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Helbredseffekt af højt indtag af ost – betydning af fermenterings-metode og fedtindhold

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1. Projektets titel

Helbredseffekt af højt indtag af ost – betydning af fermenteringsmetode og fedtindhold

Health effects of a high cheese intake - Does maturation and fat content matter?

2. Projektleder

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4. Finansieringskilder

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5. Projektperiode

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6. Projektresume

Projektet er baseret på 4 studier, 2 i grise (delprojekt A og B) og 2 i mennesker (delprojekt C og D), som overordnet søger at belyse om fedtindhold og fermentering af ost har betydning for sundhedsværdien heraf. Altså om nogle oste er sundere end andre oste.

Studierne i delprojekt A og B havde begge et parallelt design og inkluderede hver 36 krydsavlede søer i vækst. Formålet med delprojekt A var at undersøge om mager ost kan neutralisere effekten på LDL-C af samtidigt indtaget mættet fedt. Indvirkningen af diæter med ost med almindeligt fedtindhold, ost med reduceret fedtindhold + smør og smør alene, på blodlipidprofilen og fækal fedt- og energiudskillelse samt tarmmikrobiota blev undersøgt. Diæten med ost med almindeligt fedtindhold medførte en højere koncentrationer af HDL-C og total kolesterol (TC), men ikke LDL-C, i grisene i sammenlignet med diæten med smør. Der var kun en tendens til højere HDL-C og TC koncentrationer efter diæten med ost med reduceret

fedtindhold + smør sammenlignet med diæten med smør. Begge diæter med ost medførte en højere fækal fedtudskillelse sammenlignet med diæten med smør, men effekten synes stærkest for diæten med ost med almindeligt fedtindhold. Resultaterne tyder på en specifik effekt af almindelig fed ost, og at denne er forbundet med matrix af osten. Formålet med delprojekt B var, at undersøge om ost med forskellige modningstider for cheddar ost har indvirkning på koncentrationen af blodlipider, glukose og insulin samt den fækale fedtudskillelse. Modningstiden havde ingen indflydelse på fækal fedtudskillelse eller på blodlipidkoncentrationerne, med undtagelse af en lavere koncentration af ikke-esterificerede fedtsyrer (NEFAs) i grisene efter indtagelse af 14- og 24-måneder modnet oste sammenlignet med 4-måneder modnet ost. Insulin og HOMA-IR var desuden lavere efter indtag af 24-måneder modnet ost, men ikke efter 14-måneder modnet ost, sammenlignet med 4-måneder modnet ost. Resultaterne indikerer en forbedret insulinfølsomhed efter indtagelse af langtidsmodnet ost og det er muligt, at det højere indhold af bioaktive peptider og frie aminosyrer er afgørende for disse effekter. Delprojekt C var et var et randomiseret overkrydsningsstudie i 14 overvægtige postmenopausale kvinder. Formålet med studiet var, at undersøge hvordan en diæt med ost sammenlignet med en diæt med kød som kilder til mættet fedt eller isokalorisk erstatning med kulhydrater ville påvirke blodlipider, lipoproteiner, apolipoproteiner samt den fækale udskillelse af fedt og galdesyrer. Diæterne med ost og kød som kilder til mættet fedt forårsagede samme blodlipid respons, men højere koncentrationer af HDL-C og apoA-I sammenlignet med diæten med kulhydrat. Herudover sænkede diæten med ost apoB: apoA-I ratioen sammenlignet med diæten med kulhydrat. Der var ingen forskelle i koncentrationerne af TC, LDL-C, apoB eller TG imellem de tre diæter. Fækal fedtudskillelse var højest på diæten med ost, mellemliggende på diæten med kød og lavest på diæten med kulhydrat. Desuden var der højere fækal udskillelse af galdesyrer på diæterne med kød og ost sammenlignet med diæten med kulhydrat, hvilket muligvis kan forklare forskellene i blodlipidresponset. Samlet set lod det til at diæterne med ost og kød som primære kilder til mættet fedt var mindre atherogene end en diæt med højt kulhydratindhold og lavt fedtindhold. Delprojekt D var et parallelt studie med 164 forsøgsdeltagere. Formålet med studiet var at sammenligne effekten af henholdsvis fuldfed ost, fedtreduceret ost samt en isokalorisk mængde kulhydratrige fødevarer på LDL-C koncentrationer, LDL partikel størrelse fordeling og risikofaktorer for det metaboliske syndrom. Studiet viste, at et dagligt indtag af 64-112 g fuldfed ost i 12 uger ikke øgede koncentrationen af LDL-C sammenlignet med samme mængde af fedtreduceret ost. Det samme gjorde sig gældende for andre metaboliske parametre som eksempelvis kropsvægt, insulinresistens og blodtryk. Fuldfed ost havde dog en tendens til at øge HDL-C koncentrationer sammenlignet med kulhydratrige fødevarer. I en subgruppe af 85 forsøgsdeltagere fandt vi desuden, at fuldfed ost ikke ændrede LDL partikelstørrelsesfordelingen sammenlignet med fedt-reduceret ost. Vores resultater tydede dog på, at lipoprotein responset er kønsspecifikt. Subanalyser i mænd viste nemlig, at fuldfed ost reducerede antallet af LDL partikler sammenlignet med fedtreduceret ost, mens antallet af LDL partikler havde en tendens til at være højere i kvinder der havde spist fuldfed ost sammenlignet med fedtreduceret ost.

