VINEGAR MAKING

Acetic acid

Vinegar

- Legally means acetic acid product made from apples (like wine is from grapes)
- To be legal, vinegars in US must contain a minimum of 4% of acetic acid

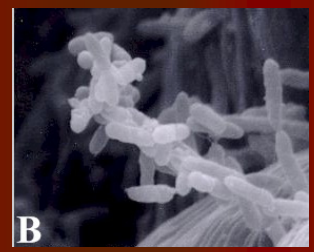
Different countries -different starting materials

- Continental Europe-grape wines
- Great Britain- malt
- Hawaii and Far East- pineapple
- USA -apple

Alcoholic Fermentation

Alcohol

O_2



VINEGAR

IMITATION VINEGAR

- In late 1800s chemist learned how to make acetic acid
- Manufacturers added water to reduce strength to 5%, colored it and sold is as a vinegar
- Imitation vinegar is still manufactured and by law the label must state that is diluted acetic acid

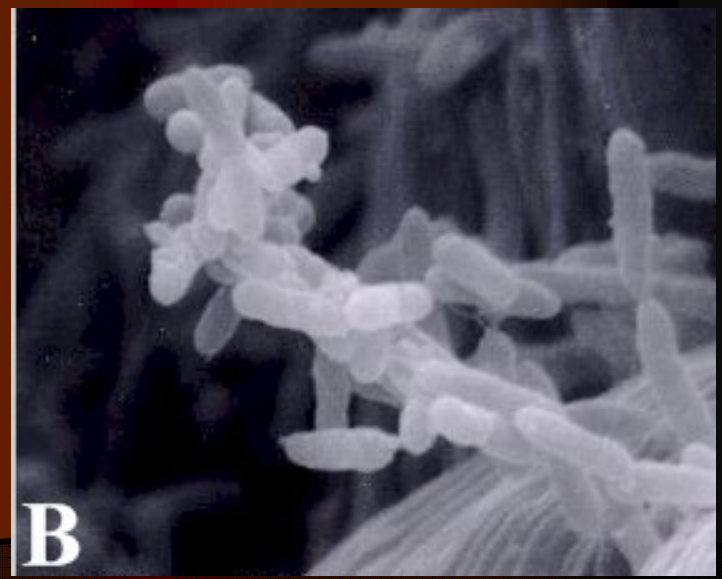
Acetic acid (fermentation?)

- $2CH_3CH_2OH + O_2 = 2CH_3COOH + 2H_20$

- Ethanol 92g/mol
- Acetic acid 120 g/mol
- Theoretical yield (120/96) x 100 = 130%
- Practical yield ~ 120%

Acetic acid bacteria

- obligatory aerobic
- nitrogen-fixing bacteria
- known for producing acid as a result of metabolic processes
- *Acetobacter aceti*



FERMENTED VINEGAR

- Made from good alcohol (wine, beer) that is fermented using acetic bacteria that convert alcohol to acetic acid
- Process can be controlled by using great care in cleanliness and introducing chosen yeast (wine) and bacteria (vinegar) to obtain good quality every time

Methods of making vinegar

- SLOW
- Home making
- Orleans process

Better flavor of vinegar

- RAPID
- The generator system
- Submerged fermentation system (bubble method)

WINE VINEGAR

- Wine that usually contains 11-12% alcohol must be diluted to 5.5-7% alcohol before using it to make vinegar
- Vinegar should contain at least 5% acetic acid to as required for preserving and pickling

MAKING WINE VINEGAR

- Utensils
  - Use glass, stainless still, enamel. Vinegar leaches molecules from iron and aluminum
- Sanitize utensils
  - Everything that will touch vinegar should be sanitized. Soak everything for 20 minutes in a solution of 2 tablespoons chlorine laundry bleach to 1 gallon of water

MAKING VINEGAR

- Dilute wine to 5.5-7% alcohol with water
- Fill sterilized containers with about 2/3 full
- Add bacteria cultures
  - Leaving wine exposed to air may sometimes star the process, but is very risky because some other organisms may grow
  - It is recommended to order pure cultures of bacteria sometimes called mother of vinegar
  - They can be purchased in any store that supplies wine making equipment. It usually comes like a clear liquid in the jar

