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Proteins from Plants: Are we ready for Revolution?

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Abstract- protein is the most important and vital part of the meal. Proteins are involved in stimulating the muscle protein synthesis. The quality of food also depends on the physical, chemical and behavioural characteristics of proteins during its processing. Long-term observational research found a link between high total and animal protein consumption and an elevated risk of cancer and diabetes. In line with the findings of observational research, plant protein is primarily liable for this positive impact. On one hand, animal proteins include all of the required amino acids found within the organic structure, making them extremely nutritious but found the culprit in imposing metabolic stress on the liver, bones, and kidney. Animal proteins have long been accused of contributing to an insufficient nutritional intake profile, which may explain the relationship with heart disease risk.

It is also worth saying that because the vegan, vegetarian, and flexitarian communities have grown, plant proteins became more popular in cuisine. Due to increase in cardiovascular risk and other disease risk, many people are inclining towards the consumption of plant-based proteins. Plant proteins are employed in the manufacture of a large range of natural products. Soy protein isolates were first commercialized in 1959. People are also turning towards a plant protein diet considering the negatives of animal protein, but allergenicity is a back-pulling force.

Plant proteins have lately received more attention as allergens, notably in Europe and therefore the US, furthermore as in relevancy innovative and transgenic foods. The oxidative alterations had a derogatory impact on the functioning of plant proteins eg. soy proteins in general. In both sexes, replacing 3% of energy from diverse protein sources from animal and with plant protein was related to a 10% decline in overall mortality. Plant-based protein consumption have relatively less mortality rate as compared to animal-based protein. Still, animal-based proteins are good source of essential amino acids than plant proteins. The link between protein consumption and mortality might also be explained by the consumption of other nutrients and physiologically active substances in protein-rich diets. Furthermore, a growing amount of clinical data, related to older persons, supports health benefits related to protein intakes that are at or above current dietary protein consumption guidelines but the source of proteins is still a point of debate and hence dilemma is constant of whether we are ready for revolution or not.

Keywords- Plant and Animal proteins, Revolution, mortality, functional foods, Plant protein allergenicity.

Introduction-

A protein is a necessary and adaptable component of meals. Aside from nutritive benefits, the physical, chemical, and behavioral features of proteins throughout processing play an important role in determining overall food quality.[1] Furthermore, a growing body of clinical research on the health advantages of protein intakes that are at or above existing dietary protein consumption recommendations for older people. Among the health benefits include an increase in lean muscle mass, functional advantages such as increased leg strength and bone density.[2]

Protein demand is expected to grow further over the world.[1] Protein demand for the world's 7.3 billion people is currently expected to be 202 million tonnes, regardless of whether we estimate a two-billion-person population growth. The long-run demand for protein would be different, depending on the assumptions made about average intake. Animal and plant protein sources both have a wide variety of uses in the food industry. The most significant milk proteins, such as whey and casein, are used to increase the viscosity and stability of many food items; albumin protein from eggs is used to increase the stability of food products. Muscles containing protein are employed in a variety of applications ranging from gelling agents to paint creation in the food business.[3] Meat is believed to be the most basic protein source, not only because of its healthy features, notably proteins, but also because of its tempting flavour. Meat proteins serve two functions. On the one hand, animal proteins contain all of the essential amino acids found in organic structures, making them incredibly nutritious. Meat proteins, on the other hand, considerably contribute to the growth and development of the food industry by supplying distinctive qualities to the goods.[4]

Protein consumption projections are particularly intriguing, with forecasts that the worldwide need for animal-derived protein would triple by 2050.[3] The need to supply increased animal feed, along with rising demand for animal-based protein, is expected to increase land pressure. As a consequence, conversion of forests, marshes, and natural grasslands to agricultural regions will increase, leading to increased GHG emissions, biodiversity loss, and loss of other key ecosystem services. This rising need for animal proteins is problematic since current large-scale agricultural practices are associated with environmental degradation and animal welfare issues. Similarly, a diet high in meat, the most popular source of protein in the Western world, has been associated to an increased risk of inflammation, metabolic syndrome, some cancers, and premature mortality. The animal agriculture industry is connected to foodborne disease in terms of human health.[5]

Diet-related sickness, antibiotic resistance, everyday food-related disease, and communicable disease are all causes for concern.[3] Plant proteins, which may be produced at low cost, can compete for market share with animal proteins (dairy, egg, and meat).[1] The agricultural price for necessary proteins (as obtained by American farmers) is 3.8–12.7 times lower than the price for cattle, pigs, and broilers. Soybeans (Rs 0.74/g) and wheat (Rs 2.22/g) continue to be less expensive per gram of protein than cows (Rs. 23.65/g), pigs (Rs. 16.26/g), and poultry (Rs. 8.87/g).[6] Plant proteins are used to supplement or replace animal proteins in meals and plant-based meat substitutes, resulting in increased nutrition, taste, and usefulness. Although meat, poultry, fish, dairy, and eggs have appropriate organic compound composition and efficient digestion, the majority of large-scale animal protein production activities have environmental effects. Plant proteins have become increasingly popular in cuisine as the vegan, vegetarian, and flexitarian populations have risen. Plant proteins are used in the production of a wide variety of natural goods.

