Old Fashioned vs. Ultra-Processed-Based Diets

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Ultra-processed foods are ready-to-heat and ready-to-eat products created to replace traditional homemade meals and dishes due to convenience and accessibility. Because of their low-fiber and high-fat and sugar composition, these foodstuffs could induce a negative impact on health. They are partially responsible for obesity and chronic non-transmissible diseases; additionally, they could impact in the prevalence of autoimmune diseases such as type 1 diabetes and celiac disease. The rationale is that the nutritional composition of ultra-processed foodstuffs can induce gut dysbiosis, promoting a pro-inflammatory response and consequently, a “leaky gut”. These factors have been associated with increased risk of autoimmunity in genetically predisposed children. In addition, food emulsifiers, commonly used in ultra-processed products could modify the gut microbiota and intestinal permeability, which could increase the risk of autoimmunity. In contrast, unprocessed and minimally processed food-based diets have shown the capacity to promote gut microbiota eubiosis, anti-inflammatory response, and epithelial integrity, through bacterial butyrate production.

ultra-processed food products autoimmunity risk type 1 diabetes celiac disease microbiota

1. Introduction

Type 1 diabetes (T1D) and celiac disease (CD) are the most important autoimmune disorders in childhood; they share the genetic predisposition given by the haplotypes DQ2 and DQ8 of the human leucocyte antigen (HLA-DQ2 and -DQ8) and some environmental risk factors. In T1D, immune response to self-antigens leads to pancreatic β-cell apoptosis, lack of insulin production, and hyperglycemia [1]; while, CD is an enteropathy triggered by dietary gluten, characterized by flattened intestinal villi and impaired nutrient absorption [2]. Lately, the prevalence of T1D and CD has increased at rates that cannot be explained only by genetic predisposition [3][4][5][6], which points towards the existence of environmental factors that increase autoimmunity risk [5][7].

Factors that affect the gut microbiota balance such as feeding patterns, infections, and antibiotic treatments during the first months of life, have been associated to an increased risk of T1D and CD [8][9]. Commensal gut microbiota plays an important role in the maturation and modulation of the immune system. Misbalance in gut microbiota at an early age can induce irreversible changes in the immune response, increasing the susceptibility to allergic and autoimmune diseases [10]. Additionally, diet is a major determinant of gut microbiota profile at any age [11]. Dietary components can cause changes in microbiota composition at genus and even at phylum level, depending on the

magnitude and duration of the dietary changes [12][13]. Current diets based on processed and ultra-processed foods could induce gut dysbiosis (i.e., overgrowth of opportunistic microorganisms or pathogen species). This promotes a pro-inflammatory response, an increase in gut permeability, and the susceptibility to autoimmune diseases, such as CD and T1D, in genetic predisposed children [14].

Due to its convenience and accessibility, ultra-processed foods, namely ready-to-eat or ready-to-heat products, have gained popularity in the last decades. They have substituted the “old fashioned diets”, of unprocessed and minimal processed foods, to prepare homemade meals and dishes [15]. The majority of ultra-processed products contain high energy density, fat, simple sugars, sodium, as well as several additives [16]. Their intake could induce nutritional imbalance and increase the susceptibility to autoimmunity through the modification of gut microbiota and/or other mechanisms.

2. Microbiota, Gut Health and Autoimmunity

T1D and CD share genetic predisposition, several risk factors, and bacterial markers of dysbiosis. The risk of autoimmune diseases in genetically predisposed individuals increases after alteration of gut microbiota, which leads to a pro-inflammatory response and increases gut barrier permeability [14][17]. Autoimmune diseases are associated with dysbiosis of gut microbiota; however, it remains unknown if these alterations are the cause or consequence of the disease [18]. Possibly, an aberrant gut microbiota and a “leaky gut”, induced by dietary components and/or other environmental factors, could be the main component that initiates a chain of reactions conducting to autoimmunity and preceding metabolic alterations that can reinforce dysbiosis.

A hypothesis, proposed by Davis-Richardson and Triplett [14], suggests that a diet with high fat and gluten, and low resistant starch, induces overgrowth of the Bacteroides genus and reduction of butyrate producing bacteria in gut microbiota. Butyrate contributes to epithelial integrity and promotes an anti-inflammatory response [19]. The high Bacteroides scenario derives in the alteration of gut permeability, allowing antigens to cross to lamina propria, and increasing the susceptibility of an autoimmune response [14].

