

Supernutrition: The Golden Key to Smart Foods and Natural Health

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Abstract

[Objective] Analyze and construct a new paradigm for nutrition and health research guided by Super Nutrition Theory, with smart food as the vehicle, artificial intelligence (AI) as the means, and precision nutrition as the pathway. [Methods] Through literature review, and based on analyzing the limitations of applying traditional nutrition theory to guide modern nutrition and health practices, we propose Super Nutrition Theory, expound its core tenets, and propose a construction pathway for nutrition and health. [Results] Super Nutrition Theory is a nutrition theory with scientificity as its connotation and universality, prospectivity, pleasantness, and rationality as its extension, serving as the theoretical forerunner for developing smart foods characterized by safety, quality, affordability, necessity, and palatability. [Limitations] The construction of modern food nutrition and health data systems involves interdisciplinary integration of food science, medicine, AI, and other fields, and the practice of Super Nutrition Theory requires multi-sectoral, interdisciplinary, and cross-domain collaboration. [Conclusion] Super Nutrition Theory proposes, for the first time, a four-level nutrition structure based on digital representation, providing an implementation pathway for introducing modern AI technology to achieve precision nutrition and intelligent health management.

Full Text

Preamble

Super Nutrition: The Golden Key to Unlocking Smart Food and Natural Health

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[Objective] To analyze and construct a new paradigm for nutrition and health research guided by super nutrition theory, with smart food as the implementation vehicle, artificial intelligence (AI) as the enabling tool, and precise nutrition as the targeted pathway. **[Methods]** Through literature review and analysis of the limitations inherent in applying traditional nutrition theory to modern nutrition and health practices, this paper proposes the super nutrition theory, elaborates its core tenets, and outlines implementation pathways for nutrition and health improvement. **[Results]** Super nutrition is a theoretical framework that takes scientific rigor as its connotation and universality, perspectiveness, enjoyability, and reasonability as its extension. It serves as the theoretical precursor for developing smart foods characterized by safety, quality, affordability, essentiality, and palatability. **[Limitations]** Constructing modern food nutrition and health data systems requires interdisciplinary collaboration across food science, medicine, AI, and other fields, while implementing super nutrition theory demands multi-departmental, cross-disciplinary, and cross-sectoral cooperation. **[Conclusions]** For the first time, super nutrition theory proposes a primary-to-quaternary nutritional structure framework based on digital characterization, providing an implementation pathway for introducing modern AI technology to achieve precise nutrition and intelligent health management.

Keywords: Nutrition, Food, Health, Digital characterization, Artificial intelligence

1. Background of Super Nutrition

As socioeconomic development progresses, the impact of diet on nutritional health has garnered increasing international attention. A 2019 *Lancet* study systematically analyzed dietary risks across 195 countries from 1990 to 2017, revealing that in 2017, 11 million deaths and 255 million disability-adjusted life years were attributable to dietary risk factors such as high sodium, high trans fats, low whole grains, low nuts, and low omega-3 fatty acids [?]. This research demonstrated that suboptimal diets cause more deaths globally than any other risk factor, including smoking [?, ?], highlighting the urgent need for dietary improvement worldwide [?].

Systematic evaluations of population-level dietary intervention effectiveness have identified several promising measures: mass media campaigns, food pricing strategies (subsidies and taxes), food and menu labeling, workplace wellness programs, and school procurement policies [?]. Cost-effectiveness analyses of these interventions indicate that targeting specific dietary factors like sodium yields both health benefits and cost savings. However, several major challenges confront efforts to improve diets through population-level interventions [?]. First, there is scarce evidence regarding the effectiveness of these measures for important dietary factors such as whole grains, nuts, and seafood. Second, most interventions produce effects far below what is required to achieve optimal

diets. Third, despite growing public and political will, few countries have successfully passed and implemented policies such as trans fat bans. Fourth, cost-effectiveness analyses typically rely on simplified assumptions that do not account for responses from consumers (e.g., substitution effects), the food industry (e.g., reformulation and pricing strategies), and other stakeholders. Fifth, many policies target only consumers without considering the broad, interconnected factors across the entire food system—such as food production, processing, and distribution—that also influence dietary consumption and are important to incorporate for effective dietary improvement [?].

Given the severe disease burden caused by diet and the limitations of existing interventions, developing new food system interventions is imperative. What are the underlying reasons for the suboptimal effectiveness of current interventions? Where should we focus when developing new interventions? These questions demand careful consideration. As consciousness determines action, and since the food system involves multiple actors—including producers, consumers, managers (policymakers), and scientific educators—each actor’s perception of and response to dietary interventions is shaped by education (e.g., understanding of diet-health relationships), economics (e.g., cost-benefit perceptions), and technology (e.g., control of processing risks). Unifying these diverse perspectives is crucial for developing new food system interventions. This paper takes health as its starting point, nutrition as its focal point, and food as its endpoint to analyze the limitations of traditional nutrition theory and propose super nutrition theory as a new theoretical reference for the cognition and decision-making of all actors in the food system.

2. Definition of Super Nutrition

Before proposing a formal definition of super nutrition, it is instructive to examine an interesting phenomenon: although over 40% of countries and regions worldwide have established dietary guidelines for their populations, global nutritional health status continues to undergo dramatic changes alongside economic and technological development [?]. First, both underweight (nutrient deficiency) and overweight (nutrient excess) represent two typical manifestations of malnutrition, with their prevalence closely correlated with economic status. Regarding nutrient deficiency, approximately 733 million people faced hunger globally in 2023—one in every eleven individuals—with one in five experiencing food insecurity in economically disadvantaged Africa [?]. Regarding nutrient excess, economic growth has been clearly shown to increase overweight and obesity rates [?]. An early study found that a 1% increase in income led to approximately 0.2%-0.3% higher prevalence of overweight or obesity [?], while a more recent survey revealed that improved economic status increased the odds of overweight or obesity by 14% [?].

