



Review Article

# Current progress in protein requirement changes and associated factors in the aging population

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**Abstract:** This review provides a comprehensive analysis of the importance of protein intake among older adults. With the global aging trend accelerating, adequate protein consumption is increasingly recognized as crucial for addressing the decline in muscle mass and function associated with aging. Research has shown that older adults require a higher protein intake (1.0–1.3 g/(kg·day)) to maintain muscle health, although the optimal recommendation remains a topic of ongoing investigation. The review highlights that the protein needs of older adults are often unmet by the recommended dietary allowance (RDA), potentially leading to health issues such as sarcopenia, weakened immune function, and delayed wound healing. Additionally, it examines various factors influencing protein intake in older adults, including socioeconomic status, education level, geographic location, and individual health conditions. The review also explores dietary patterns and protein sources, including both animal-based and plant-based proteins, and their effects on muscle protein synthesis (MPS). Finally, it underscores the critical role of sufficient protein intake in preserving the health, functionality, and quality of life of older adults, emphasizing the need for public health initiatives to address inadequate protein consumption in this population.

**Keywords:** aging; nutrition; optimal protein; protein synthesis

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## 1 Introduction

With the advent of an ageing society, the rapid growth of the adult aging population has become a global issue. By 2030, it is projected that one in every six people worldwide will be aged 60 years or older. China's aging population is also increasing dramatically, now being the largest in the world<sup>[1,2]</sup>. According to the 2020 Chinese census, the number of individuals aged 60 or older was estimated to be 264 million, accounting for 18.7% of the total population. Aging is recognized as one of the most significant risk factors for functional decline, leading to serious health consequences such as frailty, sarcopenia, cognitive dysfunction, and increased mortality<sup>[2-4]</sup>. Studies have shown that muscle is the first organ to experience age-related degeneration, contributing to a debilitating syndrome. Muscle loss manifests differently across the lifespan. In healthy individuals, muscle mass decreases by approximately 1% per year between the ages of 20 and 30<sup>[5-7]</sup>. However, muscle mass, strength, and power change slightly between the ages of 30 and 50 years. After the age of 50 years, the rate of muscle decline accelerates and may decrease by 30%–50% between the ages of 40 and 80 years<sup>[8-10]</sup>. The prevalence of muscle mass loss in the older population ranges from 4.16% to 35.23%,

with men showing a range of 6.4% to 45.9% and women from 5.67% to 37%. In general, the prevalence decreases gradually in men, whereas in women, it declines sharply after menopause.

Regarding daily protein intake, the estimated average requirement (EAR) for dietary protein is 0.66 g/(kg·day), and the Food and Nutrition Board (2008) recommends a recommended dietary allowance (RDA) of 0.8 g/(kg·day) for all adults aged 18 years and older, including those 65 years and older. It is well-established that older adults are less responsive to anabolic stimuli from protein ingestion, making them more susceptible to declines in muscle mass and physical function compared to younger adults. However, the RDA for protein intake remains the same for both older and younger adults. In 2023, The Chinese Nutrition Society (CNS) established a dietary reference intake (DRI) for protein of 1.0–1.2 g/(kg·day) for adults aged 65 years and older<sup>[11]</sup>. Therefore, older adults do require more protein than the current RDA as they age. Similarly, the 2020–2025 Dietary Guidelines for Americans (DGA) recommend a minimum intake of 5–6.5 oz/day of protein (approximately 85–110.5 g/day), depending on weekly calorie intake, for both men and women<sup>[12]</sup>. Thus, there is a need to further investigate the reasons for changes in dietary protein intake in older adults and their scientific basis to inform future

research and policy guidance. This review examines the importance of protein in the diets of older adults, the physiologic effects of aging on protein requirements, and recommends strategies to ensure adequate protein intake.

