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Minimally processed foods are more satiating and less hyperglycemic than ultra-processed foods: a preliminary study with 98 ready-to-eat foods

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Beyond nutritional composition, food structure is increasingly recognized to play a role in food health potential, notably in satiety and glycemic responses. Food structure is also highly dependent on processing conditions. The hypothesis for this study is, based on a data set of 98 ready-to-eat foods, that the degree of food processing would correlate with the satiety index (SI) and glycemic response. Glycemic response was evaluated according to two indices: the glycemic index (GI) and a newly designed index, the glycemic glucose equivalent (GGE). The GGE indicates how a quantity of a certain food affects blood glucose levels by identifying the amount of food glucose that would have an effect equivalent to that of the food. Then, foods were clustered within three processing groups based on the international NOVA classification: (1) raw and minimally processed foods; (2) processed foods; and (3) ultra-processed foods. Ultra-processed foods are industrial formulations of substances extracted or derived from food and additives, typically with five or more and usually many (cheap) ingredients. The data were correlated by non-parametric Spearman's rank correlation coefficient on quantitative data. The main results show strong correlations between GGE, SI and the degree of food processing, while GI is not correlated with the degree of processing. Thus, the more food is processed, the higher the glycemic response and the lower its satiety potential. The study suggests that complex, natural, minimally and/or processed foods should be encouraged for consumption rather than highly unstructured and ultra-processed foods when choosing weakly hyperglycemic and satiating foods.

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Introduction

Meta-analyses clearly show that healthy and Mediterranean diets can decrease the risk of developing type 2 diabetes by 15 to 23%.^{1–5} Moreover, vegetarian and Mediterranean diets significantly reduced fasting glucose by 0.36 mmol L⁻¹ and 3.89 mg dL⁻¹, respectively, fasting insulin by 1.06 μU mL⁻¹ and the HOMA-IR index by up to 0.45, which contributes to close control of carbohydrate metabolism.^{6–8} What is particularly significant is that these diets are predominantly based on consuming raw and minimally processed and plant products (fruits, vegetables, grains and seeds) in substantial quantities. Moreover, concerning the food groups and on the basis of the comparison of high *versus* low consumption, whole grains, nuts, coffee, dairy products and legumes appear to be rather protective with respect to type 2 diabetes, unlike sweetened beverages and red and/or processed meat.^{9,10} Conversely, based on the results of meta-analyses, non-healthy diets (or

western-type diets) increase the risk of type 2 diabetes by 41 to 44%.^{2,4} These diets are usually high in animal products and/or ultra-processed foods that are high in energy and low in protective compounds. Beyond conventional food groups, these results suggest that the degree of food processing also comes into play when assessing the risk of type 2 diabetes.¹¹

Within the same food group, there are indeed foods with diverse health values according to the technological processes applied.¹¹ Thus, ready-to-eat breakfast cereals for adults, such as muesli, and those for children, such as extruded cereals enriched with sugars and fat, have very different nutritional values.¹² Moreover, among 39 765 men and 157 463 women in the Health Professionals Follow-up Study and the Nurses' Health Study I and II, high intake of brown rice was associated with an 11% lower relative risk of type 2 diabetes, whereas high consumption of white rice was associated with a 17% higher relative risk of type 2 diabetes.¹³ In these two examples, the degree of processing is likely to make the difference from a nutritional point of view, not cereal as a botanical group.

Based on the NOVA classification ranking foods into 4 groups (see groups lines below) according to their extent of processing, other studies have also shown that ultra-processed food as a whole (Group 4), are nutritionally inferior to the com-

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