INDUSTRIAL FOOD FERMENTATIONS

INTRODUCTION: -

Industrial fermentation is the intentional use of fermentation by microorganisms such as bacteria and fungi to make products useful to humans. Fermented products have applications as food as well as in general industry. Ancient fermented food processes, such as making bread, wine, cheese, curds, idli, dosa, etc., can be dated to more than 6,000 years ago. They were developed long before man had any knowledge of the existence of the microorganisms involved.

Fermentation in food processing typically is the conversion of carbohydrates to alcohols and carbon dioxide or organic acids using yeasts, bacteria, or a combination thereof, under anaerobic conditions. A more restricted definition of fermentation is the chemical conversion of sugars into ethanol. The science of fermentation is known as **zymurgy**.

Fermentation usually implies that the action of microorganisms is desirable, and the process is used to produce alcoholic beverages such as wine, beer, and cider. Fermentation is also employed in the leavening of bread, and for preservation techniques to create lactic acid in sour foods such as sauerkraut, dry sausages, kimchi and yogurt, or vinegar (acetic acid) for use in pickling foods.

History

Natural fermentation precedes human history. Since ancient times, however, humans have been controlling the fermentation process. The earliest evidence of winemaking dates from eight thousand years ago, in Georgia, in the Caucasus area. Seven-thousand-year-old jars containing the remains of wine have been excavated in the Zagros Mountains in Iran, which are now on display at the University of Pennsylvania. There is strong evidence that people were fermenting beverages in Babylon circa 5000 BC, ancient Egypt circa 3150 BC, pre-Hispanic Mexico circa 2000 BC, and Sudan circa 1500 BC. There is also evidence of leavened bread in ancient Egypt circa 1500 BC and of milk fermentation in Babylon circa 3000 BC.

French chemist Louis Pasteur was the first known *zymologist*, when in 1856 he connected yeast to fermentation. Pasteur originally defined fermentation as "respiration without air".

Uses: -The primary benefit of fermentation is the conversion of sugars and other carbohydrates, e.g., converting juice into wine, grains into beer, carbohydrates into carbon dioxide to leaven bread, and sugars in vegetables into preservative organic acids.

Food fermentation has been said to serve five main purposes:

I. Enrichment of the diet through development of a diversity of flavors, aromas, and textures in food substrates
II. Preservation of substantial amounts of food through lactic acid, alcohol, acetic acid and alkaline fermentations
III. Biological enrichment of food substrates with protein, essential amino acids, essential fatty acids, and vitamins
IV. Elimination of anti-nutrients
V. A decrease in cooking times and fuel requirements

Fermented foods by region

Nattō, a Japanese fermented soybean food

- **Worldwide:** alcohol, wine, vinegar, olives, yogurt, bread, cheese
- **Asia**

  asinan, atchara, dalok, douchi, jeruk, lambanog, kimchi, miso, nata, natto, pak-siam-dong, , sake, soju, soy sauce, szechwan cabbage, chiraki, tape, tempeh, yen tsai, kumis (mare milk), kefir, shubat (camel milk), achar, appam, dosa, dhokla, dahi (yogurt), idli, kaanji, mixed pickle, jaand (rice beer), sinki, panir.

- **Africa:** fermented millet porridge, garri, hibiscus seed, hot pepper sauce, injera, oilseed, ogi, ogili,.
- **Americas:** chicha, elderberry wine, kombucha, pickling (pickled vegetables), sauerkraut, lupin seed, oilseed, chocolate, vanilla, tabasco, tibicos
- **Middle East:** kushuk, lamoun makbouss, boza
- **Europe:** sauerkraut, mead, elderberry wine, salami, prosciutto, cultured milk products such as quark, kefir, crème fraîche, smetana.
- **Oceania:** poi, kaanga pirau (rotten corn), sago

Fermented foods by type

Bean-based

doenjang, miso, natto, soy sauce, stinky tofu, tempeh, soybean paste, Beijing mung bean milk. Amazake, beer, bread, ogi, sake, sourdough, sowans, rice wine, malt whisky, grain whisky, vodka.

Batter made from Rice and Lentil (*Vigna mungo*) prepared and fermented for baking idlis and dosas

Vegetable-based

Kimchi, mixed pickle, sauerkraut, Indian pickle

Fruit-based

Wine, vinegar, cider, perry, brandy Fruit Enzyme

Honey-based

Mead, metheglin

Dairy-based

Cheese, kefir, kumis (mare milk), shubat (camel milk), cultured milk products such as quark, crème fraîche, smetana, skyr, yogurt

Fish-based

Bagoong, fish sauce, Garum, Hákarl, rakfisk, shrimp paste, surströmming, shidal

Meat-based

Jamón ibérico, Chorizo, Salami, pepperoni

Tea-based

Kombucha

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Oriental fermented foods

These fermented foods are made in the Oriental countries like Japan, Indonesia, India, Pakistan, Thailand, Philippines, Taiwan, China, Korea, and the encompassing areas. These foods were produced long before written history; some of these processes are so little known that even today one can only guess as to the organisms used.

The fermentation industry in the Orient is huge. There is considerable ancient writing in Chinese publications about foods made by fermentation, but the first scientific reports are only about 100 years old.

IMPORTANCE OF MIXED CULTURES

Relatively few genera and species of microorganisms are employed in the Oriental fermentations. Among the fungi, those used are restricted to *Rhizopus. Mucor, Amylomyces. Aspergillus*, *Monascus*, *Neurospora and yeasts.* The yeasts are represented mainly by the genera *Saccharomyces. Candida (Torulopsis),* and *Saccharomycopsis* . Among the bacteria, the lactic acid bacteria *Pediococcus, Leuconostoc, Lactobacillus,* and *Bacillus* seem to be the ones usually encountered.

Name of fermented oriental food	Microorganisms used
Soy sauce	*Aspergillus sojae* *Aspergillus oryzae* *Saccharomyces rouxii* *Candida etchellsii* *Candida versatilis* *Pediococcus halophilus* *Lactobacillus delbrueckii*
Miso	*Aspergillus oryzae* *Aspergillus sojae* *Saccharomyces rouxii* *Candida etchellsii* *Pediococcus halophilus*
Tempeh	*Rhizopus oligosporus*
Sufu	*Actinomucor elegans* *Mucor dispersus*
Natto	*Bacillus subtilis (B. natto)*

a) **Soy sauce** (S**oya sauce)**
b) **Natto**
c) **Misso**

a) **Soy sauce** (S**oya sauce)**

It is a condiment produced by fermenting soybeans with *Aspergillus oryzae* or *Aspergillus sojae* molds, along with water and salt. After the fermentation, which yields moromi, the moromi is pressed, and two substances are obtained: a liquid, which is the soy sauce, and a cake of (wheat and) soy residue, the latter being usually reused as animal feed. Most commonly, a grain is used together with the soybeans in the fermentation process. Also, some varieties use roasted grain.

