DAIRY: THE MATRIX MATTERS

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ABSTRACT

The Consumer Education Project (CEP) of Milk SA communicates the health and nutritional benefits of dairy to consumers, reaching the public and health professionals. Messages range from reinforcing well-known and long-established information to sharing the latest scientific findings on the goodness of dairy. The CEP is well-positioned to share the most recent evidence-based research on dairy and its role in health and nutrition with health professionals in South Africa.

The nutrients contained in dairy are essential for helping to meet the dietary reference intakes of the population, and specifically for providing the gap nutrients identified in South African diets. The nutrients in milk and other dairy also contribute to lowering the risk of non-communicable diseases, such as type 2 diabetes and cardiovascular disease. South Africa adopted its food-based dietary guidelines in 2013, including adding the one related to dairy: “Have milk, maas or yoghurt every day”. However, the role of dairy in health and nutrition extends beyond its nutrient content. This is most likely due to the dairy matrix effect, which refers to the sum of the nutrients and other components within the physical–chemical structure of the dairy products and how they affect health outcomes. Foods consist of many different nutrients and components (bioactive compounds and non-nutritive elements) that sit within complex physical structures – a fluid (e.g., milk) and semi-gel or spoonable structure (e.g., yoghurt) or a solid (e.g., cheese). The ‘food matrix’ describes food in terms of its physical form, nutrient content and how these interact. It is especially true for dairy foods like milk, cheese and yoghurt. Research recognises that the health effects of dairy foods surpass their nutrient benefits. Dairy, as a whole food, is greater than the sum of its parts and the unique interaction of the nutrients within the diary, referred to as the dairy matrix, is responsible for its many health benefits.

KEYWORDS

Dairy; dairy matrix; food matrix

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HYPOTHESIS

The concept of the dairy matrix explains the health benefits of dairy that go beyond its nutrient content and its impact on lifestyle diseases.

OBJECTIVES

To explain the concept of the dairy matrix and its associated health benefits and how the structure and interactions within whole dairy foods influence health outcomes.

METHODOLOGY

A comprehensive review of available literature and research addressing the dairy matrix as a potential explanation of the health effects of dairy that go beyond its nutrient content.

REVIEW

The dairy matrix – the sum of the nutrients and other components within the physicochemical structure of a whole dairy product – is important for health.

The *nutrients* contained in dairy are important for meeting dietary reference intakes, for providing the gap nutrients in South African's diets, and in determining the risk of non-communicable diseases. However, diets do not consist of nutrients in isolation. Because whole foods are consumed, South Africa has adopted *food* based dietary guidelines, including the dairy-related guideline: "Have milk, maas or yoghurt every day".

This review explains the concept of the food matrix as basis for physiological between-product differences and summarises current evidence linking different dairy products to different health endpoints. Contrary to a common assumption, Table 1 shows major between-product differences in the dairy food group. Consequently, these products may have different health effects.

TABLE 1: COMPARISON OF DIFFERENT DAIRY PRODUCTS (ADAPTED FROM THORNING 2017

Dairy product	Calcium (mg/100g)	MFGM* (mg/100g)	Protein (amount [mg/100g]; type)	Fermented	Fat structure	Protein net-work
Milk, skimmed	124	15	3.5; Whey/casein	No	Tiny native MFG/ potential MFGM	Liquid
Milk, (3.5% fat)	116	35	3.4; Whey/casein	No	Native MFG or homogenised milk fat droplets/ potential MFGM	Liquid
Yoghurt, (1.5% fat)	136	15	4.1; Whey/casein	Yes	Native MFG or homogenised milk fat droplets/ potential MFGM	Gel/ viscoelastic
Cheese (25% fat)	659	150	23.2; Casein	Yes	MFG/aggregates/ free fat	Solid/ viscoelastic
Cream (38% fat)	67	200	2; -	No	Native MFG or homogenised milk fat droplets/ potential MFGM	Liquid
Butter	15	-	<1; -	No/Yes	Continuous fat phase (water in oil emulsion)/ MFGM residue traces	-

*Milk Fat Globule (Membrane)

FOOD/DAIRY MATRIX

Foods contain nutrients and other components in a complex structure. The combination of these composing elements and the physicochemical nature of the food structure in which they are embedded is called the food matrix (Thorning 2017; Capuano 2018).

The matrix of a food influences its digestibility. The macronutrients in food must be hydrolysed into smaller products before they can be absorbed. Three factors regulate the digestion of macronutrients: The most important factor is the structural barriers within a food to the actions of digestive enzymes. The second factor is the structural organisation of the macronutrients inside a food. Last, dietary components that are simultaneously present in the gastrointestinal tract affect digestibility.

The link between animal-source food matrices and digestion is an emerging field of investigation. For dairy products, the importance of the milk fat globule and its membrane (MFGM) has been highlighted in this regard (Thorning 2017). Laboratory-based research has shown that, in cheese, the caseins form a coagulum which encapsulates fat globules, thereby affecting fat digestibility. Follow-up experiments have suggested that the fat in cheese was less accessible to lipase than the fat in butter, evident through higher faecal fat content. The increased fat excretion may, however, also be related to the simultaneous presence of calcium in the gut, which could precipitate free fatty acids as insoluble and indigestible calcium soaps.[2] The process of milk homogenisation may, on the other hand, improve lipid digestibility by reducing the size of lipid globules; hence, increasing the total surface area coming into contact with pancreatic lipase (Capuano 2018).

