EXPLORING THE EFFICIENCY OF *YARROWIA LIPOLYTICA* IN ERYTHRITOL PRODUCTION: A REVIEW

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Abstract

Erythritol, a naturally abundant and low-calorie sugar alcohol, is gaining significant importance in the food industry as a natural sweetener due to its favourable health benefits and non-cariogenic properties. Predominantly produced through microbial fermentation, erythritol serves multiple roles such as a flavor enhancer, stabilizer, sweetener, thickener, and texturizer, making it a versatile additive. Among the various microorganisms studied for its production, *Yarrowia lipolytica* has emerged as a promising candidate due to its robust metabolic activity, genetic adaptability, and efficient fermentation capabilities. Research has focused on optimizing fermentation conditions, genetic modifications, and metabolic pathways in Y. lipolytica to enhance erythritol yields. Additionally, other yeast genera, including *Trigonopsis, Candida, Pichia,* and *Moniliella,* have been explored for erythritol production. The increasing market demand for erythritol has driven extensive studies on its biosynthesis, emphasizing its potential as a sustainable sugar alternative in various industries.

Keywords: Erythritol, *Yarrowia lipolytica*, Glycerol, Yeast.

Introduction

Erythritol is a sugar alcohol with four carbons that belongs to the polyol family and is used as an osmo protectant and natural sweetener. It is a widely used ingredient in many food products, including wine, beer, soy sauce, watermelon, and mushrooms. Erythritol, which was widely used in the food and pharmaceutical industries. This sugar can be used as alternative source to sucrose. This sugar greatly beneficial to those people who having diabetes or those suffering from weight gaining problem (Mustafa *et al.,* 2024). Numerous illnesses, including obesity, ischemic heart disease, dental caries, and type II diabetes which often referred to as non-insulin dependent diabetes, are associated with an unbalanced diet (Juszczyk *et al.,* 2023). Erythritol can be used safely in the food and pharmaceutical industries since it is non-carcinogenic, non-caloric, and cannot be fermented by the bacteria that cause dental caries (Mirończuk *et al.,* 2014). Structurally, erythritol has a sugar alcohol belonging to the polyols group. It has four carbon atoms. Due to presence of the hydroxyl groups, it also exhibits antioxidative properties (Rakicka *et al.*, 2016). Erythritol is widely found in nature and has been found in seaweed, fungi, fruits, honey, mushrooms and fermented food, although always at low levels. It has been determined to be safe for human consumption even when high doses are consumed daily. It has an extremely low digestibility and does not alter blood insulin level. Because of the low insulin index, erythritol has excellent potential as a perfect sugar alternative for people with diabetes (Livesey *et al.,* 2003). Fruits (grapes, pears, melons), mushrooms, alcoholic beverages (wine, sake, and beer), and fermented foods (soy sauce, cheese, miso bean paste) have all been found to contain erythritol (Liu et *al.,* 2019).

Yarrowia lipolytica is a nonconventional yeast that was frequently utilized in the food business and was recognized as safe. It is particularly useful as the host for the manufacture of erythritol (Qui *et al.,* 2021). It could be generated as essential components of normal growth processes, although in varying quantities. The scientist reported the presence of sugar alcohols in fungi. These compounds were produced as byproducts of *A. niger*, fermentation of citric acid. It was known that during biosynthesis, citric acid fungus could create sugar alcohols, primarily glycerol, followed by erythritol, arabitol, and mannitol. Less research has been conducted on yeasts, and those that has been conducted is mostly focused on the production of polyols during the biosynthesis of citric acid. It had been demonstrated that small amounts of mannitol, arabitol, erythritol, and glucose were produced during the biosynthesis of citric acid by *Candida lipolytica* from n-paraffins and glucose (Tomaszewska *et al.,* 2014).

Exploring the versatile *Yarrowia lipolytica* strain: Applications, Characteristics, and Biotechnology potential:

Erythritol was produced industrially using biotechnological procedures due to the high costs and low yield of erythritol production with chemical methods. Glucose and sucrose were two common substrates utilized in the erythritol synthesis process. Earlier research showed that the K1 strain of *Yarrowia lipolytica* Wratislavia could convert glycerol to erythritol in the same straightforward culture media that was employed for the production of citric acid. For the past 60 years, *Yarrowia lipolytica* yeast has been employed in the production of numerous items. It can metabolize a variety of carbon sources, and its wild-type, mutant, and recombinant strains has unique qualities for a range of industrial and environmental uses. The biotechnological valorisation of glycerol, a significant by-product of biodiesel production, has received a lot of interest (Tomaszewska *et al.,* 2014). Biodiesel waste comprised water, oil residue, free fatty acids, sodium salts, and up to 80% glycerol, which could be used as a starting point for a variety of biotechnological processes. Many attempts had been made to convert glycerol through microbiological conversion into useful products, such as 1,3-propanediol, microbial biomass, lipids, erythritol, mannitol, and organic acids.

