



(REVIEW ARTICLE)



Consumption of ultra-processed foods and their link with increasing risk of cancer

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Abstract

Food and Nutrition are both the keys which provide a Healthy Diet. At the end of the day, all the Human body needs are Proteins, Fats, Vitamins, Minerals and Carbohydrates. Maintaining their levels in the body is an important consideration for a Healthy Life. Their imbalance may cause various Diseases in the body. Ultra-Processed foods are industrially manufactured, generally they are ready-to-eat products, these products are high in added sugars, salt and/or Saturated Fatty Acids and they may contain cosmetic additives such as flavorings, colouring agents and emulsifiers. They may also contain some preservatives for their longer stability after packaging. Nowadays the Consumption of ultra-processed foods (UPF) is rapidly increasing around the world specially in middle-income countries. More consumption of these Foods causes various health problems such as Overweight and Obesity, which gives rise to many serious diseases including Cancer. As many Studies are Conducted to find out whether the consumption of these foods is linked with increased risk of cancer or not, and showed that increase in UPF consumption was associated with higher risk of mortality. Moreover, the theoretical substitution of Ultra-Processed Foods with unprocessed or minimum processed foods leads to a decrease in mortality. In this review, we had studied and highlighted the harmful effects of Ultra Processed foods and their link with serious diseases such as Cancer, also we had covered causes of Cancer linked with Foods and drinks.

Keywords: Ultra-Processed foods; Overweight; Diet; Obesity; Cancer; Food Processing

1. Introduction

Ultra-processed foods are defined as "formulas of food ingredients often changed by chemical procedures and then constructed into ready-to-consume hyper-palatable food and drink items utilising flavours, colours, emulsifiers, and other cosmetic additions." These foods include savoury nibbles, reconstituted meat products, precooked frozen dinner, and soft beverages [1]. At the same time, over the past few decades, obesity and other diet-related problems are progressively increased and have become one of the causes of serious diseases [2]. Ultra-processed foods provide on average 58% of daily energy and 89% of added sugars in the US diet [3]. The nutritional value of ultra-processed foods and their role in a healthy diet is controversial. Although these foods may contribute to the intake of several essential nutrients in the American diet, they are also more likely to be excessive in Saturated Fatty Acids, added sugar and Na compared with less processed foods [4,5,6]. Ultra-Processed Foods are foods to be of poorer nutritional quality.

According to WHO, vegetables, beans, nuts, seeds, and fruits are considered as healthy foods whereas salt, saturated fat, and excess sugar containing foods are considered as disease causing [7]. Population based studies conducted in several countries, most of them using national dietary intake surveys, have shown that ultra-processed foods are typically high-energy dense products which are high in sugar, unhealthy fats and salts, and they are low in dietary fiber, protein, vitamins and minerals [8,9]. These Foods also contains Refined carbohydrates which may not just lead to being

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overweight and diabetic but also contribute to dementia, mental illness, and cancer. Some Researches has also shown that excess calories shorten the lifespan, whereas moderate caloric restriction slows the aging process and protects the body and brain [10,11,12, 13].

A wide range of food additives (about 2,500 chemicals) have been used to improve the flavour, colour, consistency, quality, and price of meals. Every day, many individuals eat numerous food additives, which have both advantages and disadvantages. Food additives play a vital role in today's abundant and nutritional food sources, allowing people to enjoy a variety of nutritious, tasty, and safe foods throughout the year. Food additives have a variety of positive impacts on foods. However, food additives may contain several metabolites, such as monosodium glutamate and nitrous compounds that are found to be carcinogens [14].

As the global consumption of highly processed foods increases, understanding the health impact of these foods has become a serious topic. Results from highly processed foods may partly account for increasing trends in the incidence of non-communicable diseases, including cancer [15].

