Industrial Foods May Harm People, A Current Review of the Evidence

Abstract

Today, the majority of American farmland is dominated by industrial agriculture, featuring chemically intensive food production in enormous single-crop farms and animal production facilities. Modern food processing industry has also grown into a large industry with revenue of hundreds billion dollars. The impacts of industrial agriculture and food processing on the environment and public health have raised concerns over the decades. This paper reviews recent publications on modern interventions commonly used in food industry including genetic engineering, pesticides and herbicides, antibiotics, hormones and food additives as well as their possible damages to human body. It also discusses the benefit to avoid industrial foods and choose organic products. The study concludes that the chemicals used in food industry may have negative influence to our health by causing allergies, autoimmune diseases and cancer. To avoid industrial foods and choose organic products may receive more valuable nutrients and prevent diseases as well.

Keywords: Industrial foods; Industrial agriculture; Food processing industry; Genetic engineering; Glyphosate; Antibiotic; Growth-promoting hormone; Recombinant bovine growth hormone; Food additives; Wheat; Organic food; Bacterial microbiota

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Abbreviations: GM: Genetically Modified; GMO: Genetically Modified Organisms; FDA: Food and Drug Administration; CDC: Centers for Disease Control; ADIs: Acceptable Daily Intakes; WHO: World Health Organization; USDA: U.S. Department of Agriculture; NO3: Nitrates; NO: Nitric Oxide; CSPI: Center for Science in the Public Interest

Introduction

Before industrial agriculture and food processing industry, people ate real food that consisted of whole grains, fruits and vegetables eaten in season or naturally preserved in the summer for winter months. Real food came from animals that grazed on pasture and were allowed to live out their natural instincts. But now industrial agriculture has taken over our food supply. Food has become "products" for the profit-driven "Big Food" [1]. In an attempt to feed more people in an easier and more productive way, food industry has changed the way food has been naturally produced for thousands of years. The food "products" full of chemicals contribute to diseases that affect people's lifespan and life quality. Obesity, cancer, allergies, autoimmune diseases, heart disease, high blood pressure and diabetes are at an all-time high, and most of these diseases are controllable by the food we consume [2,3]. This paper reviews modern interventions commonly used in food industry including genetic engineering, pesticides, antibiotics, hormones and food additives as well as their possible damages to human body. It also discusses the benefit to avoid industrial foods and choose organic products. Hopefully a deeper understanding on industrial foods would gain people's attention to the impact of industrial foods on our health and help general public to understand the importance of mastering our own health through eating healthy foods.

Genetic Engineering and Glyphosate

Genetic engineering is the process of transferring specific traits, or genes, from one organism into a different plant or animal. The resulting organism is called genetically modified organisms (GMO) or genetically modified (GM) food. A large percentage of processed foods in American supermarkets now contain genetically modified ingredients [4]. The principal transgenic crops grown commercially in field are herbicide-resistant strains, called glyphosate-resistant or Roundup Ready soybeans, corn, sugar beet, cotton and canola. In the USA, 93–94% of soy bean, 86% of corn and 95% of sugar beet are glyphosate-resistant GM products [4,5].

Extensive use of the herbicide during crop growth results in glyphosate residues on GM products. Study found that glyphosate residues were clearly detectable from GM-soybean (3.3-5.7 mg/kg) and not from non-GM controls; and non-GM-soybean had a more profitable nutritional profile than GM ones [5]. Moreover, glyphosate is highly adsorbed on most soils especially those with high organic content. Microbes are primarily responsible for the breakdown of glyphosate. It may take as many as 174 days to allow half of the herbicide to break down to its still-toxic degradation byproduct AMPA [6]. In addition, a study from the U.S. Geological Survey revealed that glyphosate and AMPA were found in over 75% of the air and rain samples tested from Mississippi in 2007 [7]. Research also found that glyphosate was detected from animal

and human urine. Cows kept in GM-free area had significantly lower glyphosate concentrations in urine than conventional farming cows. Glyphosate was detected in different organs of slaughtered cows as intestine, liver, muscles, spleen and kidney. Moreover, glyphosate was significantly higher in urine of humans with conventional diet than those with organic diet [8].

Why should we be concerned about glyphosate? As a broad spectrum herbicide, glyphosate kills most plants. It prevents the plants from synthesizing certain amino acids that are needed for plant growth. Glyphosate stops a specific enzyme pathway, the shikimic acid pathway that is necessary for plants and some microorganisms [9]. As a matter of fact, its ability to destroy microbiome of human intestinal tract is likely to cause problems for our health [10-12]. Disturbance of our intestinal flora results in a condition called dysbiosis, a term for a microbial imbalance on or inside the body. Altering susceptibility of the body to infection, allergy, and autoimmunity, dysbiosis is probably the root cause of many modern diseases such as systemic inflammation, allergy and sensitivity, autoimmune diseases and cancer [13].

