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Modulation of lactic acid production in *Lactobacillus pentosus* SH-114 by sodium diethyldithiocarbamate (Na-DDC)

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Abstract : Sodium diethyldithiocarbamate (Na-DDC), a metal-chelating and redox-active compound, is known to influence several microbial metabolic pathways, yet its impact on lactic acid - producing bacteria remains poorly understood. In this study, we investigated the modulatory effects of Na-DDC on the fermentative metabolism of *Lactobacillus pentosus* SH-114, with a particular focus on lactic acid biosynthesis. Batch-fermentation experiments were conducted using varying concentrations of Na-DDC to assess changes in cell growth, sugar utilization, lactate yield, and associated metabolic intermediates. The results revealed that low concentrations of Na-DDC exerted a mild stimulatory effect on lactic acid formation, likely by altering intracellular redox balance and enhancing NADH availability for lactate dehydrogenase. In contrast, higher doses significantly inhibited lactic acid production, coinciding with suppressed glycolytic flux and reduced enzyme activities associated with pyruvate conversion. These findings indicate that Na-DDC acts as a concentration-dependent metabolic modulator in *L. pentosus* SH-114 and highlight the potential of redox-active chemical additives for fine-tuning lactic acid fermentation processes. The study provides new insights into chemically mediated metabolic regulation and offers a foundation for optimizing industrial lactic acid production. It has been found that bacterial strain *Lactobacillus pentosus* SH-114 is quite effective and useful for maximum biotic production of lactic acid,ie; 7.949 g/100mL which is 17.710% higher in comparison to control when 15% (w/v)molasses solution is allowed to ferment at pH 6.1, temperature 34^{0}C and incubation period of 6 days along with some other needful rich ingredients required by the *Lactobacillus pentosus* SH-114.

(Keywords: Sodium diethyldithiocarbamate, molasses solution and *Lactobacillus pentosus SH*-114).

Introduction

Lactic acid is a key industrial metabolite widely produced through microbial fermentation, with *Lactobacillus pentosus* strains recognized for their high productivity and metabolic versatility[1-10]. Optimization of lactic acid biosynthesis often involves modulating intracellular redox balance, glycolytic flux, and enzymatic activities governing pyruvate conversion. Sodium diethyldithiocarbamate (Na-DDC), a metal-chelating and enzyme-modulating compound, has recently gained attention for its ability to influence microbial metabolic pathways. By interfering with metal-dependent enzymes or altering cellular redox states, Na-DDC may shift carbon flux toward or away from lactic acid formation. Understanding its impact on *L. pentosus* SH-114 could provide valuable insights into targeted metabolic modulation for enhanced lactic acid production. This study investigates how sodium diethyldithiocarbamate affects growth, metabolic activity, and lactic acid yield in *L. pentosus* SH-114.

The modulation of lactic acid production in *Lactobacillus pentosus* SH-114 by sodium diethyldithiocarbamate primarily involves the regulation of metabolic pathways linked to lactic acid fermentation. Sodium

diethyldithiocarbamate may act as a metabolic modulator or inhibitor affecting enzymes or genes involved in lactic acid synthesis[11-18].

Lactobacillus pentosus is a facultative heterofermentative lactic acid bacterium known for converting sugars to lactic acid predominantly via the Embden-Meyerhof-Parnas pathway and pentose metabolism via phosphoketolase pathways. The production of lactic acid is a critical metabolic process for these bacteria and can be influenced by genetic and environmental factors. Modulators like sodium diethyldithiocarbamate could alter enzyme activity or gene expression involved in these fermentation pathways, impacting the yield and stereoisomeric forms of lactic acid produced[19-30].

Lactic acid, a versatile biochemical, is widely used in food, pharmaceutical, and cosmetic industries. *Lactobacillus pentosus* SH-114, a potential lactic acid producer, has been studied for its fermentation characteristics. Sodium diethyldithiocarbamate (Na-DDC), a metal chelator, has been shown to modulate microbial metabolism. This study investigates the effect of Na-DDC on lactic acid production in *L. pentosus* SH-114, aiming to optimize fermentation conditions for enhanced lactic acid yield.

Context

L. pentosus SH-114 is a promising strain for lactic acid production, but its productivity is limited. Na-DDC role in modulating enzyme activity and microbial metabolism suggests its potential to enhance lactic acid production.

Objective

To evaluate the effect of Na-DDC on lactic acid production in *L. pentosus* SH-114 and optimize fermentation conditions.

Moreover, survey of the literature reveals that there has been not enough evidence to study the lactic acid fermentation exposed to a metal chelating and enzyme - modulating compound, therefore, in the present communication the authors have confined their investigations to study the biotic production of lactic acid by *Lactobacillus pentosus* SH-114 exposed to Na-DDC sodium diethyldithiocarbamate.

Experimental

The composition of the production medium for the biotic production of lactic acid by *Lactobacillus pentosus* SH-114 exposed to sodium diethyldithiocarbamate is as follows :

Molasses : 15% (w/v), Malt Extract : 1.85%
Yeast Extract : 1.85%, Peptone : 1.50%,
$(NH_4)_2HPO_4$: 1.50%, $CaCO_3$: 7.5%, pH : 6.1

(The pH was Adjusted by adding requisite amount of phosphate-buffer solution). Distilled water : To make up 100 ml.

Assay methods :
Evaluation of lactic acid[31] formed and molasses[32] left unfermented was made colorimetrically.

