

The drug called food and its role as a therapy for chronic patients: a comprehensive narrative review

Giustino Varrassi,¹ Emanuele Cereda,² Giovanni A. Ruoppolo,³ Marco Mercieri,⁴ Maurizio Muscaritoli⁵

¹Paolo Procacci Foundation, Rome; ²Clinical Nutrition and Dietetics Unit, Fondazione IRCCS Policlinico San Matteo, Pavia; ³Polo Sanitario San Feliciano, Rome; ⁴Department of Pain Medicine, Sant' Andrea Hospital, "La Sapienza" University of Rome; ⁵Department of Translational and Precision Medicine, "La Sapienza" University of Rome, Italy

ABSTRACT

The discipline of utilizing food as a medicinal agent has gained significant attention in recent years. This narrative review aims to conduct a multidimensional exploration of the inherent therapeutic properties of food. It utilizes a comprehensive methodology encompassing historical texts, contemporary scientific literature, and clinical investigations to explore the dynamic field of food as therapy. Commencing with a historical backdrop, this text traces the historical lineage of the medicinal utilization of food. It then proceeds to explore the complex interplay between nutrition, bioactive compounds, and their combined influence on human health. The unfolding

narrative highlights the significant impact of dietary patterns on the prevention and management of chronic ailments, offering valuable insights into their therapeutic potential. In this narrative review, the discipline of culinary medicine is emerging as a valuable connection between the field of nutritional science and the practical realm of dietary applications. The investigation of challenges associated with integrating food-based therapeutic modalities is thoroughly analyzed, leading to a comprehensive discussion on potential avenues for future research. Based on a rigorous methodology, this narrative review makes a valuable contribution to the growing body of knowledge on the medicinal properties of food. It provides a comprehensive and insightful perspective on this emerging field, which has the potential to impact current paradigms significantly.

Correspondence: Prof. Giustino Varrassi, Paolo Procacci Foundation, Via Tacito 7, 00193 Rome, Italy.
E-mail: g.varrassi@fondazioneprocacci.org

Key words: nutrition; food as drug; macronutrients; micronutrients; microbiome; elderly people; chronic diseases.

Contributions: all authors made a substantive intellectual contribution, read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Conflict of interest: the authors declare that no competing interests, and all authors confirm accuracy.

Ethics approval: the study did not need any ethics approval because is based on previously published and approved material.

Acknowledgments: this review article is based on the work made by an Advisory Board that has received a non-conditioning grant from Healthy Aging Research Group (HARG). It is respectful of any single component opinions. The authors have equally contributed to the discussion and the preparation of the manuscript. The publication has been possible thanks to the support of the Paolo Procacci Foundation. To them the authors are grateful.

Received: 22 March 2024.

Accepted: 30 April 2024.

Publisher's note: all claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article or claim that may be made by its manufacturer is not guaranteed or endorsed by the publisher.

©Copyright: the Author(s), 2024

Licensee PAGEPress, Italy

Advancements in Health Research 2024; 1:6

doi: 10.4081/ahr.2024.6

This article is distributed under the terms of the Creative Commons Attribution-NonCommercial International License (CC BY-NC 4.0) which permits any noncommercial use, distribution, and reproduction in any medium, provided the original author(s) and source are credited.

Introduction

The integration of food as a therapeutic tool, to some known as "food as medicine," is a longstanding concept in healthcare that continues to evolve. Throughout human history, several civilizations have acknowledged the therapeutic attributes of foods and dietary practices, demonstrating a deep comprehension of the intricate connection between nutrition and well-being.¹ In the present-day environment, there is a growing trend of reassessing and confirming the longstanding wisdom through modern scientific research.² This has resulted in a revived fascination with utilizing food to prevent and control chronic illnesses, support general wellness, and improve overall health results.³

The significance and pertinence of investigating the utilization of food as a form of medicine in contemporary times cannot be overemphasized. Considering the current global healthcare environment, characterized by significant difficulties such as the growing incidence of non-communicable illnesses, escalating healthcare expenditures, and the need to improve preventative strategies, there is a crucial need to explore the therapeutic capabilities of food.⁴

The primary objective of this narrative review is to provide a comprehensive analysis of the various aspects of food as therapy. This includes an exploration of its historical origins, an examination of its nutritional constituents, an investigation of different di-



etary patterns, and an examination of its clinical uses.⁵ By synthesizing the extant corpus of knowledge, this endeavor aims to offer a complete and empirically supported viewpoint on the significance of food within contemporary healthcare. It will explore the nutritional foundations, analyzing the effects of dietary patterns, investigating its role in preventing and managing diseases, elucidating its anti-inflammatory properties, introducing the emerging field of culinary medicine, addressing the challenges of implementation and ethical considerations, and outlining potential future research and policy directions.

Through an extensive narrative revision of the existing scientific literature, our objective is to provide healthcare professionals, policymakers, researchers, and individuals with an enhanced comprehension of the profound capacity of food to facilitate health promotion and illness prevention. By exploring the diverse functions of food in the context of healing, we aim to contribute to the continuing academic discussion regarding the integration of nutrition within modern healthcare practices. By doing so, we want to inspire constructive transformations in the quest for comprehensive wellness.

Methodology

This study employs a comprehensive descriptive framework analysis to clarify the role of food in health promotion and sickness prevention. The investigation stresses adherence to the SANRA standard,⁶ a critical feature of the approach. The study seeks to fully understand food's therapeutic capacity as a medical intervention for people suffering from chronic health concerns.

Eligibility criteria

The qualifying criteria for papers to be included in this study were painstakingly determined. Accepted papers had to be peer-reviewed empirical or perspective publications, which could also consist of editorials or commentaries. Furthermore, the inclusion criteria emphasized the importance of relevance to the study's fundamental issue, focusing on *Food and its Role as Medicine for Chronic Patients*. Journals chosen for inclusion were in any field of medicine, and preference was given to those that provided full-text access. Reviews, case reports, case series, original papers, and letters to the editor were all acceptable study types. Studies were eliminated if they did not match the relevance criteria for the selected topic and did not give appropriate reporting of aims and conclusions. These criteria were rigorously applied to ensure that papers closely related to the study's aims and focus were chosen.

