

Supporting Information for “Perspectives on future protein production”

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Table 1. Nutrition information and references related to protein sources.

Topic	Nutritional information	Reference(s)	Anti-nutritional information	Reference(s)
Livestock-derived protein (meat, eggs and dairy)	Proteins, fats and carbohydrates as micronutrients such as diverse range of minerals and vitamins	Hicks TM, Knowles SO, Farouk MM. Global Provisioning of Red Meat for Flexitarian Diets. <i>Front. Nutr.</i> 2018, 5, 50.	Cow’s milk allergy (CMA) is one of the most common food allergies in early life with an estimated prevalence in developed countries ranging from 0.5% to 3% at age 1 year. Likewise, egg allergy was 8.9% at age 1 year,	Flom, J. D., & Sicherer, S. H. Epidemiology of Cow’s Milk Allergy. <i>Nutrients</i> , 2019, 11(5), 1051. Loh, W., & Tang, M. The Epidemiology of Food Allergy in the Global Context. <i>International Journal of Environmental Research and Public Health</i> , 2018, 15(9), 2043.
Meat-derived bioactives	By-products can be valorised to create shelf-stable high protein ingredients or by enzyme hydrolysis to obtain bioactive peptides that exert physiological effects such as antihypertensive, antioxidant, antidiabetic, antimicrobial activities	Toldrá, F., Mora, L., Reig, M. New insights into meat by-product utilization. <i>Meat Science</i> 2016, 120, 54-59.		
Aquaculture-derived protein	Fish provides high-value protein, but also a wide range of essential micronutrients, including various vitamins (A, B and D), minerals (including calcium, iodine, zinc, iron and selenium) and long-chain poly-unsaturated omega-3 (LCω3) fatty acids such as docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA).”	Hosomi R, Yoshida M, Fukunaga K. Seafood consumption and components for health. <i>Glob. J. Health Sci.</i> 2012, 4(3), 72-86.	Physician-diagnosed and/or convincing seafood allergy is reported by 2.3% of the general population in the USA. Seafood allergy is of high importance in Asia where its prevalence is up to 7.7%,	Sicherer SH, Muñoz-Furlong A, Sampson HA. Prevalence of seafood allergy in the United States determined by a random telephone survey. <i>J Allergy Clin Immunol.</i> 2004, 114(1), 159-165. Davis CM, Gupta RS, Aktas ON, Diaz V, Kamath SD, Lopata AL. Clinical management of seafood allergy. <i>J Allergy Clin Immunol Pract.</i> 2020, 8, 37–44

Plant protein	High fibre and short-chain omega-3 fatty acids.	Hertzler SR, Lieblein-Boff JC, Weiler M, Allgeier C. Plant Proteins: Assessing Their Nutritional Quality and Effects on Health and Physical Function. <i>Nutrients</i> . 2020, 12(12), 3704.	The prevalence of sensitization against any specific plant food item assessed by skin prick test was usually < 1%, whereas sensitization assessed by IgE against wheat ranged as high as 3.6% and against soy as high as 2.9%.	Zuidmeer L, Goldhahn K, Rona RJ, Gislason D, Madsen C, Summers C, Sodergren E, Dahlstrom J, Lindner T, Sigurdardottir ST, McBride D, Keil T. The prevalence of plant food allergies: a systematic review. <i>J Allergy Clin Immunol</i> . 2008, 121(5), 1210-1218.
Plant protein - soy	Soy has a near complete amino acid profile and a similar Protein Digestibility-Corrected Amino Acid Score (PDCAAS) to beef and dairy, indicating that they have similar human nutritional attributes.	Hughes, G.J.; Ryan, D.J.; Mukherjea, R.; Schasteen, C.S. Protein digestibility-corrected amino acid scores (PDCAAS) for soy protein isolates and concentrate: Criteria for evaluation. <i>J. Agric. Food Chem</i> . 2011, 59, 12707–12712. Rutherford, S.M.; Fanning, A.C.; Miller, B.J.; Moughan, P.J. Protein digestibility-corrected amino acid scores and digestible indispensable amino acid scores differentially describe protein quality in growing male rats. <i>J. Nutr</i> . 2015, 145, 372–379	The prevalence of challenge-confirmed food allergy soy is 0.3% in Europe.	Nwaru B.I., Hickstein L., Panesar S.S., Roberts G., Muraro A., Sheikh A., EAACI Food Allergy and Anaphylaxis Guidelines Group Prevalence of common food allergies in Europe: A systematic review and meta-analysis. <i>Allergy</i> . 2014, 69, 992–1007.
Marine protein sources – algae/seaweed	Algae have been part of the human diet for thousands of years and provide a wide range of nutrients for health and wellbeing, including vitamins, minerals, dietary fibre and protein.	J.J. Milledge, Commercial application of microalgae other than as biofuels: a brief review, <i>Rev. Environ. Sci. Biotechnol.</i> , 2011, 10, 31-41.	There is a paucity of data on algae-induced allergy. Heavy metal concentrations in edible seaweeds are generally below toxic levels, but bioaccumulation of arsenic is a risk. The portion size of seaweed in pregnant women is recommended to be limited to avoid iodine overconsumption.	Cherry, P., O'Hara, C., Magee, P. J., McSorley, E. M., & Allsopp, P. J. Risks and benefits of consuming edible seaweeds. <i>Nutrition Reviews</i> , 2019, 77(5), 307–329.
Insect protein	Insects are of high nutritional value, rich in protein and several essential amino acids with values for protein digestibility equivalent or slightly	van Huis, A. Potential of Insects as Food and Feed in Assuring Food Security. <i>Annual Review of Entomology</i> 2013, 58, 563-583.	There is a paucity of data on insect protein induced allergy. Cross-reactivity/co-sensitisation between edible insects, crustaceans	Ribeiro, J. C., Cunha, L. M., Sousa-Pinto, B., Fonseca, J., <i>Mol. Nutr. Food Res</i> . 2018, 62, 1700030.

