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Impacts of diet-related factors on human health

Abstract

Science and technology have been developed quickly. Like a coin has two sides. On the one hand, they make our living conditions more accessible and comfortable than in old times. On the other hand, our lifestyle is becoming increasingly related to high-technology products and is far from the natural or healthy lifestyles of the old times. The high-technology products invented by humans have harmed all living organisms. This review will primarily focus on the impacts of diet-related factors on human health. Our lifestyle is becoming increasingly related to high-technology products and is far from the natural lifestyle of the old times.

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Introduction

The development of science and technology has undoubtedly improved our lives, but it has also brought about a new set of challenges. The incidence of modern diseases, such as cardiovascular diseases, diabetes, and various cancers, has skyrocketed, replacing the once-lethal diseases of the past. Diet-related factors play a crucial role in these epidemic diseases. This section will delve into the problems associated with our present-day diet, providing a comprehensive understanding of the factors that significantly impact human health.

Water quality

With the development of worldwide industrialization, our water system has been severely polluted. After being treated by the local water plant, some harmful components may still exist in the water flowing out from the plant and into households. The quality of the water pipes and filters fixed in each household also matters greatly. The water pipe materials can release heavy metals into our drinking water system,[1] causing human health problems.[2] The materials of wares for heating water or containing water also affect the water quality. Most water cups sold in the markets are made of many plastics. Although the inside material of some cups is stain-steel, their tops are made of plastic to prevent water leakages. Usually, the main component of plastics is high molecular-weight organic polymers synthesized using petrochemicals. Take Polyvinylchloride (PVC) as an example; it is not stable and can gradually break down and release hydrogen chloride (HCL), which is unfavorable to human health,[3,4] especially under heat, illumination, or radiation. Moreover, during the process of making plastics, plasticizing agents (e.g., phthalate), fillers, anti-aging agents (e.g., lead stearate), and colorants are routinely added, and these additives often contribute most to the problems related to human health. For example, phthalate has been associated with many diseases, including breast cancer, endocrine disruption, metabolic interference, liver and kidney problems, reproduction system problems, and obesity.[5–8] The lead stearate is easily dissolved by liquid, causing health problems relating to lead toxicity.[9]

Pesticides, fertilizers and other chemicals for agricultural use

Many different types of synthesized or chemical pesticides and fertilizers are used in crop farming to reduce pest damage to crops and increase crop yield. Pesticides are substances for preventing, destroying, repelling, or diminishing pests, including unwanted plants like weeds (herbicides), insects (insecticides), molds and mildew (fungicides), microbes (disinfectants), and animals like mice and rats.[10] In the US, the United States Environmental Protection Agency (EPA) and the states (the pesticide and fertilizer management division in each state's agriculture department) register or license pesticides.[10] EPA is authorized to register pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).[10] The state is authorized to regulate pesticides under FIFRA and state pesticide laws.[10] States may be more stringent on pesticides than EPA.[10] The EPA and the state must register pesticides before being distributed.[10] The 2011 pesticide report from the pesticide monitoring program by U.S. Food and Drug Administration (USDA), which was released in Jan. 2014 shows that a higher occurrence rate of pesticide residues was detected in products like kale, cilantro, radishes, potatoes, okra, spinach, lettuce leaf, peppers, cucumbers, peaches, strawberry, grapes, raspberries, blackberries, blueberries, cranberries, honeydew, apple, and cantaloupe.[11] Residues of over 173 different compounds, including the original pesticides and their related compounds, such as degradation products and metabolites, were detected in the foods sampled from the tested markets.

Pesticides contain active and inert components. Active components are the chemicals that act against pests. They can be conventional, antimicrobial, or biological.[10] The theory is that the active ingredients destroy some standard physical functionality of animals, plants, fungi, and plants. When they take effect in targeted living organism forms, they may also harm people in many ways. After being applied to the crops, pesticides can be absorbed into the water, soil, and crops and remain on the surface of crops. After being contacted or consumed, they can cause health problems in humans. Many were not present in nature but were invented and manufactured by humans. For example, the group of organochlorine insecticides can cause acute toxicity to the central neural system, liver, and kidneys; they can also accumulate in human fat tissues, increasing the chance of carcinogenicity, teratogenesis and mutagenesis.[10] Organophosphorus pesticides are toxic to the nervous system; they can disturb neural function, causing trembling, dementia, and speech disorder,[12] and increasing the risk of Alzheimer's disease.[13] Thimerosal can release mercury ions, damaging the human nervous, cardiovascular, and kidneys.[14]

The state mainly regulates the production, distribution, and use of fertilizers since each state has specific soil and geologic conditions, although some federal laws also have some related regulations. Fertilizers have been used for a long time to enhance crop production; however, excessive fertilizer use has also induced lots of problems. They can deteriorate the quality of our water system.[15] They can also be absorbed into the crops, entering the food chain and eventually causing human health problems. Fertilizers may contain some components that are harmful to human health. For example, the

nitrates in fertilizers can be reduced by some of our gut microbes (e.g., nitrifying bacteria) to nitrites,[16] which have carcinogenicity to humans.

