SLUTRAPPORT/FINAL REPORT
NR. 2024-189

Faidon Magkos:

FerMetS – Fermenterede mejeriprodukter og metabolisk syndrom

FerMetS – Fermented dairy products and metabolic syndrome

Mejeribrugets
ForskningsFond

November 2024

Final report

for collaborative projects funded via the Danish Dairy Research Foundation (DDRF)

1. Title of the project

Danish: Fermenterede mejeriprodukter og metabolisk syndrom (FerMetS)

English: Fermented dairy products and metabolic syndrome (FerMetS)

2. Project manager

Professor Faidon Magkos, NEXS, University of Copenhagen, Rolighedsvej 26, 1958 Frederiksberg C, DK. Tel +45 3533 3671, Email fma@nexs.ku.dk (taken over after Assistant Professor Nina Rica Wium Geiker who initiated the project in 2020).

3. Other project staff

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4. Sources of funding

Total: DKK 9,503,000

Arla Food for Health: DKK 5,000,000

In-kind: DKK 2,055,000

DDRF: DKK 2,448,000

5. Project period

Project period with DDRF funding:	[06/2020 – 06/2023]
Revised, if necessary:	[06/2020 – 06/2024]

6. Project summary

Danish:

Det er bredt anerkendt at fedme og metabolisk dysfunktion er tæt forbundet med risiko for at udvikle kardiometaboliske sygdomme. I løbet af de seneste årtier har fremskridt inden for medicinsk billedteknologi øget bevidstheden og forståelsen af fedt, som er lagret andre steder end fedtvævet, så som leverfedt, og dets forbindelse til metabolisk funktion selv uafhængigt af andre markører for fedme. På trods af at vægttab er den primære strategi for at reducere leverfedt, kan det være udfordrende at opnå og vedligeholde et klinisk signifikant vægttab. Ikke desto mindre er undersøgelser af koststrategier til at reducere leverfedt, uafhængigt af vægttab, begrænsede og inkonsistente, og det er derfor vigtigt at udforske strategier til at reducere leverfedt, der er uafhængige af vægttab. Observationsstudier tyder på, at indtagelse af fermenterede mejeriprodukter, især yoghurt, kan have sundhedsmæssige fordele og reducere risikoen for kardiometaboliske sygdomme, men viden om effekten af yoghurtindtag på leverfedtbalancen er begrænset.

Derfor er det overordnede formål med dette forskningsprojekt at undersøge rollen af leverfedt som en markør for metabolisk funktion og undersøge effekten af mejeriprodukter, især yoghurt, i at ændre leverfedtindholdet hos mænd med abdominal fedme under stabil kropsvægt.

For at opnå dette gennemførte vi et 16-ugers randomiseret kontrolleret forsøg, som undersøgte effekten af yoghurt sammenlignet med mælk på leverfedt og kardiometabolisk risiko hos mænd med abdominal fedme. Derudover blev der udført en tværsnitsanalyse for at sammenligne personer med lavt og højt leverfedtindhold, for yderligere at undersøge leverfedtets rolle som en markør for metabolisk funktion uafhængigt af andre almindelige mål for fedme.

Resultaterne fra dette forskningsprojekt understreger vigtigheden af leverfedtindholdet som en markør for metabolisk funktion uafhængigt af andre markører for fedme. I modsætning til vores hypotese, viste effekten af yoghurt sammenlignet med mælk ikke en overlegenhed i at reducere leverfedt eller forbedre kardiometabolisk risiko under stabil kropsvægt. Dog førte indtag af alle inkluderede mejeriprodukter, fermenterede eller ej, til lignende milde forbedringer i nogle kardiometaboliske risikomarkører uden at påvirke leverfedt.

English:

It is well established that obesity and metabolic dysfunction are closely linked to the risk of developing cardiometabolic diseases. During the past decades, advances in medical imaging technology have increased awareness and understanding of fat stored in non-adipose tissue, such as the liver, and its link to metabolic function, even independently of total body adiposity. While weight loss per se remains the primary strategy for reducing liver fat, achieving and maintaining a clinically significant weight loss is challenging. Nonetheless, evidence for dietary strategies for reducing liver fat independently of weight loss are scarce and inconsistent, and it is therefore important to explore strategies for reducing liver fat that are independent of weight loss. Observational studies suggest that consuming fermented dairy products, particularly yogurt, may have health benefits and reduce risk of cardiometabolic diseases. However, evidence on the impact of yogurt consumption on liver fat balance is limited.

Accordingly, the overarching aim of this research project was to explore the role of liver fat as a marker of metabolic function, and evaluate the effect of dairy foods, in particular yogurt, in modifying liver fat content in males with abdominal obesity during body weight stability.

To achieve this, we conducted a 16-week randomized controlled trial to investigate the effect of yogurt compared to milk on liver fat and cardiometabolic risk in males with abdominal obesity. Additionally, a cross-sectional analysis was performed to compare individuals with low and high liver fat content, to further explore the role of liver fat as a marker of metabolic function independent of other common measures of adiposity.

The results from this research project underline the importance of liver fat content as a marker of metabolic function independently of other adiposity markers. Contrary to our hypothesis, the effect of yogurt compared to milk was not superior in reducing liver fat and improving cardiometabolic risk during body weight stability. However, consumption of all included dairy products, fermented or not, led to similar mild improvements in some cardiometabolic risk markers without affecting liver fat content.

