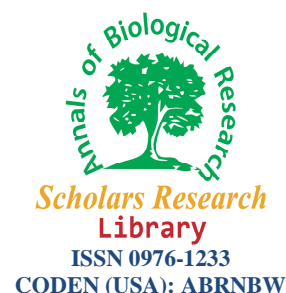




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An overview on effective parameters in production of single cell oil by microorganisms especially the fungus of *Mortierella isabellina*

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ABSTRACT

Current interest in microorganisms as sources of edible lipids, the single cell oils (SCO), centers around the ability of these microorganisms to convert agro-industrial surpluses and residues into lipids rarely found in the plant or animal kingdom [i.e. lipids containing rare poly unsaturated fatty acids (PUFAs)], while in a recent development, SCO are considered as adequate starting material for the production of biodiesels. PUFAs are valuable products because of their involvement in several aspects of human health. Production SCO in opposite of plant have many advantages, such as short life cycle, less labor requires, less affection by venue, season acclimateasier to scale up. The main aim of this review was to explain the last records about effective parameters on production of single cell oil by microorganisms especially the fungus *Mortierella isabellina*.

Keyword: single cell oil, fermentation, *Mortierella isabellina*

INTRODUCTION

Microbial lipoids, known as single cell oil (SCO) [1]. Like all living cells, microorganisms contain lipids. It indicates a triacylglycerol type of oil, similar to that found in plant and animal edible oils and fats [2]. Microorganisms product lipid for essential functioning of cell membranes and other membranous structure [3, 4]. Microbes play a key role in food industries and also o variety of valuable enzymes, amino acids, antibiotics, polysaccharides and lipids are obtain from microbial sources [5]. Poly unsaturated fatty acids (PUFAs) are valuable products because of their involvement in several aspects of human health [6]. Some of PUFAs are essential fatty acids that are not synthesized by human and must therefore be consumed in the diet for preventing nutrition_ralated illnesses [7]. These are linoleic acid 18:2n6, γ _linolenic acid (GLA) 18:3n6, α _linolenic acid 18:3n3 and arachidonic acid 20:4n6. GLA has been claims to play a role in development and prevention of some skin disease, diabetes, aging, even of rheumatic origin,

dilate veins, lower blood pressure, reduce cholesterol levels and induced apoptosis of tumor cells without harming normal cells [8]. GLA occur in human breast milk also it is produced from plant sources such as seeds of evening primrose, borage and blackcurrant [9]. Production SCO in opposite of plant have many advantages, such as short life cycle, less labor requires, less affection by venue, season acclimate easier to scale up [10]. The aim of present mini review was to explain the last records about effective parameters on production of single cell oil by microorganisms especially the fungus *Mortierella isabellina*.

1. Microorganisms for SCO productions

A variety of PUFAs has been detected in microorganisms including bacteria, algae, yeast and mold [5].

1.1. BACTERIA

Bacteria are the simplest and smallest of microbial cells [5]. Just some sort of bacteria can accumulate oil under some especial environment. But usually, the lipid composition produced by bacteria is quite different from other microbial oils [10]. Most bacteria produce complex liquid. Also bacteria have low speed of grow in compared by molds [3].

1.2. Algae

Algae for growth needs to sunlight and CO₂ therefore there are some limits in production SCO by them [6].

1.3. Yeasts

Some of the yeasts have a good potential for producing SCO such as *Rhodosporidium toruloides*, has the most lipid content and can grow on cheap carbon sources easily [5]. *Hansenula saturnus*, *Lipomyces lipofer*, *Trichosporon cutaneum* have high capacity to production SCO too [11].

1.4. Molds

Molds show a greater diversity of lipid types and fatty acids than yeasts. The main difference between the fatty acids of yeasts and molds is that the latter tend to produce much higher proportion of PUFAs and hence molds have become a target for intensive research [12, 13].

Between these microorganisms *Mortierella isabellina* has been chosen of present significant variations in relation with their biochemical response (i.e, concerning regulation of lipid accumulation process fatty acid composition) in nitrogen limited media. *Mortierella isabellina* occurs commonly in forest communities including forest seed worldwide and isolate from decayed wood with termite nests [9, 12].

2. Single cell oil production

In oleaginous microorganisms the culture medium must be low in nitrogen or Mg, P, SO₄²⁻, Fe and high in carbon availability, indeed any other feed sources expect carbon use as limiting agent [14]. When the nitrogen is exhausted cause nitrogen is essential for both protein and nucleic acid biosynthesis, the excess carbon (usually glucose or other carbohydrates) get converted in to fatty acid and then to triacylglycerols. If limited agent gets present in culture condition, lipids will metabolized [4, 15].