Novel plant proteins, such as those produced from pulses such as legumes, lentils, and chickpea, as well as proteins derived from canola, sunflowers, oats, potato, rice, and grains, have long been popular.[5] Plant-based proteins have become a fast-growing and imaginative carrier component within the food, nutraceutical, and pharmaceutical sectors, particularly in terms of sustainability and ethical considerations, thanks to the advantages they hold over their animal-derived counterparts.[7] Science and technology should support the fast rise in popularity of novel plant proteins.[5] Plant protein intake is expected to rise as people become more aware of the nutritional advantages of protein and concerns about food supply sustainability arise.[2]

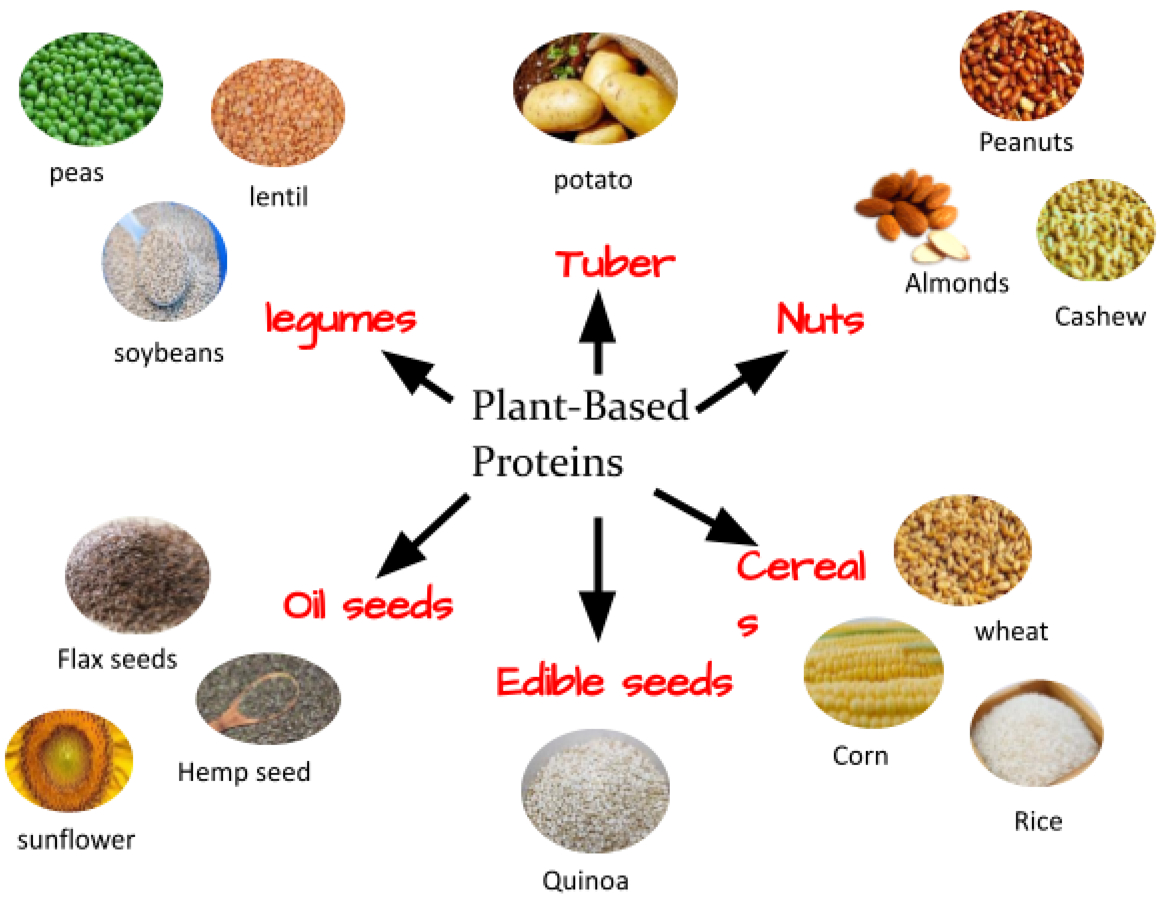

Fig.1- Plant based protein sources

Quality and need of protein-

Plant and animal protein have typical lengths of 392 and 486 amino acids, respectively. The majority of proteins in animal species have 10 exons with a normal size of -210 nucleotides. Plants contain fewer exons, but their exon length is longer on average (380 nucleotides).[8] Aggregation is induced by oxidative changes to amino acid side chain groups as well as secondary and tertiary structural alterations, which result in functional or quasi protein particles. The former is often soluble and may be formed under moderate oxidizing conditions, while the latter appears when proteins are dramatically altered at high concentrations or over long periods of time in the presence of an oxidant.[8, 9]

Food proteins include amino acids, which the human body requires, as well as other nitrogen-containing compounds such as neurotransmitters and peptide hormones. As a consequence, the need for protein necessitates the requirement for amino acids. Mammals do not manufacture enough of the nine amino acids leucine, lysine, histidine, isoleucine, methionine, phenylalanine, threonine, tryptophan, and valine, making them vital sustenance for humans. These are referred to as necessary amino acids. Mammals can produce arginine, but not in sufficient quantities to meet the needs of young species. Nonetheless, it is not required for proper human development. When present in low concentrations relative to all other amino acids, such as in intravenous amino acid combinations, it may inhibit protein synthesis. Histidine is an essential amino acid for newborn newborns. Several studies have recently indicated that adults need dietary histidine. Under some circumstances (e.g., liver damage), amino acids that are not normally required, such as cysteine and tyrosine, might undergo faulty conversion from their precursors, methionine and phenylalanine, respectively. Protein demand in children and nursing or pregnant women includes all needs linked with tissue deposition or milk production that are consistent with good health. If more protein is ingested than is necessary for metabolism, the excess is digested and the nitrogen-containing end products are expelled. It happens because proteins are not stored as a reserve in the body way lipids are in adipose tissue. While calorie intakes far beyond the real demand have not been connected to any harmful impacts, protein intakes much above the actual need have.