Soy sauce is a traditional ingredient in East and Southeast Asian cuisines, where it is used in cooking and as a condiment. In more recent times, it is also being used in Western cuisine and prepared foods.

All varieties of soy sauce are salty, earthy, brownish liquids intended to season food while cooking or at the table. Soy sauce has a distinct basic taste called *umami* (pleasant savory taste) in Japanese due to naturally occurring free glutamates. Soy sauce originated in China 2,800 years ago and its use later spread to East and Southeast Asia.

Production

Soy sauce may be made either by fermentation or by hydrolysis; some commercial sauces contain a mixture of fermented and chemical sauces.

Traditional

Traditional soy sauces are made by mixing soybeans and grain with cultures such as *Aspergillus oryzae* and other related microorganisms and yeasts. The resulting substance is called "koji" (note that the term "koji" is used both for the mixture of soybeans, wheat, and mold; as well as for only the mold). In older times, the koji was then fermented naturally in giant urns and under the sun, which was believed to contribute additional flavors. Today, the koji is generally placed in a "muro" which is a temperature and humidity controlled incubation chamber.

Some soy sauces made in the Japanese way or styled after them contain about fifty percent wheat.

Acid-hydrolyzed vegetable protein

Some brands of soy sauce are often made from acid-hydrolyzed soy protein instead of brewed with a traditional culture. This process may take only three days. Although they have a different flavor, aroma, and texture when compared to brewed soy sauces, they have a longer shelf-life and are more commonly produced for this reason. Some people feel the hydrolyzed sauces taste better, but some prefer the naturally brewed varieties. The clear plastic packets of dark sauce common with Chinese-style take out food typically use a hydrolyzed vegetable protein formula. Some higher-quality hydrolyzed vegetable protein products with no added salt, sugar or colorings are sold as low-sodium soy sauce alternatives called "liquid aminos" in health food stores, similar to the way salt substitutes are used.

Types

Soy sauce has been integrated into the traditional cuisines of many East Asian and Southeast Asian cultures. Soy sauce is widely used as a particularly important flavoring in Japanese, Thai, Korean, and Chinese cuisine. Despite their rather similar appearance, soy sauces produced in different cultures and regions are different in taste, consistency, fragrance and saltiness. Soy sauce retains its quality longer when kept away from direct sunlight.

Koji

Koji is a fungus of genus Aspergillus that is used for fermenting many ingredients in Japanese cuisine. Three species are used for brewing soy sauce:

- *Aspergillus oryzae*: Strains with high proteolytic capacity are used for brewing soy sauce. This fungus is also used for saccharification of steamed rice for brewing sake.

- *Aspergillus sojae*: This fungus also has a high proteolytic capacity.

- *Aspergillus tamari*: This fungus is used for brewing tamari.

Other microbes contained in Soy Sauce

- *Bacillus spp*.(genus): This organism is likely to grow soy sauce ingredients, bring to generate odors and ammonia.

- *Lactobacillus species*: This organism produces a lactic acid increases the acidity in the feed.

A bottle of commercially produced light soy sauce

Nutrition

A study by the National University of Singapore showed that Chinese dark soy sauce contains 10 times the antioxidants of red wine, and can help prevent cardiovascular diseases. Soy sauce is rich in lactic acid bacteria and of excellent anti-allergic potential.

b) Natto

Nattō is a traditional Japanese food made from soybeans fermented with *Bacillus subtilis*. It is popular especially as a breakfast food. As a rich source of protein and probiotics, nattō and the soybean paste miso formed a vital source of nutrition in feudal Japan. Nattō can be an acquired taste because of its powerful smell, strong flavor, and slippery texture.

The first thing noticed after opening a pack of nattō is its distinctive smell, somewhat akin to a pungent cheese. Stirring the nattō produces lots of sticky gossamer-like strings. Nattō is commonly eaten at breakfast to accompany rice, possibly with soy sauce, raw egg. The flavor of nattō can differ greatly between people; some find it tastes strong and cheesy and may use it in small amounts to flavor rice or noodles, while others find it tastes bland and unremarkable, requiring the addition of flavoring condiments such as mustard and soy sauce.

Production

Nattō is made from soybeans, typically nattō soybeans. Smaller beans are preferred, as the fermentation process will be able to reach the center of the bean more easily. The beans are washed and soaked in water for 12 to 20 hours to increase their size. Next, the soybeans are steamed for 6 hours, although a pressure cooker can be used to reduce the time. The beans are mixed with the bacterium *Bacillus subtilis natto*, known as *natto-kin* in Japanese. From this point on, care has to be taken to keep the ingredients away from impurities and other bacteria. The mixture is fermented at 40 °C for up to 24 hours. Afterwards the nattō is cooled, and then aged in a refrigerator for up to one week to allow the development of stringiness. During the aging, at a temperature of about 0 °C, the bacilli develop spores, and enzymatic peptidases break down the soybean protein into its constituent amino acids.

Medical benefits

Nattō is health-enhancing and that these claims are backed by medical research. One example is pyrazine: Pyrazine is a compound that, in addition to giving nattō its distinct smell, reduces the likelihood of blood clotting. It also contains a serine protease type enzyme called *nattokinase* which may also reduce blood clotting both by direct fibrinolysis of clots, and inhibition of the plasma protein *plasminogen activator inhibitor 1*. This may help to avoid thrombosis, as for example in heart attacks, pulmonary embolism, or strokes.

Nattō contains large amounts of vitamin K, which is involved in the formation of calcium-binding groups in proteins, assisting the formation of bone and preventing osteoporosis. Vitamin K_1 is found naturally in seaweed, liver, and some vegetables, while vitamin K_2 (Menatetrenone) is found in fermented food products such as cheese, miso, and Nattō. Nattō has large amounts of vitamin K_2, approximately 870 micrograms per 100 grams of nattō.

According to a study, fermented soybeans, such as nattō, contain vitamin PQQ, which is important for the skin. Nattō contains chemicals alleged to prevent cancer, for example, *daidzein*, *genistein*, *isoflavone*, *phytoestrogen*, and the chemical element selenium. nattō may have a cholesterol-lowering effect. Nattō is said to have an antibiotic effect, and its use as medicine against dysentery. Nattō is claimed to prevent obesity, possibly because of its low calorie content. improved digestion, reduced effects of aging, and the reversal of hair loss in men due to its phytoestrogen content, which can affect testosterone associated with baldness.

c) Miso

Miso is a traditional Japanese seasoning produced by fermenting rice, barley and/or soybeans, with salt and the fungus *kojikin* the most typical miso being made with soy. The result is a thick paste used for sauces and spreads, pickling vegetables or meats, and mixing with dashi soup stock to serve as miso soup called *misoshiru*, a Japanese culinary staple.

