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Current Status on Single Cell Protein (SCP) Production from Photosynthetic Purple Non Sulphur Bacteria

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ABSTRACT

Bacterial production of SCP have a significant advantage over other microorganisms. Single cell protein is the total protein extracted from the bacterial cultures. Apart from the nutritional benefits of single cell protein, single cell protein technology is sustainable technology. Prototroph's have high protein content with essential amino acids and less amounts of nucleic acids. PNSB are highly resistant to toxicants and contain 70-72% of crude protein. The composition of essential amino acids of these bacteria is similar to that of soyabean proteins. The application of PNSB has been used to convert to hydrogen gas (Liao, 2010) or by products such as single cell proteins. PNSB biomass is useful for fish feeding as it is rich in proteins. An in-depth analysis of the single cell production abilities of PNSB show that the purple non sulphur bacterium Rhodopseudomonas palustris would be best in terms of single cell protein production.

KEY WORDS: PNSB, Single cell protein (SCP), *Rhodopseudomonas, Rhodobacter,* Bioremediation.

1. INTRODUCTION

Advances in present day biology in Single cell protein (SCP) production processes have led to the use of microorganism rather than animal or plant sources. Recycling of waste by bacteria to protein production is both economical and environmental friendly. Bacterial production of SCP have a significant advantage over other microorganisms. Single cell protein is the total protein extracted from the bacterial cultures. Apart from the nutritional benefits (Adedayo, 2011) of single cell protein, single cell protein technology is sustainable technology. SCP refers to total proteins extracted from pure microbial cell culture and is produced using microorganisms including bacteria, fungus and algae (Anupama & Ravindra, 2000). The use of natural cheap substrates is explored for cultivating microorganisms (Grewal, 1990; Osho, 1995). Microorganisms have a much higher protein content of 30–70% in the dry mass and in particular PNSB have more than 50% protein content. Single cell protein aminoacid composition of microbial SCP has good nutritional properties (Adedayo, 2011). Generation time of *Methylophilus* is about 2 hours which saves time and large amounts of biomass can be generated. Large amounts of SCP are produced by bacteria like *Acromobacter delvaevate, Acinetobacter calcoacenticus, Aeromonas hydrophilla, Brevibacterium* (Adedayo, 2011), *Bacillus subtilis* (Gomashe, 2014), *Flavobacterium* sps, *Lactobacillus* sps, *Cellulomonas* species, *Methylophilus methylitropous* (Jenkins, 1987), *Pseudomonas fluorescens*, *Thermomonospora fusca* (Dhanasekaran, 2011). Single Cell Protein (SCP) is the best way of solving global food problem (Najafpour, 2007). If waste materials are used as substrate, waste management can also be investigated. Proteins not only function as nutrients but also perform other functions (Mahajan and Dua, 1995; Asad, 2000; Jamel 2008; Nasseri, 2011). Hydrocarbons, polysaccharides and other wastes are used for SCP production (Ashok, 2000 & Atalo and Gashe 1993). Microbial protein productions with several natural products such as grape juice byproduct, date extract, cashew apple juice have been used for production of SCP (Kuzmanova, 1989). Cellulsoe was also investigated for SCP production (Bozakuk, 2002; Zubi, 2005).

Bacterial SCP production has advantages such as rapid growth of bacteria and short generation time. They are also capable of growing on starch, sugars, methane, petroleum fractions, alcohols and various nitrogen sources including ammonia (Bamberg, 2000). The substrates which are in use are gaseous hydrocarbons, liquid hydrocarbons and alcohols are utilized by bacteria. Methanogenic bacteria lstrains are recommended for SCP production (Arora, 1991). A number of industrial waste products are being used for producing SCP (Smith and Bull, 1976; Saquido, 1981; Abou Hamed, 1993; Tipparat, 1995; Nigam, 2000; Zhao, 2010).

