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What Can Nutritional Archaeology Tell Us About Contemporary Nutritional Problems and Chronic Diseases? /

Beslenme Arkeolojisi Günümüz Beslenme Sorunları ve Kronik Hastalıklar Hakkında Bize Ne Söyleyebilir?

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Abstract:
Human diets have transformed throughout history in response to environmental, biological, cultural, and technological changes. This review describes the principal archaeological and biomolecular methods used to reconstruct past diets, examines dietary transformations from hunter-gatherer societies to modern food systems, and discusses their implications for contemporary nutrition. Human skeletal and dental remains, stable isotopes, dental calculus, archaeobotanical and zooarchaeological remains, organic residues in pottery, and coprolites provide complementary evidence. These sources indicate that hunter-gatherer diets were heterogeneous, the health effects of the transition to agriculture varied across populations, and food processing has been practiced since ancient times. Modern nutritional evidence supports consuming diverse nutrient-dense foods and fiber-rich plant foods while reducing reliance on ultra-processed products. However, clinical evidence remains insufficient to conclude that a specific ancestral diet, seasonal eating pattern, or predefined threshold of plant diversity prevents chronic diseases. Nutritional archaeology therefore provides no direct clinical recommendations but offers a complementary perspective that places modern diets within their historical context.
Keywords: Nutritional archaeology; Paleodiet; Dietary patterns; Food processing; Chronic diseases

Özet:
İnsan beslenmesi çevresel, biyolojik, kültürel ve teknolojik değişimlerle tarih boyunca dönüşmüştür. Bu derleme, geçmiş beslenmenin belirlenmesinde kullanılan başlıca arkeolojik ve biyomoleküler yöntemleri açıklamayı, avcı-toplayıcılıktan modern gıda sistemlerine uzanan beslenme dönüşümünü incelemeyi ve tarihsel kanıtların günümüz beslenme sorunları açısından sağlayabileceği çıkarımları tartışmayı amaçlamaktadır. İnsan iskeletleri ve dişleri, stabil izotoplar, dental kalkülüs, arkeobotanik ve zooarkeolojik kalıntılar, seramiklerdeki organik kalıntılar ve koprolitler geçmiş beslenmenin farklı boyutlarına ilişkin tamamlayıcı bilgiler sunmaktadır. Bu kanıtlar, avcı-toplayıcı beslenmesinin heterojen olduğunu, tarıma geçişin sağlık üzerindeki etkilerinin toplumlara göre değiştiğini ve gıda işlemenin eski dönemlerden beri uygulandığını göstermektedir. Modern beslenme kanıtları; besin değeri yüksek çeşitli kaynakların ve liften zengin bitkisel besinlerin tüketilmesini, ultra-işlenmiş ürünlere bağımlılığın ise azaltılmasını desteklemektedir. Buna karşılık belirli bir atalara özgü diyetin, mevsimsel beslenmenin veya belirli bir bitkisel çeşitlilik eşiğinin kronik hastalıkları önlediğine ilişkin yeterli klinik kanıt bulunmamaktadır. Beslenme arkeolojisi, doğrudan klinik öneri üretmeyen ancak modern beslenmeyi tarihsel bağlama yerleştiren tamamlayıcı bir kanıt alanıdır.
Anahtar Kelimeler: Beslenme arkeolojisi; Paleodiyet; Beslenme örüntüleri; Gıda işleme; Kronik hastalıklar

1.Introduction

Nutrition is one of the fundamental determinants of human health and has continually evolved throughout human history in response to environmental, economic, technological, and social factors. Today, unhealthy dietary patterns are among the leading preventable risk factors for noncommunicable diseases worldwide. A comprehensive analysis of 195 countries conducted as part of the Global Burden of Disease Study demonstrated that dietary risks contribute substantially to morbidity and mortality, particularly from cancers, cardiovascular diseases, and type 2 diabetes (GBD 2017 Diet Collaborators, 2019). The widespread availability of energy-dense, refined, and highly processed products is a major component of this transformation in the contemporary food environment. Indeed, a comprehensive review of ultra-processed food consumption found that high consumption was associated with numerous adverse health outcomes, particularly cardiometabolic outcomes (Lane et al., 2024).

Nevertheless, contemporary dietary patterns represent only a relatively brief period in human history. Human societies have undergone profound transformations, progressing from subsistence strategies based on hunting and gathering to agriculture and sedentary living, followed by urbanization, industrialization, and globalization. This process has changed not only the foods consumed but also how foods are obtained, prepared, stored, and processed, as well as dietary diversity and the ways in which humans interact with food resources. The spread of agriculture and sedentary living during the Holocene, in particular, is regarded as a major turning point in the history of human nutrition. In some populations, increasing reliance on a more limited range of staple foods, together with changing living conditions, has been associated with changes in oral and dental health, growth, infectious disease burden, and other biological indicators of health (Larsen, 1995, 2006).

The transformation of human diets was not limited to the transition from hunting and gathering to agriculture. The development of agricultural production, expansion of trade networks, urbanization, the Industrial Revolution, and advances in food production technologies reshaped food systems during different historical periods (Muslu, 2019). Particularly in the modern era, refining, industrial production, and advanced food-processing technologies have led to relatively rapid changes in the physical structure, nutrient composition, energy density, and patterns of consumption of foods. These developments have given rise to the hypothesis that potential mismatches between the long-term evolution of human biology and the modern food environment may contribute to the development of chronic diseases (Cordain et al., 2005). However, it is neither scientifically nor socially appropriate to regard the diets of past populations as ideal models for contemporary societies. These populations differed substantially from one another and from modern populations in terms of geography, climate, food availability, infectious disease burden, physical activity, lifestyles, and life expectancy.

Examining the relationships between diet and health in the past offers nutrition science a distinct evidentiary perspective. Human skeletal and dental remains, dental calculus, plant and animal remains, and organic residues in pottery provide important information about the dietary patterns of past populations when examined using stable isotope analysis, paleopathological assessment, archaeobotanical and zooarchaeological methods, ancient DNA analysis, and other biomolecular techniques made possible by modern technology. This evidence enables researchers not only to identify foods that may have been consumed but also to examine major transformations in food systems alongside changes in human biology and health indicators. Such a historical perspective may help situate contemporary nutritional issues—including dietary diversity, the consumption of plant-based foods, seasonality, and the degree of food processing—within a broader temporal framework. Nevertheless, archaeological observations cannot be translated directly into clinical or public health recommendations. The dietary and health experiences of past populations can provide a complementary perspective on the potential health implications of long-term dietary transformations only when considered alongside contemporary epidemiological and clinical evidence.

This review aims to describe, from a health sciences perspective, the principal forms of evidence and methods used in nutritional archaeology and related disciplines to investigate the dietary patterns and health status of past populations. It also evaluates the transformation of human diets from hunter-gatherer lifeways through agricultural societies to modern food systems and discusses both the implications of historical evidence for contemporary diet-related chronic diseases and the limitations of such inferences. Rather than merely summarizing the methods used to reconstruct past diets, this review critically relates archaeological findings to contemporary epidemiological and clinical evidence on nutrition and chronic diseases while explicitly addressing the limits of translating historical observations into modern health recommendations.

The literature search was conducted through Google Scholar between July and August 2026. No predefined publication-year restriction was applied; however, recent studies published primarily between 2020 and 2026 were prioritized, while earlier seminal studies were included when necessary to provide historical and conceptual context. Searches used combinations of terms related to nutritional archaeology, paleodiet, bioarchaeology, archaeological dietary reconstruction, dietary transitions, food processing, and chronic diseases. Studies were selected according to their direct relevance to the objectives of the review, with priority given to primary archaeological and biomolecular research, systematic reviews, clinical studies, and authoritative dietary guidance.