7. Project aim

Danish: Det overordnede formål med dette projekt var at undersøge rollen af leverfedtindholdet som en markør for metabolisk funktion, og at undersøge effekten af mejeriprodukter, specielt yoghurt, i at modificere leverfedtindholdet hos mænd med abdominal fedme under kropsvægtstabilitet. For at gøre dette, sammenlignede vi forsøgspersoner med lavt og højt leverfedtindhold, som ellers var velbalanceret i andre markører for fedme. Vi udførte et 16-ugers randomiseret kontrolleret forsøg for at undersøge effekten af yoghurt sammenlignet med mælk på leverfedtindholdet (primær outcome) og kardiometabolisk risiko i mænd med abdominal fedme. Indvirkningen af mælkesyrebakterier, surhed og struktur af yoghurt blev også undersøgt ved brug af to ekstra interventionsarme (varmebehandlet yoghurt og syrnet mælk). Hypotesen var at indtaget af yoghurt sammenlignet med mælk ville føre til reduktion i leverfedtindhold og forbedringer i kardiometabolisk risiko.

English: The overarching aim of this project was to explore the role of intrahepatic fat content as a marker of metabolic function, and evaluate the effect of dairy foods, in particular yogurt, in modifying intrahepatic fat content in males with abdominal obesity during body weight stability. To this end, we compared individuals with low versus high liver fat, who were otherwise well-balanced for other adiposity measures, and conducted a 16-week randomised controlled trial with four arms to investigate the effect of yogurt comparted to milk on liver fat (primary outcome) and cardiometabolic risk in males with abdominal obesity. The role of the lactic acid bacteria, acidity and structure of the yogurt were explored by two additional dairy intervention arms (heat-treated yogurt and acidified milk). The hypothesis was that the consumption of yogurt compared to milk would lead to reductions in liver fat and improvements in cardiometabolic risk.

8. Background for the project

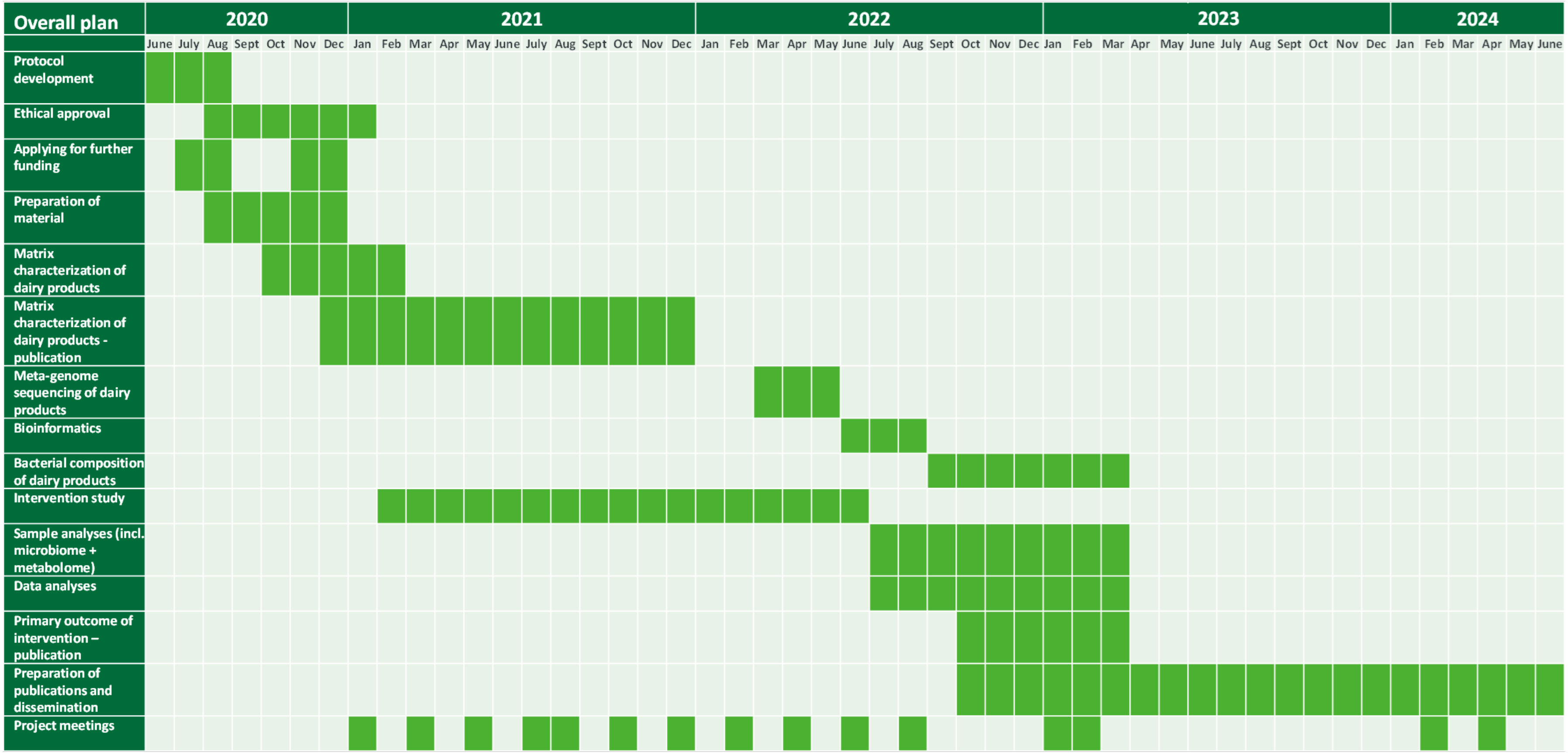
Overweight and obesity, defined as a body mass index (BMI) ≥ 25 kg/m2, affect almost 40 % of the world's population. With increasing BMI, the risk of developing metabolic dysfunction and cardiometabolic diseases such as type 2 diabetes mellitus (T2DM) and cardiovascular disease (CVD) also increases. In the past decades, advances in methods for measuring fat in tissues that are not normally associated with fat storage have made it possible to quantify liver fat, i.e. intrahepatic triglyceride (IHTG) content, which has since emerged as a strong predictor of metabolic dysfunction, even independently of BMI and total body fat. A pathological build-up of IHTG is referred to as metabolic dysfunction-associated steatotic liver disease (MASLD), previously known as non-alcoholic fatty liver disease (NAFLD), and is typically defined as steatosis affecting at least 5 % of hepatocytes. MASLD is estimated to affect 25-30 % of the adult population and is a significant contributor to the development of cardiometabolic diseases.