Second, modern processing technologies have increased the availability of convenience foods containing excessive refined carbohydrates, oils, and sugars, which are considered primary culprits behind obesity [?]. The hyperlipidemia accompa-

nying obesity is recognized as a cause of atherosclerotic cardiovascular disease [?]. A 2020 *Nature* study discovered that although hyperlipidemia had been considered characteristic of affluent Western populations since the 1980s, the countries with the highest levels of non-HDL cholesterol—a key cardiovascular disease risk marker—shifted from high-income Western European nations in 1980 to middle-income Asia-Pacific nations in 2018 [?]. China, which had among the lowest non-HDL cholesterol levels globally in 1980, reached or exceeded levels of many high-income Western countries by 2018. From 1990 to 2017, deaths attributable to high non-HDL cholesterol decreased by 50% in Western countries (950,000 vs. 480,000), while increasing threefold in East Asia (250,000 vs. 860,000) and more than doubling in Southeast Asia (110,000 vs. 310,000) [?]. The decline in Western populations' blood lipid levels resulted partly from dietary improvements, particularly substituting unsaturated fats for saturated fats [?] and reducing trans fats [?], and partly from widespread use of cholesterol-lowering statin medications [?, ?, ?]. Conversely, compared to high-income Western countries, consumption of animal-source foods, refined carbohydrates, and palm oil increased substantially in East and Southeast Asia [?, ?, ?], while statin usage remained low [?, ?]. Increased animal-source food consumption signifies dietary structure changes driven by economic development, while rising refined carbohydrate and palm oil consumption reflects the substantial impact of food processing on dietary composition.

This analysis reveals that ideal pagoda-style dietary structures rarely form naturally in either economically underdeveloped or developed countries, primarily for three reasons. First, economic constraints limit dietary choices. In economically disadvantaged contexts, the key consideration is obtaining sufficient calories at low cost, leading to plant-based carbohydrate-dominant diets with insufficient animal fats and proteins. For example, in 1982, Chinese residents derived 66.2% of energy from carbohydrates and only 22% from fats; after more than three decades of rapid economic development, by 2012, the carbohydrate energy ratio decreased to 55.0% while the fat energy ratio increased to 32.9% [?]. Second, there is a lack of scientific nutrition and health concepts. In affluent economies, “tastiness” becomes the key criterion for “eating well,” resulting in diets with drastically reduced plant-based carbohydrates and severely excessive animal fats [?, ?, ?]. In Africa, overweight/obesity is considered a symbol of prosperity and wealth [?], with South Africa' s obesity rate rising significantly from 23.5% in 2008 to 27.2% in 2012, making it the most obese country in sub-Saharan Africa since 2012 [?, ?]. Socio-cultural, environmental, and behavioral factors, including socioeconomic status, likely explain South Africa' s high obesity prevalence [?, ?]. Third, there is a lack of scientific processing. From the industrial perspective, convenience foods composed of excessive refined carbohydrates, oils, and sugars, while satisfying consumer demands for taste, convenience, or low price, feature monotonous nutritional structures that increase disease risks from dietary imbalances or unsafe factors [?, ?]. From the household cooking perspective, most foods in dietary pagodas are listed as raw ingredients, and even when based on identical recommended ingredients, dishes

prepared by different households vary in composition and taste. Combined with individual picky eating habits at the table, family members' actual nutrient intake often diverges substantially from dietary guidelines. Due to unreasonable nutritional structures, global obesity rates have risen from 12.1% in 2012 to 15.8% in 2022 [?], with over one billion people aged five and older currently obese worldwide, projected to exceed 1.12 billion adults by 2030 [?].

In summary, individual nutritional health status fundamentally depends on the quality and quantity of consumed foods, while economics (e.g., purchasing power), cognition (e.g., nutrition and health concepts), and processing (e.g., cooking methods) constitute the primary practical factors influencing food quality and quantity. Theoretically, ensuring health requires improving food quality and controlling quantity; practically, economic development and scientific processing are the main levers for promoting healthy diets. This necessitates scientifically and accurately defining what constitutes high-quality, optimal-level, and healthy foods. Unfortunately, traditional nutrition primarily investigates relationships between food components and nutritional health but rarely explores connections between processing and economic factors and nutritional health, highlighting the limitations of applying traditional nutrition theory to modern nutrition and health practices. Super nutrition aims to transcend the cognitive scope and theoretical limitations of traditional nutrition by systematically studying and elucidating relationships among food nutrition, processing, economics, and health. Its primary task is to answer five “what” questions (what should be eaten, what can be eaten, what is worth eating, what is liked to be eaten, and what is willing to be eaten) and solve one “problem” (the nutrition and health problem).

3. Five Characteristics of Super Nutrition

Abstractly, super nutrition is a nutritional theory that takes scientific rigor as its connotation and universality, perspectiveness, enjoyability, and reasonability as its extension (Figure 1 [Figure 1: see original paper]).

3.1 Scientificalness

Scientificalness aims to reveal the nutritional essence of dietary phenomena. Nutrients represent the most critical keyword embodying dietary scientific rigor in human societal development to date. Food serves as the carrier of nutrients, nutritional status manifests whether nutrients are sufficient and balanced, and disease is the inevitable result of chronically poor nutritional status. The relationship between diet and health is primarily analyzed and summarized through the lens of nutrients. As science and technology advance, nutrients required by the human body are continuously discovered and analyzed, much like proteins expressed by DNA, driving continuous development in nutrition science. Currently, confirmed essential nutrients for humans are classified into six major categories; aside from water, macronutrients like proteins and lipids are further subdivided into numerous pure nutrients such as amino acids and fatty acids.