High in protein and rich in vitamins and minerals, miso played an important nutritional role in feudal Japan. Miso is still very widely used in Japan, both in traditional and modern cooking, and has been gaining world-wide interest. Miso is typically salty, but its flavor and aroma depend on various factors in the ingredients and fermentation process. There is a very wide variety of miso available. Different varieties of miso have been described as salty, sweet, earthy, fruity, and savory.

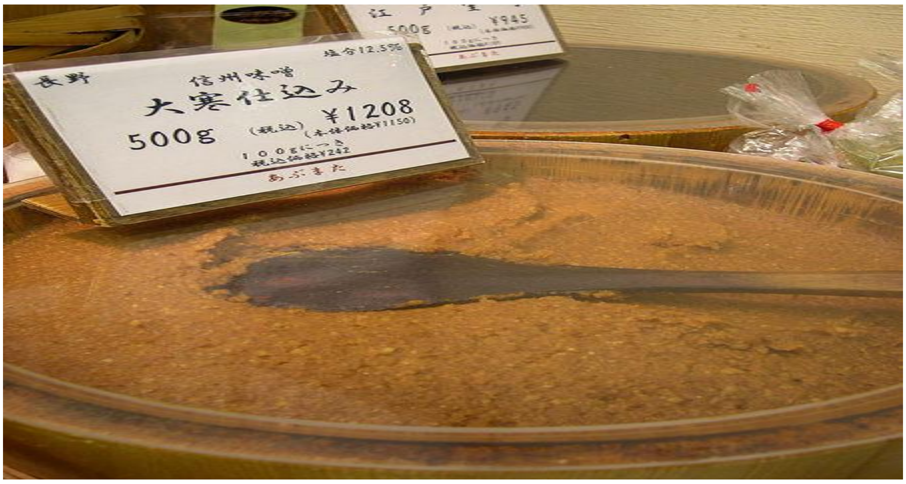
Flavor

(from left) *Koujimiso, Akamiso, Awasemiso*

The taste, aroma, texture, and appearance of miso all vary by region and season. Other important variables that contribute to the flavor of a particular miso include temperature, duration of fermentation, salt content, variety of kōji, and fermenting vessel. The most common flavor categories of miso are:

- *Shiromiso*, "white miso"
- *Akamiso*, "red miso"
- *Awasemiso*, "mixed miso"

Although white and red (*shiromiso* and *akamiso*) are the most common types of misos available, different varieties may be preferred in particular regions of Japan. In the eastern Kantō region that includes Tokyo, the darker brownish *akamiso* is popular while the western Kansai region encompassing Osaka, Kyoto, and Kobe prefer the lighter *shiromiso*.



Ingredients

The ingredients used to produce miso may include any mix of soybeans, barley, rice, buckwheat, millet, rye, wheat, hemp seed, and cycad, among others. Lately, producers in other countries have also begun selling miso made from chickpeas, corn, azuki beans, amaranth, and quinoa. Fermentation time ranges from as little as five days to several years.

Types of miso are divided by main ingredients.

- ***Kome* miso, "rice miso"**

Color is yellow, yellowish white or red, etc. Whitish miso is made from boiled soybean, but reddish miso is made from steamed soybean. Much of *Kome* miso is consumed in Eastern Japan, *Hokuriku* and *Kinki* areas.

- ***Mugi* miso, "barley miso"**

Whitish miso is produced in *Kyusyu*, Whestern *Chugoku* area in Japan,*Shikoku* areas. *Mugi* miso has a peculiar smell. Northern *Kanto* area produces reddish miso.

- ***Mame* miso, "soybean miso"**

Miso is a darker, more reddish brown than *kome* miso. This is not so sweet, but has some astringency and good *umami*. This miso requires a long maturing term. *Mame* miso is consumed in mostly *Aichi* prefecture, part of *Gifu* prefecture and part of *Mie* prefecture.

- ***Tyougou* miso, "mixed miso"**

This comes in various types, because it consists of other varieties of miso mixed together. This may improve the weak points of each type of miso. For example, *Mame* miso is very salty. But when combined with *Kome* miso, the finished product has a mild taste.

- **Red miso**

This is aged for a long time, such as over one year. Therefore, due to Maillard reaction, the color of this miso changes gradually from white to red or black, thus giving it the name red miso. Features of the taste are saltiness, and some astringency with umami. Factors in the depth of color are the formula of the soybeans themselves and the quantity of soybeans used. Generally, steamed soybeans are more deeply colored than boiled soybeans.

- **White miso**

The most widely produced miso, made in many regions of the country. Its main ingredients are rice, barley, and a small quantity of soybeans. If a greater quantity of soybeans was added, the miso would be red or brown. Compared with red miso, white miso has a very short brewing time. The taste is sweet, but the umami is soft (compared to red miso).

Storage of miso

Miso typically comes as a paste in a sealed container requiring refrigeration after opening. Natural miso is a living food containing many beneficial microorganisms such as *Tetragenococcus halophilus* which can be killed by over-cooking. For this reason, it is recommended that the miso be added to soups or other foods being prepared just before they are removed from the heat. Using miso without any cooking may be even better. Outside of Japan, a popular practice is to only add miso to foods that have cooled in order to preserve *kōjikin* cultures in miso. Nonetheless miso and soy foods play a large role in the Japanese diet and many cooked miso dishes are popularly consumed.

Nutrition and health

The nutritional benefits of miso have been widely touted by commercial enterprises and home cooks alike. Claims that miso is high in vitamin B. Miso can help treat radiation sickness, Some experts suggest that miso is a source of *Lactobacillus acidophilus*. Lecithin, a kind of phospholipid caused by fermentation, which is effective in the prevention of high blood pressure. However, miso is also relatively high in salt which can contribute to increased blood pressure in the small percentage of the population with sodium-sensitive pre-hypertension or hypertension.

• Cereal based fermented foods

a) Idli
b) Khamang Dhokala
c) Jalebi
d) Papadam

a) Idli

Idli is a south Indian savory cake popular throughout India. The cakes are usually two to three inches in diameter and are made by steaming a batter consisting of fermented black lentils (de-husked) and rice. The fermentation process breaks down the starches so that they are more readily metabolized by the body. The earliest mention of idli in India occurs in Tamil sangam literature. Also the aromatic flavour of Sambaar been mentioned in it around 6 CE. It is also found in Kannada writing of Shivakotiacharya in 920 CE.

Most often eaten at breakfast or as a snack, idlis are usually served in pairs with chutney, sambar, or other accompaniments

Preparation

To make idli, place two parts uncooked rice to one part split black lentil (minapa pappu, urad dal) in a pan and soak. Grind the lentils and rice to a paste in a heavy stone grinding vessel. Leave the paste to ferment overnight, until it has expanded to about 2½ times its original volume. In the morning, put the idli batter into the ghee-greased molds of an idli tray or "tree" for steaming. The perforated molds allow the idlis to be cooked evenly. The tree holds the trays above the level of boiling water in a pot, and the pot is covered until the idlis are done (about 10–25 minutes, depending on size).

