices or essential oils to give desired flavor characteristics to the finished product. The addition of the above spices and flavorings is optional, but if used they must be carefully sanitized to rid them of any competitive and interfering asporogenous microbial groups. Essential oils (dill, garlic, etc.) can best be sanitized by emulsifying, using conventional methods directly in the cover brine prior to heating and cooling the brine, as described earlier (Par. 4). For pure culture brine-stock pickles, or for pickles destined for use as fresh pack products the spices and flavorings are omitted.

(7) Hermetically sealing the containers with sanitized closures and incubating them at ambient temperature, room temperature, or preferably at the temperature which is optimum for the lactic acid producing bacterial species selected. The growth of the pure culture organism, introduced just prior to sealing of the containers, progresses for a period of several days after which time the fermentation of the vegetables is substantially complete and the activity of the pure culture organism subsides and finally ceases altogether. The fermented product, which is a firm-textured, essentially acetic acid-free, fermented cucumber, or other vegetable, material containing lactic acid, is ready for use in 3 to 4 days but improves with age through several months.

As a practical demonstration of the pure culture process, 144 fermentations including controls were carried out in standard quart jar containers. The freshly harvested pickling cucumbers, graded Size 1A (up to ⅞ inch diameter), were given a water wash primarily for the purpose of removing field debris and dirt and were then subjected to a heat shocking treatment that consisted of immersing the cucumbers in water at a temperature of 170° F. for a period of five minutes at which time the internal temperature of the cucumbers had reached 148° to 150° F. The heat-shocked cucumbers were then drained, packed in glass containers, and covered with brine of concentration of 7.8% salt by weight, which equilibrated at 3.0% to 3.5% and which contained an emulsion of oil of dill and garlic concentrate. The previously prepared brine had been boiled and cooled to approximately 40° to 45° F.