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Short Communication

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Value Addition in Milk Products through β-Galactosidase

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Abstract

β-Galactosidase enzyme catalyzes breakdown of lactose into glucose and galactose. Bonding between glucose and galactose molecules is broken by addition of water molecule. Lactose intolerance is becoming a major issue in world especially in south Asia. By using β-galactosidase enzyme in dairy products, we can minimize the problem of lactose intolerance in people of all ages. Lactose reduced milk and related dairy products are being produced by enzymatic hydrolysis of lactose for the people facing lactose intolerance showing the decline in β-galactosidase level. Being a hygroscopic sugar, lactose has tendency to absorb flavor and odors ultimately causing many problems in refrigerated dairy products. One of the common defects is production of sandy and rough texture or crystal formation in frozen dairy products known as lactose crystallization. This problem can be minimized by hydrolyzing with β-galactosidase enzyme. β-Galactosidase is also used in productions of GOSs (glacto oligo saccharides), used as prebiotics and beneficial to human health by facilitating the growth of intestinal microflora. Improved whey degradability can be achieved by β-galactosidase, in which lactose hydrolysis has been occurred.

In this review, a brief introduction of β-Galactosidase enzyme, class, sources, reaction, enzyme activity assay, and uses in food industry are discussed briefly. ONPG assay method is normally used to measure enzyme activity of β-Galactosidase. Most common use of this enzyme is in dairy products for lactose intolerant people.

Keywords: Milk Products; β-Galactosidase

β-Galactosidase: An Introduction

β-Galactosidase having the EC # 3.2.1.23 belongs to class hydrolases. It is widely present in microorganisms, plants and animals [1]. *E. coli* is mostly used for the study of β-Galactosidase. It is obtained from different microorganisms including bacteria (*E. coli, Lactobacillus thermophiles, Leuconostoc citrovorum, Bacillus circulans*), yeast (*Kluyveromyces lactis, Kluyveromyces fragilis*), fungi (*Aspergillus niger, Aspergillus oryzae*) [3]. β-Galactosidase has a wide range of pH to work. β-Galactosidase obtained from fungal sources have range of pH from 2.4 to 5.4 while that obtained from yeast and bacteria has pH range of 6.0 to 7.2 [5] Temperature range for fungal β-Galactosidase is 50 - 60°C, for yeast β-Galactosidase 30 - 40°C and for bacterial β-Galactosidase is 40 - 65 °C [3]. Fungal β-Galactosidase enzyme doesn't need any ion or co factor for its activity while that β-Galactosidase obtained from yeast or bacterial sources need ions i.e., Mn^{+2}, Mg^{+2} and K^{+} for working. β-Galactosidase activity is reduced or completely stopped by Ca^{+2} and other heavy metals [5,12]. Among plants it is found in tissues of different fruits i.e., apricots, almonds, apples, peaches, papaya, strawberry fruits and also found in animal organs [5-8].

Reaction

β-Galactosidase enzyme catalyzes breakdown of lactose into glucose and galactose. Bonding between glucose and galactose molecules is broken by addition of water molecule, so this is a hydrolysis reaction [4].

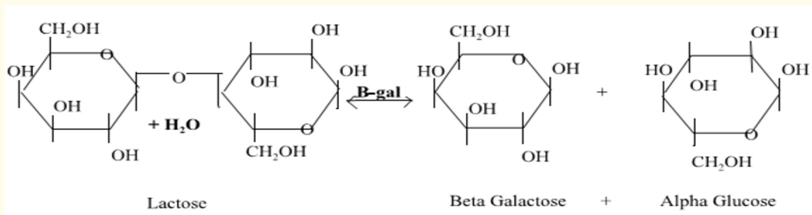

Figure 1

β-Galactosidase: Enzyme activity assay

ONPG (O-nitrophenyl- β-D-Galactopyranoside) test is normally used for β-Galactosidase assay. On addition of β-Galactosidase enzyme, bond present in ONPG between o-Nitrophenyl and galactose is broken down resulting in the formation of a galactose molecule and an o-Nitrophenyl molecule. Amount of ONPG is determined by spectrophotometric assay. Because ONPG is a colorless compound while it's cleaved product o-Nitrophenyl a yellow colored product. So activity of β-Galactosidase enzyme can be measured by change in color from colorless to yellow. When β-Galactosidase continues its activity, more and more ONPG will be degraded, so by measuring this color intensity by spectrophotometer, enzyme activity can be calculated. The absorption maximum for o-Nitrophenyl is 420 nm. By taking optical density (OD) of the solution at 420, activity of β-Galactosidase will be calculated. Is the color of solution is more yellow; this is the indication that more ONPG is degraded by the β-Galactosidase enzyme resulting the higher absorbance [4,14,15].

Applications in milk industry

This enzyme is extensively used by the food industry to improve sensory properties of foods including taste and flavor, solubility and digestibility of different products especially milk products [5, 9]. Lactose reduced milk and related dairy products are being produced by enzymatic hydrolysis of lactose for the people facing lactose intolerance showing the decline in β-galactosidase level [2, 16]. Being a hygroscopic sugar, lactose has tendency to absorb flavor and odors ultimately causing many problems in refrigerated foods. One of the common defects is production of sandy and rough texture or crystal formation in frozen dairy products known as lactose crystallization. This problem can be minimized by hydrolyzing with β-galactosidase enzyme [10,11]. β-Galactosidase is also used in productions of GOSs (glacto oligo saccharides), used as prebiotics and beneficial to human health by facilitating the growth of intestinal microflora [14]. Improved whey degradability can be achieved by β-galactosidase, in which lactose hydrolysis has been occurred [12].