Idlis are usually served in pairs with kobbari pachadi (chutney), sambar, karampodi with ghee. Kobbari pachadi and Karampodi are first used to eat in combination of idlis in Andhra Pradesh, specifically in Kostha Andhra Districts. Newer "quick" recipes for the idli can be rice- or wheat-based (rava idli). Besides the microwave steamer, electric idli steamers are available, with automatic steam release and shut-off for perfect cooking. Both types are non-stick, so a fat-free idli is possible.

Microorganisms in idli batter formation

The microorganisms responsible for the characteristic change in the batter such as souring, as well as for gas production are *Leuconostoc mesenteroides*. In the later stages of fermentation, growth of *Streptococcus faecalis* and, still later, of *Pediococcus cerevisiae* becomes significant. The fermentation of idli demonstrates a leavening action caused by the activity of the heterofermentative lactic acid bacterium, *L. mesenteroides*.

b) Khamang Besan Dhokala

Ingredients:

350gms	Gram flour (Besan)
1cup	Curd (Stirred)
1tsp	Green Chilies (paste)
1tsp	Ginger (paste)
Salt to taste	
1tsp	Soda bi-carb / Eno fruit salt
1	Lemon juice
1/2 tsp.	turmeric powder
1tbsp	Oil
For Tampering	
Few Curry leaves	
1tsp	Mustard Seeds
2tsp	Oil
Coriander leaves	(chopped)
2-3 green chilies	(vertically slit)

Preparation:

- In a bowl add gram flour (besan), Curd and water.
- Mix well and make a smooth batter. The batter should be of thick consistency.
- Add salt and set aside for 4 hours covered with a lid.
- Take the ginger and green chili paste and add to the batter. Also add turmeric powder and mix well.
- Keep the steamer or cooker ready on gas.
- Grease a baking dish (it should fit in the steamer or cooker).
- Now in small bowl take a tsp. of soda bi-carb or eno, 1tsp oil and lemon juice and mix well.
- Add this to the batter and mix well.
- Pour the batter into the greased pan and steam for 10-12 minutes or till done.
- Cool for sometime and cut into big cubes.
- Heat little oil in a small pan and add mustard seeds and curry leaves allow to splutter. Remove and pour it over dhoklas.
- Garnish the besan dhokla with coriander and slited green chilies.
- Serve with hari chutney.

Microorganisms

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c) JALEBI

Ingredients

Jalebi Batter

1. Maida (All purpose flour):	1½ Cup
2. Dahi (Yogurt) :	¼ Cup
3. Baking Soda:	¼ teaspoon

Syrup

1. Sugar:	1½ Cup
2. Water:	1½ Cup

Method

1. Jalebi batter

Mix flour and yogurt to a paste. Let it sit and ferment overnight. It works better with a day old sour Dahi. Add enough water to make it a pour-able paste, it should be neither thick, nor runny. After the fermentation is finished, just before frying, stir in baking soda.

2. Syrup

In a heavy bottom pan, combine sugar and water. Heat to a boil. Keep cooking another 20 minutes and you should have single thread consistency sugar syrup.
3. Set your deep fryer to 375 º F. Get a pastry bag with a ½" opening. Put your batter in the pastry bag. Gradually swirl the batter outward in a circular motion, or criss-cross about 2" to 3" round. Let it cook till lightly golden brown. You do not want to over cook it. Get your tongs and turn Jalebi over so that both sides are lightly golden brown. Remove Jalebi from the fryer and dip it in the warm syrup and remove.

Notes

Jalebi Color If you want to add color to Jalebi, add two drops of yellow food color and one drop of red food color in Step 1 before fermentation.

Microorganisms

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d) PAPADAM

Place of origin/usage: South India.

Nature of food: Pulse based.

Importance of the food: Important condiment or savoury food and wafer like product.

Usual composition/ingredients: Black gram, Bengal gram, lentil (*Lens culinaris*) and red gram or green gram, small quantity of peanut oil and common salt.

Method of preparation: Black gram flour or a blend of black gram with Bengal gram, lentil (*Lens culinaris*), red gram or green gram (*Vigna radiata*) flour is hand kneaded with a small quantity of peanut oil, common salt (about 8%, w/w) and then pounded into a stiff paste. The dough (sometimes with a backslop and spices added) is left to ferment for 1-6 hours. The fermented dough is shaped into small balls which are rolled into thin, circular flat sheets (10-24cm diameter, 0.2-1.2mm thick) and generally dried in the shade to 12-17% (w/w) moisture content.

Microorganism(s) involved: *Candida krusei* and *S. cerevisiae*.

Method of consumption: Used to prepare curry or is eaten by itself as a crackly snack or appetizer with meals after roasting or deep frying in oil.

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Fermented Cassava flour

Cassava, *Manihot esculenta Crantz,* is a perennial woody shrub with an edible root. In Africa, cassava is used mostly for human consumption. The roots are processed into a wide variety of granules, pastes and flours, or consumed freshly boiled. In most of the cassava-growing countries in Africa the leaves are also consumed as a green vegetable, which provides protein and vitamins A and B.

In Nigeria, cassava is traditionally powdered and heated with water to make Fufu, or mashed, sieved and fried to make Gari. There are two types of cassava flour: fermented (Lafun) and non-fermented (high quality cassava flour). The fermented flour is consumed directly in foods such as Fufu, while unfermented flour is used in bakeries and for confectionery.

Fermented cassava flours are usually prepared for eating by pasting in water and making into dough, fufu, which is eaten with cooked vegetables, and meat or fish. The use of composite flours in preparation of starchy meals often alters their compositions, and may therefore change the functional and pasting characteristics of the final product. The cassava roots were washed, peeled, and re-washed with clean portable water. They were steeped in water in plastic containers for 72hrs. At the end of the steeping period the fermented samples were rewashed with fresh water, and grated into pulp using a 3.5Hp, petrol engine powered grater.

The fermented, soft pulp was dispersed in water, and was sieved with a test sieve with operature of 2.0mm. The recovered sediment was packed in sacks and dewatered using a hydraulic press. The resulting cake was pulverized by hand, spread in trays and dried to 10% moisture content in a kiln oven at a temperature range of 50 – 55oc for 12hrs. The dried fermented cassava flour was milled into flour using a disc attrition mill, and then packaged in a air tight plastic container, labeled sample, CS.

Fermentation of cassava peels by pure culture of *S. cerevisiae* could increase its protein content from (2.4%) in nonfermented cassava to (14.1%) in fermented products (Antai & Mbongo, 1994). The fermented cassava flour with *S. cerevisiae* enhanced the protein level (from 4.4% to 10.9%) and decreased the amount of cyanide content.