MAKING VINEGAR

- Cover the container with a cloth to keep the insects out while allowing air to freely reach the stock
- Two factors require special attention when making vinegar at home:
  - Oxygen supply
  - Temperature

TEMPERATURE

- Between 80-85 F is ideal
- Low or fluctuating temperatures slow the process
- High temperatures will kill bacteria

FORMATION OF THE FILM

- After some time an acetic acid film called “mother “ will form
- It should not be disturbed
- It often becomes heavy enough to fall, in such case remove it and discard it.

VINEGAR

- Living bacteria are in the liquid
- They can be used to start the new batch of vinegar so it is not necessary to purchase new starter bacteria
- Full fermentation will take 3-4 weeks

PRESERVING VINEGAR

- Filter vinegar through a layer of cheese cloth to remove formed film-mother of vinegar, before pasteurization
- Heat vinegar before pouring it into sterilized bottles
- Bottle and place in hot water bath
- In both cases the temperature of the vinegar must reach at least 140F and should not exceed 160F and should be held at that temperature for at least 30 minutes
- Stored vinegar will stay in excellent condition almost indefinitely if it is pasteurized

AGING VINEGAR

- Vinegar has a strong, sharp bite when it is just made
- It becomes mellow when aged
- It usually lasts 6 months or longer when stored at cool, steady temperature (50-60 F)
- This undisturbed rest also allows suspended solids to fall, making the vinegar clear and bright
- Once vinegar is ready it should be kept away from oxygen because acetic acid could be converted into water and carbon dioxide

FLAVORED VINEGAR

- Flavoring can be added to homemade vinegar just before bottling
- Some additives can include: garlic, ginger, or any combination of dried fresh herbs
- Place flavoring material in a small cheesecloth bag and suspend in vinegar until the desired strength is reached
- It will take approximately 4 days, except for garlic which takes only 1 day

Orleans process

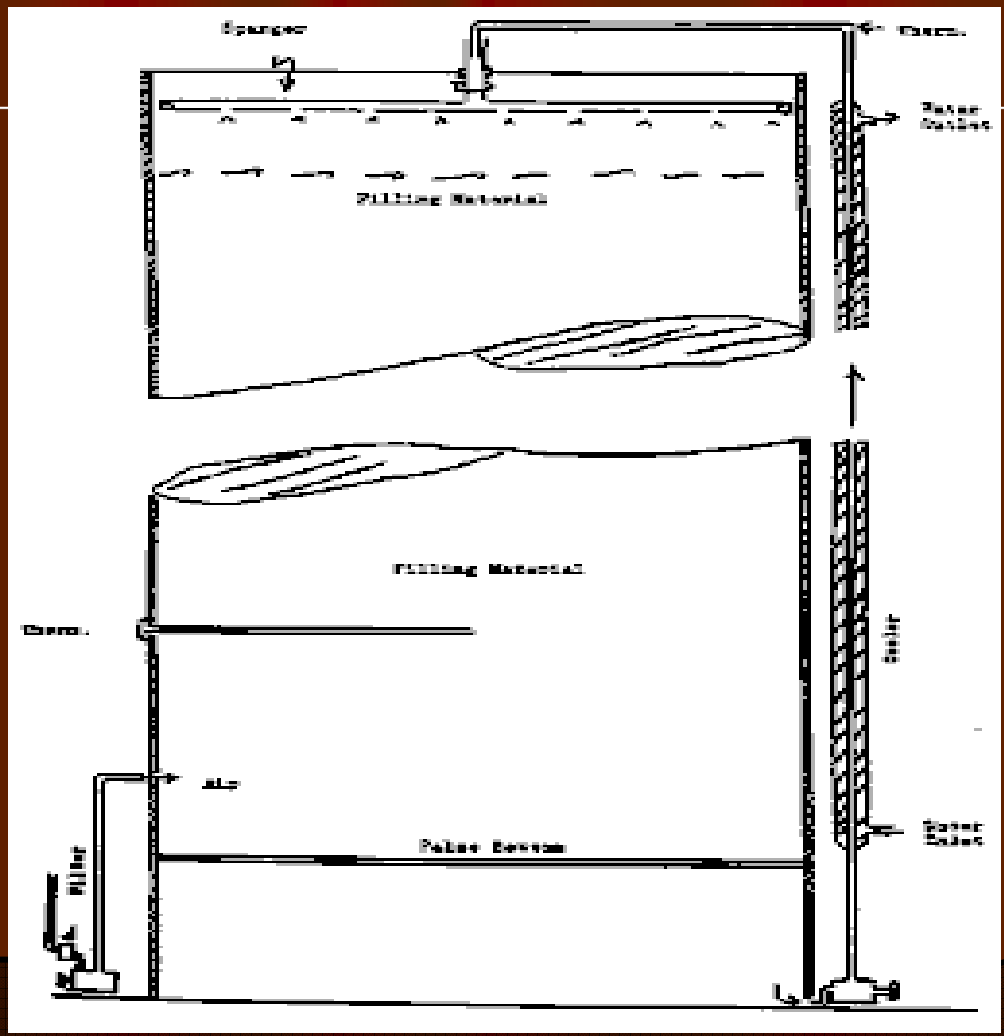
- Wine or cider is fermented in wooden barrels or covered vats
- There are screened air vents located in the top part of the container.
- Vents are screened to prevent Drosophila
- A starter culture is put into the container, and the fermentation is continued until the acetification is complete
- About 3/4 of the vinegar will be drawn off and replaced with fresh wine or other fermentable liquid.
- The process will keep repeating itself as long as quality vinegar can still be produced.
- This process is very slow (several weeks) and is usually done in small batches.