Information sources and search

A systematic strategy for information retrieval was used to achieve a thorough literature analysis. The search technique entailed a detailed analysis of multiple databases, with the research spanning the years 2010 to 2023, including the most current revisions. This search relied heavily on key databases like PubMed. The technique included Medical Subject Headings (MeSH) terminology, with a particular emphasis on capturing the substance of the study's theme, which revolved around "Food, Nutrition, Medicine, Illnesses, Health prevention" and its role in chronic patient care. The Boolean operators "AND" and "OR" were used to refine and improve search specificity. The primary search term was "The Drug Called Food AND Chronic Patients."

The core search phrase was broadened to include synonymous words, variations, and alternative expressions to ensure inclusivity. Additional terms such as "medicine for chronic conditions," "dietary interventions for chronic patients," and others were incorporated. The search was broadened to include databases such as Scopus, Embase, PsycINFO, and Web of Science, each adapted to specific characteristics and indexing terms while remaining consistent with the study's overall goal. To supplement the search coverage, a thorough assessment of references from identified publications and reviews was performed to find suitable supplemental sources. This comprehensive strategy was used to ensure that the selected publications closely aligned with the study's aims and emphasis on the role of food as medication for chronic patients.

Selection process

Two independent reviewers (EC and MM) conducted the abstract and title screenings and the full-text assessments per the qualifying criteria. This was done after the primary review author (GV) focused on pilot screenings with more than 90% agreement. Any differences of opinion were resolved by consensus or with the primary author's help.

Data charting and items

The study group devised a coding system to aid in methodically extracting formal data items specially designed for "Food as Medicine for Chronic Patients." The objectives, key conclusions of the chosen literature, and the publication type, sources, and regions covered were all retrieved using the primary data extractor (EC). An additional author (GAR) independently examined 5% of the extracted data to guarantee accuracy and dependability. From extraction until synthesis, every step of the procedure followed the guidelines and predetermined coding scheme provided by the study team. To give readers a clear picture of the methodical approach to article inclusion, a flowchart was included to depict the article selection process inside the paper visually (Figure 1). The separate extractions, which included content quotations and formal data items, were compared methodically.

Quality assessment following SANRA assessment

The outcomes of the SANRA were reported in Table 1. All 105 assessments, comprising evaluations from three raters across 35 manuscripts, were included in the subsequent statistical analysis. The mean cumulative score for all 35 manuscripts amounted to 6.28 points. Notably, the most elevated scores were assigned to item 6 (appropriate presentation of data) with a mean of 1.14, item 2 (Statement of concrete aims or formulation of questions) with a mean of 1.11. Conversely, items 1, 3, 4 and 5 garnered the lowest scores, exhibiting means of 1.00, 1.02, 0.97 and 0.88, respectively.

Historical perspective

Food utilization as a form of therapy has a long-standing historical foundation, surpassing cultural barriers and undergoing gradual transformations throughout several generations.⁴ Throughout various civilizations, food utilization for its medicinal characteristics has served as evidence of humanity's deep comprehension of the intricate connection between nutrition and health.⁵

The following part examines the extensive historical utilization of food as a form of medicine, investigating its various expressions across diverse cultures and emphasizing significant milestones that illustrate the continuing acknowledgment of food's therapeutic attributes.

Ancient civilizations

Food utilization for therapeutic intentions can be traced back to the earliest documented civilizations. The notion of food as medicine held significant prominence in traditional Chinese medicine (TCM) during ancient times in China.⁷ The Huangdi Neijing, also known as the Yellow Emperor's Inner Canon, is a seminal treatise in TCM that originated in the 2nd century BCE. This influential book places significant emphasis on the significance of maintaining health and treating illnesses through the practice of balanced nutrition and food therapy.⁸ Certain foods were recommended to achieve a state of equilibrium in the body's vital energies (qi) and to restore a balance between the contrasting forces of yin and yang.

In a similar way, it is noteworthy that ancient India's Ayurvedic tradition displayed an awareness of the medicinal properties inherent in many types of food. Ancient Ayurvedic manuscripts, which have existed for more than two millennia, include comprehensive dietary recommendations specifically designed to cater to an individual's inherent constitution (prakriti) and existing

imbalances (vikriti).⁹ The use of herbs and spices in culinary preparations was frequently done to augment their therapeutic attributes, laying the foundation for the contemporary notion of functional foods.^{8,9}

Greco-Roman influence

Within the classical Greco-Roman milieu, notable individuals such as Hippocrates and Galen produced substantial contributions to the comprehension of the intricate relationship between sustenance and well-being.¹⁰ Hippocrates, widely recognized as the progenitor of contemporary medical practices, advocated that "food should serve as one's medicine and medicine should serve as one's food." The focus of the author on dietary selections as a strategy for averting and managing illness established the groundwork for subsequent medical discourse.¹¹ Galen, a renowned physician during the ancient Roman era, made significant advancements in dietetics by formulating distinct dietary plans tailored to address specific medical ailments.¹⁰

Medieval Europe and the Islamic Golden Age

In the medieval period, Europe had a notable phenomenon characterized by safeguarding and interpreting ancient medical manuscripts, encompassing works on dietary practices and nutritional knowledge.¹² During the medieval period, Islamic scholars