During the incubation of cassava flours with or without yeast, there was an increase in the lipid with the mobility of diglyceride. Glycolipids were metabolized during the fermentation as evidenced by 17% less of hexose in the lipids. Linolenic acid fell from 11% in unincubated flour to 7% in the fermented flour. Palmitoleic acid which was a major yeast fatty acid was absent in the fermented product.

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Fermented peanut milk

Peanut milk is a non-dairy beverage created using peanuts and water. Recipe variations include salt, sweeteners, and grains. It does not contain any lactose and is therefore suitable for people with lactose intolerance. Similar in production to almond milk, soy milk, and rice milk, the peanuts are typically ground, soaked, sometimes heated, and then filtered through a fine filter: the resulting liquid is considered the "milk".

Peanut milk can be fermented with Lactobacillus delbrueckii subsp. bulgaricus and Streptococcus salivarius subsp. thermophilus, separately and in combination. Analysis of headspace volatiles revealed that hexanal, which is one of the compounds responsible for undesirable green/beany flavor in peanuts, completely disappear as a result of fermentation. S. salivarius subsp. thermophilus is more effective than L. delbrueckii subsp. bulgaricus in reducing the hexanal content. The acetaldehyde content of peanut milk increases during fermentation.

Substitution of peanut milk fermented with mixed cultures of L. delbrueckii subsp. bulgaricus and S. salivarius subsp. thermophilus for buttermilk at a level of 25% or less in ranch style salad dressings results in decreased lightness, creamy flavor, oil emulsion capacity and viscosity, but did not cause significant changes in other sensory qualities.

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Wine production

Winemaking, or **vinification**, is the production of wine, starting with selection of the grapes or other produce and ending with bottling the finished wine. Although most wine is made from grapes, it may also be made from other fruit or non-toxic plant material. Mead is a wine that is made with honey being the primary ingredient after water.

Winemaking can be divided into two general categories: still wine production (without carbonation) and sparkling wine production (with carbonation).

The science of wine and winemaking is known as oenology and the oldest known winemaking operation, estimated to be 8,000 years old, was discovered in Georgia.

Process of wine making

1 Process

2 The grapes

3 Harvesting and destemming

4 Crushing and primary (alcoholic) fermentation

- 4.1 Pressing
- 4.2 Pigeage

5 Cold and heat stabilization

6 Secondary (Malolactic) fermentation and bulk aging

7 Malolactic fermentation

8 Laboratory tests

1. Process

After the harvest, the grapes are taken into a winery and prepared for primary ferment. At this stage red wine making diverges from white wine making. **Red wine** is made from the must (pulp) of red or black grapes that undergo fermentation together with the grape skins. **White wine** is made by fermenting juice which is made by pressing crushed grapes to extract a juice; the skins are removed and play no further role. Occasionally white wine is made from red grapes, This is done by extracting their juice with minimal contact with the grapes' skins. Rosé wines are either made from red grapes where the juice is allowed to stay in contact with the dark skins long enough to pick up a pinkish color or by blending red wine and white wine. White and rosé wines extract little of the tannins contained in the skins.

To start primary fermentation **yeast** Saccharomyces cerevisiae is added to the must for red wine or juice for white wine. During this fermentation, which often takes between one and two weeks, the yeast converts most of the sugars in the grape juice into ethanol (alcohol) and carbon dioxide. The carbon dioxide is lost to the atmosphere.

After the primary fermentation of red grapes the free run wine is pumped off into tanks and the skins are pressed to extract the remaining juice and wine, the press wine blended with the free run wine at the wine maker's discretion. The wine is kept warm and the remaining sugars are converted into alcohol and carbon dioxide.

The next process in the making of red wine is secondary fermentation. This is a **bacterial** fermentation which converts malic acid to lactic acid. This process decreases the acid in the wine and softens the taste of the wine. Red wine is sometimes transferred to oak barrels to mature for a period of weeks or months; this practice imparts oak aromas to the wine. The wine must be settled or clarified and adjustments made prior to filtration and bottling.

The time from harvest to drinking can vary from a few months to over twenty years for top wines. However, only about 10% of all red and 5% of white wine will taste better after five years than it will after just one year. Depending on the quality of grape and the target wine style, some of these steps may be combined or omitted to achieve the particular goals of the winemaker. Many wines of comparable quality are produced using similar but distinctly different approaches to their production; quality is dictated by the attributes of the starting material and not necessarily the steps taken during vinification.

Variations on the above procedure exist. With sparkling wines such as **Champagne**, an additional fermentation takes place inside the bottle, trapping carbon dioxide and creating the characteristic bubbles. **Sweet wines** are made by ensuring that some residual sugar remains after fermentation is completed. This can be done by harvesting late (late harvest wine), freezing the grapes to concentrate the sugar (ice wine), or adding a substance to kill the remaining yeast before fermentation is completed; for example, high proof brandy is added when making **port wine.** In other cases the winemaker may choose to hold back some of the sweet grape juice and add it to the wine after the fermentation is done.

2. The grapes

The quality of the grapes determines the quality of the wine more than any other factor. Grape quality is affected by variety as well as weather during the growing season, soil minerals and acidity, time of harvest, and pruning method.

The most common species of wine grape is Vitis vinifera, which includes nearly all varieties of European origin.

3. Harvesting and destemming

Harvest is the picking of the grapes and in many ways the first step in wine production. Grapes are either harvested mechanically or by hand. The decision to harvest grapes is typically made by the winemaker and informed by the level of sugar (called °Brix), acid (TA or Titratable Acidity as expressed by tartaric acid equivalents) and pH of the grapes. Other considerations include phenological ripeness, berry flavor, tannin development (seed color and taste).

Destemming is the process of separating stems from the grapes. Depending on the winemaking procedure, this process may be undertaken before crushing with the purpose of lowering the development of tannins and vegetal flavors in the resulting wine.

4. Crushing and primary (alcoholic) fermentation

Crushing is the process when gently squeezing the berries and breaking the skins to start to liberate the contents of the berries. Destemming is the process of removing the grapes from the rachis (the stem which holds the grapes). In traditional and smaller-scale wine making, the harvested grapes are sometimes crushed by trampling them barefoot or by the use of inexpensive small scale crushers. These can also destem at the same time. However, in larger wineries, a mechanical crusher/destemmer is used.

The decision about destemming is different for red and white wine making. Generally when making white wine the fruit is only crushed, the stems are then placed in the press with the berries. The presence of stems in the mix facilitates pressing by allowing juice to flow past flattened skins. These accumulate at the edge of the press. For red winemaking, stems of the grapes are usually removed before fermentation since the stems have relatively high tannin content; in addition to tannin they can also give the wine a vegetal aroma.

Most red wines derive their color from grape skins and therefore contact between the juice and skins is essential for color extraction. Red wines are produced by destemming and crushing the grapes into a tank and leaving the skins in contact with the juice throughout the fermentation.

