OPEN ACCESS Freely available online

ISSN: 2161-0509
Journal of Nutritional Disorders & Therapy

Review Article

# Protein on the Plate: Decoding the Latest Science for a Healthy Planet and a Healthy You

**Stacey J Bell*, Crystal MacGregor+**

*Nutritional Consultant, Boston, Massachusetts, United States of America;+Nutritional consultant, Charlottetown, Prince Edward Island, Canada

## ABSTRACT

**Context:** Western societies get most of their protein from animals. Red meat especially has been associated in the literature with increased cardiovascular disease, type 2 diabetes mellitus, and cancer. It is also blamed in the literature for adverse environmental effects.

**Objective:** Switching people to 100% plant-based protein diets is implausible, and indeed such a solution has its own health implications.

**Design:** The paper explores the literature to support a role for including one plant-based protein meal daily in the diet. First, we provide evidence as to why consuming too much animal protein may be unhealthy to humans and the environment. Second is a review of the potential risks of consuming all dietary protein from plant-based sources. Third, we pose a hybrid approach to include both types of dietary protein sources (animal and plant), and suggest that a plant-based protein powder used in a smoothie helps achieve that goal. This doable approach is a way of mitigating both health and environmental impacts.

**Results:** Individuals determine which meal will include a plant-based protein source instead of an animal protein. Examples could include peas, beans, lentils, seeds, and nuts. Each serving should provide at least 17 grams of dietary protein, which is one-third of the daily protein need (50 g daily of dietary protein). The other two meals would each contain 17 g of dietary protein from animal sources such as meats, poultry, seafood, and dairy products. A more popular option is to make a smoothie using a plant-based protein powder. Consuming one plant-based protein meal daily as a smoothie or any other option could offset health risks (e.g., reduce risk of diabetes, heart disease, cancer) and environmental risks (e.g., less use of land, water, and chemicals).

**Conclusion:** We describe a practical way to incorporate a plant-based protein smoothie daily into the diet. This approach can be readily adopted by the public to improve human health and reduce the environmental impact from consuming animal proteins. Healthcare professionals can encourage this behavior and accentuate the benefits to their patients

**Key words:** Plant-based protein; Risks of animal protein; Limits of plant-based proteins

## INTRODUCTION

For at least the past 10,000 years, the diet of Homo sapiens included animal proteins from both flesh and milk from non-human sources [1,2]. Animal proteins provided essential amino acids and micronutrients, which lead to early man developing increased brain size and intelligence, and a decrease in tooth and gut size. The saturated fat in the meat consumed at this time varied cyclically depending upon food availability for the animal. The meat consumed by our ancestors may have been healthier than what is consumed today based on its fatty acid composition.

However, all this changed in the early and mid-19th century with the advancement of animal husbandry [2]. Cattle were fed grain, leading to not only increases in body fat of the animals, but also in changes in the fatty acid composition of the fat found in meat and milk. Mostly, the fat was rich in saturated fat with a corresponding reduction in omega-3 fatty acids and an increase in omega-6 fats. This shift in fatty acid profile may contribute to the atherogenic effects of animal protein observed today.

The Dietary Guidelines for Americans 2020-2025 recommends that Americans consume less animal proteins and increase plant-base protein sources like beans, peas, lentils, seeds, and nuts.

**Correspondence to:** Stacey J Bell, Department of Nutrition, Tufts University School of Medicine, Boston, Massachusetts, United States of America; E-mail: staceyjbell@yahoo.com

**Received:** 20-Apr-2023, Manuscript No. JNDT-23-21095; **Editor assigned:** 24-Apr-2023, PreQC No JNDT-23-21095(PQ); **Reviewed:** 15-May-2023, QC No JNDT-23-21095; **Revised:** 22-May-2023, Manuscript No. JNDT-23-21095(R); **Published:** 29-May-2023, DOI: 10.35248/2161-0509.23.13.232.

**Citation:** Bell SJ, MacGregor C (2023) Protein on the Plate: Decoding the Latest Science for a Healthy Planet and a Healthy You. J Nutr Disord Ther. 13:232.

Western diets consumed today consist of 70% more saturated fat than is recommended, which mainly comes from meats and dairy products [3]. For those consuming animal proteins, these Guidelines recommend consuming protein from no or low-fat dairy products and lean meats, and limiting red meat and processed meats.

First, this article explores the literature as why consuming too much animal protein may be unhealthy to humans and the environment. Second is a review of the potential risks of consuming all dietary protein from plant-based sources. Third, we pose the optimal balance between the two types of protein sources and how to achieve that goal. As most people in Western societies get most of their dietary protein from animal sources, any shift to include plant-based proteins may be problematic. The use of a plant-based protein powder to substitute for one animal protein meal may offer the best way to meet the new guidance for incorporating both animal and plant-based proteins into the diet. Thus, the purpose of this article is to provide scientific evidence about health and environmental risks of dietary proteins from animals and plants; and propose an optimal strategy to incorporate both into the diet by having one meal daily that incorporates a smoothie made with the plant-based powder. This is an effective way to achieve the objective of improving human health, as well as offering a means of reducing the environmental impact from animal proteins. To achieve this objective.