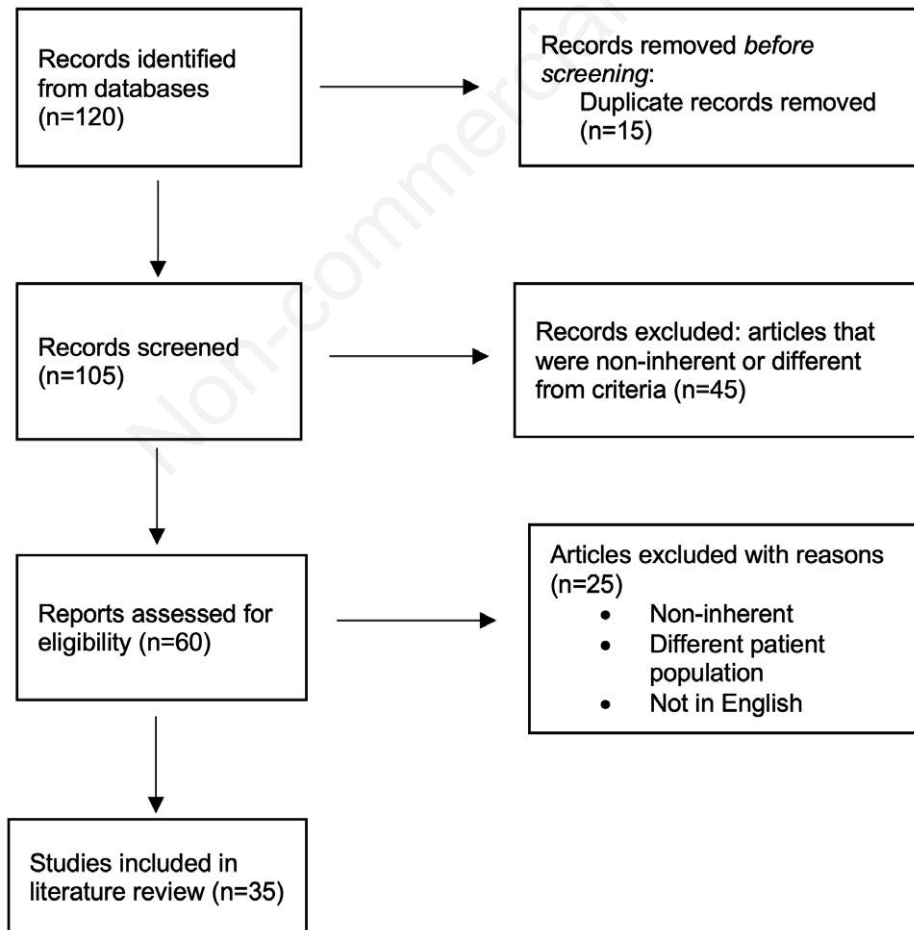


Figure 1. Flowchart of selected manuscripts.



made notable contributions to pharmacology and food therapy. Ibn Sina, more often known as Avicenna, was a prominent Persian polymath who created the Canon of Medicine.¹² This seminal work provided a detailed exploration of the relationship between food and its impact on health and sickness. The dissemination of this knowledge to Europe through translation played a significant role in developing dietetics as a medical field. Traditional Indigenous practices refer to the cultural customs and rituals passed down through generations within indigenous communities. These practices encompass a wide range of activities, including but not limited to nutrition.¹³

Indigenous communities across the globe have diligently preserved their distinct customs about food utilization for medicinal purposes. Indigenous American groups, such as Native American

communities, depended on regionally accessible flora and nourishment sources for nutrition and medicinal purposes.¹⁴ The intergenerational transmission of information about medicinal plants' utilization in culinary practices reflects a deep-rooted affinity with the natural environment and its available resources. Throughout history, numerous significant milestones have played a pivotal role in shaping the acknowledgment and understanding of the therapeutic characteristics inherent in food.¹⁴

During the Renaissance period, there was a notable revival of interest in classics, which encompassed various subjects, including dietetics. During the 18th century, Enlightenment intellectuals, including Jean Anthelme Brillat-Savarin, delved deeper into the intricate connection between food, health, and pleasure.¹⁵ This exploration is exemplified in Brillat-Savarin's notable work "Physiology of Taste".¹⁵

Table 1. SANRA score for quality assessment.

No.	Title	Justification of the article's importance for the readership	Statement of concrete aims or formulation of questions	Description of the literature search	Referencing	Scientific reasoning	Appropriate presentation of data	Total Score
1	Diet and food and nutrition insecurity and cardiometabolic disease	1	2	2	1	0	1	7
2	Dietary factors and risks of cardiovascular diseases: an umbrella review	2	2	1	1	1	0	7
3	Contribution of macronutrients to obesity: implications for precision nutrition	0	1	2	1	2	1	7
4	Food, medicine, and function: food is medicine. Part 1	0	2	1	1	2	2	8
5	Biological role of nutrients, food and dietary patterns in the prevention and clinical management of major depressive disorder	2	0	2	2	1	1	8
6	Dietary fruits and vegetables and cardiovascular diseases risk	1	1	0	2	2	0	6
7	Can we say what diet is best for health?	2	1	2	1	1	1	8
8	Healthy aging diets other than the Mediterranean: a focus on the Okinawan diet	1	0	1	1	2	1	6
9	The facts about food after cancer diagnosis: a systematic review of prospective cohort studies	0	1	1	2	0	2	6
10	Health and nutritional aspects of sustainable diet strategies and their association with environmental impacts: a global modelling analysis with country-level detail	2	1	1	1	0	2	7
11	Dietary recommendations of the French Society for Rheumatology for patients with chronic inflammatory rheumatic diseases	2	2	1	0	1	1	7
12	Diet and the role of food in common gastrointestinal diseases	1	2	2	1	2	1	9
13	Plant-based diets for cardiovascular disease prevention	2	2	2	1	0	0	7
14	Dietary patterns and cardiovascular disease: insights and challenges for considering food groups and nutrient sources	1	2	0	2	0	1	6
15	Could food act as personalized medicine for chronic disease?	0	2	1	2	2	1	8
16	Diet and cancer prevention: evidence-based medicine to genomic medicine	2	1	2	2	2	2	11

To be continued on next page

Table 1. Continued from previous page.

