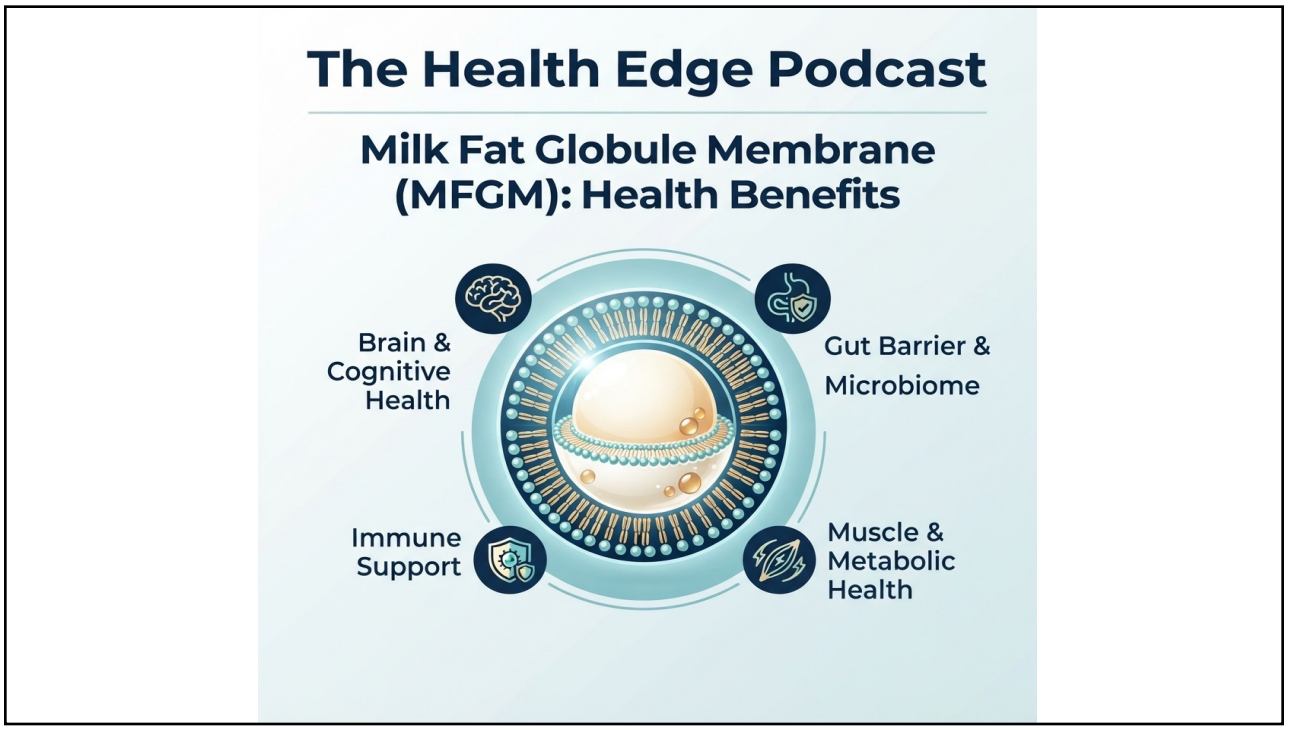


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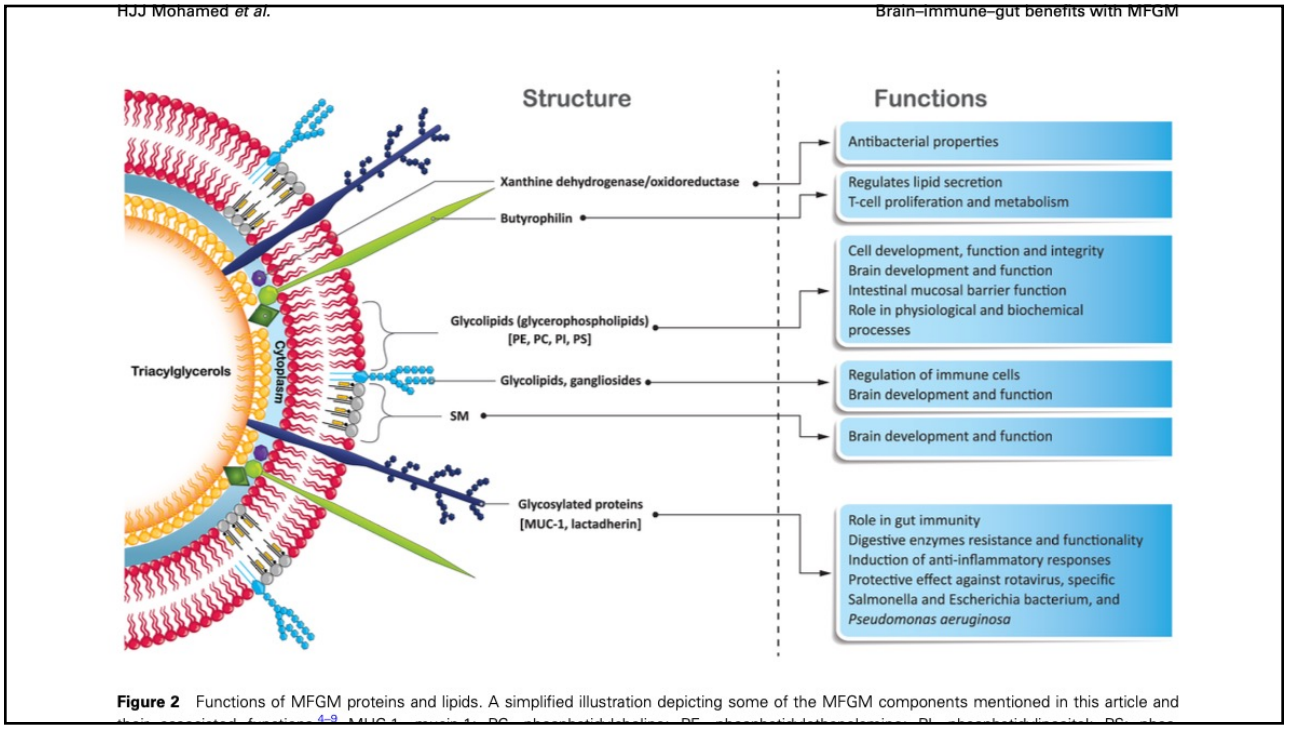
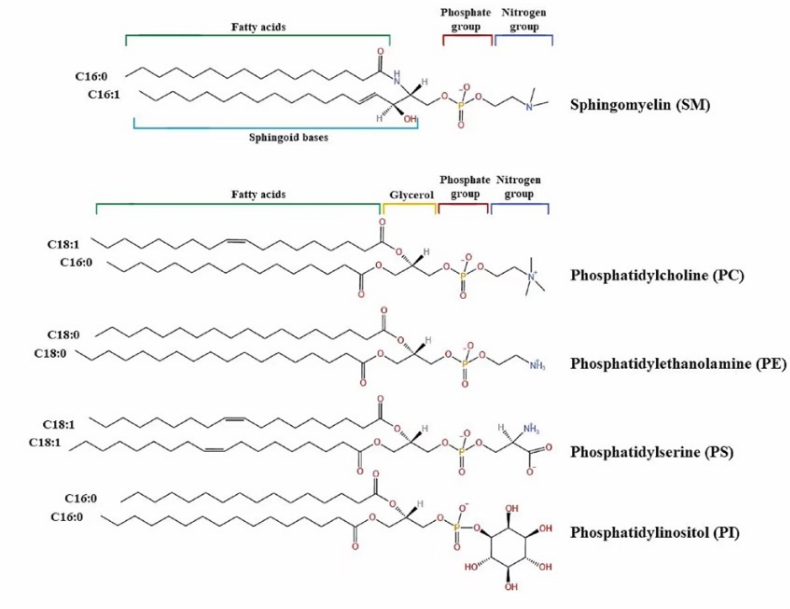


Figure 2 Functions of MFGM proteins and lipids. A simplified illustration depicting some of the MFGM components mentioned in this article and

2



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Effects of milk fat globule membrane ingestion with exercise on physical strength in healthy young adults: a randomized double-blind, placebo-controlled trial

Conclusions: We conclude that daily MFGM supplementation combined with power training are effective to improve instantaneous physical strength, such as muscle strength and power, compared with placebo in healthy young adults.

Background: The milk fat globule membrane (MFGM) is a structural membrane that covers the globules of triglycerides dispersed in an emulsion of milk. In previous human studies, MFGM ingestion combined with light aerobic exercise training improved agility in elderly individuals. The purpose of this study was to examine whether 4 weeks of daily ingestion of MFGM combined with power training improves instantaneous physical strength – muscle strength, agility, and muscle power compared with placebo (whey protein isolate) in healthy young adults.
Method: The study was designed as a randomized, double-blind, and placebo-controlled trial. Ninety-eight healthy young adults aged 20–49 completed the study intervention, and they received either an MFGM powder containing 1.7 g of fat and 160 mg of sphingomyelin or an isocaloric placebo powder daily throughout 4 weeks (3 times/week) of power training. Physical strength tests and body composition measure-

Received 9 September 2024
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KEYWORDS
Word; muscle strength; agility; muscle power; sphingomyelin

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Invited review: Milk fat globule membrane—A possible panacea for neurodevelopment, infections, cardiometabolic diseases, and frailty

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ABSTRACT

Milk is an evolutionary benefit for humans. For infants, it offers optimal nutrients for normal growth, neural development, and protection from harmful microbes. Humans are the only mammals who drink milk throughout their life. Lipids in colostrum originate mostly from milk fat globule membrane (MFGM) droplets extruded from the mammary gland. The supplementation trials as presented in this review have shown significant clinical health benefits across the human life span, which are worth further investigation.
Key words: milk fat globule membrane, infection, neural development, cardiometabolic health, frailty