	<p>lower (species dependent) than that of protein derived from egg or beef.</p> <p>Digestibility and nutrient quality showed insects were similar and suitable for both livestock feeds and for human consumption.</p>	<p>Hermans, W.J.H.; Senden J.M.; Churchward-Venne, T.A.; Paulussen, K.J.M.; Fuchs, C.J.; Smeets, J.S.J.; van Loon, J.J.A.; Verdijk, L.B.; van Loon, L.J.C. Insects are a viable protein source for human consumption: from insect protein digestion to postprandial muscle protein synthesis in vivo in humans: a double-blind randomized trial. <i>Am. J. Clin. Nutr.</i> 2021, 114, 934–944.</p>	<p>and house dust mites has been reported.</p>	<p>Bose U, Broadbent JA, Juhász A, Karnaneedi S, Johnston EB, Stockwell S, Byrne K, Limviphuvadh V, Maurer-Stroh S, Lopata AL, Colgrave ML. Protein extraction protocols for optimal proteome measurement and arginine kinase quantitation from cricket <i>Acheta domesticus</i> for food safety assessment. <i>Food Chem.</i> 2021, 348, 129110.</p>
Microbial protein	<p>Besides protein as nutritive compounds, also other cellular components such as lipids (single cell oil), polyhydroxybutyrate, exopolymeric saccharides, carotenoids, ectorines, (pro)vitamins and essential amino acids can be of value for the growing domain of novel nutrition</p>	<p>Matassa S, Boon N, Pikaar I, Verstraete W. Microbial protein: future sustainable food supply route with low environmental footprint. <i>Microb Biotechnol.</i> 2016;9(5):568-575.</p>	<p>There is a paucity of data on yeast (e.g., <i>Pichia</i> or <i>Saccharomyces</i>) protein induced allergy. <i>S. cerevisiae</i> contains both inhalant and food allergens that may induce allergic respiratory symptoms, most predominantly baker's asthma, and allergic rhinitis, but allergic reactions due to baker's yeast are rarely reported.</p>	<p>Simon-Nobbe B, Denk U, Poll V, Rid R, Breitenbach M. The spectrum of fungal allergy. <i>Int Arch Allergy Immunol.</i> 2008, 145(1), 58-86.</p>
Fungal protein	<p>Mycoprotein is a protein-rich and high in fiber. The fiber is largely insoluble and two-thirds β-glucan and one-third chitin. It contains good levels of vitamin B9 (folate), vitamin B12, calcium, phosphorous, magnesium and zinc and choline, ~180 mg per 100 g thus compares well with other foods such as cooked salmon (90 mg/100 g), pork (103 mg/100 g), dried soybeans (116 mg/100 g), bacon (125 mg/100 g), and wheat germ (152 mg/100 g).</p>	<p>Derbyshire, E.J., Joanne, D. Fungal Protein – What Is It and What Is the Health Evidence? A Systematic Review Focusing on Mycoprotein. <i>Frontiers in Sustainable Food Systems.</i> 2021, 5, 1-18.</p>	<p>A systematic evidence review indicates that incidence of allergic reactions remains exceptionally low, but it is possible that some susceptible consumers will become sensitized, and subsequently develop a specific allergy.</p>	<p>Finnigan, T., Wall, B. T., Wilde, P. J., Stephens, F. B., Taylor, S. L., & Freedman, M. R. Mycoprotein: The Future of Nutritious Nonmeat Protein, a Symposium Review. <i>Current developments in nutrition,</i> 2019, 3(6), nzz021.</p>