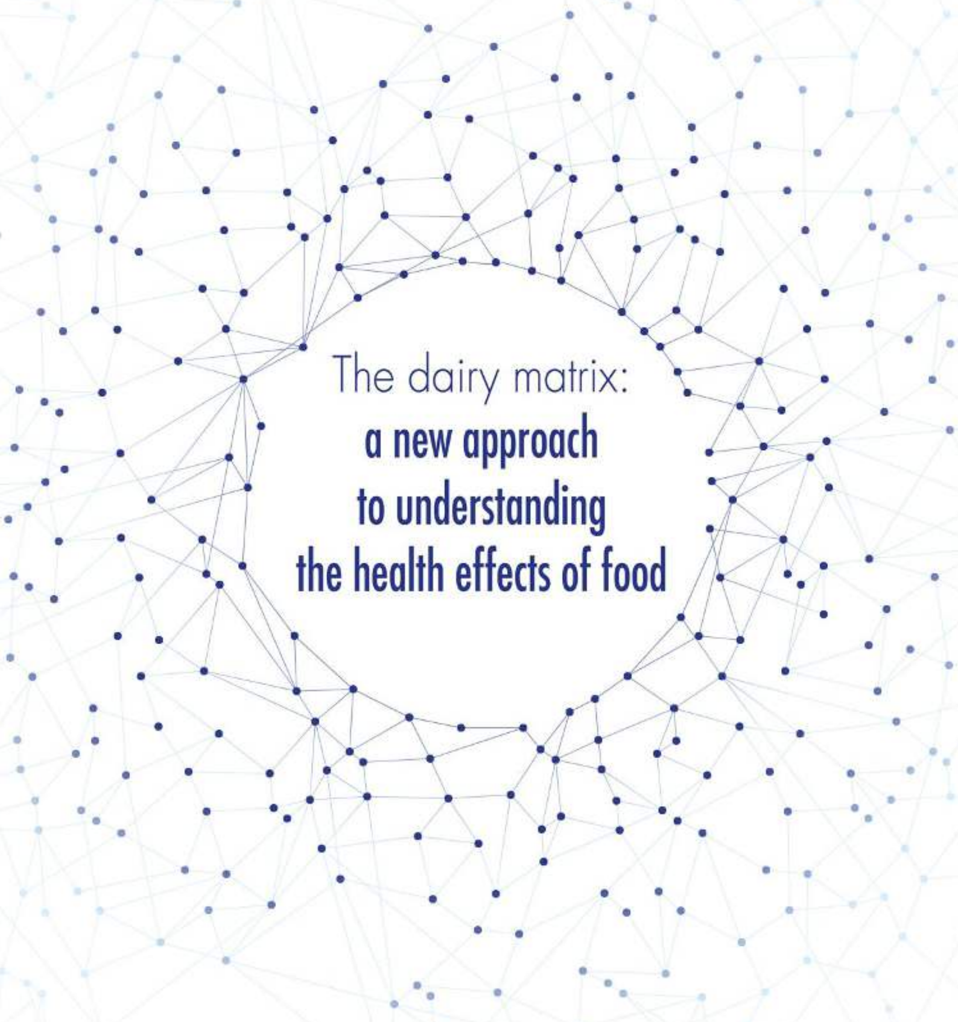

European Milk Forum

Muscle, Bones and Body Fat:

The Dairy Matrix and Body Composition

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Milk Matrix

milknutritiousbynature.eu

Overview

- What is the 'Dairy Matrix'?
- Human nutrition - Moving beyond single nutrients
- Effects of dairy matrices on body composition:
  - ✧ **Muscle**
  - ✧ **Bones**
  - ✧ **Body fat**
- Cheese – a 'matrix' example

What is the ‘Dairy Matrix’ ?

