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Sustainable Approaches for 'Protein Accessibility'

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ABSTRACT

The structural, functional and regulatory role of proteins makes them vital macro biomolecules, without which life cannot exist. Humans obtain dietary proteins as a source of amino acids from plants and animals. Though animal proteins provide all essential amino acids, they pose serious issues of carbon and water foot print, risk of diseases, loss of biodiversity due to unethical killing. The animal based protein production is neither cost-effective nor environmentally sustainable. The plant based proteins are incomplete proteins, and their production is limited by various factors such as land, water, climate, seed genotype. With ever increasing population, the food affordability, food safety, protein energy malnutrition and human health along with climate change are the global challenges in the near future. To suffice the needs of the growing population it is imperative to search new protein sources and evaluate their neutraceutical value. This review focuses on the sources and significance of plant based proteins and other alternatives available. The alternatives for plant based proteins include Mushrooms, Single Cell Proteins and Mycoproteins, The production of the alternative for plant based proteins is cost –effective, eco-friendly with significant amount of protein yield, which will be affordable to all in a sustainable manner.

Key words: *Amino acids, Pplant-based proteins, Malnutrition, Mycoproteins, Sustainable*

Introduction

Proteins are the building blocks of the cells that carry out structural, functional and regulatory functions. Dietary proteins are the source of amino acids for animals and human beings. Protein deficiency in human greatly impairs the health and well being of the individuals. Proteins are long polypeptide chains comprising of twenty different amino acids. Based on the human dietary requirement the amino acids are classified as Essential and Non- essential amino acids. Non-essential amino acids such as alanine, arginine, asparagine, aspartate, cysteine, glutamate, glutamine, glycine, proline serine and tyrosine are synthesized in the body via glucose breakdown and transamination reactions. The other nine amino acids (Phenylalanine, Valine, Tryptophan, Threonine, Isoleucine, Methionine, Histidine, Leucine and Lysine) cannot be synthesized and therefore have to be obtained from the diet. Therefore they are classified as essential amino acids (Litwack, 2018). The human diet chiefly consists of carbohydrates, proteins and fats. Dietary proteins are obtained from plants and animals. The plant proteins either contain very low or lack in any of the essential amino acid and therefore form the incomplete proteins. The animal proteins contain all amino acids and in proper amount the body needs, hence forms the complete protein. We therefore have to depend upon animals for these essential amino acids.

Studies have reported that by 2050, the global

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population is presumed to exceed 9 billion (Verstraete *et al*., 2016). This will create a tremendous demand for food, feed and fibre. The need for meat based proteins will result in increased animal breeding, their unethical killing and high cost making it less affordable to the poor. Also the animals may be diseased or infected and meat from such animals can be unsafe to human health (Sun-Waterhouse, *et al*., 2014). Increased meat production will considerably affect carbon and water foot prints and therefore is highly environmentally non sustainable. For these reasons, there is a gradual shift from animal to plant based protein. Plant based proteins have rich nutrient value, are cost effective and their production is eco friendly; therefore help to sustain the life and environment. To address the global issues of protein requirement for improving the health status of humans there is an urgent need to explore new sources of through sustainable approaches. This review focuses on the significance of plant based proteins and adoption of other alternative forms that will help to achieve the sustainable development goals.

Materials and Methodology

The present review is based upon the the critical analysis of the literature and the information from the various journals and online searches at Google scholar, pubmed, Science direct etc.

Sources of Plant based proteins

Plant based proteins may lack or may have very less amount of a particular essential amino acid in a same plant species. It may not provide the essential amino acid in the required amount the body needs. The amino acid composition in plant protein of the same species may also vary due to variation in topography, climatic and edaphic conditions, agricultural practices and different varieties used (Goldflus *et al*., 2006).

The various sources of plant proteins are (Sun-Waterhouse *et al*., 2014)

Cereals: These include wheat, rice, millet, maize etc. that forms the staple food throughout the world.

Legumes: They include Pea, soyabean, faba bean, chick pea, cow pea etc. Soyabean contains almost all essential amino acids. The protein content in Pigeon pea is rich in sulphur containing amino acids.

Pseudocereals: The Dicotyledonous plants like Quinoa, buckwheat and amaranth are considered as pseudocereals, rich in essential amino acids (Alvarez-Jubete *et al*., 2010)

Seed: They include such as seeds such as flax, Chia, Sesame, Cucurbita, Watermelon, Musk seeds. It has been reported that Flax seeds and Chia seeds do not contain lysine (Anaya *et al.*, 2015) whereas a high proportion of leucine and arginine is found in watermelon seeds (Kaul, 2011).