3. Newer Is Not Always Better

Current lifestyles have influenced dietary habits from a diet based on fresh and minimal processed foods to another with high consumption of processed and ultra-processed foodstuffs [20]. Nowadays, due to the parent’s lack of time, children end up eating ultra-processed and fast foods on a regular basis [21].

Food processing comprises all the methods and techniques used to prepare products from fresh food and other ingredients [15]. According to the processing degree and purpose, food products can be unprocessed or minimally processed foods, processed culinary or food industry ingredients, processed foods and ultra-processed food, and drink products [15][22]. Ultra-processed foods include ready-to-eat and ready-to-heat products that replace homemade meals and dishes. They are formulated with substances derived or extracted from foods and with an extensive use of additives [15]. As a result, ultra-processed products frequently have an obesogenic nutrient profile,

being less satiating and having higher glycemic loads than those of minimally processed foods [23][24]. **Figure 1** shows an example of the stages and purposes of food processing, as well as the names of food products in each stage, from fresh and minimally processed to ultra-processed food products. A more extended description of food classification according to their processing degree is shown in **Table 1**.

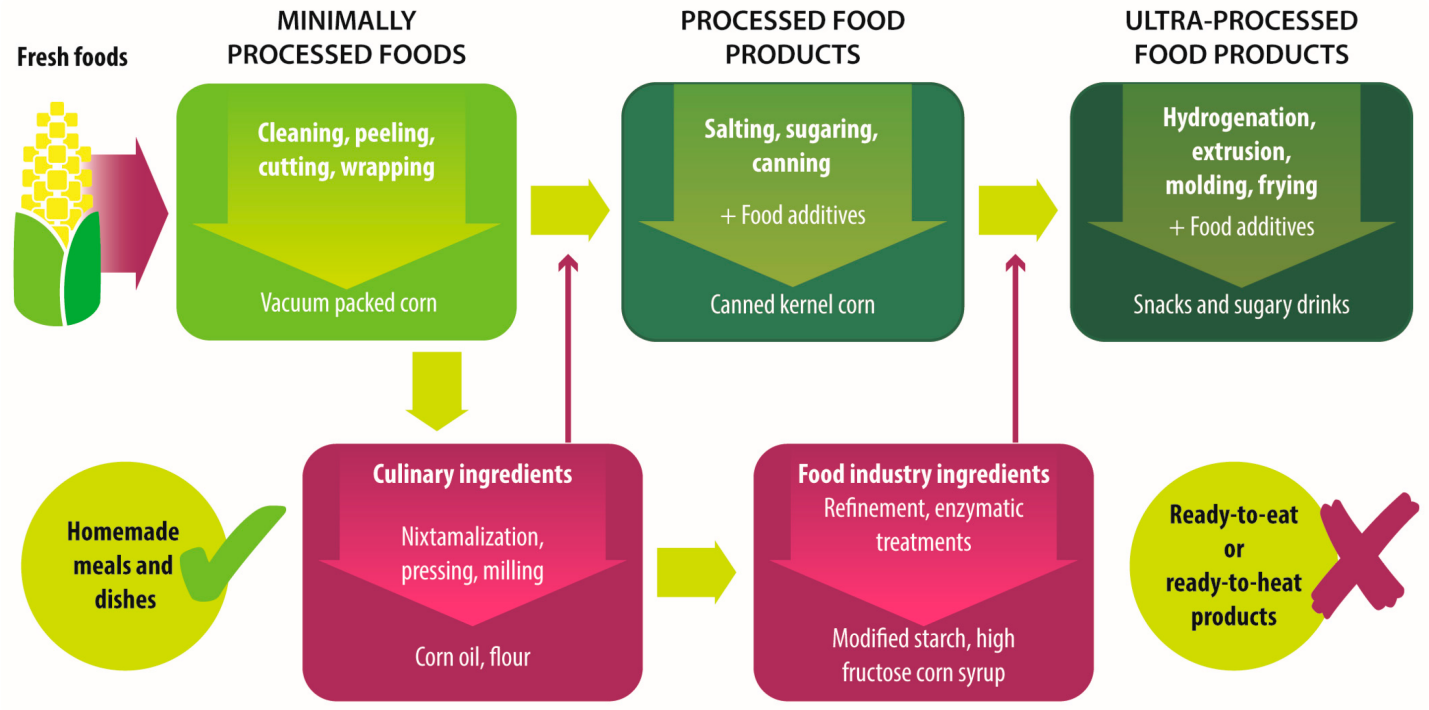

Figure 1. Industrial processing stages, from fresh food to ultra-processed food products.