2. Nutritional Archaeology and Methods Used in Research

2.1. Nutritional Archaeology: Definition and Scope

Archaeology is the scientific study of past human societies through material remains and the contexts in which they are found. Archaeological evidence contributes to our understanding of past societies' lifeways, production activities, relationships with their environments, social perceptions, and transformations over time (Pikirayi, 2025). Within this broader framework, nutritional archaeology is an interdisciplinary field that examines the food-related systems of past societies through archaeological and biological evidence.

Nutritional archaeology investigates not only which foods were consumed in the past but also the relationships between human health and lifeways and the production, procurement, preparation, storage, and consumption of these foods. The field integrates evidence and analytical approaches from archaeology, bioarchaeology, zooarchaeology, archaeobotany, paleopathology, biological anthropology, and biomolecular archaeology. The examination of archaeological materials, including human and animal remains, plant remains, cooking implements, dental calculus, and coprolites, using analytical and biomolecular methods contributes to the reconstruction of past dietary patterns (Ramadan et al., 2025).

Archaeological evidence of diet may be either direct or indirect. Seeds, grains, animal bones, and undigested food remains provide relatively direct evidence of the use of particular resources, whereas isotopic compositions and pathological changes in human remains serve as indirect indicators of longer-term dietary and health experiences. The application of genomic, proteomic, lipidomic, and metabolomic approaches to archaeological materials complements conventional morphological examinations with molecular-level information (Ramadan et al., 2025). However, because no single method can reveal every component of past diets, reliable interpretation requires the integration of multiple lines of evidence.

2.2. Dating Archaeological Evidence

To evaluate changes in past diets, archaeological evidence must be placed within a reliable chronological framework. Archaeological dating methods are generally classified as relative and numerical dating approaches. The appropriate method is selected according to the nature and

estimated age of the material, its archaeological context, and the research question. Commonly used methods are presented in Table 1 (Historic England, 2025).

Radiocarbon (^{14}C) dating is particularly important in nutritional archaeology because plant remains, human and animal bones, wood, charcoal, and other organic materials are frequently examined. The method is based on measuring the decline in the amount of radioactive ^{14}C in an organism after death. Because atmospheric ^{14}C levels have varied over time, radiocarbon measurements cannot be interpreted directly as calendar years and must be calibrated. International calibration curves such as IntCal20 are used to convert Northern Hemisphere radiocarbon ages into calendar ages (Reimer et al., 2020; van der Plicht et al., 2020).

Table 1. Principal Dating Methods Used in Archaeology

Method	Basic principle/event measured	Suitable material or evidence	Approximate applicable age range	Main limitation
Stratigraphy	Evaluation of the formation and superposition of archaeological layers	Occupation layers, structures, pits, and associated finds	Does not provide a numerical age	Disturbance, redeposition, and subsequent interventions may disrupt the chronological sequence
Typology and seriation	Chronological ordering of objects according to changes in form, technology, and frequency	Pottery, stone and metal tools, ornaments, and other cultural artifacts	Does not provide a numerical age; depends on regional reference sequences	Requires an established, reliable typological sequence and a well-defined archaeological context
Radiocarbon (^{14}C) dating	Measurement of the decline in ^{14}C after an organism's death	Wood, charcoal, seeds, grains, bone collagen, textiles, and other organic remains	Approximately 300–50,000 years before present	Contamination, reservoir effects, the old-wood effect, and calibration uncertainties may affect the results
Dendrochronology	Matching annual tree-ring growth patterns with regional reference sequences	Well-preserved wood with a sufficient number of rings	Period covered by the regional reference chronology; under suitable conditions, may provide calendar-year precision	Requires suitable tree species, sufficient rings, and a regional reference sequence; the felling date does not necessarily represent the date of use
Thermoluminescence (TL)	Measurement of radiation energy accumulated since the material was last exposed to high temperatures	Pottery, burned flint, and other heated mineral materials	From approximately several hundred years to 300,000–500,000 years	Requires accurate estimation of the natural radiation dose and a clear association between the heating event and the archaeological event

Table 1 (continued)

Optically stimulated luminescence (OSL)	Determination of the time elapsed since mineral grains were last exposed to sunlight or, in some cases, heat	Sediments containing quartz or feldspar; some heated pottery and stone	From approximately several hundred years to 100,000–300,000 years; under suitable conditions, potentially older	Inadequate exposure to light before burial may result in age overestimation
Archaeomagnetic dating	Comparison of the Earth's magnetic field recorded in heated materials as they cooled with regional reference curves	Hearths, kilns, burned floors, fired clay, and some pottery	Period covered by the regional calibration curve; generally the past several thousand years	Dates the most recent heating event; the material must have remained in situ, and an appropriate regional calibration curve is required
Uranium-series dating	Measurement of disequilibrium between uranium isotopes and their decay products	Cave formations, travertine, coral, and, in some cases, bones and teeth	Approximately 1,000–500,000 years	Open-system behavior and the subsequent uptake or loss of uranium may affect the results
Electron spin resonance (ESR)	Measurement of trapped electrons accumulated within a crystal structure through exposure to natural radiation	Tooth enamel, carbonates, quartz, burned flint, and some sediments	From several thousand years to approximately 1 million years or more	Requires modeling of the environmental radiation dose and the history of uranium uptake

Note: The age ranges are approximate; applicable lower and upper limits may vary according to the nature of the sample, measurement protocol, environmental conditions, and the analytical capabilities of the laboratory. Depending on the method, a dating result may indicate the death of an organism, the growth or felling of a tree, the last heating of a material, or the last exposure of sediment to light rather than directly dating the archaeological event itself. Results should therefore be interpreted alongside stratigraphic, typological, and other archaeological evidence.

2.3. Dietary and Health Evidence Derived From Human Skeletal and Dental Remains

Human skeletal and dental remains are among the principal biological sources used to assess the long-term health and living conditions of past populations (Larsen, 2015). Dental caries, tooth wear, periodontal changes, antemortem tooth loss, and enamel developmental defects can provide information about dietary practices and living conditions. Changes in the prevalence of dental caries, in particular, have been examined in relation to the consumption of fermentable carbohydrates and food preparation methods to investigate dietary transformations in the past. However, caries development is also influenced by numerous factors, including the oral microbiota, salivary characteristics, age, dental morphology, and oral hygiene.

Skeletal changes may provide information about growth, metabolic diseases, infections, and physiological stress. Although rickets and scurvy may be associated with particular skeletal findings, paleopathological diagnosis differs from contemporary clinical diagnosis (Snoddy et al., 2018; Mays & Brickley, 2022). Because biochemical findings and detailed clinical histories are unavailable for archaeological individuals, assessments rely on lesion morphology and skeletal distribution. A single skeletal finding should therefore not be interpreted as definitive evidence of a specific nutrient deficiency.

Similarly, porotic cranial lesions such as *cribra orbitalia* and *porotic hyperostosis*, which were previously

attributed directly to iron deficiency anemia, have complex etiologies. Anemia, infection, inflammation, parasitic diseases, and other physiological processes may produce similar changes (Brickley, 2024).

2.4. Stable Isotope Analyses

Stable isotope analysis is one of the principal biochemical methods used to reconstruct the dietary patterns of past populations. Carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope ratios preserved in human bones and teeth may retain biochemical signatures of the foods consumed. Carbon isotopes help distinguish between plants that use different photosynthetic pathways and the food webs based on them, whereas nitrogen isotopes provide information about trophic level and animal protein consumption. These analyses are also used to differentiate between marine and terrestrial food sources (Larsen et al., 2022).