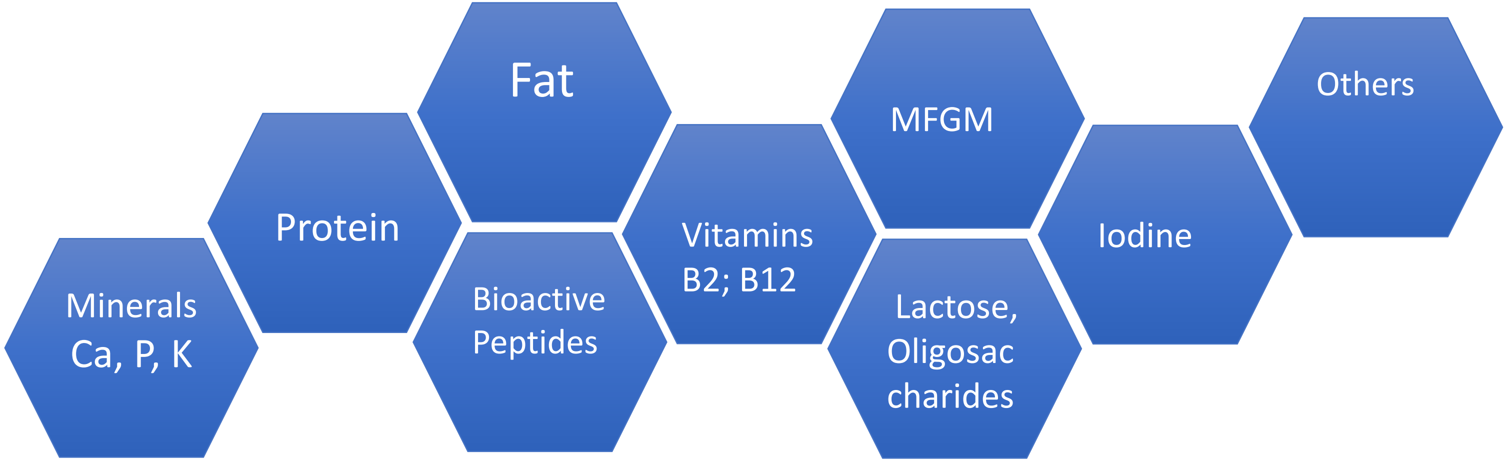
- The nutrients in dairy work as a team’ – www.ndc.ie
- ‘The constituents of milk or other dairy foods do not work in isolation, but rather interact with each other. This is the concept of the ‘dairy matrix’; the premise being that the health effects of the individual nutrients may be greater when they are combined together’
- Foods consist of a large number of different nutrients that are contained in a complex structure. The nature of the food structure and the nutrients therein (i.e., the food matrix) will determine the nutrient digestion and absorption, thereby altering the overall nutritional properties of the food.

Moving beyond single nutrients:

- Traditionally, study of nutrients and health - a ‘reductionist’ approach
- Doesn’t allow for the study of a ‘food matrix’ effect

‘Dairy’ foods are not all the same:

- The ‘Dairy’ shelf is now **Milk, cheese, and yoghurt**
- **Even this is overly simplistic -** different types of milk, cheeses and yoghurt
- The matrices within these are varied; protein, peptides, fat content, sugars



