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Influence of food structure on dairy protein, lipid and calcium bioavailability: A narrative review of evidence

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ABSTRACT

Beyond nutrient composition matrix plays an important role on food health potential, notably acting on the kinetics of nutrient release, and finally on their bioavailability. This is particularly true for dairy products that present both solid (cheeses), semi-solid (yogurts) and liquid (milks) matrices. The main objective of this narrative review has been to synthesize available data in relation with the impact of physical structure of main dairy matrices on nutrient bio-accessibility, bioavailability and metabolic effects, *in vitro*, in animals and in humans. Focus has been made on dairy nutrients the most studied, *i.e.*, proteins, lipids and calcium. Data collected show different kinetics of bioavailability of amino acids, fatty acids and calcium according to the physicochemical parameters of these matrices, including compactness, hardness, elasticity, protein/lipid ratio, P/Ca ratio, effect of ferments, size of fat globules, and possibly other qualitative parameters yet to be discovered. This could be of great interest for the development of innovative dairy products for older populations, sometimes in protein denutrition or with poor dentition, involving the development of dairy matrices with optimized metabolic effects by playing on gastric retention time and thus on the kinetics of release of the amino acids within bloodstream.

KEYWORDS

Dairy products; food structure; protein; lipid; calcium; bio-accessibility; bioavailability

Introduction

Today there are sufficient scientific evidences to include the matrix effect for defining food health potential, not only nutrient composition (Fardet, 2014a; Fardet, 2015a; Fardet, 2015b; Fardet et al., 2013). Indeed, at similar composition (nutrients and calories) two foods with distinct matrix structure – resulting from either different technological processes or different degree of chewing – may give different health potential, as shown for example with apple products (Haber et al., 1977), durum wheat pasta versus bread (Granfeldt et al., 1991), whole carrot versus carrot nutrients (Moorhead et al., 2006), almonds of different particle sizes (Grundy et al., 2016), casein versus corresponding aminoacid mixture (Dangin et al., 2001) and grilled beef meat differently chewed (Rémond et al., 2007). Concerning the carbohydrate fraction, according to starch structure (Fardet, 2015b), food particle size (Holt and Miller, 1994) and/or food density (Burton and Lightowler, 2006) it is well recognized that blood glycaemic responses may be rather different leading to different insulinemic responses with important consequences for diabetic subjects (Fardet, 2014b). Concerning the protein fraction, it has also been shown that depending on chewing (Rémond et al., 2007) or protein structure (Boirie et al., 1997) the subsequent protein metabolism and protein gain are different, also with important implications, notably in elderly populations (Dangin et al., 2003). Finally, the same is true for the lipid fraction, and depending on lipid droplet size, lipids are not metabolized similarly with again implication in clinically ill patients, as for lipase pancreatic insufficiency (Armand et al., 1999). On the other hand, concerning the fiber fraction, depending on their physico-chemical properties such as water-holding capacity, porosity, swelling behaviour and/or degree of crystallinity, they are not fermented according to the same profiles leading to production of different short-chain acid profiles within colon (Fardet, 2016). Therefore, for all these important nutrient it is not exaggerated to define slow and rapid fractions, each one impacting differently metabolism. In all these examples this is not the composition which matters but the physicochemical characteristics of the food matrix. If such effects have been widely studied for plant-based foods this is less true for animal-based foods, notably dairy products. Yet, main dairy products exhibit three different types of food structure or texture as defined by rheological science, i.e., liquid (milks and some fermented milks), semi-solid (yogurts and some fresh cheeses) and solid (most of cheeses). And in each category are encountered numerous different food structures, especially in cheeses.

Otherwise it is not only to know the food composition to estimate which nutrient fraction will be actually used by the organism. For example, in starchy foods, a fraction of starch is not digested within small intestine and arrived to the

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