Bone collagen generally reflects an integrated record of dietary protein sources during the final years of life. Because dental tissues undergo little or no remodeling after their formation is complete, they can provide information about earlier stages of life. Comparing different tissues from the same individual may therefore allow dietary changes over the life course to be examined. However, stable isotope values do not directly identify specific foods. Similar isotopic signals may arise from different food combinations, while local ecology, agricultural practices, environmental baseline values, and physiological processes may also affect the results. Higher-resolution methods, such as compound-specific stable isotope analysis of amino acids, seek to address some of these limitations (Larsen et al., 2022). Nevertheless, isotopic findings should be interpreted alongside archaeobotanical, zooarchaeological, and other biomolecular data.

2.5. Dental Calculus and Biomolecular Evidence

Dental calculus forms through the mineralization of microbial plaque on tooth surfaces and constitutes an important biological archive because it is often well preserved in archaeological specimens. Its mineralized matrix may preserve microbial DNA, proteins, environmental materials, starch granules, phytoliths, and other microparticles (Forshaw, 2022).

Microscopic analyses enable the identification of plant microremains, while proteomic and ancient DNA analyses provide more detailed biomolecular information. The study of ancient oral microbiomes has enabled researchers to investigate changes in human oral ecology, particularly those accompanying the spread of agriculture and industrialization (Forshaw, 2022; Quagliariello et al., 2022). Dental calculus can therefore be used to examine both consumed foods and diet–health interactions. However, not every material detected in dental calculus represents a food that was consumed. Inhaled environmental particles, nonfood materials, post-burial contamination, and limitations in reference databases may affect the findings. Dental calculus evidence should therefore be supported by the archaeological context and other dietary indicators.

2.6. Archaeobotanical and Zooarchaeological Evidence

Archaeobotany examines the use of plant resources and agricultural practices in past societies through plant remains recovered from archaeological sites. Macrobotanical remains, including charred seeds, grains, fruits, and plant tissues, may be examined alongside microscopic remains such as pollen, phytoliths, and starch granules. Beyond identifying the plants used, these data can provide information about their cultivation, collection, processing, storage, and preparation (Lancelotti & Madella, 2023; Styring et al., 2024; Ramadan et al., 2025). However, the presence of plant remains at an archaeological site does not by itself establish that the plant was consumed by humans. Plants may have been used as fuel, construction materials, or medicine, or may have reached the site through natural processes. Charring and other preservation processes may also cause certain species to be overrepresented in the

archaeological record. Archaeobotanical data should therefore be interpreted with consideration of the context of the finds and relevant taphonomic processes.

Zooarchaeology examines hunting, animal husbandry, butchery, and the use of animal-derived foods in past societies through the analysis of animal remains. The principal indicators assessed for these purposes include animal taxa and anatomical elements, age-at-death and sex profiles, cut and burning marks, and patterns of bone breakage. In addition to conventional morphological methods, ZooMS uses collagen peptide mass fingerprinting to facilitate the taxonomic classification of fragmented bones that cannot be identified morphologically. Its low sample requirements and capacity for the rapid examination of large faunal assemblages are important advantages (Richter et al., 2022). Nevertheless, because the number of animal remains does not directly indicate the amount consumed, zooarchaeological findings should be interpreted alongside other forms of dietary evidence.

2.7. Organic Residues in Pottery and Coprolites

Archaeological pottery may preserve chemical traces of food preparation, cooking, storage, and transportation. Lipids, in particular, may persist for long periods within porous ceramic matrices because of their hydrophobic properties and relatively high chemical stability. The analysis of lipids and their degradation products using methods such as gas chromatography and mass spectrometry may provide evidence of the use of animal fats, dairy products, plant oils, and certain marine resources (Irto et al., 2022). Organic residue analysis can provide molecular information about past food-processing practices even when visible food remains have not been preserved. However, interpretation may be complicated when the same vessel was used to prepare different foods, when lipids changed over time, or when contamination originated from soil or modern materials. A single biomarker should therefore not be regarded as definitive evidence of a particular food (Irto et al., 2022).

Coprolites, or preserved or mineralized fecal remains, provide relatively direct evidence of past diets. Macroscopic and microscopic examinations may identify bone fragments, plant tissues, seeds, pollen, starch granules, and parasite remains, while analyses of lipid biomarkers, proteins, and ancient DNA can provide more detailed information (Shillito et al., 2020). Coprolites are therefore used to investigate intestinal parasites, microbial ecology, and health status, as well as paleodiet. Their principal limitations include determining whether a specimen is of human origin and the fact that a single specimen reflects only short-term consumption before the feces were produced. Preservation conditions and post-burial taphonomic changes may also affect the components that can be detected. Coprolite findings should therefore be evaluated alongside other archaeological and paleoecological evidence (Shillito et al., 2020).

2.8. Integrating Evidence and Methodological Limitations

The methods used in nutritional archaeology reveal different dimensions of past diets. Human bones and stable isotopes may reflect long-term dietary patterns; teeth may provide information about different stages of life; dental calculus may preserve traces of particular foods and microorganisms; archaeobotanical and zooarchaeological materials may reflect resources used at the population level; pottery residues may provide evidence of food preparation practices; and coprolites may reflect short-term individual consumption.

The principal limitation when interpreting archaeological evidence from a health sciences perspective is that findings often cannot be linked directly to a specific food or disease. A skeletal lesion may result from different diseases, while an isotopic value may arise from different combinations of foods. Plant remains may represent nonfood uses, and lipids in pottery may represent the combined traces of different foods processed in the same vessel. Preservation processes are also selective: bones, teeth, charred plants, and lipids are more likely to be represented in the archaeological record, whereas soft

tissues and perishable foods are largely lost. Past dietary patterns should therefore be evaluated using multiple lines of evidence that integrate archaeological context, chronology, human and animal remains, plant remains, and biomolecular analyses rather than relying on a single finding (Ramadan et al., 2025). Archaeological findings do not constitute clinical diagnoses or evidence of causality; instead, they provide complementary indicators for understanding long-term relationships between diet and health. The principal archaeological and biomolecular methods used to reconstruct past diets are summarized in Table 2.

Table 2. Principal Archaeological and Biomolecular Methods Used to Reconstruct Past Diets

Method/evidence	Material examined	Principal information provided	Time frame reflected	Main limitation
Skeletal and dental examination	Bones and teeth	Growth, oral health, physiological stress, and potential signs of disease	Different stages of life/long term	Findings are generally not specific to a particular disease or nutrient
Stable isotope analysis	Bone collagen, dental tissues, and plant and animal remains	Protein sources, trophic level, differentiation between C_3 and C_4 plants, and marine–terrestrial resource use	Childhood or the final years of life, depending on the tissue	Does not directly identify specific foods
Dental calculus analysis	Mineralized dental plaque	Plant microremains, proteins, ancient DNA, and the oral microbiome	Cumulative exposures during the period of calculus formation	Environmental contamination and nonfood particles
Archaeobotany	Seeds, grains, pollen, phytoliths, and starch	Plant use, cultivation, processing, and storage	Settlement/context level	A plant recovered from a site was not necessarily consumed
Zooarchaeology and ZooMS	Animal bones and collagen peptides	Animal taxa, hunting, animal husbandry, and butchery practices	Settlement/context level	The number of remains does not indicate the amount consumed
Organic residue analysis of pottery	Lipids absorbed into pottery	Cooking and storage practices; use of animal fats, dairy products, plants, and marine resources	Period during which the vessel was used	Different foods may have been processed in the same vessel
Coprolite analysis	Preserved fecal remains	Short-term consumption, parasites, and microbial ecology	Short term	Uncertainty regarding human origin and the extent to which the specimen represents the individual

Note: C_3, plants using the C_3 photosynthetic pathway; C_4, plants using the C_4 photosynthetic pathway; ZooMS, Zooarchaeology by Mass Spectrometry.