## 2 Studies on optimal protein intake for aging population

Assessing protein intake in the aging population is crucial for determining whether the RDA meets their nutritional needs, as protein plays a key role in maintaining muscle mass, mobility, and independence in this group. Adequate protein intake not only aids in calcium absorption and supports bone health but also promotes optimal immune system function. Recent criticisms highlight that nitrogen balance techniques may have limitations and do not account for other health parameters such as muscle function. These recommendations are based on minimum requirements for maintaining nitrogen balance and fail to consider variations in physical activity levels (PAL). It is well established that the aging population typically has lower PAL, which necessitate a higher protein intake to maintain muscle tissue<sup>[13-16]</sup>. The mechanisms underlying muscle mass maintenance are similar across age groups. This balance is achieved through muscle protein synthesis (MPS) and muscle protein breakdown (MPB). The difference between these two processes (MPS-MPB) reflects the state of net protein balance (NPB). A positive NPB indicates an increase in protein deposition, leading to larger and stronger myofibers, while a negative NPB results in decreased protein deposition and muscle atrophy. In aging individuals, the decline in skeletal muscle mass and function is primarily due to reduced MPS, largely attributed to aging-related impairment of the mTORC1 signaling pathway, which is essential for mRNA translation and myofibrillar protein synthesis (MyoPS)<sup>[17]</sup>. Amino acids, particularly the branched-chain amino acid leucine, serve as building blocks for muscle fibers and activate the mTORC1 pathway, thereby enhancing MPS. Activation of mTORC1 stimulates mRNA translation, which is crucial for maintaining muscle mass and strength. Conversely, deficiencies in protein or amino acids can negatively affect bodily functions and reduce MPS, leading to muscle loss<sup>[18]</sup>. Therefore, strategies aimed at overcoming the anabolic resistance observed in aging skeletal muscle, improving NPB, and enhancing protein deposition have become significant areas of research. The regulation of skeletal muscle mass is dependent on the equilibrium between MPS and MPB. When MPS exceeds MPB, muscle mass increases, and when the two processes are balanced, muscle mass remains stable. Typically, MPS rises after food intake while MPB is suppressed, resulting in a positive protein balance.

As individuals age, the muscle's response to anabolic stimuli from protein intake diminishes, a phenomenon known as anabolic resistance, which can accelerate the loss of muscle mass<sup>[19]</sup>. Research indicates that older adults exhibit a weaker postprandial metabolic response to protein intake, despite having similar basal metabolic rates compared to younger individuals. For instance, older adults may require up to 140% more protein (0.60 vs. 0.25 g/(kg-day)) to achieve the same level of MPS stimulation as younger adults<sup>[20]</sup>. Gorissen *et al.*<sup>[21]</sup> reported that within 5 h post-meal, 45% of phenylalanine from dietary protein entered circulation in adults aged 71, compared to 51% in younger adults aged 22, highlighting a decline in protein utilization efficiency with age. A systematic evaluation of 18 randomized controlled trials (RCTs) involving over 1,300 participants concluded that increasing protein intake beyond the current

population reference intake (PRI) of 0.83 g/(kg-day) may have a positive effect on lean body mass<sup>[22]</sup>. Consequently, older adults are advised to increase their protein intake to optimize postprandial MPS stimulation, counteract anabolic resistance, and maintain protein homeostasis. This underscores that the anabolic response to dietary protein decreases with age, and higher protein intake can mitigate the inflammatory and catabolic conditions commonly associated with aging.

Thalacker-Mercer *et al.*<sup>[23]</sup> demonstrated that short-term inadequate protein intake can alter muscle mRNA concentrations, adversely affecting muscle morphology and function. Notably, a protein intake of 1.2 g/(kg-day) can reverse these changes and stimulate mitochondrial protein synthesis in muscle tissue. The PROT-AGE Study Group, which includes the Muscular Dystrophy, Calcium Deficiency and Wasting Association, the European Union Geriatrics Society, the International Association of Geriatrics and Gerontology, the International Institute of Nutrition and Ageing, and the Geriatrics Society of Australia and New Zealand, recommends that older adults consume 1.0–1.2 times their adult protein intake daily to maintain muscle mass and prevent conditions like oligomyopathy. Specifically, they suggest that older adults should aim for 25–30 g of protein per meal, with approximately 2.0–2.8 g of leucine<sup>[24,25]</sup>. A study by Rafii *et al.*<sup>[26]</sup> showed that the protein requirement for women over 65 years of age was 1.29 g/(kg-day) compared to 1.24 g/(kg-day) for older men. A 14-week nitrogen balance study conducted by Lonnie *et al.*<sup>[27]</sup> found that among older adults who consumed 1.1 g/(kg-day) which is slightly above the 0.8 g/(kg-day) still experienced muscle mass loss. A study by Mitchell *et al.*<sup>[29]</sup> demonstrated the effects of protein intake at the current RDA or twice it on skeletal muscle mass and physical function in older men, and the results indicated that increasing protein intake did not significantly improve lean body mass, but was effective in maintaining lean body mass. Despite these guidelines, many older adults do not meet the current RDAs for protein. For instance, over 30% of older adults participating in the National Health and Nutrition Examination Survey (NHANES) fell short of these recommendations<sup>[28]</sup>. This gap between guidelines and actual consumption may result from barriers such as limited access to protein-rich foods, lack of nutritional education, or misconceptions about dietary needs in older age. Addressing these challenges is crucial for improving muscle health and enhancing the overall quality of life in this population. Initiatives such as community programs, targeted education, and improved access to affordable, protein-rich foods could play a key role in bridging this gap and ensuring that older adults achieve optimal health outcomes.