Food additives

There are two types of food additives. One is a direct food additive. In the US, the Food and Drug Administration (FDA) regulates food additives, and companies need permission from the FDA to use them in the food market. The other type is an indirect food additive.

Direct food additives are substances added to food to maintain or enhance its safety and freshness (preservatives), improve/maintain nutrition value (nutrition supplements), improve taste (spices, natural/artificial flavor, and sweeteners), improve texture (emulsifiers, stabilizers, and thickeners), and improve appearance (color additives).

Preservatives are added to food to prevent microbial growth or undesirable chemical changes. They can be grouped into natural and synthetic categories.

Natural preservatives: Examples are salt, sugar, alcohol, and vinegar. Consuming high-salt or high-sugar foods is harmful to our health since they can cause hypertension, hyperglycemia, or even hyperlipidemia. Although these natural preservatives are called "natural," they are processed. All alcohol contains different concentrations of methyl alcohol, which is much more harmful to our health than ethanol alcohol. Vinegar itself may contain some preservatives.

Chemical industries synthesize artificial preservatives: the most widely used in the present food market. You can find them in almost all processed foods. Do not mention the harm produced by the residues of reactants, solvents, intermediate products, and by-products. They did not naturally exist on Earth originally. Our bodies cannot recognize them, making them feel confused when we encounter them, which causes metabolism disorders. They may have harmful effects on our health. For example, parabens are accumulative and carcinogenic. They can also be classified as organic chemical preservatives or inorganic chemical preservatives.

Organic chemical preservatives: For example, benzoate (benzoic acid and its salts, such as Sodium Benzoate), sorbic acid and its salts, and p-hydroxybenzoic acid (PHB). Since benzoate is widely used and easy to find in ingredient lists, let us use it to show its harm. Benzoate can harm our genes. Sodium benzoate can react with Vitamin C and produce benzene, which has been believed to be carcinogenic.

Inorganic chemical preservatives: Examples are sulfur dioxide and sulfite. Sulfur dioxide can induce asthma and allergic diseases, damage Vitamin B1, impair enzyme activities, and affect the metabolisms of carbohydrates and proteins and calcium absorption. Food preservatives can also be classified based on their functional mechanism.

Antimicrobial agents can destroy some microbes' physical structures or activities, inhibiting microbial growth. Benzoate and parabens are two common examples.

Antioxidants: Examples are sulfites, tocopherol (vitamin E), ascorbic acid (so-called 'vitamin C' in the ingredient labels), butylated hydroxy anisole (BHA), and butylated hydroxytoluene (BHT). Food can go bad when exposed to oxygen because of the oxidation processes. Antioxidants function by quenching free radicals produced in the oxidation processes. The problem is that most of these antioxidants used in the food market are synthesized and have the same problems as we mentioned above.

Chelating agents include disodium ethylenediaminetetraacetic acid (EDTA), polyphosphates, and citric acid. EDTA is cytotoxic and genotoxic.

Color additives can be natural or artificial substances added to food to improve appearance.

Natural colors are mainly extracted from natural sources such as plants, animals, or minerals. Examples are annatto extract, grape color extract, grape skin extract, Paprika oleoresin, tomato lycopene extract, fruit or vegetable juices, carrot oil, dehydrated beets, toasted partially defatted cooked cottonseed flour, cochineal extract, or carmine.[17] Many organic solvents were employed to extract them from natural sources. For example, to drive paprika oleoresin from paprika, the extraction process uses some solvents like acetone, ethyl alcohol, ethylene dichloride, hexane, isopropyl alcohol, methyl alcohol, methylene chloride, and trichloroethylene. The extraction process allows different degrees of used solvent to remain in the food and be added with these extracted colors. Researchers found the residuals of solvents used to extract natural color in related foods.[18] In 1993, the Uematsu group found the levels of methanol, acetone, and isopropanol in natural color samples exceeded the FDA standards,[19] and in 2012, Ito group found the concentration level of 2-propanol, methanol, and acetone residuals in bixin-based products were higher than the limits specified by Joint FAO/WHO Expert Committee on Food Additives (JECFA). All these organic solvents are not suitable for our health.