Moreover, glyphosate is now linked to liver and kidney damage [14,15], bone marrow damage [16], infertility [17], gluten intolerance and celiac disease [10], neurological diseases such as autism [18], depression, ADHD, Alzheimer's disease, Parkinson's disease, ALS, multiple sclerosis [11]. Chronically ill people showed significantly higher glyphosate residues in urine than healthy population [8]. In the meantime, glyphosate is pervasive in our food supply, air and water. Although the amount of glyphosate in each product may not be large, the cumulative effect, especially with as much processed food as Americans eat, could still be devastating. It may in fact be the most biologically disruptive chemical in our environment. The presence of glyphosate residues in both humans and animals could haul the entire human population towards numerous health hazards.

Antibiotics in Industrial Farming

Antibiotics play a critical role in fighting for infections, and are responsible for saving millions of human lives. Unfortunately, inappropriate use of antibiotics is threatening their efficacy. Today, antibiotics are routinely fed to livestock, poultry, and fish on industrial farms to promote faster growth and to compensate for the unsanitary conditions in which they are raised. According to the 2014 report by the Food and Drug Administration (FDA), approximately 80% of all antibiotics used in the US are fed to farm animals [19]. It is estimated that approximately 75% of all antibiotics given to animals are not fully digested and eventually pass through the body and enter the environment [20].

Study found that legal amounts of antibiotic residues in cured meats could still be high enough to kill bacteria that sausage manufacturers intentionally applied to their products. Sausage is fermented with lactic acid-producing microbes to kill dangerous bacteria like salmonella and E. coli. The researchers found that while legal levels of antibiotic residues in meat didn't kill the pathogenic bacteria, but killed the helpful microbes intended to keep the "bad" bugs at bay [21]. Yet another report from FDA in 2015 revealed that 1% of their testing samples of milk produced by U.S. dairy farmers contained drugs, in which most of them are antibiotics [22].

When bacteria are continually exposed to small amounts of antibiotics, they can develop immunity to the drug, called "antibiotics-resistant bacteria", because they have adapted to the point where antibiotics are no longer an effective means of killing them. As a result, some antibiotics have lost their effectiveness against specific infectious diseases. The Centers for Disease Control (CDC) estimates that each year in the US almost 2 million people acquire bacterial infections in hospitals, 70% of which are resistant to at least one commonly used antibiotic [23]. The use of antibiotics in food animal industry is responsible for drug-resistant bacteria emerging on farms which reach the general population through human or animal carriers, and through the food consumers eat and the environment.

Antibiotics are also known to disrupt microbial diversity of the gut flora and increase risk of developing chronic diseases such as asthma, allergy, heart disease, diabetes, cancer and obesity [24,25]]. Although antibiotic residues in food are not in large quantity, the cumulative exposure of antibiotic residues may still affect microbial diversity by inhibiting healthy bacteria.

Hormones in Industrial Farming

Growth-promoting hormones

Since the 1950s, FDA has approved a number of steroid hormone drugs for use in beef cattle and sheep. The hormones increase the animals' growth rate and the efficiency by which they convert their feed into meat [26]. Six hormones are now commonly used in almost all conventional beef cattle farms in Canada and the US: the three natural steroids, estradiol, testosterone and progesterone, and the three synthetic hormones, zeranol (an estrogen), trenbolone acetate (a steroid with androgen and glucocorticoid action) and melengestrol acetate (a potent progestin) [27]. Measurable levels of all the above growth-promoting hormones are found at slaughter in the muscle, fat, liver, kidneys and other organ meats. Based on traditional toxicity testing methods, the FDA has set Acceptable Daily Iintakes (ADIs) for these hormones [27].

Questions and controversy over the impacts of these added hormones on human development and health have lingered for decades. Due to the possible health risks for humans, the use of feeding hormones in livestock production was banned throughout the European Union in 1988. Scientists raised questions that the ADIs, a toxicity indicator, may not reflect the capacity of these hormones, which are potent endocrine disruptors, to alter normal human physiology and health in long term. Moreover, the possible effects on human populations exposed to residues of anabolic sex hormones through meat consumption have never been well studied. This gap in research is remarkable, given that every beef-eating American for over 50 years has been exposed to these hormones on a regular basis [28].