INTRODUCTION

Human milk (**HM**) is the solitary source of nutrients

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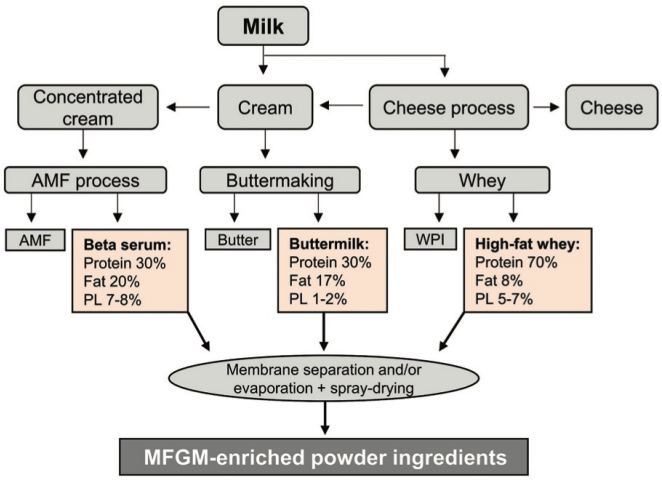


Figure 2. Milk fat globule membrane (MFGM) ingredients (modified using data from Gallier et al., 2018; Fontecha et al., 2020). AMF = anhydrous milk fat; PL = phospholipids; WPI = whey protein isolates.

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frontiers in Nutrition

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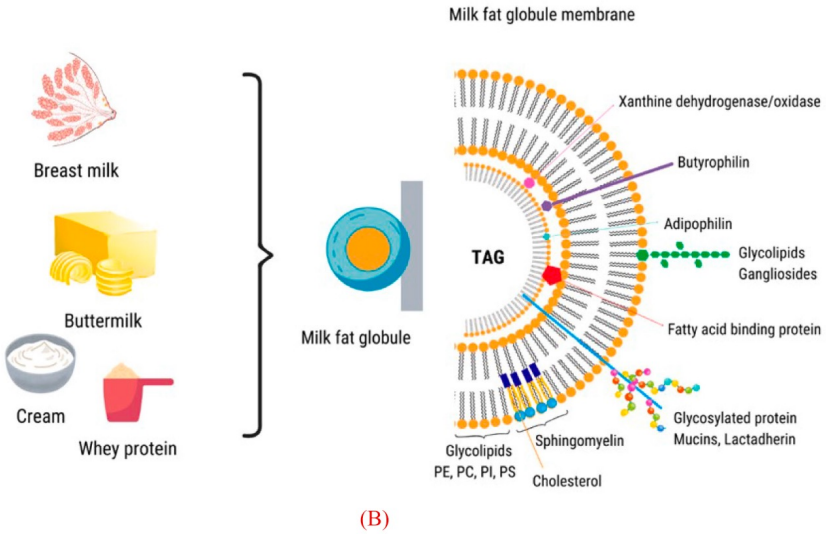
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Milk fat globule membrane in early-life nutrition: composition, production, and biological effects on infant immune maturation, intestinal development, neurocognitive function, and growth

Emine Kocyigit[1], Elif Çelik[2], Özge Cemali[3], Oya Berkay Karaca[4], Bence Raposa[5*†] and Duygu Ağagündüz[6*†]