As a consequence, it is predicted that the literature will include multiple investigations on the relationships between protein sources and dietary quality indicators. Animal proteins have been accused of leading to a lack of adequate nutritional intake profile, which may explain the link between heart disease risk. The link between meat intake and diet quality has also been explored in research distinguishing an omnivorous population classified as vegetarian and non-vegetarian who consume fish (Pesco-vegetarians) and vegetarians.[10] Meat-eaters in the European Prospective Investigation into Cancer and Nutrition (EPIC)-Oxford study had a higher calorie intake and a more diverse nutritional intake profile, with a higher qualitative contribution of saturated fatty acids and less fiber and polyunsaturated fatty acids, as previously indicated. Meat consumption has also been linked to poor diet quality in larger populations that are nearly entirely composed of meat eaters, according to profiles of intake of various essential food groups: in Europe, higher overall meat consumption was associated with lower consumption of vegetables, fruits, and grains. Cereal grains, in particular, account for a significant portion of the world's protein and calories. [11]

The relationship between people's mortality rates and their preferences for plant and animal proteins

- soy protein consumption was significantly connected to a decreased risk of lethality from breast tumours. A high intake of plant proteins from legumes, grains, and nuts was connected to a lower risk of mortality from any cause. Long-term observational studies have shown a relationship between high total and animal protein intake and an increased risk of cancer and diabetes. The usage of non-meat proteins in lieu of meat proteins has been associated to lower fasting insulin levels and Dietary intake of other nutrients and (physiologically) active chemicals in protein-rich diets might potentially explain the connection between protein consumption and mortality. When the analysis was confined to studies that had made these revisions, the negative connection of protein from plants with all-cause and heart-disease death changed slightly, but the inverse relationship of total protein intake with all-cause mortality became non-significant. reduced insulin resistance. Low-carbohydrate, high-protein, and high-fat diets were not connected to an increased risk of coronary heart disease in women. However, when vegetable fat and protein sources were used, these diets were connected to a lower risk of heart disease-related risk in women. One meta-analysis found that cutting down on three servings of processed meat per week was associated with a modest decrease in overall cancer mortality across a lifetime.

Regardless of body weight, animal protein intake was connected to hypercholesterolemia, while plant protein intake was related to decreased plasma cholesterol levels. Replacing 3% of energy from various animal proteins with proteins from plants resulted in a 10% decrease in overall mortality in both sexes. A greater plant protein diet was connected to a lower risk of total and cardiovascular disease mortality in a Japanese population.[12,13]

Plant Proteins: A Deserving Alternative to Animal Proteins-

Animal protein is more popular than plant protein, yet it is unsuitable since animal protein causes a variety of ailments.

It is critical to address the major concerns created by animal protein while also balancing the desire to change. Meat protein consumption has been linked to an increased risk of heart disease. Other research has shown that animal proteins seem to be linked to weight increase over 6.5 years, with weight gain ranging from 1 kg to 125 kg of meat ingested daily. 14 low-fat red meat items were connected, including nuts, low-fat milk, chicken, and fish. In the Nursing Health Study, a high-meat diet reduced the risk of coronary heart disease by 13 to 30 percent. A low-carbohydrate diet heavy in animal protein is connected with a 23.0 percent death rate, while a low carb diet high in vegetable protein is associated with a 20.00 percent mortality rate.[15] According to Xiao[16], the American Heart Association's Nutrition Committee has examined 22 randomized studies since 1999 and determined that soy protein separated from isoflavones (ISF) reduced LDL cholesterol while having no impact on cholesterol, triglycerides, lipoprotein (a), or blood pressure. Other consequences of the soy diet are yet to be discovered.

Ferdowsian and Barnard[17] examined plant-based diets and plasma lipids using 27 randomized controlled studies. Interventions examining a mixed diet (vegetarian or vegan diet combined with nuts, soy, and/or fiber) exhibited substantial side effects (up to 35% drop in plasma LDL cholesterol), followed by vegan and ovolacto diets. Interventions allowing a restricted quantity of lean meat led in a considerable reduction in total cholesterol and LDL levels. A large Australian research (91 men and females) found that 24 g/dL of soy protein with or without 70 to 80 mg/dL of isoflavones had no impact on cholesterin levels in unequal or equal producers.[18] Intestinal bacteria in comparable manufacturers adapt isoflavone daidzein to fit, which is physically more effective than the original chemical. Campbell et al.[19] discovered that eating soy for 12 months did not result in a significant difference in LDL cholesterol or triglyceride levels when compared to diet; however, there had been a considerable rise in apolipoprotein B levels (105.5 mg/dL vs 120.9 mg/dL; P = 0.002) and a massive reduction in apolipoprotein A levels (189.36 mg/dL vs 173.21 10 mg/dL; Kris-Etherton et al.[20] observed that the LDL cholesterol-reducing response in peanut studies indicated support for decreasing blood cholesterol levels identified in changes in the fatty acid diet profile throughout a peanut and nut scientific study.