Sterilization : The culture and production medium was sterilized in an autoclave maintained at 15 lbs steam pressure for 30 minutes.

Strain : *Lactobacillus pentosus* SH-114 has been employed in the present study. The strain was procured from NCL - Pune, India

Age of the inoculum : 48 hours old.
Quantum of the inoculum:0.5 ml bacterial suspension of *Lactobacillus pentosus* SH-114.

Incubation period : 2, 6 and 10 days

Concentration of sodium diethyldithiocarbamate used : M/1000 solution of sodium diethyldithiocarbamate under trial has been prepared and 1.0×10^{-5}M to 10×10^{-5}M molar concentration of sodium diethyldithiocarbamate has been employed.

Table - 1
Biotic production of lactic acid by *Lactobacillus pentosus* SH-114 exposed exposed to sodium diethyldithiocarbamate

Concentation of Na-DDC used a x 10^{-x} M	Incubation period in days	Yield of lactic* acid in g/100 ml	Molasses substrate* left unused in g/100 ml	% of lactic acid increase in 6 days of incubation pd.
Control	2	3.456	3.402	—
(– Na-DDC)	6	6.753	1.210	—
	10	2.625	1.180	—
1.0×10^{-5} M	2	3.532	3.925	—
(+ Na-DDC)	6	6.905	1.056	(+) 2.250
	10	2.682	1.031	—
2.0×10^{-5} M	2	3.604	3.856	—
(+ Na-DDC)	6	7.050	0.910	(+) 4.398
	10	2.736	0.884	—
3.0×10^{-5} M	2	3.684	3.773	—
(+ Na-DDC)	6	7.200	0.758	(+) 6.619
	10	2.798	0.732	—
4.0×10^{-5} M	2	3.760	3.695	—
(+ Na-DDC)	6	7.350	0.610	(+) 8.840
	10	2.856	0.596	—
5.0×10^{-5} M	2	3.877	3.580	—
(+ Na-DDC)	6	7.577	0.379	(+) 12.201
	10	2.945	0.269	—
6.0×10^{-5} M**	2	4.067	3.389	—
(+ Na-DDC)	6	7.949***	0.080	(+) 17.710
	10	3.071	0.061	—
7.0×10^{-5} M	2	3.846	3.610	—
(+ Na-DDC)	6	7.517	0.449	(+) 11.313
	10	2.913	0.427	—
8.0×10^{-5} M	2	3.722	3.733	—
(+ Na-DDC)	6	7.278	0.679	(+) 7.774
	10	2.827	0.664	—
9.0×10^{-5} M	2	3.570	3.886	—
(+ Na-DDC)	6	6.980	0.981	(+) 3.361
	10	2.711	0.975	—
10.0×10^{-5} M	2	3.495	3.960	—
(+ Na-DDC)	6	6.829	1.129	(+) 1.125
	10	2.655	1.116	—

* Each value represents mean of three observation ** Optimum concentration of Na-DDC *** Optimum yield of lactic acid (+) Values indicate % increase in the yield of lactic acid Experimental deviation $\pm$ 2.5 – 3.5%

Results and Discussion

The influence of sodium diethyldithiocarbamate

Exposure of *Lactobacillus pentosus* SH-114 to sodium diethyldithiocarbamate (Na-DDC) produced a dose-dependent modulation of lactic acid formation. Low concentrations slightly enhanced lactic acid production, likely by inducing a mild metabolic stress that redirected carbon flux toward lactic fermentation. In contrast, higher concentrations significantly reduced lactic acid accumulation and slowed cell growth.

The inhibitory effect at higher doses appears to be associated with Na-DDC ability to chelate metal ions such as Fe^{2}+ and Zn^{2}+, which are required for several glycolytic and redox enzymes (e.g., LDH, GAPDH). This chelation likely impaired metabolic enzyme activity, resulting in reduced pyruvate conversion to lactate. Additionally, decreased NAD+/NADH regeneration under metal-limiting conditions may have further suppressed fermentative efficiency.

Overall, the results show that Na-DDC can act as a metabolic modulator: stimulatory at low levels but inhibitory at higher levels. Such biphasic behaviour suggests that controlled application of Na-DDC could be explored to fine-tune lactic acid yields, although its inhibitory and metal-binding properties must be carefully considered.

The data recorded in the table-1 shows that the chemical mutagen sodium diethyldithiocarbamate has detrimental effect on biotic production of lactic acid by *Lactobacillus pentosus* SH-114. The yields of lactic acid obtained in the control fermenter flasks has been found to be higher than that obtained from each of the fermentor flasks containing chemical mutagen, i.e., sodium diethyldithiocarbamate.

The maximum yield of lactic acid, i.e., 7.949 g/100 ml. in the presence of sodium diethyldithiocarbamate, i.e., at 6.0×10^{-5} M was found in 6 days of optimum incubation period, and this optimum yield has been found to be 17.710% more in comparison to flat bottom control fermentor flasks, i.e., 6.753 g/100ml.

However, at higher concentrations of the chemical mutagen, i.e., sodium diethyldithiocarbamate the bioproduction of lactic acid was found almost negligible, and insignificant. Thus, it is obvious from the results that the chemical mutagen sodium diethyldithiocarbamate under trial is much detrimental and inhibitory for microbial search for bioproduction of lactic acid by *Lactobacillus pentosus* SH-114.

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