Most white wines are processed without destemming or crushing and are transferred from picking bins directly to the press. This is to avoid any extraction of tannin from the skins or grapeseeds, as well as maintaining proper juice flow through a matrix of grape clusters rather than loose berries. In some circumstances winemakers choose to crush white grapes for a short period of skin contact, usually for three to 24 hours. This serves to extract flavor and tannin from the skins. It also results in an increase in the pH of the juice which may be desirable for overly acidic grapes.

During the primary fermentation, the yeast cells feed on the sugars in the must and multiply, producing carbon dioxide gas and alcohol. The temperature during the fermentation affects both the taste of the end product, as well as the speed of the fermentation. For red wines, the temperature is typically 22 to 25 °C, and for white wines 15 to 18 °C. For every gram of sugar that is converted, about half a gram of alcohol is produced, so to achieve a 12% alcohol concentration, the must should contain about 24% sugars.

The sugar percentage of the must is calculated from the measured density, the must weight, with the help of a specialized type of hydrometer called a saccharometer. If the sugar content of the grapes is too low to obtain the desired alcohol percentage, sugar can be added.

During or after the alcoholic fermentation, a secondary, or malolactic fermentation malolactic fermentation can also take place, during which specific strains of bacteria (lactobacter) convert malic acid into the milder lactic acid. This fermentation is often initiated by inoculation with desired bacteria.

4.1 Pressing

Pressing is the act of applying pressure to grapes or pomace in order to separate juice or wine from grapes and grape skins. Pressing is not always a necessary act in winemaking; if grapes are crushed there is a considerable amount of juice immediately liberated (called free-run juice) that can be used for vinification. Typically this free-run juice is of a higher quality than the press juice. However, most wineries do use presses in order to increase their production (gallons) per ton, as pressed juice can represent between 15%-30% of the total juice volume from the grape.

With red wines, the must is pressed after primary fermentation, which separates the skins and other solid matter from the liquid. With white wine, the liquid is separated from the must before fermentation. After a period in which the wine stands or ages, the wine is separated from the dead yeast and any solids that remained (called lees), and transferred to a new container where any additional fermentation may take place.

4.2 Pigeage

Pigeage is a French winemaking term for the traditional stomping of grapes in open fermentation tanks. To make certain types of wine, grapes are put through a crusher and then poured into open fermentation tanks. Once fermentation begins, the grape skins are pushed to the surface by carbon dioxide gases released in the fermentation process. This layer of skins and other solids is known as the cap. As the skins are the source of the tannins, the cap needs to be mixed through the liquid each day, or "punched," which traditionally is done by stomping through the vat.

5. Cold and heat stabilization

Cold stabilization is a process used in winemaking to reduce tartrate crystals (generally potassium bitartrate) in wine. These tartrate crystals look like grains of clear sand, and are also known as "wine crystals" or "wine diamonds". They are formed by the union of tartaric acid and potassium, and may appear to be sediment in the wine, though they are not.

During the cold stabilizing process after fermentation, the temperature of the wine is dropped to close to freezing for 1–2 weeks. This will cause the crystals to separate from the wine and stick to the sides of the holding vessel. When the wine is drained from the vessels, the tartrates are left behind. They may also form in wine bottles that have been stored under very cold conditions.

During "heat stabilization", unstable proteins are removed by adsorption onto bentonite, preventing them from precipitating in the bottled wine.

6. Secondary (Malolactic) fermentation and bulk aging

During the secondary fermentation and aging process, which takes three to six months, the fermentation continues very slowly. The wine is kept under an airlock to protect the wine from oxidation. Proteins from the grape are broken down and the remaining yeast cells and other fine particles from the grapes are allowed to settle. Potassium bitartrate will also precipitate, a process which can be enhanced by cold stabilization to prevent the appearance of (harmless) tartrate crystals after bottling. The result of these processes is that the originally cloudy wine becomes clear. The wine can be racked during this process to remove the lees.

The secondary fermentation usually takes place in either large stainless steel vessels with a volume of several cubic meters, or oak barrels, depending on the goals of the winemakers. Unoaked wine is fermented in a barrel made of stainless steel or other material having no influence in the final taste of the wine. Depending on the desired taste, it could be fermented mainly in stainless steel to be briefly put in oak, or have the complete fermentation done in stainless steel. Oak could be added as chips used with a non-wooden barrel instead of a fully wooden barrel. This process is mainly used in cheaper wine.

7. Malolactic fermentation

Malolactic fermentation occurs when lactic acid bacteria metabolize malic acid and produce lactic acid and carbon dioxide. This is carried out either as an intentional procedure in which specially cultivated strains of such bacteria are introduced into the maturing wine, or it can happen by chance if uncultivated lactic acid bacteria are present.

Malolactic fermentation can improve the taste of wine that has high levels of malic acid, because malic acid in higher concentration generally causes an often unpleasant harsh and bitter taste sensation, whereas lactic acid is perceived as more gentle and less sour. Lactic acid is an acid found in dairy products. This is the reason why some chardonnays can taste "buttery". All red wines go through 100% malolactic fermentation, due to the fact that red wines have a higher acidity that needs to be softened. White wines are at the discretion of the winemaker, depending on the desired final product. If a malolactic fermentation is used on white wines, it is usually not 100%, but mostly likely somewhere less than 50%.

8. Laboratory tests

Whether the wine is aging in tanks or barrels, tests are run periodically in a laboratory to check the status of the wine. Common tests include °Brix, pH, titratable acidity, residual sugar, free or available sulfur, total sulfur, volatile acidity and percent alcohol. Additional tests include those for the crystallization of cream of tartar (potassium hydrogen tartrate) and the precipitation of heat unstable protein; this last test is limited to white wines.

9. Blending and fining

Different batches of wine can be mixed before bottling in order to achieve the desired taste. The winemaker can correct perceived inadequacies by mixing wines from different grapes and batches that were produced under different conditions. These adjustments can be as simple as adjusting acid or tannin levels, to as complex as blending different varieties or vintages to achieve a consistent taste.

Fining agents are used during winemaking to remove tannins, reduce astringency and remove microscopic particles that could cloud the wines.

Gelatin has been used in winemaking for centuries and is recognized as a traditional method for wine fining, or clarifying. It is also the most commonly used agent to reduce the tannin content. Generally no gelatin remains in the wine because it reacts with the wine components, as it clarifies, and forms a sediment which is removed by filtration prior to bottling.

Besides gelatin, other fining agents for wine are often derived from animal and fish products, such as micronized potassium casseinate (casein is milk protein), egg whites, egg albumin, bone char, bull's blood, isinglass (Sturgeon bladder), PVPP (a synthetic compound), lysozyme, and skim milk powder.

Some aromatized wines contain honey or egg-yolk extract.