## BACKGROUND

Dietary protein is essential for life and needs to be consumed daily. Much of what has been published on the adverse effects from consuming animal proteins falls into two categories: human health and environmental health. Despite these concerns, animal consumption has been increasing in both the United States and the United Kingdom [4,5]. Globally, protein availability from poultry, pork, beef and sheep meat is projected to grow by 16%, 17%, 8% and 16%, respectively, by 2031 [4].

Despite the recommended dietary protein intake being 50 g in the United States of America, total protein intake ranged on average between 62 g and 104 g daily, according to the Food Surveys Research group of the United States of America Department of Agriculture [6]. Most of the protein consumed was from animal sources with meat/poultry/seafood contributing 19% to 66% over the quintiles. Other sources include 14% to 19% of dietary protein contribution was from dairy, and 3% to 5% from eggs. In contrast, plant-based proteins contribute smaller percentages of intake with grains being the highest contribution (10% to 35% over the quintiles). Other plant-based protein intakes are smaller with seed/nuts, legumes, and soy contributing 1%-15%. Basically, this shows that despite the potential harm to both human health and the environment, no one is heeding the message of consuming less animal proteins.

Based on nearly 60 scientific articles about why individuals consume meat, omnivores seem to be attracted to meat and are unwilling to change this behavior, despite facing health concerns [7]. The main reasons for this behavior are driven by enjoyment, the belief that meat is an essential component of a healthy diet, and the lack of skills to prepare non-meat options.

## LITERATURE REVIEW

### Adverse effects from consuming animal proteins on human health

It is not surprising that consuming animal protein is associated with increased risk of chronic disease because animal proteins are inflammatory, and inflammation is associated with many chronic diseases of aging like heart diseases, type 2 diabetes, and cancer [8]. Red meat and processed meat are positively related to blood concentrations of inflammatory markers (i.e., interleukin-6, C-reactive protein, and tumor necrosis factor alpha receptor 2) (Table 1).

**Table 1:** Adverse health consequences of consuming animal proteins.

| Health condition | Comments |
|---|---|
| Mortality | Increased risk of 10% for red meat consumption (one-half serving daily). |
| | Increased risk of 13% for processed meat consumption (one-half serving daily). |
| Heart disease | Increased risk of ~12% for total and unprocessed meat consumption (one serving daily). |
| | Increased risk of 15% for processed meat consumption (one serving daily). |
| Diabetes | Increased risk of 14% to 19% for total and unprocessed meat consumption, respectively (one serving daily). |
| | Increased risk of 32% to 51% for processed meat consumption (one serving daily). |
| Cancer | Increased risk identified in colon cancer. |
| | Substituting a plant-based diet can lower risk by 20%. |

**Mortality:** Based on a study in nearly 100,000 adults, who are free of cardiovascular disease and cancer, those who consume higher quantities of red meat, and, in particular, processed meat, have a significantly greater mortality ($P<0.05$) [9]. An increase in total red meat consumption of at least half a serving per day was associated with a 10% higher mortality risk. For processed and unprocessed red meat consumption, an increase of at least half a serving per day was associated with a 13% higher mortality risk and a 9% higher mortality risk, respectively.

**Heart disease:** Coronary Heart Disease (CHD) risk was increased by 12% per one daily serving for total meat consumption, 11% for unprocessed meat, and 15% for processed meat based on data from more than 40,000 males [10]. Having one serving per day of a plant protein from nuts, legumes, or soy was associated with about a 15% decrease in CHD risk. Even substitutions of whole grains and dairy products for total red meat and eggs for processed red meat were also associated with lower CHD risk.

Ischemic Heart Disease (IHD) risk was shown to be increased in both genders with consumption of red meat and processed meat in a meta-analysis [11]. Higher consumption of unprocessed red meat was associated with a 9% per 50 g/day higher risk of IHD, and processed meat intake with an 18% higher risk. There was no association between IHD and poultry intake. This study provides substantial evidence that unprocessed red and processed meat, though not poultry, might be risk factors for IHD.

Other studies did not show an increased risk of heart disease. In a randomized study design, the benefits of plant-based proteins were clear, but the adverse effects on heart disease were less well-defined [12]. In a prospective, randomized, cross-over study in nearly 200 healthy individuals, compared with nonmeat as the major protein source, diets containing high amounts of either red or white meat, and without differences in other macronutrients, resulted in higher concentrations of LDL cholesterol and apoB. In fact, the effects of red and white meat were similar and were observed with

diets containing either low or high levels of saturated fatty acids.

Some have postulated that red meat increases the risk of heart disease because of its ability to increase Trimethylamine N-oxide (TMAO), which is a gut microbiota-generated metabolite [13]. Elevated plasma TMAO levels are observed in subjects at risk for cardiovascular disease (CVD) development and adverse CVD events including heart attack, stroke, and death [14]. TMAO was thought be derived from carnitine, choline, or both, which are from meat.

A randomized-controlled dietary intervention study explored the impact of chronic dietary patterns on TMAO levels, metabolism and renal excretion [13]. Volunteers (n=113) were enrolled in a randomized 2-arm (high or low-saturated fat) crossover-design study. Within each arm, three 4-week isocaloric diets, having 25% calories from protein, the effects of red meat, white meat, or non-meat protein on TMAO metabolism were examined. Consumption of red meat, but not white meat or non-meat, significantly increased plasma and urine TMAO, each two-fold ($P<0.0001$). From an oral isotope challenge, red meat or white meat (*vs.* non-meat) increased TMAO production from carnitine ($P<0.05$ each), but not choline. Dietary-saturated fat did not affect TMAO. Discontinuation of red meat consumption resulted in a decrease in TMAO levels. Thus, it appears that TMAO is increased from red meat consumption and may be a mechanism for its increased CVD risk.