Since the 19th century, 19 scientists have received Nobel Prizes for vitamin research, further demonstrating the core value of nutrients in nutrition science development. Therefore, nutrients constitute the core of dietary scientific rigor and the cornerstone for solving nutrition and health problems. The goal of super nutrition's scientificity is to address the question of "what should be eaten," with the fundamental requirement being to focus on discovering nutrients and their functions and analyzing how nutrients regulate health.

3.2 Universality

Universality refers to providing essential nutrients required by the human body. After clarifying "what should be eaten," identifying what can provide needed nutrients becomes the main pathway to solving nutrition and health problems. We collectively term foods that provide nutrients as "nutrient sources." Various agricultural products are well-known nutrient sources. However, each nutrient source exhibits both commonality and individuality in nutrient provision. Commonality is reflected in many foods containing multiple nutrients needed by the human body, while individuality is manifested in significant differences among nutrient sources regarding nutrient and non-nutrient content, particularly the common scenario where one nutrient category is abundant while others are scarce. For example, rice primarily provides carbohydrates like starch but contains only small amounts of essential amino acids, whereas meat mainly provides proteins, amino acids, and fatty acids but cannot satisfy carbohydrate requirements. Beyond nutrient content differences, nutrient digestibility also represents an individuality factor. Generally, plant foods containing lignin and other cell wall components have lower digestibility than animal proteins. The phrase "suitable for all ages" affirms nutrient source commonality, while "not suitable for elderly or children to eat much" reflects recognition of nutrient source individuality. When several nutrient sources are combined to fully meet macro- and micronutrient needs, optimal balance between commonality and individuality is achieved. Dietary diversification is currently the main measure for balancing nutrient source commonality and individuality, with "optimizing and promoting dietary plans for safe and nutritious agricultural product combinations for specific populations" listed as a key direction in national agricultural science and technology innovation priority areas (2024–2028). Nutrient-fortified foods represent an important means to solve this balance.

Precision nutrition, also known as personalized nutrition, is a refined nutrition and health approach targeting specific individuals. Personalized nutrition reflects nutritional individuality, while population nutrition reflects nutritional commonality. Developmentally, population nutrition forms the foundation for personalized nutrition, which in turn supplements population nutrition. Whether personalized or population-based, nutrition essentially represents the balance between nutrient source commonality and individuality. Therefore, the goal of super nutrition's universality is to address "what can be eaten," with the fundamental requirement being to focus on nutrient source development, using

appropriate nutrient ratios as the key principle to transform “what should be eaten” into “what can be eaten,” thereby promoting balance between nutrient source commonality and individuality.

3.3 Perspectiveness

Perspectiveness refers to meeting long-term health nutritional needs. The higher proportion of overweight/obese populations in developed or affluent countries [?, ?] fully demonstrates that being full and eating well does not equate to eating right. Only when both satiety and quality are achieved can value be obtained. Satiety is subjective, resulting from quantitative food intake, perceptible to consumers in the short term, and represents an individual characteristic; eating well is objective, resulting from qualitative food improvement, requiring long-term scientific evaluation, and represents a population characteristic. Why do people still become sick when eating “what can be eaten” ? The purpose of eating “what can be eaten” is to intake “what should be eaten.” For “what should be eaten,” appropriate intake quantity is the critical issue, necessitating scientifically formulated nutritional recipes based on human needs. We define the composition of daily food intake as dietary structure. Differences in dietary structure appear as variations in nutrient sources but essentially reflect differences in nutrient types and content. Monotonous nutritional structures composed of few food types often fail to balance nutrient source commonality and individuality, thereby increasing dietary risks and disease burdens [?]. A recent review published in *Cell* further supports this view, proposing a “longevity diet” strategy requiring primarily non-refined plant-based foods, with carbohydrates, proteins, and fats comprising 45%-60%, 10%-15%, and 25%-35% of total dietary energy, respectively, reinforcing the importance of non-refined and plant-based sources [?].

A 2019 *Lancet* study indicated that major dietary risk factors causing human mortality include diets high in sodium and low in whole grains, fruits, nuts and seeds, vegetables, and omega-3 fatty acids, each contributing to over 2% of total deaths [?]. However, the efficacy of fish oil as a dietary supplement for preventing cardiovascular disease has long been controversial. Synthesizing multiple studies [?] reveals an interesting paradox: “deficiency is harmful, supplementation is not beneficial” [?]. This paradox reflects the complexity of nutrition-health relationships [?] while highlighting the importance of nutritional perspectiveness—certain nutrient deficiencies may not show obvious health impacts in the short term but must not be lacking from early childhood, otherwise cumulative damage becomes irreversible. Supporting this, habitual marine fish consumption places Japan’s “low omega-3” ranking at 14th among 15 global dietary risk factors [?]. Conversely, China’s marine fish consumption is much lower, especially in inland regions, ranking China’s “low omega-3” 5th among these risk factors. Notably, aside from differing “low omega-3” rankings, the top eight dietary risk factor rankings are nearly identical between China and Japan. Given the strong negative correlation between marine fish consumption

and cardiovascular disease [?, ?], differences in omega-3 fatty acid intake may largely explain why China (0.299%) and Japan (0.069%) rank highest and lowest, respectively, among the world's 20 most populous countries in diet-related cardiovascular disease mortality [?]. Besides often overlooking specific nutrient deficiencies (e.g., omega-3 fatty acids), the health impacts of excessive nutrient intake are also easily dismissed early on, as obesity complications like hypertension and diabetes typically emerge only after years of sustained obesity [?]. Therefore, the goal of super nutrition's perspectiveness is to address "what is worth eating," with the fundamental requirement being to focus on nutritional structure regulation, using nutritional formulation as the lever and appropriate nutrient intake as the key principle to transform "what can be eaten" into "what is worth eating," thereby mastering the balance between satiety (quantitative change) and quality (qualitative change).