Samlet set kan det konkluderes at der ikke opnås samme effekt af mættet fedt der spises som del af ostematricen som mættede fedt der spises udenfor matricen men sammen med mager ost på blodlipider og fækal fedtudskillelse. Resultaterne fra humanstudierne terne støtter ikke kostanbefalingen om, at en kost med fedtreduceret ost eller en kost med lavere indhold af ost men med flere kulhydrater skulle være mere hjertesund end en kost med fuldfed ost. Desuden tyder resultaterne på at det for de fleste individer med risikomarkører for det metaboliske syndrom, er

rimeligt at inkludere fuldfed ost som en del af en sund kost. Endvidere lader langtidsmodnet ost til at kunne forbedre insulinfølsomheden, men resultaterne skal eftervises et randomiseret kontrolleret studie i mennesker.

The project is based on 4 studies, 2 in pigs (subproject A and B) and 2 in humans (subproject C and D), for which the overall aim is to investigate whether or not the fat content and ripening time of cheese matters with respect to its metabolic health impact, that is, if some cheeses are more healthy than others.

The studies in subproject A and B were both designed as parallel-arm randomized, controlled intervention studies, and each included 36 crossbred female growing pigs. The objective of subproject A was to investigate how a diet with regular-fat cheese, reduced-fat cheese + butter, or butter alone affects fasting blood lipids, fecal fat and energy excretion, and gut microbiome. Regular-fat cheese caused higher concentrations of HDL-C and total cholesterol (TC) but not LDL-C in pigs consuming the diet with compared to those consuming the diet with butter. HDL-C and TC concentrations only tended to be higher in pigs consuming the diet with reduced-fat cheese + butter. Both cheese diets caused a higher fecal fat excretion compared to the diet with butter, however, the effect seemed to be highest for the diet with regular-fat cheese. These results suggest that regular-fat cheese has a distinct effect, which may be linked to the cheese-matrix. In subproject B the objective was to investigate how cheeses with different ripening durations affect fasting blood lipid concentrations, glucose, insulin, and fecal fat excretion. No differences were found between pigs consuming short- or long-term ripened cheese regarding fecal fat excretion or bloodlipid concentrations, except for a lower non-esterified fatty acids (NEFAs) concentration in pigs consuming the 14- and 24-month ripened cheese compared to the 4-month ripened cheese. Also, the insulin and HOMA-IR were lower in pigs consuming the 24-month ripened cheese but not the 14-month ripened cheese compared to the 4-month ripened cheese. These results indicate improved insulin sensitivity with long-term ripened cheese and this may be due to the higher content of bioactive peptides and free amino acids. Subproject C was a randomized, cross-over intervention study in 14 overweight, postmenopausal women. The objective was to investigate how diets with cheese and meat as sources of SFAs or iso-caloric replacement with carbohydrates affect blood lipids, apolipoproteins, and the fecal excretion of fat and bile acids. Diets with cheese and meat as sources of SFAs caused similar blood lipid responses and higher HDL-C and apoA-I concentrations compared to the low-fat carbohydrate diet. The cheese diet also caused a lower apoB: apoA-I ratio compared to the carbohydrate diet. No differences were found in the TC, LDL-C, apoB, or TG concentrations between the three diets. The fecal fat excretion was highest on the cheese diet, intermediate on the meat diet, and lowest on the carbohydrate diet. The fecal bile acid excretion did not differ with the cheese and meat diets but were higher on these diets compared to the carbohydrate diet. This may potentially explain the differences in the blood lipid response. Hence, the diets with cheese and meat as primary sources of SFAs appear to be less atherogenic than a low-fat carbohydrate diet. Subproject D was designed as a randomized parallel study including 164 subjects. The overall aim was to compare the effects of regular-fat cheese versus an equal amount of reduced-fat cheese and an isocaloric amount of carbohydrate-rich foods on LDL-C concentrations, LDL particle size distribution and risk factors for the metabolic syndrome (MetS). We found that daily consumption of 64–112 g of regular-fat cheese for 12 weeks did not modify LDL-C concentrations or MetS risk factors differently than equal amounts of reduced-fat cheese. The same was true when regular-cheese was compared with carbohydrate-rich foods, although regular-fat cheese tended to increase HDL-C concentrations compared with carbohydrate-rich foods. In a subgroup of 85 subjects, we found that regular-fat cheese did not modify LDL