To explore possible impacts of the hormones, scientists [28] carried out a study assessing the consequences of beef consumption by pregnant women on their adult son. The study assessed sperm quantity and quality among 387 men and analyzed the data with the information of their mothers' beef consumption during pregnancy. They found that sperm concentration was 24.3% higher in the sons of mothers in the low beef consumption

group and nearly 18% of the sons born to women in the high beef consumption group had sperm concentrations below the World Health Organization (WHO) threshold for subfertility, about three-times more than in the sons of women in the low consumption group. The authors concluded that maternal beef consumption is associated with lower sperm concentration and possible subfertility, and the associations may be related to the presence of anabolic steroids and other xenobiotics in beef.

Another concern of using hormones in food industry is the recent increase of hormone-dependent cancers. Estrogens are known for their proliferative effects on estrogen-sensitive tissues resulting in tumorigenesis [29]. In Japan, hormone-dependent cancers including breast and ovarian cancer, endometrial cancer and prostate cancer have risen fivefold in the past quarter century [30]. This incidence roughly parallels the increasing consumption of beef imported from the US. Hormonal steroids including estradiol-17b have been implanted to cattle for growth promotion since 1950s in the US. A study was carried out in Japan to evaluate the levels of estradiol-17b (E2) and estrone (E1) in USA beef and Japanese beef. The study found that US beef contained significant higher levels of estrogen, particularly E2, than Japanese beef in both beef fat and red meant. The study suggests that the increasing consumption of estrogen-rich beef following steroid implantation might facilitate estrogen accumulation in the human body and could be related to the incidence of hormone dependent cancers [31]. A US study also found that zeranol (Ralgro-R), one of the six hormones approved by the FDA as a growth promoter for use in the beef, veal, and lamb industries, may have potential health impact on human consumers, particularly with respect to reproductive endocrinology and hormone-sensitive organs [32].

Recombinant Bovine Growth Hormone

Recombinant bovine growth hormone (rBGH) is another hormonal drug commonly used in farm industry in the US. Human and bovine growth hormone, also called *somatotropin*, is made by the pituitary gland and promotes growth and cell replication. Monsanto developed a recombinant version, rBGH, by using genetically engineered *E. coli* bacteria. Sold under the brand name Posilac, rBGH increases milk production 10-15% [33]. One government study from 2007 estimated that approximately 17% of all dairy cows in the US were given this GM growth hormone [34].

The use of rBGH has been under increasing scrutiny. By now, Japan, Australia, New Zealand, Canada and the 27 countries of the European Union do not allow the use of rBGH due to animal and human health concerns. Reports revealed that in addition to many other health issues, cows treated with rBGH face significant increase in the risk of clinical mastitis, a bacterial infection of the udder, which could lead to increased use of antibiotics and an increased risk of antimicrobial residues in milk and to antibiotic resistant bacteria [35,36]. Moreover, milk from rBGH-treated cows contains higher levels of Insulin Growth Factor-1 (IGF-1), a potent hormone to promote tissue growth [36]. While humans naturally have IGF-1, elevated levels in humans have been linked to various types of cancer [37,38]. Although no direct connection has been made between elevated IGF-1 levels in milk and elevated IGF-1 levels or cancer in humans, some scientists have expressed concerns over the possibility of this relationship [36]. American Cancer Society also calls for more research to help better address these concerns [39].

Additives in Processed Foods

Food preservatives (nitrates and nitrites)

The preservatives, sodium or potassium nitrates and nitrites, fights harmful bacteria in bacon, ham, salami and other processed and cured meats and also gives the meats pink coloration. However, under certain conditions, nitrite can damage cells and cause cancer. In an effort to minimize cell damage, while still preventing food-borne illnesses like botulism, the U.S. Department of Agriculture (USDA) enforces a limit of 200 parts of nitrate/nitrite preservatives per million parts of meat, by weight. Nitrates (NO_3) are different from nitrites (NO_2) by only one oxygen atom. Nitrates are turned into nitrites by bacteria in the mouth or enzymes in the body. Then, nitrites can either turn into Nitric Oxide (good) or nitrosamines (bad) [40]. If nitrite loses an oxygen atom, it turns into Nitric Oxide (NO), which reacts with the oxygen-binding proteins in the meat, changing its color. However, when nitrites are exposed to high heat, in the presence of amino acids, they can turn into compounds called nitrosamines [40]. There are many different types of nitrosamines and most of them are well-known potent carcinogens [41]. Nitrosamines are among the main carcinogens in tobacco smoke. Because most bacon, hot dogs and processed meat tend to be high in sodium nitrite and they're high in amino acids, exposing them to high heat during cooking creates the perfect conditions for nitrosamine formation [42]. It's important to keep in mind that nitrosamines mostly form during high heat. Even though vegetables also contain nitrates and nitrites, they are rarely exposed to such high heat when cooking.

