

Streptococcus lactis: structure and applications



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The following paper describes the bacteria *Lactococcus lactis* previously referred to as *Streptococcus lactis*. *Lactococcus lactis* is used in the making of dairy products. The most common of these products are milk, cheese, and yogurt. Researchers are also looking at the potential of *Lactococcus lactis* to be used in conjunction with vaccines. I chose to write about this microbe because of the many uses and interesting facts. *Lactococcus lactis* has served humanity in the past; presently it remains useful in many ways and has the potential to be even a greater asset in the future.

Lactococcus Lactis

Introduction

Lactococcus lactis (*L. lactis*), is a lactic acid bacteria (LAB) that is nonpathogenic and Gram-positive. The genus *Lactococcus* is closely related to the genus *Streptococcus* and is used extensively in the fermenting of milk. It is also the best-characterized lactic acid bacterium (Bolotin, Wincker, Mauger, Jaillon, Malarme, Weissenbach, Ehrlich, & Sorokin, 2001). By nature, *L. lactis* inhabits a function connected to plant and animal surfaces and the gastrointestinal tract of the animal. On plant surfaces, it is inactive but it is believed to reproduce in the gastrointestinal tract after being swallowed (Bolotin et al., 2001). In comparison, researchers have termed what they call a “domesticated” species of *L. lactis*. This species is used in the making of dairy products such as cheese, buttermilk, and yogurt. It also serves a different function that is identified by the use of technology such as “fast growth and rapid production of lactic acid in milk” (Bolotin et al., 2001).

Cell Morphology

Streptococcus lies under the Domain Bacteria. The term strepto means chained and the term coccus means round, therefore streptococcus cells are spherical and occur in pairs or chains that can be short or long in length (Breed, Murray, & Smith, 1957, p. 508). Up until 1985, *L. lactis* was originally classified under the genus *Streptococcus* (MicrobeWiki, n. d.). They are non-motile, do not produce spores and have a “fermentative metabolism” (Bacteria Genomes, n. d.). They also have no pigment; however, in some strains a brick-red or yellow pigment may occur under certain environments (Breed et al., 1957, p. 508). “A fermentable carbohydrate or polyhydroxy alcohol is essential for suitable growth in artificial media” (Breed et al., 1957, p. 508). “The average coccus is small about $1\frac{1}{4}\mu\text{m}$ in diameter” (Engelkirk & Engelkirk, 2011), which may vary from rough to smooth to mucoid” (Breed et al., 1957, pps. 508-509). “Carbohydrate fermentation is homofermentative with dextro rotator lactic acid as the main end result. Carbon dioxide is produced in very small amounts or not at all from sugar fermentation” (Breed et al., 1957, p. 509). With respect to their nutrition, all streptococci are particular and “and require a number of the B vitamins and amino acids for growth” (Breed et al., 1957, p. 509). Species have their own nutritional requirements. “Streptococcus is generally found wherever natural substances that contain sugars are accumulated. They occur regularly within the mouth and intestines of humans and animals, in dairy and other food products, and in plant juices that are fermenting” (Breed et al., 1957, p. 509).

Genome Properties

“ The genome of *L. lactis* is a circular chromosome with 2, 365, 589 base pair, where 86% of the genome code for protein, 1. 4% for RNA, and 12. 6% for noncoding region. 64. 2% of the genes code for known functional proteins and 20. 1% of the genes for known protein with unknown function. The remaining 15. 7% of the genes are unidentified proteins that may be unique to the *Lactococcus*” (MicrobeWiki, n. d.). According to Todar, (2011), the subspecies of *L. lactis* are used extensively as models in lactic acid bacteria research. One subspecies, *Lactococcus lactis* ssp. *cremoris* is characterized by the laboratory strains LM0230 and MG1363, and it is best preferred for the making of hard cheeses. The other subspecies, *Lactococcus lactis* ssp. *lactis* is considered the “ workhorse strain” and is represented by IL1403 (Todar, 2011). This subspecies is best preferred for the making of soft cheeses. Todar (2011) also suggests that “ beginning in 2001, these strains have been sequenced”. In other words, there is a better understanding of how these bacteria are associated with their function.

Finally, the ability to compare genomes has led to more knowledge of how the variety of *Lactococcus* strains adapt to their environments. This ability to compare has also lead to unanticipated findings. It has been suggested that this “ bacterium can perform aerobic respiration and can undergo horizontal gene transmission by the process of transformation” (Todar, 2011). With that, it is possible that *Lactococcus lactis* can be used to improve minuscule things such as “ flavor, texture, and preservation of 10 million pounds of cheese that is produced annually” (Todar, 2011).

It is important to be able to examine and decipher the characteristics of bacteria in order to “ provide data for identification and classification” (Engelkirk & Engelkirk, 2011).

Unique Properties

As previously mentioned, *Lactococcus lactis* (*L. lactis*) is “ one of the most important micro-organisms in the dairy industry” (Bacteria Genomes, n. d.). It is essential in the development and production of products by this industry. When *L. lactis* is added to milk, “ the bacterium uses enzymes to produce energy molecules (called ATP) from lactose. The byproduct of ATP energy production is lactic acid” (Bacteria Genomes, n. d.). This lactic acid that is produced by the bacterium causes the milk to curdle and separate to produce curds, which is then used for cheese and whey (Bacteria Genomes, n. d.). The specific types of dairy that use *L. lactis* for its manufacturing include the cheeses Cheddar, Colby, Camembert, Roquefort, Brie, cottage cheese, cream cheese, and other dairy products such as butter, buttermilk, sour cream, and kefir (Todar, 2011). It is also accepted as a source of vegetable fermentation for pickled cucumbers and sauerkraut and for other fermented liquids such as beer and wine.

L. lactis has also been considered for the development of delivering vaccines. “ The bacterium can be genetically engineered to produce proteins from pathogenic species on their cell surfaces” (Todar, 2011). This is done by injecting an animal with a modified strain of the bacterium by way of a nasal spray. An immune response to the strain is obtained which provides an eventual immunity to the pathogen (Todar, 2011).

Because *L. lactis* is non-pathogenic and non-colonizing it is a promising candidate for delivering biologically active proteins by mucosal routes. In a report by Chinese researchers it is described that “recombinant *L. lactis* is applicable for the development of live mucosal vaccine against hepatitis B virus (HBV)” (Zhang, Zhong, & Huan, 2011). In a lab test mice were given an oral immunization and it induced both mucosal and systemic immune responses against HBV at the same magnitude. These results indicated that the lactococci-derived vaccines could be attractive candidates as alternative HBV vaccines for preventing hepatitis B” (Zhang, Zhong, & Huan, 2011). The increased research of *L. lactis* would be beneficial to people in underdeveloped countries and where sickness and other diseases is high.

In conclusion, the bacterium *Lactococcus lactis* appears versatile. The current research suggests that, with more exploration, *L. lactis* can be used to improve the quality of dairy products as well as the health of individuals by way of vaccines.