3.4 Enjoyability

Enjoyability refers to meeting people's aesthetic (preference) needs. Fundamentally, food choices determine the nutrients and other substances that build and maintain our bodies, with "liking" identified as the most influential factor affecting food selection [?]. "Perfect color, aroma, and taste" has always been humanity's pursuit of food aesthetics. Since discovering fire, eating cooked meat not only promoted human brain and intellectual development but also enabled appreciation of enhanced flavor. The transition from raw to cooked represented a major breakthrough in food processing, demonstrating processing's unique charm in improving flavor, texture, and nutritional value. Although studies have shown excessive consumption of red and processed meat is harmful [?, ?, ?], many consumers remain personally, socially, and culturally attached to their meat-eating habits, which persist in supermarkets, menus, and social gatherings [?]. However, processing risks cannot be ignored. For example, polycyclic aromatic hydrocarbons generated during charcoal grilling pose carcinogenic risks [?]. To achieve attractive appearance or stable flavor and texture, processing of cakes, chips, popcorn, and other fried foods often involves hydrogenated vegetable oils rich in trans fats [?], whose cardiovascular disease risks are well-documented [?]. Potential health risks from producers using non-natural additives to improve color or flavor have become widespread consumer concerns [?]. Over-processing also causes nutrient losses: when grains (including rye, wheat, barley, corn, and sorghum) are milled into more or less refined fractions, 70%-80% of vitamins are lost during milling [?], and Maillard reactions during excessive heating cause severe losses of essential amino acids like lysine and leucine [?, ?]. "Developing digital characterization technologies for agricultural product quality and multi-dimensional full-component moderate processing technologies" has been listed as a key direction in national agricultural science and technology innovation priority areas (2024-2028).

Thus, harmful substance generation or beneficial substance loss during processing increases food health risks, while harmful substance reduction [?] or benefi-

cial substance increase [?] enhances food health quality. Therefore, the goal of super nutrition's enjoyability is to address "what is liked to be eaten," with the fundamental requirement being to focus on processing methods, using appropriate processing as the key principle to transform "what is worth eating" into "what is liked to be eaten," thereby reconciling the balance between aesthetics and risk.

3.5 Reasonability

Reasonability refers to meeting different populations' needs for fair and reasonable consumption. Recognizing value and affording cost are objective consumer demands for quality foods. In reality, some foods (nutrient sources) remain unpopular due to limited production regions or high costs, leading to deficiencies in certain essential nutrients. For example, marine foods have low consumption in inland areas due to high cold-chain logistics requirements, cross-regional transportation costs, and substantial losses. Although refined fish oil can supplement EPA and DHA omega-3 fatty acids, its high price and consumption burden hinder widespread promotion. First, oral fish oil provides no enjoyment and requires extra effort. Second, whether long-term consumption of fish oil "microcapsules" harms health remains unclear [?]. The Chinese government's tax exemptions and subsidies for agricultural products not only ensure supply of staple foods like pork and vegetables but also create conditions for researchers to enrich sources of affordable, nutritious foods through scientific and technological innovation. For instance, developing omega-3 fatty acid-enriched pork provides a new pathway to address omega-3 fatty acid deficiency in inland regions [?], enabling consumers to obtain essential nutrients economically while maintaining original dietary habits. Beyond economic drivers of consumption willingness, practice shows that although the "longevity diet" strategy recommends plant-based proteins and fats [?], diets do not automatically shift to lower animal protein and higher plant protein structures [?, ?]. This analysis indicates that enhancing food value (particularly health value) remains an ongoing challenge. Therefore, the goal of super nutrition's reasonability is to address "what is willing to be eaten," with the fundamental requirement being to focus on cost control and value enhancement, using balanced cost-value equivalence as the key principle to transform "what is liked to be eaten" into "what is willing to be eaten," thereby guiding development of high-quality, reasonably priced foods.

Integrating the five characteristics of super nutrition and their corresponding nutrition and health problems, we understand that nutrients are the direct substances exerting nutritional effects, nutrient sources are carriers providing nutrients, nutritional formulation determines ideal nutrient intake, and diet (processed foods) determines actual nutrient intake. Therefore, various nutrients and their respective levels required by humans can be defined as nutrition's primary structure; all nutrients and their corresponding levels and other substances contained in nutrient sources and present in nutritional formulation can be defined as secondary and tertiary structures, respectively; all nutrients and

their available levels and other substances present in diet (processed foods) can be defined as the quaternary structure (Figure 2 [Figure 2: see original paper]). Nutrition's primary through quaternary structures respectively encompass questions of "what should be eaten," "what can be eaten," "what is worth eating," and "what is liked and willing to be eaten" (Figure 1A).

On one hand, this definition scientifically reflects the physical, chemical, or biological transformation relationships from nutrients to diet and from diet to nutrients (Figure 2). Briefly, developing nutrient sources based on traditional agricultural products or through modern biological breeding or synthetic biology is key to transforming nutrition from primary to secondary structure; nutritional formulation—balancing nutrient source commonality and individuality—is key to transforming secondary to tertiary structure; processing according to food choice motivation factors (e.g., preference, cost, value) is key to transforming tertiary to quaternary structure; and intake, digestion, absorption, and metabolism are key to transforming quaternary back to primary structure. This paradigm facilitates identifying which "other substances (known non-nutrients)" are incorporated into nutrient sources, nutritional formulation, or diet, enabling discovery, utilization, and timely control of beneficial substances (functional components) and harmful substances. On the other hand, adopting this definition completely digitizes the nutrient delivery chain from nutrient sources to the human body, creating a new research paradigm for constructing food nutrition and health data systems and providing an implementation pathway for introducing modern AI technology to achieve precise nutrition and intelligent health management.