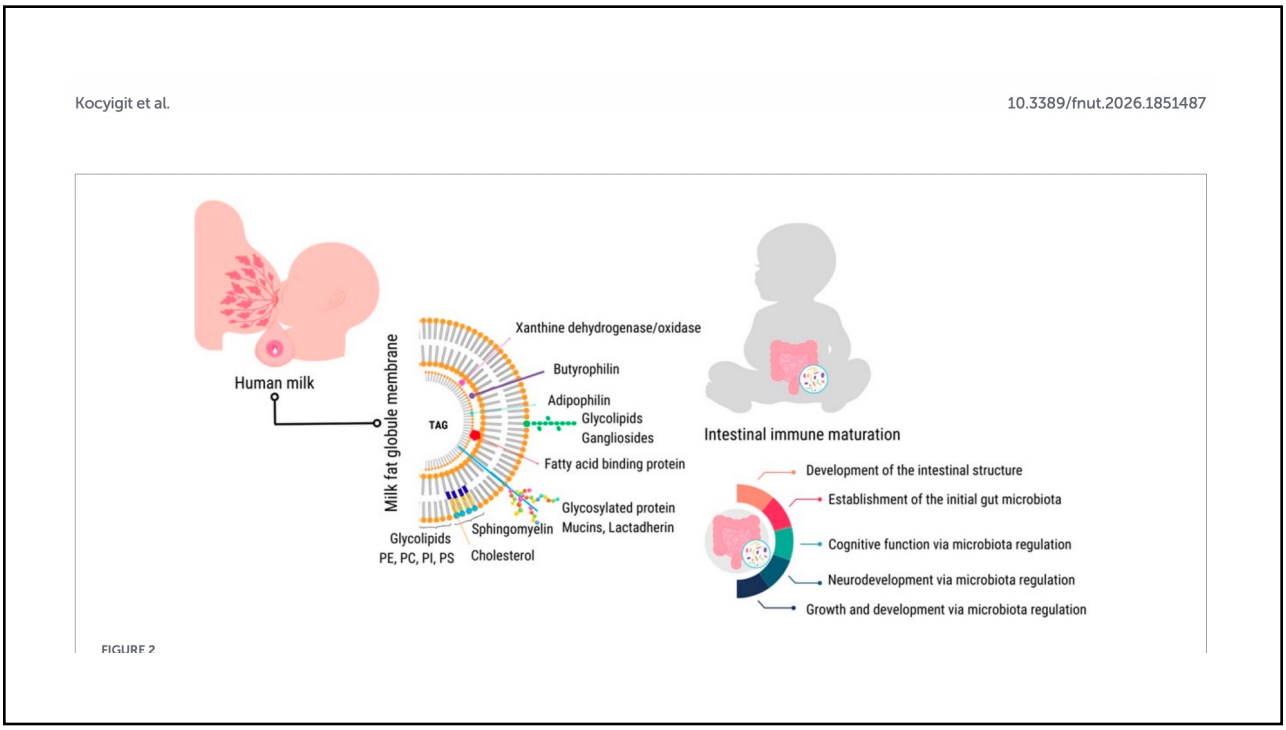
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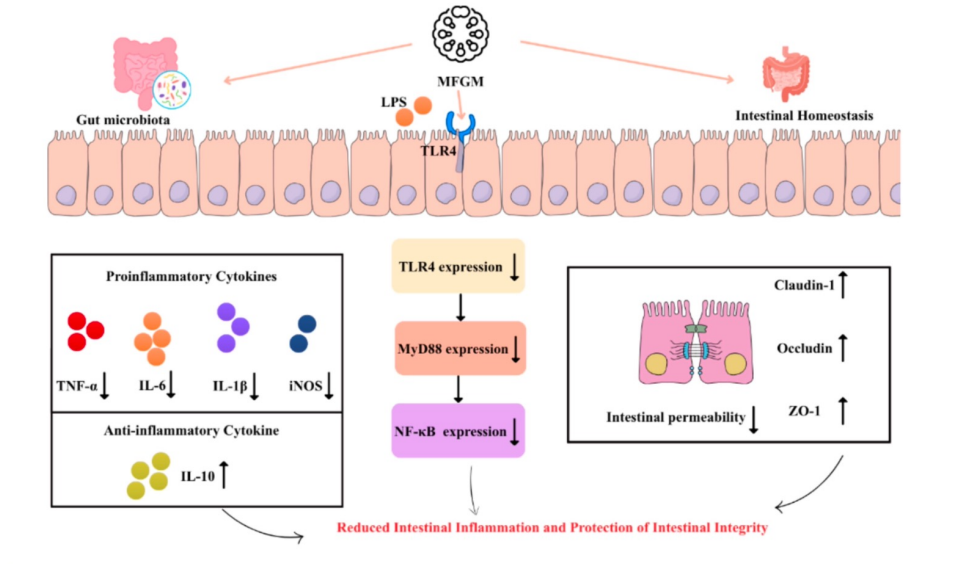


(B)

8


Kocyigit et al.
10.3389/fnut.2026.1851487
Human milk
Milk fat globule membrane
TAG
Xanthine dehydrogenase/oxidase
Butyrophilin
Adipophilin
Glycolipids
Gangliosides
Fatty acid binding protein
Glycosylated protein
Mucins, Lactadherin
Sphingomyelin
Cholesterol
Glycolipids
PE, PC, PI, PS
Intestinal immune maturation
Development of the intestinal structure
Establishment of the initial gut microbiota
Cognitive function via microbiota regulation
Neurodevelopment via microbiota regulation
Growth and development via microbiota regulation
FIGURE 2

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MFGM
LPS
TLR4
Gut microbiota
Intestinal Homeostasis
Proinflammatory Cytokines
TNF-α
IL-6
IL-1β
iNOS
Anti-inflammatory Cytokine
IL-10
TLR4 expression
MyD88 expression
NF-κB expression
Claudin-1
Occludin
ZO-1
Intestinal permeability
Reduced Intestinal Inflammation and Protection of Intestinal Integrity

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CRITICAL REVIEWS IN FOOD SCIENCE AND NUTRITION
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https://doi.org/10.1080/10408398.2023.2249992

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REVIEW ARTICLE

OPEN ACCESS Check for updates

Milk fat globule membrane: composition, production and its potential as encapsulant for bioactives and probiotics

Dan Yao[a], Chaminda Senaka Ranadheera[b], Cai Shen[b,c], Wei Wei[d] and Ling-Zhi Cheong[b]