2.1. Carbon Sources

Carbon sources play an essential role on lipid accumulation process. Various types of carbohydrates, which are raw materials deriving from agro_industrial activities are used for SCO production [16, 17]. Such as saccharose, molasses, hydrolyzed starch products such as glucose and dextrin, fructose, whey, various natural hydrolysates (e.g, tomato waste hydrolysate, rice straw hydrolysate) also long chain alcohols such as hexadecanol [18]. GLA production in glucose as a carbon sources is more than fructose and fructose is same as molasses and SCO production in glucose is more than lactose, starch and pectin respectively [19, 20]. Because hydrolytic enzymes such as α _amylase, β _galactosidase and polygalacturonase are not enough for metabolic activities [21]. Total lipid increase in glucose concentration in the medium. This maybe because generally fungi grow rapidly in simple sugar compared to complex molecules [22].

2.2. Nitrogen Sources

Certain yeasts have been reported to produce higher concentration of lipid when grown with an organic rather than an inorganic nitrogen source [23]. Some of nitrogen sources have effect on lipid accumulation like NH_4Cl , asparagineglutamate, ammonium tartrate and yeast extract [22]. Yeast extract is the best nitrogen source, its replacement by corn steep liquor and baker's yeasts exerted more or less similar impact on fungal metabolism to produce GLA, thus indicating an economical alternative to yeast extract [24].

3. Metabolic Pathway

Converting long chain alcohols to high value pufa obey from this way [17]:

Alkan \rightarrow Alcohol \rightarrow Aldehyde \rightarrow Fatty acid

The biosynthesis route responsible for GLA in fungi has been suggested to be n_6 route, which involves the following consecutive reactions: oxidation of hexadecanol to palmitic acid, elongation of palmitic acid to stearic acid selective desaturation of the latter to oleic acid catalysed by Δ^9 stearoyl_CoA desaturase and then similarly, to linoleic acid and linolenic acid catalysed by Δ^{12} oleyl_CoA desaturase and Δ^6 inoleyl_CoA desaturase respectively [25].

3.1. Solid-state fermentation

Solid state fermentation has been occasionally used for the SCO production, because of its low cost compared to submerge culture. This fermentation system however is not suitable for production of pure PUFAs, because the substrate lipid that co_extract with the produced SCO tend to reduce the PUFA content of final product [26, 27]. Solid state fermentation is a process in which microorganisms grow at a moist solid substrate in the absent of free water. Solid state fermentation simulates fermentation reaction accruing in the nature and allows microbial utilization of raw agro_materials or by products of the agro food industries. In solid state fermentation fungal colonies divided to some of circular rings that showing different ages. Solid state cultures provide an experimental system where hyphae of different ages belonging to the same tallus can be separated and studied [28, 29].

3.2. Submerged Fermentation

In submerged culture, mycelia of different ages intertwine to form either pellets or mats or both depending on culture conditions. Therefore, lipid analysis during growth in submerge culture involves an inherent error cause by the inevitable agglomeration of young and aged mycelia [1, 12].

3.3. Effect of different factors on sco production

OXYGEN: as all oleaginous microorganisms are aerobic, the supply of oxygen to the culture is the rate limiting factor. pH and oxygen supply all have some effect on the properties of the lipid types and on the nature fatty acyl groups that are being produced [30].

Metal Ion Concentration: metal ion concentration on lipid and GLA production by *Cunnigamella* sp. 2A1 have significant effect on lipid accumulation such as Fe, Mg, Zn. Either Zn having the most effect with an increase of GLA yield ($\frac{\text{g GLA}}{\text{g lipidless biomass}}$) achieved [3, 31]. Temperature has a reverse relation with production SCO and at PH equal 6.5_7 lipid accumulation will increase [60].

CONCLUSION

The production of SCO by fungi has been understood for many years, and this knowledge has led to the development of effective studies in this field. Clearly, there is a great potential for using fungi especially *Mortierella isabellina* as 'fungi factories' for producing PUFAs. Cultivation conditions are one of effective parameters biosynthesis of SCO by *Mortierella isabellina*. This is a novel clue to rapidly gain high production of PUFAs.