particle size distribution compared to reduced-fat cheese after a 12-week intervention. However, our results suggested that lipoprotein response is gender-specific. In men, regular-fat cheese intake reduced total LDL particle number compared with reduced-fat cheese, whereas regular-fat cheese consumption tended to increase total LDL particle number compared with reduced-fat cheese in women.

*In conclusion, there does not seem to be a similar effect of saturated fat consumed as part of the cheese matrix and saturated fat consumed outside the matrix together with reduced-fat cheese. The results from the studies in humans do not s*upport the dietary recomm*endation that a diet with reduced-fat cheese is less atherogenic than a diet with regular-fat cheese or a diet with no cheese but a higher carbohydrate content. Furthermore, our results suggest that for most individuals with risk factors of the metabolic syndrome, it is reasonable to include regular-fat cheese as part of a healthy diet. Finally, long term ripened cheese seems to improve insulin sensitivity, but the results should be confirmed in a randomized controlled trial in humans.*

7. Projektets formål

Projektets formål er at undersøge, hvorvidt indtag af forskellige typer ost, mhp. fermenteringslængde og fedtindhold påvirker blodlipidprofil, blodtryk og fedtfordøjeligheden forskelligt. Desuden undersøges om et højt dagligt indtag af ost påvirker risikomarkører for sygdom i en klinisk relevant grad i en rask og sårbar studiepopulation.

The aim of the project is to investigate if consumption of different types of cheese, differing in maturation length and fat content, affect the blood lipid profile and blood pressure differently and if the fat absorption is efficiency affected, and to investigate if the consumption of high daily amounts of cheese affect risk markers of disease to a clinically relevant extent in healthy subjects and in a vulnerable study population.

8. Projektets baggrund

Hjertekarsygdomme er den største årsag til dødelighed på verdensplan. Metaboliske forstyrrelser, så som forhøjede koncentrationer af LDL kolesterol (LDL-C), triglycerid (TG) og reduceret koncentration af HDL kolesterol (HDL-C) samt insulin resistens øger risikoen for hjertekarsygdom. I mange lande er fokus i de officielle kostanbefalinger for forebyggelse af hjertekarsygdom på, at reducere indtaget af mættet fedt, specielt fra primærkilderne mejeriprodukter og kød. Et observations studie har konkluderet at mættet fedt fra kød øger risikoen for udvikling af hjertekarsygdom, mens mættet fedt fra mejeriprodukter sænker risikoen herfor. Fødevarer indenfor gruppen af mejeriprodukter har sandsynligvis ikke samme indvirkning på risikoen for at udvikle hjertekarsygdom. Det lader især til, at indtag af ost ikke er forbundet med risikoen for hjertekarsygdom. Dette er muligvis på grund af lavere optagelse af fedt fra ost, forårsaget af det høje calcium og fosfatindhold i ost. Dette kan muligvis også forklare den mindre øgning der ses i LDL-C koncentrationen efter indtag af ost, trods det høje indhold af mættet fedt. Ost er som en gruppe af mejeriprodukter meget forskelligartet m.h.t. indhold af fedt, protein og calcium. Desuden varierer metoden, der anvendes til modning, samt modningstiden betydeligt imellem forskellige typer af ost. Dette indvirker muligvis på, hvorledes indtag af ost påvirker den kardiometaboliske sundhed.