Nuts: They are Walnut, Chestnut, Hazel nut, almonds and peanuts that contain high quality lipid and fatty acids and also rich in proteins. Pequi almonds are rich in sulphur containing amino acids but lacking lysine, whereas Baru almonds are rich in essential amino acids. Valine and lysine are absent in peanuts.

The agricultural crop production is limited by the availability of land and water. These limitations have to be addressed and therefore the other alternative forms of plant based proteins needs to explore.

Alternative protein sources

Mushrooms: the Zero fat food

Although the mushroom industry has grown rapidly, the most preferred edible mushrooms are Shiitake mushroom *(Lentinula edodes*), followed by oyster mushroom (*Pleurotus* sp) and button mushroom (*Agaricus bisporus*) out of the 2000 species of Mushrooms growing worldwide. Mushrooms are the fruiting bodies of white rot fungi belonging to Basidiomycetes. They grow on agricultural waste, forest litter, on soil, dung, tree trunks and dead wooden logs. They help to recycle nutrients and have significant health benefits. Mushrooms contain all essential amino acids, high protein, carbohydrates and Vitamins. They are a very good source of minerals and dietary fibres (Bano and Rajarathanum, 1988). They are a low-calorie food, help to boost immunity, prevents cancer and slows down aging (Satyaveer and Rajanna, 2022). The agricultural and the forest by-products can be utilized for mushroom cultivation.

Single Cell Proteins: The term Single cell protein refers to the purified proteins isolated from the microorganisms and / or the bulk of dried cells of microorganisms like bacteria, algae, yeast and fungi with high protein content. They are rich in proteins with various essential amino acids (lysine and me-

thionine) and vitamins (Jacob-Lopes *et al*., 2006).

SCPs are used in animal feed and nutrition, as food additives (vitamin and aroma carriers and emulsifying agents), as starter culture (baker's and brewer's yeast) and in paper and leather processing industries. They do not require large land surface and large water supply for its production (Mekonen and Hoekstra, 2014). SCP production utilizes the bio-degradable agro industrial residues, high energy resources (methanol, natural gas), sulfite waste liquor and Carbondioxide as substrates to produce tons of proteins. Depending upon the microorganism and the choice of substrate, submerged or solid waste fermentation can be carried out. After fermentation the biomass is harvested and further purified. Thus this is a cost- effective and eco- friendly approach that can be advanced for combating the protein need (Anupama and Ravindra, 2000; Vermeulen *et al*., 2012).

Table 1. Microorganisms and substrate used for SCP production

Microorganism	Substrate
Bacteria	
Rhodopseudomonas gelatinosus	Wheat bran
Methylomonas sp	Methane broth
Streptomyces sp	Methanol
Escherichia coli	Ram horn
Cellulomonas sp	Agro- industrial waste
Algae	
Chlorella salina	Alkaline waste effluent
Spirulina maxima	Sunlight and Carbondioxide
Diatoms	Sunlight and Carbondioxide
Fungi	
Aspergillus oryzae	Rice bran
Aspergillus niger	Apple pomace, banana waste
Penicillium citrinum	Rice bran
Trichoderma harzianum	Cheese whey filtrate
Saccharomyces cerevisiae	orange pulp, molasses

Source: Shariff *et al.* (2021)

Mycoproteins:

Mycoprotein is low fat, high-protein food with a meat like texture produced as fermentation product by the filamentous fungus *Fusarium venenatum.* The Food and Drug Administration in the US has designated it as a Safe food for human consumption since 2002 (Denny *et al*., 2008). This food is presently marketed and sold in 19 different countries by Marlow Foods, UK under the brand name as Quorn. (Souza Filho *et al.,* 2019). Mycoprotein provides high proportion of essential amino acids dietary fibre and antioxidants, along with selenium and zinc and also a little amount of sodium. Many studies have reported that the consumption of Mycoproteins helps to promote muscle synthesis, lowers blood cholesterol and controls blood sugar levels (Dunlop *et al*., 2017). Large scale production of Mycoproteins using lignocellulosic residues as substrate will help to fight hunger in the coming years (Souza Filho *et al.,* 2019).

Conclusion

Plant based proteins are safe for consumption and highly sustainable compared to animal based proteins. There is an urgent need to spread awareness among people regarding the amino acid composition in proteins, the alternative forms of plant based proteins available and the intake of right combinations of plant foods to fight protein malnutritition. Cost- effective, environment friendly production of Single cell proteins, Mycoproteins and Mushrooms by using agro- industrial waste and forest waste as substrates for microorganisms with minimal water and land requirement is a sustainable approach for easy protein accessibility and good health.