Orleans process

Rapid-generator process (Schutzenbach)

- Fermentation is done in a container that consists of two chambers.
- The larger (upper) chamber is packed with solid materials almost to the top (wood shavings, corncobs etc.) (bacteria attach to it)
- The upper chamber is separated from the lower chamber by a screen.
- Air is injected & blown upward through the screen and through the solid materials, & the air escapes through the top.
- The fermenting liquids are distributed evenly over the top of the material, & allowed to percolate through the material.
- The resulting liquid is then pumped back to the top & recirculated until the alcohol content is reduced to 1/2 percent.
- The vinegar is drawn off and fresh alcoholic solution is added.

Frings acetator or generator



Submerged culture fermentation (bubbling)

- First was developed during World war II for the production of penicillin
- Tiny bubbles of air are pass through the solution of ethanol
- Agitated by propellers, dispersing cells of acetic acid bacteria

Essentials for vinegar generator

- Must provide for the introduction of fresh substrate without disturbing the content of alcohol or the surface growth
- Must provide easy sampling for titration
- Must protect system from contamination
- Must have means of temperature control

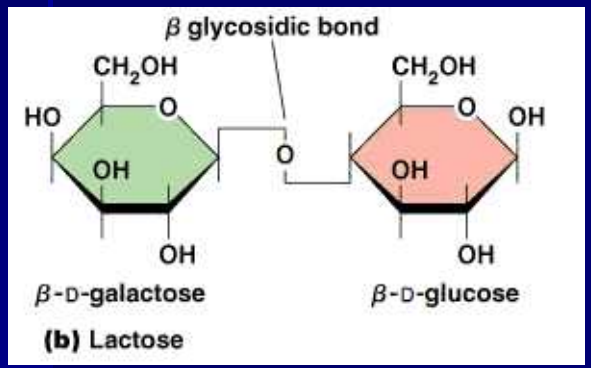
Rate of acetic acid production

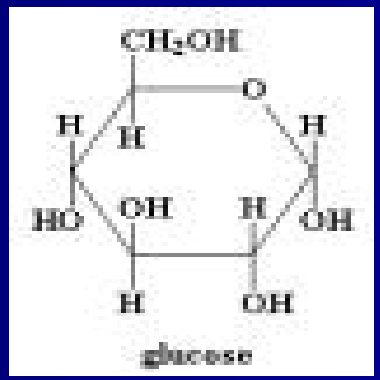
- The inherent capacity of *Acetobacter aceti* to convert alcohol to acetic acid
- The amount of ethyl alcohol (6-8 % opt. 12% tolerated)
- The temperature (80F opt, 68-96 range)
- The amount of aeration of surface area of the growth matherial

