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The Impact of Ultra-Processed Foods on Nutritional Quality, Food Safety and Human Health

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Abstract: The global consumption of ultra-processed foods (UPFs) has significantly increased, prompting growing concerns regarding their impacts on human health and food safety. This article reviews the potential risks of ultra-processed foods to human health, especially their effects on nutritional components, obesity, chronic diseases, and food safety. The article first summarizes nutritional alterations associated with ultra-processing, highlighting the loss of beneficial nutrients and their subsequent implications for public health. Next, it explores mechanisms through which UPFs contribute to obesity and discusses evidence linking their consumption to chronic conditions such as diabetes and cardiovascular disease. Furthermore, the review addresses critical yet underexplored food safety risks arising during UPF production and storage, including chemical contaminants and food additives. Notably, while considerable research has emphasized health outcomes related to UPFs, studies on food safety aspects remain limited. By addressing this research gap, this article provides a foundational basis for informed public policy formulation. Finally, the review emphasizes the necessity of comprehensive, longitudinal studies to fully understand the long-term health and safety implications of UPF consumption.

Keywords: Ultra-processed foods, nutritional components, human health, food safety, chronic diseases

1. Introduction

As global eating habits transition to convenience foods, the consumption of ultra-processed foods has risen sharply. This shift is closely related to a variety of health problems. Ultra-processed foods, produced through complex industrial technologies and containing many additives and processed ingredients, are highly dependent on large-scale industrial production processes, which not only prolongs their shelf life but also enhances their commercial appeal. However, behind this convenience lies a potential threat to human health. The concept of ultra-processed foods was first proposed by Brazilian scholar Carlos Monteiro in 2009 [1], referring to foods produced through sophisticated industrial techniques and incorporating numerous additives and processed ingredients. According to Monteiro's definition, ultra-processed foods refer to “foods produced through industrial processes, which are usually rich in large amounts of sugar, salt, unhealthy fats, and artificial additives and chemical preservatives to enhance flavor and extend shelf life, lacking the essence of natural foods” [2,3].

Ultra-processed foods are significantly different from unprocessed foods, minimally processed foods, and processed foods. Unprocessed foods are natural ingredients, while minimally processed

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and processed foods are foods that have been simply processed or have had a small amount of ingredients added (e.g., toasted bread and canned vegetables). Ultra-processed foods typically contain many unnatural ingredients, such as salt, sugar, and oil, and often no longer have the complete natural food components but are instead composed of processed raw materials and various chemicals [4,5]. For example, sweet and savory bagged snacks, candies and industrialized desserts, frozen foods, instant noodles, instant soups, and various sauces and seasonings [3], which are common ultra-processed foods, often lose most of their nutritional value during processing, and may even have additives that may be harmful to health.

The production model of these foods also greatly differs from traditional home cooking, as these foods depend heavily on large-scale industrial production processes, granting them a longer shelf life and higher commercial appeal [6,7]. In recent years, with rapid urbanization and the widespread adoption of modern lifestyles, the consumption of ultra-processed foods has shown explosive growth. According to global health data, the consumption of ultra-processed foods is closely related to a variety of health problems. According to research by Monteiro et al., the proportion of ultra-processed foods in the global food system has increased significantly, especially in high-income countries, where ultra-processed foods account for more than 50% of daily energy intake.

World Health Organization (WHO) data indicate that the prevalence of obesity and chronic diseases continues to rise in many countries, partly driven by increased consumption of ultra-processed foods [8]. The high incidence of chronic diseases such as obesity, cardiovascular disease, and diabetes has become a major public health challenge worldwide. In 2016, approximately 1.3 billion adults worldwide were obese, with most coming from high-income countries [9]. Furthermore, extensive evidence highlights that frequent consumption of ultra-processed foods contributes significantly to chronic diseases such as obesity, type 2 diabetes, cardiovascular diseases, and certain cancers [10]. Many studies have proven that ultra-processed foods usually contain high sugar, high salt, high fat, and low fiber, and long-term intake may lead to weight gain, fat accumulation, and dysfunction of internal organs [2]. However, research on the specific impact of ultra-processed foods on food safety is relatively limited. Food safety involves harmful components in food and pollution problems in the processing process. The processing of ultra-processed foods may introduce potential health hazards, such as the residue of harmful chemicals and the pollution of plastic particles [11]. Against this background, researching the impact of ultra-processed foods on health has become particularly important.

Therefore, this article aims to deeply analyze the impact of ultra-processed foods on human health and food safety by reviewing existing literature and exploring how to effectively reduce the consumption of ultra-processed foods and improve public health.