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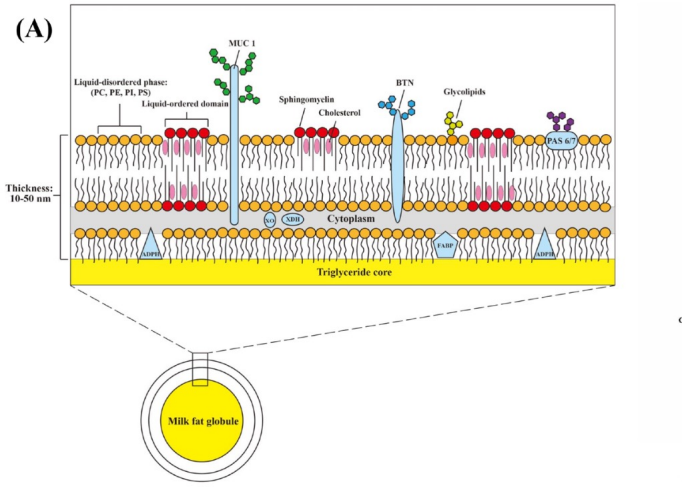
ABSTRACT

Milk fat globule membrane (MFGM) is a complex trilayer structure present in mammalian milk and is mainly composed of phospholipids and proteins (>90%). Many studies revealed MFGM has positive effects on the immune system, brain development, and cognitive function of infants. Probiotics are live microorganisms that have been found to improve mental health and insulin sensitivity, regulate immunity, and prevent allergies. Probiotics are unstable and prone to degradation by environmental, processing, and storage conditions. In this review, the processes used for encapsulation of probiotics particularly the potential of MFGM and its constituents as encapsulating materials for probiotics are described. This study analyzes the importance of MFGM in encapsulating bioactive substances and emphasizes the interaction with probiotics and the gut as well as its resistance to adverse environmental factors in the digestive system when used as a probiotic embedding material. MFGM can enhance the gastric acid resistance and bile resistance of probiotics, mainly manifested in the survival rate of probiotics. Due to the role of digestion, MFGM-coated probiotics can be released in the intestine, and due to the biocompatibility of the membrane, it can promote the binding of probiotics to intestinal epithelial cells, and promote the colonization of some probiotics in the intestine.

KEYWORDS

Colonization; encapsulation; gastric acid and bile resistance; Milk fat globule membrane; probiotics

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foods

MDPI

Review

Milk Fat Globule Membrane: Structural Organization, Bioactive Constituents, and Therapeutic Applications

Hongchen Lv [1], Mengqi Sun [1], Mengmeng Mi [2], Shujuan Sun [2], Yan Zhao [1], Xinyi Du [1], Xu Zhang [1], Mingxia Zhu [1], Yun Wang [2], Muhammad Zahoor Khan [1], Changfa Wang [1,*] and Mengmeng Li [1,*]

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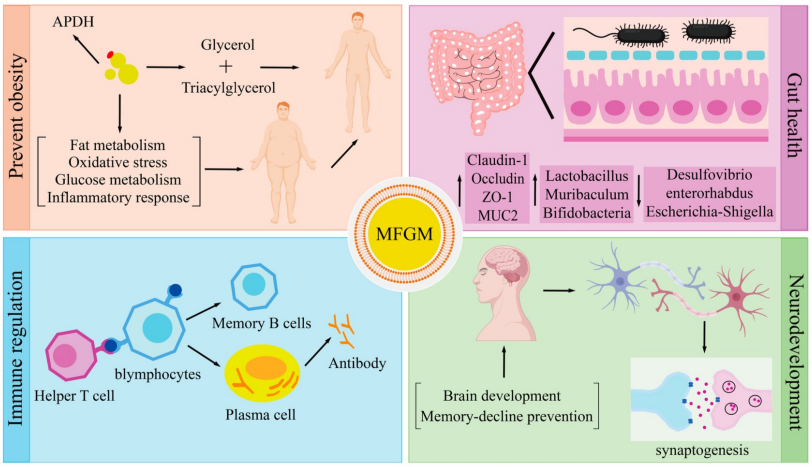
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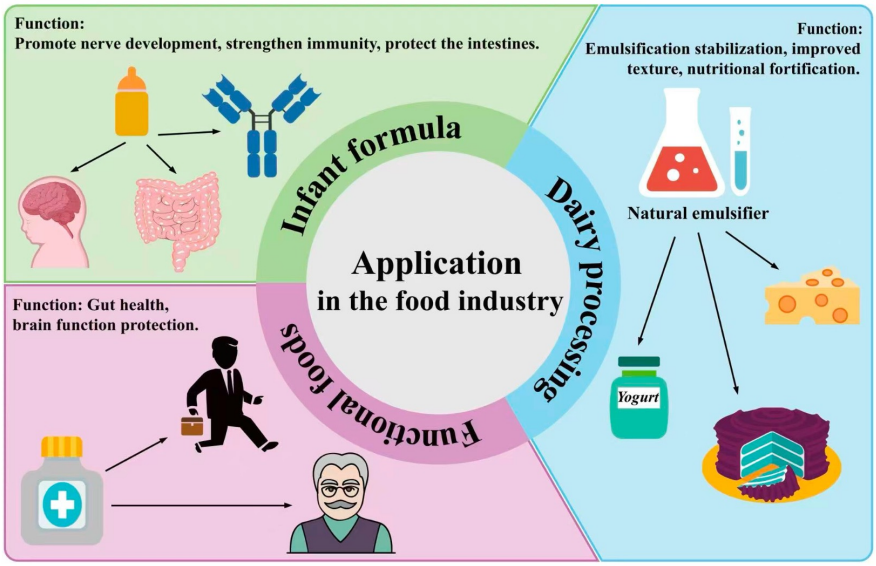
Abstract