As a result, in addition to the favorable acid profile, nuts and nuts include other bioactive compounds (such as arginine, phenolics, and resveratrol) that contribute to their many cardiovascular advantages. Many evaluations of experimental investigations, according to Altorf-van der Kuil[21], have identified no association between dietary protein consumption and substantial signaling or high blood pressure occurrence. Protein seems to have a favourable influence on vital signs, which is consistent with biomarker research and randomized controlled trials. Plant proteins, according to the results of the observational research, also play an important part in this favourable impact.

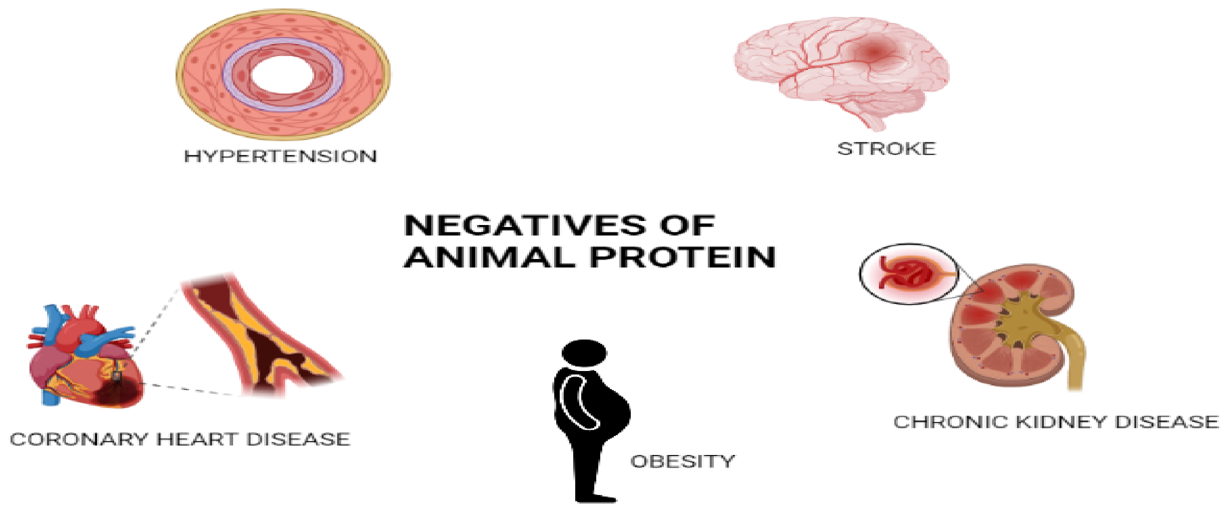

Fig.2- Negatives of Animal proteins

There was a scarcity of knowledge regarding proteins derived from specific origins (for example, fish, milk, grains, soybeans, and nuts). There is evidence that people with high blood pressure and/or adulthood are more susceptible to dietary protein. When compared to carbohydrate-based therapy, meat-based therapies diminish the major indications.[22] However, it was shown to be adversely related both to systolic and diastolic blood pressure (P = 0.0045 and 0.0096, respectively). Fruit and vegetable consumption has also been demonstrated to have a negative correlation with both systolic and diastolic potency in each unit area after 6 months (P = 0.0003 and 0.0157, respectively).[23] Initially, animal and plant proteins accounted for 66% and 34% of daily protein consumption, respectively, and the general pattern remained consistent at all stages despite minimal changes (Dietary Approaches to Stop Hypertension-DASH and diet). Gender, ethnicity, age, and weight status, on the other hand, have all had a substantial impact on donor patterns from various food groups in comparison to the omnivorous diet for weight loss.[24] Giving food options had little impact, and there was no correlation with diet type.[25] In an extremely large (176 participants) 18-month weight loss trial, a vegetarian diet had no effect on any outcome variable when compared to an omnivorous weight loss diet.[25] Both a lack of hydration and a high protein diet are major risk factor for urolithiasis.[26] Protein consumption stimulates renal acid secretion, and acidic burdens are also guarded by bone, which secretes calcium. The potential of this protein-induced hypercalciuria to bind to calcium kidney stones is restricted.[27] Furthermore, animal protein is a good source of purines, which are precursors to uric acid. Excessive consumption of animal protein is therefore linked to hyperuricosuria, a condition present in certain acid stone patients.[28] The pH of the urine has a significant impact on acid digestion. Whether or not hyperuricosuria exists, when the pH falls below 5.5 to 6.0, the generation of acid diminishes and the acidity lowers. Stone formation is increased (urine citrate levels decline and urine saturation of unrelated acid rises).[29]

Furthermore, it was shown that animal protein-rich meals were related with improved digestion in a three-day 12-day dietary trial in which the nutritional diet comprised of vegetable protein, vegetable and egg yolks, or animal protein. unrelated acid as a result of a drop in urine pH.[30] Furthermore, acid load decreased citrate depletion, and urine crystallization experiments revealed that animal protein consumption enhanced uric acid production.[30] Another research found that increasing protein consumption alters urine acid and citrate excretion rates as well as urinary ability to inhibit calcium oxalate monohydrate crystal agglomeration. Another research found that a high protein consumption caused alterations in urinary uric acid and citrate excretion rates, as well as a reduction in urines capacity to block calcium oxalate monohydrate crystal agglomeration.[31] Reduced urine ability to avoid calcium oxalate crystal agglomeration may give a physicochemical explanation for the syndrome. The impact of a high protein diet on the production of kidney stones. Conclusion In virtually all trials, vegetable protein outperforms animal protein, with lower rates of heart disease, renal stones, and high blood pressure. Plant proteins are gaining popularity as a functional food.

