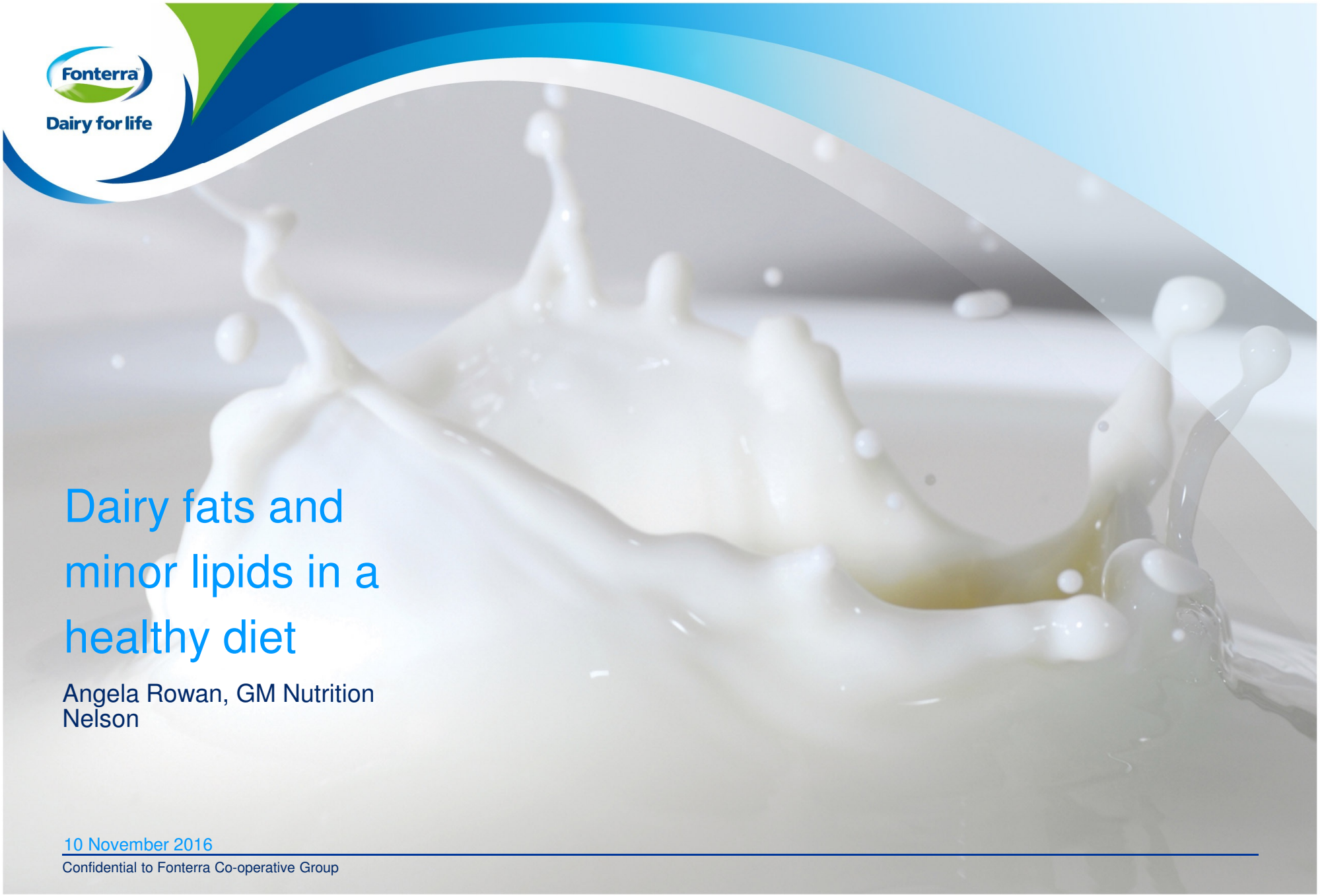


Dairy fats and minor lipids in a healthy diet

Angela Rowan, GM Nutrition
Nelson

10 November 2016

Overview

- Dairy fats – what lipids are present?
- What does the evidence say about dairy as a source of fat and its role in health?
- What biological role might minor lipid components play?

Milk is a natural source of dietary fat

Milk naturally contains around 3.5-4.7% fat

- ~98% Triglycerides
  - *~70-75% Saturated fatty acids*
  - *~18-24% Monounsaturated fatty acids*
  - *~2.4% Polyunsaturated fatty acids*
  - *~2-6% Trans fatty acids*
- ~2% Other Lipids
  - *Complex lipids*
    - ✓ *Phospholipids*
    - ✓ *Gangliosides*
  - *Other lipid components (e.g. cholesterol, diglyceride)*
  - *Fat soluble "vitamins"*

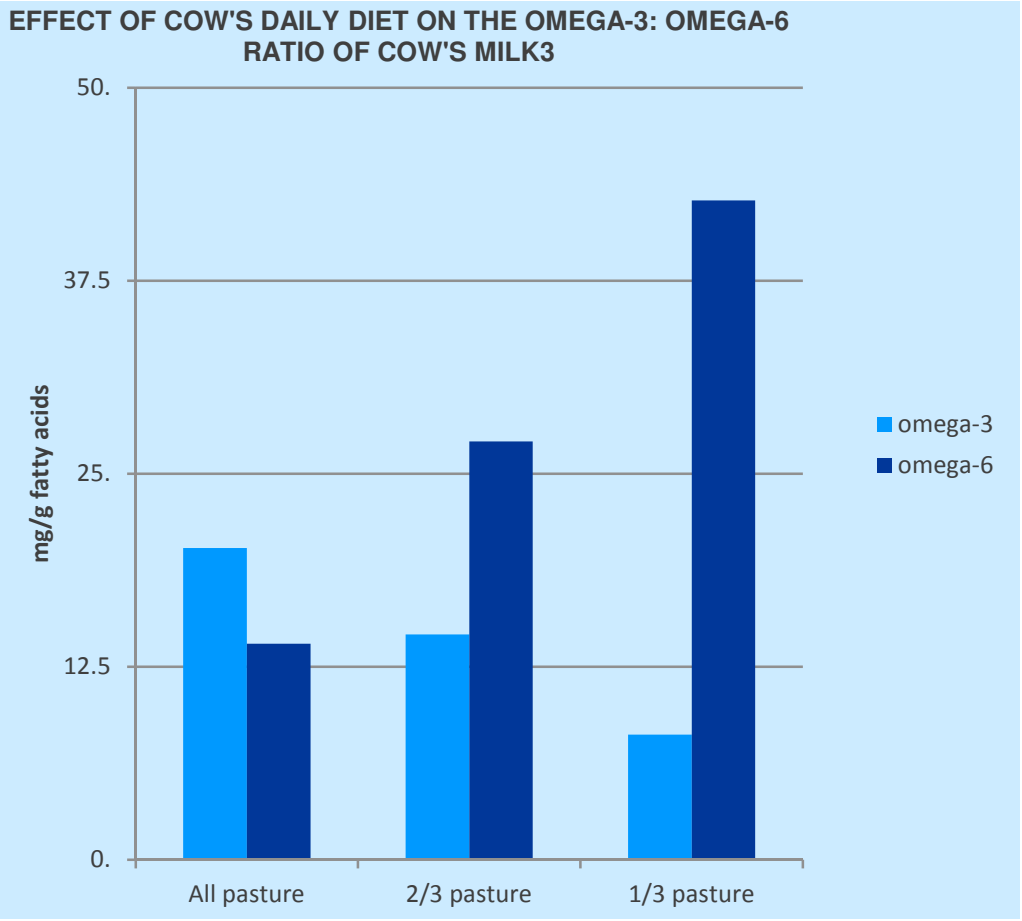
MacGibbon AKH & Taylor MW (2006) Composition and structure of bovine milk lipids. In PLHMPF Fox (Ed.), Advanced dairy chemistry. Lipids (3rd Ed, Vol 2, pp 1-42). New York, NY, USA.

