Technology, Diet, and the Burden of Chronic Disease

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FROM AN EVOLUTIONARY PERSPECTIVE, FOOD IS EITHER difficult to get or difficult to eat. Humans lack the strength and speed of large carnivores and the specialized digestive track of herbivores. Indeed, the diet of early hominids was mostly limited to fruits and insects. For this reason, humans have long strived to develop technologies to improve food availability, digestibility, safety, transportability, and storage life. However, the rate of change in food technology has greatly accelerated, with major implications to human nutrition and health.

Three Revolutions in Food Technology

The first transformative technology, dating to approximately 2 million years BCE, was the development of stone tools for hunting and food preparation in the Paleolithic era. Stone tools, together with the use of fire for cooking, dominated food culture for more than 95% of human existence as a species. These technologies produced a substantial improvement in diet quality and diversity (eg, large animals, tubers, nuts), supported the development of a larger brain, and aided evolution of modern *Homo sapiens*.

About 12 000 years BCE, domestication of staple grains ushered in the Agricultural Revolution, fostering a huge increase in available calories, a massive expansion of human populations, and creation of civilization. However, the advent of agriculture also caused the first widespread occurrences of protein- and micronutrient-deficiency diseases, because grains tend to have a lower ratio of nutrients to calories than animal and other plant foods. Archeological evidence suggests that mean stature decreased by several inches with transition from a hunter-gatherer to agrarian lifestyle,[1] a loss that has only recently been recovered in Western countries.

The Industrial Revolution of the 19th century allowed for mass production of refined flour and concentrated sugar, setting the stage for what might be termed the commodity-based diet, characterized by food extrusion technology, petrochemicals, and biotechnology. This era culminated in the widespread dissemination of ultraprocessed products such as fast food throughout the United States.

Ultraprocessing and Chronic Disease

Ultraprocessed products (a term coined by Monteiro et al[2]) may resemble natural foods, but actually represent a radically new creation. Strawberry Splash Fruit Gushers, for example, has only a trivial amount of strawberries (from concentrate), presumably for the purposes of marketing. The product contains highly processed ingredients never before present in the food supply, including 7 variants of sugar and partially hydrogenated fat.

The tremendous variety of ultraprocessed products marketed today derives predominantly from extreme chemical and mechanical manipulation of just 3 species—corn, wheat, and soy—and animals fed these commodities, representing a transformation from species diversity to product diversity of the diet. In an anecdotal report,[3] a television reporter commissioned an isotopic analysis of his hair and found that 69% of the carbon could be traced to corn, highlighting Pollan's concerns about the dominance of this one species in the US diet.[4]

A diet based on ultraprocessed products may promote obesity and chronic disease through a variety of mechanisms, including high energy density; large portion size; low content of fiber, micronutrients, and phytochemicals; poor-quality dietary fat; high glycemic load; and high-intensity flavoring.

The removal of water during processing promotes shelf life and decreases transportation costs, but also increases the number of calories contained in a bite of food. Acutely, individuals regulate solid food intake by volume more so than calories.[5] Over the long term, habitual energy density is inversely related to dietary quality and directly related to body weight. High energy density may promote overconsumption especially in the context of large portion sizes. When young children were given small, medium, or large portions of macaroni and cheese for lunch, calorie intake did not differ. However, intake increased with increasing portion size among older children, suggesting that individuals may lose the ability to recognize, or learn to disregard, internal satiety mechanisms in the modern food environment.[6]

Ultraprocessed products are concentrated in calories, but deficient in fiber, micronutrients, and phytochemicals (plant substances that may mediate some of the protective effects of vegetables and fruits against diabetes, heart disease, and

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cancer). A 10-oz, 90-kcal portion of strawberries has 5 g of fiber, significant amounts of several vitamins and minerals, and dozens of phytochemicals, whereas a 1-oz portion of Fruit Gushers also has 90 kcal but virtually none of these beneficial constituents.

Dietary fat quality of ultraprocessed food tends to be exceptionally poor, with reliance on trans fat and saturated fat (solid at room temperature) for product stability. These fats increase risk for heart disease,[7] whereas protective polyunsaturated fats tend to be removed or destroyed in the manufacturing process. Similarly, food processing increases glycemic index, a measure of how quickly carbohydrate-containing foods increase blood glucose. In a multicenter study of 773 adults who had lost at least 8% of baseline body weight, individuals assigned to a low glycemic index diet regained significantly less weight over 6 months than those assigned to a high glycemic index diet.[8] In addition, ultraprocessed products typically emphasize sugar, salt, and fat. This high-intensity flavoring, often further enhanced with artificial ingredients, may override endogenous satiety mechanisms and produce behavior akin to addiction.

Observational research suggests that a diet based on ultraprocessed products such as fast food causes excessive weight gain and chronic disease.[9] In contrast, a diet with key features of minimally processed foods—including high cereal fiber, folate (a marker of vegetable consumption), and long-chain omega-3 polyunsaturated fat; a high ratio of total polyunsaturated to saturated fat; and low trans fat and glycemic load—appears to prevent heart disease[10] and other obesity-related complications.

Toward a More Appropriate Use of Technology

Food processing is a fundamental aspect of human culture and industrial methods are necessary to support a world population that now exceeds 6 billion. Extensively processed foods like refined flour, sugar, and oils have been consumed by humans for millennia as ingredients in meals made primarily from whole or minimally processed foods. The problem, as Monteiro et al[2] argue, is the creation of a dietary pattern based on factory-made, durable, hyperpalatable, aggressively marketed, ready-to-eat or heat foodstuffs composed of inexpensive, highly processed ingredients and additives. Reducing the burden of obesity-related chronic disease requires a more appropriate use of technology that is guided by public health rather than short-term economic considerations (BOX).

Box. Example of Measures to Promote a More Appropriate Use of Food Technology

Government
- Restructure agricultural subsidies to promote high-quality foods (eg, vegetables, fruits, and legumes)
- Regulate food advertising/marketing, especially to children
- Adequately fund school lunch and related nutrition programs

Public
- Buy fewer ultraprocessed products
- Prepare meals from basic ingredients in the home
- Give preference to restaurants that prepare meals from scratch

Schools
- Prepare lunch and snack foods from whole ingredients
- Institute a new "home economics" curriculum to promote cooking

Restaurants
- Provide intermediate option between gourmet food and fast food—convenient, inexpensive meals prepared from whole foods (eg, Chipotle Mexican Grill)

Industry
- Use higher nutritional value ingredients vs commodities
- Market minimally processed/traditionally processed products (eg, stone ground bread, steel-cut oats)
- Use preservation methods that protect polyunsaturated fats

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