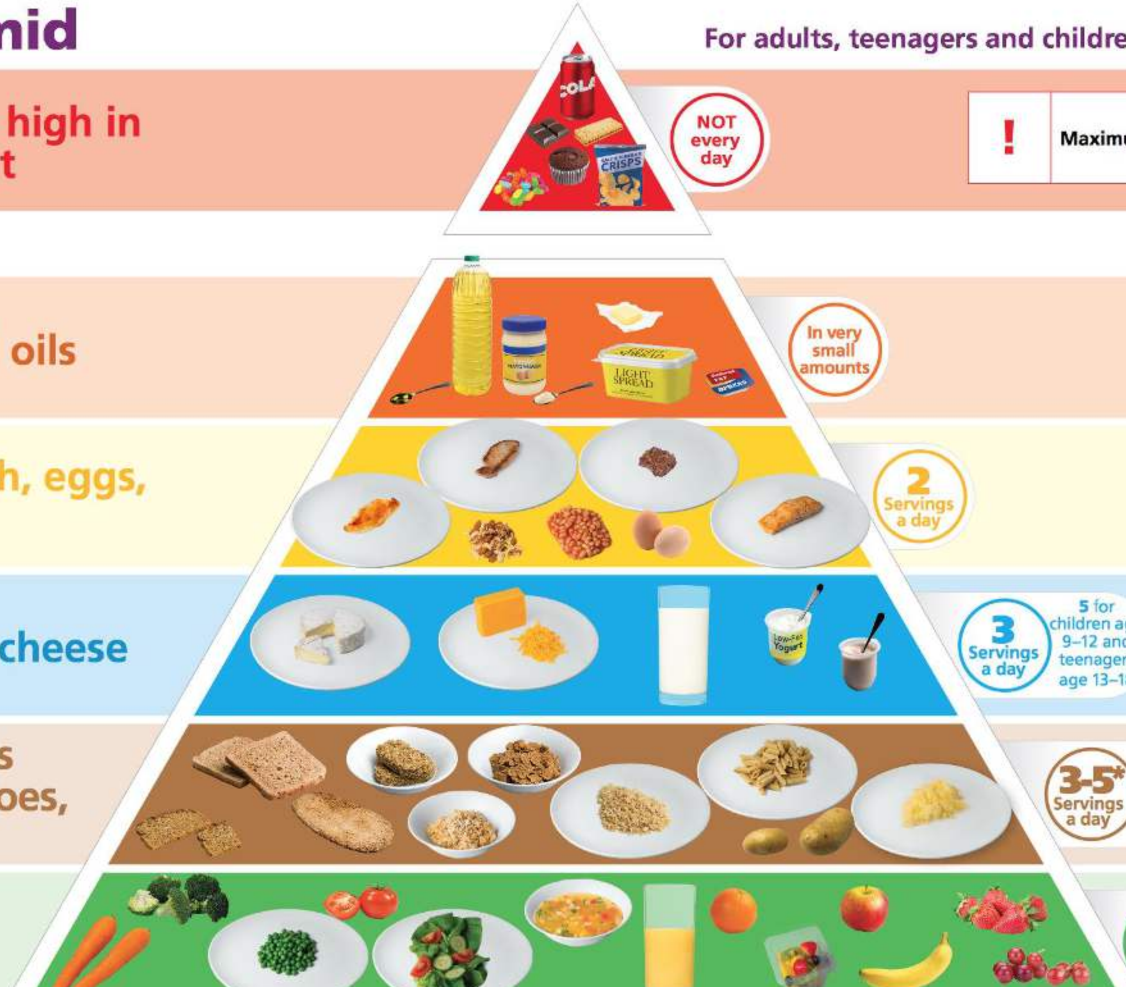
Healthy Food for Life

www.healthyireland.ie

hi Healthy Ireland

The **Food Pyramid**

For adults, teenagers and children aged five and over



Not needed for good health.

Foods and drinks high in fat, sugar and salt — NOT every day — ! Maximum once or twice a week

Needed for good health. Enjoy a variety every day.

Fats, spreads and oils — In very small amounts

Meat, poultry, fish, eggs, beans and nuts — 2 Servings a day

Milk, yogurt and cheese — 3 Servings a day; 5 for children age 9–12 and teenagers age 13–18

Wholemeal cereals and breads, potatoes, pasta and rice — 3-5* Servings a day; Up to 7* for teenage boys and men age 19–50

Vegetables, salad and fruit — 5-7 Servings a day

Adapted from Thorning *et al*, (2017) AJCN

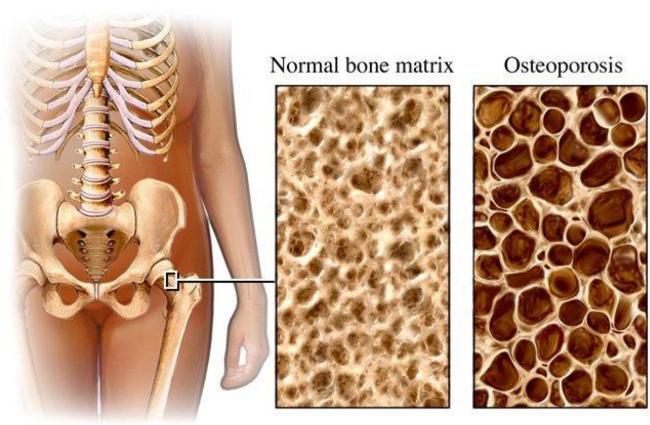
'Dairy' foods are not all the same:

TABLE 2
Bioactive components and supramolecular structures in different dairy products[1]

	Calcium, mg/100 g	Phosphorus, mg/100 g	MFGM,[2] mg/100 g	Protein,[3] g/100 g, type	Fermented	Fat structure[4]	Protein network
Cheese[5] (25% fat)	659	510	150	23.2, Casein	Yes	MFG/aggregates/free fat	Solid/viscoelastic
Milk (skimmed, 0.5% fat)	124	97	15	3.5, Whey/casein	No	Tiny native MFG/potential MFGM fragments	Liquid
Milk (whole, 3.5% fat)	116	93	35	3.4, Whey/casein	No	Native MFG or homogenized milk fat droplets/potential MFGM fragments	Liquid
Yogurt (1.5% fat)	136	99	15	4.1, Whey/casein	Yes	Native MFG or homogenized milk fat droplets/potential MFGM fragments	Gel/viscoelastic
Cream (38% fat)	67	57	200	2, —	No	Native MFG or homogenized milk fat droplets/potential MFGM fragments	Liquid
Butter	15	24	—	<1, —	No/yes[6]	Continuous fat phase (water-in-oil emulsion)/MFGM-residue traces	—

[1] All values are approximate amounts. MFG, milk-fat globule; MFGM, milk-fat globule membrane.
[2] General estimation on the basis of Dewettinck et al. (11) and Conway et al. (12).
[3] According to food-composition tables from The Technical University of Denmark (13).
[4] General estimation on the basis of Michalski (14) and Michalski et al. (15) and references therein.
[5] Semihard Danbo type, as a point example among many different cheese types.
[6] Depends on the production method used. With indirect biological acidification, starter culture is added to the butter after churning.

Bone health: Evidence for Matrix Effects



Bone strength: Quality, structure, Mass and Turnover [1]

- 80-90% of BM content = Ca and P [1]
- Also requires: Protein, Vitamins A,C , D and K , Mg, Zn, Cu, Fe and Fluoride

Dairy foods: Contain a favourable P: Ca ratio (0.8:1) & range of interacting nutrients [2]

Dairy calcium appears more beneficial than other forms – stimulates renal resorption, meaning a longer-lasting effect

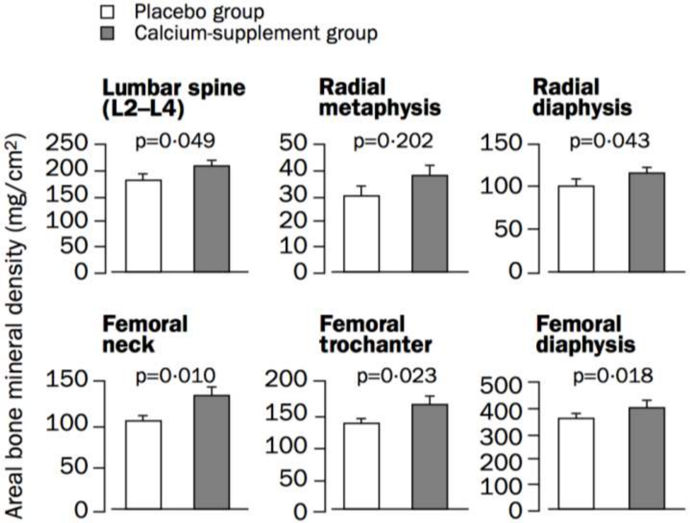
1. Ilch & Kirstetter (2000) Nutrition and Bone Health, J Am Coll Nutr
2. Bonjour et al (2011) J Am Coll Nutr 30:438S-448S

Bone health: Evidence for Matrix Effects

- Follow up study of bone mineral mass in 8y girls [3]
- Supplemented with dairy-derived calcium phosphate, or placebo, for n=48 weeks