Benefits of NZ milk

New Zealand has a moderate climate and cows graze outdoors all-year round.

This means they are mainly grass-fed and that gives their milk some unique benefits:

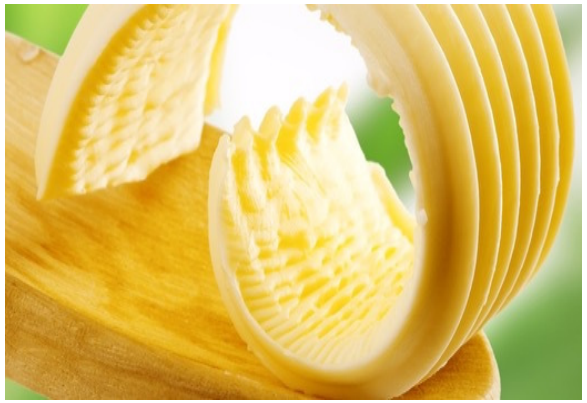
- More beta-carotene gives New Zealand milk its golden colour.[1,2]
- Grass-fed cows produce significantly higher levels of omega-3 fatty acids compared to grain-fed cows.[3]
- Pasture-fed cows produce milk with higher levels of conjugated linoleic acid (CLA) – evidence suggests unique health benefits of CLA.[3]



References: [1]Clancy (2006) Greener Pastures. Union of Concerned Scientists; [2]Jensen (1999(J Dairy Res 66(4):511-22; [3]Dihman et al. (1999), J Dairy Sci 82:2146-56.

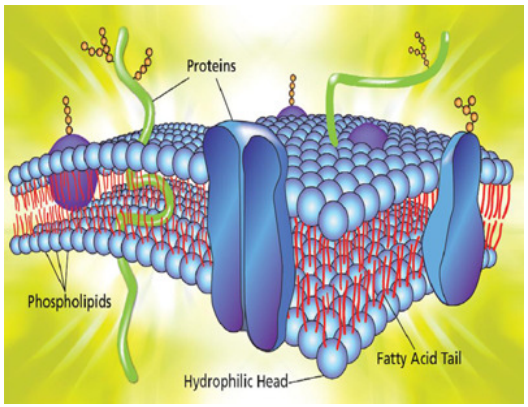
Dietary fats are essential for good health

Dietary fats play an important role in the diet and need to be included for good health.



Source of energy and essential fatty acids

Young children are advised to drink full-fat milk because of their high energy needs for growth.



Structural components for the body

Milk fat globule membrane provides **phospholipids** and other components that can be used by the body.

Carrier of fat-soluble vitamins and supports absorption.

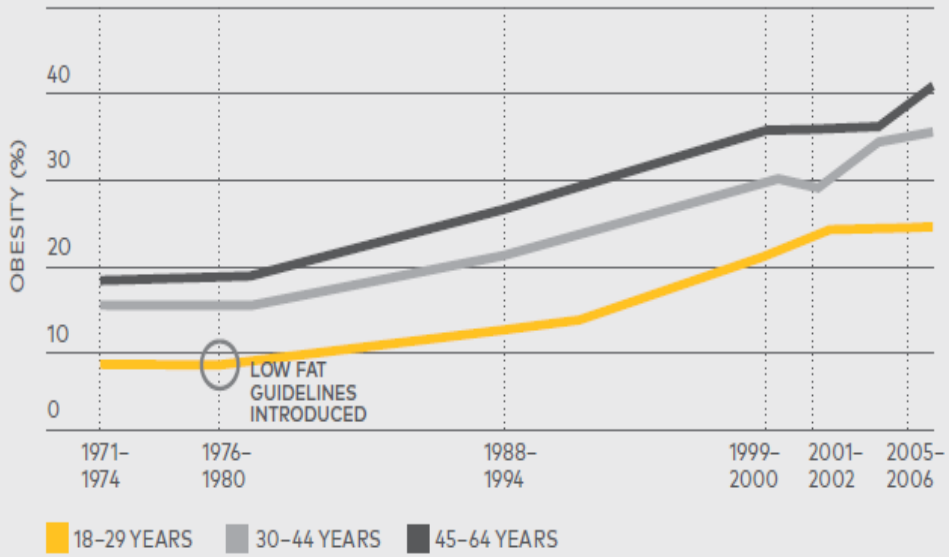
Low fat milk and dairy also lacks the naturally present **fat-soluble vitamins and beta-carotene**.

Industry responded to call for low fat options – is it time for a rethink on low fat advice?

- The proportion of fat in the diet is not associated with excess body weight & cardiovascular health – it is the overall calories that count.
- Low-fat diets have failed to deliver positive outcomes for health.
- Fat in the diet was replaced by refined carbohydrates – with worse health outcomes.

THE LOW FAT DIET MYTH

In 1977, the low fat diet was recommended to all Americans. Interestingly this coincides with the start of the increase in obesity in the USA. Although correlation does not equal causation, people did start to cut back on traditional foods like butter and replace them with processed 'low fat' foods high in carbohydrates.[13]



Is low-fat dairy better?

Dairy products are a key contributor to saturated fat in many countries.

There has been a big push towards consumption of low-fat and reduced-fat dairy products.

Dairy – including full-fat dairy – is beneficial or neutral for cardiovascular health

There is a beneficial or neutral association between dairy intake (including full-fat dairy) and CVD risk.[1,2]

- **9%↓ risk of stroke** and non-significant lower risk of heart disease with **total dairy**, including full-fat dairy.[1]
- **11%↓ risk of heart disease** and **13% ↓risk of stroke** with **cheese** consumption.[1]
- No association between **moderate butter** consumption and CVD and a 4% ↓risk of type 2 diabetes.[3]

Dairy has been associated with lower blood pressure.[4,5]

- One review found dairy was associated with a **13% ↓ risk of developing high blood pressure**.[5]
- **Greater saturated fat intake** from dairy products was associated with a lower risk score.[6]

References: 1. Alexander et al. (2016) Brit J Nutr 115:737-750; 2. Qin et al. (2015) Asia Pac J Clin Nutr 24(1):90-100; 3. Pimpin et al. (2016) PLOS ONE, doi:10.1371/journal.pone.0158118; 4. Soedamah-Muthu et al. (2012) Hypertension 60(5):1131-7; 5 Ralston et al. (2012) J Hum Hypertension 26:3-13; 6. Drehmer et al. (2015) J Nutr 146:81-89

Dairy is associated with lower risk of type 2 diabetes

Dairy intake is linked with a reduced risk of type 2 diabetes.