**Diabetes:** In patients with diabetes, the relationship between mortality and red and processed meat consumption is stronger than seen in patients with heart disease [15]. Based on following nearly 20,000 men and women for up to 20 years, the risk of type 2 diabetes was significantly related to red meat and processed meat consumption ($P<0.001$) [16]. One serving daily increase in total red meat led to a 14% increase risk of type 2 diabetes, and a 32% increase for processed meat at the same amount. These results were corroborated by a meta-analysis on more than 400,000 individuals where diabetes risk increased by 19% per 100 grams for unprocessed red meat, and 51% per 100 grams for processed red meat [16]. Substitutions of one serving of nuts, low-fat dairy and whole grains per day for one serving of red meat per day were associated with a 16% to 35% lower risk of type 2 diabetes.

The benefits of plant-based diets for reducing the risk of type 2 diabetes were examined recently in more than 140,000 post-menopausal women over 16 years [17]. The plant-based diet, referred to as the Portfolio Diet, was defined as being rich in plant protein (soy and legumes, nuts), fiber, plant-sterols; and low in saturated fat and cholesterol. The risk of developing type 2 diabetes was 23% lower in those who had the best adherence to the Portfolio Diet. Similar risk reductions were observed for women who adhered to the Dietary Approaches to Stop Hypertension (DASH) diet and the Mediterranean diet. These findings further other studies showing that a plant-based diet, which is low in red meat but not devoid of it is, associated with a lower risk of type 2 diabetes.

Simply exchanging one serving of red meat for another protein source, or adopting a mostly plant-based diet was not only beneficial for risk reduction of type 2 diabetes, but also for those who already have this condition [16,18]. Individuals with type 2 diabetes, who adopt a plant-based diet, experienced a myriad of benefits based on a systematic review [18]. Based on 11 studies including 433 individuals with an average age of 55 years, plant-based diets were significantly associated with improvement in emotional well-being, physical well-being, feeling less depressed, quality of life, general health, hemoglobin A1c levels, weight, having lower total cholesterol and low-density lipoprotein cholesterol, compared with adhering to diets typically recommended to patient with diabetes. Thus, plant-based diets not only improve health, but also the management of diabetes.

**Cancer:** More than 30 years ago, Willett et al. showed an association between animal fat consumption and an increased risk of colon cancer based on a study including more than 88,000 women, aged 34 to 59 years [19]. Over six years, the relative risk for colon cancer for consuming beef, pork, or lamb as the main meal daily was 2.49 compared to women who consumed these less than monthly. Similarly, processed meats and liver were associated with increased risk of colon cancer, whereas skinless poultry and fish were associated with a decreased risk.

A couple of decades later, the same group explored the relationship between colorectal cancer later in life and animal protein consumed during adolescence [20]. These finding were based on a group of nearly 20,000 women, 34 to 51 years of age, who were asked about animal protein intake when they were younger. The intake of red meat and fish during adolescence was not associated with colorectal adenoma risk later in life. However, the intake of poultry during adolescence was associated with a 20% lower risk of colorectal cancer. Replacement of one serving per day of red meat with one serving of poultry or fish was associated with 41% and 35% decreased risks for rectal adenomas and advanced adenomas, respectively. These findings suggest that during adolescence, poultry intake may be protective against colorectal cancer, whereas red meat had no association.

More recently, an association between colorectal cancer risk and different plant-based diets was observed in nearly 80,000 males and 90,000 women [21]. Quintiles for three plant-based diets were compared: overall plant-based diet index, a healthy plant-based diet index, and an unhealthy plant-based diet index. In contrast to men, no relationship was observed in women between any of the three diets and colorectal cancer risk. Over 19 years, colorectal cancer risk was 23% lower for the overall plant-based diet and 20% lower for the healthy plant-based diet across the quintiles. The risk reduction was stronger for the overall plant-based diet for Japanese American, Native Hawaiian, and White groups compared to the African American or the Latino group. The decreased risk with the healthy plant-based diet was found consistently across racial and ethnic groups. Based on this study, a greater adherence to a plant-based diet is associated with a reduced risk of colorectal in men, but not in women.

A group of European investigators explored whether red meat and processed meat were related to other forms of cancer besides colorectal [22]. Prospectively, over six years, more than 60,000 healthy adults were followed for dietary intake and the development of breast and prostate cancers. Red meat intake was significantly associated with an increased risk of both cancers. In this study, processed meat intake had no relationship to either cancer, which may have been attributable to its low intake in this cohort.