Lamothe *et al*. (2017) compared the digestion kinetics of milks, yoghurts and cheeses in a simulated gastrointestinal environment. They noted that different technological processes had a different impact on the various dairy product matrices, which, in turn, influenced nutrient release.

DAIRY PRODUCTS AND DISEASE RISK

In real life the effects of dairy products on (ill) health are the major concern. Table 2 summarises the main findings of such studies.

Numerous mechanisms have been proposed for the differential effects of dairy products. This includes lowering of fat digestibility by dairy components (e.g., MFGM) or by calcium and phosphate; lowering of cholesterol absorption by the MFGM; association between fat digestibility and blood lipid response; regulation of the blood lipid response by MFGM, milk phospholipids or dairy matrix fermentation (Thorning 2017). In addition, the physical structures and textures of the various dairy products mentioned in Table 1 could affect digestion and absorption, appetite sensations as well as the protein metabolism. Examples include the semisolid (gel) vs fluid or solid states, the intermediate metabolites (e.g., bioactive peptides) and different processing methods that affect the micro- and macrostructure of the dairy matrix.

CONCLUSION

Notwithstanding considerable knowledge gaps in this field, the following represents one of the consensus points derived during an expert meeting on the topic: Milk, yoghurt, cheese, butter and cream are each unique (apart from their fat content) and should be studied accordingly.

The role of dairy in health and nutrition

TABLE 2: STUDIES LINKING DIFFERENT DAIRY PRODUCTS TO DIFFERENT END-POINTS (EXTRACTED FROM THORNING 2017)

Type of study	Disease end point	Main findings
Meta-analyses of observational studies	Stroke risk	Total dairy intake: Not associated Specific products: • Total milk: Per 200g/d increment in intake: 7% lower risk (RR: 93; 95%CI: 0.88, 0.98). • High-fat (but not low-fat) milk: Direct association. • Cheese: Per 40g/d intake marginally inverse association (RR: 0.97; 95%CI: 0.94, 1.01). • Yoghurt: No association. • Combining intake of >=2 dairy products: Per 200g/d intake: 9% lower risk (RR: 91; 95%CI: 0.83, 1.01).
	Hypertension	Total dairy, low-fat dairy and milk: Linear inverse association Specific products: • Low-fat dairy: Per 200g/d: 4% lower risk (RR: 0.96; 95% CI: 0.93, 0.99). • High-fat dairy, fermented dairy, yoghurt: no association.
	Type 2 Diabetes mellitus	Total dairy intake: Inverse relationship per 200g/d increment (RR: 0.97; 95% CI: 0.95, 1.00) Specific products: • Yoghurt: For 80g vs 0g/d: RR: 0.86; 95%CI: 0.83, 0.90. • Cheese, cream, total milk, low-fat milk, high-fat milk, total high-fat dairy: Not associated.
Intervention studies comparing dairy products to dairy components	Body weight and body composition	• Cow's milk vs control vs soy milk fortified with calcium vs calcium-carbonate supplement: Weight loss 5.8%, 4.3% 3.8%, 4.8% respectively, suggesting a dairy matrix effect related to the calcium and protein. • Skimmed milk vs casein vs whey protein compared with water: Skimmed milk and milk proteins increased lean and fat mass, suggesting dairy protein (rather than matrix) effect.
	Cardiovascular risk	• Calcium from milk and low-fat yoghurt attenuated postprandial lipaemia, in contrast to calcium supplement. • Calcium supplement vs meal with supplement vs dairy product meal vs calcium-fortified juice: Largest delay in serum calcium elevation in dairy product meal. • 30g/d Grana Padano cheese vs placebo (i.e. flavoured bread mixed with fats and salts of equivalent composition): Cheese resulted in lower systolic and diastolic blood pressure.
	Bone health	• Calcium supplement vs calcium plus vitamin D vs cheese: Cheese had higher % change in cortical thickness of tibia in 10 to 12-year old girls. • Dairy products vs calcium supplement vs control: Dairy products consumers had greatest improvement in pelvis and spine density and total bone mineral density.
Interventions controlling for within dairy-product differences	Blood lipids	• Cheese, milk and butter in whole diets made "equivalent" through addition of fat, protein and lactose: No difference between cheese and milk in terms of effect on blood lipids, yet butter still increased LDL-cholesterol. Thus, protein and lactose do not explain difference between cheese and butter on blood lipids. • Meals including 45g fat in sour cream, whipped cream, butter or cheese resulted in different post-prandial effects on serum triglycerides and HDL cholesterol (Hansson 2018).
Interventions with full diet designs	Blood lipids	• Cheese vs butter: Fat delivered as butter has a different effect than fat delivered in cheese matrix. • Cheese vs full-fat yoghurt: No difference. • Buttermilk (rich in MFGM) vs skimmed milk with same amount of fat vs butter: Buttermilk and skimmed milk similar, but butter increased total cholesterol.

extends beyond its nutrient content. The bio-functionality refers to the sum of nutrients and other components within a particular dairy matrix structure. This knowledge adds to our current understanding of dairy–disease relationships, explains some contradictory findings in previous research, and suggests new opportunities of personalised integration of dairy products into the lifestyles of individuals. At the same time, the strong international movement towards dietary patterns attempts to explain even better the link between diet and disease.

Complexity replaces simplicity:

From nutrient, to whole food and its matrix, to dietary patterns within a particular lifestyle.

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