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Impacts of diet-related factors on human health

Abstract

Science and technologies has been developed quickly. Like a coin have two sides. On one hand, it seems that they make our living conditions become easier and more comfortable than old times. On the other hand, our lifestyle is becoming more and more related to high technology products and far away from natural or healthy lifestyles in the old times. All living organisms on the planet have been harmed by the high-technology products invented by human beings. This review will mostly focus on the impacts of diet-related factors on human health. Our lifestyle is becoming more and more related to high technology products and far away from natural lifestyle in the old times.

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Introduction

The development of science and technology has helped us achieve more convenient and comfortable life by invention of high-technology industrialized products and extend human lifespan by eliminating some old diseases via advanced medical knowledge and technologies. However, the incidence rate of new-era diseases including cardiovascular diseases, diabetes and different kinds of cancers have increased greatly meanwhile, replacing the lethal diseases during the old times. Diet-related factors are among important contributors of these epidemic diseases. Follows are reviewing the problems related to present-day diet, which are one of the important factors impacting human health.

Water quality

With the development of world-wide 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 flowing into households. The qualities of the water pipes and filters fixed in each household also matter a lot. The water pipe materials can release heavy metals to our drinking water system,[1] causing health problems in human.[2] The materials of wares for heating water or containing water also affect the water quality. The majority of water cups selling in the markets are made of multitude types of plastics. Although the inside material of some cups are stain-steel, that of their tops are made of plastic for preventing the water leakages. Usually the main component of plastics is high molecular weight organic polymers synthesized using petro chemicals. 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 contributes 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 problem, and obesity.[5–8] The lead stearate is easy to be dissolved out by liquid, causing health problems relating to lead toxicity.[9]

Pesticides, fertilizers and other chemicals for agricultural use

To reduce pest damage to crops and increase the crop yield, many different types of synthesized or chemical pesticides and fertilizers are being used in crop farming nowadays. Pesticides are substances for preventing, destroying, repelling or diminishing pests including unwanted plants like weed (herbicides), insects (insecticides), molds and mildew (fungicides), microbes (disinfectants), and animals like mice and rats.[10] In US, 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] State is authorized to regulate pesticide under FIFRA and state pesticide laws.[10] States may be more stringent on pesticides than EPA. Pesticides have to be registered by EPA and the state in both before being distributed. The 2011 pesticide report from pesticide monitoring program by U.S. Food and Drug Administration (USDA) which was released in Jan. 2014 shows that higher occurrence rate of pesticide residues were detected in produces 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 its related compounds such as degradation products, 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 for the active ingredients to take effect is to destroy some normal physical functionality of animals, plants, fungi and plants and when they take effect in targeted living organism forms, they may also harm people to different degrees in many ways. After being applied to the crops, pesticides can be absorbed into the water, soil, crops and remain on the surface of crops. After being contacted or consumed, they can cause health problems in human. Many of them were not present in nature, but invented and manufactured by human. For example, the group of organochlorine insecticides can cause acute toxicity to central neural system, liver and kidneys; they can also accumulate in human fat tissues increasing the chance of its carcinogenicity, teratogenesis, and mutagenesis.[10] Organophosphorus pesticides are toxic to nerve system; they can disturb neural function causing trembling, amentia, speech disorder,[12] and increase the risk of Alzheimer's disease.[13] Thimerosal can release mercury ions damaging nervous system, cardiovascular system and kidneys in human.[14]

The production, distribution and use of fertilizers are mainly regulated by state since each state has their specific soil and geologic conditions, although some federal laws also have some relating regulations. Fertilizers have been used for long time to enhance the crop productions; however, excessive fertilizer use has also induced

lots of problems. They can deteriorate the qualities of our water system.[15] They can also be absorbed into the crops, entering into the food chain and eventually causing health problems in human. Fertilizers may contain some components harmful to human health. For example, the nitrates in the fertilizers can be reduced by some of our gut microbes (e.g. nitrifying bacteria) to nitrites,[16] which have carcinogenicity to human.

Food additives

There are two types of food additive. One is direct food additive. In US, the food additives are regulated by Food and Drug Administration (FDA), and to be used in the food market, they need to get the permission from FDA. The other type is indirect food additive.