- Supported by data from two large cohorts which found that ↑ **levels of dairy fat biomarkers** were associated with a significantly **43-52% ↓ risk of developing type 2 diabetes**.[1]

Higher dairy intake may lower the risk of metabolic syndrome.

- **14-15% ↓risk of metabolic syndrome in high vs. low dairy consumers.**[2,3]

Fermented dairy products & higher fat levels may be more beneficial.

- Consumption of 80 g of yoghurt/day was associated with a **14% ↓ risk of type 2 diabetes**.[4]
- A recent study[5] found that **saturated fats** in dairy may be bringing about this association.

References:1. Yakoob et al. (2016) Circulation 133(17):1645-54; 2. Chen et al. (2015) Scientific Reports 5:14606; 3. Kim & Je (2015) Diabetic Medicine 33(4):428-40; 4. Gijsbers et al. (2016) Am J Clin Nutr, 103(4):1111-24; 5. Drehmer et al. (2015) Am J Clin Nutr ,doi:10.3945/ajcn;

Dairy for a healthy body weight

Dairy consumption – including high-fat dairy – helps with weight management.

- One study found that women **gained 13% less weight** with ↑ **total & high-fat** (but not low-fat) **dairy**.[1]
- Three other studies in women found **cheese, regular and low-fat dairy were neutral for weight gain**, and **yogurt** was associated with **weight loss**.[2]
- **Children** with high vs. low dairy intakes have a **38% ↓ risk of childhood overweight/obesity**.[3]

Dairy consumption may help people actively trying to lose weight.

- Supplementing an energy-restricted diet with dairy led to
  - ↑ **Body fat loss**[4,5]
  - While **maintaining more lean-mass** (muscles)[4]

References: [1]Rautianien et al. (2016) Am J Clin Nutr doi: 10.3925/ajcn.115.118406; [2]Mozaffarian et al. (2011) N Engl J Med 364:2392-2404; [3]Lu et al. (2016) Eur J Clin Nutr, doi: 10.1038/ejcn.2015.226; [4]Abargouei et al. (2012) Int J Obes (Lond), doi:10.1038/ijo.2011.269; [5]Booth et al. (2015) Brit J Nutr 114:1013-1025.

Summary - fat & dairy and metabolic health

Dietary fat	Saturated fat	Dairy - including high-fat dairy
* **No association** with weight gain or obesity * Essential for health * Valuable source of energy * Provides building blocks * Carrier of fat-soluble vitamins	* **No independent association** with cardiovascular risk * Not all saturated fats are the same - they have unique effects * Dairy saturated fats may be beneficial * Replacement with refined carbohydrates is likely more detrimental	* **Neutral or beneficial association** with cardiovascular health * Lower risk of – stroke – diabetes – high blood pressure – metabolic syndrome * Cheese has been associated with lower risk of stroke & heart disease * Dairy is associated with less weight gain & beneficial for weight loss

Focus on single nutrients is not helpful and may inadvertently lead to unhealthy diets

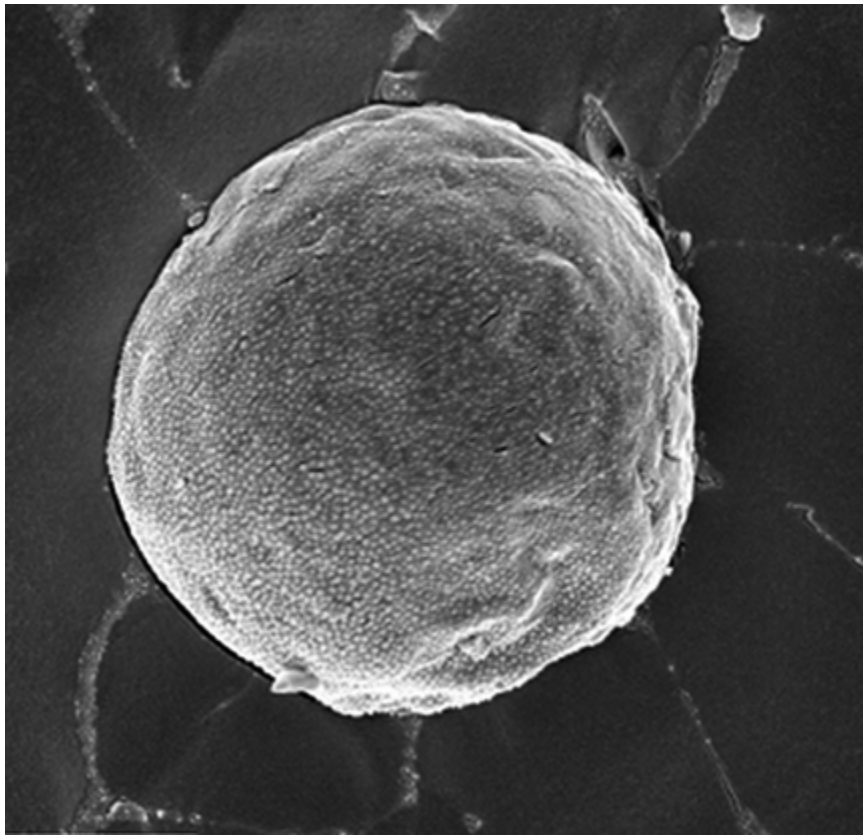
When making dietary recommendations, it is important to:

1. **Consider the whole food matrix**
   Focusing on one single nutrient ignores the potential effect of other nutrients and the food matrix
2. **Consider potential knock-on effects**
   Reduced fat and saturated fat intakes has led to replacement with refined carbohydrates, with likely worse effects

What other components of dairy fats are we missing out on?

Recommendations should be based on whole foods and in the context of a whole diet.