The milk fat globule membrane (MFGM) wraps around the surface of the milk fat globule, separating the internal lipid core from the external environment. MFGM is a complex tri-layer membrane structure composed of polar lipids, sphingolipids, and functional proteins. In recent years, research on the biological characteristics of MFGM has been continuously

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Systematic Review

Systematic Review and Meta-Analysis of Milk Fat Globule Membrane Supplementation for Mental Well-Being

Charlotte Mawson [1], Andrew M. Carroll [1], Stefanie Evas [1,2,3], Sarah J. Spies [1] and Maher Fuad [1,*]

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Abstract

Background/Objectives: The milk fat globule membrane (MFGM) is a complex structure of polar lipids, gangliosides, and glycoproteins that has demonstrated anti-inflammatory, neuroprotective, and gut-modulatory effects in preclinical and human studies, but its effects on adult psychological outcomes have not been systematically synthesised. **Methods:** We conducted a systematic literature search across multiple databases using combined relevant keywords and Medical Subject Headings terms, with manual reference checks to ensure comprehensiveness. Of the 35 articles initially identified, 3 randomised controlled trials met the inclusion criteria: adult participants (≥20 years); bovine MFGM supplementation; a placebo or control group; and outcomes measuring stress, anxiety, or depression. A random-effects meta-analysis was performed, calculating standardised mean differences for stress, anxiety, and depression outcomes. **Results:** MFGM supplementation produced small but statistically significant reductions in stress and anxiety. Effects on depression were non-significant, though directionally favourable. Risk-of-bias assessments were conducted using Cochrane criteria and indicated low concerns across trials. Publication bias was not indicated, but interpretation was limited by the small number of studies. **Conclusions:** Whilst the evidence for depression is inconclusive, bovine MFGM supplementation may confer modest benefits for stress and anxiety in adults and could be part of a nutritional strategy to support overall mental well-being.

Nutrients 2026, 18, 342

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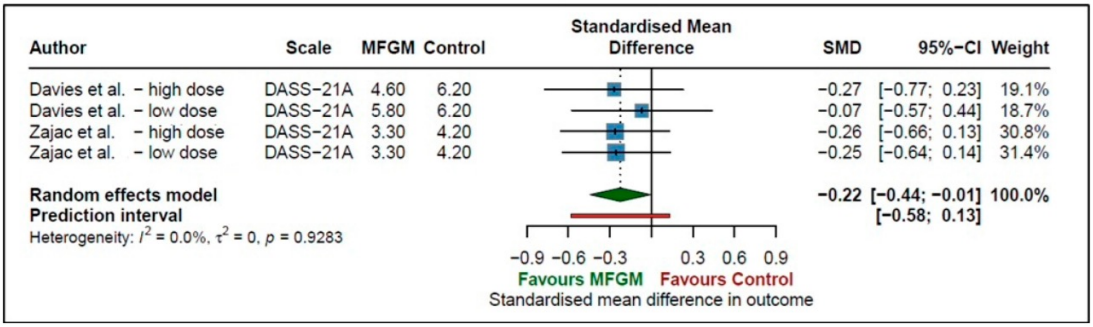


Figure 4. Effect of MFGM supplementation on anxiety measures in adults [31,32].

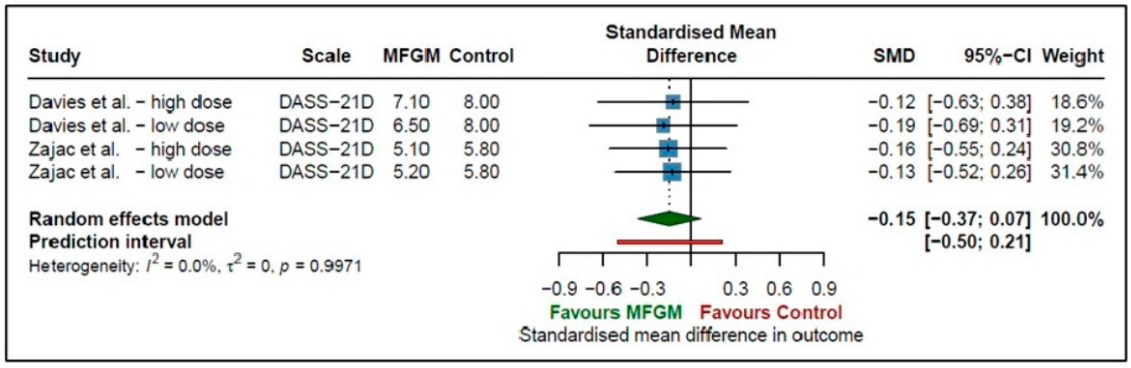


Figure 5. Effect of MFGM supplementation on depression measures in adults [31,32].