Weight loss is the predominant treatment option for reducing IHTG, but weight loss can be difficult to obtain and even more difficult to maintain in the long-term. Therefore, there is a need for exploring strategies for reducing IHTG that are independent of weight loss. Instead of focusing on isolated nutrients when exploring dietary strategies for reducing IHTG during body weight stability, it may be more appropriate to consider the whole food matrix. For instance, the whole dairy matrix is rather complex, and seems to exert favourable effects on health, that are not apparent when collectively considering the isolated nutrients present in the dairy matrix. Potential beneficial effects on health resulting from the consumption of fermented dairy products, particularly yogurt, have received increasing attention recently, and evidence from observational studies has linked consumption of yogurt with reduced risk of developing cardiometabolic diseases. Nonetheless, with particular reference to IHTG balance during body weight stability, evidence of the effect of yogurt consumption is scarce.

Accordingly, the overarching aim of this project was to explore the role of IHTG as a marker of metabolic function and evaluate the effect of dairy foods, in particular yogurt, in modifying IHTG in males with abdominal obesity during body weight stability.

9. Sub-activities in the entire project period

The updated gantt chart below describes all study-related activities that took place during the whole study period:



10. Deviations

A 1-year extension was necessary to account for 1) Delays in recruitment for the randomized controlled trials and study conduct during 2020 and 2021 because of COVID19, and 2) Maternity leave from 03/2023 until 12/2023 of the PhD student who was responsible for the management of the project and analysis and writing up the results from the human intervention study.

11. Project results

The study was a 4-arm parallel randomized controlled trial, which started with a 4-week lead-in standardization period, during which participants were instructed to substitute all habitual dairy consumption with 400 g/day of regular full-fat milk, and was followed by a 16-week active intervention period, during which participants were instructed to consume 400 g/day of one of the allocated intervention product (group allocation ratio 1:1:1:1): regular milk, regular yoghurt, acidified milk, or heat-treated yoghurt.

One hundred men with metabolic syndrome were enrolled in the study (Figure 1). During the standardization lead-in period, 10 subjects dropped out of the study; hence, 90 subjects initiated the 4-arm intervention period. During the intervention period, another 10 subjects dropped out mostly because of personal reasons (2 subjects dropped out during the first month of the intervention period because they did not like the allocated dairy product). From the 80 completers of the intervention study, 19 were excluded from the cross-sectional analysis of groups with high and low liver fat due to missing data.

