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Abstract

The effects of exogenous calcium on fungal pellet morphology during preculture and L-lactic acid production were studied. The results showed that addition of exogenous calcium could induce pellet formation. The diameter of the pellet increased with increasing concentration of exogenous calcium, including $CaCl_2$ and $CaCO_3$. The smaller pellet precultured with low concentration of soluble calcium ($CaCl_2$) was beneficial for L-lactic acid production because the pellet was dense and the large inner part of the pellet was inactive. By contrast, the larger pellet precultured with high concentration of insoluble calcium ($CaCO_3$), except 8.0 g/L $CaCO_3$, was beneficial for L-lactic acid production. Supported by the $CaCO_3$ powder, the entire biomass layer was fully active, and the highest L-lactic acid productivities of 1.22 g/L h and 58.6 g/L L-lactic acid were reached using the 1.5 mm pellet.

Keywords (separated by '-') *Rhizopus oryzae*

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Chapter 25
Effects of Calcium on the Morphology of *Rhizopus oryzae* and L-lactic Acid Production

Yong-Qian Fu, Long-Fei Yin, Ru Jiang, Hua-Yue Zhu and Qing-Cheng Ruan

Abstract c , c c , c c , - c c c , c . , - , c c , c , c .
c c c c , c c , c 2 3. c , c c , c c (2) fic - c c c c c , c . c , c , c c c (3), c 8.0 / 3, fic - c c c c , c . 3 , c , - c c c c 1.22 / 58.6 / - c c c c 1.5 .

Keywords *Rhizopus oryzae* · · , c c · - c c c ·

25.1 Introduction

c , fi c c c , c , c , c c , c , c c , c , c , c c , c , c , c c , c 1 . , fi c c c , c c c cc , c c 2 .

.- . (✉) · .- . · . · .- . · .- . , c , , 318000, , c
- : , c . , c

.- . . (.), *Advances in Applied Biotechnology*, c , c c 332, 10.1007/978-3-662-45657-6_25

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.: 25 : 19-11-2014 : 4:51 pm : 234/243

fi , c , , c
3 . fi c
c c .
4, 5 c - c -
. c fic
c , c
c .
c c 6–8 . ,
c c , c c -
, c , , , (, c , c),
c , , c . , c c
c ; (. ., *Rhizopus* .)
, (. ., *Penicillium*
chrysogenum) 4, 9 . ,
c c
.
c fl c fi -
, c c fi .
, c - 10
fi c
fi c fl c , c
c c . c
c c .
c c c c .
c fi c
c , c
c c 11, 12 . c c -
c c c , c
, . , c c
, c c , c c ,
, c c 2, 3, 11 . -
, c c , c , c c c c , c $^{2+}$,
c c ,
c 13, 14 .
c c c c . , .
15 c $^{2+}$ c
Fusarium graminearum 3/5, $^{2+}$ c c
c .
c c c *F. graminearum*,
c . 16 . c 17
c c $^{2+}$ c c
c c c
c . c c $^{2+}$ (>50)
$^{2+}$
. c c
c - . , Ž š č . 13 ,

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1×10^{-3} $^{2+}$
c . 3.84 ± 0.84 .
$^{2+}$ c c 1×10^{-2} ,
c *Rhizopus nigricans* c .
c c , c c $^{2+}$
fi c - , c , - ,
, c . c c ,
c c c c - fi ,
c *Rhizopus oryzae*. c
fl c c c c -
R. oryzae, c *R. oryzae* c
- c c c fic . , c c c , c ,
c c , , c c c , - c c
c c *R. oryzae* c .

25.2 Materials and Methods

25.2.1 Microorganism and Growth

Rhizopus oryzae -45, *R. oryzae* 395, .
( ) 30 ° 7 .
, c c c
c . 4 ° .

25.2.2 Preculture Conditions

c c c ( ): 20.0
c ; 2.0 ; 0.2 $_2$ $_4$, 0.2 $_4$·7 $_2$; 0, 2.0, 4.0,
6.0 $_2$ 0, 2.0, 4.0, 6.0, 8.0 $_3$ (c c
c); . 50
$_2$/ $_3$ 250 fl
(121 ° 20).
c , 15.0 100.0 / $_2$ 0.1–0.4 $_3$
c 20 . c
c c , c
115 ° 30 . $_2$ fi $_3$
c 250 fl
$_2$/ $_3$ c c c .
c fl c c 1×10^6 /
, c (150) 30 ° 18 .
.

