REVIEW

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The role of dietary plant and animal protein intakes on mitigating sarcopenia risk

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Purpose of review

To highlight contemporary findings comparing the digestibility of animal and plant proteins, their stimulatory effects on muscle protein synthesis, and associations with sarcopenia.

Recent findings

Animal proteins are more digestible than plant proteins, resulting in greater amino acid availability and stimulation of muscle protein synthesis. However, isolated plant proteins, plant protein blends, and modified plant proteins enriched with indispensable amino acids can elicit comparable digestion and absorption kinetics to animal proteins. More research is needed to determine whether these modified plant protein sources can effectively mitigate sarcopenia risk.

Summary

Both animal and plant protein foods can be incorporated into a healthful eating plan that limits risk of age-related diseases, such as sarcopenia. Humans eat food rather than isolated nutrients; as such, considering the context of the overall diet and its impact on health, instead of solely focusing on individual nutrients in isolation, is important.

Keywords

beef, dairy, muscle loss, muscle protein synthesis, protein isolates, soy

INTRODUCTION

Sarcopenia (i.e., age-related muscle loss) impairs function later in life and is associated with morbidity and mortality [1▪]. Current recommendations for preventing and mitigating sarcopenia are focused on routine physical activity, particularly resistance-type exercise training, combined with an optimal intake of dietary protein, emphasizing high indispensable amino acid density-based protein foods. The importance of indispensable amino acid intake for muscle integrity is often presented in the context of animal-based protein foods. Plant-based diets, however, have become increasingly popular for their perceived health and environmental/sustainability benefits. These tenets are not inherently at odds, yet related discussions often emphasize risks versus benefits associated with plant- and animal-derived proteins, and vice versa [2,3].

These discussions and related references to plant-based diets can often be misconstrued as implying required adherence to an animal-free (i.e., vegan) eating pattern. This is not, however, the singular representation of a plant-based diet [4]. Instead, this term is one that emphasizes intake of plant foods as the foundation for an overall healthful approach to eating that can, and typically does, include meat and other animal products. Although the focus of this review is the effects of plant- and animal-derived dietary protein intake on sarcopenia mitigation, we remind the reader that these protein sources do not need to be mutually exclusive and that an emphasis on overall nutrient density within an omnivorous diet - along with routine physical activity - can be the foundation for good health throughout the life cycle. With that theme in mind, this manuscript reviews the

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KEY POINTS

- Animal protein foods typically stimulate muscle protein synthesis and enhance muscle integrity more than plant protein foods.
- Plant protein blends, plant protein isolates, and indispensable amino acid-enriched plant proteins may offer muscle-related benefits comparable to animal proteins.
- Overall diet quality is an important factor to consider when evaluating the impact of varied protein sources on muscle health.

contemporary (i.e., 2021–2022) literature relating plant- and animal-derived proteins to muscle health, as reflected by digestion and absorption kinetics, their subsequent effects on muscle protein synthesis, and resulting clinical outcomes.

DIGESTION AND ABSORPTION OF ANIMAL AND PLANT PROTEIN

Stimulating muscle protein synthesis and/or mitigating muscle protein breakdown provides the intramuscular conditions for muscle protein retention. Muscle protein synthesis is reliant on amino acid availability and, as such, much of the discussion of the impact of animal- versus plant-derived dietary protein has centered on the ability of these food sources to elicit increases in plasma amino acid concentrations, particularly indispensable amino acids. The Digestible Indispensable Amino Acid Score (DIAAS) is the current preferred method for assessing the bioavailability of indispensable amino acids in a given protein food [5].

Animal proteins are generally considered to be of higher quality than plant proteins, in that they are more easily digested and readily provide all of the indispensable amino acids necessary to stimulate muscle protein synthesis and support muscle integrity [1▪,2,6,7▪▪]. Although DIAAS are higher for animal foods than plant foods, this scoring method is not without its limitations and has been criticized for not discerning differences in bioavailability related to heat processing [3] and for primarily measuring ileal digestibility of individual protein sources in young pigs [8]. However, the DIAAS of individual food items are additive in mixed meals [9], suggesting that the pairing of protein sources to balance limiting indispensable amino acids, typically referred to as 'complementary proteins', can be an effective strategy for improving plasma indispensable amino acid availability to support muscle protein synthesis.

The opposite may also be true, in that the typically lower DIAAS of plant foods compared to animal foods are attributed to antinutritional factors present in high amounts in the plant food matrix. These include phytates, saponins, and tannins and other polyphenols, which may contribute to lower indispensable amino acid availability, greater ureagenesis, and diminished stimulation of muscle protein synthesis post ingestion [6]. These inhibitory factors are present in intact plant foods and may not be specific to the isolated plant proteins themselves. As an example, consuming pea protein isolate for16 weeks elicited similar digestibility, utilization, and effects on nitrogen balance as casein and whey in aged rats [10]. In healthy women and men receiving naso-ileal tube feedings, the digestibility and indispensable amino acid availability of pea protein extract was comparable to casein, with certain limitations for leucine, lysine, valine, and phenylalanine [11▪]. Similarly, 30 g milk protein ingestion resulted in quicker and overall greater increases in plasma leucine, lysine, methionine, and total amino acid concentrations over 5 h post ingestion, compared to ingesting 30 g potato-derived protein [12▪]. Further investigation of leucine bioavailability from plant proteins is warranted, given leucine's potential as an independent stimulator of muscle protein synthesis [6].