No.	Title	Justification of the article's importance for the readership	Statement of concrete aims or formulation of questions	Description of the literature search	Referencing	Scientific reasoning	Appropriate presentation of data	Total Score
17	Bacillus coagulans and its spore as potential probiotics in the production of novel shelf-stable foods	2	0	2	2	2	1	9
18	Food and diet in health and longevity: we eat what we are	2	2	2	1	1	1	9
19	Between food and medicine: artificial digestion, sickness, and the case of Bengel's food	0	2	1	1	1	2	7
20	Dietary approaches to stop hypertension via indo-mediterranean foods, may be superior to DASH diet intervention	2	2	1	1	2	1	9
21	Uptake of gluten-free food guide recommendations in celiac disease	2	1	2	1	1	2	9
22	Association of ultra-processed food intake with cardiovascular and respiratory disease multimorbidity: a prospective cohort study	1	1	2	2	1	2	9
23	A review study of a green diet and healthy ageing	2	2	1	2	2	1	10
24	Food and food products on the Italian market for ketogenic dietary treatment of neurological diseases	2	1	1	2	1	2	9
25	Mediterranean diet and life expectancy; beyond olive oil, fruits, and vegetables	2	1	1	2	2	1	9
26	A heart-healthy diet for cardiovascular disease prevention: where are we now?	1	2	2	1	0	2	8
27	A vegan diet is associated with a significant reduction in dietary acid load: post hoc analysis of a randomized controlled trial in healthy individuals	1	2	2	2	1	2	10
28	Dietary components and risk of cardiovascular disease and all-cause mortality: a review of evidence from meta-analyses	2	2	2	2	2	2	12
29	Food polyamine and cardiovascular disease—an epidemiological study	0	2	1	2	2	1	8
30	Anti-inflammatory activity of extra virgin olive oil polyphenols: which role in the prevention and treatment of immune-mediated inflammatory diseases?	2	1	1	1	2	1	8
31	Paradigm shift: the end of "normal science" in medicine understanding function in nutrition, health, and disease	2	1	0	2	2	1	7
32	A systematic review of the effect of retail food environment interventions on diet and health with a focus on the enabling role of public policies	2	1	1	1	2	2	9
33	Diet during pregnancy: Women's knowledge of and adherence to food safety guidelines	2	2	2	1	2	1	10
34	The immune-supportive diet in allergy management: A narrative review and proposal	1	1	1	1	2	2	8
35	Mechanisms of food-induced symptom induction and dietary management in functional dyspepsia	2	1	2	2	2	1	10

Identifying vital nutrients, including vitamins and minerals, and elucidating their functions in preventing deficiency disorders were significant scientific advancements during the 19th and early

20th centuries. This event represented a significant turning point in comprehending the fundamental relationship between nutrition and overall well-being.¹⁶ The notion of functional foods gained



prominence in the latter part of the 20th century, also because of the most recent biochemical discoveries, highlighting the possible health advantages associated with specific constituents of food that extend beyond its fundamental nutritional value. This approach has sparked a new scholarly investigation into the therapeutic attributes of many food substances, such as probiotics, antioxidants, and omega-3 fatty acids.¹⁶

The resurgence of culinary medicine has become increasingly prominent in recent decades, serving as a valuable connection between nutrition science and culinary arts.¹⁶ There has been a growing trend among medical schools and healthcare organizations in recent years to incorporate culinary education into their curricula.¹⁷ This integration aims to provide healthcare professionals and patients with valuable practical knowledge and skills that can be utilized to enhance health outcomes by making informed food choices. The lasting significance and profound impact of employing food as medicine in contemporary healthcare is underscored by its historical trajectory.¹⁸ This statement offers evidence of the enduring knowledge that has directed humanity to utilize the healing properties of the foods we ingest. In this narrative review, we are further investigating the intersection between ancient wisdom and contemporary scientific knowledge, thereby facilitating the emergence of novel methodologies in the realm of health and wellness.

Physiology of nutrition: unraveling the essential elements, emphasizing micronutrients

The field of nutrition serves as the fundamental basis for the numerous physiological mechanisms that govern our bodily functions, and it assumes a crucial role in influencing our overall health and state of well-being.¹⁹ The concept comprises a wide range of components, including macronutrients (such as carbohydrates, proteins, and fats) and micronutrients (such as vitamins and minerals), which serve as the foundational factors for promoting well-being. Comprehending the physiological aspects of nutrition offers valuable insights into the intricate dynamics and impacts of these constituents on our physiological systems at multiple levels.²⁰

The role of macronutrients in human nutrition

Carbohydrates serve as the principal energy source for the human body. Upon ingestion, carbohydrates undergo a process of enzymatic breakdown, resulting in the production of glucose, a readily available source of energy for cellular metabolism.²¹ Essential for proper brain function, muscle activity, and general energy balance, these factors play an important role.

Proteins are crucial in various biological processes and essential for tissue structure, enzymatic activity, and immune system functionality.²² Amino acids, which serve as the fundamental constituents of proteins, influence several metabolic pathways, impacting processes including growth, repair, and immunological function.

Fats, despite their historically stigmatized perception, are essential for maintaining optimal health. Adipose tissues fulfill various physiological functions inside the human body, including acting as a reservoir for energy, safeguarding vital organs, preserving the integrity of cell membranes, and aiding in the assimilation of fat-soluble vitamins.²³ The comprehension of the macronutrient composition in an individual's diet is crucial for the preservation of metabolic homeostasis. In fact, some of them – such as polyunsaturated fatty acids belonging to the n-3 (or ω3) and n-6 (or ω6) series - not only have relevant structural functions

but have important immunomodulatory properties.²⁴ The diverse life phases and differing physical activities necessitate distinct macronutrients to ensure optimal bodily functioning.²⁵

Micronutrients: the imperceptible yet essential factors

Micronutrients, as their nomenclature suggests, are essential in small amounts, although their role in preserving health is of utmost importance.²⁶ The items above encompass vitamins and minerals.