As shown in the table, these methods are complementary rather than interchangeable. Definitive conclusions about past dietary patterns or their contemporary implications therefore cannot be drawn from any single method.

3. Historical Transformation of Human Diets

Human diets have transformed in response to changes in environmental conditions, subsistence strategies, sedentary living, technological developments, and food production systems. This historical process, extending from hunter-gatherer lifeways through agriculture and industrialization to modern food systems, is summarized in Figure 1.

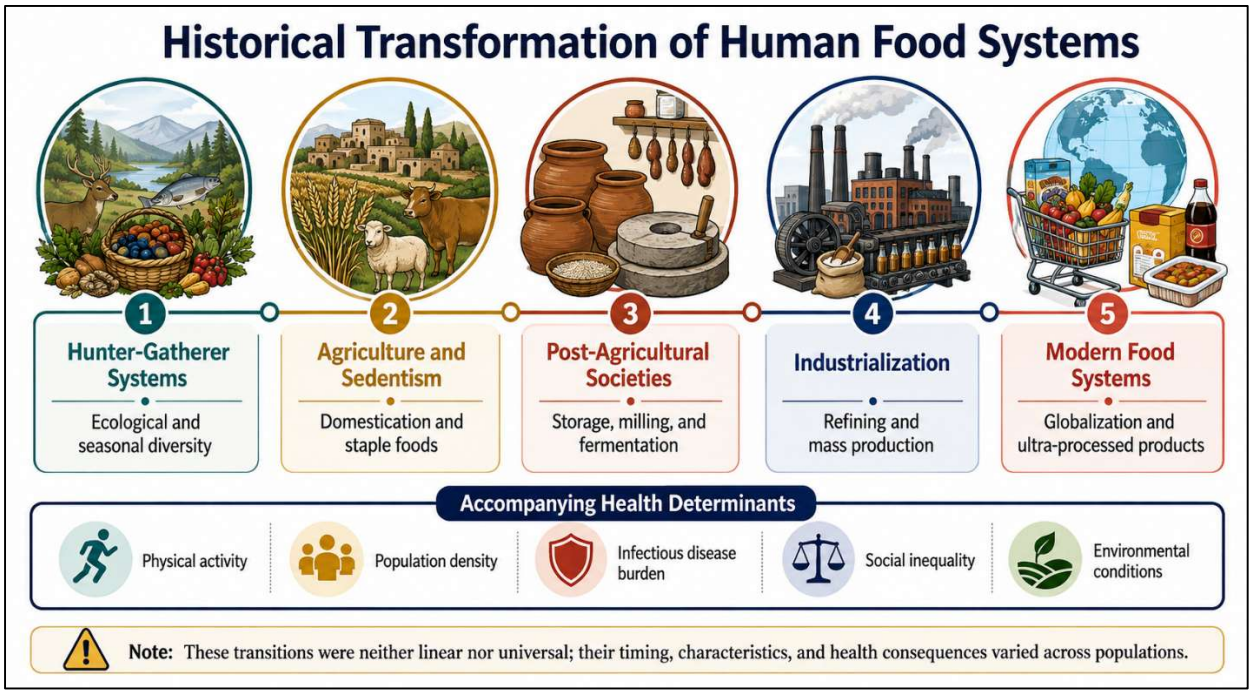


Figure 1. Historical Transformation of Human Food Systems and Accompanying Health Determinants

Note: The figure was generated using ChatGPT's image-generation tool (OpenAI) and subsequently reviewed and edited by the author for scientific accuracy and consistency with the manuscript.

3.1. Diets in Hunter-Gatherer Societies

Preagricultural diets cannot be characterized in terms of a single, unchanging "hunter-gatherer diet." The dietary and subsistence strategies of hunter-gatherer communities varied substantially according to geography, ecology, climate, access to seasonal resources, social organization, and available technologies (Schulting, 2014). Archaeological and biomolecular evidence for the use of wild grains, tubers, roots, fruits, and nuts alongside animal resources demonstrates that preagricultural diets were heterogeneous and adapted to diverse ecological conditions.

Advances in isotopic and biomolecular methods have enabled the reassessment of several conventional assumptions about hunter-gatherer diets. Multiproxy stable isotope analyses of human remains from Late Stone Age hunter-gatherers at Taforalt, Morocco, indicated that plant resources constituted an important component of this population's diet. When considered alongside archaeobotanical and dental evidence, these findings suggest that some human populations consumed substantial amounts of plant foods even before the advent of agriculture (Moubtahij et al., 2024). Characterizing hunter-gatherer diets as a uniform model based predominantly on meat consumption is therefore inconsistent with the available evidence.

This variability suggests that humans developed flexible dietary strategies that enabled them to use diverse food resources. However, preservation biases in the archaeological record mean that not all consumed foods can be detected to the same extent. Durable materials such as animal bones and teeth are more likely to be preserved, whereas many plant foods and soft tissues disappear over time. The relative contributions of plant and animal foods to hunter-gatherer diets should therefore be evaluated according to the specific population, period, and archaeological context.

3.2. The Transition to Agriculture and Dietary Transformation

One of the major transformations in the history of human nutrition was the spread of sedentary living and the domestication of plants and animals, processes that developed independently in different regions beginning in the early Holocene. The transition to agriculture was not a universal "revolution" that occurred at a single point in time but a prolonged process that unfolded at different rates and in different forms across geographical regions. The use of wild resources did not disappear entirely during this period; instead, crop cultivation, animal husbandry, hunting, and gathering continued in varying proportions (Li, 2022).

The spread of agricultural production substantially altered the relationships between societies and their food resources. Domesticated grains and other staple crops became dietary mainstays in many agricultural societies because they provided substantial amounts of energy, could be stored, and could support growing populations. In some archaeological populations, the transition to agriculture has been associated with increasing reliance on a narrower range of staple foods and changes in dietary composition (Larsen, 1995, 2006). However, because agricultural systems, cultivated plant and animal species, local ecologies, and access to wild resources varied, this pattern cannot be generalized to all early agricultural societies.

Agriculture transformed not only food production but also the ways in which food was stored, prepared, and distributed within societies. The grinding, cooking, and storage of grains contributed to more regular energy supplies, while animal domestication enabled the exploitation of secondary products such as milk in addition to meat. The transition to agriculture should therefore be understood not merely as a reduction in dietary diversity or a deterioration in diet but as a comprehensive transformation of food production and consumption systems (Parkinson et al., 2023; Parkinson, 2026).

3.3. Diet and Food Processing in Agricultural Societies

As sedentary agricultural societies developed, technologies for producing, processing, and storing plant and animal resources became increasingly diverse. Molecular residues preserved in archaeological pottery indicate that grains could be prepared together with animal-derived products and that early agricultural societies employed complex culinary practices. The detection of cereal biomarkers alongside dairy and animal fats in pottery recovered from Neolithic settlements in Scotland suggests that grains may have been prepared together with dairy products or other animal-derived foods (Hammann et al., 2022).

Food processing is not unique to the modern era. Practices such as grinding, cooking, drying, and fermentation have played important roles in human nutrition by affecting the edibility, digestibility, safety, shelf life, and, in some cases, nutrient bioavailability of foods (Knorr & Watzke, 2019). The grinding and thermal processing of grains, in particular, were among the key technological developments that facilitated their effective incorporation into human diets (Thielecke et al., 2021). Describing dietary history as a transition from an "unprocessed diet" to a "processed diet" is therefore misleading. From a historical perspective, the critical change was not the existence of processing itself but the nature, intensity, scale, and purpose of the methods employed. Whereas traditional methods generally focused on improving safety, digestibility, shelf life, or sensory properties, industrialization transformed food production into a larger-scale and technologically more complex system.

