Chapter

Cucumber Pickles and Fermentations

Sarmad Ghazi Al-Shawi and Sadiq Jaafir Aziz Alneamah

Abstract

Cucumber sometimes used in sodium chloride solution as a substrate in lactic acid bacteria fermentation. The good fermentation always depending on many overlapped physical, chemical and microbial factors related with suspension of a strong and porous vegetables in a fluid. Keeping the cucumber integrity is very critical issue, and this may affect on the fermentation of liquid ingredients. This chapter tries to focus on the current efforts that conducting to control on the factors that affecting on cucumber fermentation. Modern and advanced technologies of recent studies are included within this chapter just like reducing the brining sodium chloride concentration, fresh cucumber gas exchange to develop their brining properties by using lactic acid bacteria cultures, developing an anaerobic cucumber fermentation tank system; preventing of cucumber gaseous spoilage by pouring of CO_2 from fermentation brines.

Keywords: lactic acid bacteria, cucumbers, fermentation, sodium chloride, brine

1. Introduction

1.1 Historical perspective

Different fermented foods could be categorized according to fermentation products just like organic acids which consisting of acetic acid and lactic acid (dairy and vegetables); and peptides and amino acids resulted from protein (fish and other fermentations); CO_2 (bread); and alcohol (wine and beer) [1, 2]. Food fermentation is one of an early the most precise innovations created and developed by people.

In Asia, coastal foragers during the age of primitive pottery (8000 to 3000 b.c.) were thought to have fermented vegetables before developing of crop-based agriculture [3]. It is possible that dairy fermentations in Middle East came after cattle domestication, alcohol was the first discovered fermented product from fruit fermentation. Many advanced fermentation procedures to produce alcohol by using the cereals were created nearly 4000 b.c., just like producing wine from rice in Asia and beer in Egypt [1]. In Asia, many composed references regarding fermentation innovation were found in historic poems Shijing Chinese book (1100 to 600 b.c.), that celebrates "the thousand wines of Yao," in referring to a kingdom in China from 2300 b.c. Cucumber thought were first fermented nearly 2000b.c. in Middle East. Old composed records came from the remains of papers of a play (The Taxiarchs) by Eupolis a writer from Greece (429–412 b.c.), also in Christian Bible, pickles were repeated many times. The fermented cabbage and kimchi on the Korean style, is

expected to have established in the primitive pottery age from the wizened vegetables ordinary fermentation stored in seawater [1].

Sauerkraut on European style is thought was established in China, while the technique might be transferred to Europe at the invasion time of Mongol to central Europe in the 13th century. Nowadays, the vegetable fermentation industry is conducting on an enormous scale. Companies in United States that working on cucumber pickles fermentations may have 1000 fermentation tanks of forty-thousand-liter capacity at one site.

Throughout the ages, it was believed that cucumber pickle as the fairly fermented cucumber to which spices, vinegar, salt, and sometimes sugar has been added. While the preservation was not required by using the heat. Recently, fresh packed pickles, manufactured by adding of spices, salt, and vinegar to the fresh cucumbers under pasteurized preservation, are representing a huge portion of pickle industry.

Industrial treatments tentatively preserve around 40% of crop through the fermentation in NaCI brines that contain fermentable carbohydrates which converting into acetic acids, ethanol, lactic acid, CO_2, and other compounds by naturally existence lactic acid bacteria and yeast. This procedure uses to expand the using equipment packing line and workers to throughout the year operation in manufacturing of the final product.

Traditionally, fiberglass, wood, and polyethylene tanks are used for the fermentation that might require 10–21 days (period of storage in the same tanks is generally less than 1 year) and sometimes longer. Tanks are put outdoors to give the opportunity for sunlight ultraviolet irradiation to hit the surface of the brine and subsequently inhibiting yeasts and molds growing, and other microorganisms on the surface of the brine.

During the fermentation of cucumber pickles, brine storage and processing operations are liable to the reactions of oxidation which affect adversely on the quality properties. In spite of pickles are flooded in brine during fermentation and bulk-storage, while the containers are opening, which encourage the exposure to air and sunlight.