	Placebo group (n=54)	Calcium-supplemented group (n=62)
Age (years)	8·0 (0·1)	7·9 (0·1)
Height (cm)	127·4 (0·7)	128·1 (0·8)
Weight (kg)	26·6 (0·6)	26·3 (0·5)
Body-mass index (kg/m²)	16·3 (0·3)	15·9 (0·2)
Bone-mineral density (mg/cm²)		
Radial metaphysis	301 (4)	293 (3)
Radial diaphysis	431 (4)	437 (4)
Femoral neck	622 (10)	640 (10)
Femoral trochanter	497 (8)	508 (7)
Femoral diaphysis	1026 (11)	1028 (11)
Lumbar spine	618 (7)	619 (9)

All values are mean (SD).



- Increases in BMM maintained for 3 years post-intervention

3. Bonjour *et al* (2001) The Lancet 358, 1208-12

Bone health: Evidence for Matrix Effects

Dairy foods have greater effects than equivalent Ca supplements:

- An intervention using **cheese** to supplement Ca observed a greater increase in BMD vs Ca alone, or Ca + Vit D (as supplements) (4)

- When supplemented with 700mg Ca via dairy foods, BMD increased by up to 10%, vs 1-5% with 700 mg given as non-dairy supplement (5)

✧**Protein may enhance Ca balance by promoting absorption**
✧**Casein phosphatides and / or lactose may enhance Ca absorption**
✧**Fermented dairy may further enhance Ca absorption**

[4]Kerstetter *et al* (1995) Nutr Res Rev 328-332
[5] Cheng *et al* (2005) AJCN 82:1115-1126

Muscle : Evidence for Matrix Effects

- Performance nutrition: Recovery after exercise
- Healthy Ageing: Maintenance of Muscle Mass

Ideal Rehydration Fluid:

- Na
- K
- Slow gastric emptying

Muscle Recovery & Repair:

- High quality protein
- Essential AA's
- BCAAs
- Skeletal AA uptake

Glycogen Re-synthesis

Muscle : Evidence for Matrix Effects

- Healthy Ageing: Maintenance of Muscle Mass

Sarcopenia: Age-related loss of muscle mass

- ✧ Higher protein intakes to stimulate MPS
- ✧ Protein quality – Leucine is key – Whey protein a good source
- ✧ Studies suggest greater effects of dairy (Whey) protein than EAAs alone (6,7)

- Evidence for matrix effects – further research needed on different dairy products
- Studies also suggest **25-30g protein, at each meal,** is optimal for prevention (8)

[6]Phillips et al., (2009) Am J Coll Nutr 28:343-354
[7]Katsanos et al (2008) Nutr Res 28: 651-658
[8]Paddon-Jones & Ramussen (2009) Curr Opin Nutr Metab Care, 12: 86-90

Body Fat: Evidence for Matrix Effects

- Dairy foods – contain a variety of fat and protein levels:
- A range of observational studies suggest a role in weight
- control : (9)

	Low (*n* 499)		Medium (*n* 500)		High (*n* 500)		
	Mean	SD	Mean	SD	Mean	SD	*P*
(A) Calculated as g/d total dairy products†							
Nutrient information							
MD dairy products (g)	107·9[a]	47·9	249·3[b]	41·6	515·7[c]	180·7	<0·01
MD dairy servings	0·97	0·6	1·8	0·6	3·3	1·2	<0·01
Demographic information							
Age (years)	43·3	16·9	45·1	17·1	45·1	17·1	0·12
BMI (kg/m^2)‡	27·8[a]	5·5	26·9[b]	4·7	26·6[b]	5·0	0·01
M:F ratio§	41:59		49:51		48:42		<0·01
SES (1:2:3:4)‖¶	43:19:16:22		48:19:15:18		49:18:13:19‖		0·44

(9) Feeney *et al* (2016) BJN

(Milk, cheese, yoghurt, cream, butter)