**Other conditions:** Limited data are available on metabolic syndrome, dementia, and COVID-19 [23-25]. A systematic review explored the impact of animal or plant protein intake on metabolic syndrome risk using the following variables: hypercholesterolemia, hypertriglyceridemia, blood pressure, glucose homeostasis, and body composition [23]. Consumption of soy protein (with isoflavones, but not soy protein without isoflavones), and

other plant proteins (pea and lupine proteins, wheat gluten), led to a 3% greater decrease in both total and LDL cholesterol compared with animal protein. There is some evidence that soy protein with isoflavones may reduce the risk of heart disease (i.e., hypercholesterolemia and hypertension), but no conclusions could be drawn about the factors relating to glucose homeostasis and waist circumference. Thus, metabolic syndrome risk does not seem to be related to consumption of either animal or plant proteins.

The impact of a plant-based diet appears to have an important effect on reducing the risk of developing COVID-19 and, if contracted, not becoming severely ill [24]. In a Perspective in the European Journal of Clinical Nutrition, Kahleova and Barnard reviewed what is known about dietary intake and COVID-19. They cite studies showing that consuming a plant-based diet results in a 9% lower risk of COVID-19, a 73% lower risk of moderate-to-severe COVID-19, and a 41% lower risk of severe COVID-19. Thus, plant-based protein diets appear to decrease the risk of more severe forms of COVID-19.

Based on a systematic review, data are emerging that support a role for healthy diets in reducing dementia risk [25]. A healthy diet was considered to be rich in plant-based foods (e.g., fruit, vegetables, and other plant-derived products), fish; and low in meat, saturated fat, and added sugar. Better adherence to a Mediterranean diet is associated with less cognitive decline or dementia. Other healthy, plant-based dietary patterns were shown to be associated with reduced cognitive decline and/or a reduced risk of dementia.

In summary, despite the overwhelming evidence that most chronic diseases of aging are associated with consuming animal proteins, especially red meat and processed meat, the dietary practice of consuming animal protein continues. Substitution of just one meat-meal daily with a plant-based protein may improve health. Adopting a healthier diet including reducing the intake of sodium, red meat and processed meat, and increasing whole grains, nuts, vegetables, and fruits, could reduce premature deaths in adults by around 20% [26].

## Adverse effects from consuming animal proteins on planetary health

According to the EAT-Lancet Commission, global food production threatens the climate and constitutes the largest driver of environmental degradation [26]. Immediate action is required according to the report including: global shift toward healthy diets including reducing red meat and dairy foods in deference to consuming more plant-based options; improved food production practices; and cutting food loss and waste in half.

Growing crops for food poses risks to the environment by: increasing greenhouse gas emissions, crop use, and the use of water, nitrogen, and phosphorus. Meats (beef, lamb, pork, and poultry) pose the greatest risk based on these criteria. Eggs and milk are next as far as harm; foods that affect the environment the least include fruits, vegetables, legumes, seeds/nuts, vegetable/palm oils, and grains.

To obtain global improvement in the environment by 2050, dietary habits would need to change with the doubling in the consumption of healthy foods such as fruits, vegetables, legumes, and nuts, coupled with at least a 50% reduction in less healthy foods such as added sugar and red meat [26].

The ill-effects of food production on the environment are diminished with increased replacement of animal-sourced foods with plant-based foods [26]. Vegan and vegetarian diets are associated with the greatest reduction in greenhouse-gas emission. Diets that replaced ruminants with alternatives such as fish, poultry, and pork also showed reduced environmental adverse effects, but smaller benefits compared to plant-based alternatives. A subsequent study looked at the impact of four different plant-based diets on environmental and cardiovascular disease risk [27]. Individuals in this study consumed one of these diets: Alternative Healthy Eating Index (AHEI), Plant-Based Diet Index (PDI), unhealthy PDI, and healthy PDI. The environmental impact was determined from more than 65,000 individuals by considering: greenhouse gas emissions, irrigation water, nitrogenous fertilizer, and high-quality cropland use. Higher scores on the AHEI diet were associated with a 23% decreased risk of cardiovascular disease; 30% lower greenhouse gas emissions; and lower need of fertilizer, cropland, and water ($P<0.0001$).

Similarly, those in the highest two quintiles of healthy PDI had a 29% lower risk for cardiovascular disease and lower greenhouse gas emissions, nitrogen fertilizer, cropland, and water use (all, $P<0.001$) [27]. In contrast, those who had the highest score for adhering to the unhealthy PDI, experienced a 15% higher risk for cardiovascular disease and the diet required significantly more cropland ($P<0.0001$) and fertilizer ($P<0.0008$).

Based on the foods consumed by participants in this study, most greenhouse gas emissions were associated with animal-based; the greatest impact was from red and processed meat (31%) [27]. Other animal products had less environmental impact-13% for dairy, 9% for poultry, and 6% for fish. Fruit juice, vegetables, and fruit had less of an impact (3%-5%). Red and processed meat also contributed to the most use of cropland (59% of the use based on the participants' diets), water use (26%), and fertilizer (25%).

Dairy products' impact on the environment was less than for red meat and processed meat, and was responsible for 9% use of cropland, 7% use of water, and 9% for fertilizer use [27]. Vegetables use considerable water (25% of the use based on the participants' diets), with fruit and nuts considerably less, 7% and 5%, respectively.

Based on what is known about healthy eating and environmental impact, it is clear that the two are aligned. Consumption of a healthy diet, which has little red meat and processed meat like in the AHEI, leads to a reduction in risk of cardiovascular disease, other chronic conditions like type 2 diabetes, and mortality. This type of diet also significantly reduces greenhouse gas emissions, and the need for cropland, irrigation water, and nitrogenous fertilizer. In contrast, unhealthy dietary patterns (i.e., unhealthy PDI), increased the risk of cardiovascular disease and had adverse effects on the environment.