Additionally, pickle tanks' brines are usually spread with air in order to mix the components and to release CO_2, and at the time of transferring to processing operations, pickles are removed from brine and subsequently exposes to light and oxygen. Also, the brines and pickles content of traces prooxidant metals just like copper, zinc and iron which act together with oxygen and light to be in charge of pigments oxidation and developing undesirable flavors sometimes, and this may lead to considerable economic loss of the market value.

1.2 Cucumber fermentations

Cucumber (*Cucumis sativus*) fermentation in United States is conducted in 30,000–40,000 liter, fiberglass tanks with open top and placed outdoors to allowing the surface to exposure to sunlight. Sunlight UV radiation is dependent to suppression the surface aerobic yeasts that have the ability to utilize lactic acid that resulted from fermentation. Cucumbers are submerged totally with salt brine and kept under the brine surface with wooden headboards. Fermentation is usually conducted in 6% NaCl. Calcium chloride typically added the cover brine in order to keep the fragile texture, and firm of the fermented cucumber throughout fermentation and storage [4]. The fermentations of cucumber usually subject a homolactic acid fermentation, that is not resulting CO_2 from sugars. Although CO_2 could be produced via cucumbers respiration and via malate decarboxylation over the beginning of fermentation [4]. Some of lactic acid bacteria have an analytical malolactic

enzyme that converting malate to lactate and CO_2. The reaction of malolactic enzyme takes place intracellularly resulting in proton absorption, subsequently increasing the internal pH of the cell. Although it is a recommendable reaction in winemaking (applied to removing the acidity of wines), the fermentation of malolactic in cucumbers may lead to formation of "bloaters," or undesirable pockets of internal gas, resulting in decreasing the yield of the production [5]. In order to prevent the formation of bloater, the fermentation of cucumber is clean with air to get rid the surplus CO_2 from the tank [6]. In order to restrict the growing of aerobic microorganisms in air-purged cucumber fermentations, especially molds and yeasts, acetic acid (0.16%) or potassium sorbate (~0.04%) could be used as aids in processing [7].

Air purging may be stopped each day several hours to control aerobic microorganisms' excessive growth. Usually, cucumber is fermented with *Lactobacillus. plantarum* and other LAB and may store for year in fermentation tanks in degrees under than 0 °C while NaCl concentration commonly increase to 10–15% during the storage to reduce freezing damage and keeping the required fermented cucumber texture. Cucumber should be washed before selling in order to remove the excess salt and then using different packages (jars, pouches, plastic pails) with suitable covers in packaging. The covers usually contain spices, acetic acid, and lactic acid residues. Pasteurization sometimes is used for fermented pickles while heat treatment is not used for big containers. Excessive growth of microorganisms is eliminated by low pH, organic acids, and absence of fermentable sugars. Cucumber fermentations depend on the growing of LAB that existence naturally on cucumbers surface. Although, some starter cultures are added to cucumber fermentation to get a consistent product, adding *Lactobacillus plantarum* does not decarboxylate malic acid (subsequently does not form bloaters) [9], and this approach has been created, developed, and tasted to identify culture growing capability in cucumber fermentations [10]. A procedure for starter culture preparation that suitable for the requirements of kosher is applicable to producers [11]. The brined cucumbers' primary pH is nearly 6.5. Recycled brine could be used in commercial fermentations, or adding acetic acid to brine solutions. This acid addition may help in removing the excess CO_2 and encouraging LAB growth, so the commercial fermentations' primary pH could vary basically. Some of the metabolites could have an inhibitory effect on the other bacteria just like peroxides, bacteriocins, and peptides [12]. There might be 1.5% lactic acid, pH (3.1–3.5), few or no sugar at the end of fermentation. In such an environment that is acidic, anaerobic, high salty, and lacks sugar, there are a low number of microorganisms that have the ability to grow and survive to preserve cucumbers. Sometimes during storage, fermented cucumbers expose secondary undesired fermentation which is identified by pH increasing, lactic acid vanishing, propionic and butyric acid formation. Deterioration of fermented cucumber happening at the spring season beginning when increasing the surrounding temperature. Increasing propionic and butyric acid concentrations lead to smelly spoilage [13]. The microbial environment of this spoilage presently is not closely defined but may attribute to the growth of bacteria that form spores such as clostridia when increasing the pH above 4.6. The salt concentration of the fermented cucumbers is about (6% or more) and this is very high for consumption directly by humans. Therefore, the salt concentration is reduced to around 2% by water washing directly before packing and distribution. This treatment lead to high salt concentrations of the waste stream in addition to a high BOD resulting from the organic ingredients that are existed in the brine and that spread out of cucumbers over the process of desalting. Hence, cucumber brine of the desalting process is commonly recycled and might be utilized another fermentation [14]. The brines fermentation could be treated in order to expel the softening enzymes (mostly polygalacturonases) before