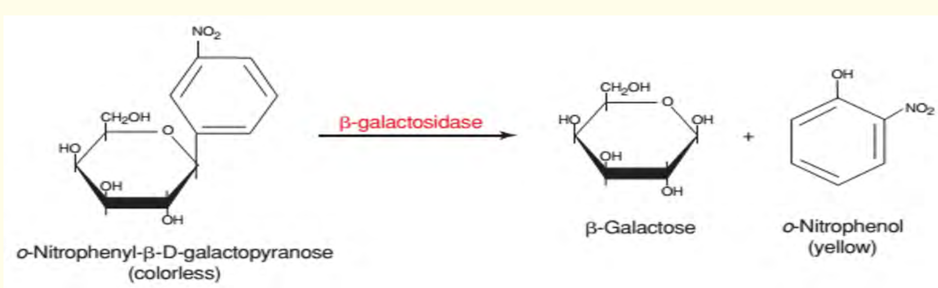

Figure 2

Key points

Mostly work is done on β-galactosidase for the problem of lactose intolerance and production of GOSs. β-galactosidase mainly emphases on the improvement of innovative milk-based products with hydrolyzed lactose, that can be suitable for the lactose intolerant people. This can be used to improve the technological, textural, physical and scientific properties of non-fermented dairy products. Catabolism of lactose is preferred using enzymes especially β-galactosidase, due to lower solubility ranges of lactose. As high concentration of lactose found in fermented dairy products i.e., ice cream, butter, cheese curd, yogurt, etc., can prompt extreme lactose crystallization. This lactose crystallization ultimately results in coarse and abrasive surface of texture of dairy products. Catabolism of lactose in milk-based products also increases the adaptability, richness and better physical properties. Use of beta-galactosidase prior to condensation of milk may decrease the lactose contents to a favorable level, on which lactose can't be problematic as cause of lactose crystallization. There are also research studies on improving the sensory and textural properties of frozen foods to counteract lactose crystallization. Moreover, β-galactosidase can also be used as constructive agent for production of various galacto-oligo-saccharides intended to be used as prebiotics for beneficial gut microflora and probiotics.

Future Perspectives

Apart from applications of β-galactosidase enzyme in improving of dairy products, gene of β-galactosidase is now being tried to use in the viral replicons and transposons for the cancer gene therapy [17]. The use of immobilized β-galactosidase in hydrolysis of lactose is a topic of considerable scientific and technological interest.

Bibliography

1. Haider T and Husain Q. "Immobilization of β-galactosidase by bioaffinity adsorption on concanavalin: A layered calcium alginate-starch hybrid beads for the hydrolysis of lactose from whey/milk". *International Dairy Journal* 19 (2009): 172-177.
2. Heyman B. "Lactose Intolerance in Infants, Children and Adolescents". *Pediatrics* 118.3 (2006): 1279-1286.
3. Mlichová Z and Rosenberg M. "Current trends of β-galactosidase application in food technology". *Journal of Food and Nutrition Research* 45.2 (2006): 47-54.
4. http://biology.kenyon.edu/courses/biol10/110pdfs/15bgal.pdf
5. Husain Q. "β Galactosidases and their potential applications: a review". *Critical Reviews in Biotechnology* 30.1 (2010): 41-62.
6. NagyZ., *et al*. "Beta-galactosidase of Penicillium chrysogenum: production, purification, and characterization of the enzyme". *Protein Expression and Purification* 21.1 (2001): 24-29.
7. Lazan H., *et al*. "Papaya beta-galactosidase/galactanase isoforms in differential cell wall hydrolysis and fruit softening during ripening". *Plant Physiol Biochem* 42.11 (2004): 847-853.
8. Trainotti L., *et al*. "Beta Galactosidases with a lectin-like domain are expressed in strawberry". *Journal of Experimental Botany* 52.361 (2001): 1635-1645.
9. Grosova Z., *et al*. "Perspectives and applications of immobilized βgalactosidase in food industry: a review". *Czech Journal of Food Sciences* 26 (2008): 1-14.
10. Panesar PS., *et al*. "Microbial production, immobilization and applications of β-D-galactosidase". *Journal of Chemical Technology and Biotechnology* 81 (2006): 530-543.
11. Bayramoglu G., *et al*. "Immobilization of β galactosidase onto magnetic poly (GMA-MMA) beads for hydrolysis of lactose in bed reactor". *Catalysis Communications* 8 (2007): 1094-1101.
12. Jurado E., *et al*. "A new kinetic model proposed for enzymatic hydrolysis of lactose by a β-galactosidase from Kluyveromyces fragilis". *Enzyme and Microbial Technology* 31 (2002): 300-309.
13. Mahoney RR. "Galactosyl-oligosaccharide formation during lactose hydrolysis: a review". *Food Chemistry* 63 (1998): 147-154.
14. Michael J Leboffe and Burton E Pierce. "A Photographic Atlas for the Microbiology Laboratory". 4th Edition (2011): 86.
15. Sumathy R., *et al*. "A Study on β-galactosidase of lactobacillus sp from milk products and its applications". *IJABPT.* 3.4 (2012): 138-148.
16. Servera., *et al*. "Transient lactose-reduced milk can be achieved through in vivo transfection of β-galactosidase gene in rat mammary gland". *Academia Journal of Biotechnology* 1.6 (2013): 096-104.
17. Lee JS., *et al*. "Growth inhibitory effect of triple anti-tumor gene transfer using Semliki Forest virus vector in glioblastoma cells". *International Journal of Oncology* 28.3 (2006): 649-654.