Non-animal-based filtering agents are also often used, such as bentonite (a volcanic clay-based filter), diatomaceous earth, cellulose pads, paper filters and membrane filters (thin films of plastic polymer material having uniformly sized holes).

10.Preservatives

The most common preservative used in winemaking is sulfur dioxide, achieved by adding sodium or potassium metabisulphite. Another useful preservative is potassium sorbate.

Sulfur dioxide has two primary actions, firstly it is an anti microbial agent and secondly an anti oxidant. In the making of white wine it can be added prior to fermentation and immediately after alcoholic fermentation is complete. If added after alcoholic ferment it will have the effect of preventing or stopping malolactic fermentation, bacterial spoilage and help protect against the damaging effects of oxygen. Additions of up to 100 mg per liter (of sulfur dioxide) can be added, but the available or free sulfur dioxide should be measured by the aspiration method and adjusted to 30 mg per liter.

In the making of red wine sulfur dioxide may be used at high levels (100 mg per liter) prior to ferment to assist stabilize color otherwise it is used at the end of malolactic ferment and performs the same functions as in white wine. However, small additions (say 20 mg per liter) should be used to avoid bleaching red pigments and the maintenance level should be about 20 mg per liter. Furthermore, small additions (say 20 mg per liter) may be made to red wine after alcoholic ferment and before malolactic ferment to overcome minor oxidation and prevent the growth of acetic acid bacteria.

Potassium sorbate is effective for the control of fungal growth, including yeast, especially for sweet wines in bottle. However, one potential hazard is the metabolism of sorbate to geraniol a potent and very unpleasant by-product. To avoid this, either the wine must be sterile bottled or contain enough sulfur dioxide to inhibit the growth of bacteria. Sterile bottling includes the use of filtration.

11.Filtration

Filtration in winemaking is used to accomplish two objectives, clarification and microbial stabilization. In clarification, large particles that affect the visual appearance of the wine are removed. In microbial stabilization, organisms that affect the stability of the wine are removed therefore reducing the likelihood of re-fermentation or spoilage.

The process of clarification is concerned with the removal of particles; those larger than 5–10 micrometers for coarse polishing, particles larger than 1–4 micrometers for clarifying or polishing. Microbial stabilization requires a filtration of at least 0.65 micrometers. However, filtration at this level may lighten a wines color and body. Microbial stabilization does not imply sterility. It simply means that a significant amount of yeast and bacteria have been removed.

12.Bottling

A final dose of sulfite is added to help preserve the wine and prevent unwanted fermentation in the bottle. The wine bottles then are traditionally sealed with a cork, although alternative wine closures such as synthetic corks and screw caps, which are less subject to cork taint, are becoming increasingly popular. The final step is adding a capsule to the top of the bottle which is then heated for a tight seal.

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Sauerkraut

Sauerkraut is finely shredded cabbage that has been fermented by various lactic acid bacteria, including *Leuconostoc*, *Lactobacillus*, and *Pediococcus*. It has a long shelf-life and a distinctive sour flavor, both of which result from the lactic acid that forms when the bacteria ferment the sugars in the cabbage.

Sauerkraut is made by a process of pickling called lacto-fermentation that is analogous to how traditional (not heat-treated) pickled cucumbers and kimchi are made. Fully cured sauerkraut keeps for several months in an airtight container stored at or below 15 °C (60 °F). Neither refrigeration nor pasteurization is required, although these treatments prolong storage life.

Fermentation by lactobacilli is introduced naturally, as these air-borne bacteria culture on raw cabbage leaves where they grow. Yeasts also are present, and may yield soft sauerkraut of poor flavor when the fermentation temperature is too high. The fermentation process has three phases. In the first phase, anaerobic bacteria such as *Klebsiella* and *Enterobacter* lead the fermentation, and begin producing an acidic environment that favours later bacteria. The second phase starts as the acid levels become too high for many bacteria, and *Leuconostoc mesenteroides* and other *Leuconostoc* spp. take dominance. In the third phase, various *Lactobacillus* species, including *L. brevis* and *L. plantarum*, ferment any remaining sugars, further lowering the pH.

Health benefits have been claimed for raw sauerkraut. It contains vitamin C, lactobacilli, and other nutrients

Procedure

1. Trim the cabbage heads, removing the outer leaves and all bruised or soiled tissue.

2. Wash the trimmed heads thoroughly with tap water.

3. Cut the heads in half, removing the hard, central core.

4. Shred the cabbage with the cabbage shredder. Be careful not to shred your fingers!!

5. Weigh the shredded cabbage. Mix in the salt such that a final concentration of 2.5% is achieved. Complete, even mixing of the salt is highly critical!

6. Pack the shredded cabbage into the crocks, filling to approximately 75-80% of total volume. Compress the mixture moderately while avoiding crushing or bruising the cabbage tissue.

7. Add the lid and weights and finally cover with cheesecloth.

8. Incubate the crocks at 21 to 24°C for 5-6 weeks.

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Fermented Meat Products: Sausages

I. Introduction

Meat fermentation is a low energy, biological acidulation, preservation method which results in unique and distinctive meat properties such as flavour and palatability, colour, microbiological safety, tenderness, and a host of other desirable attributes of this specialized meat item. Changes from a raw meat to a fermented product are caused by “cultured” or “wild” microorganisms which lower the pH.

Since this is a biological system, it is influenced by many environmental pressures that need to be controlled to produce a consistent product. Some of these factors would include a fresh, low-contaminated, consistent raw material, a consistent inoculum, strict sanitation, control of time, temperature, and humidity during production, smoke, and appropriate additives. Lactic acid which accounts for the antimicrobial properties of fermented meats, originates from the natural conversion of glycogen reserves in the tissues and from the added sugar during product fermentation.

A desirable fermentation product is the outcome of acidulation caused by lactic acid production and lowering the water activity (aw) caused by the addition of salt (curing) and drying. Both natural and controlled fermentations involve lactic-acid bacteria (LAB). Their growth must be understood to produce a safe and marketable product.

Most starter cultures, today, consist of lactic acid bacteria and/or micrococci, selected for their metabolic activity which often improves flavour development. The reduction of pH and the lowering of water activity (aw) are both microbial hurdles that aid in producing a safe product. Fermented sausages often have a long storage life due to added salt, nitrite, and/or nitrate, low pH due to lactic acid production by LAB organisms in the early stages of storage, and later drying which reduces the water activity (aw).

2. Raw Meat

Beef, mechanically separated beef (up to ~ 5%), pork, lamb, chicken, mechanically separated chicken (up to ~ 10%), duck, water buffalo, horse, donkey, reindeer, gazelle, porcupine, whale, fish, rabbit, by-products and other tissue from a variety of species can be used to make fermented meat products.

Fermented meat is often divided into three groups.

a) Whole pieces of meat – e.g.; country ham (sometimes fermented), biltong, and jerky. The major product in this category is hams and since these products are often uncooked.