LACTIC ACID FERMENTATION

Requirements

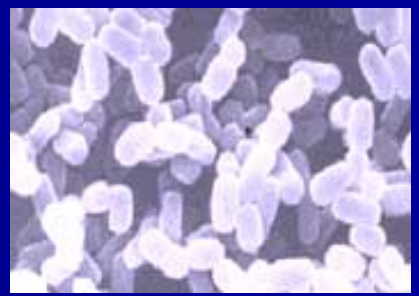
- Starting fermentable sugar (glucose, lactose)



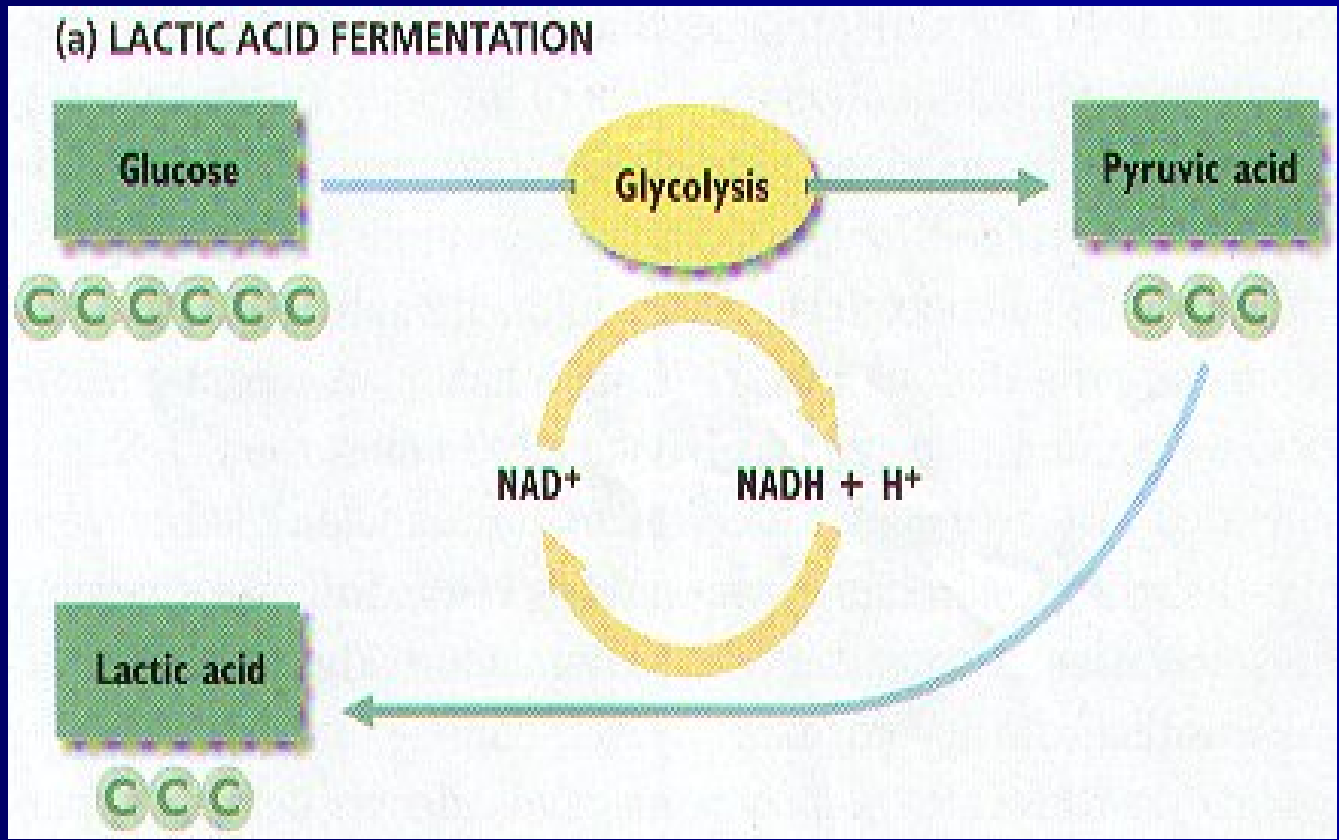


- Microorganisms

(lactic acid bacteria or fungi)



Fermentation



Microorganisms

- Lactic acid fermentation is caused by some fungi and bacteria.
- The most important lactic acid producing bacteria is *Lactobacillus*.
- Other bacteria which produce lactic acid include:
- *leuconostoc mesenteroides,*
- *pediococcus cerevisiae,*
- *streptococcus lactis ,*
- *bifidobacterium bifidus*.

Lactic acid bacteria

- Lactic acid bacteria refers to a large group of beneficial bacteria that have similar properties and all produce lactic acid as an end product of the fermentation process.
- They are widespread in nature and are also found in our digestive systems.

Lactic acid bacteria

- **Homolactic fermentation**
- The fermentation of 1 mole of glucose yields two moles of lactic acid;
- **Heterolactic fermentation**
- The fermentation of 1 mole of glucose yields 1 mole each of lactic acid, ethanol and carbon dioxide;

Nisin

- Nisin was the first bacteriocin derived from fermentation of a lactic-acid bacterium
- Approved by the FDA in April 1989 to prevent the growth of botulism spores in pasteurized process-cheese spreads.
- Does not inhibit Gram-negative organisms, yeasts or fungi, but does inhibit most Gram-positive organisms including spore-formers such as *Clostridia botulinum* and heat-resistant spoilage organisms.

Homofermenter	**Facultative homofermenter**	**Obligate heterofermenter**
Enterococcus faecium	*Lactobacillus bavaricus*	*Lactobacillus brevis*
Enterococcus faecalis	*Lactobacillus casei*	*Lactobacillus buchneri*