References

Alvarez-Jubete, L., Arendt, E. K. and Gallagher, E. 2010. Nutritive value of pseudocereals and their increasing use as functional gluten-free ingredients. *Trends in Food Science & Technology*. 21: 106-113. https://doi.org/10.1016/j.tifs.2009.10.014

Anaya, K., Cruz, A.C., Cunha, D.C., Monteiro, S. M. and Dos Santos, E. A. 2015. Growth impairment caused by raw linseed consumption: can trypsin inhibitors be harmful for health? *Plant Foods for Human Nutrition.* 70:338-343.

Anupama, and Ravindra, P. 2000. Value–added food: single cell protein. *Biotechnolgy Advances.* 18: 459-479. https://doi.org/10.1016/s0734-9750(00)00045-8.

Bano, Z. and Rajarathanum, S. 1988. Pleurotus mushroom Part II. Chemical composition nutritional value, post harvest physiology, preservation and role as human food. *Critical Reviews in Food Science & Nutrition.* 27: 87-158.

Chang, S.T. 2006. The world mushroom industry: trends and technological development. *International Journal of Medicinal Mushrooms.* 8: 297-314.

Denny, A., Aisbitt, B. and Lunn, J. 2008. Mycoprotein and health. *Nutrition Bulletin,* 33: 298-310. https://

doi.org/10.1111/j.1467-3010.2008.00730.x

Dunlop, M. V., Kilroe, S. P., Bowtell, J. L. and Finnigan, T. J. A. 2017. Mycoprotein represents a bioavailable and insulinotropic non- animal derived dietary protein source: a dose response study. *British Journal of Nutrition*. 118: 673-685.

Goldflus, F., Ceccantini, M. and Santos, W. 2006. Amino acid content of soybean samples collected in different Brazilian states: harvest 2003/2004. *Brazilian Journal of Poultry Science*, 8: 105-11

Jacob- Lopes, E., Zepka, L.Q., Queiroz, M.I. and Netto, F.M. 2006. Protein characterization of the Aphanothece Microscopica Nageli cyanobacterium cultivated in parboiled rice effluent. *Food Science. & Technology.* 26 : 482-488.

Kaul, P. 2011. Nutritional potential, bioaccessibility of minerals and functionality of watermelon (*Citrullus vulgaris*) seeds. *Brazilian journal of Poultry Science.* 44: 1821-1826. https://doi.org/10.1016/j.lwt.2011.04.001

Litwack, G. 2018. *Proteins - in Human Biochemistry*, Academic Press, 63-94. ISBN 9780123838643. https://doi.org/10.1016/C2009-0-63992-1

Mekonnen, M.M. and Hoekstra, A.Y. 2014. Water footprint bench marks for crop production: a first global assessment. *Ecological Indicators.* 46: 214-233.

Satyaveer and Rajanna, K.B. 2022. Health Benefits and Medicinal Value of Mushrooms. *Agriculture & Environment.* 3(9): 13-17

Sharif, M., Zafar, M.H., Aqib, A.I., Saeed, M., Farag, M.R. and Alagawany, M. 2021. Single cell protein: Sources, mechanism of production, nutritional value and its uses in aquaculture nutrition. *Aquaculture.* 531 (5) :1-9. https://doi.org/10.1016/j.aquaculture.2020.735885

Souza Filho., P. F., Andersson, D., Ferreira, J. A. and Taherzadeh, M.J. 2019. Mycoprotein: environmental impact and health aspects. *World Journal of Microbiology and Biotechnology*. 35(147) :1-8. https://doi.org/10.1007/s11274-019-2723-9

Sun-Waterhouse, D., Zhao, M. and Waterhouse, G.I. 2014. Protein modification during ingredient preparation and food processing: approaches to improve food process ability and nutrition. *Food and Bioprocess Technology*. 7 (7): 1853-1893. https://doi.org/10.1007/s11947-014-1326-6

Vermeulen, S.J., Campbell, B.M., Ingram, J.S.I. 2012. Climate change and food systems. *Annual Review of Environment and Resources*. 37: 195-222. https://doi.org/10.1146/annurevenviron-020411-130608

Verstraete., W., Clauwaert, P. and Vlaeminck, S.E. 2016. Used water and nutrients: Recovery perspectives in a 'panta rhei' context. *Bioresource Technology.* 215:199-208