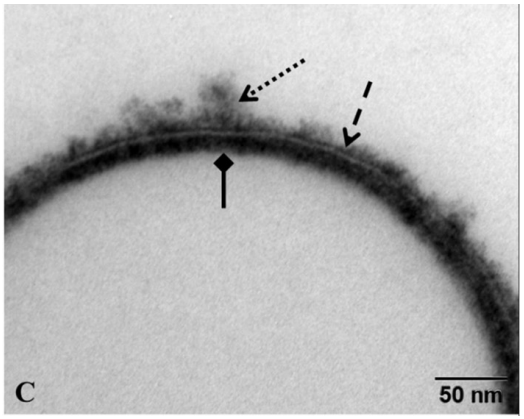
Minor components in Dairy Fat

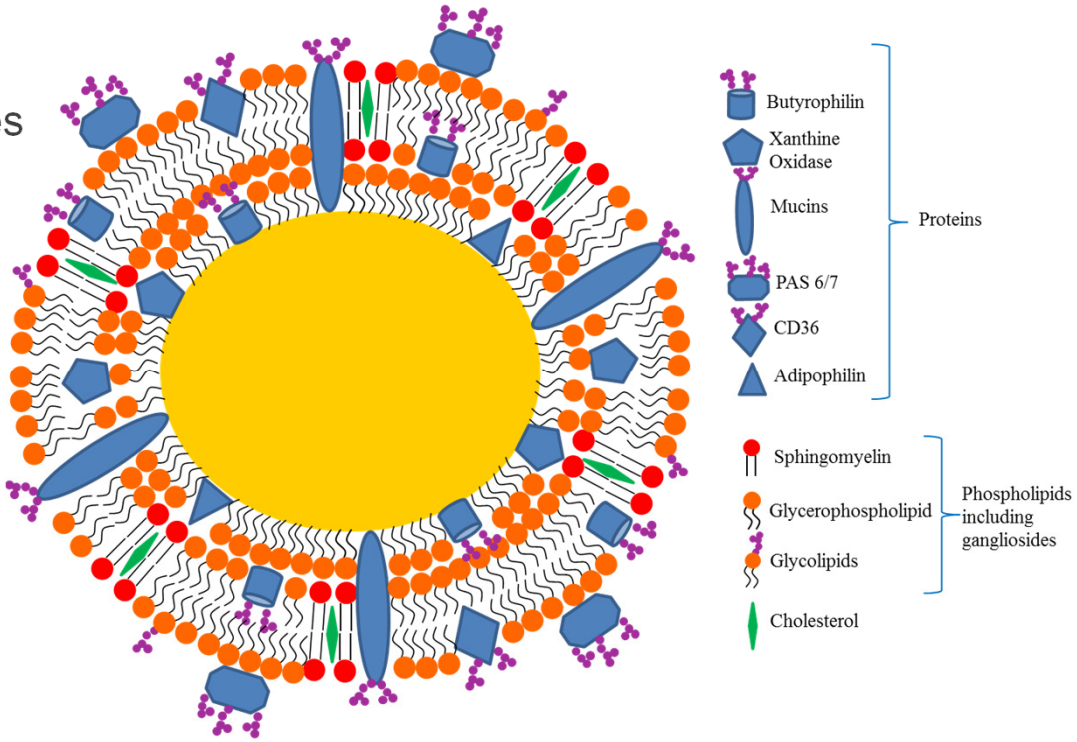


Luo J, et al. RSC Adv., 2014,4, 48963-48966, DOI: 10.1039/C4RA06171C

MFGM as a source of complex milk lipids: gangliosides and phospholipids

- MFGM, thickness 10 – 50 nm, contains:
  - Proteins (1–2% of total milk proteins): butyrophilin, mucins, xanthine oxidase, adipophilin, etc
  - Polar lipids (1% of total milk lipids):
    - Phospholipids: PC, PE, PI, PS, SM
    - Glycolipids: gangliosides and cerebrosides
  - Cholesterol



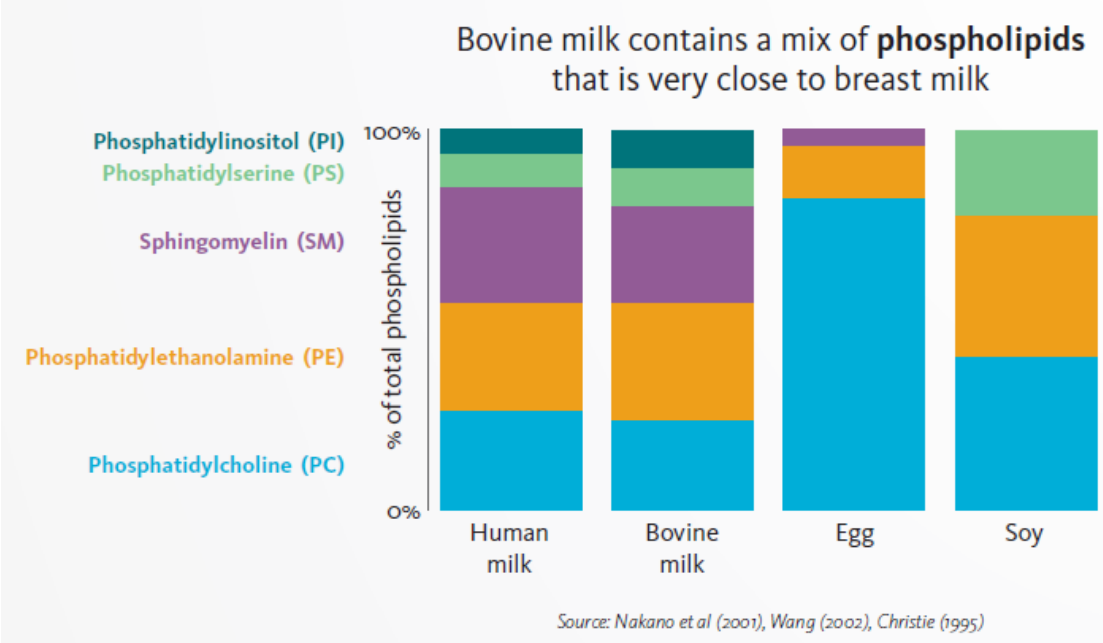


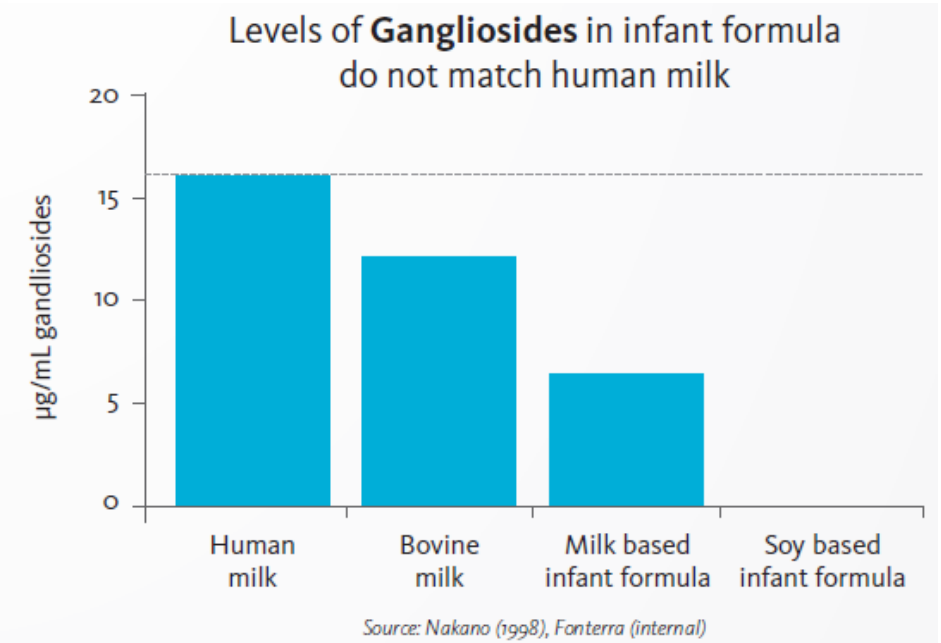
From Gallier et al. (2015). A novel infant milk formula concept: Mimicking the human milk fat globule structure. *Colloids and Surfaces B: Biointerfaces, 136*, 329-339.

Adapted from Gallier et al. (2012). Structural changes of bovine milk fat globules during in vitro digestion. *Journal of Dairy Science, 95*(7), 3579-3592.