Vitamins are a class of chemical molecules that fulfill diverse functions within different metabolic pathways. For example, vitamin C, a known antioxidant, protects our cells from the harmful effects of oxidative stress.²⁷ Vitamin D plays a crucial role in the absorption of calcium and the maintenance of bone health.²⁷ In contrast, the B vitamins are needed for energy metabolism, DNA synthesis, and the proper functioning of the neurological system.²⁸ Vitamin A plays a crucial role in bolstering the immune system, while vitamin K is of paramount importance in facilitating the process of blood coagulation. Every single vitamin possesses a distinct physiological role that contributes to the overall state of well-being, and an insufficiency in any one vitamin can result in a variety of health complications.²⁹

Minerals are inorganic elements that play a pivotal role in several physiological functions. In addition to its role in promoting skeletal and dental health, calcium plays a vital role in facilitating muscular contraction, transmitting nerve impulses, and facilitating the coagulation of blood.³⁰ Iron has a crucial role as a fundamental constituent of hemoglobin, a vital protein responsible for transporting oxygen within the bloodstream. Magnesium is essential in facilitating muscle and neuron function, regulating blood glucose levels, and promoting optimal bone health. Potassium has a crucial role in the regulation of blood pressure and cardiac rhythm.³¹ In contrast, zinc is essential for wound healing, immunological function, and DNA synthesis. The presence of these minerals is crucial for the optimal functioning of the human body, and their deficiency can give rise to various health issues.³² Figure 2 highlights important pyramidal aspect of food as medicine.

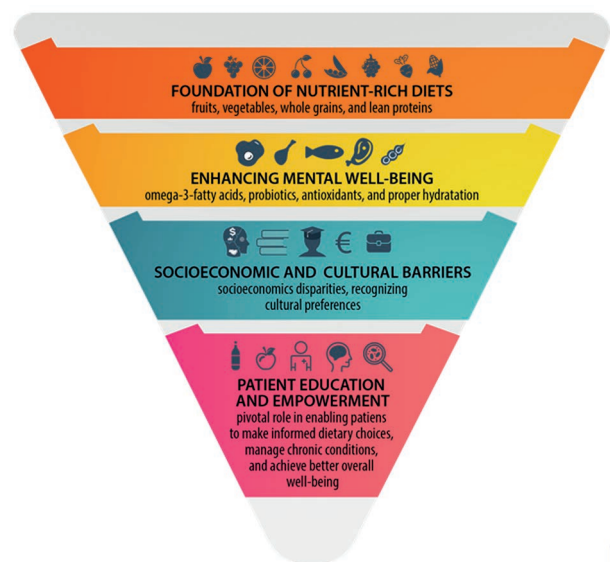


Figure 2. Pyramid of food as medicine for chronic diseases.

The physiological dimensions of nutrition encompass more than the fundamental roles of macronutrients and micronutrients. The researchers explore the complex interplay among these components and their influence on metabolic pathways, immunological reactions, developmental processes, and overall well-being.³³ Individual variances, dietary preferences, and environmental impacts further complicate the intricate field of nutritional science. Understanding the physiological aspects of nutrition, particularly the equilibrium of macronutrients and the importance of micronutrients, is essential not only for preventing deficiencies but also for enhancing overall well-being and chronic ailments.³⁴

Acknowledging the significance of nutrition in the physiological regulation of our bodies enables individuals to make well-informed dietary decisions that promote general well-being and extended lifespan. This statement emphasizes that nutrition is not solely a question of ingesting food but rather a scientific discipline that significantly impacts our physiological development throughout our lifespan.³⁵

Significance of the microbiome: the impact of nutrition on the composition of our internal ecosystem and its effects on health

The human body can be characterized as a highly complex ecosystem, with the microbiome as a central component. The microbiome consists of an extensive population of microorganisms, numbering in the billions that reside within various body regions, such as the gastrointestinal tract, skin, oral cavity, and other mucosal surfaces.³⁶ The diverse assemblage of bacteria, viruses, fungi, and other microbes exerts a significant influence on our overall health and state of well-being. Equally intriguing is the profound correlation between the dietary intake we consume and the overall well-being of our microbiome.³⁷

Comprehending the microbiome: an ecologically varied system

The human microbiome is a complex and varied ecological system that exhibits individuality in its composition. It impacts diverse physiological processes, encompassing digestion, nutrient assimilation, immunological response, and psychological well-being.³⁶ The gut microbiota, predominantly within the gastrointestinal system, is vital in preserving general well-being.

Interplay between nutrition and microbiome: a mutually beneficial association

The relationship between nutrition and the microbiome is bidirectional. The dietary choices we make exert a substantial influence on the composition and functionality of our gastrointestinal microbiota.³⁸ Consequently, the microbiome plays a pivotal role in modulating the metabolic processes involved in the digestion and absorption of nutrients from the ingested food. This complex interaction unfolds in different manners. Including dietary fiber from sources such as fruits, vegetables, and whole grains in individual's diet contributes to the provision of sustenance for advantageous gut microbiota, also preventing neurodegeneration and neurodamages.³⁹ The bacteria engage in the process of fermentation of fiber, resulting in the production of short-chain fatty acids (SCFAs) that possess anti-inflammatory characteristics and contribute to the regulation of metabolism.^{24,38}

Probiotics and fermented foods

Certain food items such as yogurt, kefir, and sauerkraut are known to contain probiotics, which are living microorganisms capable of providing advantageous effects on human health upon consumption. Probiotics can enhance the diversity and maintenance of a well-functioning gut microbiome.³⁷

Polyphenols

Polyphenols, present in various dietary sources such as green tea, red wine, and dark chocolate, are plant-derived substances that function as prebiotics, nourishing advantageous microorganisms residing in the gastrointestinal tract.⁴⁰ They have the potential to enhance microbial diversity throughout the microbiome.

The composition of macronutrients in one's dietary intake, encompassing carbohydrates, proteins, and fats, can potentially impact the proliferation of specific bacterial species within the gastrointestinal tract.³⁷ Diets that are heavy in sugar and fat have the potential to facilitate the expansion of less desirable bacterial species.