A recent carefully controlled study by Mitchell *et al.*<sup>[29]</sup> showed that increasing protein intake to twice the RDA (i.e., 1.6 g/(kg-day)) resulted in a significant increase in lean tissue mass in healthy older men. Mao *et al.*<sup>[30]</sup> provides significant insights into the protein needs of older adults in China. With the aging population expected to exceed 300 million by 2025, understanding adequate protein intake becomes increasingly crucial. By employing the Indicator Amino Acid Oxidation (IAAO) method to assess the protein requirements of healthy adults aged 65 and over, reveal that their EAR and recommended nutrient intake (RNI) are 0.91 g/(kg-day) and 1.17 g/(kg-day). This study offered valuable data specific to China's elderly population and advocated for a reevaluation of dietary recommendations to address their unique nutritional needs, which is vital for future public health policies. These findings also laid the foundation for the 2023 update of the CNS's RDA for protein.

Similarly, Huang *et al.*<sup>[31]</sup> investigated whether increasing protein intake to 1.3 g/(kg-day) could improve visceral fat accumulation and serum cardiovascular risk markers in functionally limited older adults. They found that protein intake above the RDA reduced visceral adipose tissue but did not improve cardiovascular disease risk markers. These results highlight the recognized need for higher protein intake among aging populations compared to younger adults. However, the upper limit for safe and effective protein intake remains unclear. Researchers continue to compare different levels of protein intake with the RDA, consistently finding that increased protein consumption tends to yield better outcomes. This underscores an important consideration: while higher protein intake appears beneficial, its effects vary depending on individual health conditions and specific metrics.

Howard's study<sup>[32]</sup> further reinforced this notion, demonstrating that increased protein intake during recovery from anterior cruciate ligament (ACL) reconstruction enhanced MyoPS, protein hydrolysis, and myogenic gene expression. Their findings suggested that MyoPS was higher at 1.9 g/(kg-day) compared to 1.2 g/(kg-day), indicating a potential stimulatory effect of increased daily protein intake on MyoPS during injury-mediated wasting states. Additionally, higher protein intake was associated with lower mortality rates in individuals aged 65 years or older<sup>[33]</sup>. However, the exact upper limit for protein intake remains undefined. In a recent study by Lee *et al.*<sup>[34]</sup>, the effects of protein supplementation on nutritional status and quality of life were evaluated in elderly patients after surgery. The study found that elderly patients with impaired protein digestion and intake who received supplementation demonstrated significantly higher protein intake ( $77.3 \pm 5.3$  g vs.  $56.7 \pm 6.0$  g,  $P = 0.049$ ), improved quality of life, better nutritional status, and faster walking speeds compared to those without supplementation. Protein intake was positively correlated with muscle mass. These findings underscore the critical role of dietary interventions in enhancing walking ability and overall well-being in older adults.

Reflecting on these findings on Table 1, it is evident that tailored protein recommendations must consider the unique needs of older adults. While these studies indicate that higher protein intake generally yields positive outcomes, a more nuanced approach is required to determine the optimal intake for individuals based on their health status and functional goals. Moreover, improving nutritional education and accessibility will be essential to ensure that older adults can achieve these benefits effectively.