4. Theoretical Perspectives of Super Nutrition

4.1 Contradiction Viewpoint

Super nutrition theory employs a contradiction perspective to identify major misconceptions in consumers' understanding of dietary health issues. First, recognition of nutrient source commonality and individuality remains at the phenomenological level without penetrating essence. For example, comparing rice and red meat, ordinary consumers recognize their commonality as both filling the stomach and their individuality as meat being tastier or more satiating, yet remain unaware that satiety's essence lies in carbohydrates (rice's main nutrient), proteins, and fats (red meat's main nutrients) all providing energy through catabolism; tastiness's essence lies in meat's amino acids and fatty acids as flavor substances; and satiation's essence lies in proteins and fats having higher energy density than carbohydrates. Second, "low cost and satiety" has become the key measure of cost-value equivalence, and "tastiness" the key measure of "eating well," ignoring the hidden risks of essential nutrient deficiencies in low-cost foods and safety risks implied by "tastiness." Influenced by these one-sided views, consumption of excessive refined carbohydrates, oils, and sugars has increased, with these foods considered primary causes of modern obesity [?]. Therefore, super nutrition theory uses "scientificity" to identify that diet's essence is nutrient intake, and through "universality," "perspective-

ness,” “enjoyability,” and “reasonability” identifies four key points for achieving scientific diets: balancing commonality and individuality in nutrient sources, balancing satiety and quality in dietary structure, balancing aesthetics and risk in processing, and balancing cost and value in economics.

4.2 Connection Viewpoint

Super nutrition theory employs a connection perspective to analyze how interactions between nutrients and the human body and between consumers and producers regulate dietary health status (Figure 1B). Given that nutrients are the core of nutritional scientificity and the heart is the core of human life, we can metaphorically use the heart to represent nutritional scientificity. Since food choices are made by hands, which also typify commonality and individuality, we can use balanced left and right hands to represent nutritional universality. Since satiety, tastiness, and cost-effectiveness are perceived and analyzed by the brain—where satiety is controlled by hypothalamic neural centers (located in the brain’s central region) [?], emotions (e.g., liking) are primarily controlled by the right brain’s affective consciousness area [?], and logic (e.g., cost analysis) is primarily controlled by the left brain’s rational consciousness area [?]—we can metaphorically center on the heart position (symbolizing scientificity) and represent nutritional reasonability, perspectiveness, and enjoyability through balances formed by the brain’s left, central, and right regions between instinctual awareness (“cost,” “satiety,” “aesthetics”) and opposing awareness (“value,” “quality,” “risk”) during nutrient reasoning or perception (Figure 1B). This illustration can vividly explain how super nutrition’s five characteristics are internally connected with scientificity as connotation and universality, perspectiveness, enjoyability, and reasonability as extension. To more intuitively demonstrate these interconnections, we can conceptualize the human heart as the center of the “equator,” revealing that features north of the “equator”—“commonality,” “cost,” “satiety,” and “aesthetics”—are easily perceived by consumers in the short term, representing nutrient sources’ explicit characteristics where consumer agency dominates (e.g., tastiness is consumer-determined, requiring producers to passively meet demand). Conversely, features south of the “equator”—“individuality,” “value,” “quality,” and “risk”—are not easily perceived by consumers in the short term (e.g., dietary quality requires time to manifest), representing nutrient sources’ implicit characteristics where producer agency dominates because producers must actively improve these features to meet consumer health needs. Producers can only satisfy consumers by understanding their needs, while actual consumption patterns feedback to producers, influencing food reproduction. Thus, producers and consumers form a unified yet opposing whole.

4.3 System Viewpoint

Super nutrition theory employs a systems perspective to organically integrate contributions and pathways of various actors in the food system to human di-

etary health. If nutrient sources' explicit characteristics are considered "yang" factors affecting consumer nutrition status, their implicit characteristics are "yin" factors. Based on this, nutrition issues can be further abstracted as "yin-yang" problems, where the "white" and "black" elements in the Taiji diagram respectively symbolize the "phenomenon" and "essence" of scientificity (Figure 1C). Food system actors' grasp of nutritional scientificity can be analogously understood as follows: if the white "yang" side represents consumers, the black "yin" side represents producers (Figure 1D). The dialectical unity between food producers and consumers necessitates actors who can stand both in consumers' and producers' shoes to identify and solve humanity's dietary health problems. Who are these actors? They are managers and scientific educators who formulate policies. Retaining a bit of black in the "yang" side and a bit of white in the "yin" side not only reflects the interpenetrating relationship between producers and consumers but also represents the special roles played by managers and scientific educators in the food system (Figure 1D). Abstracting nutrition issues as "yin-yang" problems further highlights the significant impact and profound meaning of interactions among producers, consumers, managers, and scientific educators on population nutritional health status during the process of grasping nutritional scientificity. Therefore, super nutrition applies yin-yang theory to scientifically explain the new nutrition and health theory, vividly depicting role positioning for ensuring nutritional health and establishing pathways through which food system actors contribute to nutrition and health, thereby transcending traditional nutrition theory's limitations. Overall, consumers grasp food quality and quantity through cognition and choice, producers ensure food quality and quantity through cognition and processing, managers control food quality and quantity through laws and policies, and scientific educators enhance food quality and quantity through research. Cognition depends on education, choice depends on economic strength and value recognition, processing depends on technology, and research and management depend on talent. Thus, super nutrition theory provides a theoretical foundation for unifying education, science, and talent as an integrated "trinity" in the food industry and for organically integrating "government, industry, academia, research, and application." Popularizing super nutrition theory can enhance food system actors' cognitive height, breadth, and depth regarding dietary health issues, strengthen their nutrition and health awareness and social responsibility, foster a social atmosphere where everyone discusses, understands, and applies science, and promote more open-minded thinking, vision, and active collaboration to solve humanity's shared dietary health challenges.