## Potential risks of consuming only protein from plant-based sources

The nutritional literature supports the notion that animal proteins, especially consuming large amounts of red meat and processed meats, are not only unhealthy by increasing the risk of many chronic diseases of aging, but also are more harmful to the environment than other protein options from plants. Rarely do decisions align like this, and it seems that most individuals would be willing to adopt a diet that offers the best human and planetary health. However, some have concerns that there could be problems with adopting with only plant-based proteins (Table 2).

**Table 2:** Potential risks of consuming only plant-based foods.

| Potential risk | Comments |
|---|---|
| Eating only plant-based foods does not lead to improved health. | Increased risk of cardiovascular disease by 30% to 45%, if unhealthy plant-based foods are consumed.<br>Message is confusing as to what constitutes a healthy plant-based diet. |
| Many plant-based foods may be unhealthy but have minimal effect on the environment. | Many plant-based foods are processed.<br>Most sales in supermarkets (96%) are processed foods.<br>Based on 57,000 processed foods, most have minimal adverse effects on the environment. |
| Consuming mostly plant-based foods may lead to micronutrient deficiencies. | Examples: vitamins A and B12, zinc, iron, and omega-3 fatty acids. |
| Some plant-based proteins have poor essential amino acid profiles. | Poor plant-based proteins may impair protein synthesis leading to poor growth in the young and poor health in adulthood. |

First, despite the fact that a healthy diet is low in red meat and processed meats, it is still possible to consume unhealthy plant-based foods, leading to harm to human and environmental health [27]. Healthy plant-based food groups include: whole grains, fruits, vegetables, nuts, legumes, vegetable oils, and tea and coffee. However, there are also unhealthy plant-based food groups: fruit juices, sugar-sweetened beverages, refined grains, potatoes, and sweets and desserts. Eating large amounts of unhealthy plant-based foods has been shown to increase the risk of cardiovascular disease by 30% to 45% [28]. Thus, someone could eat minimal red meat and processed meats but still include many unhealthy plant-based options and be no better off in terms of health.

The message about eating plant-based foods is confusing [27-29]. Without proper definitions of what constitutes healthy plant-based foods, both human and environmental health could suffer. Several decades ago, nutrition experts told the public to avoid fat in the diet. Many adopted this practice, yet increased their intake of refined carbohydrates, thereby increasing the risk of many chronic diseases of aging. Just saying "Eat Plant-Based Foods" is not the correct message based on based on the diet consumed today, which is rich in processed foods potentially containing healthy plant-based foods. It is the correct message to recommend eating plant-based foods for few individuals who only eat fresh, non-processed foods. According to one study, most foods (96%) sold in supermarkets in the United Kingdom and Ireland contains more than one ingredient in them, indicating they were processed [29].

Second, all plant-based foods are not healthy, and paradoxically, some of these unhealthy ones have no impact on the environment [29]. Based on an assessment of 57,000 products, many plant-based foods deemed to be unhealthy actually have minimal effects on the planet related to greenhouse gas emissions, land use, water stress, and fertilizer use, especially of nitrogen and phosphorus containing products [29]. For example, sugary beverages (e.g., carbonated sugary beverages, fruit juices) have a low environmental impact; many desserts and pastries have an intermediate one. None of these plant-based foods can be considered healthy, despite having no, or minimal, environmental effect.

Third, plant-based proteins may be missing some essential nutrients (e.g., vitamins A and B12, zinc, iron, and omega-3 fatty acids); these can only be obtained from animal-based foods and thus, consuming only plant-based foods may lead to deficiencies [30]. Golden and colleagues describe an extreme situation in which more than 1 million individuals rely on fish consumption to assure nutrient adequacy and avoid potential problems related to childhood mortality, reduced immune function, and cognitive deficits. Residents of low-latitude developing nations are particularly vulnerable to nutrient deficiencies because fish populations are decreasing due to over-fishing, climate changes, or both. Thus, the need for animal protein to provide micronutrients needs to be considered when suggesting that adopting only a plant-based diet is ideal.

Fourth, some plant proteins have poor amino acid profiles, meaning that they do not support human protein synthesis. It is not enough to consume adequate grams of dietary protein - it is necessary to get the full complement of essential amino acids and that these are in the right ratios. The daily needs of each are well-known [31]. Of course, one could consume more of a poor-quality protein to assure that essential amino acid needs are met, or consume other foods that provide the missing amino acids. However, some aver that 45% to 60% of dietary protein needs to come from animal sources in order to meet the essential amino acid and micronutrient needs [32].

A scoring system, referred to as Dispensable Indispensable Amino Acid Score (DIASS), has been developed to assess protein quality based on amino acid patterns [33-35]. The optimal amino acid patterns (i.e., a score close to 100) are found in animal proteins like from eggs, milk [35]. In contrast, many plant-based proteins have lower DIASS such as chickpeas (83), oats (84), almond (40), peanut butter (46), rice (57), and white bread (29) [36]. Thus, it is possible that in an attempt to consume a plant-based diet, amino acid quality may be poor, thereby impairing health.