The process of nutrient absorption is influenced by the gut flora, which contributes to the breakdown of complex carbohydrates, the synthesis of specific vitamins (such as B vitamins and vitamin K), and the facilitation of critical mineral absorption, including calcium and magnesium.³⁷

Influence of the microbiome on human health

The gut microbiome not only performs the function of food digestion but also engages in active communication with our immune system and impacts our overall well-being. A well-balanced and heterogeneous microbiome is linked with a range of health advantages. The maintenance of digestive health is closely associated with the establishment and maintenance of a well-functioning gut microbiome.³⁷ This symbiotic relationship between the host and the microbial community residing in the gastrointestinal tract is crucial in preventing many gastrointestinal disorders, such as irritable bowel syndrome (IBS) and inflammatory bowel disease (IBD), by fostering a harmonious and stable gut environment.¹⁹ The modulation of the immune system can be facilitated by a microbiome in a state of equilibrium, hence decreasing the likelihood of allergies and autoimmune disorders.

Metabolism

The microbiome has the potential to influence metabolic health, hence modulating energy storage and utilization inside the body. Obesity and metabolic problems are linked to an imbalance in the gut microbiota.¹⁹ The relationship between mental health and the gut-brain link is an expanding field of study, with increasing evidence indicating that the microbiome has the potential to impact mood, stress reactivity, and other mental health disorders such as depression and anxiety.³⁸ An unbalanced microbiome has been identified as a potential factor in the development of chronic inflammation. This condition has been associated with several health complications, including cardiovascular diseases and malignancies.⁴¹

Nutrient utilization

The microbiome plays a crucial function in facilitating nutrient absorption, hence guaranteeing optimal utilization of the nutrients present in our diet. The nutritional nexus of health is a



critical aspect that warrants careful consideration and examination.²¹ The study of the relationship between nutrition and the microbiome, as well as the subsequent effects of the microbiome on health, is an intriguing and continuously developing area of research. This statement highlights the significant importance of maintaining a well-balanced diet to foster a healthy microbiome, which subsequently contributes to the overall maintenance of good health.³⁷ As the field of research progresses, our understanding of the interconnectedness between our dietary choices and our internal environment becomes more profound, illuminating novel approaches to enhance well-being and mitigate the risk of illness. The comprehension of the complex interplay between nutrition and the microbiome highlights the important significance of the dietary choices we make to sustain our bodies, as well as the extensive consequences of these choices on our overall health.⁴²

Impact of age-related physiological changes on nutrition and health

The process of aging is accompanied by a wide range of physiological changes that have significant implications for both nutrition and general health. As individuals age, physiological changes influence their nutritional requirements, metabolic processes, and susceptibility to chronic ailments.⁴² Comprehending these age-related modifications is imperative for formulating approaches to uphold well-being and avert persistent illnesses via prudent dietary selections.

Physiological alterations in the geriatric population

Metabolism

The metabolic rate tends to decline as individuals age, resulting in a decrease in the quantity of calories needed. This shift is attributed to the reduction in muscle mass and the decrease in physical activity.⁴³ Furthermore, the aged population should prioritize making well-informed food choices due to the potential impact of metabolic inefficiencies on nutrient absorption. The aging process can result in a decline in the secretion of gastric acid and the activity of digestive enzymes, impacting the operation of nutrient breakdown and absorption within the digestive system.¹¹ This phenomenon may lead to an increased susceptibility to dietary deficits.

Alterations in appetite and taste perception frequently occur among the aged population. A decline in taste perception might result in a diminished level of pleasure derived from food consumption, thereby impacting the individual's inclination to consume a diverse and nutritionally balanced diet.¹³ The aging process is accompanied by a gradual reduction in muscle mass and bone density, resulting in frailty and elevated susceptibility to falls and fractures. Ensuring sufficient consumption of protein, calcium, and vitamin D is crucial in addressing these issues.

Consequences for nutrition and health

Gaining a comprehensive understanding of the physiological alterations that occur in conjunction with the aging process is necessary to effectively address the nutritional requirements and health-related obstacles faced by the elderly people.⁴⁴ These modifications have multiple implications.

Nutritional needs

The elderly population have a decreased caloric requirement yet an augmented demand for specific nutrients, like calcium, vitamin D, and vitamin B12. Ensuring sufficient protein consumption is crucial to mitigate muscle atrophy and sustain optimal physical performance.⁴³ Promoting dietary diversity is crucial to addressing the distinctive nutritional requirements of the geriatric population adequately. This encompasses consuming a diverse array of fruits, vegetables, whole grains, lean sources of protein, and nutritious fats. The aged population often experiences alterations in thirst perception, leading to a prevalent issue of dehydration.⁴⁵ Maintaining proper hydration is of utmost importance for overall well-being since it has the potential to influence cognitive performance and physical health.

Chronic pathologies

Older individuals face an increased susceptibility to the onset of chronic ailments, including cardiovascular disease, diabetes, and osteoporosis. Several of them may also experience a significant dysphagia, which can severely affect the nutritional condition.⁴⁶ Adequate diet can have a substantial impact on the prevention and management of certain health conditions.⁴⁷

Role of nutrition in the prevention and treatment of chronic pathologies

The process of aging is frequently correlated with a heightened susceptibility to chronic illnesses; however, it is essential to note that this outcome is not an unavoidable fate. The utilization of nutrition plays a significant role in both the prevention and management of the illnesses mentioned above. The following procedure outlines the steps necessary to accomplish the task at hand.⁴⁷ The maintenance of cardiovascular health can be facilitated through the consumption of a diet that is abundant in fruits, vegetables, whole grains, lean meats, and healthy fats. This dietary approach has been shown to effectively regulate blood pressure and cholesterol levels, hence mitigating the likelihood of developing heart disease.⁴⁸

The management of diabetes involves the implementation of strategies such as regulating carbohydrate consumption and selecting meals with a low glycemic index, which can effectively aid in the maintenance of optimal blood glucose levels.⁴⁹ This is especially important for its connections with the cardiovascular complications of diabetes.⁵⁰ Furthermore, the maintenance of an optimal body weight plays a pivotal role in the prevention and management of diabetes.