Plant proteins are now widely recognized as excellent, flexible, and easily accessible sources of functional and physiologically active dietary components. The human health effects of a high-quality protein diet have attracted a lot of attention due to its alleged advantages for weight control, metabolism, and healthy aging.[32] Numerous studies on the impact on cardiovascular risk, glycemia, and satiety are being conducted.[2] Plant-based protein blends with other biodegradable polymers are useful in the creation of novel products as well as the investigation of thermodynamic and kinetic processes influenced by external variables such as pH, ionic strength, and temperature.[33] As with dairy products, protein polymer and colloidal properties are changed to give desirable nutritional architectures. Proteins with 20 amino acids are adaptable enough to need a variety of configurations for catalytic activity (enzymes), tissue development (collagen), and movement activities (myosin and actin), to mention a few biological functions.[34]

Because of their nutritional importance, plant proteins are increasingly being investigated by newer product developers to offer three-dimensional assemblies with suitable physical, chemical, or enzymatic treatment that may enhance structure, texture, dissolution, and interfacial/bulk stability. Groundnut protein concentrates and oat-based gels were also utilized as emulsifying and foaming agents to increase consumer acceptability and plant protein intake in the diet. On average, 9 100 g of Bengal gram (chana) has roughly 17 g of protein. The protein content of red gram (arhar) and black gram (urad) is higher (24 g per 100 g). 35 Lysine, an essential aminoalkanoic acid, is more plentiful in oat protein. This feature suggests that, once digested, oat protein may be beneficial to persons who are gluten sensitive or allergic. Cereals, which are abundant in bioactive peptides, might also be good to your health. Barley includes a high concentration of garage proteins, mostly hordeins. Protein content ranges from 10% to 17% in ordinary barley grain. Although barley protein has a higher nutritional value, it is seldom employed as a protein supplement in modern diets. B-hordein, C-hordein, D-hordein, and globulin are among the major proteins discussed here. Barley contains angiotensin-converting enzyme (ACE) inhibitory peptides, lunasine, and xanthan oxidase-inhibitory peptides. [36] Jiaqi Huang's study found that plant protein intake was substantially inversely associated with age-adjusted mortality from all causes in both men and women. Wheat storage proteins include 32 low molecular weight glutenin, 32 high molecular weight glutenin, alpha-, gamma-, and omega-gliadin. Wheat proteins have been shown to be a decent stimulator of cholecystokinin and glucagon-like peptide 1 (GLP-1) release when exposed to human duodenal tissue; hence, wheat protein is employed as a dietary supplement in weight management. Angiotensin-converting enzyme inhibitors, as well as dipeptidyl peptidase-4 and phosphoenolpyruvate carboxylase inhibitors, were found in high concentrations in alpha-gliadin.[36] Isoflavones are considered to be abundant in soybeans, especially isolated soy proteins. Soy meals have been demonstrated to protect against cardiovascular disease, some types of cancer, and osteoporosis. Proteins and peptides have received a great deal of attention as multifunctional molecules with physiological and nutritional significance. Plant proteins are extensively researched in the manufacture of emulsifiers and stabilizers in order to overcome structural flaws and achieve qualities similar to their animal counterparts.[33]

Plant Protein Allergenicity: The Dark Side of Plant Proteins

Allergic illness is growing increasingly frequent across the world, and current data predict that food allergies will become much more of a worry than they were before.[37] Allergy is defined as "an negative health outcome caused by a specific immunological reaction that occurs in a predictable way following exposure to a certain food".[38] The health effect, known as an allergic reaction, occurs when the system attacks normally benign food proteins. Symptoms might range from mild to life-threatening at times. In the United States, over 170 things have been recognized as allergy triggers.[2] Allergy is a trendy and potentially dangerous illness that may have a detrimental influence on sufferers' well-being.