Technological functionality of MFGM

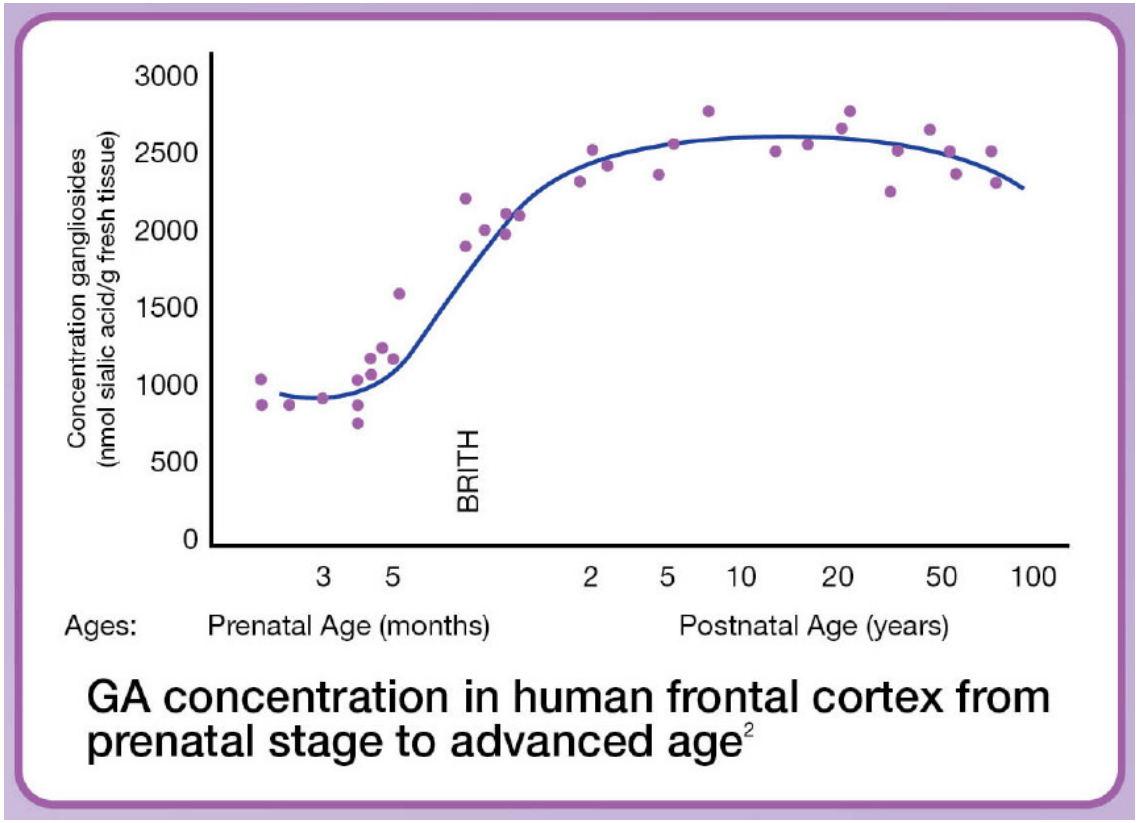
- Stabilize fat globules and prevent coalescence and aggregation
- Good emulsification properties for oil-in-water emulsions
- Other properties: liposome formation, water retention, reduction of free oil content, baking improver...





Health effects: Brain development and cognitive function

- Phospholipids are important structural components of the neuronal membranes.
- Simple sphingolipids such as ceramide and sphingomyelin play very important roles in cell function & are particularly abundant in the nervous system.
- PC and SM source of choline for brain development of the infant.
- Gangliosides make up about 1% of the dry weight of the brain & represent about ~6% to 10% of the total lipid mass in the brain.

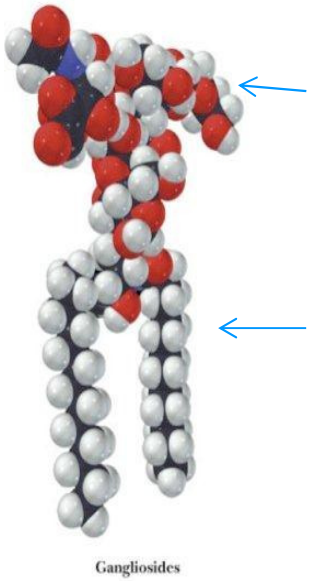


GA concentration in human frontal cortex from prenatal stage to advanced age[2]

McJarrow et al. (2009) Nutr Rev 67, 451–63
Rahmann (1999) Behavioural Brain Research 66, 105-16
Svennerholm et al. (1989) Biochim Biophys Acta. 1005, 109-17
Wang B et al (2003) Eur J Clin Nutri 57, 1351-69
Svennerholm et al. (1989) BBA 1005, 109-117

Gangliosides for Brain development and cognitive function

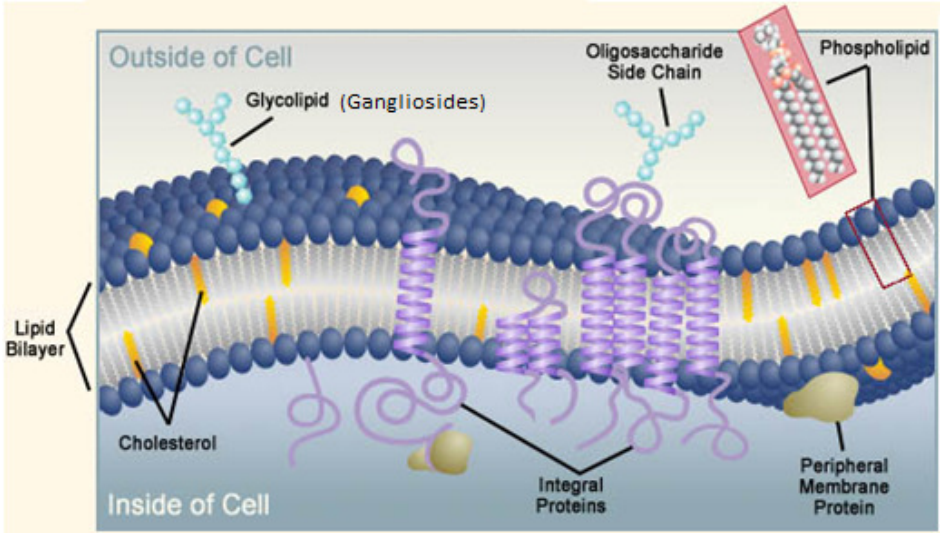
- Higher concentration of Gangliosides occur in the brain of breastfed infants
- Ganglioside are involved in synaptogenesis, neuronal growth, migration and maturation, neuritogenesis and myelination[1,2].