These indispensable amino acid limitations are likely related to the structure of the proteins themselves within their native food sources. Recent analysis of a plant-based beef analogue shows fewer protein secondary structures (i.e., α-helices and β-sheets) and in vitro assays demonstrate lower digestibility and resulting release of fewer bioactive peptides from digestion, relative to real beef [13]. The blending of proteins can potentially enhance overall digestibility and indispensable amino acid availability [6,7▪▪].

Ageing itself also affects protein digestibility and indispensable amino acid availability. Age-related chewing impairment negatively impacts mechanical digestion of food, resulting in lower plasma amino acid concentrations and suppressed muscle protein synthesis [14]. Splanchnic extraction of indispensable amino acids increases with age, which further limits their release into circulation [1▪]. In support, combined data from 18 randomized controlled trials shows significant suppression of protein digestion and phenylalanine absorption in older (71 ± 5 years) relative to younger (22 ± 3 years) men, following consumption of intrinsically labeled casein [15▪].

In short, animal proteins are more easily digested than plant proteins and allow for robust increases in circulating indispensable amino acid availability. More research is needed to determine whether and how plant proteins can be blended or enhanced to improve indispensable amino acid availability to support whole-body and muscle protein requirements.

MUSCLE PROTEIN SYNTHETIC RESPONSE TO ANIMAL AND PLANT PROTEIN

Given the favorable amino acid content and digestibility of animal proteins, there is general consensus that they exert a stronger stimulation of muscle protein synthesis than do nonisolated plant proteins [7▪▪,16]. There is potential, however, for enhancing the muscle protein synthetic stimulatory effects of plant proteins by enriching plant foods with specific limiting amino acids and/or isolating the proteins themselves from potential antinutritional factors found in their native food matrix.

Recent data demonstrate that a lysine-enriched wheat and chickpea protein blend generates a postprandial increase in muscle protein synthesis in young men similar to that achieved by ingesting an isonitrogenous amount of chicken [16]. This occurs despite greater plasma concentrations of leucine, branched-chain amino acids, and indispensable amino acids following consumption of chicken versus the lysine-enriched blend of wheat and chickpea protein. Not surprisingly, plasma lysine concentrations were greater after ingesting the enriched plant protein blend, although plasma methionine concentrations were markedly lower, as methionine is often a limiting indispensable amino acid in plant proteins. Although the 5 h postprandial muscle protein synthesis rates were statistically similar between the two test proteins (time × treatment, $P = 0.068$), we note that the increase in muscle protein synthesis, relative to the postabsorptive state, was 81% for chicken and 48% for plant; a 1.7-fold greater rise for chicken versus the enriched plant protein blend.

Although the two protein sources used in the abovementioned study were isonitrogenous (40 g protein), the higher carbohydrate and fat content of the plant protein blend underlies a significant 60% greater energy load (1286 versus 802 kJ) to achieve similar muscle protein synthesis rates as ingesting chicken [16]. This energy difference should not be underappreciated and needs to be considered when conducting effective diet planning incorporating plant protein foods. Recommended actions to compensate for the typical lower protein synthetic stimulus elicited by plant proteins, as compared to animal proteins, include increasing the amount consumed, blending protein sources to ensure adequate indispensable amino acid intake, and enriching the content of limiting amino acids [7▪▪]. Identifying plant protein isolates with indispensable amino acid profiles similar to those of animal proteins is another avenue for future research.

One such potential source of isolated plant proteins with comparable indispensable amino acid profiles is potato protein. Potato protein concentrate is derived from the residue created during potato starch extraction and is reported to have an amino acid profile similar to milk protein and sufficient to meet current WHO/FAO/UNU amino acid requirements [12▪]. In a study involving young men, ingesting 30 g potato protein stimulated muscle protein synthesis to a similar extent as ingesting 30 g milk protein over a 5 h recovery from resistance exercise. Although plasma leucine, lysine, methionine, and total amino acid concentrations were all lower following potato protein than milk protein ingestion, postprandial muscle protein synthesis rates were not different over the total 5 h recovery window, nor during the early (0–2 h) or late (2–5 h) phases of recovery. These promising data strengthen the call for continued research and identification of plant-derived proteins that can optimally stimulate muscle protein synthesis. This future research should be expanded to older populations to determine the impacts of age-related anabolic resistance on these postprandial muscle protein synthesis rates and the therapeutic potential of such plant proteins in mitigating risk of sarcopenia.

