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Bacterial cellulose production on whey – an overview of prospects

Sergejs Koļesovs, Kristaps Neiberts, Maija Rukliša, Pāvels Semjonovs*

Institute of Biology, University of Latvia, Ojāra Vācieša street 4, Riga, Latvia, LV-1004
* Corresponding author: *psem@latnet.lv*

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Bacterial cellulose (BC) is a biopolymer with a wide range of potential applications starting from the food and packaging industry to biomedicine and electronics. Despite its high potential, BC large-scale production remains still challenging (Jozala *et al.*, 2015; Azeredo *et al.*, 2019). The high cost of growth media, which can reach up to 30% of production costs is one of them. To decrease production costs, the use of industrial and agricultural by-products (Table 2), including whey (Table 1 and 2), as alternative growth media can be considered. Whey is the main high-volume by-product of the dairy industry and can be considered as an alternative growth medium for BC production despite its low valorisation opportunities. Only a few research articles are dedicated to the evaluation of BC productivity on whey media. BC production on whey medium is highly strain-specific and is associated with strains' ability to hydrolyse lactose which is the main C source in whey (Semjonovs *et al.*, 2017; Revin *et al.*, 2018). Several strains do not support BC synthesis on whey or lactose-containing media (Thompson and Hamilton, 2001).

Our study shows that *Komagataeibacter rhaeticus* P-1463 can produce up to 1.95 ± 0.15 g/L of BC (dry weight) during 10 days of cultivation on the unhydrolyzed whey medium, thus assimilating lactose and relevant monosaccharides as C substrate. Moreover, *K. rhaeticus* P-1463 utilises galactose and lactose in a modified HS medium (Table 1). Whey enzymatic pretreatment with β-galactosidase increased BC production by *K. rhaeticus* P-1463 to 2.41 g/L (dry weight). Probably there are limiting factors besides C and N concentrations restricting BC production in whey medium.

Table 1. BC production on standard and modified HS media (*K. rhaeticus* P-1463)

Medium	BC dry weight, g/L	Productivity QX, g/L/d
HS medium	3.68 ± 0.03	0.37
Modified HS medium with lactose	2.85 ± 0.04	0.29
Modified HS medium with galactose	2.1 ± 0.02	0.21
Whey	1.95 ± 0.15 g/L	0.19

Table 2. Comparison of BC production on whey with other alternative substrates.
Table adapted from (Kolesovs and Semjonovs, 2020)

Mudium	Strain	BC dry weight, g/L	Reference
Whey medium (no pre-treatment)	*K. rhaeticus* P-1463	1.95	*Current research*
Hydrolised whey (β-galactosidase pre-treated)	*K. rhaeticus* P-1463	2.41	*Current research*
Whey	*G. sucrofermentans* B-11267	5.45	(Revin *et al.*, 2018)
Whey	*K. xylinus* DSM 2325	6.77	(Rollini *et al.*, 2020)
Corn steep liqour	*A. xylinum* NRRL B-42	6.7	(Cerrutti *et al.*, 2016)
Orange juice	*A. xylinum* NBRC 13693	5.9	(Kurosumi *et al.*, 2009)
Apple juice	*A. xylinum* NBRC 13693	3.9	(Kurosumi *et al.*, 2009)
Pineaple juice	*A. xylinum* NBRC 13693	3.9	(Kurosumi *et al.*, 2009)
Molases	*A. xylinum* BPR2001	5.3	(Bae and Shoda, 2004)
Glycerol	*G. xylinus* CGMCC no. 2955	5.97	(Zhong *et al.*, 2013)
Wheat enzymatic hydrolysate	*A. xylinus* ATCC 23770	8.3	(Chen *et al.*, 2013)
Coconut water (*Nata de Coco*)	Acetic acid bacteria	712.9 (wet weight)	(Phong *et al.*, 2017)

Conclusions

Currently whey can be recognised as challenging and still quite a problematic alternative growth substrate for large-scale BC production. It was shown that whey is a suitable and promising medium for BC synthesis by acetic acid bacteria strain *K. rhaeticus* P-1463. At the same time, the use of untreated whey results in significantly lower BC if compared to standard HS medium. Further extensive studies may improve the prospects in both – the search for cheap alternative growth substrates for industrial BC production and valorisation of whey.

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