Cancer is a severe public health issue that affects all human communities. Unfortunately, it is a tissue-level variety illness, and this variation is a big problem for its particular diagnosis, followed by therapy efficacy. The prostate, lung and bronchus, colon and rectum, and urinary bladder have the largest percentages of cancer types in males, correspondingly. Breast, lung and bronchus, colon and rectum, uterine corpus, and thyroid cancer are the most common in women [16]. The high morbidity and mortality of cancer are related with the increasing prevalence of risk factors such as overweight, smoking, the increased aging and growth of the population [17].

The relationship between diet, nutrition, obesity and cancer has advanced in the last decades. In particular, malignancies of the digestive system, breast, prostate, and other organs are affected significantly by food and dietary components. The National Research Council (USA) Committee on Diet, Nutrition, and Cancer began investigating whether a high-fat diet was linked to an increased risk of cancer at various locations in the 1980s (particularly, breast, colon and prostate). Diet, nutrition, and obesity were found to have a significant effect in carcinogenesis. The effects of caloric intake, lipid type and amount (animal or vegetable), protein, red or processed meat, vitamins, minerals, fibre, and other dietary elements on the development of neoplasms have been examined. There is significant evidence relating the use of food products/items to higher occurrences of particular malignancies in human organs and body parts. Some common meals and beverages are classified as carcinogenic because they include natural toxins, adulterants, artificial colourants, additives, preservatives, and pesticide residues, among other undesirable/unavoidable chemicals/ingredients [18,19].

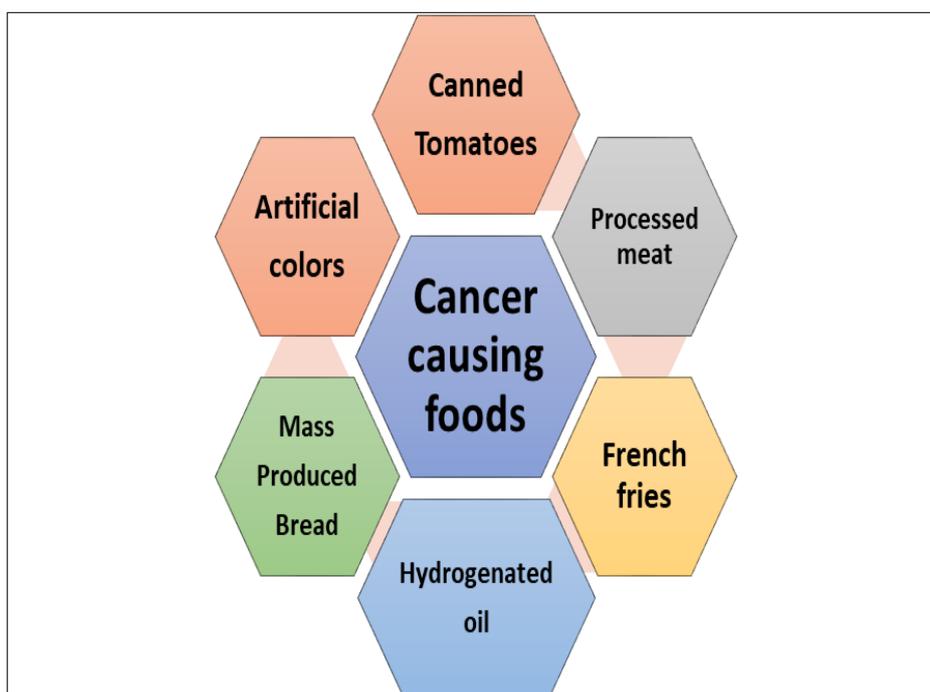


Figure 1 Cancer causing ultra-processed foods

Ultra-processed food and drinks includes package breads and buns; sweet or savoury packaged snacks, industrialized confectionery and desserts; sodas and sugar drinks; meat balls, poultry and fish nuggets, and other reconstituted meat products change with addition of preservatives other than salt (for example, nitrites); instant noodles and soups; frozen or shelf stable ready meals; and other food products made mostly or entirely from sugar, oils and fats, and other substances not commonly used in culinary preparations such as hydrogenated oils, modified starches, and protein isolates [20].