Carcinogenic nitrosamines are a well-known problem in processed meats, and manufacturers are required to limit the amount of nitrites they use. To minimize daily exposure to nitrosamines, choosing "nitrate-free" meats is a way to go.

Artificial food coloring

Artificial food coloring makes the foods more appealing and desirable. Every year, food manufacturers pour 15 million pounds of artificial food dyes into U.S. foods. Although the safety of these dyes has been called into question, the FDA still maintains that the artificial food coloring currently permitted for use meet strict safety requirements. However, recent scientific studies have linked these food colors to a number of potential health problems, most notably certain types of cancer in animals and attention-deficit disorder and hyperactivity in children.

According to the Center for Science in the Public Interest (CSPI), nine of the food dyes currently approved for use in the United States are linked to health issues ranging from cancer and hyperactivity to allergy-like reactions. For instance, Red # 40, which is the most widely used dye, may accelerate the appearance of immune system tumors in mice, while also triggering hyperactivity in children. Blue # 2, used in candies, beverages, pet foods and more, was linked to brain tumors. And Yellow # 5, used in baked goods, candies, cereal and more, may not only be contaminated with several cancer-causing chemicals, but it's

also linked to hyperactivity, hypersensitivity and other behavioral effects in children. Another dye, Red # 3, has been acknowledged for years by the FDA to be a carcinogen, yet is still in the food supply [43].

The effect of artificial food colors on child behavior has been studied for more than 35 years. In a double-blind, placebo-controlled study of the ingestion of synthetic food colorings, tartrazine (Yellow 5), and behavioral change in approximately 800 children, one of six dose levels of tartrazine (1, 2, 5, 10, 20, 50 mg) was administered randomly each morning, and behavioral ratings were recorded by parents at the end of each 24 hours. Significant reactions were observed at all six dose levels. A dose response effect was obtained. With a dose increase greater than 10 mg, the duration of effect was prolonged. This study concluded that behavioral changes in irritability, restlessness, and sleep disturbance were associated with the ingestion of tartrazine (Yellow 5) in some children. A dose response effect was also observed [44].

A 2012 publication examined the controversial topic of artificial food coloring and hyperactivity in children and gave testimony to the 2011 FDA Food Advisory Committee. The authors noted that while artificial food colors were not a major cause of ADHD, they did seem to affect both children with and without ADHD [45]. A 2009 publication reviewed clinical studies and meta-analysis of 15 double-blind clinical trials and found that artificial food coloring increased hyperactive behavior in already hyperactive children. The paper concluded that it was best for children to avoid artificial food colors [46].

Industrial Wheat Farming

Wheat is the most common food in American diet. For most Americans, every single meal and snack contains foods made with wheat flour. However, recent report has indicated that more and more people can't eat wheat due to celiac disease, an autoimmune reaction to wheat protein gluten that causes damage to small intestine, or non-celiac gluten sensitivity (NCGS). It is estimated that 1 in 133 Americans suffer from celiac disease with many more cases undiagnosed and unaccounted for [47]. By now, nearly everyone knows that white flour is not healthy for you and many Americans choose "gluten-free" to fix long-standing digestion issues and they feel better. But wheat has been used for thousands of year in human history. Why didn't it cause problem then? It is clear that there could be more to this than gluten along. But what's wrong with modern wheat? How did an ancient food staple become toxic junk food?

First of all, the wheat of today may not be the same grain our forebears ground into their daily bread. In fact, everything has changed dramatically in the past 50 years under the influence of industrial agriculture. It suggests that wheat gluten proteins undergo considerable structural change with hybridization. Genetic differences generated via thousands of human-engineered hybridizations make for substantial variation in composition, appearance, and qualities important not just to chefs and food processors, but also potentially to human health [48].

Industrial farming has also changed the way we grow, harvest, and process wheat. In addition to use of pesticides and herbicides during wheat growth, pre-harvest application of glyphosate to wheat was also reported [10,49]. The procedure was clearly described in the manual prepared by Monsanto, the company that makes the herbicide [50]. Residual glyphosate in wheat products has been suggested to be the cause for gluten intolerance and celiac disease [10].