Nature identical colors: They have the same chemical structures found in natural sources, but they were chemically synthesized rather than being extracted from natural sources out of the consideration of cost saving.[20] β-Carotene is an example.[20] The identical color of nature is not safe either. Put aside the residues of reactants and byproducts used and produced in the reaction left in the reaction product beta-carotene. First, the natural beta-carotene is a cis-trans isomeric mixture containing two different isomers (9-cis and all-trans with the same molecular formula but different structure). In contrast, the synthetic beta-carotene comprises the all-trans isomer.[21] That means synthesized beta-carotene is not entirely natural, making its possible effect on human health unclear. Evidence supports that 9-cis beta-carotene is a more potent antioxidant than all-trans isomer and has many beneficial functions, such as being a potential precursor of 9-cis-retinoic acid, which has anti carcinogenic action.[22] The cis form is believed to be a potent quencher for single-oxygen free radicals; however, beta-carotene can function as an antioxidant and pro-oxidant depending on the oxidative stress status and availability of other antioxidants.[23] Under the condition of high oxidative stress, such as in the lungs of smokers who have not taken enough other antioxidants, high levels of beta-carotene, especially the all-trans form, can produce long-existing all-trans beta-carotene free radicals, which start their cell-damaging chain reactions, thus acting more as pro-oxidants than antioxidants.[23]

Synthetic colors: They do not occur naturally and are synthesized by the chemical industry. Current synthetic colors permitted by FDA for food use are blue 1, blue 2, blue 3, orange B (limited use), citrus red 2 (limited use), red 3, red 40, yellow 5, and yellow 6.[17] Then why are there only yellow 5 and 6? Where is yellow 1, 2, 3 and 4? Many synthesizes got permission as food additives from the FDA at one time since they passed the safety assessment by the FDA and no adverse effects were observed for some time use, making them be conceived no harm to human health during the time of their use; however, as time goes, the adverse effects relating to them appeared, making them be banned by FDA eventually. For example, red 2 was approved by the FDA as a food additive but was banned by the FDA in 1976,[24] due to its possible carcinogenic activity.[25] Other examples are red 4, red

32, orange 1, orange 2, yellow 1, yellow 2, yellow 3, yellow four, and violet 1. It is not difficult to understand- although the FDA evaluates the long-term effect of food additives, that defined long-term may not be long enough compared to the life length of a human. No adverse effect showing up during the experimental period cannot rule out the possible happening of adverse effects after being used for longer than the experimental time; also, the animal models the experiments employed are different from humans, so no adverse effect in an animal model cannot exclusively rule out the possibility of adverse effect in human. FDA allows the use of currently approved synthesized colors as food additives because no adverse effects have been seen. Some harmful effects may need to take a longer time to appear. The yellow 5, which is currently legal to be used as a food additive, can cause itching or hives in some of our population.[25] Combining all these facts makes it possible that some current in-use synthetic colors would harm human health to different degrees. Additionally, we cannot get enough pure pigments from natural sources or pure synthetic pigments. Above, we are talking about the issues relating to synthetic color. Even if the pure synthetic color has no unfavorable effect on health, the reactants and byproducts residues in the synthetic color can be the problem.

Enriched nutrients: Common examples are vitamins, minerals, and amino acids. Many bakeries were made using enriched grain powders. All these vitamins have the same problems we mentioned above. Usually, synthetic vitamins are not the same as the vitamins in our bodies. Also, natural vitamins have more components than synthesized ones, which only contain the core chemical and usually need to work with other co-factors, including some specific minerals. So, supplying our bodies with synthetic vitamins may deplete more minerals and other crucial bioactive factor reserves. For these minerals used for nutrient enrichment, their raw material sources are ores, brine, industrial waste, industrial chemicals, and agricultural products.[26] They are all derived after several steps of chemical processes, such as extraction, decomposition, oxidation-reduction reaction, synthesis, filtration, and distillation (Tianjin Chemical Research Institute 1999). Without digging into the details of these chemical procedures, the safety of these manufactured products is doubtful.

Sweeteners: They were used to impart food sweetness. Based on the calories they contain, they can also be grouped as non-nutritive sweeteners and nutritive sweeteners. Non-nutritive sweeteners have less than 2% energy of sucrose with equal sweetness; they are usually not carbohydrates. Examples are sugar alcohols like glycerol, ethylene glycol, sorbitol, mannitol, and xylitol. Sweeteners can also be classified as natural and synthetic. Table sugar (sucrose) is a common natural sweetener from cane and beets. It has been linked to obesity, tooth decay, and gout. The wildly used high-fructose corn syrup (HFCS) has shown an association with increased incidence of obesity, type 2 diabetes, non-alcoholic fatty liver, and metabolic syndrome.[27] Agave nectar, which is derived from plant agave, has a lower glycemic index compared to table sugar, but overconsumption may reduce insulin sensitivity, increase triglyceride levels, trigger metabolic syndrome, and enhance uric acid formation.[28–30] Compared to other natural sweeteners, honey has a trace amount of nutrients and relatively lower calories. Most artificial sweeteners share their goodness of efficient sweetness and free calories, but many of them are not as safe as we expected. For example, acesulfame potassium (Saccharin) has been linked to cancer in tested animals [31] and overconsumption may result in glucose intolerance owing to the interactions between saccharin and gut microbes.[32] The carcinogenic effects of aspartame are controversial,[33] However, people with phenylketonuria (PKU) especially need to be careful about their consumed amount since aspartame contains phenylalanine, and people with PKU have a lower ability to metabolize phenylalanine.[34]