## HOW TO ACHIEVE THE OPTIMAL BALANCE BETWEEN ANIMAL AND PLANT PROTEIN SOURCES IN THE DIET

Given what is known about the adverse effects of animal protein on health and the environment, and the limitations of only consuming plant-based proteins, the optimal strategy for human and planetary health seems to be some combination of both sources of protein [16-18]. Simply substituting one meat meal with a plant-based one may be sufficient to reap the health benefits to humans and to the environment. One easy way to do this is to use a plant-protein powder and reconstitute it to make a smoothie; this approach may allay the fears of those who don't know how to prepare plant-based protein foods. And, the powder can be "doctored" up with things like fruits and vegetables to enhance its flavor and substitute for a meal. Doing this at breakfast seems to be the easiest approach.

Not all plant-based protein powders are alike. A good plant-based protein that could substitute for an animal protein should contain the right mix of essential amino acids, be easy to prepare and tasty, be readily digestible, and may contain added nutrients that are often lacking in the diet. In addition, it should provide about 150 kcal, keeping total energy levels modest so that other

in Table 3 (https://epicure.com/en-us/product/power-up-vanilla-protein-blend). It can be reconstituted with any beverage-water, milk, plant-based milk alternatives, and juices. The plant-based protein powder contains 20 grams of dietary protein per serving,

which is comprised of 66% pea protein (contributing 13.2 grams of protein) and 34% fava beans (also called broad beans, contributing 6.8 g of protein). It has 130 kcal, contains bromelain, which has been shown to enhance digestion, includes a probiotic, Bacillus coagulans, that has been shown to promote gastrointestinal health, and provides potassium, which is lacking in the diet of most Americans [37-39] (Table 3).

**Table 3:** Characteristics and an example of a good plant-based protein powder.

| Characteristics of a good plant-based protein | Example of a good plant-based protein (based on one serving of 35 grams of powder) |
|---|---|
| Energy (kcal) close to 150 | 130 |
| Protein (g): 15-30 | 20 as 66% pea protein (contributing 13.2 grams of protein) and 34% fava beans or broad bead (contributing 6.8 g of protein) |
| Protein (g): 15-30 | 20 as 66% pea protein (contributing 13.2 grams of protein) and 34% fava beans or broad bead (contributing 6.8 g of protein) |
| Carbohydrate (g): 5-15 and low in added sugar and contains fiber | 8 (of which 3 g are added sugar and 1 g is dietary fiber) |
| Fat (g): 0-10 g, limited in saturated and trans fats | 2 g (no saturated or trans fats) |
| Sodium (mg): 100-500 | 290 (13% Daily Value) |
| Digestive enzymes | 91 gelatin digesting units (GDUs) of bromelain |
| Other added nutrients that are lacking in the diet but promote health | Potassium (995 mg): lacking in the diet and support heart health Probiotics (Bacillus coagulans [1B cfu]): to support intestinal health and promote digestion |

Protein quality is important when selecting a plant-based protein that is intended to substitute for an animal one. We were unable to calculate the DIASS of this plant-based protein powder, because the ideal digestibilities of the amino acid composition of the proteins (i.e., fava bean and pea protein) in a pig are unknown. Instead, we considered essential amino acid profile, because it is impossible to achieve a high DIASS if the amino acid profile is poor. The daily goal is to get 100% of the essential amino acid daily in at least 50 grams of total dietary protein [31]. Since the plant-based protein is substituting for one meal, the goal is to get one-third of both; as such, the goal is 17 g of dietary protein and one-third of each of the essential amino acids (Table 4).

**Table 4:** Essential amino acid contribution from one serving of a plant-based protein powder*.

| Essential amino acid | Amount needed daily (mg/50 g dietary protein)+,^ | Amount per serving from a plant-based protein powder (total mg from fava bean+pea protein)# | Percentage of daily essential amino acid need met from one serving (%) |
|---|---|---|---|
| Histidine | 550 | 508 | 92 |
| Isoleucine | 650 | 836 | 130 |
| Leucine | 950 | 1,471 | 150 |
| Lysine | 800 | 1,447 | 180 |
| Methionine+cysteine | 850 | 410 | 48 |
| Phenylalanine+tyrosine | 950 | 1,455 | 150 |
| Threonine | 450 | 706 | 160 |
| Tryptophan | 250 | 156 | 62 |
| Valine | 650 | 896 | 140 |

*Per 35 g serving of powder, this contains 20 g dietary protein. The protein powder is comprised of 66% pea protein (contributing 13.2 grams of protein) and 34% fava beans or broad bead (contributing 6.8 g of protein)

+Amino acid needs mg/g dietary protein. National Research Council (US) Subcommittee on the Tenth Edition of the Recommended Dietary Allowances. Recommended Dietary Allowances: 10th Edition. Washington (DC): National Academies Press (USA); 1989. 6, Protein and Amino Acids.

^Daily dietary protein requirement: women 46 g and men 56 g; used 50 g

Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (2002/2005) and Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate (2005).

+,^:-To calculate daily amino acid needs for adults; multiply mg amino acid/g protein by 50.

#Fava bean amino acid composition. Data Type: SR Legacy Food Category: Legumes and Legume Products FDC ID: 173754 NDB Number:16054.

#Pea protein amino acid composition. Data Type: SR Legacy Food Category: Legumes and Legume Products FDC ID: 172428 NDB Number:16085.