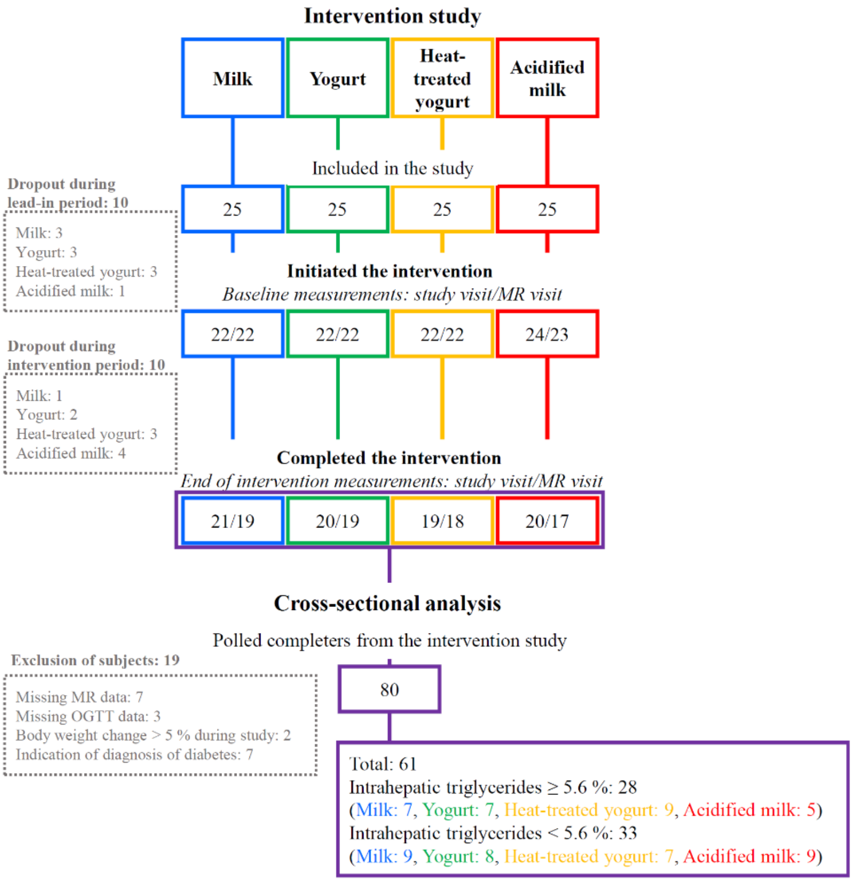


Figure 1: Flow chart of subjects through the study
MR = magnetic resonance

Mild to moderate adverse events were reported during the study period, summing up to 47 adverse events of which 16 were related to gastrointestinal symptoms, 23 were related to infection (including COVID-19 and symptoms related to the COVID-19 vaccine), 7 were related to various body aches, and 1 was categorised as other. No differences were detected between the groups (all P > 0.05).

Subjects were successful in keeping a stable body weight during the intervention period, as changes in body weight for all completing subjects were (mean (95 % CI)) -0.3 (-0.8; 0.2) kg from baseline (milk: 0.0 (-0.9; 0.0) kg, yogurt: -0.8 (-1.7; 0.2) kg, heat-treated yogurt: -0.1 (-1.1; 0.9) kg, acidified milk: -0.3 (-1.2; 0.7) kg), with no differences between groups (all P > 0.05).

Compliance with study products was 96 % (97 % for completers and 83 % for dropouts) and no differences between groups were detected (all P > 0.05). Within the per protocol data, a total of 14 subjects were excluded (7 due to study product compliance < 90 %; 2 due to body weight change 5 % during the intervention; 5 due to indications of diagnosis of diabetes at baseline).

The 90 subjects who initiated the intervention had an age of (median (Q1; Q3)) 58.0 (50.0; 63.8) years, BMI of (mean (SD)) 32.4 (3.4) kg/m2, and waist circumference of (mean (SD)) 115 (8.6) cm. The baseline characteristics of the four intervention groups are presented in Table 1.

Table 1: Baseline characteristics for subjects initiating the intervention

	Milk (n = 22)	**Yogurt** (n = 22)	**Heat-treated yogurt** (n = 22)	**Acidified milk** (n = 24)
Age (years)	55 (51;60)	58 (50;66)	60 (51;64)	60 (53;65)
Height (meter)	1.83 ± 0.08	1.80 ± 0.09	1.79 ± 0.07	1.82 ± 0.08
Body weight (kg)	108 ± 13.5	105 ± 14.2	103 ± 13.8	109 ± 14.3
Body mass index (kg/m^2)	32.3 ± 3.4	32.3 ± 3.4	32.3 ± 4.1	32.7 ± 3.1
Waist circumference (cm)	116 ± 8.8	115 ± 8.4	114 ± 8.7	117 ± 8.5
SAD (cm)	26.6 ± 2.9	27.1 ± 3.6	25.7 ± 1.9	26.9 ± 2.6
Body fat (%)	36.2 ± 4.4	35.3 ± 3.9	37.7 ± 4.9	37.5 ± 5.3
VAT (cm^3)	245 ± 89.8	271 ± 116	270 ± 94.5	269 ± 104
SAT (cm^3)	309 ± 81.7	301 ± 104	280 ± 95.9	300 ± 117
Liver fat (%)	6.8 (4.0;12.4)	5.9 (2.8;18.4)	6.0 (4.3;10.2)	6.5 (2.7;14.7)
Pancreas fat (%)	6.5 (4.0;12.0)	6.6 (4.1;12.2)	8.1 (4.7:12.5)	7.0 (4.4;13.5)

Data are presented as mean ± standard deviation for variables that are normally distributed and as median (quartile 1; quartile 3) for variables that are non-normally distributed; Missing data from magnetic resonance from 1 subject in the group consuming acidified milk. SAD, sagittal abdominal diameter; VAT, visceral adipose tissue; SAT, subcutaneous adipose tissue.

The habitual dairy intake prior to initiating the standardization lead-in period was (median (Q1; Q3)) 372 (228; 570) g/day and no differences were detected between groups both in total habitual dairy intake and subcategories of dairy foods (all P > 0.05).

Dietary intake during the study, i.e. total energy (kcal/day), protein E %, fat E % and carbohydrate E % for all groups combined is presented in Figure 2. No differences were detected in total energy, fat and protein intakes between groups (all P > 0.05).