the recycling [15], which acts on degrading cucumber cell's pectic substances and softening the fruits.

1.3 Critical factors for fermenting cucumbers

Fermentation is influenced by variables due to cucumbers, environmental conditions under which they are kept during fermentation, and microorganisms that are naturally present or intentionally added. Since it is so important to maintain the structural integrity of cucumbers, both physical and chemical factors are involved. The interactions between these factors lead to an extremely interesting and complex fermentation process [16]. A lot of research on the fermentation of cucumbers and other fruits and vegetables has been done. However, there is an incomplete understanding of the interactions between the microbiological, chemical, and physical factors involved.

Before the cucumber fermentation industry can take full advantage of the biotechnology revolution that looms for many fermentation industries, more understanding of these interactions is needed [17].

1.4 Microbial changes in spoilage

The production of CO_2 in the cover brine of fermenting vegetables by heterofermentative LAB and fermentative species of yeasts has been linked with gas pockets formation inside the cucumber, which called formation of bloater (**Figure 1**). Homofermentative LAB capable of decarboxylating malic acid, as example *L. plantarum*, might cause bloating by producing a sufficient CO_2 when combined with the CO_2 formed from the respiring vegetable tissues [9, 18]. Prevention of bloater formation was effective in fermented cucumber brines by using nitrogen or air [6, 19]. Air purging has to be carefully controlled as it may result in fruit softening due to mold growth [20, 21] reduced brine acidity due to yeast growth and off-colors and flavors. The addition of potassium sorbate to fermentation brines, including the application of spray to brine surfaces, is widely used to minimize the growth of yeast and the development of CO_2.

Oxidative yeasts may cause malodorous spoilage of fermented cucumbers to develop. The lactic acid generated during fermentation can be consumed by these microorganisms, with a subsequent increase in pH that facilitates the development of spoilage microorganisms [22, 23]. In cucumbers, lactic acid produced during primary fermentation can be catabolized by yeasts of the genera Pichia and Issatchenkia, causing an increase in pH.

Pectinolytic enzymes derived from plant material or microbes can cause the softening of brined vegetables (**Figure 2**).

Mold growth accompanying film-forming yeast growth on the brine surface can cause softening of cucumbers. In the absence of sunlight and the presence of minimal amounts of oxygen, heavy scum yeast and/or mold growth is generally the result of neglecting brine material during extended storage. [25]. In order to maintain anaerobic conditions and to limit the growth of surface yeasts and molds, Pickled cucumber tanks are usually held indoors, with a seated plastic cover weighted down with water or brine. Mold polygalacturonases associated with cucumber flowers can also result in the softening of brined cucumbers. [26] By draining and rebrining the tank with calcium chloride, this problem can be reduced. 36 hours after the initial brining procedure. However, this solution is not about salt disposal. Recycled brines are instead treated to inactivate the softening enzymes, if necessary. [15] The addition of calcium chloride may slow down the rate of fermenting cucumbers' enzymatic softening. This should not, however, be relied upon