Body Fat: Evidence for Matrix Effects

Table 1. Metabolic markers of health across tertiles of total dairy consumption

Variable	*Low (1.25–180.6 g)*		*Medium (181.3–323.2 g)*		*High (324.2–1630.0 g)*		*P-value*
	n	*Mean ±s.e.*	n	*Mean ±s.e.*	n	*Mean ±s.e.*	
BMI (kg m^{-2})	465	27.8^{c} ±4.6	476	$26.8^{c,d}$ ±5.4	470	26.7^{d} ±4.9	< **0.001**
Body fat (%)	439	31.1^{c} ±0.7	442	27.6^{d} ±0.7	437	26.8^{d} ±0.5	< **0.001**
Muscle mass (kg)	435	51.6 ±0.6	440	51.4 ±0.6	435	50.4 ±0.4	0.195
Waist circumference (cm)	406	93.7^{c} ±11.0	428	91.0^{d} ±1.0	429	87.8^{e} ±13.4	< **0.001**
Waist-to-hip ratio	408	0.89^{c} ±0.01	427	0.88^{d} ±0.01	429	0.86^{e} ±0.1	< **0.001**

(All dairy, from all foods and recipes)

(*figures adjusted for gender, age and energy intakes)

- [10] Feeney *et al* (2017) Nutr & Diabetes

Body Fat: Evidence for Matrix Effects

- Dairy foods – source of casein (slow) and whey (fast) proteins
- EAAs and Leucine (whey)

- Evidence suggests that dairy protein can help to maintain skeletal muscle mass during energy restriction [11]

- Evidence is mixed regarding whether casein or whey is more beneficial, either for weight loss or body composition [12, 13]

- [11] Fresdedt *et al* (2008) *Nutr Metab (5): 1-8*
- [12]) Lacroix *et al* (2006) Am J Clin Nutr. 84 (5): 1070-1079
- [13] Dangin *et al* (2001) Am J Physiol Endocrinol Metab 280 (2): E340-E348
-

Moving towards Patterns of intake:

Tertiles vs Patterns:

Cluster 1
Full fat Milk

Cluster 3
Butter and
Cream

Cluster 2
Low fat milk, yoghurt

- Feeney *et al* (2017) Nutr & Diabetes

Dietary patterns of dairy:

Table 2. Cluster characteristics—dairy intakes per MJ in the different clusters (*n* = 1497) and %energy from macronutrients

Variable	*'Whole milk' Cluster* n *675*	*'Reduced fat milks and yogurt' Cluster* n *56z4*	*'Butter and cream' cluster* n *258*	P-*value*
	Mean ± *s.e.*	*Mean* ± *s.e.*	*Mean* ± *s.e.*	
Mean daily saturated fat per g	32.2[a] ± 14.0	25.7[b] ± 11. 0	32.2[a] ± 11.8	< **0.001**
Mean daily total fat per g	80.6[a] ± 31.4	67.5[b] ± 26.0	80.7[a] ± 26.8	< **0.001**
% energy MUFA	12.7[a] ± 2.7	11.7[b] ± 2.7	12.6[a] ± 2.6	< **0.001**
% energy PUFA	5.9 ± 2.1	6.1 ± 2.5	5.9 ± 1.8	0.46
% energy SFA	13.8[a] ± 3.5	12.2[b] ± 3.5	14.0[a] ± 3.3	< **0.001**
% Energy fat	34.7[a] ± 6.3	32.0[b] ± 6.6	34.9[a] ± 6.2	< **0.001**
% Energy protein	16.4[a] ± 3.4	17.8[b] ± 3.7	16.5[a] ± 3.8	< **0.001**
Age/years	43.5 ± 17.1	45.7 ± 16.9	44.5 ± 17.2	0.074
Energy/MJ	8.7[a] ± 2.9	7.9[b] ± 2.6	8.8[a] ± 2.6	< **0.001**
Male:female ratio	58:42	41:59	46:54	< **0.001**
Total milk per mL	26.7[a] ± 21.5	33.4[b] ± 21.8	23.9[a] ± 16.4	< **0.001**

- Feeney *et al* (2017) Nutr & Diabetes

Dietary patterns of dairy:

