

# Microbial metabolism



## **Introduction**

Microorganisms are very important to human life in not only sustaining life but also improving the health of the whole community. Fermented foods arise due to the relationship of human beings to the environment of microorganisms (Doelle, 2007). Bacteria and yeasts help in production of cheese, yogurt, bread and beer among others. These foods are essential for my survival because they provide necessary nutrients to the body.

Microorganisms preserve fermented foods that can be stored for a long period without expiring. Bacteria and yeasts are present in the environment hence making fermentation process easier. The fermentation ecosystem must include microbes, an organic material that has to be fermented, solution for the fermentation process and lastly, a vessel or container that has a controlled gate (Katz, 2003). Fermentation affects the supply of food in many countries and without the microbes (bacteria and yeasts) that produce these foods the body would wither and become susceptible to various diseases. The process of fermentation occurs in nature but when it is controlled, it involves the microbes converting sugars into common products such as lactic acid and alcohol. When I consume fermented foods, they introduce microflora to the body and later inhabit it. Fermentation occurs through two distinct microorganisms: fungi (yeasts and molds) and bacteria. Fermentation by fungi produces alcoholic beverages and bread while bacteria fermentation is responsible for cheese, pickled eggs and yogurt. Animal or plant ingredients with the help of bacteria or fungi obtained from cultures kept in laboratories or from the environment.

This essay will discuss how microorganisms and their metabolic capabilities are significant in the fermentation process of one major pathway: Embden-Meyerhof pathway. This pathway is used in the production of beer, bread, cheese and yogurt that form essential foods needed in a healthy diet.

### Fermentation Process

Fermentation is the process where living microorganisms produce lactic acid or alcohol in solutions (glucose) from either plants or animals. The organic compound (solution with sugars) is partially oxidized using microbes and the substrate produces all ATP.

Image adapted from (Kenneth, 2011)

The substrate that is glucose in the diagram above is oxidized to pyruvate, which is an organic intermediate. NAD is the oxidizing agent used in the process of fermentation (Kenneth, 2011). When ATP is synthesized, some energy is released due to oxidation. Pyruvate is an oxidized intermediate and it is reduced by NADH<sub>2</sub> (reducing agent) to end products. NADH<sub>2</sub> balances the redox reaction when energy is being produced. The above diagram shows fermentation of glucose to lactic acid. Lactic fermentation involves the use of *Lactobacillus*. The glucose (substrate) turns to pyruvate after being oxidized and then the pyruvate is reduced to form lactic acid. Pairing oxidations to reductions will maintain the redox balance within different pathways, for example, the fermentation of lactic acid is through Embden-Meyerhof pathway (Kenneth, 2011).

### Embden-Meyerhof Pathway

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Bread-makers, brewers and cheese-makers mostly use this pathway. To produce CO<sub>2</sub> and ethanol, the pathway is operated by *Saccharomyces*.

Lactic acid bacteria are used to produce the lactic acid. Other bacteria in the production of alcohols, fatty acids and gasses also use this pathway.

Embden-Meyerhof pathway (E-M) is essential in fermentation because the products are important components of beverages and foods (Kenneth, 2011). In the E-M pathway shown below, *Lactobacillus* reduces pyruvate to lactate (lactic acid) while yeast (*Saccharomyces*) reduces pyruvate to ethanol (alcohol) and CO<sub>2</sub>.

Image adapted from (Kenneth, 2011)

E-M fermentations that are done using bacteria lead to many end products especially fermented foods. In Homolactic fermentation, the end product is lactic acid. The bacteria used to produce fermented milk and other milk products include *Lactobacilli*, *Streptococci* and *Lactococci*. The end products include: buttermilk, yogurt, cottage cheese, sour milk, cheddar cheese and other dairy products that are fermented. Enterobacteriaceae pathway is for mixed acid fermentations (Kenneth, 2011). The products of this pathway include a mixture of acetic acid, lactic acid and ethanol among others.

### Major Fermentors in Food Fermentation

Fermented foods are very important for nutrition and for social events such as birthday parties and graduation parties. The major fermented products that are essential to life include bread, coffee, butter, cheese, beer, olives,, sausages, soy sauce, vinegar, wine and yogurt (Scott & Sullivan, 2008).

Bread results from fermenting grain flour that is used as the raw material

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and the bacteria used to ferment it are *Saccharomyces cerevisiae*. Bread is included in different meals and it is essential in providing carbohydrates to the body. Coffee is a beverage that keeps the mind alert when studying for exams or during academic lectures. The raw material used to produce coffee is the coffee bean that is ground, and the microbe for fermentation is called *Erwinia dissolvens* (Scott & Sullivan, 2008). Butter is a dairy product that is produced from milk as its raw material, and using *Streptococcus* species or *Leuconostoc* species as the fermentors. Bakers use butter in baking cakes, cookies and bread among other products. Cheese is an end product of dairy. Foods prepared using cheese include: pizza, meat stews and cooked vegetables while it can be eaten raw. The raw material for producing cheese is milk and the microbes for fermentation are *Lactobacillus* species, *Lactococcus* species, *Pediococcus* species and *Streptococcus* species (Ross et al., 2002). Beer is an alcoholic drink that is consumed during social events such as parties or during weekends. The raw material for beer preparation is grain malt that is fermented using *Saccharomyces cerevisiae* (McGovern et al., 2004). Wine is an extravagant alcoholic drink that tastes better with age. This means that microbes used in fermenting it will preserve it in an enclosed bottle and ferment it further. Grapes are the raw material for wine while *Saccharomyces cerevisiae* and *Saccharomyces bayanus* are the fermentors (Berry & Slaughter, 2003; Fleet, 1992).

## Conclusion

Microorganisms and their metabolic capabilities are significant in fermentation process because they provide sustenance and improve the health of the body. Fermented foods are very essential to human survival

because they provide microbes that protect the body from infections. They can be preserved for long periods hence elimination hunger during winter and dry seasons when fresh foods are not available. The major pathway used in the fermentation process for different foods is known as Embden-Meyerhof Pathway. This pathway is a three-step process that bakers and brewers use to produce fermented food. The glucose is oxidized to a pyruvate then reduced by either bacteria or yeast to form dairy end products and alcohol respectively.