3.4. Industrialization and the Emergence of the Modern Food System

Industrialization constituted another major technological transformation in human nutrition. Mechanical milling, refining, industrial sugar production, canning, refrigeration, and the development of transportation networks weakened the geographical link between production and consumption and

made the food supply partially independent of seasonal constraints. Although these developments provided substantial benefits in terms of food safety, shelf life, and accessibility, they also led to extensive changes in dietary composition (Baker et al., 2020; Knorr & Watzke, 2019).

With the emergence of modern food systems, refined ingredients, added sugars, fats, and products manufactured from various industrial ingredients became increasingly accessible. The growing contribution of ultra-processed foods to the global food supply, particularly over recent decades, is a defining feature of the nutrition transition. Baker et al. (2020) demonstrated that this increase cannot be attributed solely to individual preferences but must be considered in relation to structural transformations in food systems, urbanization, technological developments, global trade, and the political-economic dynamics of large-scale production. Nevertheless, it is inappropriate to classify all food-processing methods within the same health-related category. Processing can improve food safety and shelf life, modify nutrient bioavailability, and facilitate access to nutritious foods. By contrast, the increasing dietary contribution of products based on extensive industrial formulation remains a major area of debate in contemporary nutrition science. From a historical perspective, the distinguishing change was not that humans began processing foods but that the technological capacity, scale, and function of processing within the food system were transformed.

3.5. Overall Assessment of the Historical Dietary Transformation

Archaeological and biomolecular evidence indicates that the history of human diets did not follow a unidirectional or homogeneous trajectory. Dietary patterns varied among hunter-gatherer societies, the transition to agriculture occurred in different forms across geographical regions, and reliance on particular staple foods increased in some societies, whereas mixed subsistence strategies persisted for extended periods in others. Although food processing has existed since ancient times, industrialization substantially changed its scale, technological characteristics, and role in human diets. These findings do not support the notion that a single ideal model of human nutrition existed in the past. Instead, the archaeological record indicates that human diets were shaped by the capacity to adapt to environmental and technological conditions and to use diverse food resources. Accordingly, contemporary inferences should focus on the relationships between human health, food-source diversity, and transformations in production and processing systems rather than on replicating a particular historical dietary model (Bates, 2024).

Transformations in food systems simultaneously altered health-related factors such as lifeways, population density, exposure to infectious diseases, physical activity, and social organization. Consequently, health changes observed following agriculture or industrialization cannot be attributed solely to diet. Nevertheless, human skeletal and dental remains and other bioarchaeological indicators allow the health changes accompanying these transformations to be examined over extended periods. The following section evaluates evidence of these changes in oral and dental health, growth, nutritional deficiencies, and other health indicators (Bates, 2024).

4. Health-Related Evidence of Historical Dietary Transformations

4.1. Changes in Oral and Dental Health

Teeth are among the principal sources of biological evidence used to evaluate historical dietary changes. Dental caries, tooth wear, antemortem tooth loss, and periodontal changes can provide information about the composition and preparation of consumed foods. However, these indicators are not specific to diet; age, the oral microbiome, salivary characteristics, dental morphology, the physical structure of foods, and oral hygiene may also affect oral and dental health (Forshaw, 2022; Larsen, 2015).

With the spread of agricultural production, increased consumption of grains and other carbohydrate-

rich staple foods in some populations has been associated with changes in the frequency of dental caries. Nevertheless, recent archaeological research indicates that this relationship is neither simple nor universal. The joint examination of plant microremains in dental calculus and dental caries in the Neolithic population of Tepecik-Çiftlik enabled evidence of plant food consumption and processing to be integrated with indicators of oral health (Santiago-Marrero et al., 2025). Such multiple-lines-of-evidence approaches provide a more comprehensive assessment than dietary inferences based solely on caries prevalence.

Dietary transformations have also been shown to leave detectable signatures in the oral microbiome. A study of 76 dental calculus samples from Paleolithic hunter-gatherers and Neolithic and Copper Age agricultural populations reported that oral microbiome composition changed gradually, rather than abruptly, during the transition to agriculture (Quagliariello et al., 2022). This finding supports the interpretation of the transition to agriculture as a prolonged and population-specific transformation rather than an abrupt and universal shift. Overall, dental evidence indicates that changes in carbohydrate sources and food preparation methods were associated with oral health. However, because the direction and magnitude of this relationship may vary across populations, food type, preparation method, consumption frequency, and oral ecology should be considered together.

4.2. Growth, Stature, and Physiological Stress

Skeletal growth is influenced by nutrition, infectious disease burden, and other environmental conditions, as well as genetic potential. Adult stature and skeletal dimensions are therefore used to assess growth conditions during childhood and adolescence in past populations. The conventional interpretation of the transition to agriculture proposed that stature and body size declined among early farmers relative to hunter-gatherers. However, large archaeological datasets indicate that this change was more complex both regionally and temporally.

Analyses encompassing hundreds of archaeological sites and thousands of individuals have found that long-term changes in body size were associated with transformations in subsistence strategies but did not occur uniformly across all regions. In some regions, the decline began before the adoption of agriculture, whereas in others it became evident after the transition. The temporal overlap between later increases in body size in certain parts of Europe and developments such as the expansion of dairying indicates the dynamic nature of the relationship between diet and growth (Parkinson et al., 2023; Parkinson, 2026).

A study evaluating approximately 15,000 years of European bioarchaeological data in relation to growth, diet, physical activity, and demography found that demographic expansion in early agricultural societies coincided with a reduction in body size. This relationship was explained in terms of potential energy allocation trade-offs between growth and reproduction within a life-history framework. Nevertheless, persistent regional differences indicate that the transition to agriculture did not have a single universal effect on growth (Parkinson, 2026). Reduced stature or body size in early agricultural societies should therefore not be interpreted solely as a direct consequence of undernutrition. In addition to dietary quantity and quality, recurrent infections, childhood diseases, physical activity, population density, fertility patterns, and genetic background may affect growth. Skeletal growth should be regarded as an integrated indicator of overall living conditions rather than as a marker specific to any single factor (Larsen, 2015; Parkinson et al., 2023; Parkinson, 2026).

4.3. Nutritional Deficiencies and Skeletal Findings

Pathological changes observed in bones and teeth are used to investigate nutritional deficiencies in past populations (Meyer, 2016). Although scurvy and rickets may be associated with particular skeletal findings, enamel hypoplasia and certain cranial lesions may be used to assess physiological stress. However, none of these findings alone provides a definitive diagnosis.

Scurvy resulting from prolonged and severe vitamin C deficiency can affect bone formation and connective tissue metabolism, producing potentially characteristic skeletal changes, particularly in children (Snoddy et al., 2018). Rickets may leave morphological changes associated with impaired mineralization of the growing skeleton. In archaeological specimens, however, diagnosis should be based on the combined assessment of findings across different skeletal regions rather than on a single lesion. Rickets should also not be interpreted solely as a direct indicator of dietary calcium deficiency (Mays & Brickley, 2022). Similarly, porotic cranial lesions such as *porotic hyperostosis* and *cribra orbitalia* require careful interpretation. Although these findings were frequently attributed to iron deficiency anemia in the past, their etiology is more complex. Different forms of anemia, infections, inflammatory processes, parasitic diseases, and other nutrition-related factors may contribute to similar changes (Brickley, 2024). These lesions therefore do not directly indicate the prevalence of a specific nutrient deficiency.