The prevention of osteoporosis involves ensuring sufficient consumption of calcium and vitamin D, in addition to engaging in weight-bearing workouts. These measures contribute to the preservation of bone density and the mitigation of osteoporosis and fracture risks.⁵¹

The maintenance of cognitive health can be facilitated by consuming nutrient-dense foods, which are characterized by their high content of antioxidants and omega-3 fatty acids.⁵² These dietary components have been shown to promote brain function and mitigate the likelihood of cognitive decline.

The promotion of gastrointestinal health can be facilitated through the consumption of a diet that is rich in fiber, fluids, and probiotics, hence mitigating the likelihood of encountering gastrointestinal complications.⁵³

The maintenance of a robust immune system is facilitated by an adequate diet, which serves to mitigate the susceptibility to infections and diseases.⁵⁴ Finally, a moderate consumption of red

wine might support all these functions, with the benefits of the polyphenols inhibiting aromatase.⁵⁵

Conclusions

Nutrition represents the basis for the survival of every living being. The significance of nutrition is of utmost importance in the prevention of chronic diseases and the promotion of overall well-being, especially among older adults. The process of aging is accompanied by a multitude of physiological modifications that have the potential to influence both nutrition and overall health. Nevertheless, acquiring knowledge about these new conditions and engaging in well-informed decision-making regarding food can help alleviate numerous difficulties linked to aging. By acknowledging the need to make prudent dietary selections and customizing nutritional plans to cater to the distinct requirements of the elderly, we can contribute to their ability to age with vigor and elegance while simultaneously alleviating the incidence and the prevalence of chronic illnesses.

References

- Brandt EJ, Mozaffarian D, Leung CW, et al. Diet and food and nutrition insecurity and cardiometabolic disease. *Circ Res* 2023;132:1692-706.
- Chareonrungrueangchai K, Wongkawinwoot K, Anothaisintawee T, Reutrakul S. Dietary Factors and risks of cardiovascular diseases: an umbrella review. *Nutrients* 2020; 12:1088.
- San-Cristobal R, Navas-Carretero S, Martínez-González MÁ, et al. Contribution of macronutrients to obesity: implications for precision nutrition. *Nat Rev Endocrinol* 2020;16: 305-20.
- Hyman M, Bradley E. Food, medicine, and function: food is medicine. Part 1. *Phys Med Rehabil Clin N Am* 2022; 33:553-70.
- Ortega MA, Fraile-Martínez Ó, García-Montero C, et al. Biological role of nutrients, food and dietary patterns in the prevention and clinical management of major depressive disorder. *Nutrients* 2022;14:3099.
- Baethge C, Goldbeck-Wood S, Mertens S. SANRA-a scale for the quality assessment of narrative review articles. *Res Integr Peer Rev* 2019;4:5.
- Zhao X, Tan X, Shi H, Xia D. Nutrition and traditional Chinese medicine (TCM): a system's theoretical perspective. *Eur J Clin Nutr* 2021;75:267-73.
- Tian Y, Shi Y, Zhu Y, et al. The modern scientific mystery of traditional Chinese medicine processing--take some common traditional Chinese medicine as examples. *Heliyon* 2024; 10:e25091.
- Jeitler M, Wottke T, Schumann D, et al. Ayurvedic vs. conventional nutritional therapy including low-FODMAP diet for patients with irritable bowel syndrome - A randomized controlled trial. *Front Med (Lausanne)* 2021;8:622029.
- Salas-Salvadó J, Huetos-Solano MD, Garcia-Lorda P, Bulló M. Diet and dietetics in al-Andalus. *Br J Nutr* 2006;96: S100-4.
- Springmann M, Wiebe K, Mason-D'Croz D, et al. Health and nutritional aspects of sustainable diet strategies and their association with environmental impacts: a global modelling analysis with country-level detail. *Lancet Planet Health* 2018;2:e451-61.
- Daien C, Czernichow S, Letarouilly JG, et al. Dietary recommendations of the French Society for Rheumatology for patients with chronic inflammatory rheumatic diseases. *Joint Bone Spine* 2022;89:105319.
- Pearlman M, Akpotaire O. Diet and the role of food in common gastrointestinal diseases. *Med Clin North Am* 2019; 103:101-10.
- Hemler EC, Hu FB. Plant-based diets for cardiovascular disease prevention: all plant foods are not created equal. *Curr Atheroscler Rep* 2019;21:18.
- Chong GT. Jean-Anthelme Brillat-Savarin's 1825 treatise on the mouth and ingestion. *Singapore Dent J* 2012;33:31-6.
- Toribio-Mateas MA, Spector TD. Could food act as personalized medicine for chronic disease? *Per Med* 2017;14: 193-6.
- Mallya J, K T, Shettigar P. Uncovering culinary medicine research themes: Current status and future direction. *F1000 Res* 2023;12:173.
- Poshadri A, Deshpande HW, Khodke UM, Katke SD. *Bacillus coagulans* and its spore as potential probiotics in the production of novel shelf-stable foods. *Curr Res Nutr Food Sci J* 2022;10:858870.
- Rattan SIS, Kaur G. Nutrition, food and diet in health and longevity: we eat what we are. *Nutrients* 2022;14:5376.
- Savarino G, Corsello A, Corsello G. Macronutrient balance and micronutrient amounts through growth and development. *Ital J Pediatr* 2021;47:109.
- Singh RB, Nabavizadeh F, Fedacko J, et al. Dietary approaches to stop hypertension via Indo-Mediterranean foods may be superior to DASH diet intervention. *Nutrients* 2022; 15:46.
- Dong M, Li P, Luo J, et al. Oligopeptide/histidine transporter PHT1 and PHT2 - function, regulation, and pathophysiological implications specifically in immunoregulation. *Pharm Res* 2023;40:2585-96
- Li H, Li S, Yang H, et al. Association of ultra-processed food intake with cardiovascular and respiratory disease multimorbidity: A prospective cohort study. *Mol Nutr Food Res* 2023; 67:e2200628.
- Coniglio S, Shumskaya M, Vassiliou E. Unsaturated fatty acids and their immunomodulatory properties. *Biology (Basel)* 2023;12:279.
- Fong BYF, Chiu WK, Chan WFM, Lam TY. A review study of a green diet and healthy ageing. *Int J Environ Res Public Health* 2021;18:8024.
- Berger MM, Shenkin A, Schweinlin A, et al. ESPEN micronutrient guideline. *Clin Nutr* 2022;41:1357-424.
- Martinez-Gonzalez MA, Martin-Calvo N. Mediterranean diet and life expectancy; beyond olive oil, fruits, and vegetables. *Curr Opin Clin Nutr Metab Care* 2016;19:401-7.
- Selhub J, Troen A, Rosenberg IH. B vitamins and the aging brain. *Nutr Rev* 2010;68:S112-8.
- Kanasaki K, Kumagai A. The impact of micronutrient deficiency on pregnancy complications and development origin of health and disease. *J Obstet Gynaecol Res* 2021;47: 1965-72.
- Kwok CS, Gulati M, Michos ED, et al. Dietary components and risk of cardiovascular disease and all-cause mortality: a review of evidence from meta-analyses. *Eur J Prev Cardiol* 2019;26:1415-29.
- Castañeda-Bueno M, Ellison DH, Gamba G. Molecular