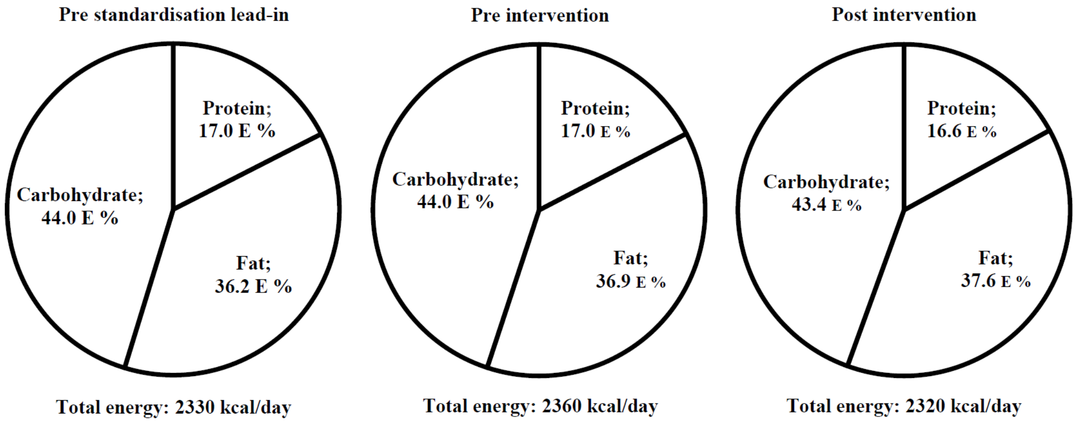


Figure 2. Dietary intake during the study
Data presented for subjects with valid dietary registrations pre standardization lead-in (n= 52) pre intervention (n= 55) and post intervention (n = 53).

No effects of the intervention or differences between groups were detected in the primary outcome, IHTG content (Figure 3). Further, no effects of the intervention or differences between groups were detected in body anthropometry, body composition, and fat distribution (i.e. body weight, BMI, waist and hip circumferences, total body fat percentage, visceral abdominal fat, subcutaneous abdominal fat, and pancreas fat, glucose metabolism, lipid profile, and blood pressure).

There were, however, main effects of time for fasting insulin (decrease), insulin resistance index HOMA-IR (decrease), total cholesterol (decrease), LDL cholesterol (decrease), HDL cholesterol (decrease), systolic blood pressure (decrease) and diastolic blood pressure (decrease). These data suggest modest improvements in cardiometabolic risk factor profiles in all groups but no product-specific effect.

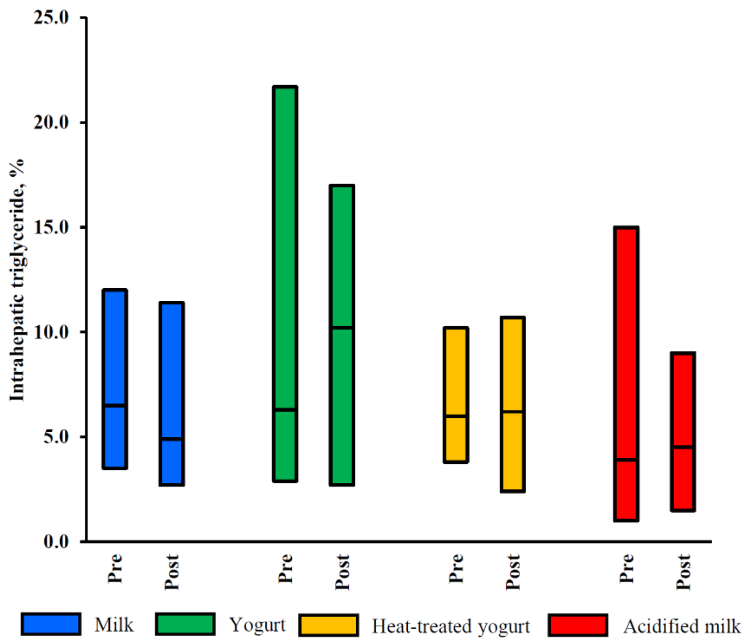


Figure 3. Effect of the intervention on intrahepatic triglyceride (IHTG) content
Complete case analyses presented as median (quartile 1; quartile 3). Data were analysed using linear mixed models with a fixed group × time interaction and adjustment for subject id as random effect and site of magnetic resonance scan as a fixed effect. Missing data from 2, 1, 1 and 3 in the group consuming milk, yogurt, heat-treated yogurt and acidified milk, respectively.

From the 80 completers of the intervention study, 19 subjects were excluded from the cross- sectional analysis (Figure 1). No differences were detected in the distribution of subjects from the original dairy intervention groups in the "low liver fat" (LLF) and "high liver fat" (HLF) groups (P = 0.727). Subjects in the HLF group had 5-fold higher IHTG content compared to the subjects in the LLF group. While there was a slight difference in age (HLF subjects were younger), the two groups were similar in anthropometry, body composition, fat distribution and ectopic fat deposition other than liver fat (Table 2). Higher concentrations of glucose, insulin, C-peptide, HOMA-IR and triglyceride, and lower concentrations of HDL cholesterol were observed in subjects in the HLF group compared with subjects in the LLF group; there were no differences in HbA1C, total cholesterol, LDL cholesterol and blood pressure (Table 2).