CLINICAL IMPACT OF DIETARY ANIMAL AND PLANT PROTEIN

Sarcopenia and frailty commonly overlap as detrimental clinical manifestations in older adults. Along with resistance exercise training, dietary protein intake is a key therapeutic target for the prevention and mitigation of both. With the observation of anabolic resistance in aged muscle, nutrition recommendations emphasize a nutrient-dense diet with increased intake of high-quality protein foods (reviewed in [1▪]).

This emphasis on high-quality protein foods has traditionally implied higher animal protein intakes. Indeed, dietary animal protein intake has been associated with greater retention of muscle mass in older adults (reviewed in [2]). A recent 14-year prospective analysis has also shown higher functional status scores, lower risk of impairment, and smaller declines in hand grip strength in older adults (≥50 years at baseline) with greater animal protein intakes [17▪]. Similarly, a 15-year longitudinal study of older men (median 50 years at baseline) showed significant associations between a traditional Anglo-

Australian dietary pattern (i.e., greater consumption of red, white, and processed meats, unprocessed-fish, fruits and vegetables, wholegrain cereals, nuts, and discretionary foods) and DEXA-derived skeletal muscle index; of note, neither a Western-style dietary pattern nor one higher in plant and lower in animal foods were related to measures of muscle health [18▪].

This is not to say that plant foods are not salubrious for older populations. This same study showed benefits of an anti-inflammatory diet on skeletal muscle index, with anti-inflammatory characteristics attributed to nutritional factors well represented in plant-based diets [18▪]. The real concern, rather, is the density of protein and indispensable amino acids in plant foods [7▪▪] and the ability to consume a sufficient amount of bioavailable indispensable amino acids to optimally stimulate muscle protein synthesis in the face of anabolic resistance. This may be difficult to accomplish without greatly increasing overall energy intake [19], but plant protein isolates and indispensable amino acid-enriched (specifically leucine and limiting indispensable amino acids) plant foods may offer comparable alternatives to animal proteins [6]. Despite their beneficial amino acid profiles, negative associations have been tied to soy-based meat and dairy alternatives since their classification as ultra-processed foods [20]. However, young men receiving supplemental soy protein isolate as part of an isonitrogenous (1.6 g protein/kg body mass/d) vegan diet gained similar muscle mass and strength as their omnivorous counterparts consuming mixed foods with whey protein supplementation [21]. Augmenting indispensable amino acid intake via isolated protein supplementation in the context of an isonitrogenous diet, without introducing additional antinutritional factors from whole plant foods, likely underlies these comparable results. It will be important to repeat this study design with older volunteers to determine if this principle persists in the presence of age-related anabolic resistance.

The contemporary literature generally correlates muscle mass and functional outcomes with higher animal protein intakes, but there are recent data that suggest the opposite [22,23]. A large prospective study illustrated a lower risk of developing frailty for women with higher plant protein intake and higher risk for those consuming more animal protein, though total protein intake was interestingly not associated with frailty indices [22]. The association model was adjusted for potential confounders, though it is still worth noting that those individuals classified as consuming a higher plant protein diet also had a lower BMI, less incidence of smoking, were more active, and consumed an overall healthier diet at baseline. The inverse association between plant protein intake and frailty was stronger for those with low versus high quality dietary intake. Additionally, the detrimental effect of animal protein on frailty disappears when the type of fat is removed from the statistical model. This suggests that overall diet quality is a significant contributor to functional status throughout aging and that the complete diet must be considered when assessing the impact of total protein and protein type on muscle integrity and function.

The same research group published similar data relating a higher intake of red meat to risk of frailty [23]. Again, baseline data reveal certain inequities, with women who consumed the most red meat also presenting with higher BMI, greater energy intake, less physical activity, greater incidence of smoking, lower education and income, and a poorer overall diet quality. Risk reduction estimates showed protective effects against development of frailty with the substitution of fish (22%) and nuts (14%) for red meat. Once more, the context of the overall diet is paramount, as consumption of a comparable amount of indispensable amino acids from nuts versus meat requires significantly higher total energy intake [19], a factor which cannot be overlooked when considering the risk-benefit ratio for overall health.

Direct evaluations of the effect of protein type on sarcopenia are limited. Additional randomized controlled trials in those at high risk are needed to delineate the effects of protein type on age-related muscle loss.

CONCLUSION

The contemporary literature supports the consensus that animal protein foods, relative to their native plant counterparts, offer greater benefit in terms of digestibility, increasing plasma indispensable amino acid availability, stimulating muscle protein synthesis, and supporting muscle integrity and mitigating risk of frailty and sarcopenia. There is promising emerging evidence, however, that plant protein isolates, plant protein blends, and indispensable amino acid-enriched plant proteins can elicit comparable muscle-related effects. As emphasized throughout this review, the overall context and quality of the diet should not be overlooked when considering the impact of varied protein sources. Both animal and plant protein foods can offer nutritional benefits beyond the protein itself and high-quality food selection within these categories is just as important, if not more so, for overall health and well being than is the protein source.

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Conflicts of interest

There are no conflicts of interest.

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■ of special interest
■■ of outstanding interest

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