Milk fat for health promotion

The potential of milk-derived medium-chain fatty acids to improve health aspects related to obesity, glycemic control, and blood lipid profile.

Unique milk fatty acids

Most of the fat in milk is comprised of triacylglycerol, a glycerol molecule to which three fatty acids are esterified. Milk fat comprises a large variety of fatty acids, and the diversity of triacylglycerol species is great. The typical fatty acids in milk, as in the typical Danish diet, are long-chain fatty acids with a chain length of 16-18 carbon atoms. Medium-chain fatty acids refer to fatty acids, which consist of 8-12 carbon atoms. Medium-chain fatty acids make up ~10% of the total fat in milk. Milk is a unique dietary source of medium-chain fatty acids, as only less common food items such as coconut oil and palm kernel oil contain significant quantities of medium-chain fatty acids. Interestingly, the presence of medium-chain fatty acids in infant milk is greatly conserved between humans and across animal species, indicating their importance to infant development. Medium-chain fatty acids have biochemical properties rendering them attractive substrates in the body. Due to a greater hydrophilicity than the long-chain fatty acids, medium-chain fatty acids are thought to more readily enter cell mitochondria (the energy producing organelle) for oxidation.

Medium-chain fatty acids and health

Medium-chain fatty acids have in previous human experiments been shown to improve insulin sensitivity and lower body weight, the latter by increasing energy expenditure and reducing appetite. In the laboratory of Professor Bente Kiens at the Dept. of Nutrition, Exercise and Sports, University of Copenhagen we have data from humans showing that dietary replacement of only 30 g long-chain fatty acids by medium-chain fatty acids prevented development of insulin resistance during 3 days overfeeding. Intriguingly, the mechanisms for the metabolic benefits are unknown. Unlike the more abundant long-chain fatty acids, which enter the blood via the lymphatic system as triacylglycerols packaged into lipid-carrying particles, medium-chain fatty acids are directly absorbed from the intestine into the portal vein to the liver, where they are metabolized. We hypothesize that this direct entry may trigger the release of factors from the liver, which mediate the metabolic benefits in other tissues such as brain, skeletal muscle, and adipose tissue. One such factor could be ketone bodies and it is known that intake of medium-chain fatty acids leads to an increased amount of ketone bodies in the blood. Over-

Project info

Title: SMiL – Special Milk Lipids for Health.
Project manager: Professor Bente Kiens, Department of Nutrition, Exercise and Sports, University of Copenhagen.
Participants: Aarhus University, University of Copenhagen, and Arla Foods for Health.
Project period: January 2021 to December 2024.
Objective: Medium-chain fatty acids have been shown to lower body weight and improve the metabolic syndrome. We want to create a novel dairy ingredient rich in medium fatty acids and assess its potential health benefits, while also identifying mechanisms and biomarkers for medium chain fatty acid action.
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THE DANISH DAIRY RESEARCH FOUNDATION

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all, we want to investigate whether and how medium-chain fatty acids affect physiological and health outcomes, such as resting metabolic rate, appetite, insulin sensitivity, and the blood lipid profile.

Enrichment of milk medium-chain fatty acids

Lars Wiking and Zheng Guo at Aarhus University (Dept. of Food Science and Dept. of Engineering, respectively) will for the first time combine raw milk selection, dry fractionation, and short-path distillation to generate milk lipid fractions enriched in medium-chain fatty acids. Milk fat fractionation based on volatility of the lipid molecules by short-path distillation has in our preliminary studies shown 2-3 times enrichment of medium-chain fatty acids in the distillate compared to the native milk fat. After in-depth characterization and optimization, this novel medium-chain fatty acid-rich fraction will be produced for testing in humans. At University of Copenhagen (Dept. of Nutrition, Exercise and Sports) in the laboratories of Kiens and Kleinert, experiments in both humans and rodents will reveal whether the novel MCFA-rich dairy fat prototype has impact on insulin sensitivity, energy expenditure, satiety, and plasma lipid profile. Furthermore, we also aim at illuminating the molecular mechanisms. The primary endpoint is whether the medium-chain fat-rich dairy prototype can prevent insulin resistance and reduce appetite in humans and rodents.