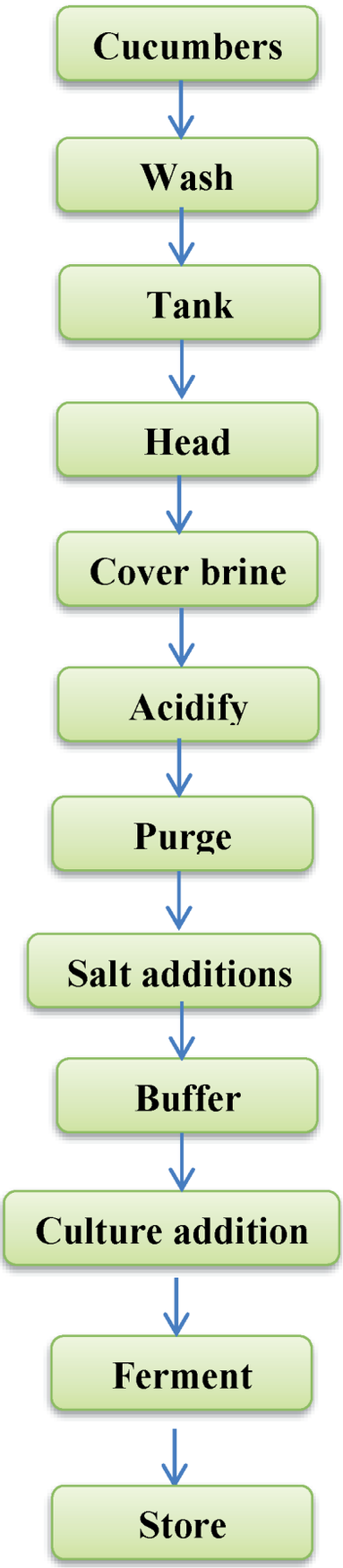

Figure 1.
Steps brine fermentation of cucumber [8].

to eliminate problems with enzymatic softening. Care must be taken to minimize the contamination of flowers and plant debris by cucumbers, especially small fruits, which may be a source of contamination by pectinolytic molds. Due to the reduced

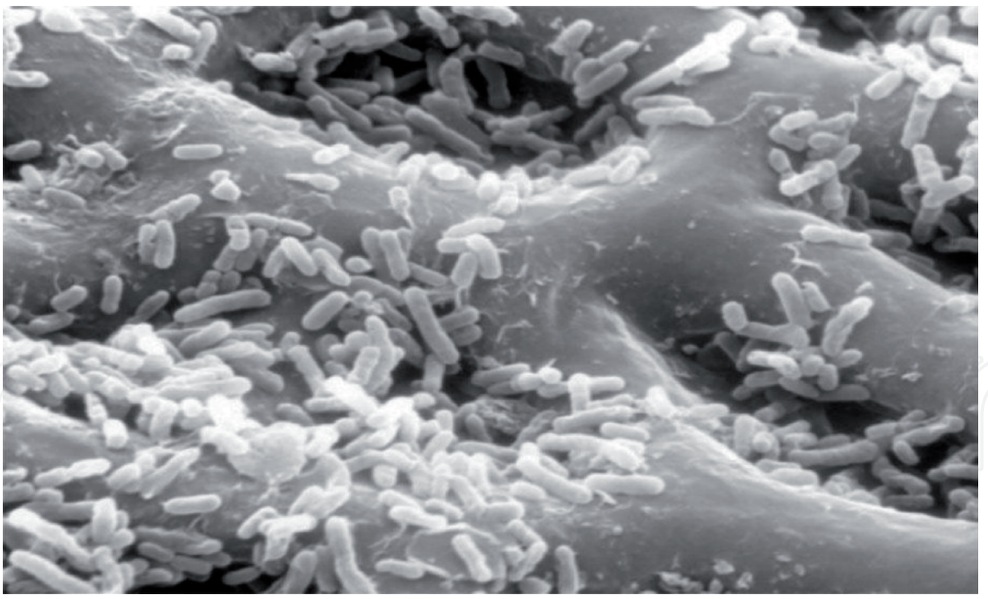

Figure 2.
Lactobacillus plantarum cells colonizing the cucumber tissue [24].