Although enamel developmental defects may indicate disruptions to growth during childhood, they may result from infection, undernutrition, or other systemic stressors. Indicators of physiological stress in bones and teeth should therefore be treated as complementary evidence of the overall biological stress experienced by past populations rather than as diagnostic markers of a specific nutrient deficiency (Larsen, 2015; Meyer, 2016).

4.4. Sedentary Living, Population Density, and Infectious Disease Burden

Explaining the health changes accompanying the transition to agriculture solely in terms of diet overlooks the multidimensional nature of the Neolithic transformation. In many regions, the spread of agriculture occurred alongside increased sedentism and population density, close contact with domesticated animals, changes in waste management and sanitation, and transformations in physical activity. All these factors may have affected the transmission of infections and the overall disease burden (Larsen et al., 2019).

The Neolithic settlement of Çatalhöyük in Anatolia provides a detailed example of this process. Bioarchaeological analyses covering approximately 12 centuries of occupation demonstrate that population density, mobility, physical workload, diet, and disease exposure changed concurrently over time (Larsen et al., 2019). Increasing reliance on domesticated plant carbohydrates and changes in dental caries and other health indicators were evaluated alongside contemporaneous transformations in population and lifeways. The Çatalhöyük example demonstrates that diet, exposure to infection, physical activity, and social organization changed within the same historical process. Consequently, skeletal changes cannot be attributed solely to agricultural diets. The effects of agriculture on health should instead be evaluated as part of a broader ecological and social transformation.

4.5. Did the Transition to Agriculture Worsen Human Health?

The transition to agriculture was long regarded in the bioarchaeological literature as a period of general deterioration in human health. This interpretation was based on increases in dental caries, reductions in adult stature, and a greater frequency of skeletal indicators of stress in some early agricultural populations. However, large datasets and multiproxy analytical approaches indicate that this relationship was more complex.

The transition to agriculture was not a single biological or cultural event. Different species were domesticated in different regions, diverse subsistence strategies were developed, and hunting and gathering sometimes continued alongside agricultural production. Correspondingly, changes in oral health, body size, and other health indicators also varied across regions. In some regions, adverse changes in growth conditions coincided with the transition to agriculture; in others, the same pattern was not observed or the change began before agriculture was adopted (Larsen, 1995, 2006; Larsen et al., 2019; Parkinson et al., 2023).

Health changes in early agricultural societies cannot be explained solely by dietary diversity or nutrient intake. Sedentism, population density, infectious disease burden, physical workload, fertility patterns, sanitation, and social inequalities changed concurrently. A life-history perspective suggests that environmental conditions may create energy allocation trade-offs among biological processes such as growth, reproduction, and immune function (Parkinson, 2026). The available evidence therefore does not support the conclusion that agriculture universally worsened human health.

The transition to agriculture fundamentally altered diet, lifeways, and disease ecology and was associated in some populations with adverse changes in indicators of dental health, growth, and physiological stress. However, these effects varied according to geography, period, subsistence strategy, and social conditions. This conclusion also indicates that archaeological evidence does not support the replication of a particular historical diet in modern societies. Human health is shaped by interactions among the diversity, quality, and processing of foods, as well as infectious disease burden, physical activity, environmental conditions, and social circumstances. Inferences from the past regarding contemporary chronic diseases should therefore be evaluated within this multifactorial framework. The principal health indicators used to evaluate historical dietary transformations and their interpretive limitations are summarized in Table 3.

Table 3. Principal Health Indicators Used to Evaluate Historical Dietary Transformations and Their Interpretive Limitations

Health indicator	Potential relationship with diet/lifeways	Alternative explanations	Appropriate interpretation
Dental caries	Consumption of fermentable carbohydrates and food preparation practices	Age, oral microbiome, saliva, dental morphology, and oral hygiene	Not a definitive measure of carbohydrate exposure in isolation
Tooth wear	Physical structure of foods and processing methods	Non-masticatory use of teeth and environmental particles	Should be evaluated within its specific context
Stature and skeletal dimensions	Childhood nutrition and growth conditions	Infection, physical activity, genetic background, and demography	An integrated indicator of overall living conditions
Enamel hypoplasia	Disruptions to growth during childhood	Infection and other systemic stressors	Not specific to a particular nutrient deficiency
Lesions consistent with scurvy	Prolonged, severe vitamin C deficiency	Differential diagnoses and preservation-related limitations	The distribution of lesions should be evaluated collectively
Changes consistent with rickets	Impaired mineralization	Vitamin D, calcium, sunlight exposure, and metabolic factors	Should not be interpreted solely as evidence of calcium deficiency
Cribra orbitalia and *porotic hyperostosis*	Anemia and physiological stress	Infection, inflammation, parasites, and different forms of anemia	Not direct indicators of iron deficiency
Oral microbiome	Changes in diet and lifeways	Environment, geography, medications, and other exposures	A complementary biological indicator of dietary transformation

5. From Past Diets to Contemporary Chronic Diseases: Insights From Nutritional Archaeology

5.1. Food Diversity and Diet Quality

Archaeological evidence indicates that human diets have varied throughout history according to environmental conditions, available food resources, and technological capabilities. The plant and animal resources used by hunter-gatherer communities differed geographically, while the transition to agriculture increased reliance on a limited number of staple foods in some populations. However, these observations do not demonstrate that food diversity alone produces better health outcomes. In modern nutrition science, the foods from which diversity is derived are as important as diversity itself.

Systematic reviews and meta-analyses of prospective cohort studies indicate that greater adherence to high-quality dietary patterns emphasizing vegetables, fruits, whole grains, legumes, and nuts is associated with lower risks of all-cause mortality, cardiovascular disease, type 2 diabetes, and certain cancers (Schwingshackl et al., 2018). Evidence comparing healthy and unhealthy dietary patterns also supports the conclusion that chronic disease risk is related not merely to the number of foods consumed but to the overall composition of the diet (Schwingshackl et al., 2018; Wang et al., 2023). The principal lesson from nutritional archaeology is therefore not that individuals should consume as many different foods as possible. A more defensible approach is to promote a high-quality dietary pattern comprising foods from different food groups, particularly nutrient-dense plant sources. Whereas the archaeological record demonstrates the human capacity to flexibly use diverse food resources, modern epidemiological evidence indicates that the quality of these resources is important for health outcomes.

5.2. Plant Foods, Dietary Fiber, and Metabolic Health

The importance of plant resources in human diets did not begin with agriculture. Archaeobotanical findings, dental calculus analyses, and stable isotope studies indicate that wild plants could also constitute important food resources in preagricultural societies. The substantial contribution of plant foods identified among the Taforalt hunter-gatherers provides a recent example (Moubtahij et al., 2024). However, this finding demonstrates the ecological variability of past diets rather than indicating that all hunter-gatherers consumed predominantly plant-based diets.

Dietary fiber constitutes one of the areas with the strongest evidence linking plant foods to health in modern nutrition science. Systematic reviews and meta-analyses indicate that higher fiber intake is associated with lower risks of several noncommunicable diseases, including coronary heart disease, stroke, type 2 diabetes, and colorectal cancer. In the comprehensive evaluation by Reynolds et al. (2019), comparisons of higher versus lower fiber intake indicated an approximately 15–30% lower risk across several clinical outcomes. Consumption of fiber-rich foods such as whole grains has also been associated with favorable health outcomes (Reynolds et al., 2019; Veronese et al., 2018).