Lactobacillus acidophilus	*Lactobacillus coryniformis*	*Lactobacillus cellobiosus*
Lactobacillus lactis	*Lactobacillus curvatus*	*Lactobacillus confusus*
Lactobacillus delbrueckii	*Lactobacillus plantarum*	*Lactobacillus coprophilus*
Lactobacillusleichmannii	*Lactobacillus sake*	*Lactobacillus fermentatum*
Lactobacillus salivarius		*Lactobacillus sanfrancisco*
Streptococcus bovis		*Leuconostoc dextranicum*
Streptococcus thermophilus		*Leuconostoc mesenteroides*
Pediococcus acidilactici		*Leuconostoc paramesenteroides*
Pedicoccus damnosus		
Pediococcus pentocacus		

Conditions for lactic acid fermentation

- Addition of a sufficient amount of fermentable carbohydrates
- Reduced O_2 during the fermentation process and storage of the fermented product.
- Rapid multiplication of the starter culture and sufficient production of lactic acid.

Lactic fermentation products

- Western world: yogurt, sourdough breads, sauerkraut, cucumber pickles and olives
- Fermented meats
- Middle East: pickled vegetables
- Korea: kimchi (fermented mixture of Chinese cabbage, radishes, red pepper, garlic and ginger)
- Russia: kefir
- Egypt: laban rayab and laban zeer (fermented milks), kishk (fermented cereal and milk mixture)
- Nigeria: gari (fermented cassava)
- South Africa : magou (fermented maize porridge)
- Thailand : nham (fermented fresh pork)
- Philippines : balao balao (fermented rice and shrimp mixture)

Fermented vegetables

- Sauerkraut
- Pickles

Fermentation

- Lactic acid fermentations are carried out under three basic types of condition:–
- dry salted,
- brined and
- non-salted.
- Salting provides a suitable environment for lactic acid bacteria to grow which impart the acid flavor to the vegetable.