As previously noted, the trend toward higher plant protein intake stems from studies revealing that the source of protein, rather than the amount of proteins taken, impacts human health. To lower the risk of many ailments, healthcare professionals recommend replacing cattle and processed meats with alternative protein sources such as soy, beans, nuts, or other plant-based proteins. Parents and caregivers are increasingly providing plant-based milk alternatives to their infants and early children, as well as integrating more veg choices in their children's daily meal plans, such as plant-based nuggets and burgers. Such dietary choices may have unanticipated repercussions. Every protein source, such as lupines, has the potential to produce sensitivity. Lentils, peanuts, chickpeas, and beans are also closely related to the Lupinus genus. In the 1990s, lupin flour and protein components were introduced as soy and wheat alternatives in European nations. Since its introduction, some peanut-allergic persons have reported allergic cross-reactions. This was also seen in Australia, and the International Union of Immunological Societies Allergy Nomenclature Subcommittee within the EU, as well as Australia, has now included lupine to its priority allergen lists.[37] Plant proteins have been chemically investigated for many years, with the separation of protein from gluten in wheat going back more than 250 years. Plant proteins have recently garnered more attention as allergies, particularly in Europe and hence the United States, as well as in the context of novel and transgenic foods. The four principal groups of plant-based food allergies are the prolamin superfamily, the cupin superfamily, the Bet v 1 family, and profilins. The prolamin and cupin superfamilies are responsible for over half of the allergens identified in plants. The prolamin family of seed proteins includes wheat, barley, rye, soybean, rice, maize, and sunflower. As a consequence, the prolamin superfamily has become the most significant and widely distributed group of allergens identified in plant foods.[39] Soy allergy is a common cause of food allergies in children, although little is known about its natural history. Soy allergy affects around 0.4 percent of children, making it almost half as common as peanut allergy.[40]

Tofu and soy sauce were among the first soy products accessible to humans. Soy protein isolates were first sold in 1959. Since 1950, when some milk-allergic toddlers switched to soy formula and developed soy allergy, until the 1960s, when bigger intakes of soy protein in varied food sources were available, the prevalence of soy allergies has increased. Soy, on the other hand, is an excellent source of plant-based protein.[40] Peas, peanuts, beans, lentils, and soybeans are all members of the legume family. Due to observed allergy responses, pea proteins are viewed as a less allergenic alternative to other proteins such as soy and wheat. The use of pea protein in the human diet has been steadily increasing in the United States.[41] Legumins (storage proteins) occurring in high quantities in many seeds have been identified as allergens in numerous plant species.[22] Although there is no indication that the prevalence of food allergies has increased, national surveys suggest that peanut allergies have tripled since the late 1990s.[42] Visit the Allergy Research Resource Program (FARRP) database (http://www.allergenonline.com/) to learn more about the many forms of allergies.

Fig.4- Plant Proteins and Allergenicity

Proteins from plants, especially crops, are the most frequent allergens in our everyday lives, functioning as roadblocks to the revolution. Several proteins contained in wheat, rice, soybean, peanut, and maize have indeed been demonstrated to cause allergic responses in those who are sensitive to them. The majority of plant food allergies have been identified as proteins from diverse protein families and superfamilies, with the Tryp alpha amyl family accounting for 16.88% of all allergens in plant foods. Eight proteins in rice seeds have been identified as allergens according to their IgE-binding activity: Os07g11330.1, Os07g11360.1, Os07g11380.1, Os07g11380.2, Os07g11410.1, Os07g11510.1, and Os08g09250.1. 2S.43 Albumin is a protein present in the seeds of many plants that acts as a storage protein. This allergy is prevalent in peanuts, soybeans, almonds, sesame, and buckwheat. Peanut (Ara h 10, Ara h 11, Ara h 14, and Ara h 15) oleosins, sesame (Ses I 4 and Ses I 5) oleosins, and hazelnut (Ses I 4 and Ses I 5) oleosins have all been identified as allergenic chemicals (Cor a 12, Cor a 13, and Cor a 15). Plant defensins are cysteine-rich peptides with an 8-kDa molecular weight that have antifungal and antibacterial activities. Peanut defensins were extracted using chloroform/methanol (Ara h 12 and Ara h 13). Gly m 2 (soybean defensin) has also been identified as a possible allergen. The most frequent wheat allergy components are gliadin and glutenin, which make up gluten.[44] Because all dietary proteins are alien to the body's immune system, only very few plant and animal proteins activate an IgE-mediated immune response in a small proportion of people, we can bring about a revolution if we disguise the negatives of plant proteins.[2]

Conclusion-

In virtually every research, plant protein beats animal protein, with lower rates of heart disease, renal stone development, and blood pressure. However, as compared to animal proteins, they fall short in terms of total nutrition. The allergenicity of plant proteins is also a limiting factor in bringing about this transformation. It is tough to commit to a single choice since both protein sources offer advantages and disadvantages. People should choose their protein source while keeping the drawbacks in mind. As a result, the issue of whether we are ready for revolution continues.