### 3 The role of protein in promoting healthy longevity

Protein deficiency in older adults can lead to sarcopenia, a condition characterized by the progressive loss of muscle mass and strength. This decline in muscle mass increases the risk of falls, fractures, and functional decline<sup>[35]</sup>. Inadequate protein intake has also been shown to impair wound healing and weaken the immune response, thereby increasing susceptibility to infections<sup>[25]</sup>. Older adults are particularly vulnerable to loss of physical function, especially following prolonged bed rest. A chronic imbalance between MPS and catabolism, coupled with reduced activation of the mTOR nutrient signaling pathway, exacerbates muscle loss and can result in significant decreases in lean body mass even in the absence of exercise<sup>[36]</sup>. In hospitalized patients, this muscle loss is associated with decreased immune function, impaired wound healing, and delayed recovery post-discharge<sup>[37]</sup>. Given that many older adults in hospitals or nursing homes experience such challenges, supplemental protein energy can be a critical strategy to mitigate these effects and support recovery.

Protein deficiency in the elderly significantly impairs immune function, increasing susceptibility to infections and diseases. As protein is essential for the synthesis of antibodies and other immune components, inadequate intake weakens the immune response and prolongs recovery times<sup>[38]</sup>. These physiological changes can adversely affect not only physical health but also mental well-being and self-esteem. Cognitive function is also closely linked to protein intake. Research has shown that insufficient protein during aging contributes to cognitive decline, as it plays a critical role in neurotransmitter function and overall brain health<sup>[39]</sup>. Cognitive impairments can range from mild memory issues to severe dementia, affecting the quality of life and independence of older adults. In addition, protein is vital for recovery and healing, particularly following surgery or injury. Deficiencies slow tissue repair, increase the risk of complications, and prolong recovery times<sup>[40]</sup>. This can result in extended hospital stays, elevated healthcare costs, and a decline in overall health. The socioeconomic implications of protein deficiency among the aging population are equally significant. A higher incidence of complications and related diseases escalates healthcare costs, placing additional strain on public health systems and financial burdens on families<sup>[41]</sup>.

The concept of "healthy longevity" has gained increasing prominence, emphasizing not only the extension of lifespan but

Table 1 Studies related to optimal protein intake.

| Year of the study | Main findings                                                                                                                                                                                                                                                                         |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2007              | Thalacker-Mercer <i>et al.</i> <sup>[23]</sup> show that inadequate protein intake can negatively affect muscle health, and that 1.2 g/(kg-day) can reverse these effects                                                                                                             |
| 2013              | Cermak <i>et al.</i> <sup>[24]</sup> and Bauer <i>et al.</i> <sup>[25]</sup> suggest older adults should consume 25–30 g of protein per meal with 2.0–2.8 g of leucine; PROT-AGE Study Group recommends 1.0–1.2 times adult protein intake daily for older adults <sup>[24, 25]</sup> |
| 2015              | Rafii <i>et al.</i> <sup>[26]</sup> find that the protein requirement for women over 65 is slightly higher than for men                                                                                                                                                               |
| 2018              | Lonnie <i>et al.</i> <sup>[27]</sup> find that even 1.1 g/(kg-day) protein intake results in muscle mass loss in older adults                                                                                                                                                         |
| 2019              | Krok-Schoen <i>et al.</i> <sup>[28]</sup> show over 30% of older adults in NHANES do not meet RDAs for protein; Mitchell <i>et al.</i> <sup>[29]</sup> show that doubling the RDA protein intake increases lean tissue mass in older men                                              |
| 2020              | Mao <i>et al.</i> <sup>[30]</sup> employs the IAAO method found EAR and RNI are 0.91 g/(kg-day) and 1.17 g/(kg-day)                                                                                                                                                                   |
| 2021              | Huang <i>et al.</i> <sup>[31]</sup> find that protein intake above RDA reduces visceral fat but does not improve cardiovascular disease risk markers                                                                                                                                  |
| 2022              | Howard <i>et al.</i> <sup>[32]</sup> suggest that increasing protein intake may stimulate MPS during injury                                                                                                                                                                           |
| 2023              | Mantzouranis <i>et al.</i> <sup>[33]</sup> associate higher protein intake with lower mortality in people aged 65 or older                                                                                                                                                            |
| 2024              | Lee <i>et al.</i> <sup>[34]</sup> show that protein supplementation improves nutritional status and quality of life in elderly patients after surgery                                                                                                                                 |