A whole grain of wheat is composed of three layers: the bran, germ and endosperm. Today's milling industry is designed for mass-production, using high-temperature, high-speed steel rollers. The resulting white flour, made from the endosperm only, is nearly all starch with little nutritional value [51]. Modern wheat starch contains high levels of a super starch called amylopectin A, a long chain of glucose with very high value of glycemic index, meaning converted to glucose very fast. Thus, over intake of wheat product is suggested to be the major contributor to obesity, diabetes, heart disease, cancer, dementia, depression and so many other modern illnesses [48,52].

Flour used to be aged with time to improve baking quality. Now, it is treated with chlorine to instantly produce similar qualities in the flour. It believes that the use of chlorine for bleaching flour is considered an industry standard. The chlorine gas undergoes an oxidizing chemical reaction with some of the proteins in the flour, producing alloxan as an unintended byproduct [51]. Alloxan is the byproduct of xantophyll oxidation, a reaction where the yellow compounds Xantophylls in wheat that react with oxygen, causing flour to turn white [53]. Alloxan is a poison that is used to produce diabetes animal models in the lab. Alloxan causes diabetes because it produces enormous amounts of free radicals in pancreas and destroys the beta cells [54]. Given the raging epidemic of diabetes and other chronic diseases in this country, can we afford to a toxin such as this one in our bread, even if it is present in small amounts?

Organic Farming and Natural Food Movement

Organic farming is a form of agriculture that relies on techniques such as crop rotation, green manure, compost, and biological pest control. Organic farms do not use GM seed, synthetic pesticides or fertilizers. Certified organic refers to agricultural products that have been grown and processed according to uniform standards that have been verified by USDA.

Eating organically grown foods is the only way to avoid the cocktail of chemical poisons present in industrially grown food. It also helps us to avoid GM food as well as hormones, antibiotics and drugs in animal products. A recent research in 2014 reviewed a large number of studies comparing organically grown foods with conventionally grown ones and found that higher amounts of pesticide residues and in many cases also of heavy metals were seen in the conventionally produced crops compared to the organic ones. The research also concluded that animal studies as well as *in vitro* studies showed a clear indication of a beneficial effect of organic food/extracts as compared to conventional ones. Thus, consumption of organic food seems to be positive from a public health point of view [55].

Moreover, organically grown foods have more nutrients, vitamins, minerals, enzymes, and micronutrients, than commercially grown foods because the soil is managed and nourished with sustainable practices by responsible standards. A 2001 research reviewed 41 published studies comparing the

nutritional value of organically grown and conventionally grown fruits, vegetables, and grains and concluded that there were significantly more of several nutrients in organic foods crops [56].

Since the past two decades the market for organic food and other products has grown rapidly. However, organic agriculture currently occupies only 1% of global cropland. A 2015 research analyzed the financial performance of organic and conventional agriculture from 40 years of studies covering 55 crops grown on five continents. The study found that, in spite of lower yields, organic agriculture was significantly more profitable than conventional agriculture and had room to expand globally [57]. Moreover, with its benefits in health and environment, organic farming and natural food movement is likely to contribute a larger share in maintaining public health and sustainably feeding the world.

Discussion

The incidence and prevalence of allergies, autoimmune diseases and cancer has increased dramatically over the past decades. Immunologic dysregulation is the cause of these non-infectious inflammatory diseases. The gastrointestinal tract is the primary site of interaction between the host immunity and microorganisms [58]**.** It is now evident that the gut microbiota has a profound effect on the host immune system. The evidence from recent studies supports the concept whereby disturbances in the bacterial microbiota in gastrointestinal tract result in immunological dysregulation that may underlie these non-infectious inflammatory disorders such as allergies, autoimmune and cancer [58-60]. Aside from the genetic factors, environmental factors play an important role in shaping the microbiota and, therefore, should be treated with caution as inappropriate practices. This study reviews some environmental factors from industrial agriculture and food processing including GE with glyphosate-resistant, antibiotics in farming, hormone usage in animal farming and additives in food processing. Many of these factors disturb bacterial microbiota in gastrointestinal tract and others promote cancer growth in sensitive tissue types. The cumulative exposure of human population to the chemicals explains the rising of the allergies, autoimmune and cancer that parallels the increase in using chemicals in industrial agriculture and food processing. Therefore, eating organically grown foods to avoid the cocktail of chemicals in GM products as well as hormones, antibiotics and drugs in industrially processed animal products benefits in health and prevents diseases.

Conclusion

Traditionally grown foods and industrial foods are different in many ways. Modern interventions such as GE, pesticides and herbicides, antibiotics, hormones and food additives in industrial agriculture and food processing industry may have negative influence to our health. To avoid industrial foods and choose organic products may receive more valuable nutrients and prevent modern diseases as well.

Conflict of Interests

There is no any financial interest or any conflict of interest exists.

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