: T1 Standard Unicode : 330743_1_En : 978-3-662-45656-9
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25.2.3 Fermentation

c c c ( ): 80.0
c , 3.0 (4)2 4, 0.25 4·7 2 , 0.04 4·7 2 ,
0.2 2 4, 40 3· 3 c
121 ° 20 . c c c
(115 ° 30). - c c c c 3.0
(c c fic,) 2.0 , c
c, 300 c, . c,
30 °
0.5 300 , c . 3
, c
6.0 c, . c,
48 68 . c - c
c ( ) .

25.2.4 Analytical Methods

c c c , c , ,
. c c c c c ,
c c c , 80 °
c , c . .
.
c , , c c c c c (,
680 , , ; -101 c c ,
, ; -87 c 300 × 7.8 , -
,) c : , 20 μ ; ,
0.005 2 4; fl , 0.8 / ; c , 60 ° 18 .
c 60 ° .
c (,).

25.3 Results and Discussion

25.3.1 Effects of Exogenous Calcium on the Growth of R. oryzae

c, *R. oryzae*
c c c c
25.1. c c c
c, 25.1.

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Table 25.1 *R. oryzae* 18 c c, c , c c

	c (/)				( )		c c c	(/)
2	6.0		5.3	4.8	–	–	–	6.01 ± 0.30
	4.0		5.2	3.7	1.2	1.0–1.5	,	6.42 ± 0.32
	2.0		5.2	3.6	0.8	0.5–1.0		6.21 ± 0.31
	0		5.0	4.5	–	–	–	5.90 ± 0.30
3	2.0	fi	5.5	4.6	1.0	0.5–1.5	, , c	6.30 ± 0.32
	4.0		5.8	5.1	1.2	1.0–1.8		6.86 ± 0.34
	6.0		6.0	5.8	1.5	1.0–2.0	, fl	7.02 ± 0.35
	8.0		5.9	6.1	2.3	1.5–3.0	, , 3	8.14 ± 0.41

143 fi

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.: 25 : 19-11-2014 : 4:51 pm : 239/243

c c 2 3 c .
1.2 1.5 . 3
3 c c (8.0 /).
2.3 . , c c (2) fic
, c c (3).
c c c c (-
c c) c .
c c fic .
14 , c 12 , .
15 . c fic c c , c
2+ - c , , - c ,
. c 2+ c c
c 16, 17, 19 c
c c 17 . c c 2+ c
16 . , c 2+
c c (., 2+ c c c 16)
c c c 2+ c c , c .
Ž š č 11 fi
c fi
, c fl c , c c
c . c
, c c . 2+ c
c , c c c .
c c c (. 25.1)
, c c (. 25.1). , c c -
, c c c (. 25.1c,),
c c c c c
(. 25.1 ,).

25.3.3 *Effect of Exogenous Calcium on L-lactic Acid Production*

25.2 , - c c c , c , , c c c ,
c c c , c c c , c , - c c c -
c *R. oryzae* , c -
c , . , c c c c
21.4 32.2 / c , 0 / 2 8.0 / 3,
c . fi - c c c , c c 30.3 57.2 /
c , 2. - c c c , c 57.2 /
2.0 / 2. , fi - c c c
, c c 39.2 58.6 / c , 3.
- c c c , c 58.6 / , 6.0 /
3. , - c c c , c , , 2

Table 25.2 *R. oryzae* c c

c c	2			3			
	0	2.0	4.0	2.0	4.0	6.0	8.0
c c (/)	82	81	83	82	84	83	82
c c (/)	21.4	2	3	9	2	3	32.2
- c c c c (/)	30.3	57.2	54.1	39.2	53.2	58.6	25.1
- c c c c (/)	0.50	0.72	0.68	0.54	0.65	0.73	0.504
- c c c c (/ $^{-1}$ $^{-1}$)	0.446	1.02	0.902	0.576	1.02	1.22	0.369
(/)	7.8	5.4	5.8	6.1	4.2	2.7	9.4
( )	68	56	60	68	52	48	68

c 3 c , - c c c c -
c 20 % (1.02 / $^{-1}$ $^{-1}$ 2.0 / 2 1.22 / $^{-1}$ $^{-1}$ 6.0 / 3).
c 2.0 / 2 6.0 / 3.
c c c
c 20 , c c c 21 , c c c 22 , c 23 .
c ,
c fic 11, 24 . ,
fic .