Derfor ønskes det med dette projekt at undersøge om A) fedtindholdet i ost og B) fermenteringstiden af ost har betydning for de observerede effekter af ost på

blodlipidprofil og fedtfordøjelighed. Hovedparten af kontrollerede humane interventionsstudier har anvendt smør som kontrol. Imidlertid er det usandsynligt, at personer der undgår ost for at forbedre kosten, som kompensation ville øge indtaget af smør. Mere sandsynligt vil osten blive erstattet af andre fødevarer. Derfor ønskes det med dette projekt også at C) undersøge betydningen af ost i kosten i forhold til en kost uden ost, hvor ost erstattes med en isokalorisk mængde af andre fødevarer. Det er desuden muligt at fed ost erstattes med mager ost for at mindske indtaget af mættet fedt, derfor ønskes det også at undersøge D) effekten af et højt indtag af henholdsvis en mager og en fed type ost, i et studie af længere varighed.

9. Projektets delaktiviteter i hele projektperioden

Delprojekt A

Griseforsøg Ib: Et parallelt forsøg med 3 interventions-arme i grise, som undersøger effekten af ostens matrix-fedtindhold (30+ og 45+) sammenlignet med smør, i makronæringsstof-balancerede diæter, på kropsvægt, blodlipid profil, fedtfordøjelighed og tarmmikrobiota.

Status: Gennemført og publiceret

Delprojekt B

Griseforsøg Ia: Et parallelt forsøg med 3 interventions-arme i grise, som undersøger effekten af ostens fermenteringstid (4 mdr. 14 mdr. og 24 mdr.) på kropsvægt, blodlipidprofil, insulin og glukose samt fedtfordøjelighed.

Status: Gennemført og publiceret

Delprojekt C

Humanforsøg II: Et 3 x 2-ugers overkrydsningsforsøg med raske postmenopausale kvinder i alderen 45-68 år, som undersøger effekten af ost (fuldfed Danbo og Cheddar) i kosten sammenlignet med fedtrigt kød eller kulhydrat på blodlipid profil, blodtryk, fedtfordøjelighed og andre risikomarkører.

Status: Gennemført og publiceret

Delprojekt D

Humanforsøg III: Et 12-ugers parallelt forsøg med mennesker med det metaboliske syndrom, hvor effekten af ostens fedtindhold på rikomarkører for diabetes og hjertekarsygdom undersøges. I en subgruppe af ca. 40 forsøgspersoner vil forskelle i glukose, insulin og appetitfølelse efter endt intervention ligeledes undersøges i et måltidsstudie.

Status: Gennemført og hovedartiklen er publiceret (øvrige to manuskripter er under udarbejdelse).

10. Projektets resultater

Delprojekt A

Betydning af fedtindhold I oste-matricen for indvirkningen på blodlipidprofil, fækal fedtudskillelse og tarmmikrobiota hos grise i vækst.

Sammendrag: Kost med ost med almindeligt fedtindhold, reduceret fedtindhold+ smør, eller smør (**Table 1**) påvirkede ikke LDL-koncentrationen forskelligt i grise. Indtag af kosten med ost med almindeligt fedtindhold resulterede i højere TC og HDL-kolesterol koncentrationer sammenlignet med kosten med smør, hvorimod indtaget af kosten med ost med reduceret fedtindhold+ smør kun tenderede til et højere total kolesterol og HDL-kolesterol i sammenlignet med kosten med smør **(Table 2)**.

Begge kosttyper med ost øgede den fækale udskillelse af fedt sammenlignet med kosten med smør (**Figure 1**). Der var en stærk korrelation imellem indtage calcium og den fækale fedtudskillelse (**Figure 2B**). Overordnet medførte kosten med ost med almindeligt fedtindhold flere ændringer i sammensætningen af tarmmikrobiomet end kosten med ost med reduceret fedtindhold+ smør (**Figure 3**). Forskellene imellem kosten med ost med reduceret fedtindhold+ smør og kosten med smør var generelt mindre end ændringerne imellem kosten med ost med almindeligt fedtindhold og kosten med smør, hvilket tyder på en indvirkning af ostematricen.