REFERENCES

- [1] S. Fakas, A. Makri, M. Mavromati, M. Tselepi, G. Aggelis, *Bioresource Technol.* **2009**. 100: 6118-6120.
- [2] N. Fidler, B. Koletzko, T.U. Sauerwald, *Zb. Biotehni.ke fak. Univ. v Ljubljani. Kmetijstvo. Zootehnika.* **1999**. 74: 37-45.
- [3] F. Muhid, W.N.N. Wan Nawi, A.J. Abdul Kader, W.M. Wan Yusoff, A. Abdul Hamid, *J. Biological Sciences.* **2008**. 8(4): 80-85.
- [4] D. Somashekar, G. Venkateshwaran, S. Sambaiah, B.R. Lokesh, *Process Biochem.* **2002**. 38: 1719-1724.
- [5] C. Ratledge, *Biochimie.* **2004**. 86: 807-815.
- [6] D.L. Alonso, F.G. Maroto, *Biotechnol. Advances.* **2000**. 18: 481-497.
- [7] U.N. Das, *Med. Sci. Monit.* **2007**. 13(7): Ra 119-131.
- [8] S.M. Tauk-Tornisielo, L.S. Arasato, A.F. de Almeida, J.S. Govone, E.N. Malagutti, *Brazilian J. Microbiol.* **2009**. 40: 342-345.
- [9] T. Watanabe, Y. Watanabe, T. Fukatsu, R. Kurane, *Mycoscience.* **1998**. 39: 475-476.
- [10] Q. Li, W. Du, D. Liu, *Appl. Microbiol. Biotechnol.* **2008**. 80: 749-754.
- [11] M. Li, G.L. Liu, Z. Chi, Z.M. Chi, *Biomass Bioenerg.* **2010**. 34: 101-107.
- [12] J.J. Shen, F.C. Li, Q.L. Yang, D.W. Feng, S. Qin, Z.B. Zhao, *Marine Sci.* **2007**. 3(8): 38-41.
- [13] G. Vicente, L.F. Bautista, R. Rodriguez, F.J. Gutierrez, I. Sadaba, R.M. Ruiz-Vazquez, S. Torres-Martinez, V. Garre, *Biochem. Eng. J.* **2009**. 48: 22-27.

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- [14] G. Aggelis, G. Mamalakis, M. Komaitis, *La Rivista Italiana Delle Sostanze Grasse*. **1995**. *LXXII*: 211-213.
- [15] S. Papanikolaou, S. Sarantou, M. Komaitis, G. Aggelis, *J. Appl. Microbiol.* **2004**. 97: 867-874.
- [16] A. Kavadia, M. Komaitis, I. Chevalot, F. Blanchard, I. Marc, G. Aggelis, *JAOCS*. **2001**. 78(4): 341-346.
- [17] M. Xian, J. Yan, Y. Kang, J. Liu, Y. Bi, K. Zhen, *Lett. Appl. Microbiol.* **2001**. 33: 367-370.
- [18] S.U. Ahmed, S.K. Singh, A. Pandey, S. Kanjilal, R.B.N. Prasad, *Food Technol. Biotechnol.* **2006**. 44(2): 283-287.
- [19] A. Chatzifragkou, S. Fakas, M. Galiotou-Panayotou, M. Komaitis, G. Aggelis, S. Papanikolaou, *Eur. J. Lipid Sci. Technol.* **2010**. 112: 1049-1056.
- [20] S. Papanikolaou, M. Galiotou-Panayotou, S. Fakas, M. Komaitis, G. Aggelis, *Eur. J. Lipid Sci. Technol.* **2007**. 109: 1060-1069.
- [21] S. Papanikolaou, M. Komaitis, G. Aggelis, *Bioresource Technol.* **2004**. 95: 287-290.
- [22] S.D. Dyal, S.S. Narine, *Food Res. Int.* **2005**. 38: 445-467.
- [23] C. Evans, C. Ratledge, *J. Gen. Microbiol.* **1984**. 130: 1693-1696.
- [24] S.D. Dyal, L. Bouzidi, S.S. Narine, *Food Res. Int.* **2005**. 38: 815-829.
- [25] M. Xian, J. Nie, Q. Meng, J. Liu, C. Zhou, K. Kang, K. Zhen, *Lett. Appl. Microbiol.* **2003**. 36: 182-185.
- [26] C.N. Economou, G. Aggelis, S. Pavlou, D.V. Vayenas, *Biotechnol. and bioengin.* **2010**. 108(5): 1049-1055.
- [27] C.N. Economou, A. Makri, G. Aggelis, S. Pavlou, D.V. Vayenas, *Bioresour Technol.* **2010**. 101: 1385-1388.
- [28] M. Čertík, Z. Adamechová, L. Németh, *Chem. Listy*. **2008**. 102: s544-s545.
- [29] S. Fakas, S. Bellou, A. Makri, G. Aggelis, In: G. Aggelis, (Ed.), Single cell oil and gammalinolenic acid production by *Thamnidium elegans* grown on raw glycerol. Microbial conversions of raw glycerol (Nova Science Publishers Inc., New York, **2009**) 85-100.
- [30] M. Zhu, L.J. Yu, Y.X. Wu, *J. Ind. Microbiol. Biotechnol.* **2003**. 30: 75-79.
- [31] P.A. Botham, C. Ratledge, *J. Gen. Microbiol.* **1979**. 114: 361-362.