References-

1. Ismail, B. P.; Senaratne-Lenagala, L.; Stube, A.; Brackenridge, A., Protein demand: review of plant and animal proteins used in alternative protein product development and production. *Anim Front* **2020,** *10* (4), 53-63.
2. Hertzler, S. R.; Lieblein-Boff, J. C.; Weiler, M.; Allgeier, C., Plant Proteins: Assessing Their Nutritional Quality and Effects on Health and Physical Function. *Nutrients* **2020,** *12* (12).
3. Rubio, N. R.; Xiang, N.; Kaplan, D. L., Plant-based and cell-based approaches to meat production. *Nature Communications* **2020,** *11* (1), 6276.
4. Joshi, V.; Kumar, S., Meat Analogues: Plant based alternatives to meat products- A review. *international journal of food fermentation and technology* **2016,** *5*, 107-119.
5. Lonnie, M.; Laurie, I.; Myers, M.; Horgan, G.; Russell, W. R.; Johnstone, A. M., Exploring Health-Promoting Attributes of Plant Proteins as a Functional Ingredient for the Food Sector: A Systematic Review of Human Interventional Studies. *Nutrients* **2020,** *12* (8).
6. Lusk, J. L.; Norwood, F. B., Some Economic Benefits and Costs of Vegetarianism. *Agricultural and Resource Economics Review* **2009,** *38* (2), 109-124.
7. Gomes, A.; Sobral, P. J., Plant Protein-Based Delivery Systems: An Emerging Approach for Increasing the Efficacy of Lipophilic Bioactive Compounds. *Molecules* **2022,** *27* (1).
8. Ramírez-Sánchez, O.; Pérez-Rodríguez, P.; Delaye, L.; Tiessen, A., Plant Proteins Are Smaller Because They Are Encoded by Fewer Exons than Animal Proteins. *Genomics Proteomics Bioinformatics* **2016,** *14* (6), 357-370.
9. Xiong, Y. L.; Guo, A., Animal and Plant Protein Oxidation: Chemical and Functional Property Significance. *Foods* **2020,** *10* (1).
10. Kelemen, L. E.; Kushi, L. H.; Jacobs, D. R., Jr.; Cerhan, J. R., Associations of Dietary Protein with Disease and Mortality in a Prospective Study of Postmenopausal Women. *American Journal of Epidemiology* **2005,** *161* (3), 239-249.
11. Mariotti, F., Animal and Plant Protein Sources and Cardiometabolic Health. *Adv Nutr* **2019,** *10* (Suppl_4), S351-s366.
12. Naghshi, S.; Sadeghi, O.; Willett, W. C.; Esmaillzadeh, A., Dietary intake of total, animal, and plant proteins and risk of all cause, cardiovascular, and cancer mortality: systematic review and dose-response meta-analysis of prospective cohort studies. *Bmj* **2020,** *370*, m2412.
13. Huang, J.; Liao, L. M.; Weinstein, S. J.; Sinha, R.; Graubard, B. I.; Albanes, D., Association Between Plant and Animal Protein Intake and Overall and Cause-Specific Mortality. *JAMA Intern Med* **2020,** *180* (9), 1173-1184.

14. Clifton, P. M., Protein and coronary heart disease: the role of different protein sources. *Curr Atheroscler Rep* **2011,** *13* (6), 493-8.
15. Liu, A. G.; Ford, N. A.; Hu, F. B.; Zelman, K. M.; Mozaffarian, D.; Kris-Etherton, P. M., A healthy approach to dietary fats: understanding the science and taking action to reduce consumer confusion. *Nutr J* **2017,** *16* (1), 53.
16. Xiao, C. W., Health effects of soy protein and isoflavones in humans. *J Nutr* **2008,** *138* (6), 1244s-9s.
17. Ferdowsian, H. R.; Barnard, N. D., Effects of plant-based diets on plasma lipids. *Am J Cardiol* **2009,** *104* (7), 947-56.
18. Thorp, A. A.; Howe, P. R.; Mori, T. A.; Coates, A. M.; Buckley, J. D.; Hodgson, J.; Mansour, J.; Meyer, B. J., Soy food consumption does not lower LDL cholesterol in either equol or nonequol producers. *Am J Clin Nutr* **2008,** *88* (2), 298-304.
19. Barańska, A.; Błaszczuk, A.; Kanadys, W.; Baczewska, B.; Jędrych, M.; Wawryk-Gawda, E.; Polz-Dacewicz, M., Effects of Soy Protein Containing of Isoflavones and Isoflavones Extract on Plasma Lipid Profile in Postmenopausal Women as a Potential Prevention Factor in Cardiovascular Diseases: Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Nutrients* **2021,** *13* (8).
20. Kris-Etherton, P. M.; Hu, F. B.; Ros, E.; Sabaté, J., The role of tree nuts and peanuts in the prevention of coronary heart disease: multiple potential mechanisms. *J Nutr* **2008,** *138* (9), 1746s-1751s.
21. Altorf-van der Kuil, W.; Engberink, M. F.; Brink, E. J.; van Baak, M. A.; Bakker, S. J.; Navis, G.; van 't Veer, P.; Geleijnse, J. M., Dietary protein and blood pressure: a systematic review. *PLoS One* **2010,** *5* (8), e12102.
22. Hodgson, J. M.; Burke, V.; Beilin, L. J.; Puddey, I. B., Partial substitution of carbohydrate intake with protein intake from lean red meat lowers blood pressure in hypertensive persons. *The American journal of clinical nutrition* **2006,** *83* (4), 780-787.
23. Wang, Y. F.; Jr, W. S. Y.; Yu, D.; Champagne, C.; Appel, L. J.; Lin, P. H., The relationship between dietary protein intake and blood pressure: results from the PREMIER study. *Journal of Human Hypertension* **2008,** *22* (11), 745-754.
24. Lin, P. H.; Miwa, S.; Li, Y. J.; Wang, Y.; Levy, E.; Lastor, K.; Champagne, C., Factors influencing dietary protein sources in the PREMIER trial population. *J Am Diet Assoc* **2010,** *110* (2), 291-5.
25. Burke, L. E.; Hudson, A. G.; Warziski, M. T.; Styn, M. A.; Music, E.; Elci, O. U.; Sereika, S. M., Effects of a vegetarian diet and treatment preference on biochemical and dietary variables in overweight and obese adults: a randomized clinical trial. *Am J Clin Nutr* **2007,** *86* (3), 588-96.
26. Goldfarb, D. S.; Coe, F. L., Prevention of recurrent nephrolithiasis. *Am Fam Physician* **1999,** *60* (8), 2269-76.
27. Goldfarb, S., Dietary factors in the pathogenesis and prophylaxis of calcium nephrolithiasis. *Kidney Int* **1988,** *34* (4), 544-55.
28. Delimaris, I., Adverse Effects Associated with Protein Intake above the Recommended Dietary Allowance for Adults. *ISRN Nutr* **2013,** *2013*, 126929-126929.
29. Reddy, S. T.; Wang, C. Y.; Sakhaee, K.; Brinkley, L.; Pak, C. Y., Effect of low-carbohydrate high-protein diets on acid-base balance, stone-forming propensity, and calcium metabolism. *Am J Kidney Dis* **2002,** *40* (2), 265-74.
30. Breslau, N. A.; Brinkley, L.; Hill, K. D.; Pak, C. Y., Relationship of animal protein-rich diet to kidney stone formation and calcium metabolism. *J Clin Endocrinol Metab* **1988,** *66* (1), 140-6.
31. Kok, D.; Iestra, J. A.; Doorenbos, C. J.; Papapoulos, S., The Effects of Dietary Excesses in Animal Protein and Sodium on the Composition and the Crystallization Kinetics of Calcium Oxalate Monohydrate in Urines of Healthy Men*. *The Journal of clinical endocrinology and metabolism* **1990,** *71*, 861-7.
32. Huang, J.; Liao, L. M.; Weinstein, S. J.; Sinha, R.; Graubard, B. I.; Albanes, D., Association Between Plant and Animal Protein Intake and Overall and Cause-Specific Mortality. *JAMA Internal Medicine* **2020,** *180* (9), 1173-1184.
33. Paramita, V. D.; Panyoyai, N.; Kasapis, S., Molecular Functionality of Plant Proteins from Low- to High-Solid Systems with Ligand and Co-Solute. *International Journal of Molecular Sciences* **2020,** *21* (7).
34. Foegeding, E. A., Food Protein Functionality--A New Model. *J Food Sci* **2015,** *80* (12), C2670-7.
35. Rampal, P., An Analysis of Protein Consumption in India Through Plant and Animal Sources. *Food Nutr Bull* **2018,** *39* (4), 564-580.
36. Cavazos, A.; Mejia, E., Identification of Bioactive Peptides from Cereal Storage Proteins and Their Potential Role in Prevention of Chronic Diseases. *Comprehensive Reviews in Food Science and Food Safety* **2013,** *12*, 364-380.
37. Jappe, U.; Vieths, S., Lupine, a source of new as well as hidden food allergens. *Mol Nutr Food Res* **2010,** *54* (1), 113-26.
38. Sampson, H. A.; Aceves, S.; Bock, S. A.; James, J.; Jones, S.; Lang, D.; Nadeau, K.; Nowak-Wegrzyn, A.; Oppenheimer, J.; Perry, T. T.; Randolph, C.; Sicherer, S. H.; Simon, R. A.; Vickery, B. P.; Wood, R.; Bernstein, D.; Blessing-Moore, J.; Khan, D.; Lang, D.; Nicklas,

