FDE 437
FERMENTATION TECHNOLOGY

Pickle Production

Pickle (*Turşu in Turkish*)

- In a very general sense, **pickles** refer to any vegetable (or fruit) that is preserved by salt or acid. With the amount of salt added and lactic acid produced by lactic acid bacteria, these two ingredients create an environment that can inhibit the growth of other spoilage microorganisms.

- During the production of fermented vegetables and fruits by lactic acid bacteria (LAB), sugars in raw materials are broken down into mainly lactic acid. Lactic acid and other produced acids help preservation of the product. Lactic acid fermentation also contributes to the sensory characteristics of foods such as desirable flavor, taste, texture, and appearance.

- Pickles are generally produced by **lactic acid fermentation** of fruits and vegetables. Actually, pickling is a kind of preservation technique of foods, especially vegetables.

Pickles

- A wide range of vegetables and fruits mainly cucumber, peppers, cabbages, tomatoes, and to a lesser extent, onions, carrots, cauliflower, okra, celery, mango, turnips, artichokes, beans, etc., have been preserved by pickling.

- Although pickles can be made from a wide variety of different vegetables and fruits, vegetables are more suited for the pickle production because of their structure.

- Certainly, the vegetable most often associated with pickles is the cucumber.

- **Pickles** (fermented cucumbers) and **Sauerkraut** (fermented white cabbage) are the most important commercially fermented vegetables in the world. Kimchi is also an important Asian variant of sauerkraut obtained by the fermentation of Chinese cabbage and mixed with some ingredients such as garlic, onions, and different kinds of herbs. (*The Korean version of sauerkraut is called kimchi.*)

- Only sauerkraut and cucumbers will be discussed, as the same general principles apply to the fermentation of all vegetables and fruits.

- In general they are fermented in brine, which eliminates other organisms and encourages the lactic acid bacteria.

Raw materials and auxiliary materials used in pickle production

Vegetables and Fruits:

- Although pickles can be made from a wide variety of different vegetables and fruits, vegetables are more suited for the pickle production because of their structure.

- Cucumber is the leading one among the vegetables used in pickle production in the world.

- Other than cucumbers, cabbages, green tomatoes, green peppers, and *acur* (Armenian cucumber) are the most popular vegetables used to prepare pickles.

- In addition, melon (*kelek*), carrots, green beans, red beets, and egg plants are used in some regions, depending on consumer preference.

Raw materials and auxiliary materials used in pickle production

Water:

- Water is used in pickle production both for cleaning purposes and for the preparation of brine.
- The water used in the preparation of brine must comply with sanitary conditions and should not contain heavy metal ions and basic salts.
- The hard and chalky water causes the sediments to collapse due to the acid formed as a result of fermentation and an unpleasant brine appearance; also, it neutralizes the acid formed by fermentation and causes a decrease in acidity.
- Since the water to be used in the production of pickles contains antimicrobial substances such as chlorine, which will prevent the proliferation of LABs, the water should not contain chlorine.

Raw materials and auxiliary materials used in pickle production

Salt:

- Rock salt is commonly used in the production of pickles.
- It is extremely important that these salts are pure and do not contain other metal ions.
- Impurities and metal ions that may be present in coarse rock salts that are not sufficiently purified may deteriorate the taste and color of the pickle, as well as cause softening-like deterioration due to the inability to adjust the salt concentration of the brine properly.

Vinegar:

- In the production of pickles, vinegar is initially used in the brine preparation stage to reduce the pH of the brine, to encourage the proliferation of LABs, or to prepare new brine for the pickles that have completed fermentation before sale.
- Dark-colored vinegar is not preferred as it will deteriorate the color of pickles and brine. If vinegar is thought to be added to the pickle and the colors of the vegetables are desired to be preserved, it would be appropriate to use colorless alcohol vinegar.

Raw materials and auxiliary materials used in pickle production

Additives:

- Garlic, parsley, fresh mint leaves, ginger, fresh dill leaves, and bay leaves are also often used as flavoring agents in the production of pickles *(turşu)*.