Other direct food additives: Other food additives can be emulsifiers, stabilizers and thickeners, binders, texturizers, spice, flavor, flavor enhancers, fat replacers (and components of formulations used to replace fats), pH control agents and acidulants, leavening agents, anti-caking agents, humectants, yeast Nutrients, dough strengtheners and conditioners, firming agents, enzyme preparations, and gases.[17] They may confuse our body, increase the burden on our metabolic system, and scavenge the nutrient reserves in our body for their metabolisms, causing different extents of health problems.

Indirect food additives: Wraps, cooking utensils, dishware, and water cups: Food wraps and containers made of papers and plastics all contain toxic materials, and since their chemical properties are not stable, they can be released into the contact with food quickly, especially when they touch the oily things because many components of plastics have more non-polar chemical functional groups making them more lipophilic. Nowadays, many cooking utensils have layers of chemical coats used to confer the appliances with non-stick or other expected functions; however, all of them are synthetic and have different degrees of toxicity. The toxic materials in these layers, like Polytetrafluoroethylene (PTFE) or Perfluorooctanoic Acid (PFOA), will give out after inevitable damage or under high heat will and then pollute our food and air.[35,36] In addition, the cling wraps we use when microwaving things can emit more toxic gases like hydrogen chloride into the air and food than usual.

Food contaminants

The microbes in the food can produce toxins, which are bad for human health. For example, most crops, especially peanuts and corn, are contaminated by Aspergillus flavus, which produces Aflatoxins, which are very toxic and strongly carcinogenic.[37] Microbes can decompose the nitrates in vegetables into nitrites, which are strong oxidizers. After being consumed, they can oxidize the iron (II) hemoglobin into iron (III) hemoglobin, making them lose the ability to transport oxygen in the body system and then leading to tissue hypoxia.[38] The fatty acid in nuts is easy to rancid when exposed to oxygen.

Cooking methods

At high temperature above 150°C, carbohydrates produce acrylamide, carcinogenic to humans.[39] Proteins at high temperatures will produce benzopyrenes,[40] which can intercalate into DNAs causing cancers.[41] Similarly, fatty acids under heat will experience a series of reduction, oxidation, chemical bond breakage, and isomerization, leading to composition changes unfavorable to health, including decreased unsaturated fatty acids and increased saturated fatty acids and trans fatty acids.

Conclusion

For water quality, we should check if the aqueducts in our household are too old for use, and it is advisable to set up a tap filter. Also, boiling water for 3 minutes before serving can help remove the remaining chlorides used by water plants. Choosing products without too many agricultural-use chemical residues is more reliable. Fruits have a long growth period, so to ensure they can be sold in the markets all through the year, their storage time is usually longer than that of vegetables. To preserve them well, producers commonly add kinds of preservatives and waxes to the surfaces of fruits. We should choose seasonal products; it is always good practice to wash well or peel to

remove additives before serving.[42] If we want to make or have food with beautiful colors, choosing synthetic colors or colors extracted from natural products by industry is unnecessary. Instead, we can obtain natural colors at home, such as vegetables, fruit, or grass juice. For example, to get the green color, we can boil some spinach in water and remove it, or you can get the spinach juice by adding spinach and water into a blender. In this way, the food we make is not only colorful but also contains some nutrients from spinach, and it is also healthier than industrial products since it does not contain any industrial-use chemical residues. We can use vegetables such as carrots, red amaranth, and purple cabbage, fruits like blueberry and strawberry, and grass such as Ay Tsaoor, or mix them to get the colors we desire to have.[43–45]

For food containers, we can choose glass, ceramic, or stainless steel. For cooking utensils, we can choose iron pans for stir-frying. For other uses, we can choose good-quality stainless-steel pots, bamboo steamers, or ceramic pots. We should avoid high-temperature cooking methods like frying. If not serving raw, boiling, steaming, or stewing methods can be relatively safe; next is baking or microwaving. Stir-frying or frying in deep oil is not recommended since these methods can cause food and cooking utensils to release harmful chemicals into our food and air. In short, when we choose products in the markets, we should carefully consider all possible risk factors. Quantity means everything. If we need to consume processed foods, choose the ones made from more natural ingredients as much as you can. If they put us in a good mood, we can have them occasionally, but control the amount we consume each time and avoid having them too often.

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Conflicts of interest

The author declared that there are no conflicts of interest.

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