In large-scale meta-analyses, greater adherence to healthy plant-based dietary patterns has been associated with lower risks of type 2 diabetes, cardiovascular disease, cancer, and all-cause mortality (Wang et al., 2023). However, not all plant foods have the same health effects. Although patterns based on vegetables, fruits, whole grains, and legumes are associated with favorable outcomes, refined grains, sugar-sweetened beverages, and plant-derived products of low nutritional quality do not confer the same benefits. Dose–response meta-analyses also indicate that healthy and unhealthy plant-based diet indices may be associated with mortality in opposing directions (Etesami et al., 2025).

Evidence that past populations used plant resources does not justify recommending a specific "ancestral" plant-based diet to modern populations. A more reliable point of convergence between archaeological evidence and modern nutritional evidence is the importance of diverse, fiber-rich, and nutrient-dense plant foods within a healthy dietary pattern.

5.3. Plant Diversity and the Gut Microbiota

The gut microbiota is an area of growing interest in comparisons of past and modern dietary patterns. Dietary fiber and other nondigestible plant components are metabolized by the colonic microbiota, contributing to the production of various metabolites, including short-chain fatty acids. Systematic reviews of randomized controlled trials indicate that fiber interventions can alter specific components of the gut microbiota (So et al., 2018). However, the relationships among plant food diversity, microbial diversity, and chronic diseases are too complex to be explained by a simple causal model. Popular thresholds prescribing the consumption of a specific number of different plant foods per week are not clinically validated targets for chronic disease prevention. Similarly, the assumption that

greater microbial diversity invariably indicates better health is an oversimplification.

A biologically plausible connection can be drawn between the diversity of plant resources identified archaeologically and modern microbiota research. Nevertheless, the available evidence does not support reconstructing a specific "ancestral microbiota" or consuming a predefined number of plant foods as an evidence-based intervention for preventing chronic diseases.

5.4. Seasonality: From a Historical Characteristic to a Modern Dietary Recommendation?

Before the development of modern food systems, food availability was more directly influenced by climate, geography, and seasonal cycles. Among hunter-gatherer communities, plant maturation periods, animal migration and reproductive cycles, and environmental conditions altered the foods available throughout the year. The development of agricultural production and storage, followed by global trade and cold-chain technologies, progressively reduced the dependence of food consumption on seasonal constraints (Baker et al., 2020; Bates, 2024).

Longitudinal research among Hadza hunter-gatherers maintaining a traditional lifestyle has demonstrated seasonal cycling in the gut microbiota. Smits et al. (2017) reported that certain microbial taxa declined or became undetectable during one season and reappeared in subsequent seasons. This finding suggests that seasonal variation in diet and environmental exposures may be associated with microbial ecology. However, this observation does not demonstrate that seasonal eating prevents obesity, type 2 diabetes, cardiovascular disease, or other chronic diseases. Controlled clinical evidence examining the independent, long-term health effects of seasonality remains limited. Moreover, populations such as the Hadza differ from modern populations not only in diet but also in physical activity, environmental exposures, medication use, sanitation, and other lifestyle characteristics. Although seasonality is therefore an important historical and ecological feature, the available evidence is insufficient to support it as an independent clinical recommendation for chronic disease prevention.

5.5. Degree of Food Processing, the Food Matrix, and Metabolic Health

Food processing has been an integral component of human diets since ancient times. Grinding, cooking, drying, and fermentation have improved food safety, digestibility, shelf life, and sensory properties. It is therefore scientifically inappropriate to formulate the lesson from the past as a recommendation to "avoid processed foods." What distinguishes the modern era is not the existence of processing but its degree, purpose, technological characteristics, and the structure of the resulting product (Knorr & Watzke, 2019; Dicken, 2026).

The relationship between ultra-processed foods and health is important in this context. In a randomized controlled trial, participants were provided ultra-processed and unprocessed diets in a crossover design. Although the diets were matched as closely as possible for energy, macronutrients, sugar, sodium, and fiber, participants consumed approximately 500 kcal more per day and gained weight during the ultra-processed diet period (Hall et al., 2019). This finding provides experimental evidence that food processing may influence *ad libitum* energy intake and body weight regulation beyond conventional nutrient composition.

In the randomized trial by Dicken et al. (2025), minimally processed and ultra-processed diets were compared, with both designed to comply with healthy dietary guidelines. Weight loss occurred during both dietary periods but was greater during the minimally processed diet period. This result suggests that the degree of processing may play an additional role in energy balance and weight regulation even when general dietary recommendations are followed.

The experimental findings are also consistent with the epidemiological literature. An umbrella review of epidemiological meta-analyses associated greater exposure to ultra-processed foods with numerous adverse health outcomes, including cardiometabolic diseases and mortality (Lane et al., 2024).

Nevertheless, ultra-processed foods constitute a heterogeneous category, associations with health may vary across subgroups, and residual confounding cannot be fully excluded in observational studies (Dicken, 2026).

The food matrix is another concept relevant to this discussion. The physical structure of foods and the organization of nutrients within that structure may affect the rate and extent to which nutrients and bioactive compounds become accessible during digestion. The physiological effects of a food may therefore depend not only on its energy and nutrient content but also on the physical and structural matrix in which these components are embedded (Bornhorst & Singh, 2014; Capuano et al., 2018; Capuano & Janssen, 2021). However, this concept should not be interpreted as evidence that particular foods directly prevent chronic diseases; clinical outcomes should be evaluated in relation to the specific food and processing method.

5.6. What Can Be Translated From Past Dietary Patterns to the Present?

Evidence from past dietary patterns is most useful for identifying long-term variation in food sources and food systems rather than for reconstructing a diet for modern use. The relative contributions of plant and animal resources varied according to geography and ecology in preagricultural populations, while the transition to agriculture produced different food systems across regions.

Evidence from the past can be used to evaluate the relatively recent features of modern food systems from a long-term perspective. The conclusions most strongly supported by modern evidence are that the consumption of fiber-rich, high-quality plant foods should be increased and that high dependence on ultra-processed products should be reduced. Food diversity should be considered not merely in terms of the number of different foods consumed but in relation to the inclusion of diverse, nutrient-dense sources in the diet. Although the food matrix is biologically meaningful and constitutes an emerging area of research, evidence regarding clinical outcomes remains more limited. There is also insufficient clinical evidence to recommend seasonal eating independently for chronic disease prevention.

The principal contribution of nutritional archaeology to the health sciences is therefore not to idealize the past but to demonstrate the historical variability of human diets and evaluate modern food systems within a long-term framework. Archaeological observations may generate hypotheses, but clinical recommendations should be developed on the basis of randomized controlled trials, prospective cohort studies, systematic reviews, and meta-analyses. Considering these two bodies of evidence together may provide a broader temporal perspective on relationships between diet and health without directly attributing causality. The implications of nutritional archaeology for contemporary nutrition and the status of the corresponding modern evidence are presented in Table 4.