Lactic Acid Fermentation

1. General Properties of Lactic Acid Bacteria
2. Biochemistry of Lactic Acid Fermentation
3. Lactic Acid Fermentation in Pickle Production
4. Controlled Fermentation

1. General Properties of Lactic Acid Bacteria

- **LAB** are unicellular prokaryotes of Gram (+), non-sporulating, catalase-negative, facultative anaerobic, nonmotile, non-respiring cocci or rods, and acid-tolerant organisms.

- They form lactic acid as the major end product from the fermentation of carbohydrates. The produced lactic acid may be in the form of L (+) or D (−) or a mixture of both.

- From a practical, food-technology point of view, the following genera are considered the principal LAB:
- *Aerococcus*, *Carnobacterium*, *Enterococcus*, *Lactobacillus*, *Lactococcus*, *Leuconostoc*, *Oenococcus*, *Pediococcus*, *Streptococcus*, *Tetragenococcus*, *Vagococcus*, and *Weissella*.

- LAB are generally mesophilic (30-35°C) but can grow at temperatures as low as 5°C or as high as 45°C.

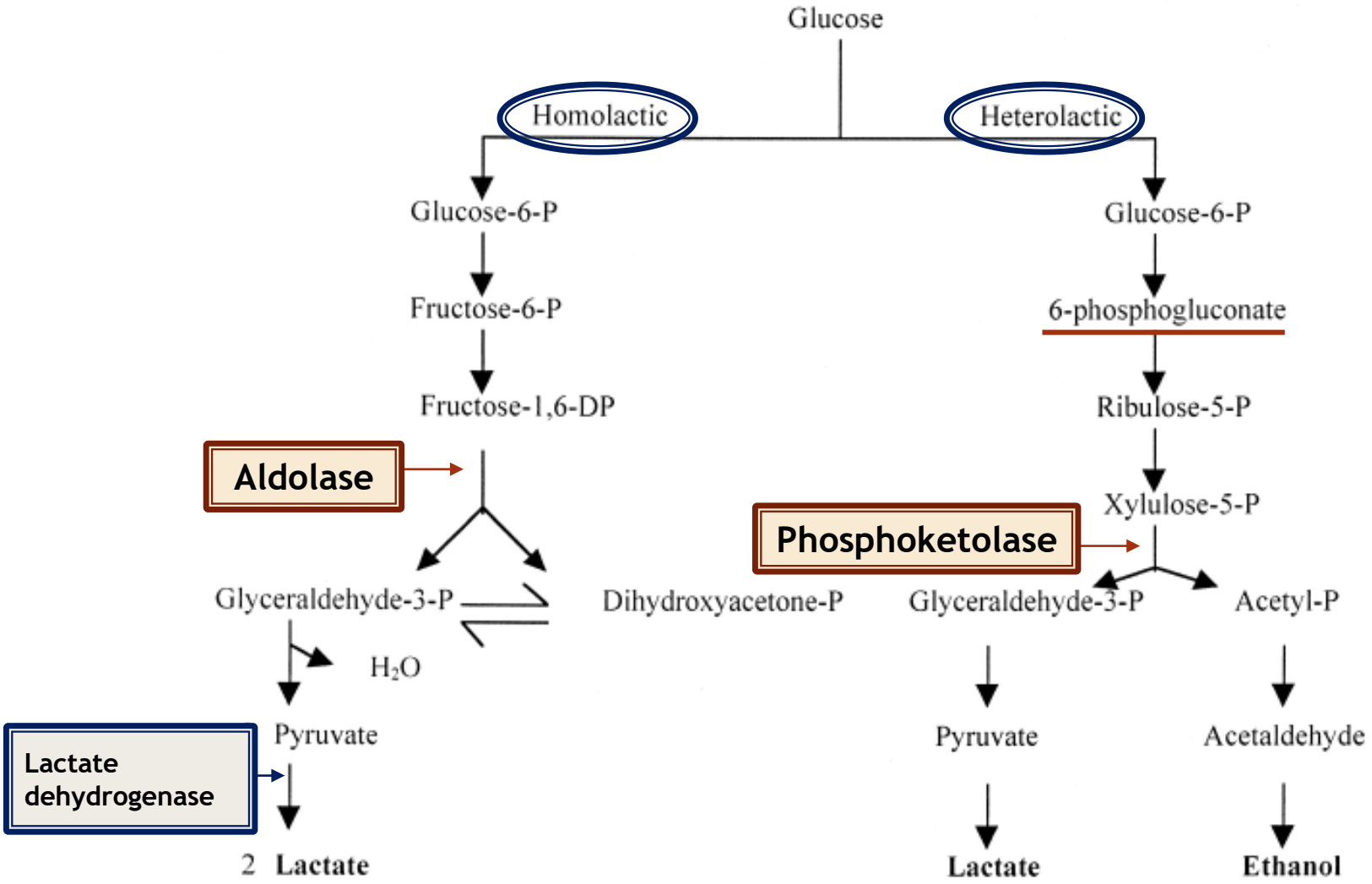
- Similarly, while the majority of strains grow at pH 4.0–4.5, some are active at pH 9.6 and others at pH 3.2.