PNSB for SCP Production: Usage of photosynthetic bacteria for bioremediation is being explored as microorganisms are capable of removing organic substances in waste water (Hiraishi, 1989; Madigan, 2000; Noparatnaraporn, 1986) producing byproducts such as protein, carotenoids, hopanoids, phytohormones, aminolevulinic acid and vitamins (Kobayashi and Tchan, 1973; Getha, 1998; Banerjee, 2000). They have flexible metabolic pathways and being used for wastewater purification in recent times (Siefert, 1978; Howard, 1987; Imhoff, 1992; Kantachote, 2005; Yegani, 2005; Chae, 2006). Purple non sulphur photosynthetic bacteria (PNSB) are) are versatile organisms which widely distributed in different ecological niches (Holt, 1994; Zhu, 2002; Hoogewerf, 2003; Holt, 1994; Okubo, 2006; Kaewsuk, 2010). Anupama and Ravindra, (2000) suggested bacterial production of SCP has more advantages than other groups. Prototroph's have high protein content with essential amino acids and less amounts of nucleic acids (Sasikala and Ramana, 1995, Merugu, 2008). PNSB are highly resistant to toxicants (Ding, 2008; Madukasi, 2010) and contain 70-72% of crude protein (Kim and Lee, 2000). Kim and Lee (2000), studied the use of *Rhodopseudomonas palustris* as fish feed. The composition of essential amino acids of these bacteria is similar to that of soyabean proteins (Azad, 2001). The application of PNSB has been used to convert to hydrogen gas (Liao, 2010) or by products such as single cell proteins. PNSB biomass is useful for fish feeding as it is rich in proteins (Honda, 2006). The factors which can be optimized for PNSB cultivation are anaerobic condition, light (in lux), pH, carbon, nitrogen, agitation and growth factors (Honda, 2006; Kaewsuk, 2010). Growth has been studied in photosynthetic pond (Honda, 2006), batch photo-bioreactor and membrane photo-bioreactor (Kaewsuk, 2010). Methionine and phenylalanine concentrations were low (Noparatnaraporn and Nagai, 1986) in *Rubrivivax* (Rhodocylcus) *gelatinosus* R1 biomass when compared to other similar findings of other authors. *R.gelatinosus* R1 biomass aminoacid composition was same that of algae (Prasertsan, 1993). Essential fatty acids are essential for growth of fish (Izquierdo, 1996) which are present in these bacterial feed (Loo, 2012). Kim and Lee (2000), estimated USD 79 per kg production of PNSB but this can be made cost effective if agro industrial wastewaters are used as substrate. Merugu, (2012) has reported photosynthetic bacterial growth in cellulose has carbon source. Bender & Phillips (2004) and Banerjee, (2000) suggested the use of PNSB as cheaper alternative protein sources for fish feed. *Rhodocyclus gelatinosus* found in many industrial effluents hydrolyzes starch and gelatin (Holt, 1994) and may find application in enhancing their colour due to production of spirilloxanthin series of pigments (Kobayashi and Kurata, 1978; Noparatnaraporn and Nagai, 1986). Salma, (2007) has recommended purple non sulphur bacteria as a source of single cell protein. Imhoff (2006) suggested the use of PNSB with simultaneous SCP production. Kantachote, (2005) reported a protein percentage of 66.7 from Wastewater from a latex rubber sheet processing from *Rhodopseudomonas blastica*. About 72-74% of SCP protein from sludge and sago starch processing using *Rhodopseudomonas palustris* was observed by Geetha, (1998) which was used as aquaculture feed. Elisa, (2002) observed 67.6% of SCP from *Rhodocyclus gelatinosus* cultured in Poultry slaughterhouse wastewater which was used as feed supplement. Napavarn & Nagai (1986), used *Rhodobacter sphaeroides P47* cultured in Pineapple waste and reported 6.6% SCP. *Rhodopseudomonas palustris* P1cultured in fermented pineapple extract contained 65% SCP and used for the treatment of latex rubber sheet wastewater (Nastee, 2014). He, (2010) reported 52% SCP from *Rhodobacter sphaeroides Z08* grown in Soybean waste water. *Rhodovulvum sulphidophilum* grown in Glutamate Malate medium produced 15.6% SCP (Maneewan, 2010). Elisa (2003), reported 50.6% from *Rhodocyclus gelatinosus* cultivated from pig farm waste. Balloni, (1987) reported 58% SCP from *Rhodopseudomonas and R. fulvum* cultivated from sugar refinery wastewater. *Rhodocyclus gelatinosus* grown in miso-like effluent medium produced 63% SCP (Sasaki, 1981). *Rhodobacter sphaeroides* P47 grown in dehydrated medium from Pineapple peel waste produced 66.6% SCP (Noparatnaraporn, & Nagai, 1986). Prasertsan, (1993) reported 50% SCP from *Rhodocyclus gelatinosus* cultivated in seafood processing wastewater. *Rhodopseudomonas sp.* grown in Synthetic 112 medium produced 11% SCP (Tan, 2014). *Rhodopseudomonas palustris & Rhodobacter blasticus* grown in wastewater from noodle production produced 50% SCP (Worowit, 2016). Saejung & Thammaratana (2016) reported 60.1% SCP production from culturing *Rhodopseudomonas sp.* CSK01 cultured from Municipal wastewater. *Rhodocyclus gelatinosus R7* produced 56% SCP from Tuna condensate (Poonsuk, 1997). Alexandre, (2009) reported 45% SCP from *Rhodobacter capsulatus* cultivated from Synthetic medium. *Rhodopseudomonas acidophila* produced 23% SCP from synthetic medium (Pfennig, 1969). Napavarn, (1987) reported 56% SCP from *Rhodocyclus gelatinosus* cultivated in Cassava waste. *Rhodopseudomonas palustris* grown in simulated waste water produced 45% SCP (Honda, 2006). Kim, (1999) reported 74% SCP *Rhodopseudomona spalustris* grown in photosynthetic sludge which was used as diet for aquaculture. *Rhodopseudomonas capsulatu*s grown in cow dung contained essential sulphur amino acids (Gupta, 2016). *Rhodobacter* sphaeroides grown in Cassava waste also produced essential aminoacids which was used as Fish meal (Napavarn, 1986).

