BAG-IN-BOX TECHNOLOGY: Storage Stability of Process-Ready, Fermented Cucumbers

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ABSTRACT

Process-ready, fermented cucumbers were microbiologically stable for up to 6 months when held at 4% salt, and up to 12 months when 0.1% sodium benzoate also was present. At 2% salt, some fermentations were unstable at 6 months of storage. Microbial instability was associated with a rise in brine pH (from 3.5 initially), increases in CO_2 and acetic acid concentrations, and a decrease in lactic acid concentration. A rise in CO_2 concentration was associated with bloater formation. The composition of the bag in which the fermented cucumbers were held influenced the growth of oxidative (film-forming) yeasts in brine near the bag surface. These yeasts seemed to grow to an extent limited by the rate of oxygen permeation through the plastic bag. Ultra-low density polyethylene (3-mil, 4-ply) seemed too oxygen-permeable for extended (several months) storage of the brine-stock in the bags. A polynylon layer in the bag provided a greater but not complete oxygen barrier.

INTRODUCTION

The use of high concentrations of salt traditionally has been used to assure the microbial and quality stability of brine-fermented cucumbers held in bulk tanks. The brined cucumbers are held in the tanks from a few to many months as a means of extending the processing season. The tanks have open tops, which facilitate filling and emptying. During storage, the brine surface must be exposed to UV rays of sunlight to prevent the growth of oxidative yeasts and molds which will utilize the acid produced during fermentation, resulting in a rise in pH with resultant growth of spoilage and potentially pathogenic microorganisms.

There has long been a concern for holding the cucumbers in open tanks, and particularly outdoors because of possible entry of foreign material. Also, oxygen from air exposure is known to cause flavor and other quality problems during storage. Various methods have been tested to solve the above problems, including use of oil to blanket the brine surface and, thereby, prevent surface growth of yeasts and molds (Etchells and Veldhuis, 1939), addition of a plastic tank cover before fermentation (Finlay and Johnston, 1956) and a post-fermentation tank cover (J. L. Etchells, unpublished), holding the tanks indoors with artificial UV light mounted over the brine surface (Fabian and Bryan, 1932), and fermenting/storing the cucumbers in anaerobic tanks (Fleming et al., 1983). Sufficient problems or objections with all of these procedures have prevented their broad acceptance.

The bag-in-box concept (Fleming et al., 2002) is an attempt to find a commercially acceptable method to answer the above concerns, while offering a means of eliminating wastes and improving product quality. However, the fermented cucumbers must be stable from microbiological and quality standpoints for commercial acceptability. The objectives of this study were to determine the storage stability of bag-in-box fermented cucumbers and factors influencing this stability. Some of the factors studied included salt concentration, use of the preservatives sodium benzoate and potassium sorbate, and type of material used to construct the bags.

MATERIALS AND METHODS

Microbiological Analyses

Brines were analyzed for total aerobes, lactic acid bacteria, yeasts, and molds with plating media, as described by Fleming et al. (2001). Dilutions for plating were made in sterile 0.85% saline and were then plated with a model D Spiral Plater (Spiral Systems, Inc., Cincinnati, OH).

Chemical Analyses

Malic, lactic, and acetic acids were analyzed by HPLC with an HPX-87H column (Bio-Rad, Richmond, CA) with 0.03N sulfuric acid as the eluant. The column was heated to 140°F (60°C) at a flow rate of 0.8 mL/min. A photodiode array detector (model UV6000, Thermal Separations) set at 210 nm (Frayne, 1986) was used for the detection of these organic acids. Sorbic acid was also analyzed by HPLC using a Bio-Rad Fast Acid column with 0.03N sulfuric acid at 0.9 mL/min and 140°F. The sorbic acid was detected at 240 nm. Fructose, glucose, and ethanol were detected on a refractive index detector (model 410, Waters Associates, Inc., Milford, MA) coupled in series after the photodiode array UV detector. Dissolved CO_2 was measured as described by Fleming et al. (1974). Salt (NaCl) was measured by titration, as described by Fleming et al. (2001).

Headspace Gas Analysis

For taking gas samples by needle and syringe, a strip of duct tape (~6 x 2 inches) was adhered to the outer surface of the bag in the area above the brined cucumbers near the base of the bag snout (see Fig. 7 of Fleming et al., 2002). A 21-gauge needle, attached to a 12 cc plastic syringe (Monoject), was inserted through the taped portion of the bag and about 10 cc of the gas was withdrawn. The needle end was inserted into a solid rubber stopper to prevent escape of the gas. Three replicate samples were taken and transported to the laboratory for analysis that day when possible. After sampling, another strip of duct tape was placed over the strip of duct tape through which the sampling needle was inserted. When analysis was delayed, the syringed samples were stored under water until analysis, as suggested by Blankenship and Hammett (1987). The samples were analyzed with a Hach Carle Gas Chromatograph (Series 400 AGC, EG & G Chandler Engineering, Broken Arrow, OK) as described by McConnell (2001). Composition of the gas was expressed as percentages of CO_2, O_2 and N_2, based on a standard gas mixture.

Product Evaluation

Fermented cucumbers were evaluated for bloater damage, and the damage was expressed as "bloater index," as described by Fleming et al. (1977). Cucumber firmness was measured with a USDA Fruit Pressure Tester, as described by Bell et al. (1955).

Experimental Design for Storage Stability

After opening the fermentation/storage bag and evaluating the cucumbers, 5-gal pails of cucumbers and brine were returned to the

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ABOUT THE COVER:

Bulk storage in brine has been an economic means of extending the processing season of pickling cucumbers since before the 1930's (1). When larger sizes of cucumbers began to constitute a higher proportion of the crop in the 1960's, bloater formation resulted in buoyancy force sufficient to rupture tank heading timbers (2), but purging of CO_2 from the brine reduced bloater damage and buoyancy forces within the tank (3). However, use of high concentrations of salt in brine storage requires washing of the excess from the brine-stock before conversion to finished products, which requires the use of aeration ponds to biodegrade the organic matter (4), but still results in problems in the handling of salt and other non-biodegradable wastes. The use of fiberglass and polyethylene tanks (5) has reduced salt leakage that was prominent with wooden tanks (1-3), but relatively high salt concentrations are still used to serve as insurance against vagaries of nature due to tanks being open to the atmosphere. Closed tanks have been considered by the industry (6), but various factors have resulted in modernized brine yards of open-top, fiberglass and polyethylene tanks and a waste handling system (7). This issue of the journal is devoted largely to summarizing efforts to design and test a pilot system (8) for preserving "process-ready," brined cucumbers with improved quality and reduced wastes, and with intended benefits to the producer and processor of pickling cucumbers.

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Bulk Storage in Brine Since the 1930's





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