2. Biochemistry of Lactic Acid Fermentation

- Two main sugar fermentation pathways can be distinguished among lactic acid bacteria.

- **Homolactic fermentation:** Glycolysis (Embden-Meyerhof-Parnas pathway) results almost exclusively in lactic acid as the end product under standard conditions, and the metabolism is referred to as homolactic fermentation.

- **Heterolactic fermentation:** The 6 phosphogluconate/phosphoketolase pathway results in significant amounts of other end products such as ethanol, acetate, and CO_2 in addition to lactic acid, and the metabolism is referred to as heterolactic fermentation.



Fermentation of glucose in homofermentatives and heterofermentatives

3. Lactic Acid Fermentation in Pickle Production

Sequence of microbial types during natural fermentation of brined vegetables

Stage	Prevalent microorganisms
Initiation/Start	Various Gram-positive and Gram-negative bacteria
Primary fermentation	Lactic acid bacteria, yeasts
Secondary fermentation	Fermentative yeasts
Post-fermentation	Aerobic: surface growth of oxidative yeasts, molds and bacteria Anaerobic: none

- The natural fermentation of cucumbers has been categorized into four distinct stages: **initiation**, **primary fermentation**, **secondary fermentation**, and **post-fermentation.**

4. Controlled Fermentation

- Pickle fermentation is mostly carried out spontaneously by lactic acid bacteria found in the natural microflora of vegetables.
- The natural fermentation of cucumbers has been categorized into four distinct stages: **initiation**, **primary fermentation**, **secondary fermentation**, and **post-fermentation.**
- The controlled fermentation procedure is intented to eliminate two of these stages, initiation and secondary fermentation.
- Development of a suitable anaerobic tank for the pickle industry is intended to eliminate post-fermentation microbiological problems.

- It was reported that *Lactobacillus plantarum* strains are appropriate starter cultures for vegetable fermentations and commercially used in the fermentation of cucumbers, cabbages, and table olives.

Manufacture of fermented pickles

- The manufacture of fermented pickles starts with selection and sorting of cucumbers.
- Cultivars for pickles are different from those intended for the fresh market.
- Furthermore, only small or immature cucumbers, harvested when they are green and firm, are used for pickles. Cucumbers should be straight and uniform with a length to diameter ratio of 3 : 1.
- They are then washed, sorted, and transferred to tanks, and a brine solution is added.
- (The cucumbers are sorted according to their diameter, and those that are too long are cut to a length that will readily fit into jars).
- The flowers on cucumbers should be removed since the flowers contain polygalacturonase that plays a significant role in softening cucumbers by hydrolysing the polysaccharide matrix.