Hydrophilic head (contains sialic acid)

Hydrophobic tail which 'anchors' it into the structure of the cell (contains ceramide)

Gangliosides



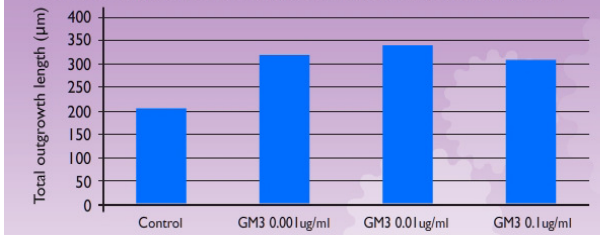
1. Wang et al (2003) Am J Clin Nutr 78, 1024-9
2. Hernell et al (2016) J Pediatr 173S, S60-5

In vitro research shows that milk derived GA promotes neurite outgrowth – critical for synapse formation

- GA extracted from milk lipids were applied to neuronal cells and neurite outgrowth was studied
- Neuronal cell neurite outgrowth was increased

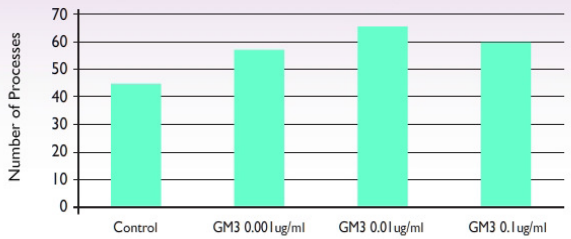
Graph 1 : Significant increase in total neurite length

Effect of Ganglioside GM3 in vitro on neuronal cell neurite growth



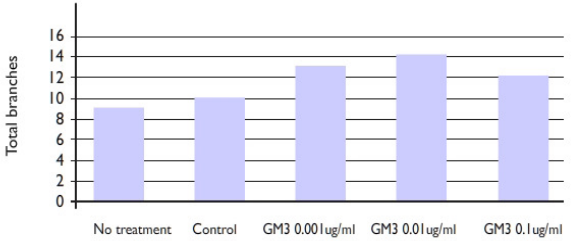
Graph 2 : Significant increase in the total number of processes

Effect of Ganglioside GM3 on number of new processes on neuronal cell neurites



Graph 3 : Significant increase in the number of neurite branches

Effect of Ganglioside GM3 on number of branches on neurite outgrowths



Lim et al (2010) Effects of complex milk lipid components on neurodevelopment in vitro. Neuroscience.

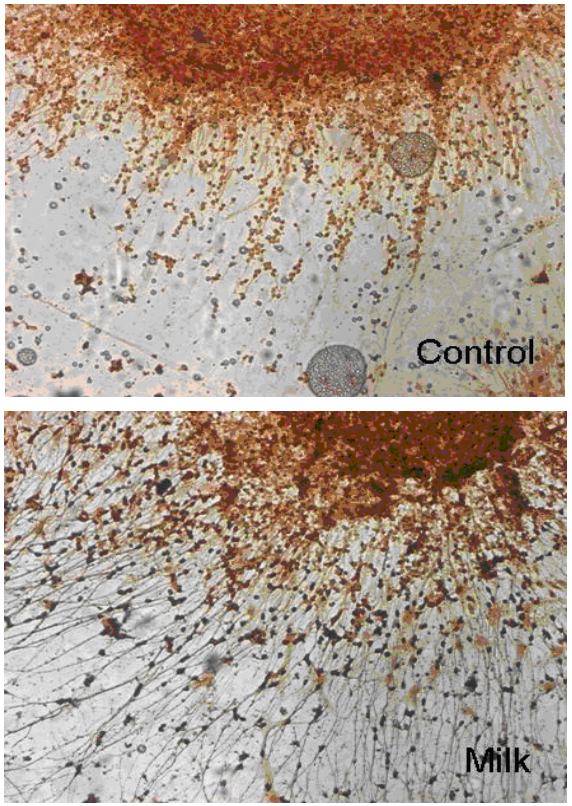


Figure 1. Milk derived GA promoted the development of extensions from the brain cell – network formation

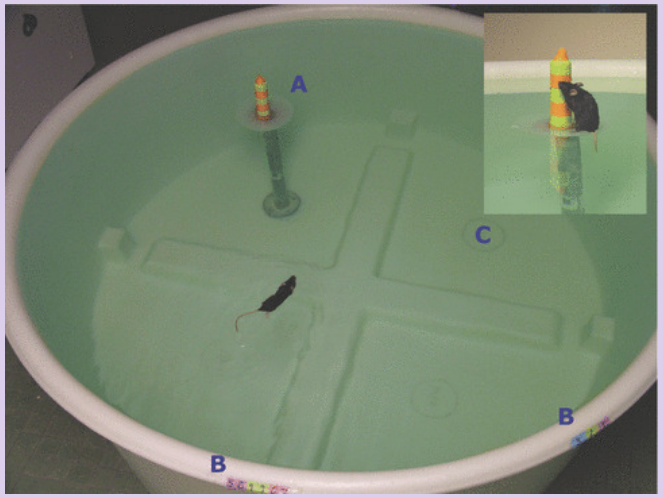
(Prof. Mendez-Otero personal communication)

Preclinical studies support the effects of GA on memory & learning

Pre-clinical studies show that dietary MFGM components result in better learning capacity (recognition and memory)[1], improved spatial learning and affected brain growth and composition[2].

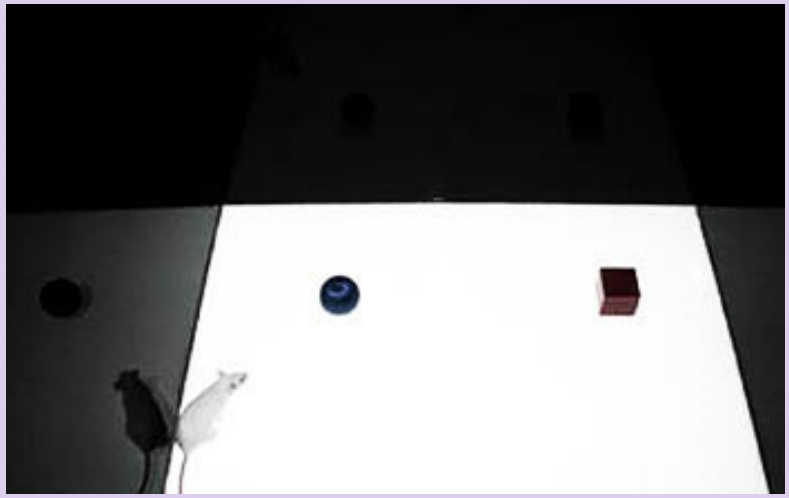
Morris Water Maze

Widely used as an assessment of spatial learning and memory. This is measured as animal performance in navigating a water maze to a central platform.