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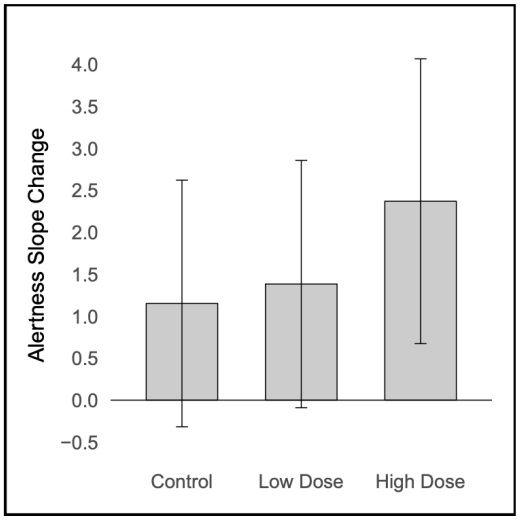
Original Research Article

The effect of milk fat globule membrane phospholipid supplementation on cognitive function in older adults with subjective memory complaints—a randomized, double-blind, placebo-controlled trial

Ian T Zajac [1,2,*], Naomi Kakoschke [1], Stefanie Evas [1,3], Barbara Kuhn-Sherlock [4], Katie Wood [1], Rebecca King [5], Lizanne Arnoldy [5], James Dekker [6], Caroline Gunn [6], Maher Fuad [6], Andrew Scholey [5,7,8], Alastair MacGibbon [6], David J White [5]

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Milk Fat Globulin Membrane

- Clinical research shows that the Milk Fat Globule Membrane (MFGM)—a complex trilayer of polar lipids, phospholipids, sphingolipids, and bioactive proteins surrounding milk fat droplets—provides targeted health benefits across infancy and aging.
- Clinical trials demonstrate that enriching infant formula with bovine MFGM narrows the gap between formula-fed and breastfed infants:
- Cognitive and Behavioral Development: Early-life supplementation improves scores in cognitive, language, motor, and attention development.
- Immune Protection: It significantly reduces the incidence of acute otitis media (middle ear infections), upper respiratory tract infections, fever episodes, and diarrhea.
- Gut Health: It supports intestinal barrier integrity and modulates the infant gut microbiome and metabolome

JGH Open. 2022 Jun 1;6(7):454–461. doi: 10.1002/jgh3.12775

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Milk Fat Globulin Membrane

Adult and Older Adult Benefits

- Brain Health and Cognition: In trials involving older adults, MFGM phospholipid supplementation has been shown to improve subjective alertness, support functional biomarkers related to brain health (such as active B12 and homocysteine modulation), and potentially benefit memory or mood, though direct objective cognitive gains in healthy older adults require longer study durations.
- Cardiometabolic Health: Adult clinical studies suggest that MFGM components can positively influence cardiovascular markers by helping to lower serum cholesterol, triglycerides, and blood pressure.
- Physical Function: Preclinical and clinical observations also point to potential improvements in muscle strength, balance, and agility in older populations.

The American Journal of Clinical Nutrition 122 (2025) 1161–1173

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Physical Function and Muscle Strength

- Clinical research shows that MFGM acts as a neuromuscular enhancer rather than a standalone muscle-building protein, primarily by supporting the integrity of neuromuscular junctions and myelin sheaths.
- When comparing whole food sources versus concentrated supplements for milk fat globule membrane (MFGM), supplements deliver higher, standardized clinical doses with fewer calories, while traditional whole dairy foods like true buttermilk offer naturally intact membranes alongside broader nutrition. Because standard commercial dairy processing—such as homogenization, skimming, and churning—physically strips away or disrupts the delicate membrane, the specific form of dairy you choose makes a substantial difference in how much MFGM you actually consume, as detailed in Nutrition Reviews' analysis of MFGM processing.