amount of brine surface in contact with air compared to the total volume, softening is not a very serious problem in bulk Spanish-style cucumber fermentation. Yeasts and/or molds on the plastic drums used during the conditioning operations (sizing, grading, pitting, stuffing, etc.) can, however, cause softening. [22]. Desalting is used to prepare non-pasteurized fermented cucumbers, followed by the addition of cover liquor, often containing acetic acid and preservatives. Sugar is added to sweet pickles at concentrations of up to 40 percent. The main spoilage organisms in such products are osmotolerant yeasts, and a preservation prediction chart, based on the concentration of acid and sugar required for shelf stability, has been developed. On the surface of the liquid, aerobic molds and film yeasts may grow, mainly as a result of defective jar closure. Spoilage microorganisms in sweet pickles include yeasts [27] and lactobacilli, particularly the heterofermentative *Lactobacillus fructivorans*. In order to prevent the growth of LAB and yeast, non-fermented pickle products in which acetic acid is added to fresh cucumbers (known as fresh-pack pickles) are pasteurized. Recommended procedures include 165 °F (74 °C) for 15 minutes, as described by [28]. Spoilage usually occurs due to improper processing (insufficient heat to pasteurize) and/or improper acidification of pasteurized pickle products, so that a balanced brine product of pH 3.8 to 4.0 is not achieved. Molds and film yeasts are factors in cases of poor jar closure, where oxygen is introduced into the container, as with sweet pickles.

This can lead to a potentially dangerous situation triggered by an increase in pH as the spoilage microorganisms consume organic acids. Germination of *Clostridium botulinum* spores can occur if the pH rises above 4.6. Non-acidified refrigerated products are sold commercially under a variety of names, including half-sour dills, real kosher dills, new kosher dills, sour overnight dills, garlic pickles, new half-sour pickles, new half-sour pickles, new half-sours, new home-style pickles, etc. [29]. These cucumbers may be kept at room temperature in barrels for a few days or longer and then refrigerated at 2–5 ° C to allow fermentation to occur. Microbial growth, enzymatic activity, and the curing process continue at a slow rate under cooling conditions. [29] The gaseous spoilage of the product is caused primarily by the previously mentioned microbial groups that form gas. Due to the much lower concentrations of salt added to these product types, softening issues in refrigerated-fermented products may develop. To such products, fresh, whole garlic cloves and

other spices are normally added. It is possible that these spices contain softening enzymes. Whether the half-sour products are manufactured in bulk or in the retail jar, for more than a few weeks, the very nature of the product makes it difficult to maintain good quality. The barreled product achieves the Good Manufacturing Practices (GMP)-recommended brine pH of 4.6 or lowers for acidified foods typically before or shortly after refrigeration, and then slowly begins to produce acid. For a product made in a retail jar, this recommended condition for brine-product pH cannot be ensured because there is no uniform process adopted by the packers in which the product is initially acidified or intentionally incubated for the development of natural fermentation with lactic acid.

The refrigerated fresh-pack (non-fermented) products contain 2–3 percent NaCl and sometimes sodium benzoate or other preservatives and are acidified with vinegar at a balanced pH of around 3.7. [29] The cucumbers are not heated, like the half-sour pickles, either before or after packing. The products will maintain an acceptable quality for several months if properly acidified, refrigerated, and preserved. However, recipes containing no vinegar or other acid in the initial cover liquor should be considered with caution. Quality assurance of cucumber products begins with the removal of the cucumber's outer leaves and woody core. In addition to its undesirable texture, the existing sucrose in the core could be utilized by *Lactobacillus mesenteroides* resulting in formation of dextran which lead to a stringy and slimy texture. Cucumbers marketed under refrigerated conditions are preserved by the addition of sodium benzoate and metabisulfite [30]. Chemical changes that can result in discoloration (browning) and the formation of objectionable flavors influence the shelf life of such products. The growth of naturally occurring yeasts in cucumbers may result from uneven salting during cucumber preparation and may induce pink coloring and vegetable softening. Spanish-style olives were formerly preserved in cover solutions containing relatively high salt concentrations through fermentation. However, it has been demonstrated that an appropriate combination of low pH (3.5), combined acidity (0.025) mill equivalents (mEq)/L) and moderate proportions of acid (>20.4%) and salt (>25.0%) is also able to preserve well-cured cucumbers [31]. Incompletely cured cucumbers or those with characteristics outside the ranges necessary for complete stabilization without heat treatment have been gradually used to allow pasteurization to be commercialized. [22] In some cases, particularly when pasteurization is not recommended (plastic bags, seasoned olives, etc.), producers used authorized preservatives such as potassium sorbate or sodium benzoate [31].