Table 1. Classification of food according to its processing degree *.

Group	Definition	Processing	Examples
Unprocessed foods	Fresh foods directly obtained from plants or animals.	No industrial processing.	Fresh fruits, vegetables, meat, eggs, grains and legumes.
Minimally processed foods	Physical alteration of unprocessed foods.	Peeling, cutting, drying, pasteurization, refrigeration, freezing, vacuum packing, simple wrapping.	Chilled, frozen or dried fruits, vegetables, meat and poultry; pasteurized or powdered milk; vegetables or fruit juices without added sugar.
Processed culinary	Substances extracted from unprocessed or	Pressing, refining, grinding, milling.	Salt, sugar, flour, vegetable oil, starches, butter, etc.

Group	Definition	Processing	Examples
ingredients	minimally processed foods used to prepare dishes and meals.		
Processed food industry ingredients	Substances extracted from unprocessed or minimally processed foods used in the formulation of ultra-processed foods.	Hydrogenation, hydrolysis, use of enzymes and additives.	High fructose corn syrup, lactose, milk and soy proteins.
Processed foods	Products made by adding sugar, salt, oil, fats or other culinary ingredients, to minimally processed foods.	Preservation or cooking methods, non-alcoholic fermentation.	Bread, cheese, canned vegetables and legumes, fruits in syrup, salted nuts and seeds, smoked and salted meat.
Ultra-processed foods	Industrial formulations manufactured mainly from processed food industry ingredients.	Frying, deep frying, curing, extrusion, molding, extensive use of additives, such as preservatives, colorants, flavorings, non-sugar sweeteners, emulsifiers, etc. [15][22][24]	Ready-to-heat, ready-to-eat or ready-to-drink products like carbonated drinks, sweet or savory snacks, breakfast cereals, fruit yoghurt, sausages, hams, instant soups, pre-prepared meals and dishes, infant formulas, baby food.

Consumption of processed and ultra-processed food products has increased in the last decades in both developed and developing countries. For instance, from 1987 to 2009, its consumption increased in Brazil from 20.3% to 32.1%. Sausages, ready meals, sweets, soft drinks, and other sugary drinks increased more than double in every socioeconomic level, with higher tendency in the lower ones [25]. According to the Pan American Health Organization, from 2000 to 2013, the sales of ultra-processed products growth from 1.5% to 68.4% among thirteen Latin American countries [22]. Similarly, in Canada there was an increase in the caloric share of ready-to-eat products from 28.7% to 61.7%, in the period of 1938 to 2011, displacing the consumption of fresh or minimally processed foods [20].

The disproportionate consumption of ultra-processed food products is adversely impacting general health. An ecological study made in nineteen European countries found that dietary energy from ultra-processed foods ranked

from 10.2% to 50.7%, and its consumption positively correlated with the prevalence of obesity [16]. Also, in a Spanish cohort of middle-age adults, there was a positive association between ultra-processed food consumption and hypertension risk [26], which can be associated to salt content and other lifestyle behaviors.

The negative effects of ultra-processed foodstuffs on children can be even more dangerous, influenced by aggressive marketing [27]. In Brazil, processed and ultra-processed food products contributed with 19.7% and 37% of the energy intake in children younger and older than 24 months, respectively [28]. These products, in addition to the high total, saturated, and/or trans-fat, free sugars and sodium [27], have additives as emulsifiers, preservatives, colorings, and flavorings that also represent health risks. In Brazilian adolescents, ultra-processed products consumption was associated with metabolic syndrome [29] and it was a predictor of higher increase of total cholesterol and LDL cholesterol from preschool to school age [30]. Because of high glycemic load, the frequent intake of these products can induce obesity and insulin resistance in genetically predisposed children, which accelerate beta-cell apoptosis, conducing to an early T1D onset [31].

4. Dietary Components Shape Gut Microbiota

Diet is the main factor that influences gut microbiota composition [32]. Dietary impact has been actively studied in the last years, after the pioneering study of De Fillipo et al. [33]. They found a remarkable difference in the microbiota profile between children from a rural community in Africa and those of an urban area in Italy. African children consumed a grain-based diet with high dietary fiber intake and their microbiota was abundant in Bacteroidetes, especially in the Prevotella genus; meanwhile Italian children had a westernized diet (high in fat and animal protein) and Firmicutes (mainly Faecalibacterium) dominated their microbiota.