Direct food additives: They are something added to food to keep or enhance the food's 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: They are added to food for preventing microbial growth or undesirable chemical changes. They can be grouped into natural and synthetic categories.

Natural preservatives: Examples are salt, sugar, alcohol and vinegar. It's well-known that consuming high-salt or high-sugar foods are harmful to our health since they can cause hypertension, hyperglycemia or even hyperlipidemia. Although these natural preservatives are called "natural", they are actually 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.

Artificial preservatives: They are synthesized by chemical industries and are the most wildly used in the present food market. You can find them almost in all of the processed foods. Don't mention the harms produced by the residues of reactants, solvents, intermediate products and by-products. They don't naturally exist on the Earth originally. Our body can't recognize them making our body feel confused when encounter them and therefore causing our metabolism disorders. They themselves may have harmful effect on our health. For examples, parabens have been found accumulative and carcinogenic. They can also be classified as organic chemical preservatives or inorganic chemical preservatives.

Organic chemical preservatives: Examples are benzoate (benzoic acid and its salts such as Sodium Benzoate), sorbic acid and its salts, and p-hydroxybenzoic acid (PHB). Take benzoate as an example to show their harms since it's really widely used and it's easy for us to find it in the ingredient lists. 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 the Vitamin B1, impair the enzyme activities, and affect the metabolisms of carbohydrates and proteins and the absorption of calcium. Based on the functional mechanism, food preservatives can also classified into the following groups.

Antimicrobial agents: They can destroy some physical structures or activities of microbes, 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 hydroxyanisole (BHA) and butylated hydroxytoluene (BHT). Food can go bad when exposed to oxygen because of the oxidation processes. Antioxidants function by quencheing free radicals produced in the oxidation processes. The problems are most of these antioxidants used in the food market are synthesized and have the same problems as we mentioned above.

Chelating agents: Examples are disodium ethylenediaminetetraacetic acid (EDTA), polyphosphates and citric acid. EDTA has found cytotoxic and genotoxic.

Color additives: They can be natural or artificial substances added to food for improving appearance.

Natural colors: They are mostly extracted from natural sources such as plant, animal or mineral. 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] To extract them from natural sources, many different types of organic solvents were employed in the process. 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 make it possible that different degree of used solvent remaining in the food added with these extracted colors. As a matter of fact, researchers found the residuals of solvent which were used for extracting natural color in relating 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).Apparently all these organic solvents would not be good 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 nature identical color 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 are cis-trans isomeric mixtures containing two different isomers (9-cis and all-trans with same molecular formula but different structure), while the synthetic beta-carotene is consisted of the all-trans isomer.[21] That means, synthesized beta-carotene is not completely natural, making its possible effect on human health unclear. Evidences supported 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 anticarcinogenic action.[22] The cis form is believed to be a potent quencher for single-oxygen free radicals; however, beta-carotene can function as antioxidant and pro-oxidant depending on the oxidative stress status and availability of other antioxidants.[23] Under condition of high oxidative stress, such as in the lungs of smokers who haven't 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 don't occur naturally and are synthesized by 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 there is only yellow 5 and 6? Where is yellow 1, 2, 3 and 4? Actually many