1.5 Fermentations biochemistry

Usually, fermentation is defined as an anaerobic process. Within the cucumber fermentation process, LAB and yeast convert glucose and fructose into lactic acid, ethanol, acetic acid, and CO_2. The homofermentative LAB main pathway is breaking down of one six-carbon sugar (glucose) to produce two molecules of three-carbon lactic acid. More complex metabolism is used by Heterofermentative organisms. At the beginning, glucose is converted into CO_2 five-carbon sugar phosphate, and furthermore degraded into lactic acid and a two-carbon compound, acetic acid or ethanol [32]. We shall concentrate here on vegetable fermentation biochemical features that link to quality of the product. So far, many researches are paying more attention in vegetables fermentation and storage, especially cucumbers, with reduced salt. Vegetable fermentations' chloride waste can be extremely reduced in case of reducing the required salt for fermentation and storage in order to exclude the desalting step before the conversion to final products. Many research studied the relationship between concentration and type of the salt [33]. Replacing

of NaCl with various cations and anions on fermentation of sugar in cucumber juice. The most interesting thing, fructose was the most preferred fermentable sugar to *Lactobacillus plantarum* more than glucose in most of experiments. Along with addition of different salts, the utilization of sugar was decreasing as anion or cation concentrations increasing. [33, 34] have identified various volatile ingredients in cucumbers that fermented with *Lactobacillus plantarum* (2% NaCl). About 37 volatile ingredients were determined, and as a result of fermentation, there was a little change in most of them. Inhibition of (E, Z)-2,6-nonadienal and 2-nonenal production was the most outstanding fermentation effect on cucumber volatiles. [35] Characterized trans- and cis-4-hexenoic acid as the strongest odors that specify the brine aroma properties of commercially fermented cucumbers in nearly 6% NaCl. [36] Illustrated that exposing the slurries (2% NaCl) of fermented cucumber to oxygen resulting in formation of nonenzymatic hexanal plus a series of trans unsaturated aldehydes with 5–8 carbon atoms that linked with oxidized odor intensity development the tissue of fermented cucumber. In the existence of light, about 100 μg/ml concentration of calcium disodium EDTA preserve nonfermented pickles against bleaching of pigments and lipid oxidation [15]. Although, when using this compound, there was a little reduction in pickles' firmness retention. Firmness retention in cucumbers fermentation and storage is a key quality issue. It is difficult to assure the firmness retention (in reduced salt fermented cucumbers) equal to what can be accomplished by fermenting and storage in 6% NaCl or more. Nevertheless, over many previous years there was a wide understanding for softening of cucumber tissue.

[21] Showed the importance of calcium in keeping fermented cucumbers' firmness. It was found that first-order kinetics is followed by the nonenzymatic softening of acidified, blanched cucumber tissue [37]. The mentioned kinetic manner made it reasonable to identify the activation of entropy and enthalpy of cucumbers' nonenzymatic softening, although that the chemical reactions in charge of softening were not known. At 1.5 M NaCl, both activation of entropy and enthalpy were high. Cucumber softening was inhibited by calcium because it reduced activation entropy too much into a limit that activation overall free energy was reduced [38]. This behavior of thermodynamic is resembled to that which occurs when changing conformation of polymers, just like in denaturation of protein. It is totally differed from the observed properties of pectin acid hydrolysis. [39] Figured out that pectin's acid hydrolysis rate was inefficient to be the reason for non-enzymatic softening the tissue of the cucumber. [40] Identified salt, temperature, and calcium concentrations combined effects on fermented cucumber tissue's softening rate. The softening kinetics of fermented cucumbers did not follow the first-order simple reaction. Just like the tissues of many other plants, cucumber possesses enzymes that have the ability to degrade the ingredients of plant cell walls, which may lead to changing in the texture.