2. Nutritional degradation and public health implications

The impact of ultra-processed foods on nutritional components is multifaceted, primarily characterized by decreased nutrient density and the lack of micronutrients [12]. During ultra-processing, many vitamins, minerals, and fiber naturally present in whole ingredients are substantially diminished or entirely removed, leading to a significant reduction in the overall nutritional value of the resulting products. Ultra-processed foods have about 80% less fiber than unprocessed foods, while the content of added sugar is several times higher [2]. Taking wheat-based puffed snacks as an example, the refined processing causes the key micronutrients such as zinc (loss rate 32±5.1%), iron (28±4.7%), and vitamin B1 (41±6.3%) in the raw materials to be systematically stripped away. The performance of fruit UPFs is even worse: the industrial pulping process causes the dietary fiber loss rate of orange juice to reach 92%, and the thermal degradation rate of vitamin C is as high as 67%. This "nutritional hollowing" effect is particularly prominent in ready-to-eat

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foods - after a brand of canned vegetables is sterilized, the vitamin C and folic acid content decreases by 83% and 59% respectively (compared with fresh ingredients). This nutritional change increases the risk of dietary imbalance, which in turn causes health problems related to chronic malnutrition, especially among vulnerable populations.

This nutritional degradation forms a vicious cycle of public health vulnerability. Global nutrition monitoring shows that the UPF energy supply ratio of low-income families in Brazil is as high as 34.7% [7], which directly leads to an increase in the zinc intake deficiency rate of children aged 12-36 months to 41%. In sub-Saharan Africa, the average daily UPF consumption (385g) of urban slum residents is significantly positively correlated with the child stunting rate (32.1%). More seriously, the cheap nature of UPFs makes them the main carrier of food subsidy programs.

3. Ultra-processed foods and diseases

3.1. Obesity

3.1.1. Metabolic regulation imbalance mechanism of obesity

Ultra-processed foods (UPFs) induce fat accumulation through multiple physiological pathways. High fructose corn syrup (HFCS) inhibits the activity of POMC neurons in the arcuate nucleus of the hypothalamus (c-Fos expression ↓62%) while activating AgRP neurons, continuously stimulating the desire to eat. Trans fatty acids (such as hydrogenated vegetable oils) increase the rate of adipocyte differentiation by 2.8 times through the PPARγ/SREBP-1c pathway, while inhibiting the activity of CPT1A, a key enzyme for mitochondrial β-oxidation. Emulsifiers destroy the thickness of the intestinal mucus layer (reduced by 41±8.2 μm), triggering systemic inflammation mediated by the TLR4/MyD88 pathway (serum LPS ↑2.3 times), which in turn leads to hypothalamic leptin resistance (p-STAT3 signal ↓74%). This is the deep mechanism of the sudden increase in calorie intake in the Hall test.

3.1.2. The link between ultra-processed foods and obesity

Obesity has become a global public health problem, and the consumption of ultra-processed foods is one of the important factors in the obesity epidemic. Many studies have found that ultra-processed foods demonstrated that ultra-processed foods often contain high levels of sugars and unhealthy fats, and their high palatability can easily promote excessive consumption and overeating [13]. Due to intensive industrial processing, these foods are more readily absorbed, facilitating excessive caloric intake and subsequent weight gain, ultimately contributing to obesity [14]. Hall et al.'s randomized controlled trial showed that ultra-processed diets lead to an increase of about 500 kcal in daily calorie intake and cause a weight gain of nearly one kilogram within two weeks.

According to a study based on large-scale population data, the intake of ultra-processed foods significantly correlates with an increase in body mass index (BMI) [7]. For every 10% increase in the intake of ultra-processed foods, the risk of obesity increases by 15%. In addition, ultra-processed foods may also promote obesity by affecting the mechanisms of satiety and energy expenditure, increasing food intake and reducing energy expenditure [15-17].

3.2. Diabetes

Ultra-processed foods are related to not only obesity but also the occurrence of various chronic diseases [18]. Studies have shown that long-term intake of ultra-processed foods may lead to an increased risk of type 2 diabetes [19,20], cardiovascular disease [21], and cancer [2,22]. These

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chronic diseases collectively account for approximately 11 million deaths annually, representing 22% of global mortality. The core pathways of UPFs driving insulin resistance include adipose tissue dysfunction, liver metabolic hijack, and β-cell oxidative stress. The addition of sugar-induced adipocyte hypertrophy could trigger local hypoxia and macrophage infiltration and disrupt insulin receptor substrate 1 (IRS-1) phosphorylation.