4.4 Practice Viewpoint

Super nutrition theory employs a practice perspective to identify pathways for scientifically achieving dietary health. Super nutrition theory is the theoretical precursor for developing nutrition and health foods. Given that product health and safety [?], nutritional value [?, ?, ?], taste [?, ?], and risk perception [?] are identified as the most prominent drivers of food choice [?], agreeable foods rep-

resent the bond for harmonious coexistence between consumers and producers. Foods produced under super nutrition theory theoretically possess five characteristics: safety, quality, affordability, essentiality, and palatability. Safety means levels of known risk factors comply with recognized standards (e.g., compliance for hazardous substances and specific nutrient content). Quality means possessing excellent intrinsic quality (e.g., health quality) and extrinsic quality (e.g., sensory quality). Affordability means fair and reasonable pricing that meets different populations' consumption needs. Essentiality means containing appropriate proportions of essential nutrients. Palatability means optimal physical and chemical properties perceived through touch and taste. Safety, affordability, essentiality, and intrinsic quality are quantitatively described rational indicators, while palatability and extrinsic quality are qualitatively described perceptual indicators, embodying the combination of rationality and perceptibility, quantitative and qualitative measures. Using the English initials of safety, quality, affordability, requirement, and tasty, foods produced under super nutrition theory can be named Smart foods. Smart foods' five characteristics organically transform and apply super nutrition theory' s five goals of "should eat (essential), can eat (safe), worth eating (quality), like to eat (palatable), and willing to eat (affordable)," achieving theoretical-practical integration (Figure 1E).

In conclusion, super nutrition theory, following the cognitive logic of nutrients \rightarrow nutrient sources \rightarrow nutritional formulation \rightarrow diet, for the first time proposes and defines primary-to-quaternary nutritional structures based on digital characterization and organically integrates processing and economics—two major macro elements—into nutrition theory' s scientific formulation, establishing their contributions to nutrition and health. Super nutrition theory' s proposal creates a new research paradigm for constructing food nutrition and health data systems and provides an implementation pathway for introducing modern AI technology to achieve precise nutrition and intelligent health management. Under super nutrition theory, producing Smart foods aims to enable consumers to adequately intake all essential nutrients under conditions of safety, quality, fair pricing, and deliciousness. Only under super nutrition theory can Smart foods be produced, and only with Smart foods can natural health be achieved. Therefore, super nutrition is the golden key to unlocking Smart foods and natural health.

References

- [1] GBD 2017 Diet Collaborators. Health effects of dietary risks in 195 countries, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet* 393,1958-1972 (2019).
- [2] GBD 2013 Risk Factors Collaborators, Forouzanfar MH, Alexander L, et al. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 386, 2287-323 (2015).

- [3] GBD 2015 Risk Factors Collaborators. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 388, 1659–724 (2016).
- [4] FAO, IFAD, UNICEF, WFP and WHO. The State of Food Security and Nutrition in the World 2023. Urbanization, agrifood systems transformation and healthy diets across the rural-urban continuum. Rome, FAO. <https://doi.org/10.4060/cc3017en> 2023.
- [5] Islam, A. N. M. S. et al. The global burden of overweight-obesity and its association with economic status, benefiting from STEPs survey of WHO member states: A meta-analysis. *Prev. Med. Rep.* 46,102882 (2024).
- [6] Bu, T. et al. Relationship between national economic development and body mass index in chinese children and adolescents Aged 5–19 from 1986 to 2019. *Front. Pediatr.* 337 (2021).
- [7] Ferretti, F. & Marian, M. Simple vs. complex carbohydrate dietary patterns and the global overweight and obesity pandemic. *Int. J. Environ. Res. Public Health.* 14,1174 (2017)
- [8] Seydel, G. S. et al. Economic growth leads to increase of obesity and associated hepatocellular carcinoma in developing countries. *Ann. Hepatol.*, 15, 662-672 (2016)
- [9] Bradley,P. Refined carbohydrates, phenotypic plasticity and the obesity epidemic, *Medical Hypotheses* 131, 109317 (2019)
- [10] Wali, J. A. et al. Determining the metabolic effects of dietary fat, sugars and fat-sugar interaction using nutritional geometry in a dietary challenge study with male mice. *Nat. Commun.* 14, 4409 (2023)
- [11] Arshad, S. et al. Replacement of refined sugar by natural sweeteners: focus on potential health benefits. *Heliyon* 8, e10711 (2022)
- [12] Powell-Wiley, T. M. et al. Obesity and Cardiovascular Disease: A Scientific Statement From the American Heart Association. *Circulation.* 143, e984-e1010 (2021)
- [13] NCD Risk Factor Collaboration (NCD-RisC). Repositioning of the global epicentre of non-optimal cholesterol. *Nature* 582, 73-77 (2020).
- [14] Bentham, J. et al. Multi-dimensional characterisation of global food supply from 1961 to 2013. *Nat. Food* 1, 70-75 (2020).
- [15] Miller, J. C. et al. Trends in serum total cholesterol and dietary fat intakes in New Zealand between 1989 and 2009. *Aust. N. Z. J. Public Health* 40, 263-269 (2016).
- [16] Eriksson, M. et al. Greater decreases in cholesterol levels among individuals with high cardiovascular risk than among the general population: the northern Sweden MONICA study 1994 to 2014. *Eur. Heart J.* 37, 1985-1992 (2016).
- [17] Arnett, D. K. et al. Twenty-year trends in serum cholesterol, hypercholesterolemia, and cholesterol medication use: the Minnesota Heart Survey, 1980-1982 to 2000-2002. *Circulation* 112, 3884-3891 (2005).
- [18] Houterman, S., Verschuren, W. M., Oomen, C. M., Boersma-Cobbaert, C. M. & Kromhout, D. Trends in total and high density lipoprotein cholesterol and their determinants in The Netherlands between 1993 and 1997. *Int. J.*

Epidemiol. 30, 1063–1070 (2001).