Resultater:

Table 1. Food, micronutrient and macronutrient composition of the three experimental diets

	Run-in/ BUT diet	RED diet	REG diet
Energy (kJ 100g^{-1} diet)[a]	1,495.3 (1,529.3)	1,475.9 (1,520.1)	1,481.2 (1,550.6)
Total calcium (g 100 g^{-1} diet)[a]	0.6 (0.6)	0.9 (0.9)	0.8 (0.9)
Cheese (g 100 g^{-1} diet)	-	35.3	35.3
Butter (g 100 g^{-1} diet)	10.6	5.2	-
Potato protein (g 100 g^{-1} diet)	12.1	-	2.1
Wheat (g 100 g^{-1} diet)	25.3	24.4	25.6
Water (g 100 g^{-1} diet)	16.9	-	1.8
Barley (g 100 g^{-1} diet)	31.7	31.7	31.7
Calcium carbonate (g 100 g^{-1} diet)	1.1	1.1	1.1
Mono calcium phosphate (g 100 g^{-1} diet)	0.8	0.8	0.8
Feed salt (g 100 g^{-1} diet)	0.3	0.3	0.3
Micromineral/ vitamin mix (g 100 g^{-1} diet)	0.2	0.2	0.2
Celite marker (g 100 g^{-1} diet)	1.0	1.0	1.0
Fat (energy %)	27.6	28.0	27.8
Protein (energy %)	18.6	18.9	18.8
Carbohydrate (energy %)	53.8	53.2	53.3

[a] Mean of duplicate analyses are shown in brackets.
Abbreviations: BUT, butter; RED, reduced-fat cheese + butter; REG, regular-fat cheese.

Table 2. Lipid concentrations and ratios in the pigs before and after consuming the BUT, RED or REG diet for 14 days

	BUT diet	RED diet	REG diet	P_{diet}
TC (mmol L^{-1})				
Pre-intervention	2.98 ± 0.10	2.97 ± 0.10	2.87 ± 0.12	0.035
Post-intervention	3.54 ± 0.13[a]	3.61 ± 0.16[ab]	3.77 ± 0.13[b]	
HDL-C (mmol L^{-1})				
Pre-intervention	1.27 ± 0.05	1.29 ± 0.06	1.28 ± 0.05	0.027
Post-intervention	1.43 ± 0.04[a]	1.45 ± 0.06[ab]	1.61 ± 0.06[b]	
LDL-C (mmol L^{-1})				
Pre-intervention	1.47 ± 0.07	1.37 ± 0.13	1.35 ± 0.08	NS
Post-intervention	1.81 ± 0.08	1.78 ± 0.11	1.77 ± 0.08	
TG (mmol L^{-1})				
Pre-intervention	0.43 ± 0.04	0.43 ± 0.04	0.37 ± 0.04	NS
Post-intervention	0.49 ± 0.04	0.49 ± 0.04	0.51 ± 0.04	
LDL-C:HDL-C				
Pre-intervention	1.18 ± 0.06	1.09 ± 0.12	1.07 ± 0.05	NS
Post-intervention	1.26 ± 0.06	1.24 ± 0.08	1.10 ± 0.06	
TC:HDL-C				
Pre-intervention	2.37 ± 0.07	2.32 ± 0.07	2.26 ± 0.06	NS
Post-intervention	2.48 ± 0.07	2.51 ± 0.07	2.34 ± 0.05	

Values are means ± SEM, n=35. P_{diet} reports the overall effect by ANCOVA with post-intervention as dependent variable and diet, pre-intervention, and period as fixed variables. Different superscript letters significantly differ, $P < 0.05$.