According to aerobic fermentation, a lot of oxygen is needed, which throughout the industrial production process produced a lot of mechanical and biothermal heat. It is crucial to use a lot of cooling water in order to prevent the metabolic loss and bacterial infection risk that arose from temperatures above 32°C. However, the latter significantly raises the price of industrial erythritol manufacturing on a large scale. When osmophilic yeast is employed as the production strain, saccharides like sucrose, glucose, or enzymatic hydrolysis of starch are frequently utilized in the industrial manufacture of erythritol. There were reports of enhanced growing techniques and high-production strains. Much progress had been made in improving the erythritol production titer in *Y. lipolytica* through the use of metabolic engineering (Wang *et al.,* 2020). While some of these methods had been developed on an industrial scale, they suffered from high fermentation media costs and the production of unwanted byproducts such as mannitol and organic acids, which complicated downstream processing. The oleaginous yeast *Y. lipolytica* served as a host for heterologous protein synthesis and was a model organism for a variety of functions, including lipid metabolism and polyol production (Szczepanczyk et al., 2023). *Yarrowia lipolytica* was also found to be a productive erythritol producer recently (Carly *et al.,* 2017).

Table 1. Yield of Erythritol using different microbial strains utilizing carbon sources

Sr. no	Strains	Carbon source	Yield%	Reference
1	*Yarrowia lipolytica*	Glycerol, Molasses	55%	Mironczuk *et al.,* (2015)
2	*Yarrowia lipolytica* A101	Glycerol	43%	Mironczuk *et al.,* (2016)
3	*Trichosporon sp.*	Glucose	47%	Park *et al.,* (1998)
4	*Torula sp.*	Glucose	48%	Oh *et al.,* (2001)
5	*Yarrowia lipolytica* CICC 1675	Pure Glycerol	N.A.	Yang *et al.,* (2014)
6	*Aureobasidium pullulans*	Xylose	26%	Guo *et al.,* (2016)
7	*Yarrowia lipolytica* K1	Crude Glycerol	56%	Mironczuk *et al.,* (2014)
8	*Candida sorbosivorans*	Glucose	38%	Saran *et al.,* (2015)
9	*Yarrowia lipolytica* MK1	Glycerol	58%	Mironczuk *et al.,* (2017)
10	*Moniliella pollinis*	Sugarcane juice	38%	Deshpande *et al.,* (2022)

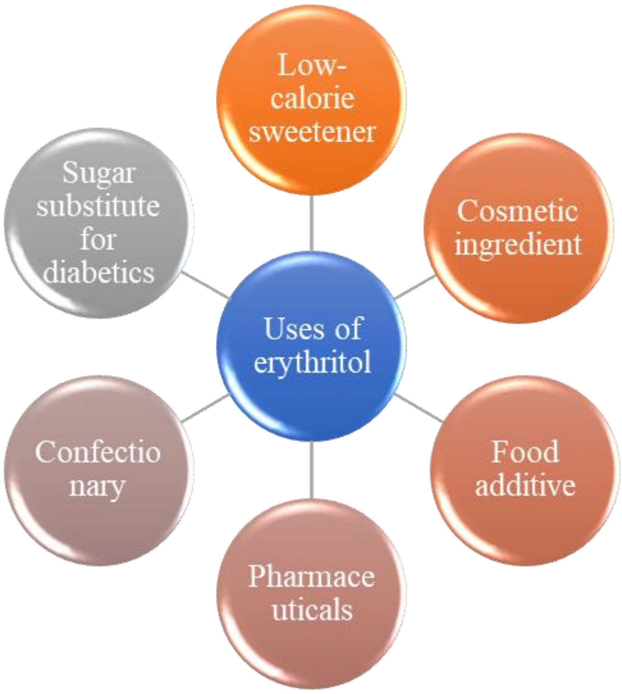

Figure 1. Uses of erythritol (Tomaszewska *et al.,* 2014; Carly *et al.,* 2017; Liu *et al.,* 2019; Mustafa *et al.,* 2024)

Conclusion:

The rising rate of obesity in wealthy countries is currently a major issue for such countries. People used to consume excessive amounts of fat and carbs before the industrial revolution, which led to an increase in body weight and, as a result, a higher risk of various ailments like diabetes and cardiovascular disease. This study shown bacteria *Yarrowia lipolytica* Wratislavia K1 can biosynthesis erythritol from pure or crude glycerol using the RBC system. Traditionally, the primary methods for increasing erythritol productivity in *Y. lipolytica* were to optimise the culture medium or the culturing conditions. The ability of *Y. lipolytica* to catabolise erythritol with glycerol presents a significant hurdle in the development of an effective erythritol production process. Glycerol acts as both a substrate and an osmotic regulator. *Y. lipolytica* produced erythritol efficiently using a two-stage osmotic pressure control fed-batch fermentation technique. The process characteristics, such as erythritol yield and productivity, being greatly improved, which is beneficial for industrial applications. When compared to glucose, crude glycerol, as a carbon source, could effectively limit the synthesis of by-products while increasing erythritol production. This suggests that *Y. lipolytica* has a significant potential for producing value-added products from crude glycerol. The proposed medium including YE and crude glycerol was confirmed to be suitable for industrial-scale erythritol synthesis. Furthermore, this procedure appears to be particularly effective for large-scale erythritol production due to the low number of by-products created. Another advantage is that the biomass produced after erythritol manufacturing can be used for animal feed. Erythritol production is critical for cell homeostasis and the correct response to osmotic stress. Because of the importance of this step, yeast may have evolved alternate pathways for erythritol production.

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