Nutr J. 2015 Aug 25;14:85. doi: 10.1186/s12937-015-0073-5

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Whole Food Sources of MFGM

- MFGM sits on the outside of milk fat droplets, meaning its concentration depends heavily on how fat is separated and processed.
- True Churned Buttermilk. When cream is churned into butter, the fat globules rupture and release their outer membranes into the watery liquid left behind. This makes traditional buttermilk one of the richest natural food sources of MFGM, though modern cultured buttermilk made from skim milk contains almost none.
- Unhomogenized Whole Milk and Cream. Raw or gently pasteurized unhomogenized dairy retains intact fat globules surrounded by their natural trilayer membrane. Standard supermarket homogenization blasts milk through tiny nozzles under high pressure, shattering the globules and replacing much of the natural MFGM with casein and whey proteins.
- High-Fat Dairy Products. Whole milk yogurt, sour cream, and certain aged cheeses contain moderate amounts of polar lipids, whereas standard butter and butter oil (ghee) have had the membrane washed away during churning and clarification.

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Concentrated Supplement Forms

- Most human clinical trials on adults and older adults rely on isolated MFGM ingredients rather than liquid milk to reach therapeutic lipid thresholds without adding excess saturated fat or calories.
- Whey Protein Phospholipid Concentrate (WPPC). These powders are derived from cheese whey or buttermilk serum using microfiltration and ultrafiltration. They typically contain 50% to 70% protein alongside 15% to 25% MFGM polar lipids, making them popular for older adults targeting both muscle protein synthesis and neuromuscular function.
- Purified MFGM Lipid Extracts. Available in capsules or bulk powders, these extracts concentrate total phospholipids and sphingomyelin (often 40% to 75% polar lipids) with minimal protein or lactose. They are typically used in trials evaluating cholesterol reduction, stress resilience, and brain biomarkers.
- Commercial Product Labels. Because "MFGM" is a structural term, supplement labels often list ingredients as whey protein phospholipid concentrate, milk phospholipids, dairy polar lipids, or branded ingredients (such as Lacprodan MFGM-10 or SureStart MFGM).

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Choosing Between Them

- Choose whole foods if you want a budget-friendly, everyday dietary approach to support general cardiometabolic health, and you have access to churned buttermilk (check labels for "sweet cream buttermilk" rather than cultured low-fat milk) or cream-top (non-homogenized) whole milk.
- Choose a supplement if you are lactose intolerant or aiming to replicate the exact clinical doses (1 g to 4 g of MFGM phospholipids daily) studied for older adult balance, muscle torque, and stress reduction.
- Older Adult Agility and Balance. In double-blind trials on elderly populations, daily MFGM intake (often standardized around 1 g/day or ~160 mg of sphingomyelin) combined with light aerobic or rhythmic exercise significantly improved agility, balance, and physical fitness scores compared to exercise alone. Adult Strength and Power. Studies in healthy young and middle-aged adults show that pairing MFGM supplementation with resistance or power training improves peak muscle torque, leg press strength, and motor unit recruitment without necessarily increasing total lean muscle mass

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Brain Health, Mood, and Stress Resilience

Mixed Cognitive Outcomes.

- A 16-week randomized controlled trial of 263 adults aged 55–75 published in the American Journal of Clinical Nutrition found no significant improvement on standard cognitive batteries (such as RBANS) among older adults with subjective memory complaints. However, a smaller pilot trial of MFGM-enriched milk reported improved episodic memory in older female participants, suggesting longer durations or baseline impairment levels may influence results.
- Alertness and Neurotransmitters. In the 16-week older adult trial, high-dose MFGM phospholipids (4.0 g/day) helped maintain subjective alertness during demanding cognitive testing. Both low-dose (1.7 g/day) and high-dose groups also showed increased plasma levels of the neurotransmitters serotonin and GABA, alongside higher active vitamin B12 and lower homocysteine.
- Stress Reduction. A 12-week trial in moderately stressed adults published in ScienceDirect's Journal of Functional Foods found that daily MFGM supplementation (600 mg to 1,200 mg) significantly reduced perceived stress scores compared to placebo.

https://examine.com/research-feed/study/1wvkgd/

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Cardiometabolic and Inflammatory Markers

- Clinical trials evaluating lipid profiles in adults suggest that MFGM polar lipids help limit intestinal cholesterol absorption.
- Cholesterol and Lipid Reduction. Multiple adult trials—including the 16-week older adult trial—found that daily MFGM intake reduced total cholesterol, low-density lipoprotein (LDL) cholesterol, and triacylglycerols.
- Lower Systemic Inflammation. High-dose MFGM supplementation in older adults significantly decreased tumor necrosis factor-alpha (TNF-α), a pro-inflammatory cytokine associated with age-related vascular and cognitive decline.

Am J Clin Nutr. 2025 Nov;122(5):1161-1173.

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Practical Context and Dosage

Most clinical studies use concentrated MFGM powders, enriched milk drinks, or bioactive whey protein concentrates rather than standard fluid milk, because conventional dairy processing disrupts the membrane. Typical study doses range from 600 mg to 1,200 mg of total MFGM (or 160 mg of sphingomyelin) daily for neuromuscular and stress benefits, up to 1.7 g to 4.0 g of MFGM phospholipids daily in cognitive biomarker trials. Whole dairy foods like buttermilk and unhomogenized cream naturally retain higher amounts of intact MFGM than skim milk or standard butter.

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