also the importance of living free from major chronic diseases, often referred to as “healthy years”<sup>[41]</sup>. Studies have shown that individuals experiencing muscle loss are at higher risk of severe complications, including falls, osteoporosis, and increased mortality<sup>[42]</sup>. This condition also negatively impacts on their psychosocial well-being and social functioning, contributing to an estimated annual hospitalization cost of approximately \$40.4 billion<sup>[43]</sup>. The deterioration of physical health frequently leads to diminished social roles, placing significant burdens on caregivers, reducing social participation, and resulting in psychological challenges among older adults. These factors collectively lower their quality of life. Poor social participation has been linked to adverse outcomes, including reduced self-rated health, diminished ability to perform activities of daily living (ADLs) and instrumental activities of daily living (IADLs), and heightened feelings of negative emotions<sup>[44]</sup>. Thus, prioritizing adequate protein intake among older adults is critical not only for maintaining physical health but also for supporting their overall well-being. Proper nutrition, particularly sufficient protein consumption, plays an increasingly vital role in promoting health and quality of life as individuals age. Families, caregivers, and healthcare providers must advocate for and implement dietary strategies that enhance both physical and mental health outcomes in the elderly.

#### 4 Diverse protein sources for the aging population: recommendations by protein type

In 440 B.C., the Greek physician Hippocrates famously stated, “Let food be your medicine and your medicine be food.” Today, various dietary patterns, such as low-carb diets, the Okinawan diet, and the Mediterranean diet, are recognized for their health-promoting effects and potential to slow the aging process. Low-carb diets have been shown to reduce the risk of chronic diseases by limiting carbohydrate intake. Research by Osborne and colleagues<sup>[45]</sup> in 1917 demonstrated that restricting food intake in young female rats slowed growth while enhancing fertility and increasing lifespan. However, it is essential to ensure that protein intake is not restricted in your diet.

The aging population can obtain protein from both animal and plant sources. Animal proteins—such as lean meats, poultry, fish, eggs, and dairy products—are typically higher in essential amino acids (EAA) and offer superior quality in terms of digestibility and bioavailability compared to plant proteins<sup>[46]</sup>. Meanwhile, plant-based protein sources like legumes, nuts, seeds, and soy products provide additional health benefits through their fiber and micronutrient content<sup>[47]</sup>. The ability of protein to stimulate MPS is influenced by its leucine content. Older adults may require 2.5–3.0 g of leucine per meal to overcome anabolic resistance. Animal proteins are typically higher in leucine compared to plant proteins, making them particularly effective in maintaining muscle mass<sup>[19,48]</sup>. Whey protein is especially valuable due to its high leucine content and rapid digestion. In contrast, many plant-based proteins are low in lysine and methionine, which can limit their anabolic effects<sup>[49]</sup>. The rate of protein digestion and uptake determines the amount of immediately available EAA to stimulate the MPS response. Protein synthesis responses are higher and peak faster compared to slower-absorbed proteins. Plant-based proteins are generally more challenging to digest than animal-based proteins, largely due to processing methods and the presence of “anti-nutritional factors.” For instance, the Bowman-Birk trypsin inhibitor, found in soy flour, soy milk, soy isolate, and soy protein concentrate, inhibits the enzymatic activity of pepsin

and trypsin in the gastrointestinal tract, potentially reducing protein availability for MPS<sup>[50]</sup>. Additionally, the ingestion of plant proteins, such as soy proteins, has been associated with increased protein oxidation, indicating that the amino acids from these sources may be preferentially utilized for urea production, thereby leaving fewer amino acids available to stimulate MPS<sup>[51]</sup>.

However, Levine *et al.* analyzed data from the National Health and Nutrition Examination Survey (NHANES) and found that the association between protein intake and mortality varied by age group and protein type. Among people aged 50–65 years, high protein intake was associated with a 75% increase in total mortality and a fourfold increase in cancer and diabetes mortality over an 18-year follow-up period. This association was significant only for animal proteins, but not for plant proteins. In the NHS and HPFS, higher animal protein intake was positively associated with cardiovascular mortality, whereas higher plant protein intake was negatively associated with all-cause and cardiovascular mortality, and there was no evidence of an effect of age, in which plant-based nutrients represent the majority of the food intake, is likely to maximize health benefits in all age groups<sup>[52]</sup>. Given the differences in digestibility and quality among various protein sources, it is essential to consider these factors when developing nutritional interventions aimed at preventing age-related muscle loss.