Processes include different preservation or cooking processes, as well as non-alcoholic fermentation in the case of breads and cheese. Other Processed Foods Includes Industrial processes like hydrogenation, hydrolysis, extruding, moulding, reshaping, and pre-processing by frying. Flavouring agents, colours, emulsifiers, humectants, non-sugar sweeteners, and other cosmetic additives are often added to these products [21].

The wide range of additives contained in ultra-processed foods are titanium dioxide (TiO₂), a common food additive that contains nanoscale particles. Titanium dioxide used as whitening agent and also used in packaging in contact with food or drinks to provide a better texture and antimicrobial properties [22]. Daily intake of titanium dioxide may be associated with an increased risk of chronic intestinal inflammation and carcinogenesis. Another issue to be concerned about is the production of carcinogenic nitrosamines in meats containing sodium nitrite when the meat is burned or overcooked. These N-nitroso compounds may be involved in risk of colorectal cancer [20]. Meat processing, such as overheating, curing and smoking, can result in formation of carcinogenic chemicals, which includes N-nitroso-compounds (NOC) and polycyclic aromatic hydrocarbons (PAH). These chemicals cause DNA damage and this proven that the consumption of processed meat is highly carcinogenic to human [23].

Ultra-processed food also increases the exposure to phthalates and bisphenols in industrial products. These chemicals used as packaging material. Phthalates and bisphenols are associated with verity of adverse effects on health related to their ability to disrupt the endocrine system and its endocrine disruptor properties led to the endocrine cancer [24].

1.1. Food processing classification system

The concept of ultra-processed food has been established as a result of technical advancements and an increase in the availability of highly processed foods (UPF). Epidemiological research increasingly uses classification systems for foods based on processing. Due to changes in the scope and purposes of food processing, new classification systems for foods have been developed. According to study report, the degree of processing, seven different food classification systems have been proposed by researchers worldwide.

All items were grouped into one of four groups: 1—non-processed or unprocessed or minimally processed food; 2—basic or primary processed food; 3—moderately processed food; 4—highly or ultra-processed food [25].

In 2007, the Mexican National Institute of Public Health (NIPH) proposed the first classification system [26]. In Europe the International Agency for Research on Cancer (IARC) researchers developed another one classification in 2009 using methodology devised for the European Prospective Investigation into Cancer and Nutrition (EPIC) study. To investigate the consumption of highly industrially processed foods in EPIC study, each reported food was recoded according to its degree of processing and was classified into three main categories.

Highly processed foods: Foods that have been industrially prepared, such as those from bakeries and catering businesses, and require no or little household preparation other than heating and cooking. Bread, cereals, cheese, commercial sauces, canned foods including jams, commercial cakes, biscuits, and sauces are examples.

Moderately processed foods: There are two groups of foods in this category. First, industrial and commercial foods that have undergone relatively minor processing and are consumed without further cooking, such as dried fruits, raw vacuum-packed or under controlled atmosphere foods (for example, salads), frozen basic foods, extra virgin olive oil, and fruits and vegetables canned in water/brine or in their own juice. Second, foods processed at home and prepared/cooked from raw or moderately processed foods (for example, vegetables, meat and fish cooked from raw fresh ingredients, or vacuum packed, deep-frozen, canned in water/brine or in own juice).

Non-processed foods: Foods consumed raw without any further processing/preparation, except washing, cutting, peeling, squeezing (for example, fruits, non-processed nuts, vegetables, crustaceans, molluscs, fresh juices) [27].

In Brazil, Monteiro and collaborators developed a novel classification system from the distinction between processed and unprocessed food. They developed the NOVA classification system, which was revised in 2015 "NOVA is a food

categorization that classifies foods based on the quantity and purpose of processing rather than nutrients." This classification divides foods into four categories based on their degree of processing [28].