In a multivariable Cox proportional hazards model for specific causes and corrected for known risk factors—including sociodemographic, anthropometric, lifestyle, medical history, and nutritional factors—Srour et al. found that a higher proportion of ultra-processed foods significantly correlated with an elevated risk of type 2 diabetes [23]. According to the research by Monteiro and his team, ultra-processed foods are significantly associated with weight gain, insulin resistance, and the occurrence of cardiovascular disease.

3.3. Other chronic diseases

Beyond obesity and diabetes, certain chemical additives in ultra-processed foods, such as artificial sweeteners and preservatives, may also have negative effects on health. Long-term exposure to these chemicals may increase the risk of cancer [24], allergic reactions, and neurological disorders [25]. He et al. confirmed through animal experiments and clinical studies that certain additives in ultra-processed foods can disrupt endocrine functions and are associated with various health problems. The high sugar, salt, and fat content of these foods are major risk factors for chronic diseases, and their high caloric density and lack of nutrients further exacerbate this problem [26]. Newly emerged hazardous substances (NEoHs) in UPFs exacerbate multi-organ lesions through advanced glycation end products, nanoplastic carrier effect, and microbial-host co-metabolism disorder. These mechanisms could lead to systemic chronic inflammation and organ damage in the long term.

4. The impact of ultra-processed foods on food safety

4.1. Food additives

Food safety refers to the absence of harmful substances in food during production, processing, transportation, and consumption, and that it will not harm human health when consumed. However, some harmful substances may be introduced during the production of ultra-processed foods, including chemical additives, preservatives, and pesticide residues. Although these additives are generally considered safe, excessive intake may pose potential health risks. For example, preservatives such as nitrates and nitrites, commonly used in processed meats, have been shown to elevate the risk of foodborne illnesses and chronic diseases [27]. Bouvard et al.'s research indicates that preservatives such as nitrates and nitrites in processed meats are associated with an 18% increased risk of colorectal cancer. Studies show that preservatives and artificial colors in some ultra-processed foods are related to the occurrence of health problems such as cancer and allergic reactions. Additionally, during food storage, transportation, and heating processes, these chemical additives may degrade or interact to form harmful substances, further exacerbating food safety risks [28, 29].

4.2. Byproducts produced during the production of UPF

Ultra-processed foods commonly undergo intensive manufacturing techniques, such as high-temperature heating and extrusion, which can lead to the formation of harmful byproducts and contaminants. For example, furan, a potentially toxic substance, is frequently detected in significantly higher concentrations—approximately two to three times higher— in industrial

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breakfast cereals, canned foods, and coffee. Although furan may be detected in home-cooked/baked foods (such as toast), especially in foods rich in carbohydrates, industrial processes are likely to lead to a significant increase in furan content [30]. The Food Safety Authority suspects that this substance is hepatotoxic and genotoxic.

4.3. Food contamination

In addition, ultra-processed foods carry an elevated risk of contamination during the manufacturing, packaging, and storage stages, posing a food safety risk. This risk of contamination underscores the importance of ensuring compliance with food safety standards during the processing and packaging of ultra-processed foods. And in ultra-processed foods, the detection rate of microplastics is as high as 70%. These pollutants enter the human body through the food chain and may pose a potential threat to health [31].

5. Discussion

Globally, the regulatory intensity and standards for ultra-processed foods need to be strengthened [32]. Although many additives have been approved by food safety authorities, their long-term effects on human health are still unclear. For example, certain artificial colors and preservatives may be associated with hyperactivity and allergic reactions in children. Researchers emphasize the need for more stringent testing and monitoring of food additives, especially given the growing concerns about their potential toxicity.

Studies have shown that ultra-processed foods may lead to nutritional imbalances, increase the risk of obesity and chronic diseases, and pose potential threats to food safety. However, there are still some gaps in the current research on ultra-processed foods, especially in terms of food safety, and more in-depth monitoring and research on harmful ingredients in these foods should be strengthened in the future. Monterio et al. suggest that governments should take measures such as taxation, labeling regulations, and public education to reduce the consumption of ultra-processed foods and promote the intake of natural foods.

6. Conclusion

This article, through a comprehensive analysis of ultra-processed foods, points out their multiple impacts on health and food safety. By reducing the intake of ultra-processed foods, the occurrence of obesity and chronic diseases can be effectively prevented, and food safety can be promoted. However, research on ultra-processed foods remains to be deepened, especially in terms of their impact on food safety, and future research should further on the potential risks in food processing and long-term health impacts and develop effective policies and interventions.

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