- For general pickling process, especially used for cucumbers, after vegetables are sorted, sized, and washed, they are placed into the fermentation vessels including salt solution (5%–10%), preferably rock salt.

- The cucumbers-to-brine ratio is nearly 1:1, therefore, the actual salt concentration is actually less.

- During fermentation, salt level is monitored, and salt is added when it is necessary. For some vegetables, salting can be done by mixing with up to 2.5% dry salt, for example, cabbage in the case of Sauerkraut production.

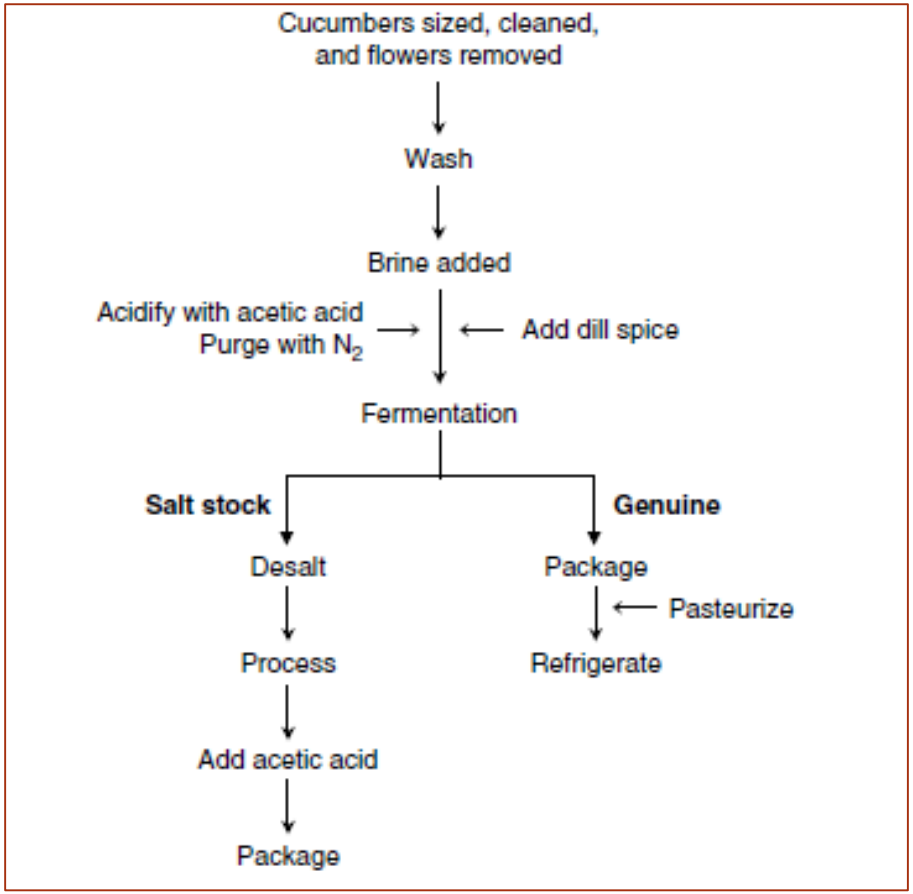
- Sometimes, acetic acid is added to the brine to promote a better fermentation by decreasing the pH below 4.5, especially in low-salt brines.

- Initial low pH and moderate salinity promote LAB to dominate over the other microbial groups from the early crucial steps of fermentation.

- LAB ensure the safety by preventing the growth of other microorganisms and at the same time extend the shelf life of the final product.

- In some cases, calcium chloride ($CaCl_2$) is added to fermentation brines around 0.2%–0.4% to give a crisp texture.

- Some flavor compounds can also be added. Especially dill herb or its seed or oil is added for flavor during the manufacture of genuine pickles.


Cucumbers sized, cleaned, and flowers removed
Wash
Brine added
Acidify with acetic acid
Purge with N_2
Add dill spice
Fermentation
Salt stock
Genuine
Desalt
Package
Pasteurize
Process
Refrigerate
Add acetic acid
Package