This product is rubbed with dry salt and nitrate/nitrite, spices (pepper, allspice, coriander, mustard, sometimes juniper berries, and sugar or molasses). Curing normally takes two days per pound of the cut. Initial temperatures are usually between 5 to 10ºC (41-50ºF) for 10 to 15 days. Additional rubbings with cure are often used during this period and the hams are usually stored at this temperature for an additional 20 to 50 days to allow salt penetration to the interior. The temperature is gradually raised in stages over weeks or months. Hams may or may not be smoked.

Cold smoking is often accomplished at 30 to 40°C (86 to 104ºF) for several days. During the drying/maturation period, the temperature is usually increased from 13 to 18°C (55 to 64ºF) to 30 to 35ºC (86 to 95ºF) in the later stages of drying.

Hams are often aged from one (U.S) to two (Southern Europe) years. These procedures result in water activity (aw) of 0.9 in high moisture products to 0.75 in low moisture products.

b) Meat chopped into small pieces – sausages, for example, salami. Product is chopped, mixed with salt, sometimes nitrite and/or nitrate, sugar, usually starter cultures, and seasoning, stuffed into casings.

3. Inoculum

These wild inocula usually do not conform to any specific species but are usually related to *Lactobacilli plantarum*. However, other species such as *L. casei* and *L. leichmanii*, as well as many others, have been isolated from traditionally fermented meat products.

L. plantarum, *Pediococcus pentosaceus,* or *P. acidilactici* are the most used starter cultures [to obtain a pH 4.6-5.1 at 32°C (90ºF)]. In Europe, the most used starter cultures include *Staphylococcus xylosu, S. carnosuss,* and to a lesser extent *Micrococcus* spp. (pH 5.2-5.6 at a temperature of <24ºC; 75ºF).

They can sometimes produce an excellent flavoured, unique product due to production of metabolites, in addition to lactic acid, such as volatile acids, alcohol, carbon dioxide which results in a more balanced flavour than can be produced by homofermentative starter cultures. Now, combined starter cultures are available in which one organism produces lactic acid (e.g. *Lactobacilli*) and another improves desirable flavours (*Micrococcaceae, L. brevis. L. buchneri*). This translates into a lot of very good product and almost no undesirable fermented product. However, very little excellent product is produced since many starter cultures are often homofermentative or, in some cases, a combination of just a few species of microorganisms.

Primary genera of lactic acid bacteria most often used in food would include nonpathogenic *Streptococcus, Lactobacillus* (e.g. *sake, plantarum, gasseri*), *Leuconostoc and Pediococcus* (e.g *cervisiae* later reclassified as *acidilactici*, *pentosaceous*) and again, their main purpose is to produce lactate. However, *P. pentosaceus* can use hexoses and pentoses and to produce lactate, ethanol, and acetate. Magnesium is also required since enzymes in the glycolysis pathway contain enzymes that are stimulated by this mineral and thus, magnesium can lead to accelerated pH decline.

4. Flavour enhancers

Flavour enhancers would include coccal Gram-positive *Staphylococcus* (e.g. *xylosus, carnosus*), *Kocuria* (e.g. *varians*) and *Micrococcus* (e.g. varians now called *Kocuria varians*). Micrococci are also used to reduce nitrate to *Pediococcus acidilactici* and *P. pentosaceus* are the most widely used starter cultures in the U.S.

Yeast, *Dabaryomyces hansenii,* and *Candida,* and molds *Penicillum nalgiovens, P. chrysogenum,* and *P. cemembertii* are the major species used for meat production and are used for surface inoculation.

Salt is very important for flavour purposes of the end product, and is often used as a carrier for curing and flavouring agents. Sodium chloride is the major additive that will allow lactic acid bacteria to grow and will inhibit several unwanted microorganisms. Sodium chloride is added for flavour and texture and inhibits Gram negative bacteria while allowing Gram positive lactic acid bacteria to grow. Salt levels above 3% often cause some concern since *Staphylococcus aureus* is also salt tolerant and could grow during fermentation.

Nitrite 80 to 240 (in U.S. 156) mg/kg is used for antibacterial, colour, and antioxidant purposes.

Simple sugars such as glucose (dextrose, 0.5 to 1%, a minimum of 0.75% is often recommended) which is the fermentation substrate can be readily used by all lactic acid bacteria. The quantity of sugar influences the rate and extent of acidulation, and also contributes favorably to flavour, texture, and yield properties.

Spices (e.g black, red, and white pepper, cardamom, mustard, all spice, paprika, nutmeg, ginger, mace, cinnamon, garlic), are often included in fermented meat formulas. Spices are used for flavour, an anti-oxidant properties, to stimulate growth of lactic bacteria, and have an antimicrobial effect.

Sodium ascorbate is used for improvement and stability of colour and retardation of oxidation.

Processing conditions can influence the rate of acid production and also the ultimate pH in traditional products. The type of microorganism will also influence fermentation and the final flavour. Time, temperature, humidity, and smoke are also variables that control the quality of the final product.

5. Fermentation

Facultative or obligate anaerobes which belong to the Gram-positive acidogenic (primarily lactic acid) bacteria such as the genera *Lactobacillus, Streptococcus, Pediococcus, Leuconostoc, Lactococcus*, and *Enterococcus are* used which can metabolize several *saccharides*(with different degrees of efficiencies) into lactic acid, alcohols, aliphatic compounds, lipids, and some amino acids. In fermented sausage, this group of organisms simultaneously performs two functions, reducing nitrate and nitrite to nitric oxide and when combined with myglobin is responsible for cured colour, and by anaerobic glycolysis to produce DL-lactic acid from glucose which reduces the pH.

6. Smoking

Smoking depends on tradition and product type in the area the product is produced and can vary from no smoke to heavy smoke. If smoked, it is used to contribute flavor and to retard surface bacteria, molds and yeast. Smoke adds hundreds of antimicrobial and aroma compounds including organic acids (e.g. formic, acetic, propionic, butyric, isobutyric) and phenols (antioxidants), and carbonyls. These compounds contribute to coagulation of the surface proteins and inhibit the growth of microorganisms,

7. Heating

Most semi-dry sausages are heated after fermentation and/or smoking and this often increases the pH. Often, an internal temperature of 137°F (58.3°C) is used. Most semi-dry sausages need to be fully cooked to ~ 160ºF (71ºC). If heated to 160º (71ºC),

8. Packaging

Fermented, semi-dry sausages after chilling need to be packaged to prevent further weight loss, exposure to oxygen, and contamination. Clear, high-barrier films are the most common packaging material for both intact sausage and sliced product since they contain high oxygen and moisture barriers and will retard flavour and colour losses.

9. Storage

It is usually recommended to hold most fermented products at refrigerated temperatures during storage and marketing even though dried products are often shelf stable. Good hygiene to prevent cross-contamination and bacterial growth is necessary.