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Beyond nutrient-based food indices: a data mining approach to search for a quantitative holistic index reflecting the degree of food processing and including physicochemical properties†

Anthony Fardet, *[a] Sanaé Lakhssassi[a] and Aurélien Briffaz[b]

Processing has major impacts on both the structure and composition of food and hence on nutritional value. In particular, high consumption of ultra-processed foods (UPFs) is associated with increased risks of obesity and diabetes. Unfortunately, existing food indices only focus on food nutritional content while failing to consider either food structure or the degree of processing. The objectives of this study were thus to link non-nutrient food characteristics (texture, water activity (a_w), glycemic and satiety potentials (FF), and shelf life) to the degree of processing; search for associations between these characteristics with nutritional composition; search for a holistic quantitative technological index; and determine quantitative rules for a food to be defined as UPF using data mining. Among the 280 most widely consumed foods by the elderly in France, 139 solid/semi-solid foods were selected for textural and a_w measurements, and classified according to three degrees of processing. Our results showed that minimally-processed foods were less hyperglycemic, more satiating, had better nutrient profile, higher a_w, shorter shelf life, lower maximum stress, and higher energy at break than UPFs. Based on 72 food variables, multivariate analyses differentiated foods according to their degree of processing. Then technological indices including food nutritional composition, a_w, FF and textural parameters were tested against technological groups. Finally, a LIM score (nutrients to limit) ≥8 per 100 kcal and a number of ingredients/additives >4 are relevant, but not sufficient, rules to define UPFs. We therefore suggest that food health potential should be first defined by its degree of processing.

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Introduction

Up to now, food health potential has mainly been evaluated by scientists based on indices that indicate nutrients to encourage and which to limit, *e.g.*, the Nutrient-Rich Food Index[1] or the NDS (Nutrient Density Score) and LIM (LIMited nutrient score) indices.[2] However two food matrices of identical nutritional composition but whose structure is not the same may not have the same health potential due to differences in nutrient bioavailability and satiety.[3] In other words, despite identical composition, one calorie of a given food is not necessarily the equivalent of one calorie of another food. For example, foods may have a different glycemic index due to different degrees of starch gelatinization, food density, food matrix disintegration or particle size[4] as has been clearly demonstrated for apple,[5] bread,[6] wheat grain,[7] and plantain.[8] Therefore although nutritional composition tables may be useful in providing an overview of which macro-nutrients and micronutrients the food supplies to the organism, they fail to mention nutrient bioavailability or satiety. Yet the scientific literature clearly shows that this is a fundamental aspect of food health potential.[4,9]

In practice, food health potential needs to be defined by both the structure of the food (qualitative aspect) and nutrient composition (quantitative aspect).[4] The problem today is that very few data are available on the structure of foods (*i.e.*, density, hardness, thickness porosity, water activity (a_w), water holding capacity, viscosity, *etc.*); and no table of structural food characteristics exists. What is more, only a few studies have linked these characteristics with health potential in animals[10] and humans.[4,11] Given the increasing consumption of ultra-processed foods, there is therefore an urgent need to collect physical and physical-chemical food characteristics, and to link them with health effects in humans.

[a]*Université Clermont Auvergne, INRA, UNH, Unité de Nutrition Humaine, CRNH Auvergne, F-63000 Clermont-Ferrand, France. E-mail: anthony.fardet@clermont.inra.fr; Fax: +33(0)4 73 62 47 55; Tel: +33(0)473 62 47 04*
[b]*CIRAD, UMR Qualisud, TA B-95/16, 73 rue J-F. Breton, F- 34398 Montpellier Cedex 5, France*

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