Industrial benefit

Collectively, we are combining state-of-the-art technology and biology to create a new dairy product that has the potential to become a nutritional tool to help combat obesity, type 2 diabetes, and metabolic syndrome. Such functional foods are in high demands by consumers. Moreover, the project will lead to optimization of processes related to milk fractionation and distillation.

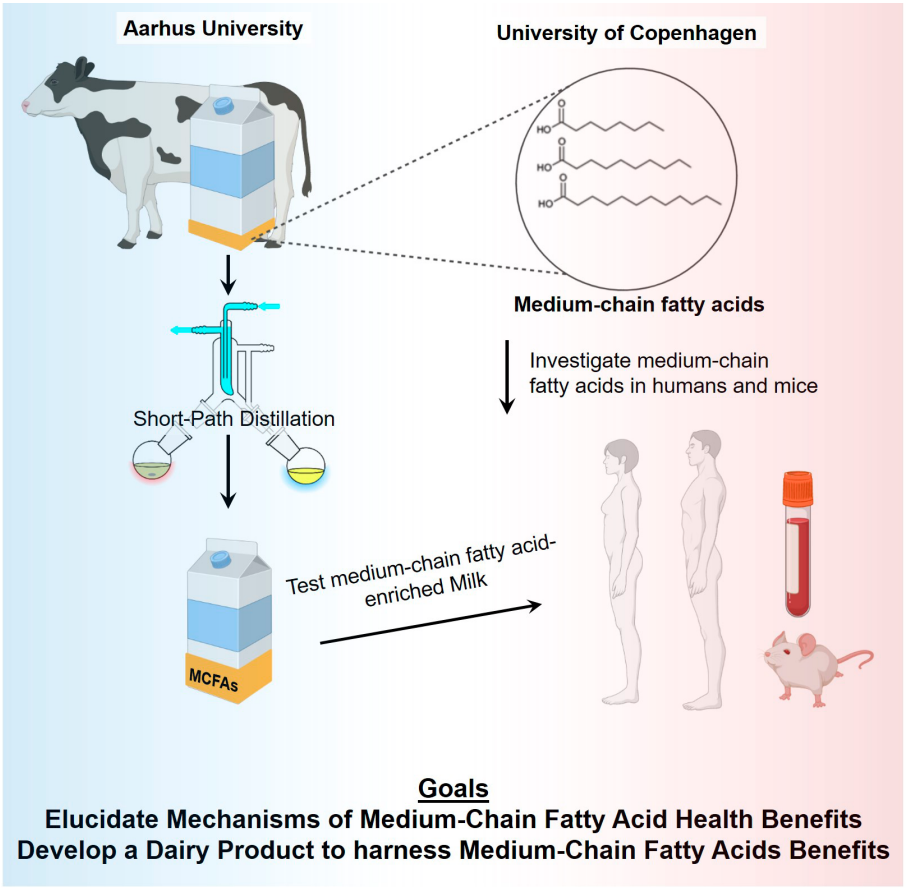

Figure 2 Illustration of the project work packages

Summary

Fractionation of milk fat is today mostly done for obtaining improved textural functionalities of the fats. We aim for targeting the composition of the fat fraction to obtain specific health benefits, by selecting cow milk with the highest medium-chain fatty acid content and using short-path distillation, so we can test a milk product, which is much higher in medium-chain fatty acids than raw milk. In human experiments, we will investigate the potential for health benefits and their novel mode-of-action. We hypothesize that milk-derived medium-chain fatty acids may have therapeutic potential in prevention of the typical lifestyle diseases such as obesity, abnormal lipid profile, and insulin resistance.