Table.1. SCP Production from Photosynthetic Purple Non Sulphur Bacteria

Organisms	**Source of organism**	**Protein (%, mg/g dry wt)**	**Application**	**Reference**
Rhodopseudomonas blastica	Wastewater from a latex rubber sheet processing	66.7	Proposed to be used as Animal feed	Kantachote, (2005)
Rhodopseudomonas palustris	Sludge and sago starch processing	72–74	As aquaculture feed	Geetha, (1998)
Rhodocyclus gelatinosus	Poultry slaughterhouse wastewater	67.6	Poultry feed	Elisa, (2002)
Rhodobacter sphaeroides P47	Pineapple waste	66.6	Feed supplement	Napavarn & Nagai (1986)

Rhodopseudomonas palustris P1	Fermented pineapple extract	65	Treatment of latex rubber sheet wastewater	Nastee (2014)
Rhodobacter sphaeroides Z08	Soyabean waste water	52	Bioremediation	He, (2010)
Rhodovulvum sulphidophilum	Glutamate Malate Medium	15.6	Fish feed supplement	Maneewan (2010)
Rhodocyclus gelatinosus	Pig farm waste	50.6	Remediation	Elisa, (2003)
Rhodopseudomonas and R. fulvum	Sugar refinery wastewater	58	Remediation	Balloni, (1987)
Rhodocyclus gelatinosus	miso-like effluent medium	63	Remediation	Sasaki, (1981)
Rhodobacter sphaeroides P47	Dehydrated medium from Pineapple peel waste	66.6	Remediation	Noparatnaraporn, & Nagai (1986)
Rhodocyclus gelatinosus	Seafood processing wastewater	50	Remediation	Prasertsan, (1993)
Rhodopseudomonas sp.	Synthetic 112 medium	11	Remediation	Tan, (2014)
Rhodopseudomonas palustris & Rhodobacter blasticus	Wastewater from noodle production	50	Remediation	Worowit, (2016)
Rhodopseudomonas sp. CSK01	Municipal wastewater	60.1	Remediation	Saejung & Thammaratana (2016)
Rhodocyclus gelatinosus R7	Tuna condensate	56	Remediation	Poonsuk, (1997)
Rhodobacter capsulatus	Synthetic medium	45	Remediation	Alexandre, (2009)
Rhodopseudomonas acidophila	Synthetic medium	23	Remediation	Pfennig (1969)
Rhodocyclus gelatinosus	Cassava waste	56	Remediation	Napavarn, (1987)
Rhodopseudomonas palustris	Simulated waste water	45	Remediation	Honda, (2006)
Rhodopseudomonaspalustris	Photosynthetic sludge	74	Diet for aquaculture	Kim, (1999)
*Rhodopseudomonas capsulatu*s	Cow dung	Essential sulphur amino acids	Fish feed	Gupta, (2016)
Rhodobacter sphaeroides	Cassava waste	Essential aminoacids	Fish meal	Napavarn, (1986)

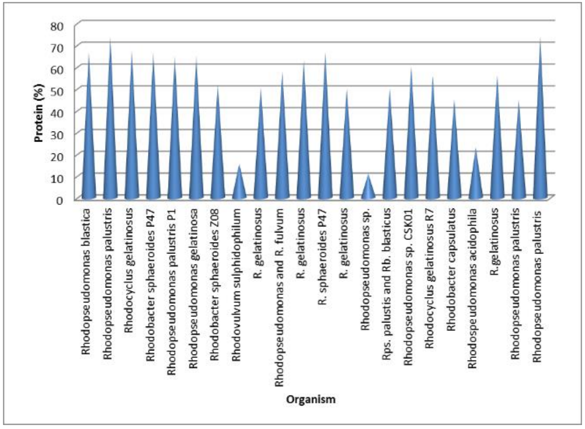

Figure.1. Graphical Representation Of Scp Production By Pnsb

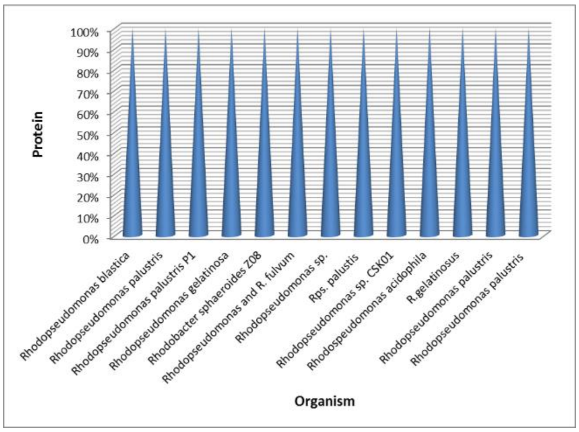

Figure.2. Graphical representation Of SCP production by Rhodopseudomonas genus

2. CONCLUSION

An in-depth analysis of the single cell production abilities of PNSB show that the purple non sulphur bacterium *Rhodopseudomonas palustris* would be best in terms of single cell protein production. Further work for SCP production should involve using *Rhodopseudomonas palustris* instead of other genus in this group as this organism is more versatile and best suited for the production of Single cell protein.

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