Table 2: Age, anthropometry, body composition, fat distribution and ectopic fat deposition, glucose metabolism, lipid profile and blood pressure in subjects with low and high liver fat content

	LLF (n = 33)	HLF (n = 28)	P-value
Age, anthropometry, body composition, fat distribution and ectopic fat deposition			
Age (years)	62 (56; 66)	55 (47; 61)	0.026
Body mass index (kg/m^2)	31.5 ± 2.7	32.1 ± 2.9	0.372
Body fat (%)	36.5 ± 5.1	35.7 ± 4.0	0.538
Waist circumference (cm)	114 ± 7.5	115 ± 8.9	0.493
Hip circumference (cm)	110 ± 5.3	111 ± 6.3	0.260
Visceral adipose tissue (cm^3)	246 ± 87.8	274 ± 94.9	0.244
Subcutaneous adipose tissue (cm^3)	293 ± 96.8	283 ± 90.3	0.738
Intrahepatic triglyceride (%)	2.0 (1.5; 3.5)	13.1 (8.2; 19.7)	<0.001
Pancreas fat (%)	7.8 (4.9; 12.2)	7.6 (3.9; 11.4)	0.399
Glucose metabolism			
Glucose (mmol/L)	5.6 (5.4; 6.0)	6.0 (5.7; 6.3)	0.041
Insulin (pmol/L)	46.4 (18.2; 85.9)	83.0 (45.8; 134)	0.005
C-peptide (pmol/L)	692 (569; 861)	892 (727; 1172)	0.002
HbA1C (mmol/mol)	40.2 ± 2.6	39.4 ± 4.3	0.375
HOMA-IR	1.9 (0.8; 3.9)	3.6 (2.1: 6.3)	0.004
Lipid profile			
Cholesterol (mmol/L)	4.7 ± 0.9	4.6 ± 1.0	0.448
LDL-C (mmol/L)	3.0 ± 0.8	3.1 ± 0.7	0.910
HDL-C (mmol/L)	1.2 ± 0.3	1.1 ± 0.3	0.013
Triglyceride (mmol/L)	1.2 ± 0.4	1.5 ± 0.7	0.022
Blood pressure			
Systolic (mmHg)	123 ± 12.3	125 ± 11.0	0.548
Diastolic (mmHg)	82.6 ± 7.1	84.5 ± 7.5	0.338

Data are presented as mean ± standard deviation for normally distributed variables and as median (quartile 1; quartile 3) for non-normally distributed variables. Data were analysed using simple linear regression models with adjustment for original intervention group. LLF, low liver fat; HLF, high liver fat; HbA1C, glycated haemoglobin; HOMA-IR, homeostatic model assessment for insulin resistance; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol.

Participants with HLF had greater pancreatic insulin secretion in the fasting and postprandial states, lower whole-body insulin sensitivity and greater hepatic insulin resistance, lower whole-body insulin clearance, and lower oral disposition index than those with LLF (Figure 4).