NOVA defines food processing as "physical, biological, and chemical procedures employed after foods are isolated from nature and before they are ingested or prepared as dishes and meals."

1.1.1. Group 1

Unprocessed or minimally processed foods: Minimally processed foods are natural foods that have been transformed by methods such as drying, crushing, grinding, fractioning, filtering, roasting, boiling, non-alcoholic fermentation, pasteurization, refrigeration, chilling, freezing, storing in containers, and vacuum-packaging. These techniques are intended to preserve natural foods, make them fit for storage, or make them safe, palatable, or more enjoyable to ingest. For examples Fresh meat and milk, grains, legumes, nuts, fruits and vegetables, roots and tubers, Teas, coffee, herb infusions, tap water and bottled spring water also belong to this group.

1.1.2. Group 2

Processed culinary ingredients: Processed culinary ingredients, such as oils, butter, sugar and salt, are substances derived from Group 1 foods or from nature by processes that include pressing, refining, grinding, milling and drying. The purpose of such processes is to make durable products. They are not intended to be taken on their own, but rather to be combined with Group 1 items to form freshly prepared beverages, dishes, and meals.

1.1.3. Group 3

Processed foods: They are edible by themselves or, more usually, in combination with other foods. The goal of processing in this class is to increase the durability of Group 1 foods or to change or improve their sensory attributes. For examples: bottled vegetables, canned fish, fruits in syrup, cheeses and freshly made breads.

1.1.4. Group 4

Ultra-processed foods: Processes employed in the manufacturing of group 4 items include salting, sugaring, baking, frying, deep frying, curing, smoking, pickling, and canning, as well as the use of preservatives and cosmetic chemicals, the incorporation of synthetic vitamins and minerals, and complex forms of packaging [21, 29].

In 2011, Asfaw from the International Food Policy Research Institute (IFPRI) established a food categorization system in Guatemala based on prior research assessing the role of processed food items to food supply in low-income nations. These food items were classified into three food groups as unprocessed, partially (primary) processed and highly processed based on the degree of processing. Food items that have undergone secondary processing into a readily edible form are classified as highly processed food items. These foods are likely to have a high degree of added sugars, fats, and salt. For examples: Pastries, cookies, crackers, sausage and prepared meats, ice cream, frozen desserts, breakfast cereals, confectionery (sweets, chocolate), fat spreads and shortening, pasta products soft drinks, prepared meals like dried soup, formula, and complementary foods. Primary or partially processed foods include food items such as bread, corn products, vegetable oils, and dairy products [30].

The International Food Information Council Foundation (IFIC) proposed another food categorization system based on processing level in the United States of America (USA) in 2012 to determine the contribution of processed foods to nutrient intake in the US diet. All foods in the diet may be classified into one of the IFIC Foundation categories based on the degree of processing and the physical, chemical, and sensory modifications that occur as a result of processing. The first stage or type of processing, "minimally processed," includes items that maintain the majority of their original qualities, such as washed and packed fruits and vegetables and roasted nuts. "Foods processed for preservation," The next phase of processing includes canned tuna and beans, as well as frozen fruits and vegetables, for nutritional improvement and freshness. Foods in the "mixtures of combined ingredients" category comprise sugars, spices, oils, colours, flavours, and preservatives intended to promote safety, taste, and attractive appearance. Cake mix, canned tomato sauce, salad dressing, and rice are among examples. The next stage is "ready-to-eat processed foods," which include morning cereal, crackers, ice cream, yoghurt, luncheon meats, fruit drinks, and carbonated beverages. The final category, "prepared foods/meals," includes foods packaged for freshness and ease of preparation such as frozen dinners and entrees as well as prepared deli foods [5].