Table 4. Implications of Nutritional Archaeology for Contemporary Nutrition and The Status of Modern Evidence

Historical/archaeological observation	Contemporary nutritional counterpart	Nature of modern evidence	Supported inference
Use of diverse food resources in past populations	Food diversity and diet quality	Systematic reviews and meta-analyses of cohort studies	Diversity should be evaluated alongside nutritional quality
Use of plant resources before the advent of agriculture	Plant foods and dietary fiber	Systematic reviews and meta-analyses	Increasing the consumption of fiber-rich, high-quality plant foods is supported
Diversity of plant resources	Diet–microbiota interaction	Intervention studies and emerging mechanistic evidence	No specific diversity threshold can be recommended

Seasonal variation in historical food availability	Seasonal eating	Limited observational and mechanistic evidence	Cannot be independently recommended for chronic disease prevention
Historical use of grinding, cooking, and fermentation	Food processing	Historical evidence and food science research	Not all processing methods are equivalent in terms of health
Development of the modern industrial food system	Ultra-processed foods	Randomized controlled trials and epidemiological meta-analyses	Reducing high reliance on ultra-processed products is supported
Consumption of foods within their structural matrices	Food matrix	Intervention studies and emerging mechanistic evidence	Biologically meaningful; further research on clinical outcomes is required
Substantial heterogeneity of past diets	The "ideal ancestral diet" concept	Multiple archaeological and biomolecular findings	A universal "ancestral" or Paleo dietary model is not supported

6. Importance and Limitations of Nutritional Archaeology From a Health Sciences Perspective

6.1. From the Past to Clinical Recommendations: Limits of the Evidence

Nutritional archaeology enables the investigation of dietary transformations over thousands of years and the biological changes that accompanied them. Human skeletal and dental remains, stable isotopes, dental calculus, archaeobotanical and zooarchaeological remains, and organic residues provide important information about the food resources, food preparation practices, and health status of past populations. However, the distinction between archaeological observations and clinical evidence must be maintained when interpreting these findings.

Although archaeological data can demonstrate how dietary and health indicators changed concurrently over time, they do not provide evidence of causality in the contemporary clinical research sense. For example, increases in dental caries, reductions in body size, or changes in indicators of physiological stress have been observed in some populations during the transition to agriculture. However, population density, infectious disease burden, physical activity, sanitation, fertility, and social organization also changed during the same period (Larsen et al., 2019; Parkinson, 2026). Similarly, evidence that a particular food was consumed in the past does not demonstrate that it is beneficial for preventing or treating diseases today. The principal function of nutritional archaeology is therefore not to generate direct clinical recommendations but to formulate hypotheses, situate modern food systems within their historical context, and demonstrate the long-term variability of human diets. Archaeological observations must be supported by contemporary epidemiological and experimental evidence before they can be translated into health recommendations.

6.2. Implications for Health Professionals

For health professionals, this historical variability underscores the need to avoid universalizing findings from any single past population. Archaeological and biomolecular findings indicate that, even among hunter-gatherer societies, the relative contributions of plant and animal foods varied according to ecology, geography, and seasonal conditions (Moubtahij et al., 2024; Schulting, 2014).

This historical diversity is consistent with contemporary healthy dietary principles. The Food and Agriculture Organization of the United Nations and the World Health Organization state that healthy diets may take different forms depending on individual characteristics, cultural context, locally available foods, and dietary traditions, while adequacy, balance, moderation, and diversity remain fundamental principles (Food and Agriculture Organization of the United Nations & World Health Organization, 2024). Current World Health Organization recommendations similarly support diverse dietary patterns that include whole grains, vegetables, fruits, and legumes and are based predominantly on unprocessed or minimally processed foods (World Health Organization, 2026).

An archaeological perspective also demonstrates the need for careful use of the term "processed food" in health communication. Grinding, cooking, drying, and fermentation have formed part of human diets for thousands of years and have provided important benefits in terms of food safety, digestibility, and preservation. Health messages should therefore focus not on avoiding all forms of food processing but on reducing dietary patterns based on ultra-processed products and increasing the dietary contribution of nutrient-dense, fiber-rich, and less processed foods (Hall et al., 2019; Lane et al., 2024; Dicken et al., 2025).

6.3. Evolutionary Mismatch: A Useful Framework, but Not Clinical Evidence

Differences between the environments in which human biology evolved and modern living conditions are described in the evolutionary medicine literature using the concept of "evolutionary mismatch." This approach proposes that certain biological traits that may have been advantageous or neutral under past environmental conditions can be associated with adverse health outcomes in rapidly changing modern environments. Gene–environment interactions are examined within this framework in research on noncommunicable diseases such as obesity, type 2 diabetes, and cardiovascular disease (Cordain et al., 2005).

However, evolutionary mismatch is not the sole explanation for modern chronic diseases. Human populations continued to undergo biological and cultural adaptation after the emergence of agriculture. Contemporary diet and health are influenced by numerous factors in addition to genetic background, including socioeconomic conditions, life expectancy, physical activity, environmental exposures, and access to healthcare. An evolutionary perspective may therefore provide a hypothesis-generating framework, but it cannot serve as the clinical justification for prescribing a specific "evolutionarily appropriate diet" (Cordain et al., 2005).

6.4. Avoiding the Romanticization of the Past

One of the principal risks in translating nutritional archaeology into the health sciences is the idealization of the dietary and health conditions of past populations. The archaeological record indicates that, although past populations used diverse naturally available food resources, they also experienced infections, nutritional deficiencies, growth restriction, dental diseases, and physiological stress. Generalizations that all preagricultural populations were healthy or that agriculture universally worsened human health are inconsistent with the heterogeneity of the evidence.

A lower observed frequency of a particular disease in past populations also cannot be attributed solely to diet. Life expectancy, age distribution, premature mortality from infections, the absence of diagnostic facilities, and selection processes affecting archaeological samples limit direct prevalence comparisons with modern populations. This issue is particularly important for chronic diseases whose incidence increases with age.

Nutritional archaeology is not a call to return to the past but a means of evaluating continuities and discontinuities between past and present through scientific evidence. For health professionals, the most reliable approach is to test historical observations against modern clinical evidence and translate into practice only those principles supported by the contemporary evidence hierarchy. In this way, the long-term perspective provided by archaeology can be integrated with evidence-based nutrition practice.

7. Conclusion

Nutritional archaeology demonstrates that human diets cannot be understood solely in terms of the contemporary food environment but have been shaped by interactions among environmental, biological, cultural, and technological transformations over thousands of years. Skeletal and dental evidence, stable isotopes, dental calculus, archaeobotanical and zooarchaeological remains enable

researchers to investigate not only what past populations consumed but also how changes in food systems occurred alongside changes in health indicators. The available evidence does not support a single ideal "ancestral" dietary model. Hunter-gatherer dietary patterns were heterogeneous, the health effects of the transition to agriculture varied across geographical regions and populations, and food processing has been practiced since ancient periods of human history. Inferences regarding contemporary chronic diseases should therefore be based on general principles derived from the long-term transformation of human diets rather than on attempts to replicate a particular historical diet.

The principles most strongly supported by modern evidence include consuming diverse, nutrient-dense foods; assigning an important place in the diet to fiber-rich plant foods such as vegetables, fruits, whole grains, and legumes; and reducing high reliance on ultra-processed products. By contrast, clinical evidence remains insufficient to support a role in chronic disease prevention or treatment for seasonal eating or the reconstruction of a specific form of "ancestral" food diversity. The approach adopted by the Food and Agriculture Organization of the United Nations and the World Health Organization similarly emphasizes that healthy diets can take different forms while maintaining the principles of adequacy, balance, moderation, and diversity (Food and Agriculture Organization of the United Nations & World Health Organization, 2024; World Health Organization, 2026).

In conclusion, nutritional archaeology does not provide a direct prescription for preventing or treating chronic diseases. Instead, it offers a long-term perspective that helps situate modern diets and food systems within human history. Evaluating archaeological findings alongside modern epidemiological and clinical evidence may facilitate a more comprehensive understanding of contemporary nutritional problems within the historical transformation of human diets.

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Generative Artificial Intelligence Use: Figure 1 was generated using ChatGPT's image-generation tool (OpenAI) for the purpose of visually summarizing the historical transformation of human food systems. The author subsequently reviewed and edited the figure for scientific accuracy, relevance, and consistency with the manuscript and assumes full responsibility for its final content.

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