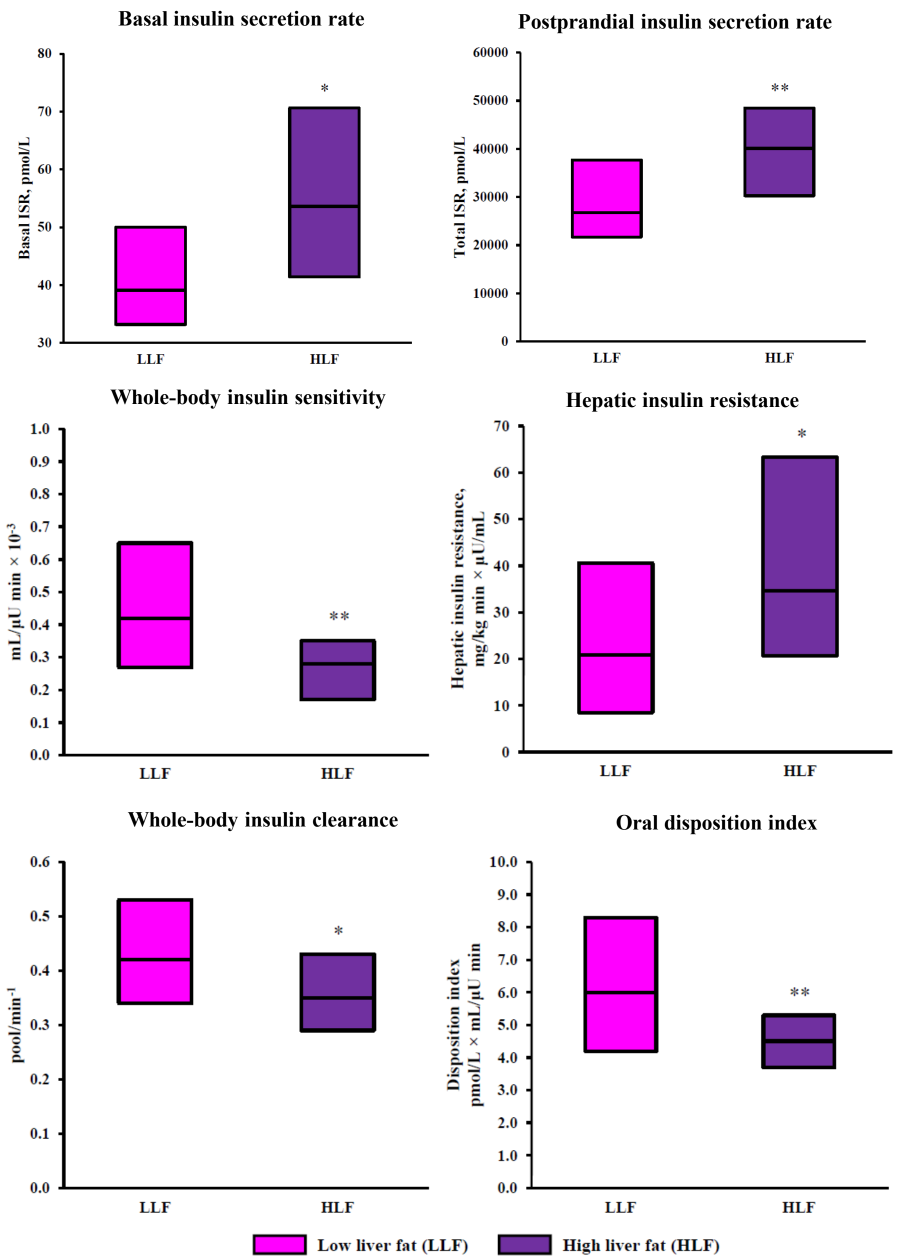


Figure 4: Metabolic function in men with low liver fat (LLF) and high liver fat (HLF)

NMR-based metabolomics was conducted on plasma, urine, and fecal samples collected at baseline and after the intervention. Both consumption of acidified milk and heat-treated yogurt resulted in changes in the fecal metabolome including decreases in the level of amino acids (leucine, valine, and threonine) and branched-chain fatty acids (isobutyrate) that indicated an altered protein putrefaction and proteolytic metabolism in the gut. In the plasma metabolome, an increase in citrate was found for yogurt consumption. No difference in the urine metabolome was found. Consequently, metabolomics analyses indicated that consumption of heat-treated yogurt and acidified milk exerted similar effects on the metabolic activity in the gut as yogurt consumption.

Microbiome analyses were also conducted in fecal samples collected at baseline. We were able to identify three different gut microbiome community structures, and thus participants were categorized in one subgroups dominated by the genus *Prevotella* (P), a second subgroup dominated by *Bacteroides* and *Phocaeicola* (BP), and a third subgroup dominated by GGB9786 (G) (**Figure 5**). At baseline, the P group, BP group and G group had 22, 27 and 42 participants, respectively.

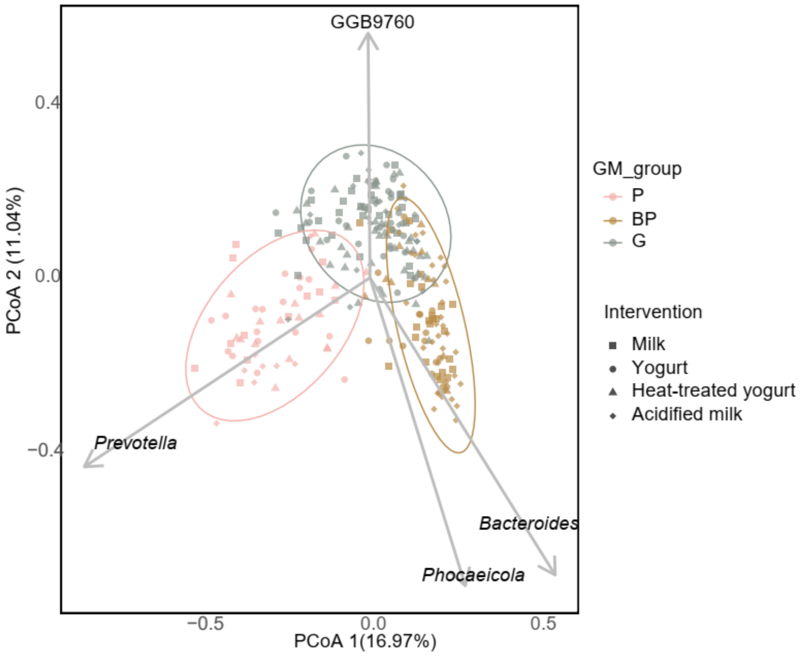


Figure 5. Principal Component Analysis of all samples at microbial genus level

The improvement rates of each group under each intervention were assessed by measuring changes of insulin, glucose, HDL, liver fat and triglyceride concentrations after intervention (**Table 3**). We found that participants in the BP group exhibited an 100 % improvement rate in fasting insulin concentration under the milk intervention, which was significantly higher than that of the G group. In addition, participants in the G group showed an 87.5% improvement rate in liver fat content under the yogurt intervention, which was significantly higher than the other two groups. These results suggested the necessity of designing dietary interventions based on participants' gut microbiome composition and microbial community types.