One serving of the plant-based protein powder provides 20 g of dietary protein, which is 40% of the daily dietary protein requirement, therefore exceeding the goal of 17 g. In addition, the daily essential amino acid requirements of one-third were met or exceeded for each. The rate-limiting amino acid was the sum of methionine and cysteine, but this still exceeded the expected goal (48% instead of 33%). Most amino acids (6/9) exceeded 100% of the daily goal (i.e., isoleucine, leucine, lysine, phenylalanine+tyrosine, threonine, and valine). Even if the protein digestion was not complete, this profile shows that this protein blend is still of very high quality according to its amino acid composition.

## CONCLUSION

Evidence is strong that animal proteins, especially consumption of red meat and processed meat, are deleterious to human and planetary health. Plant-based proteins offer healthy alternatives, yet their use has not been universally adopted because many think that they taste poorly, do not know how to prepare them, or both. In addition, total substitution of plant-based for animal proteins may not be optimal for human health in that they lack essential nutrients and amino acids. There is confusion about what constitutes a healthy plant-based diet. The best solution is to substitute one animal protein meal with a plant-based option. We provide a simple way of doing that with a plant-based protein powder that is easy to prepare into a smoothie, tasty, and rich in essential amino acids. This approach overcomes some of the obstacles and limitations of adopting a plant-based diet exclusively.

## CONFLICT OF INTEREST

Dr. Bell and Ms MacGregor are consultants to the company that manufactures the plant-based protein powder described herein.

## REFERENCES

1. Pobiner B. Evidence for meat-eating by early humans. Nat Educ Knowl. 2013;4(6):1.
2. Cordain L, Eaton SB, Sebastian A, Mann N, Lindeberg S, Watkins BA, et al. Origins and evolution of the Western diet: health implications for the 21st century. Am J Clin Nutr. 2005;81(2):341-354.
3. McGuire S. US department of agriculture and US department of health and human services, dietary guidelines for Americans, 2010. Washington, DC: US government printing office, January 2011. Adv Nutr. 2011;2(3):293-294.
4. Leiva M. Is meat consumption declining? Investment Monitor. 2022.
5. Economic Research Service; U.S. Department of Agriculture. Per capita red meat and poultry consumption expected to decrease modestly in 2022. Chart Gallery. 2022.
6. Hoy MK, Murayi T, Moshfegh AJ. Diet Quality and Food Intakes samong US Adults by Level of Animal Protein Intake, What We Eat in America, NHANES 2015–2018. Curr Dev Nutr. 2022;6(5):nzac035.
7. Valli C, Rabassa M, Johnston BC, Kuijpers R, Prokop-Dorner A, Zajac J, et al. Health-related values and preferences regarding meat consumption: a mixed-methods systematic review. Ann Intern Med. 2019;171(10):742-755.
8. Tabung FK, Smith-Warner SA, Chavarro JE, Wu K, Fuchs CS, Hu FB, et al. Development and validation of an empirical dietary inflammatory index. J Nutr. 2016;146(8):1560-1570.
9. Zheng Y, Li Y, Satija A, Pan A, Sotos-Prieto M, Rimm E, et al. Association of changes in red meat consumption with total and cause specific mortality among US women and men: two prospective cohort studies. Br Med J. 2019;365.
10. Al-Shaar L, Satija A, Wang DD, Rimm EB, Smith-Warner SA, Stampfer MJ, et al. Red meat intake and risk of coronary heart disease among US men: prospective cohort study. Br Med J. 2020;371.
11. Papier K, Knuppel A, Syam N, Jebb SA, Key TJ. Meat consumption and risk of ischemic heart disease: A systematic review and meta-analysis. Crit Rev Food Sci Nutr. 2021:1-2.
12. Bergeron N, Chiu S, Williams PT, M King S, Krauss RM. Effects of red meat, white meat, and nonmeat protein sources on atherogenic lipoprotein measures in the context of low compared with high saturated fat intake: a randomized controlled trial. Am J Clin Nutr. 2019;110(1):24-33.
13. Wang Z, Bergeron N, Levison BS, Li XS, Chiu S, Jia X, et al. Impact of chronic dietary red meat, white meat, or non-meat protein on trimethylamine N-oxide metabolism and renal excretion in healthy men and women. Eur Heart J. 2019;40(7):583-594.
14. Crimarco A, Springfield S, Petlura C, Streaty T, Cunanan K, Lee J, et al. A randomized crossover trial on the effect of plant-based compared with animal-based meat on trimethylamine-N-oxide and cardiovascular disease risk factors in generally healthy adults: Study With Appetizing Plantfood—Meat Eating Alternative Trial (SWAP-MEAT). Am J Clin Nutr. 2020;112(5):1188-1199.
15. Qian F, Riddle MC, Wylie-Rosett J, Hu FB. Red and processed meats and health risks: how strong is the evidence?. Diabetes Care. 2020;43(2):265-271.
16. Pan A, Sun Q, Bernstein AM, Schulze MB, Manson JE, Willett WC, et al. Red meat consumption and risk of type 2 diabetes: 3 cohorts of US adults and an updated meta-analysis. Am J Clin Nutr. 2011;94(4):1088-1096.
17. Glenn AJ, Li J, Lo K, Jenkins DJ, Boucher BA, Hanley AJ, et al. The Portfolio Diet and incident type 2 diabetes: findings from the Women's Health Initiative prospective cohort study. Diabetes Care. 2023;46(1):28-37.
18. Toumpanakis A, Turnbull T, Alba-Barba I. Effectiveness of plant-based diets in promoting well-being in the management of type 2 diabetes: a systematic review. BMJ Open Diabetes Res Care. 2018;6(1):e000534.
19. Willett WC, Stampfer MJ, Colditz GA, Rosner BA, Speizer FE. Relation of meat, fat, and fiber intake to the risk of colon cancer in a prospective study among women. N Engl J Med. 1990;323(24):1664-1672.
20. Nimptsch K, Bernstein AM, Giovannucci E, Fuchs CS, Willett WC, Wu K. Dietary intakes of red meat, poultry, and fish during high school and risk of colorectal adenomas in women. Am J Epidemiol. 2013;178(2):172-183.
21. Kim J, Boushey CJ, Wilkens LR, Haiman CA, Le Marchand L, Park SY. Plant-based dietary patterns defined by a priori indices and colorectal cancer risk by sex and race/ethnicity: the Multiethnic Cohort Study. BMC Med. 2022;20(1):1-4.
22. Diallo A, Deschasaux M, Latino-Martel P, Hercberg S, Galan P, Fassier P, et al. Red and processed meat intake and cancer risk: results from the prospective NutriNet-Santé cohort study. Int J Cancer. 2018;142(2):230-237.
23. Chalvon-Demersay T, Azzout-Marniche D, Arfsten J, Egli L, Gaudichon C, Karagounis LG, et al. A systematic review of the effects of plant compared with animal protein sources on features of metabolic syndrome. J Nutr. 2017;147(3):281-292.
24. Kahleova H, Barnard ND. Can a plant-based diet help mitigate Covid-19?. Eur J Clin Nutr. 2022;76(7):911-912.
25. Van de Rest O, Berendsen AA, Haveman-Nies A, de Groot LC. Dietary patterns, cognitive decline, and dementia: a systematic review. Adv Nutr. 2015;6(2):154-168.
26. Willett W, Rockstrom J, Loken B, Springmann M, Lang T, Vermeulen S, et al. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. The Lancet. 2019;393(10170):447-492.
27. Musicus AA, Wang DD, Janiszewski M, Eshel G, Blondin SA, Willett W, et al. Health and environmental impacts of plant-rich dietary patterns: a US prospective cohort study. Lancet Planetary Health. 2022;6(11):e892-e900.
28. Satija A, Bhupathiraju SN, Spiegelman D, Chiuve SE, Manson JE, Willett W, et al. Healthful and unhealthful plant-based diets and the risk of coronary heart disease in US adults. J Am Coll Cardiol. 2017;70(4):411-422.
29. Clark M, Springmann M, Rayner M, Scarborough P, Hill J, Tilman D, et al. Estimating the environmental impacts of 57,000 food products. Proc Natl Acad Sci. 2022;119(33):e2120584119.
30. Golden CD, Allison EH, Cheung WW, Dey MM, Halpern BS, McCauley DJ, et al. Nutrition: Fall in fish catch threatens human health. Nature. 2016;534(7607):317-320.
31. Institute of Medicine. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. Washington, DC: The National Academies Press. 2005.
32. Vieux F, Rémond D, Peyraud JL, Darmon N. Approximately Half of Total Protein Intake by Adults Must be Animal-Based to Meet Nonprotein, Nutrient-Based Recommendations, With Variations Due to Age and Sex. The Journal of Nutrition. 2022;152(11):2514-2525.