Subsequently, other studies found that dietary components, like fat, carbohydrates, protein, fiber, and some food additives, were associated to specific changes in the microbiota composition [12][34]. These findings are significant during infancy and childhood, because lactation regime (formula or breastfeeding), age and type of solid food introduction, and subsequent diet composition, profoundly impact microbiota establishment and maturation possibilities [11][35][36]. Surprisingly, many food products exclusively designed for infants such as baby foods, milk formulas, and ready-to-eat breakfast cereals, are in the classification of ultra-processed food products [15][22].

In children, an adult-like microbiota is established around 3–5 years old and its composition remains relatively stable throughout life [37], except by 30–40% of its structure, which can be modified by diet and other environmental factors [36]. Depending on dietary components, changes can be positive or unfavorable. For example, the shift to an animal-based diet (high fat and protein content) increases the abundance of bile-tolerant microorganism like Alistipes, Bilophila, and Bacteroides [13]. Thus, if specific diet components support particular bacterial abundance, the impact of ultra-processed food consumption on microbiota structure can be foreseen through their ingredients.

5. Are Old Fashioned Diets Better?

Disadvantages of ultra-processed food excessive consumption have been described here, but little was addressed about the benefits of a fresh and minimally processed food-based diet. Fresh and minimally processed foods are the counterpart of ultra-processed products; their content of fiber, protein, complex carbohydrates, and micronutrients is high, while sodium is low and additives are null [16]. In addition, according to the processing degree, the satiety potential of ingested foods diminishes and the glycemic load increases [23]. **Table 2**, presents a comparison of the characteristics of compounds and overall effects of diets composed of unprocessed foods vs. ultra-processed food products.

Table 2. Comparative characteristics of compounds and overall effects of old fashioned diet vs. ultra-processed food-based diet.

Characteristic	Old Fashioned Diet (Unprocessed or Minimally Processed Food-Based Diet)	Ultra-Processed Products-Based Diet
Fiber *	↑ Dietary fiber from vegetables, whole grains and cereals.	↓ Dietary fiber due to the refining process.
Fat *	Balance between saturated and unsaturated fats, depending on food selection.	↑ Total fat and trans fat added or generated by the processes of baking and frying.
Carbohydrates *	↑ Complexes carbohydrates and natural resistant starch from whole grains and cereals.	↑ Added sugars in sweets, confectionary and soft drinks.
Protein *	↑ Amount and quality of protein from fresh meat, eggs, fish and poultry.	↓ Quantity of protein often accompanied by added fat.
Micronutrients *	↑ Quantity of vitamins and minerals if all food groups are included in a balanced way.	↓ Concentration of vitamins and minerals due to the refining process if not fortified.
Sodium *	Sodium intake depends mainly on the added salt to foods.	↑ Amounts of sodium.

Characteristic	Old Fashioned Diet (Unprocessed or Minimally Processed Food-Based Diet)	Ultra-Processed Products-Based Diet
Additives *	Free of additives.	Extensive use of additives like emulsifiers, coloring, flavoring, and preservatives.
Effect on ♀:		
Gut microbiota ‡	Eubiosis with high abundance of butyrate producer bacteria.	Dysbiosis marked by *Bacteroides* and gram-negative Proteobacteria.
Bacterial Metabolites ɣ	↑ Production of butyrate	↑ Production of acetate and other short chain fatty acids.
Immune response §	Anti-inflammatory response.	Pro-inflammatory response.
Epithelia integrity §	Thigh junction's integrity due to the production of butyrate.	Altered intestinal permeability due to dysbiosis or emulsifiers' effect.
Susceptibility to T1D or CD ¶	Reduced susceptibility.	Increased susceptibility.

↑: higher; ↓: lower; T1D: type 1 diabetes; CD: celiac disease; * [15][16][20][21][22][23][24][25][26][27][28][29][30][38]; ♀ Comparing high in fiber and resistant starch vs. high in fat, sugars and emmulsifiers diets. ‡ [11][12][13][14][33][36][39][40][41][42][43][44][45][46][47][48][49][50][51][52][53][54]. ɣ [17][39][41][42][50]. § [14][17][34][39][55][56][57][58]. ¶ [11][17][31][55].

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