- mechanisms for the modulation of blood pressure and potassium homeostasis by the distal convoluted tubule. *EMBO Mol Med* 2022;14:e14273.
32. Fantacone ML, Lowry MB, Uesugi SL, et al. The effect of a multivitamin and mineral supplement on immune function in healthy older adults: A double-blind, randomized, controlled trial. *Nutrients* 2020;12:2447.
 33. Hyman M. Paradigm shift: the end of "normal science" in medicine understanding function in nutrition, health, and disease. *Altern Ther Health Med* 2004;10:10-5, 90-4.
 34. Mah CL, Luongo G, Hasdell R, et al. A systematic review of the effect of retail food environment interventions on diet and health with a focus on the enabling role of public policies. *Curr Nutr Rep* 2019;8:411-28.
 35. Klimova B, Novotny M, Valis M. The impact of nutrition and intestinal microbiome on elderly depression - A systematic review. *Nutrients* 2020;12:710.
 36. Kennedy MS, Chang EB. The microbiome: Composition and locations. *Prog Mol Biol Transl Sci* 2020;176:1-42.
 37. Burz SD, Causevic S, Dal Co A, et al. From microbiome composition to functional engineering, one step at a time. *Microbiol Mol Biol Rev* 2023;87:e0006323.
 38. Mueller UG, Linksvayer TA. Microbiome breeding: conceptual and practical issues. *Trends Microbiol* 2022;30:997-1011.
 39. Corriero A, Giglio M, Inchingolo F, et al. Gut microbiota modulation and its implications on neuropathic pain: A comprehensive literature review. *Pain Ther* 2024;13:33-51.
 40. Shah MA, Faheem HI, Hamid A, et al. The entrancing role of dietary polyphenols against the most frequent aging-associated diseases. *Med Res Rev* 2024;44:235-74.
 41. Coussens LM, Werb Z. Inflammation and cancer. *Nature* 2002;420:860-7.
 42. Tristan Asensi M, Pagliai G, Lotti S, et al. Adherence to the Mediterranean diet and ultra-processed foods consumption in a group of Italian patients with celiac disease. *Nutrients* 2023;15:938.
 43. Lee ZY, Loh CTI, Lew CCH, et al. Nutrition therapy in the older critically ill patients: A scoping review. *Ann Acad Med Singap* 2022;51:629-36.
 44. Leggio M, Colivicchi F. Healthy diet and cardiovascular prevention: time to go further with a precision medicine approach? *J Am Coll Cardiol* 2020;76:631-2.
 45. Kenney WL, Chiu P. Influence of age on thirst and fluid intake. *Med Sci Sports Exerc* 2001;33:1524-32.
 46. Wirth R, Dziewas R, Beck AM, et al. Oropharyngeal dysphagia in older persons – from pathophysiology to adequate intervention: A review and summary of an international expert meeting. *Clin Interv Aging* 2016;11:189-208.
 47. Di Giosia P, Stamerra CA, Giorgini P, et al. The role of nutrition in inflammaging. *Ageing Res Rev* 2022;77:101596.
 48. Bianchi VE. Impact of nutrition on cardiovascular function. *Curr Probl Cardiol* 2020;45:100391.
 49. Olanrewaju OA, Sheeba F, Kumar A, et al. Novel therapies in diabetes: a comprehensive narrative review of GLP-1 receptor agonists, SGLT2 inhibitors, and beyond. *Cureus* 2023;15:e51151.
 50. Iqbal F, Shuja MH, Azam L, et al. Effect of sodium-glucose cotransporter 2 inhibitors on 24-hour ambulatory blood pressure in patients with type-2 diabetes and hypertension: an updated meta-analysis. *Endocr Pract* 2024:S1530-891X (24)00079-X. Online Ahead of Print.
 51. Skalny AV, Aschner M, Tsatsakis A, et al. Role of vitamins beyond vitamin D3 in bone health and osteoporosis (Review). *Int J Mol Med* 2024;53:9.
 52. Brunner S, Mayer H, Qin H, et al. Interventions to optimise nutrition in older people in hospitals and long-term care: Umbrella review. *Scand J Caring Sci* 2022;36:579-98.
 53. Beam A, Clinger E, Hao L. Effect of diet and dietary components on the composition of the gut microbiota. *Nutrients* 2021;13:2795.
 54. Weyh C, Krüger K, Strasser B. Physical activity and diet shape the immune system during aging. *Nutrients* 2020;12:622.
 55. Pergolizzi J, LeQuang JAK, Wagner M, et al. Red wine as an aromatase inhibitor: A narrative review. *Cureus* 2024;16:e59587.