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6. A Study on Lactic Acid Fermentation Properties and Applications

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ABSTRACT

In 1780 C.W. Scheele found lactic acid in sour milk, which resulted in its industrial production in 1881 and Fermi received lactic acid through fermentation. The annual world production of lactic acid is forecast to reach 259,000 tonnes by 2012. Lactic acid is an organic acid that is naturally produced and can be used in a wide range of industries such as cosmetics, pharmaceutics, chemical, food and medical industries, most recently. The sugars derived from renewable resources can be fermentation, which makes it an ecologically friendly product which has been attracting great interest in recent years.

KEYWORDS

Lactic Acid, lactic acid bacteria, applications, fermentation foods, Fermentation.

Introduction:

In food, agricultural and clinical applications, lactic acid bacteria (LAB) play a significant role. The bacteria included in the category are described as gramme positive, non-sportive, non-respiring cocci or rods that create the main end-product of lactic acid during carbohydrate fermentation.

There are four different types of core group, *Lactobacillus, Leuconostoc, Pediococcus* and *Streptococcus*, in common accord. Recent taxonomic revisions proposed several new genera, with *Aerococcus, Alloiococcus, Carnobacterium, Dolosigranulum, Enterococcus, Globicatella, Lactoccus, Oenococcus, Tetragoccus, Vagococcus and Weissella* currently being the remaining group. [1, 2]

The three primary ways in which the favour of fermented food products will be manufactured and developed are: one) glycolyzing, two) lipolysis (fat depletion) and three) proteolysis (degradation of proteins). [5]

Lactate, a major result of carbohydrate metabolism, is transformed into diacetyl, acetoin, acetaldehyde or acetic acident by a fraction of the intermediary pyruvate (some of which can be important for typical yoghurt favours).

LAB contributes relatively little to lipolysis while proteolysis is the major biochemical pathway to flavour development in fermented foods.

For the continued development of distinct flavour in fermented food products, degradations of these components may also be converted into alcoholics, aldehydes, acids, esters and sulphur compounds. [4, 5]

Over the past decades, lactic acid production has expanded dramatically mainly due to the development of new applications and goods. Global demand for lactic acid was projected at around 714.2 kilo in 2013, with yearly growth forecast at 15.5% to 1,960.1 kilo in 2020. (Abdel-Rahman and Sonomoto 2016).

The United States (31% of total use of lactic acid in 2013), followed by China and Western Europe, are the third largest consumer markets in the world. In China, export demand and consumption in the food and beverage industries exceeded Western Europe.

In 2013, Purac, Cargill and Henan Jindan Lactic Acid Technical Co. Ltd. were the world's top three producers of lactic acid. Combined capacities were 505,000 tons. Cargill supplies its subsidiary Nature Works with mainly lactic acid products for polylactic acid production (PR Newswire 2016).

Bacteria of lactic acid are among the best microorganisms studied. In the fields of multidrug resistance, bacteriocins, the quorum sensing, osmoregulation, autolysins and bacteriophages important new advances were developed in lactic acid bacteria study.

The construction of genetically grade lactic acid bacteria for food has also progressed. This has offered new possibilities in many industries for these bacteria (Konings et al. 2000).

The desirable characteristics are its ability to quickly and totally ferment cheap raw materials requiring minimum nitrogenic substances, the production of low cell weight and the low volume and negligible amounts of other byproducts, providing high yields of prefered stereo-specific lactic acid under conditions of low pH and high temperature.

The choice of an organisation depends mostly on the fermentation of the carbohydrate. Sugar can ferment lactobacillus delbreuckii subspecies. Bulgaricus is capable of using lactose in Lactobacillus delbreuckii subspecies.

Lactosis and galactose can be used with Lactobacillus helveticus. Fermentation of starch is possible for Lactobacillus amylophylus and Lactobacillus amylovirus. Glucose, sucrose and galactose can be fermented by lactobacillus lactis. In fermenting sulfite waste liquor, lactobacillus pentosus was used.

Lactic Acid Properties:

Lactic acid is a liquid of 15°C and 1 atm (yellow to colourless) odourless.

Hydroxycarboxylic acid is the simplest.

Table 1 shows in detail thermodynamic characteristics.

Table 1: Physical properties of lactic acid.

Molecular weight	90.08
Melting point	16.8°C
Boiling point	82°C at 0.5 mm Hg 122°C at 14 mm Hg
Dissociation constant, K_a at 25°C	1.37x 10^{-4}
Heat of combustion, ΔH_c	1361 KJ/mole
Specific Heat, C_p at 20°C	190 J/mole/°C

Lactic acid, both an alcohol and an acid, has an optical activity conferred by asymmetric carbon.

The lactic acid and D (-)-lactic acid can be found in two optical-active shapes, L(+), or race-shaped, that is, a L(+)-lactic acid and D(-)-lactic acid mixture.

Both are physically the same (melting point, solubility, dissociation constant, density,) and chemically similar, unless other optical compounds are present in reactions.

The difficulty to separate the chemicals using existing procedures is one result of these reactions (chromatography, distillation, and fractional crystallization).

Therefore, while using compounds having optical activity, it is vital to choose proper separation strategies.