Novel Object Recognition Test

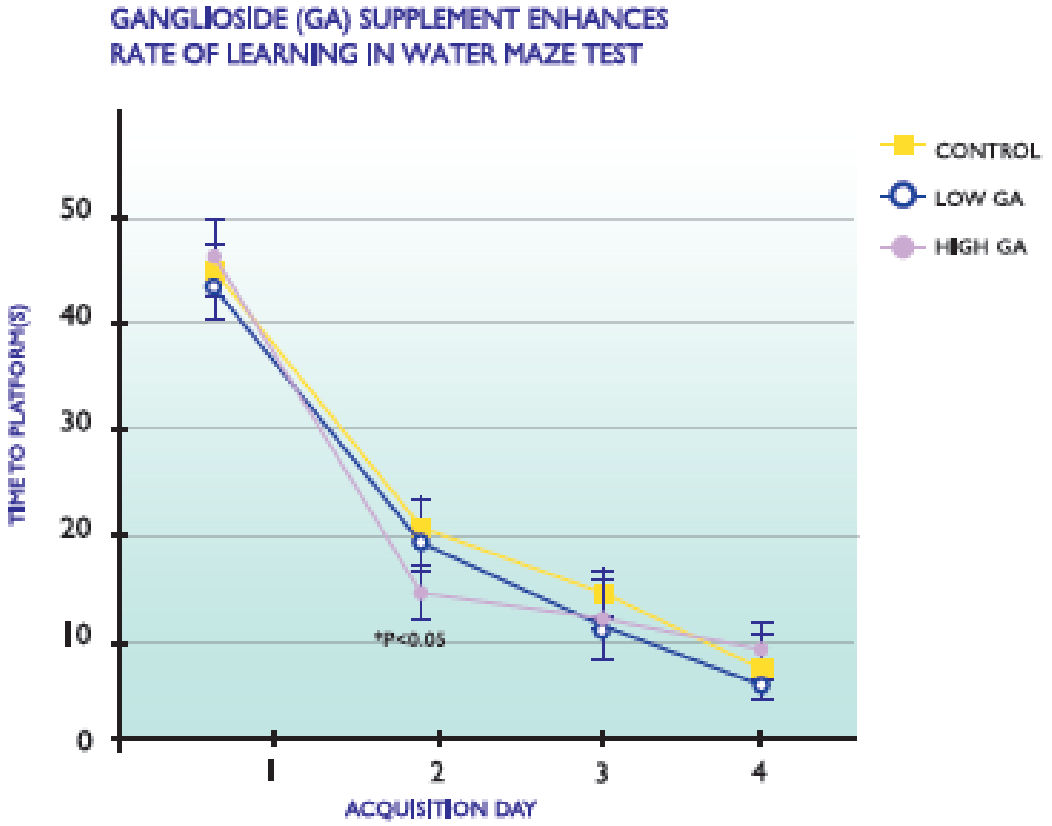
Widely accepted behavioural testing methodology for the testing of memory for familiarity and recognition of novelty in the environment

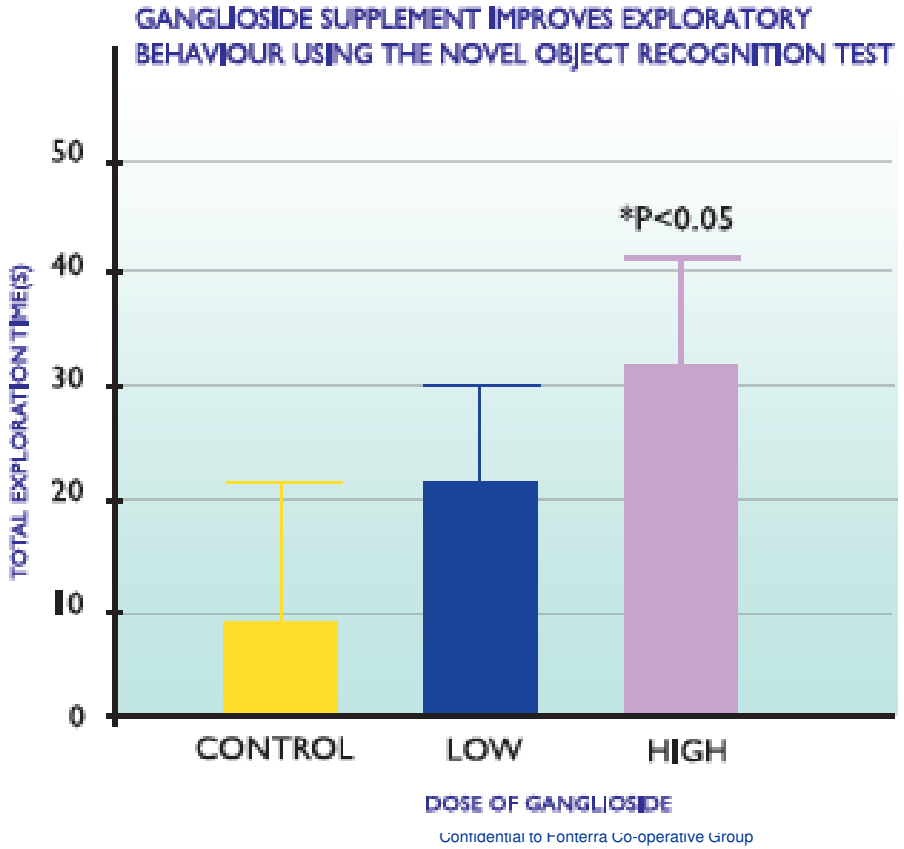


1. *Vickers et al (2009) Nutr Res 29, 426-43*
2. *Liu et al (2014) J Nutr 144, 1903–9*

Preclinical research supports that GA improved memory & resulted in a faster rate of learning

- Significant decrease in the time taken to solve the water maze due to a faster rate of learning the task rather than faster physical performance, ie swim speed
- The novel object recognition test also demonstrated significant improvements in exploratory behaviour and in memory