Abbreviations: BUT, butter; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; RED, reduced-fat cheese + butter; REG, regular-fat cheese; TC, total cholesterol; TG, triglycerides

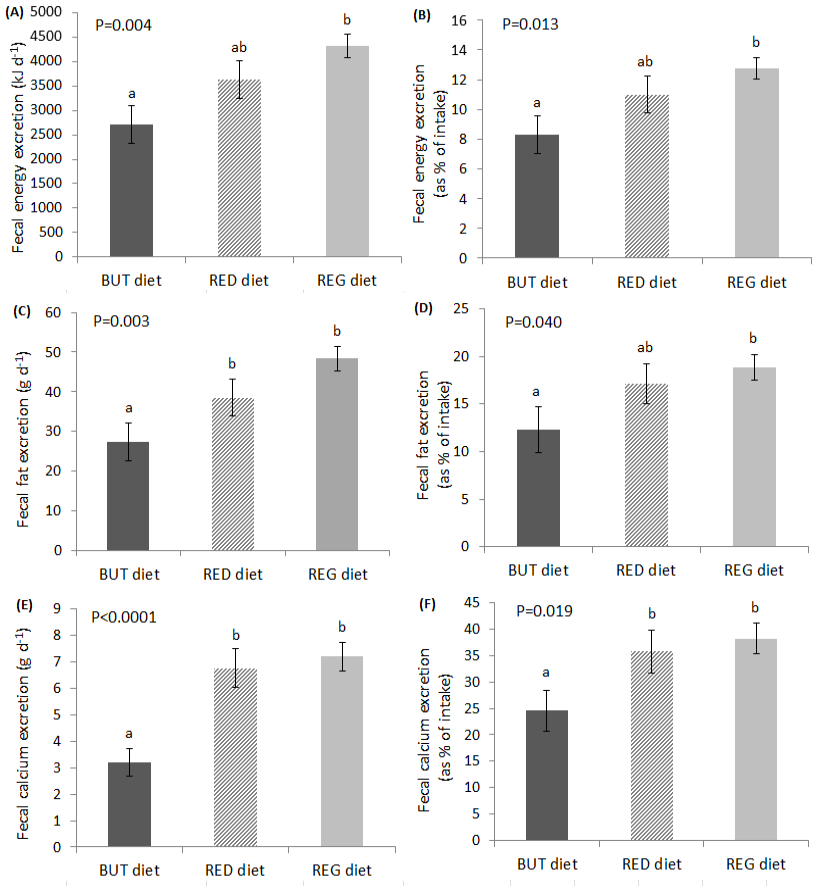


Figure 1. Fecal excretion of energy, fat, and calcium on the three diets. Data represents means ± SEMs of two replicate analyses (n=35). (A) Fecal energy excretion (kJ d^{-1}). (B) Fecal energy excretion (as % of intake). (C) Fecal fat excretion (g d^{-1}). (D) Fecal fat excretion (as % of intake). (E) Fecal calcium excretion (g d^{-1}). (F) Fecal calcium excretion (as % of intake). Groups with no letters in common differs significantly, $P < 0.05$ by ANCOVA adjusted for period and weight change. Error

bars are shown as SEM. Abbreviations: BUT, butter; RED, reduced-fat cheese + butter; REG, regular-fat cheese; kJ, kilojoule; d, day; g, gram.