In cucumbers, many activities of enzymes have been found such as exopolygalacturonase, pectinesterase, and endopolygalacturonase [41]. When fermenting or acidifying of cucumber, methyl groups are removed from pectin by pectinesterase [42]. Nevertheless, pectin's' enzymatic hydrolysis by polygalacturonases from cucumber has not been identified if it is a significant factor in fermented cucumbers' softening. Adding of fungal polygalacturonases into the tanks of fermentation, especially on the flowers attached to small cucumbers has been linked to the commercially importance of fermented cucumbers' enzymatic softening. [43] developed a sensitive new method of diffusion plate to determine the activity of polygalacturonase in the brines of fermentation and found that alumino-silicate clay has the ability of adsorbing and removing the activity of polygalacturonase from the brines of fermentation that are recycled. Enzymes which could hydrolyze

polysaccharides of the cucumbers cell wall have not studied widely comparing with the enzymes that degrade pectin. [45] Showed that the activity of endo-β-1,4- gluconase in cucumber is inhibited under pH of 4.8 while endoglucomannan-splitting enzyme retains its activity under pH of 4.0 but is inhibited within the fermentation. In fresh cucumbers, they characterized 6 enzymes which hydrolyze p-nitrophenyl-glycosides of β-d-glucose, β-d-galactose, α-d-galactose, β-d-xylose, α-d-mannose, and α-l-arabinose, which were inhibited throughout the fermentation. The enzymes that have the ability to hydrolyze the synthetic substrates are widespread in plants. Resemble enzymatic activities were found in olives, pears, and Semillon grapes.

[44, 45] Discovered the same p-nitrophenyl glycosidases detected by [44] in cucumbers. She reported undetectable levels in 2% NaCl brines throughout the first week of fermentation [46, 47]. Gathered calcium addition, fresh cucumbers' blanching relatively to enzyme inactivation, and a quick fermentation using a malolactic-negative *Lactobacillus plantarum* culture for cucumbers' fermentation and keeping a required texture in reduced (4%) sodium chloride concentration. [48] Found notable degradation products of glucosinolate in cucumbers fermented with *Lactobacillus sakei* compared to cucumbers manufactured with lactic acid bacteria starter cultures. [49] Reported that ascorbigen, a compound resulted from a degradation product reaction of indole glucosinolate (glucobrassicin) and ascorbic acid, is the cucumbers' dominant glucosinolate degradation product. Glucoraphinin existed in fresh cucumbers was converted over the fermentation into sulforphorane, however, sulforphorane was a relatively small glucosinolate degradation product in fermented cucumbers. There are many concerns about the biogenic amines' formation in cucumbers. [50] Reported that storing cucumbers up to 12 months led to the formation of tyramine. While very trace amounts of tryptamine, histamine, and spermine were determined. These findings were assured in a study on vegetable products which concluded that tyramine concentration was about 4.9 mg/100 g in canned cucumbers [51], and the same finding and the concentration reported by [50]. No health risk existed referring to these mentioned biogenic amine levels, with the possible exception that individuals taking medications possessing monoamine oxidase inhibitors.

1.6 Fermented cucumbers-related problems

Compared to the fermentation of liquids such as beer, wine, and milk, unique problems are involved in the fermentation of whole vegetables. Structural integrity has to be preserved in whole vegetables, which is not a factor with liquids [52]. Tissue softening is also a serious defect that can be caused by pectinolytic enzymes of either microbial (primarily fungal) source [53] or of the cucumber fruit itself. Off-flavors and off-colors may result from improper methods of fermentation and handling.

The cucumber pickle industry is faced with waste disposal, in addition to spoilage problems. These wastes consist of the salt used to prevent softening during fermentation and storage, and the organic wastes. Salt concentrations used greatly exceed the 2–3 percent desired in the final product [54].