In the United States, the University of North Carolina (UNC) designed a new classification system in 2015, with changed category names and representative food products from the American diet. Foods are categorised into categories ranging

from least processed to highly processed. A classification system was developed to define into four categories based on the degree of industrial food processing.

The simplest category is "unprocessed and minimally processed," which comprises single-ingredient foods and drinks that have undergone no or very few alterations that do not alter the intrinsic qualities of the food as found in its raw or natural, unprocessed state. Fresh fruits, vegetables, milk, eggs, and unseasoned meat are a few examples.

Although "basic processed" foods and drinks have been processed, they continue to exist as distinct items. "Processed basic ingredients," such as sugar, oil, or whole-grain flour, are separate food components extracted or refined from unprocessed/minimally processed foods by physical or chemical procedures that alter the food's intrinsic qualities. Extraction, pressing, clarifying, refining, purification, and milling are all processes. Examples are refined-grain flour or pasta, white or instant rice, and fruit or vegetables canned. Products "moderately processed for flavour" are single slightly or simply processed foods that have flavour additives (sweeteners, salt, flavours, or fats) added to enhance flavour. They are readily recognized from their original plant or animal origins. Examples include salted almonds, canned fruit in syrup, and canned vegetables with additional salt.

"Highly processed" meals and drinks are multi-ingredient industrially manufactured products that have been treated to the point that the original plant or animal source can no longer be identified. For examples: Ketchup, margarine, mayonnaise, jarred pasta sauce, condiments, dips, sauces, toppings, ingredients in mixed dishes, refined-grain breads, sugar-sweetened beverages (SSBs), cookies, salty snacks, candy, and prepared mixed dishes [4]. In 2018, the Food Standard Australia New Zealand also proposed to dichotomize foods and beverages into not processed or processed. However, this categorization does not differentiate processed products based on their degree of processing, which makes assessing highly or ultra-processed food challenging. Systems that don't differentiate between processed food and highly/ultra-processed food were determined not to be included. Systems of food classification with primarily local or regional applicability were also eliminated. Therefore, two classifications were not considered [31].

1.2. Food processing techniques and their health outcomes

Industrial food processing is defined as all methods and techniques used by the food, drink and associated industries to turn whole fresh foods into food products. Processes used in the production of ultra-processed food products include salting, sugaring, baking, frying, deep frying, curing, smoking, pickling, canning, and also frequently the use of preservatives and Cosmetic chemicals, the incorporation of synthetic vitamins and minerals, and sophisticated packaging. These industrial processes are all designed to create durable, accessible, convenient, attractive ready-to eat or ready-to-heat products [32]. Maillard reaction also involve in food processing. When food products are processed or cooked at high temperatures, a chemical reaction between amino acids and reducing sugars occurs, resulting in distinct flavours and a brown colour. So, it is often used in food industry for giving food different taste, colour, and aroma [33]. Maillard reaction has been reported that some MRPs particularly melanoidins have beneficial effects on health such as antioxidative [34].

Maillard reaction products such as high carboxymethyl lysine (CML) promote diabetes and cardiovascular diseases while acrylamide acts as a carcinogen [35,36].

For example, Ultra-high temperature (UHT) treatment or conventional sterilization process is often used to process milk for improving quality and safety. Milk is rich in protein and sugar. As a result, it is evident that processing milk at high temperatures may result in the formation of MRPs. MRPs may behave as chelating agents to chelate metal cations by forming different soluble and insoluble complexes and thereby can affect protein and mineral bioavailability [37,38, 39].

The deep-frying method proceed on high temperatures that can change the nutrient compositions [40]. The deep heated frying generally emits the toxic fumes in which two toxic chemicals: polycyclic aromatic hydrocarbons (PAHs) and aldehydes are a notable impact on human health. The exposure these chemicals is largely through ingestion and breathing in humans and severely causes various malignancies viz., lung, stomach, esophagus, and skin [41].