R.; Oppenheimer, J.; Portnoy, J.; Randolph, C.; Schuller, D.; Spector, S.; Tilles, S. A.; Wallace, D.; Sampson, H. A.; Aceves, S.; Bock, S. A.; James, J.; Jones, S.; Lang, D.; Nadeau, K.; Nowak-Wegrzyn, A.; Oppenheimer, J.; Perry, T. T.; Randolph, C.; Sicherer, S. H.; Simon, R. A.; Vickery, B. P.; Wood, R., Food allergy: a practice parameter update-2014. *J Allergy Clin Immunol* **2014,** *134* (5), 1016-25.e43.
39. Shewry, P. R.; Beaudoin, F.; Jenkins, J.; Griffiths-Jones, S.; Mills, E. N. C., Plant protein families and their relationships to food allergy. *Biochemical Society Transactions* **2002,** *30* (6), 906-910.
40. Savage, J. H.; Kaeding, A. J.; Matsui, E. C.; Wood, R. A., The natural history of soy allergy. *Journal of Allergy and Clinical Immunology* **2010,** *125* (3), 683-686.
41. Lu, Z. X.; He, J. F.; Zhang, Y. C.; Bing, D. J., Composition, physicochemical properties of pea protein and its application in functional foods. *Crit Rev Food Sci Nutr* **2020,** *60* (15), 2593-2605.
42. Gupta, R. S.; Warren, C. M.; Smith, B. M.; Jiang, J.; Blumenstock, J. A.; Davis, M. M.; Schleimer, R. P.; Nadeau, K. C., Prevalence and Severity of Food Allergies Among US Adults. *JAMA Network Open* **2019,** *2* (1), e185630-e185630.
43. Wang, J.; Yang, L.; Zhao, X.; Zhang, D.; Li, J., Characterization and Phylogenetic Analysis of Allergenic Tryp_alpha_amyl Protein Family in Plants. *Journal of agricultural and food chemistry* **2013,** *62*.
44. Maruyama, N., Components of plant-derived food allergens: Structure, diagnostics, and immunotherapy. *Allergol Int* **2021,** *70* (3), 291-302.