Table 3. Markers of metabolic health across clusters of dairy consumption

Variable	*Cluster 1 'Whole milk'*		*Cluster 2 'Reduced fat milks and yogurt'*		*Cluster 3 'Butter and cream'*		P-value
	n	*Mean ± s.e.*	n	*Mean ± s.e.*	n	*Mean ± s.e.*	
Healthy Eating Index	488	23.3[c] ± 8.5	371	28.0[d] ± 10.0	189	25.0[e] ± 9.4	< **0.001**
BMI (kg m^{-2})	601	26.9 ± 4.6	512	27.3 ± 5.4	239	227.1 ± 4.9	0.474
Body fat (%)	589	29.3 ± 9.1	497	29.1 ± 8.9	231	29.2 ± 8.9	0.593
Muscle mass (kg)	400	50.8 ± 11.0	301	52.3 ± 11.2	161	51.4 ± 11.1	0.205
Waist circumference (cm)	378	89.7 ± 12.3	301	89.2 ± 12.3	166	89.2 ± 14.0	0.443
Waist-to-hip ratio	378	0.87 ± 0.1	301	0.87 ± 0.1	166	0.87 ± 0.1	0.802
BP—systolic (mmHg)	249	123.41 ± 1.0	205	125.42 ± 1.2	164	120.6 ± 1.6	0.053
BP—diastolic (mmHg)	249	78.2 ± 10.7	205	77.7 ± 10.5	105	76.9 ± 10.8	0.338
Serum trigs (mmol l^{-1})	251	1.31[c,d] ± 0.05	212	1.36[c] ± 0.06	106	1.13[d] ± 0.07	**0.028**
Serum total cholesterol (mmol l^{-1})	264	4.94[c] ± 0.07	216	5.16[d] ± 0.06	109	4.8[c] ± 0.1	**0.015**
Serum direct HDL (mmol l^{-1})	262	1.54 ± 0.02	214	1.62 ± 0.03	108	1.57 ± 0.04	0.126
LDL-C (calculated) (mmol l^{-1})	259	2.80 ± 0.06	213	2.91 ± 0.07	108	2.72 ± 0.09	0.217

- Feeney *et al* (2017) Nutr & Diabetes

Dairy & metabolic health: Intervention studies

Author (year)	Population	Study design and measurements	Key Findings
Tholstrup *et al*, 2004	14 healthy m, aged 20-31	RCT – everyone did all 3 arms - 20% energy from cheese/milk/ daily for 3 wks. Cheese: 205g per 10MJ energy.	Fasting LDL was higher after the butter diet vs the cheese (p=0.037 after 3 weeks) Same trend (0.057) for total cholesterol
Biong, 2004	22 healthy subjects (9 m) aged 23-54	RCT, 3 arms. 1:Jarlsberg cheese, 2:butter+calcium, 3:butter+egg white protein	Total cholesterol sig. lower after CH diet than after BC diet (–0·27 mmol/l; P=0·03),LDL down 0.22,but,p=0.06 (NS)
Sofi *et al*, 2010	10 healthy subjects, 6f. Median age 51.5	200g per week pecorino, naturally enriched in CLA, or control cheese (commercially available)	Significant improvement in markers of heart health.
Hjerpsted et al 2011	49 men and women healthy aged 22-69 (mean age 55.5 yr, mean BMI 25.2	Subjects replaced 13% energy with fat from either cheese or butter, for 6 weeks, following a 14d run in (normal diet).	No diff between LDL and HDL between run-in and cheese diet. Cheese diet resulted in better lipid profile than butter diet
Schlienger et al, 2014	Mildly hypercholesterolemic subjects	Subjects ate 2x daily servings of Camembert cheese (intervention) or 2 x 125g ff yog (control group).	No change in bp. or in plasma lipids following 2 weeks cheese vs 2 weeks yog. consumption
Hostmark et al (2009)	18,770	Associations between cheese intake and blood lipids	Trigs lower and HDL cholesterol higher in those with greater cheese intake
Nilsen et al (2014)	N=186, 56%f, mean age 51y	Gamalost (a Norwegian cheese) consumption, BP	Self reported cheese consumption associated with reduced bp