Table 3. Insulin and liver fat improvement rates in subjects with different gut microbiome community type

Intervention	Variable	Valid records	Number improved (%)	*P*-values		
				G vs BP	BP vs P	G vs P
Milk	Insulin	G (9)	4(44.44)	**0.034**	0.1	1
		BP (7)	**7 (100)**			
		P (4)	2(50.00)			
Yogurt	Liver fat	G (8)	**7 (87.50)**	**0.01**	1	**0.032**
		BP (4)	0			
		P (5)	1(20.00)			

Conclusion: This study highlights the importance of IHTG content as a marker of metabolic function, even independently of other important markers of adiposity and particularly viscera fat. Furthermore, the null results of the interventions on IHTG during weight stability reinforce the importance of calorie restriction leading to weight loss for depleting IHTG. The purported superiority of yogurt compared to milk in reducing IHTG content and improving cardiometabolic risk during body weight stability was not confirmed by our clinical intervention study. In fact, it appeared that all dairy intervention products mildly improved some cardiometabolic risk markers without affecting IHTG content, which further indicates that beneficial changes in metabolic function can manifest, at least partly, independently of a reduction in IHTG content. Nevertheless, our findings raise the possibility that different dairy products differentially affect health outcomes, including liver fat, in people with different gut microbiome compositions. This possibility should be explored further.

12. The relevance of the results, including relevance for the dairy industry

Our study found that supplementation with all 4 dairy products resulted in **mild but similar improvements** in the cardiometabolic risk factor profile in men with the metabolic syndrome. We did not observe any independent effects of the dairy matrix, or of the fermentation byproducts (lactic acid bacteria and lower pH) on the health-related outcomes measured. It thus seems that incorporating **any dairy product** in the daily diet can provide some health benefits, even in the face of body weight stability and without changing body composition or fat accumulation in key metabolic organs such as the liver. Understanding the commonalities of different dairy products, rather than focusing on their differences, may therefore be key for understanding the mechanisms behind the improved health outcomes.

13. Communication and knowledge sharing about the project

Papers in international journals:

Nielsen SD, Jakobsen LMA, Geiker NRW, Bertram HC. Chemically acidified, live and heat-inactivated fermented dairy yoghurt show distinct bioactive peptides, free amino acids and small compounds profiles. Food Chem 2021; 376: 131919. https://doi.org/10.1016/j.foodchem.2021.131919

Sandby K, Geiker NRW, Dalamaga M, Gronbaek H, Magkos F. Efficacy of dietary manipulations for depleting intrahepatic triglyceride content: implications for the management of non-alcoholic fatty liver disease. Curr Obes Rep 2021; 10: 125-33. https://doi.org/10.1007/s13679-021-00430-4

Sandby K, Magkos F, Chabanova E, Petersen ET, Krarup T, Bertram HC, Kristiansen K, Geiker NRW. The effect of dairy products on liver fat and metabolic risk markers in males with abdominal obesity - a four-arm randomized controlled trial. Clin Nutr 2024; 43: 534-42. https://doi.org/10.1016/j.clnu.2023.12.018

Correia BSB, Sandby K, Krarup T, Magkos F, Geiker NRW, Bertram HC. Changes in Plasma, Urine, and Fecal Metabolome after 16 Weeks of Consuming Dairy With Different Food Matrixes - A Randomized Controlled Trial. Mol Nutr Food Res 2024; 68 (5): e2300363. https://doi.org/10.1002/mnfr.202300363

Sandby K, Krarup T, Chabanova E, Geiker NRW, Magkos F. Accumulation of fat in the liver is associated with increased insulin secretion independent of total body fat, visceral adipose tissue, and pancreatic fat. J Clin Endocrinol Metab (in press). https://doi.org/10.1210/clinem/dgae572

Easily read papers:

Bertram, H.C., Nielsen, S.D., Jakobsen, L.M.A., Geiker, N.R.W. 2023. Hvad indeholder yoghurten af væsentlige lavmolekylære forbindelser, Dansk Kemi, 104, 4, 36-39.

Sandby, K. Geiker, N.R.W. 2022. Fermenterede mejeriprodukter og sundhed. Mælkeritidende, nr 11.

Student theses:

Karoline Sandby. Liver fat, metabolic dysfunction and effects of dairy foods in individuals with abdominal obesity. PhD Thesis, University of Copenhagen, 2024.

Oral presentations at scientific conferences, symposiums etc.:

N/A.

Oral presentations at meetings:

Bertram, H.C., Geiker, N.W., Sandby, K. 2023. Potential health benefits of fermented dairy. Oral presentation at Dairy Research Day, March 23, Herning, Denmark.

Magkos, F. 2023. The FerMetS study. Arla Food for Health Conference 2023, October 9, Aarhus, Denmark

Magkos, F. 2024. The FerMetS study. DDRF Health & Nutrition coordination group meeting, May 14, Frederiksberg, Denmark.

Poster presentations:

Nielsen, S.D.-H., Jakobsen L.M.A., Geiker, N.R.W., Bertram, H.C. 2022. Chemically acidified, live and heat-inactivated fermented dairy yoghurt show distinct peptide, free amino acids and small compounds profiles. Arla Food for Health Conference, September 29, 2022, Aarhus, Denmark.

Correia, B.S.B., Sandby, K., Krarup, T., Magkos, F., Geiker, N.R.W., Bertram, H.C. 2023. What is the ideal control arm in a dairy intervention from a metabolomics perspective? Annual IMGC Symposium, University College Cork, Ireland, September 6-8, 2023.

Other:

N/A.

14. Contribution to master and PhD education

The educational output of this project included the completion of 1 PhD studentship (graduated in September 2024).

15. New contacts/projects

N/A.