Cooking methods that use high heat may raise the risk of prostate cancer. The addition of oil or fats, as in deep- frying it may be concern with the causing high risk of prostate cancer. Deep frying includes the formation of potentially carcinogenic agents such as aldehydes, acrolein, polycyclic aromatic hydrocarbons, and acrylamide. Deep frying food includes, French fries, fried chicken, fried fish, doughnuts and snack chips [42].

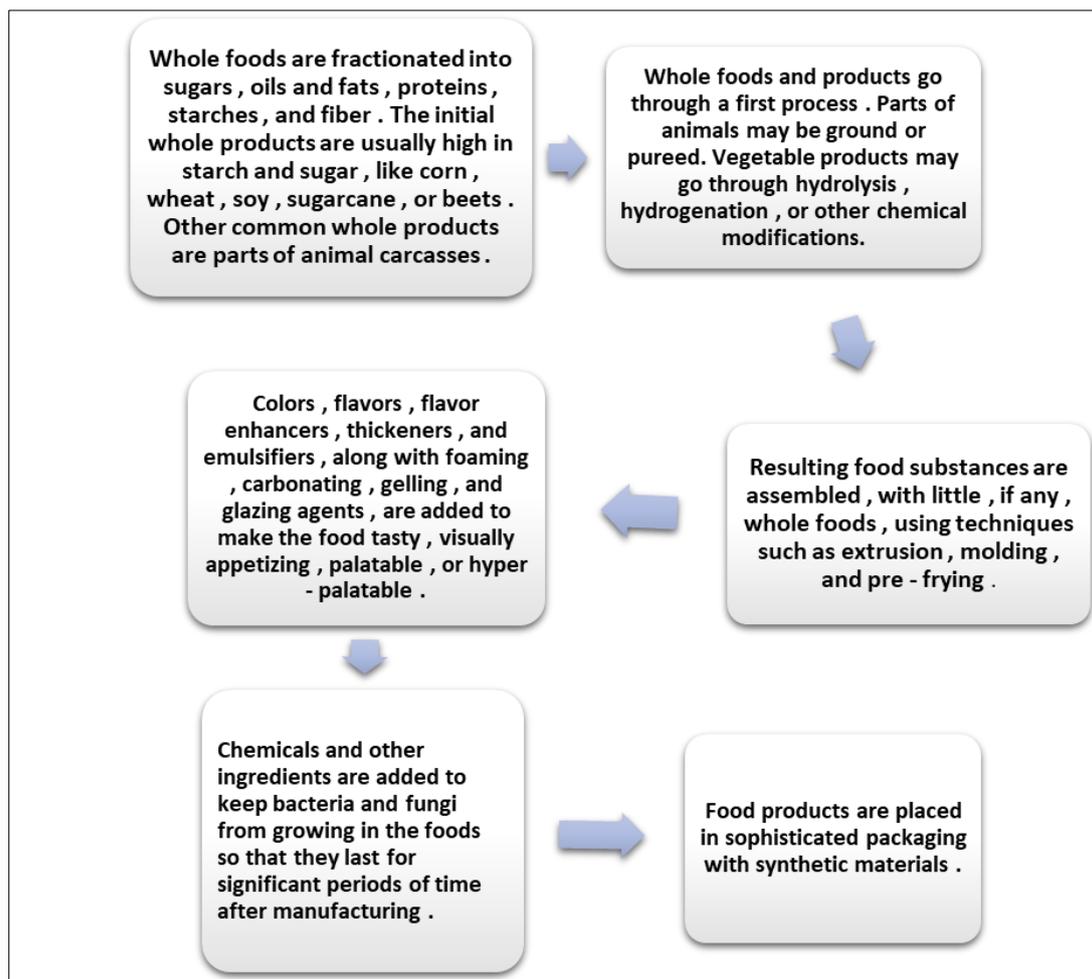


Figure 2 General process for ultra- processed foods [43]