How does salt preserves food?

- The chloride ion is a bacterial poison
- Limits moisture availability
- Oxygen solubility is reduced
- Dehydrates protoplasm causing plasmolysis
- Interferes with enzyme action

- Generally yeast, bacteria and molds do not grow in saturated salt solution @ 26.5% sodium chloride at room temperature

Dry salted

- Vegetable is treated with dry salt
- The salt extracts the juice from the vegetable and creates the brine
- As soon as the brine is formed, fermentation starts and bubbles of carbon dioxide begin to appear.
- Fermentation takes between one and four weeks depending on the ambient temperature

Sauerkraut

- sauerkraut literally translates as acid cabbage
- *Leuconostoc mesenteroides*
- *Lactobacillus plantarum*

- Shredded cabbage is placed in a jar and salt is added.
- Mechanical pressure is applied to the cabbage to expel the juice, which contains fermentable sugars and other nutrients suitable for microbial activity.
- The first micro-organisms to start acting are the gas-producing cocci *(L. Mesenteroides).* These microbes produce acids.
- When the acidity reaches 0.25 to 0.3% (calculated as lactic acid), these bacteria slow down and begin to die off, although their enzymes continue to function.
- The activity initiated by the *L. mesenteroides* is continued by the lactobacilli *(L. plantarum and L. Cucumeris)* until an acidity level of 1.5 to 2% is attained.
- The high salt concentration and low temperature inhibit these bacteria to some extent.
- Finally, *L. pentoaceticus* continues the fermentation, bringing the acidity to 2 to 2.5% thus completing the fermentation.

Temperature effect

- The optimum temperature for sauerkraut fermentation is around 21ºC.
- A variation of just a few degrees from this temperature alters the activity of the microbial process and affects the quality of the final product.
- Therefore, temperature control is one of the most important factors in the sauerkraut process.
- A temperature of 18º to 22º C is most desirable for initiating fermentation since this is the optimum temperature range for the growth and metabolism of *L. mesenteroides*.

Effects of salt

- Imparts firmness
- Inhibits putrefactive bacteria formation
- Withdraws water from the cabbage
- Added to a final concentration of 2.0 to 2.5%

Spoilage

- Aerobic soil micro-organisms break down the protein and produce undesirable flavor and texture changes
- Dark colored sauerkraut (caused by spoilage organisms)
- Pink kraut is a spoilage problem. It is caused by a group of yeasts which produce an intense red pigment in the juice and on the surface of the cabbage

Brine salted fermented vegetables

- For vegetables which inherently contain less moisture.
- A brine solution is prepared by dissolving salt in water (a 15 to 20% salt solution).
- Fermentation takes place well in a brine of about 20 salometer.
- The vegetable is immersed in the brine and allowed to ferment.
- The strong brine solution draws sugar and water out of the vegetable, which decreases the salt concentration.
- It is crucial that the salt concentration does not fall below 12%, otherwise conditions do not allow for fermentation. To achieve this, extra salt is added periodically to the brine mixture.

Pickles

- The washed cucumbers are placed in large tanks and salt brine (15 to 20%) is added.
- The cucumbers are submerged in the brine, ensuring that none float on the surface - this is essential to prevent spoilage.
- The strong brine draws the sugar and water out of the cucumbers, which simultaneously reduces the salinity of the solution.
- In order to maintain a salt solution so that fermentation can take place, more salt has to be added to the brine solution.
- If the concentration of salt falls below 12%, it will result in spoilage of the pickles through putrefaction and softening.

- The color of the cucumber surface changes from bright green to a dark olive green as acids interact with the chlorophyll.
- The interior of the cucumber changes from white to a waxy translucent shade as air is forced out of the cells.
- The specific gravity of the cucumbers also increases as a result of the gradual absorption of salt and they begin to sink in the brine rather than floating on the surface.