25.3.4 *Microscopic Analysis for the Morphology of Mycelial Pellet*

c c c (. 25.2) c
25, 26 .

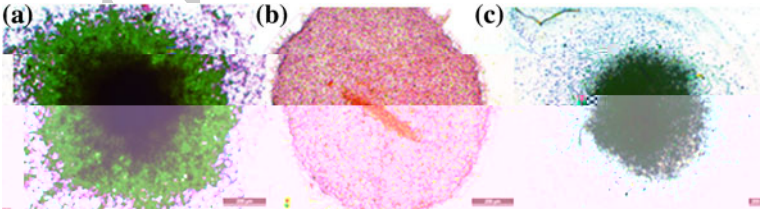

Fig. 25.2 c *R. oryzae*
c c (**a** 2.0 / 2; **b** 6.0 / 3; **c** 8.0 / 3). c c c c (2500)

c c .
Aspergillus niger , 0.4 . c
fl c c *A. niger* c fi
c c c ,
c 27 . 0.8
c 2.0 / 2 c ,
fi c (. 25.2). c
0.2 . c
. 3 c , , c
c 3, fic c (. 25.2).
, 3 c
cc , , c c c ,
fi c . , 3 -
28, 29 . , c
(. 25.2). , c 3
. 3 , c .
c c , c
c , 2. 3 c c
c , c 3 (. 25.2c) c
- c c c c .

25.4 Conclusion

c c c
c c c , c -
. c c c , c
. c c c
c c c , c 2 3. c ,
2 (. 25.2) c , ,
c . , c ,
c c c c (2), fi - c c c
c . c , c c c
c c (3), c 8.0 / 3, fic - c c c
c . c c c 3 -
c , c c 3 (6 / 3),
c , c ,
fi c c (. 25.2).
3 , c - c c
c c 1.22 / −1 −1 58.6 / - c c c
1.5 . c 3 c
- c c c c c , 8.0 / 3.

AQ1

Acknowledgments fi c c
(. 21106091), c c
(12 06004).

References

1. (2012) c
Rhizopus oryzae c c . c c
94:875–886
2. (2005) c fi
. c c 69:375–384
3. (2000) fi . c c
70:1–32
4. (2007) fi *Rhizopus*
oryzae c c c . c c 136–140:689–701
5. (1977) : .
c 19:781–799
6. (2011)
c c c *Rhizopus oryzae*. c
c 48:39–47
7. (2000) c *Rhizopus oryzae* 20344.
c c 84–86:779–789
8. c (2012) c fi
c c c fi . 49:499–510
9. ü (1998) c *Penicillium chrysogenum*
c c - c
. c 59(6):762–775
10. c - (1991) c c . c
9:63–68
11. Ž .496 9(.498 - 28 c)-623.8((c 2(7( )-44.9813004.981331.4079293.72

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20. , , , , (2006) -(+)- c c c c
fi *Rhizopus oryzae* 395. c c
129–132:844–853
21. , (1977) : .
c 19:781–800
22. (2004) c c
c . c 22:189–259
23. , , , (1993) fl c c c
c c c *Penicillium chrysogenum*. c
9:83–90
24. , , , , é - (2010) c
fi *Aspergillus niger* c c c c c c
c c c c . c 101:1920–1926
25. c , ä c , c , , (2012)
c - *Aspergillus niger*:
c c . c 109(2):462–471
26. , , c , (2012) c c
fi c - c . c 34
(11):1975–1982
27. , , , (2005) fi
Aspergillus niger. c 92:614–623
28. c , , c (2010) : c c
- c c . 2:1–5
29. , c , c c , c (2007) c c - c c,
fi c : c c c
. c 99:491–498

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