Consumption of cured and broiled meat by the mother during pregnancy may result in childhood cancer. There are five meat categories that increase the risk of cancer (ham, bacon, or sausage; hot dogs; hamburgers; bologna, pastrami, corned beef, salami, or lunch meat; charcoal broiled dishes) [44]. Higher concentration of nitrate occurs in the cured meats and in the stomach after a meal that includes bacon or some other food cured with sodium nitrite. Such high concentrations of nitrite react most rapidly and are, therefore, most likely to lead to greater endogenous formation of nitrosamides and other N-nitroso compounds. Due to the formation of these compounds in cured meats increasing the risk of brain tumors in pediatric patients [45]. Grilling, roasting, smoking, barbecuing these are the thermal treatment of food processing. During these processing polycyclic aromatic hydrocarbons are primarily formed which is increasing cancer risk in the human body. Contamination by PHAs is due to generation by direct pyrolysis of food nutrients and deposition from smoke produced through incomplete combustion of thermal agents [46].

1.3. Hidden dangerous additives and contaminants in ultra-processed foods:

Food additives are chemicals added to food to improve the flavour, texture, colour, or chemical preservatives, taste, appearance, or serve as a processing aid. Some additives are known to be harmful to the human body and some are classified as carcinogens or cancer-causing agents. The excessive intake of food additives for a prolonged period of time will affect our health [47]. Food preservatives and additives also known as chemical food contaminants. Antimicrobials such as benzoic acid, nitrites, and sulphites, and antioxidants such as butylated hydroxy anisole (BHA), butylated hydroxytoluene (BHT), ascorbic acid, and tocopherols, have most likely influenced the food production patterns and eating habits. These food preservative chemicals have benefits on man, not only by the preservation and increased palatability of food, but also by affording protection against the pathological effects of reactive oxygen species (ROS) which are associated with cancer, cardiovascular disease and aging [48]. To prevent botulism, sodium nitrite is used as a preservative in lunch meats, hams, sausages, hot dogs, and bacon. Even though it is helpful for suppressing the bacteria that cause botulism, sodium nitrite can react with proteins or during high-heat cooking to generate carcinogenic N-nitrosamines. It has been linked to cause cancer [49]. The commonly sodium benzoate has been used to extend shelf life

of bottled tomato paste to 40 weeks without loss of quality. However, it can form the carcinogen benzene when combined with vitamin C [50].

Phthalates and bisphenols are multifunctional synthetic chemicals widely used in industrial products. They are used in food contact materials or food processing plastics can transfer to food. Consumption of certain foods, such as dairy, meat, spices, flour, wheat, or grains, has been linked to higher urine concentrations of certain phthalate metabolites. Consumption of canned foods and beverages has been linked to greater urine bisphenol A concentrations. The exposure of some phthalates and bisphenol A are associated with wide-ranging adverse health outcomes related to their ability to disrupt the endocrine system [24].

Bisphenol A has been shown to play a role in the pathogenesis of several endocrine disorders including female and male infertility, precocious puberty, hormone dependent tumours such as breast and prostate cancer and several metabolic disorders including polycystic ovary syndrome (PCOS) [51].

The food additive E171, composed of titanium dioxide particles, has been shown to contain up to 55% of nanosized particles (TiO₂-NPs) and is among the most commonly used mineral particle-based food additive in consumer products. TiO₂ can disrupt the intestinal barrier and induce intestinal inflammation, also the impact of titanium on intestinal carcinogenesis. The tumour formation is linked to dysplastic changes in the colonic epithelium, but also to a dramatic decrease in goblet cells (mucin-secreting cells) leading to intestinal barrier disruption [52]. In numerous foods, including soft drinks, jelly-filled candies, baked meals, jam, marmalade, confectionery, and canned vegetables and fruits, citric acid (CA; E-330) is employed as an acidulant, pH regulator, taste enhancer, preservative, and antioxidant synergist. CA is genotoxic and/or cytotoxic to human dental cells also, CA has DNA-damaging effect especially at higher concentrations in human lymphocytes [53].