Thus, after storing the brine, the excess salt must be leached from the cucumbers before they are processed into finished products. Disposal of this non-biodegradable waste salt is a source of serious environmental concern. As the salt is extracted during leaching, soluble cucumbers, including desirable nutrients and flavor compounds, are also removed. These desirable components are not only lost, they must be degraded before being discharged into waterways. Discharge of salt and organic materials into municipal disposal systems typically entails an extra expense for pickle companies, since municipalities must charge for recovering the cost of handling such waste. [55] (**Figure 3**).

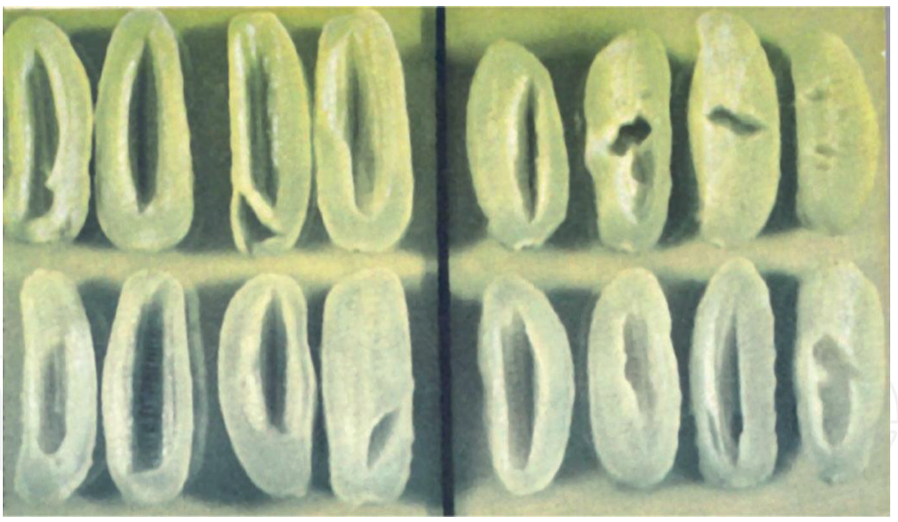

Figure 3.
Cucumber bloater defect caused by carbon dioxide microbiologically produced during fermentation by either yeasts or LAB [56].

1.7 Preventing flavor formation

Purge-and-trap analysis of cucumber slurries' volatile ingredients in 2 percent reduced-salt salt brine before and after cucumber fermentation. Volatile components' comparison before and after fermentation led to the derivation that the main influence of fermentation on volatile flavors was to prohibit the enzymatic production of E, Z-2,6-nonadienal and 2-nonenal enzymes in cucumbers [34]. These aldehydes are the major ingredients in charge of cucumbers' fresh flavor [57]. Although, after a few days of cucumber fermentation, when tearing the tissue of cucumber, the pH descends low enough to deactivate the enzymes that forming these compounds. In fresh cucumber slurries, just benzaldehyde, ethyl benzene, and o-xylene were not found within the volatile ingredients characterized in the fermented cucumbers. Recently, the absence of flavor influence of volatile aldehydes is the main effect of the fermentation on flavor [35]. In fermented pickled cucumber brines, a low influence of volatility flavor compound was characterized. Adding of saturated salt to brine samples and heating to 50 °C, SPME (solid-phase microextraction) fiber sampling followed by GC-olfactometry resulted in the identification of a component with an odor close to that of the fermentation brine. The component with a fermentation brine odor was characterized as *trans*-4-hexenoic acid. The existence of cis-4-hexenoic acid was also tentatively characterized. A solution containing 25 ppm trans-4-hexenoic acid, 10 ppm phenyl ethyl alcohol, 0.65 percent lactic acid, 0.05 percent acetic acid, and 8 percent sodium chloride in a reconstitute experiment had an odor very similar to that of fermented cucumber brine. Lactic acid, acetic acid, and sodium chloride concentrations are acceptable for commercial brines after completing the fermentation. Adding of phenyl ethyl alcohol resulted in in a few enhancements in the matching odor. For that, the key component in the simulated brine solution was trans-4-hexenoic acid. The source of trans-4-hexenoic acid in fermentation brines is, unfortunately, not recognized.

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