33. Dietary protein quality evaluation in human nutrition. FAO Food and Nutrition paper 92. Rome. 2013.

34. Wolfe RR, Rutherfurd SM, Kim IY, Moughan PJ. Protein quality as determined by the Digestible Indispensable Amino Acid Score: evaluation of factors underlying the calculation. Nutr Rev. 2016;74(9):584-599.

35. Herreman L, Nommensen P, Pennings B, Laus MC. Comprehensive overview of the quality of plant-And animal-sourced proteins based on the digestible indispensable amino acid score. Food Sci Nutr. 2020;8(10):5379-5391.

36. Marinangeli CP, House JD. Potential impact of the digestible indispensable amino acid score as a measure of protein quality on dietary regulations and health. Nutr Rev. 2017;75(8):658-667.

37. Chakraborty AJ, Mitra S, Tallei TE, Tareq AM, Nainu F, Cicia D, et al. Bromelain a potential bioactive compound: a comprehensive overview from a pharmacological perspective. Life. 2021;11(4):317.

38. Kalman DS, Schwartz HI, Alvarez P, Feldman S, Pezzullo JC, Krieger DR. A prospective, randomized, double-blind, placebo-controlled parallel-group dual site trial to evaluate the effects of a Bacillus coagulans-based product on functional intestinal gas symptoms. BMC Gastroenterol. 2009;9:1-7.

39. Cogswell ME, Zhang Z, Carriquiry AL, Gunn JP, Kuklina EV, Saydah SH, et al. Sodium and potassium intakes among US adults: NHANES 2003–2008. Am J Clin Nutr. 2012;96(3):647-657.