Table 1 Health outcomes of additives containing ultra – processed food items

Additive's	Food items	Health outcomes
Acrylamide [59,58]	French fries, potato chips, biscuits, bread.	Ovarian and endometrial cancer
Perfluorooctanoic acid [56]	Microwave popcorn	Lung cancer
Sodium nitrates [49]	Process meat Hot dogs	Pancreatic cancer, high risk of leukaemia
Parabens [60]	Preservatives	Breast cancer
Omega-6 fats [60]	Refined vegetable oil	Heart disease and cancer
Bisphenols and phthalates [24]	Food packaging material	Endocrine disruptor
Titanium dioxide [53]	Food and drinks packaging material	High risk of chronic intestinal inflammation and causes cancer
N-nitroso and polycyclic aromatic hydrocarbons [41]	Processed meat	Stomach, lungs, Colorectal cancer DNA damage
Tartrazine (colouring agent) [54,55]	Soft drinks, cereals, sauces	Thyroid cancer, migraine
Citric acid [53]	soft drinks, jelly sweet, jam, marmalade, candy	genotoxic and/or cytotoxic, DNA-damaging

Tartrazine has the potential to harm people' health by causing hyperactivity in children, allergies, and asthma. Sweetmeat, soft drinks, cotton candy, cereals (corn flakes and muesli), flavoured chips (Doritos and Nachos), cake mixtures, soups, jam, sauces, ice cream, some rice, candy, chewing gum, marzipan, jelly, gelatins, mustard, marmalade, yoghurt, and noodles are just a few of the foods that contain tartrazine. Non-food items containing tartrazine include soaps, cosmetics, shampoos and other hair treatments, conditioners, pastels, crayons, and stamp dyes. A diversity of immunologic reactions has been recognized in tartrazine consumption, comprising general fatigue, nervousness, migraines, clinical depression, purple skin spots, and disruption in sleep [54,55].

Researchers from the Swedish National Food Administration revealed in April 2002 that they had discovered higher amounts of acrylamide in regularly consumed baked and fried dishes. Acrylamide is a neurotoxic in humans and a carcinogen in animals, and the International Agency for Research on Cancer (IARC) has categorized it as a possible human carcinogen (IARC, 1994) [56].

Acrylamide, a possible human carcinogen, is produced during the high-temperature cooking of a variety of widely eaten foods. It is widespread; approximately 30% of calories consumed in the United States are from foods containing acrylamide [57]. Increased risks of postmenopausal endometrial and ovarian cancer increasing with dietary acrylamide intake [58].

2. Conclusion

Ultra- processed foods are often characterized by lower nutritional quality and the presence of additives, substances from packaging that comes into contact with food, and compounds formed during production, processing, and storage, all which increases the risk of cancer and other health related problems. As the global consumption of highly processed foods rises, the health impact of these foods becomes more significant. Food technologies are commonly developed to preserve and maintain food quality attributes. Some ultra - processed foods possess health benefits, such as, increased shelf life and nutritional bioavailability. On other side, ultra - processed foods have negative impacts, such as high content of artificial additives and nutritional loss, which increases the risk of cancer and other health problems. The classification systems address multiple characteristics of industrial foods as well as eating culture and also analysing the contribution of each food group to total diet quality. Food additives are chemicals that are added to food in order to improve the flavour, texture, colour, or chemical preservatives, taste, appearance, perform as a processing aid. These chemicals are proven to be hazardous to human health, with some even being classified as carcinogens. From the overall discussion we conclude that, consumption of ultra - processed food increases the risk of cancer. Hence, to minimize the risk of developing health problems due to food additives and preservatives, one should avoid the foods containing these additives and preservatives and also over cooked or extra processed food.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest, financial or otherwise.

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