The pure isomers have more value than the racemic mixture since they are employed for specialized industrial purposes, e.g. L(+)-lactic acid, a biodegradable semi-cristalline and thermosetting polymer, is used in the manufacture of L(+)-polylactic acid. Another application is the manufacture of D (-)-polylactic acid, where lactic acid is D(-)-isomer.

Applications of LAB:

Lactic acid is a precursor to many products, and has a broad array of applications in chemical, pharmaceutical and food.

Lactic acid applications and requirements are illustrated in Fig. 1. While available on the market long ago, new uses have only led to large growth in demand in recent decades.

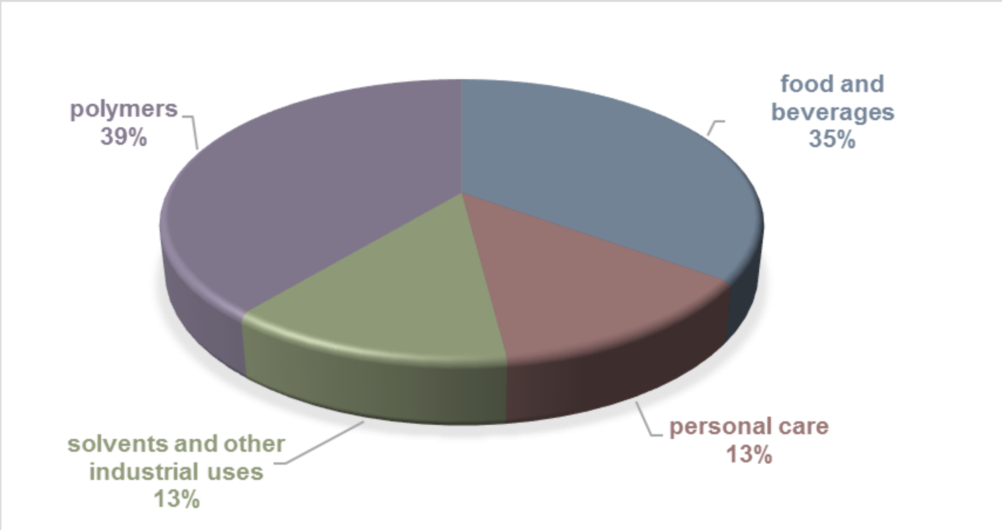

Fig. 1: Lactic acid uses and demands (The Essential Chemical Industry Online 2013)

Lactic acid has a lot of uses in the food industry, which represents a considerable proportion of demand (35%). The acidulant is used as a preservative in olives and pickled vegetables for its moderate acid flavour, compared to other acids in food.

It is also used to produce sweets, bread, soft drinks, beer and other items in order to regulate the pH level and suppress leftover bacteria in the food processing. In fermented foods, such as yoghurt, butter and canned vegetables, this is also an important element.

- **Starter Cultures for Fermented Foods:**

Certain sugars are fermented by LAB and the origins of the fermented foods are lost in antiquity. We know that the largest part of these products come from the dairy products category, notably from cheese, yoghurt, fermented milk, however currently starter cultures are used for fermented meat products, fish, pickled vegetables and olives and a wide array of cereal products.

The resulting product characteristics depended on the dominance of the most suited strain, but the earliest production was based on spontaneous fermentation as a result of the development of the micro-flora naturally found in the raw material and its surroundings. Today the bulk of fermented products are made by adding selected, well-defined starter cultures, specific for each distinct product with well-defined characteristics. See for an overview of starting cultures. [6]

- **Adjunct Cultures:**

Secondary or adjunct cultures or adjunct cultures are defined as any crop whose main job is not acid generation which is deliberately incorporated into fermented food manufacturing at some point.

Additional cultures are utilized to balance some of the biodiversity eliminated by pasteurization, enhanced hygiene and the addition of defined starter culture for cheese production. They are generally non-starter LABs, which affect the flavour and speed up the maturation process. [7, 8]

- **Bio-protective Cultures:**

Some LABs were identified as producing bacteriocins, i.e., ribosomal produced polypeptides, which can have a bacteriocidal or bacteriostatic effect on other bacteria. Bacteriocins generally lead to cell death by blocking the production of the cell wall or by distorting the membrane through the creation of holes. Consequently bacteriocins are significant in food fermentation where food deterioration or food infections can be prevented. Nisin is the most widely-applied bacteriocin in the food sector and utilized in at least 50 nations as a food additive, especially for cheese processing, dairies and canned foods. [9]

- **Probiotic Culture:**

The probiotic is defined by Fuller as "a live microbial feed supplement that benefits the host animal by improving the gut microbial balance." LAB is considered to be an important category of probiotic bacteria. [10] Salminen et al. suggested that probiotics are microbial cell preparations or microbial cell components that have a beneficial effect on the host's health and well-being. Commercial cultures for food use include *Lactobacillus spp*, *Bifidobacterium spp.* and *Propionibacterium spp*. LABs are most widely utilized for functional foodstuffs with probiotics: *Lactobacillus* acidophilus, *Lactobacillus casei*, *Lb. reuteri*, *Lactobacillus rhamnosus and Lb. plantarum.*

Conclusion:

The LAB microorganisms used to fermentation and protect food are most frequently utilised. Their importance is mostly related to the safe metabolism of organic acids and other metabolites while they increase in foods with the help of available sugar.

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