Studies comparing the anabolic properties of various plant and animal protein sources are important to determine whether specific nutritional protocols can be developed to maximize muscle health in older adults. Differences between dairy proteins, particularly whey proteins, and soy proteins have been well studied in adults and young adults. The study showed that soy protein intake resulted in lower MPS than whey under rest and post-exercise conditions<sup>[53]</sup>. Additionally, Volek *et al.*<sup>[54]</sup> conducted an experiment with 63 randomly assigned healthy adults who underwent a full-body resistance training program and took isocaloric supplements containing carbohydrate, whey (24 g), or soy protein (24 g) for 9 months, whey supplementation significantly increased fasting plasma leucine concentrations and lean body mass gain instead of soy protein supplementation. However, a meta-analysis conducted by Messina *et al.*<sup>[47]</sup> concluded that there were no differences in lean body mass and strength responses to resistance training to soy protein supplementation compared with whey protein in healthy omnivorous adults aged 18–70 years.

Animal proteins, including lean meats, poultry, fish, eggs, and dairy products, are generally richer in EAA and offer superior digestibility and bioavailability compared to plant proteins<sup>[46]</sup>. In contrast, plant-based sources like legumes, nuts, seeds, and soy provide additional health benefits from their fiber and micronutrient content<sup>[47]</sup>. A study by Campbell *et al.*<sup>[55]</sup> found that women consuming an omnivorous diet ( $1.00 \pm 0.08$  g/(kg·day)) gained more lean body mass over 12 weeks than those on a lacto-ovo vegetarian diet ( $0.78 \pm 0.10$  g/(kg·day)). Interestingly, increasing protein intake on the vegetarian diet to 1.15 g/(kg·day) diminished these differences, indicating that higher overall protein intake can mitigate the distinct effects of different protein sources on muscle outcomes. Therefore, it's essential to consider not just the type of protein consumed, but also the total protein intake within the dietary context. As older adults seek to maintain muscle mass and strength, focusing on a balanced diet that includes a variety of protein sources may be the most effective strategy. This approach could harness the benefits of both animal and plant proteins, promoting not only muscle health but also overall

nutritional adequacy. Emphasizing diversity in protein sources may also enhance adherence to dietary recommendations, helping older adults achieve better health outcomes while enjoying a varied and satisfying diet.

## 5 Factors to consider for adequate protein intake

Dietary preferences and eating habits are primary determinants of protein consumption, often linked to changes in appetite, taste, and digestive function<sup>[56]</sup>. Additionally, socioeconomic factors play a vital role in shaping the type and quantity of protein-rich foods consumed by the aging population. Recent studies have shown that the most significant increase in protein intake below the EAR and the greatest decrease above the RNI were observed among participants residing in rural areas<sup>[57]</sup>.

A significant percentage of individuals aged 70 and older, particularly those with only primary education or limited literacy skills, report protein intake below the EAR. In contrast, individuals with secondary or higher education levels experience a more notable decline in protein consumption compared to their peers. Key factors influencing protein intake include food availability and accessibility, which can vary by geographic location and local food resources<sup>[58]</sup>. Regions with limited food diversity often face lower protein intake and an increased risk of nutritional deficiencies. Psychological factors, such as stress and emotional eating, also play a role in shaping dietary patterns, leading to fluctuations in protein consumption<sup>[59]</sup>. Additionally, individuals living in urban areas tend to experience a more rapid decline in protein intake compared to those in rural settings, highlighting the need for targeted nutritional interventions that consider geographic and educational demographics<sup>[60]</sup>. Education and awareness regarding nutritional needs are critical; individuals who are well-informed about protein sources and their benefits are more likely to meet their protein requirements<sup>[61]</sup>. In contrast, a lack of nutritional education can result in inadequate protein intake and related health issues. Economic constraints also limit access to high-quality protein sources, such as lean meats and dairy products, often forcing individuals to rely on cheaper, less nutrient-dense options. Food insecurity and economic challenges exacerbate this issue, leading to insufficient protein intake and associated health problems<sup>[57,62]</sup>. This trend emphasizes the importance of understanding how socioeconomic status and location impact dietary choices, particularly among older populations at greater risk for inadequate protein intake. Therefore, understanding the interplay between education, food availability, and socioeconomic status is essential for addressing dietary choices, especially among older adults at risk of inadequate protein intake. Targeted interventions are critical to enhance nutritional education and improve access to quality protein sources, thereby promoting better health outcomes in this vulnerable population.

## Conflicts of interest

The authors declare that there are no conflicts of interest in this work. Guiju Sun is an associate editor of Food & Medicine Homology, but was not involved in the processing, peer review or decision making of this article.

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