[19] Vartiainen, E., Laatikainen, T., Tapanainen, H. & Puska, P. Changes in serum cholesterol and diet in North Karelia and all Finland. *Glob. Heart* 11, 179–184 (2016).

[20] Micha, R. et al. Global, regional, and national consumption levels of dietary fats and oils in 1990 and 2010: a systematic analysis including 266 country-specific nutrition surveys. *Br. Med. J.* 348, g2272 (2014).

[21] Leth, T., Jensen, H. G., Mikkelsen, A. A. & Bysted, A. The effect of the regulation on trans fatty acid content in Danish food. *Atheroscler. Suppl.* 7, 53–56 (2006).

[22] Kypridemos, C. et al. Quantifying the contribution of statins to the decline in population mean cholesterol by socioeconomic group in England 1991 - 2012: a modelling study. *PLoS ONE* 10, e0123112 (2015).

[23] Ford, E. S. & Capewell, S. Trends in total and low-density lipoprotein cholesterol among U.S. adults: contributions of changes in dietary fat intake and use of cholesterol-lowering medications. *PLoS ONE* 8, e65228 (2013).

[24] He, Y. et al. The dietary transition and its association with cardiometabolic mortality among Chinese adults, 1982–2012: a cross-sectional population-based study. *Lancet Diabetes Endocrinol.* 7, 540–548 (2019).

[25] Wolmarans, P. Background paper on global trends in food production, intake and composition. *Ann. Nutr. Metab.* 55, 244–272 (2009).

[26] Roth, G. A. et al. High total serum cholesterol, medication coverage and therapeutic control: an analysis of national health examination survey data from eight countries. *Bull. World Health Organ.* 89, 92–101 (2011).

[27] Zhang, M. et al. Prevalence of dyslipidemia and achievement of low-density lipoprotein cholesterol targets in Chinese adults: a nationally representative survey of 163,641 adults. *Int. J. Cardiol.* 260, 196–203 (2018).

[28] 杨慧霞 & 王俊平. 1982-2012 年中国居民膳食摄入变化. *食品工业* 41,244-248 (2020).

[29] Neema, S. et al. “Fat People Are More Respected” : Socio-Cultural Construction of Obesity and Overweight Risk & Prevention in Ugandan Communities. In: Falade, B., Murire, M. (eds) *Health Communication and Disease in Africa*. Palgrave Macmillan, Singapore. 2021.

[30] Sartorius, B. et al. Determinants of Obesity and Associated Population Attributability, South Africa: Empirical Evidence from a National Panel Survey, 2008-2012. *Plos One* 10, e0130218 (2015).

[31] Micklesfield, L.K. et al. Socio-cultural, environmental and behavioural determinants of obesity in black South African women. *Cardiovasc. J. Afr.* 24, 1–7 (2013).

[32] Alaba, O.A. & Chola, L. Prevalence of age-adjusted obesity in South Africa and the influence of social determinants: an ecological analysis. *Lancet* 381, S6 (2013).

[33] NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in underweight and obesity from 1990 to 2022: a pooled analysis of 3663 population-representative studies with 222 million children, adolescents, and adults. *Lancet* 403, 1027–50 (2024).

[34] Kelly, T. et al. Global burden of obesity in 2005 and projections to 2030.

Int. J. Obes. 32, 1431-1437 (2008)

[35] Yu, C.C. et al. The epidemiology of obesity. *Metabolism* 92, 6-10 (2019).

[36] Longo, V.D. & Anderson, R.M. Nutrition, longevity and disease: From molecular mechanisms to interventions. *Cell* 185, 1455-1470 (2022).

[37] Kromhout, D. et al. The inverse relation between fish consumption and 20-year mortality from coronary heart disease. *N. Engl. J. Med.* 312, 1205-1209 (1985).

[38] Ascherio, A., et al., Dietary intake of marine n-3 fatty acids, fish intake, and the risk of coronary disease among men. *N. Engl. J. Med.* 332, 977-982 (1995).

[39] Hu, F.B., et al., Fish and omega-3 fatty acid intake and risk of coronary heart disease in women. *JAMA* 287, 1815-1821 (2002).

[40] He, K., et al., Accumulated evidence on fish consumption and coronary heart disease mortality: a meta-analysis of cohort studies. *Circulation* 109, 2705-2711 (2004).

[41] Del Gobbo, L.C., et al., ω -3 Polyunsaturated Fatty Acid Biomarkers and Coronary Heart Disease: Pooling Project of 19 Cohort Studies. *JAMA Intern. Med.* 176, 1155-66 (2016).

[42] Roncaglioni, M.C., et al., n-3 fatty acids in patients with multiple cardiovascular risk factors. *N. Engl. J. Med.* 368, 1800-1808 (2013).

[43] Bowman, L., et al., Effects of n-3 Fatty Acid Supplements in Diabetes Mellitus. *N. Engl. J. Med.* 379, 1540-1550 (2018).

[44] Manson, J.E., et al., Marine n-3 Fatty Acids and Prevention of Cardiovascular Disease and Cancer. *N. Engl. J. Med.* 380, 23-32 (2019).