Dairy & metabolic health: Intervention studies

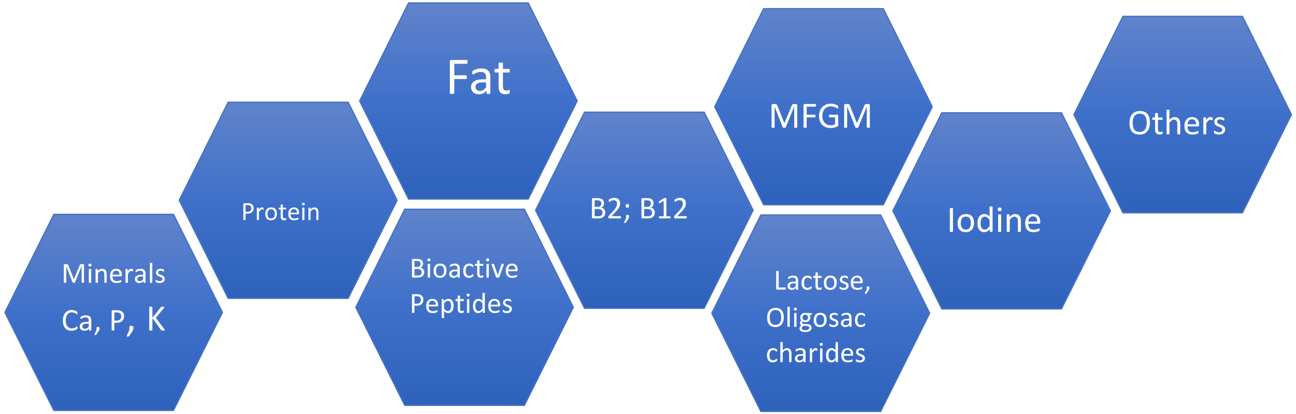
Author (year)	Population	Study design and measurements	Key Findings
Aune et al (2013)	Varied;	Systematic review, coupled with dose-response meta-analysis on risk of T2D	8% lower risk of T2D per 50g cheese consumption High-fat dairy consumption associated with healthier BMI and body composition
Thorning et al (2015)	14 o/w females, post- menopausal mean age 59, mean BMI 28.8	Subjects completed randomised cross-over trial, consisting of 3 arms 1) high cheese (96–120g) 2) non-dairy, high-meat 3) a non-dairy, low-fat, high-carbo control. Measured impact on lipids &fecal fat excretion	Diets w/ cheese and meat as primary sources of SFAs cause higher HDL –c & apo A1 - & appear less atherogenic than low-fat, high-carbohydrate diet. Cheese diet increases fecal fat excretion.
Nilsen et al (2015)	153 healthy male & female participants	Participants randomized to one of three groups: Gamalost, a low-fat Norwegian cheese (50 g/day), Gouda-type 27% fat (80 g/day) (matched for protein), control group -limited cheese intake.	Cholesterol levels did not increase after high intake of 27% fat Gouda-type cheese over 8 weeks' intervention, and stratified analysis showed that participants with metabolic syndrome had reduced cholesterol by end.

Summary: Cheese consumption: overall 'healthier' blood lipid profiles (higher HDL, lower LDL and lower trigs). Some questions remain:

- **How important is the matrix?**
- **Is the effect seen for all populations?**

‘Dairy’ foods are not all the same:

- The ‘Dairy’ shelf is now **Milk, cheese, and yoghurt**
- **Even this is overly simplistic -** different types of milk, cheeses and yoghurt
- The matrices within these are varied; protein, peptides, fat content, sugars



Cheese Matrix Studies - UCD

- Tests the hypothesis that fat needs to be **within the cheese matrix** to see effects

Effect of Cheese matrix on heart health

Inclusion Criteria: *Over 50's population, with BMI of 25 or over*

Intervention*: 49g fat daily in 3 matrices (cheese, butter or reduced fat cheese) for 6 weeks*

Outcomes*: Markers of heart health (LDL-C, HDL-C, key inflammatory cytokines*

Group A – 120g full-fat Irish Cheddar
Group B – 120g reduced fat Irish Cheddar, + butter
Group C – Butter, Calcium Caseinate powder, Calcium Tablet (500mg)
Group D – Delayed – As per A but 6 weeks no cheese first