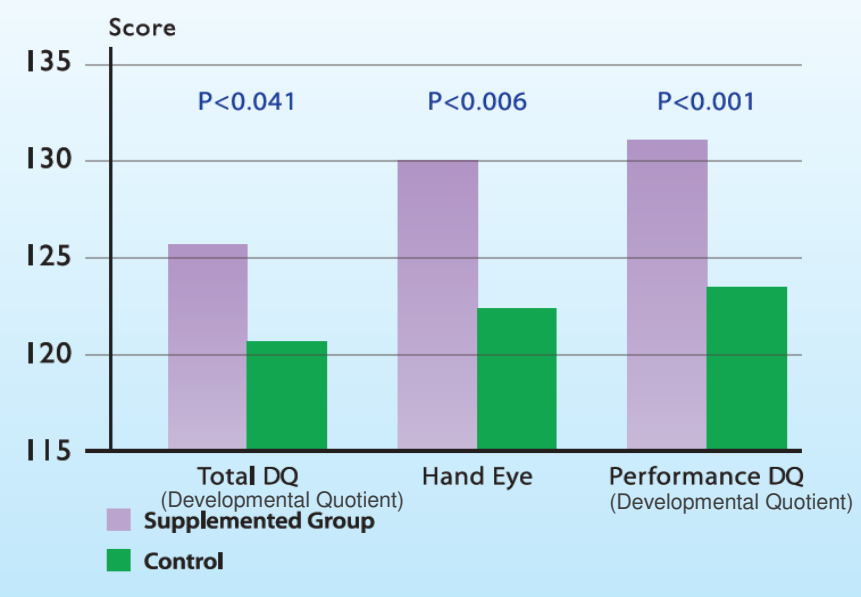




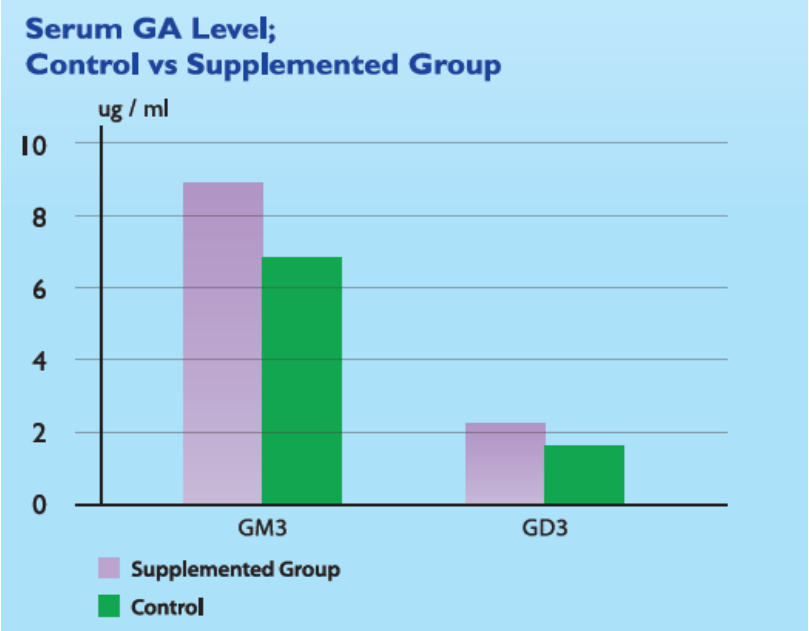
Vickers et al (2009) Nutrition Research 29, 426-435

Pilot study in infants: Increased dietary GA can help support normal cognitive development in infants

- Double-blind, randomized, controlled, parallel group clinical trial
- Normal healthy term infants received the treatment or control from 2-8 weeks of age until 24 weeks
  - Control group (n=30) received standard infant formula
  - Treatment group (n=29) received the same formula supplemented with complex milk lipid to increase the GA content to approximately 11 to 12 µg/ml (based on breastmilk data at the time)
  - Reference group (n=32) consisted of normal healthy exclusively breast-fed infants.
- Cognitive development (Griffith Scales) and serum GA were measured before and after intervention



Impact of supplementation on developmental status at early stage of life.



Gurnida et al (2012) Early Human Development 88, 595-601

Supplementing infant formula with MFGM improved cognitive development at 12 months of age

- In a subsequent prospective, double-blind, randomized controlled trial, infants were fed an MFGM-supplemented, low-energy, low-protein experimental formula (2-6 months) and cognitive development was tested using Bayley Scales of Infant and Toddler Development at 12 months
  - The cognitive score was significantly higher in the MFGM-supplemented infant formula group than in the standard infant formula group (105.8 ± 9.2 compared with 101.8 ± 8.0; P = 0.008).
  - The cognitive score in the MFGM-supplemented infant formula group was not significantly different from that in the breastfed reference group (106.4 ± 9.5; P = 0.73).

Timby et al (2014) Am J Clin Nutr 99, 860-8

Rationale for optimising levels in infant formula: Gangliosides in human breast milk

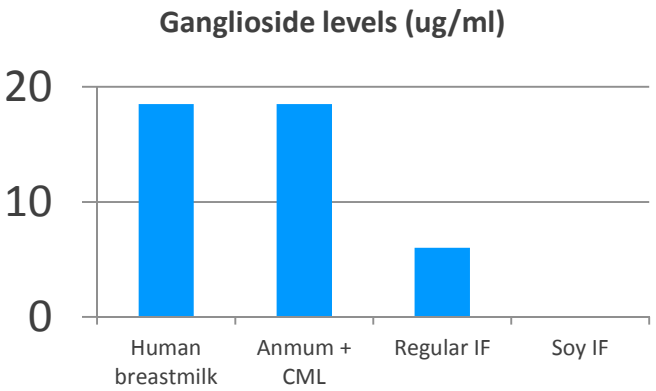
- Carried out surveys of human breast milk minor lipid composition using up to date, validated and published HPLC-Mass spectrometry method
- Changes in Ganglioside concentration measured over 12 months lactation
- The average GA level in breast milk is 18.5 mg/L (Mature milk 30 – 180 days).
- We have used these new data to optimise our Anmum Infant Formula Ganglioside level

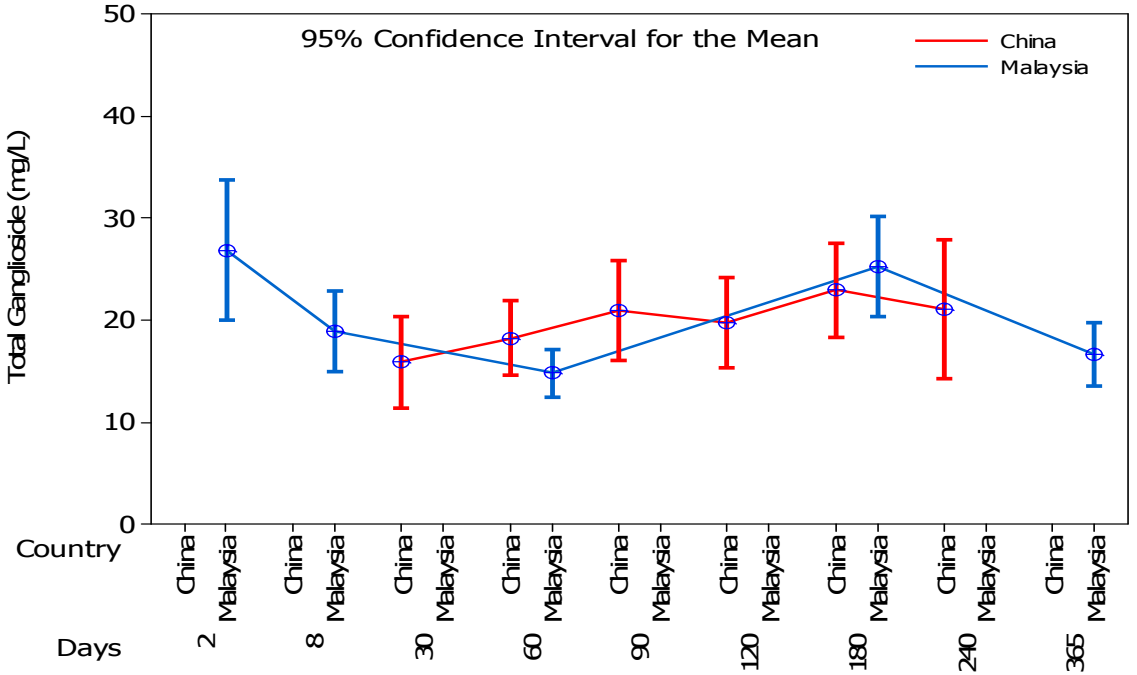
Lipids
DOI 10.1007/s11745-015-4073-1

ORIGINAL ARTICLE

Lactational changes in concentration and distribution of ganglioside molecular species in human breast milk from Chinese mothers

Lin Ma[1] · Xihong Liu[2] · Alastair K. H. MacGibbon[1] · Angela Rowan[3] · Paul McJarrow[1] · Bertram Y. Fong[1]





In Summary

- And we are investing considerable time and research effort into the role of minor MFGM components in health especially brain development

NEW ZEALAND INNOVATION AWARDS® 2016 | WINNER INNOVATION IN FOOD & BEVERAGE

- New Zealand produces high quality milk that has many nutritional benefits and interesting minor components for health

Thank You!

Fonterra
Dairy for life