RESEARCH BRIEF

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LEGUMES AS A SUSTAINABLE SOURCE OF PROTEIN IN HUMAN DIETS

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Overview

This paper reviews the advantages and disadvantages of increasing the production and consumption of legumes in order to meet growing global protein demand. Demand for protein is likely to increase significantly over the next few decades to keep pace with a growing population, which is projected to reach nearly ten billion by 2050 (UN, 2019). The Organization for Economic Cooperation and Development predicts that meat consumption will increase by 12 percent over the next decade, with developing countries expected to account for much of this growth as per capita income increases (OECD/FAO, 2020). However, production of animal source foods is responsible for a significant proportion of global Greenhouse Gas (GHG) emissions, water consumption, and land use (Henchion et al, 2017). Legumes, including soybeans, peanuts, common beans, common peas, chickpeas, cowpeas, fava beans, lentils, and others, have a much more favorable GHG and water footprint than animal source foods, and have additional environmental advantages such as soil nitrogen fixation.

Key findings

Legumes have the potential to become a major source of high-quality protein in the human diet, as they are inexpensive and almost universally available. For each legume, the authors listed the Protein Digestibility-Corrected Amino-Acid Score (PDCAAS), which is a measurement on a scale of 0-1 of the human body's ability to absorb and digest protein from a given food. On average, legumes have a PDCAAS rating of 0.5-0.7, and of the legumes reviewed in this paper, pea protein and soy protein have the highest PDCAAS ratings (0.89 and 0.91-1.0, respectively). In comparison, the PDCAAS scores of beef and egg protein are 0.92 and 1.0, respectively (Schaafsma, 2000). Legumes that score lower are better consumed in combination with other foods, such as grains. Legumes are also good sources of complex carbohydrates, dietary fiber, iron, zinc, and vitamin B. Legumes can be cultivated in a range of temperatures and altitudes, suggesting that they may be especially resilient to future climate shifts. Additionally, legumes can improve soil quality through nitrogen fixation, reducing the need for nitrogen fertilizers. Replacement of all or some animal source protein with legumes could substantially reduce global GHG emissions.

Limitations of legume production and consumption include fluctuation in yield, crop loss due to stressors such as insect damage and adverse weather, low profitability, allergy, high alkaloid content, potential for aflatoxin contamination, and considerable time required for cooking. Legumes are limited in some essential sulfur amino acids, although these can be supplemented by consumption of cereals. Legumes also contain certain anti-nutritional factors that may interfere with protein digestibility, although these can be reduced by soaking, boiling and fermenting legumes. Future innovations in breeding and genetic modification may enable legume farmers to overcome many of these barriers by developing strains that result in greater yield and are more resistant to stressors. Ultimately, greater availability, awareness, and economic access to legumes will be required to facilitate a dietary shift from animal protein to legume consumption.

Below is a table highlighting common legumes with their production region, PDCAAS score, protein content, and nutrition information, listed in order of metric tons produced annually, from most to least.

Legume	Total global production (Mt/year)	Production region	Protein digestibility (PDCAAS score*)	Protein content (g/100g)	Nutrition information
Soybean	346	Soybeans are produced throughout the world and grow well in both temperate and tropical climates.	0.91 1.0 (soy protein isolate)	13	Rich in all essential amino acids
Peanut	62	Peanuts are grown in tropical and subtropical areas.	0.51	26	Rich in all essential amino acids except methionine, lysine, and threonine
Common bean	30	Common beans are cultivated in a wide range of elevations, from sea level to 3000 m. Today the top 3 producers are India, Myanmar, and Brazil.	0.61	24**	Higher in methionine compared to most legumes except soybean
Common pea	15	Common peas are adapted to fertile, well-drained soils and can tolerate low temperatures.	0.69 0.89 (pea protein concentrate)	5	Relatively high in lysine content
Chickpea	14	Chickpeas are grown during the winter in the tropics and during the summer in temperate areas. Production largely occurs in unirrigated areas of south Asia and Africa.	0.52	21	Limited in tryptophan, methionine, and cysteine
Cowpea	7	Cowpeas are grown during the warm season in semiarid regions of Africa, Asia and Latin America.	0.38	24	Rich in leucine, lysine and phenylalanine; limited in methionine and cysteine
Fava bean	6	Fava bean is an annual seasonal crop that can be grown in mild, cool, and Mediterranean climates.	0.60	26	High in vicine and convicine; limited in tryptophan and methionine
Lentil	6	Lentil is cultivated in warm temperate, subtropical, and high altitude regions. It can be grown in a range of soil types and pH and is tolerant to drought and low temperature.	0.52	25	Limited in methionine & tryptophan
Pigeonpea	5	Pigeonpea grows in semi-arid tropical and subtropical regions. It is well adapted to rain-fed agriculture and tolerant to drought.	0.78***	7	Limited in isoleucine, lysine, methionine, and tryptophan
Lupin	1	Lupins are grown in a wide range of conditions, largely on land not suitable for other legumes.	0.60	36	High in alkaloids
Bambara bean	0.2	Bambara beans are predominantly grown in Africa, and can tolerate poor soil, drought and salt stress. It is also relatively resistant to disease.	0.77***	24	Limited in methionine and tryptophan

*If multiple PDCAAS values exist for a legume, the average was listed
**Used dry black beans as proxy for common bean
***True digestibility, or the proportion of a given food absorbed from the digestive tract into the bloodstream, used in place of PDCAAS

Recommendations for increasing production and consumption of legumes

- A significant proportion of all soybeans and lupins produced worldwide are used for animal feed. Some legume production can be reallocated from livestock feed to provide food for humans in order to help meet growing demand for protein.

- Policies should be implemented to offer farmers financial incentives for cultivating legumes over more profitable crops.

- Institutions should continue to advance research and technology, such as genetic engineering to facilitate development of legume cultivars that are more resistant to drought and pathogens and richer in sulfur amino acid content.

- National and international dietary guidelines should recommend increased consumption of legumes as part of a healthy, low environmental impact diet. The current U.S. Dietary Guidelines recommend consuming 3 cups of legumes per week, while the EAT Lancet Planetary Health Diet recommends three-quarters to 1 cup cooked beans daily.

Promotional benefits of legume consumption

- Increased consumption of legumes is associated with lower body weight, waist circumference, and blood pressure. Higher legume consumption has also been found to reduce risk of type 2 diabetes and cardiovascular disease.

- Beans have much lower GHG emissions, land, and water footprints than animal-source protein, especially beef and dairy. A widespread dietary shift from beef to beans could help mitigate climate change and preserve valuable natural resources.

- The variety and versatility of legumes means that they can be added to a wide range of dishes, including soups, stews, burgers, curries, or salads.

Launched in 2003, Meatless Monday is a nonprofit initiative of **The Monday Campaigns,** working in collaboration with the Center for a Livable Future (CLF) at the Johns Hopkins Bloomberg School of Public Health. Meatless Monday's goal is to reduce meat consumption by 15 percent for our personal health and the health of the planet.

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