[45] Nicholls, S.J., et al., Effect of High-Dose Omega-3 Fatty Acids vs Corn Oil on Major Adverse Cardiovascular Events in Patients at High Cardiovascular Risk: The STRENGTH Randomized Clinical Trial. *JAMA* 324, 2268-2280 (2020).

[46] Bhatt, D.L., et al., Cardiovascular Risk Reduction with Icosapent Ethyl for Hypertriglyceridemia. *N. Engl. J. Med.* 380,11-22 (2019).

[47] 张东山. 鱼油预防冠心病?一个超级营养素如何在证明自己的道路上屡败屡战. 知识分子,2023. https://mp.weixin.qq.com/s?__biz=MzIyNDA2NTI4Mg==&mid=2655531620&idx=1&sn=00e82dacd6c6a

[48] Segula, D. Complications of obesity in adults: A short review of the literature. *Malawi. Med. J.* 26, 20-24 (2014)

[49] Ehrmantraut, L.E. et al. Self-selected diets: Exploring the factors driving food choices and satisfaction with dietary variety among independent adults. *Food Qual. Prefer.* 117, 105154 (2024).

[50] Onwezen, M.C. & Dagevos, H. A meta-review of consumer behaviour studies on meat reduction and alternative protein acceptance. *Food Qual. Prefer.* 114, 105067 (2024).

[51] Dyremark, A. et al. Polycyclic aromatic hydrocarbon (PAH) emissions from charcoal grilling. *Atmos. Environ.* 29, 1553-1558 (1995).

[52] Wongmaneepratip, W. & Vangnai, K. Effects of oil types and pH on carcinogenic polycyclic aromatic hydrocarbons (PAHs) in grilled chicken. *Food Control* 79, 119-125 (2017).

[53] Kim, H.J. et al. Effect of charcoal type on the formation of polycyclic

- aromatic hydrocarbons in grilled meats. *Food Chem.* 343, 128453 (2021).
- [54] Reming, V. et al. Trans fats in America: a review of their use, consumption, health implications, and regulation. *J. Am. Diet. Assoc.* 110, 585-592 (2010).
- [55] Esmailzadeh, A. & Azadbakht, L. Home use of vegetable oils, markers of systemic inflammation, and endothelial dysfunction among women. *Am. J. Clin. Nutr.* 88, 913-921 (2008).
- [56] Kummerow F.A. The negative effects of hydrogenated trans fats and what to do about them. *Atherosclerosis* 205, 458-465 (2009).
- [57] Allen, B. C. et al. Meta-regression analysis of the effect of trans fatty acids on low-density lipoprotein cholesterol. *Food Chem. Toxicol.* 98, 295-307 (2016).
- [58] Mahmud, N. et al. A review of different frying oils and oleogels as alternative frying media for fat-uptake reduction in deep-fat fried foods. *Heliyon* 9, e21500 (2023).
- [59] Hegedüs, M. et al. The influence of milling on the nutritive value of flour from cereal grains. 7. Vitamins and tryptophan. *Plant Foods Hum. Nutr.* 35, 175-180 (1985).
- [60] Tucker, B. W. et al. Loss of available lysine in protein in a model Maillard reaction system [Easily damaged by processing and/or storage of food, amino acids]. *Acs Symposium Series-American Chemical Society* 1983.
- [61] Nutritional Consequences of the Maillard Reaction. Amino Acid Availability from Fructose-leucine and Fructose-tryptophan in the Rat. *J. Nutr.* 103, 657-663 (1973)
- [62] Chen X. & Kitts D. D. Antioxidant and Anti-Inflammatory Activities of Maillard Reaction Products Isolated from Sugar-Amino Acid Model Systems. *J. Agric. Food Chem.* 59, 11294-11303 (2011).
- [63] Sun, Y. et al. Effects of n-3 polyunsaturated fatty acids and selenomethionine supplementation on physicochemical properties, oxidative stability and endogenous enzyme activities of fresh pork loin. *Food Chem.* X 101949 (2024).
- [64] Onwezen, M. C. et al. Social norms support the protein transition: The relevance of social norms to explain increased acceptance of alternative protein burgers over 5 years. *Foods* 11, 3413 (2022).
- [65] Anand, B. K. & Brobeck, J. R. Localization of a "feeding centre" in the hypothalamus of the rat. *Proc. Soc. Exp. Biol. Med.* 77, 323-324 (1951).
- [66] Lindell, A. K. Continuities in emotion lateralization in human and nonhuman primates. *Front. Hum. Neurosci.* 7, 464 (2013).
- [67] Corballis, M. C. Left Brain, Right Brain: Facts and Fantasies. *PLoS Biol.* 12, e1001767 (2014).
- [68] Bryant, C. & Barnett, J. Consumer acceptance of cultured meat: An updated review (2018-2020). *Appl. Sci.* 10, 5201 (2020).
- [69] Florença, S. G. et al. The motivations for consumption of edible insects: A systematic review. *Foods* 11, 3643 (2022).
- [70] Pakseresht, A. et al. Review of factors affecting consumer acceptance of cultured meat. *Appetite* 170, 105829 (2022).
- [71] Weinrich, R. Opportunities for the adoption of health-based sustainable dietary patterns: A review on consumer research of meat substitutes. *Sustain-*

ability 11, 4028 (2019).

[72] Mina, G. et al. The Potential Future of Insects in the European Food System: A Systematic Review Based on the Consumer Point of View. *Foods* 12, 646 (2023).

[73] Valli, C. et al. People' s Values and Preferences about Meat Consumption in View of the Potential Environmental Impacts of Meat: A Mixed-methods Systematic Review. *Int. J. Environ. Public Health* 20, 286 (2022).

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