synthesized got permission as food additive by FDA at one time since they passed the safety assessment by FDA and no adverse effects were observed for a period of time use, making them being 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 being banned by FDA eventually. For example, red 2 was approved by FDA as food additive but was banned by FDA in 1976,[24] since its possible carcinogenic activity.[25] Other examples are red 4, red 32, orange 1, orange 2, yellow 1, yellow 2, yellow 3, yellow 4 and violet 1. It's not difficult to understand- although FDA evaluate the long-term effect of food additive, but that defined long-term may not long enough, by comparing to the life length of human. No adverse effect showing up during the experimental period of time 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 is different from human, so no adverse effect in animal model can't exclusively rule out the possibility of adverse effect in human. FDA allows using the currently approved synthesized colors as food additives just because presently no adverse effects were seen in their use. Some harmful effects may need to take longer time to appear. Actually the yellow 5, which is currently legal to be used as food additive, has been found to be able to cause itching or hives in some portion of our populations.[25] By combining all these facts together, it is very possible that some of current in-use synthetic colors would harm human health to different degrees. Additionally, we cannot get pure enough pigments from natural sources, not mention to get pure enough synthetic pigments. Above we are talking about the issues relating to the synthetic color. To say the least, even if the pure synthetic color doesn't have any 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 the synthetic vitamins are not real vitamins in our body. Also, the real vitamin have more components as the synthesized one, which only contain the core chemical, and usually need to work with other co-factors including some specific minerals. So supplying our body with more synthetic vitamins may deplete more mineral and other important bioactive factor reserves in our body. For these minerals used as nutrients 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.[26] 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 energy they contain, they can also be grouped as non-nutritive sweeteners sand nutritive sweeteners. Non-nutritive sweeteners only 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 common natural sweetener derived from cane and beets. It has been linked to obesity, tooth decay and gout. The wildly used high-fructose corn syrup (HFCS) has shown its association with increased incidence of obesity, type 2 diabetes, non-alcoholic fatty liver, metabolic syndrome.[27] Agave nectar, which is derived from plants agave, has lower glycemic index comparing to table sugar, but overconsumption may reduce insulin sensitivity, increase triglyceride levels, trigger metabolic syndrome and enhanced uric acid formation.[28–30] Compared to other natural sweeteners, honey has trace amount of nutrients and relatively lower calorie. Most artificial sweeteners share their goodness of efficient sweetness and free calorie, 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] but people with phenylketonuria (PKU) specially need to be careful about their consumed amount since aspartame contains phenylalanine and people with PKU has lower ability of metabolize phenylalanine.[34]

Other direct food additives: Other food additives can be emulsifier, 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 of 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 so they can release into the contacted food easily, 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 Perfuorooctanoic 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 that we use when microwaving things, can emit more toxic gas like hydrogen chloride into the air and food than usual.

Food contaminants

The microbes in the food can produce toxins, which are bad to human health. For example, most crops, especially the peanuts and corns are contaminated by Aspergillus flavus, which produce Aflatoxins known as very toxic and strong carcinogenic.[37] The nitrates in the vegetables can be decomposed by microbes to nitrites, which are strong oxidizers. After being consumed, they can oxidize the iron (II) hemoglobin into iron (III) hemoglobin, making them lost 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 will produce acrylamide, which is carcinogenic to human.[39] Proteins at high temperature will produce benzopyrenes,[40] which won the capability of intercalating into DNAs causing cancers.[41] The same, fatty acid under heat will experience a series of reduction, oxidation, chemical bonds 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 the water quality, we should check if the aqueducts in our household is too old for use and setting up a filter for the tap is advisable. Also, before serve, boiling water for 3 minutes can help remove the remaining chlorides used by water plants. It's more reliable to choose the produces without too much agricultural-use chemical residues. Since the long growth period of fruits, to make sure they can be provided in the markets all through the year, their storage time are usually longer than vegetables and for preserving them well, the producers commonly add kinds of preservatives and waxes on the surfaces of fruits. It's better for us to choose the seasonal produces and it's always a good practice to wash well or peel to remove additives before serve.[42] If we want to make or have food with beautiful colors, it's not necessary to choose synthetic colors or colors extracted from natural products by industry. Instead, we can obtain the natural colors at home from vegetable, fruit or grass juice. For example, to get the green color, we can boil some spinach in water followed by removing spinach or you can get the spinach juice by adding spinach and water into a blender. In this way, the food we made is not only colorful, but also contains some nutrients from spinach and it's also healthier than using the industrial products since it doesn't contain any industrial-use chemical residues. The same, we can use vegetables such as carrots, red amaranth and purple cabbage, fruits like blueberry and strawberry, grass like Ay Tsaoor, or mix them to get the colors we desire to have.[43–45]

For food containers, we can choose the ones made of glass, ceramic or stainless steel. For the 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. For cooking methods, it's better for us to avoid high temperature methods like frying. If not serving as raw, boiling, steaming or stewing methods can be relative safe ways to use; next is baking or microwaving. Stir-frying or frying in deep oil is not recommended since these methods can make the food and cooking utensils release bad chemicals to 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 really need to consume the processed foods, choose the ones made from more natural ingredients as possible as you can. If they make us have a good mood, we can have them occasionally, but just control the amount we consume each time and avoid to have them too often.

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Conflicts of interest

The author declared that there are no conflicts of interest.

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