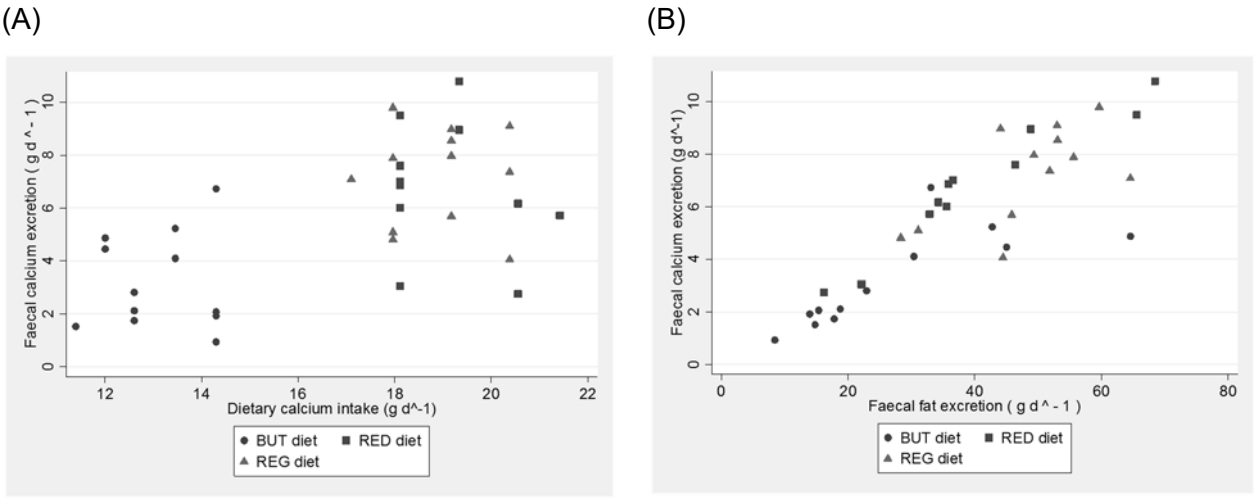


Figure 2. (A) Scatter plot of dietary calcium intake (g d^{-1}) and fecal calcium excretion (g d^{-1}) on the three diets. (B) Correlation scatter plots of fecal calcium excretion (g d^{-1}) and fecal fat excretion (g d^{-1}) on the three diets. Abbreviations: BUT, butter; RED, reduced-fat cheese + butter; REG, regular-fat cheese.

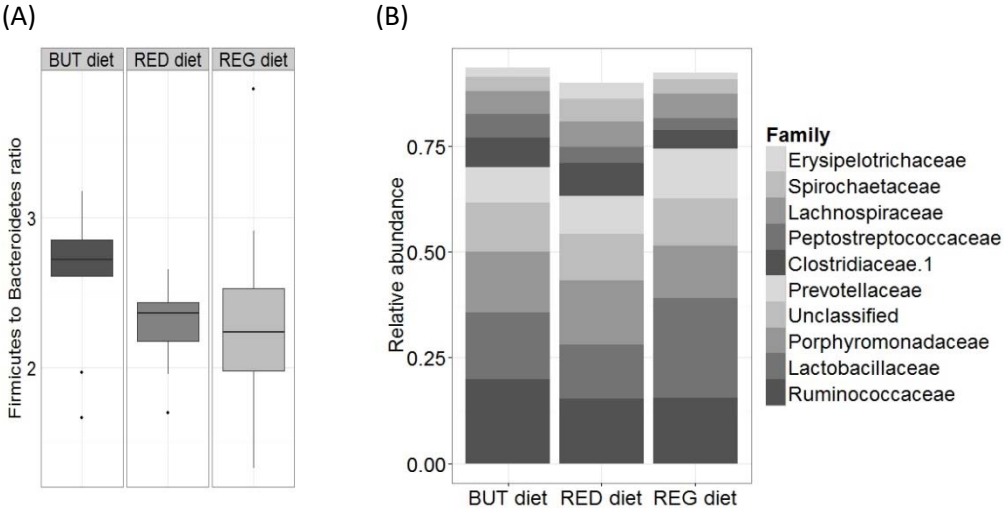


Figure 3. A) *Firmicutes* to *Bacteroidetes* ratio of the gut microbial communities after intake of the three diets (two replicate analyses, n=27). The top and the bottom of the box represent upper and lower quartiles, respectively, and the band within the box is the median. The whiskers indicate the minimum and the maximum. *Significantly different from BUT diet, $P < 0.05$ by Bonferroni-adjusted t-tests. B) Taxa summary plots showing the mean relative abundance of the 10 most abundant bacterial families in the three diets (two replicate analyses, n=27). Abbreviations: BUT, butter; RED, reduced-fat cheese + butter; REG, regular-fat cheese.

Publikation: Tanja K. Thorning, Anne Raben, Nathalie T. Bendsen, Henry H. Jørgensen, Pia Kiilerich, Ylva Ardö, Janne K. Lorenzen, Karsten Kristiansen, and Arne Astrup. **Importance of fat content of cheese-matrix for blood lipid profile, fecal fat excretion, and gut microbiome in growing pigs.** *International Dairy Journal, 2016;61:67-75*

Delprojekt B

Modningsgraden af cheddarost påvirker koncentrationen af frie fedtsyrer og insulin i blod hos grise i vækst.

Sammendrag: Cheddar ost modnet hhv. 4, 14 og 24 måneder anvendtes i forsøget (**Table 3 and Figure 4 + 5**). Indtag af langtidsmodnet cheddar ost forbedrede indikatorer for insulin følsomhed i 3-måneder gamle grise i sammenligning med korttidsmodnet cheddar. Specielt forårsagede 24-måneder modnet cheddar laver koncentrationer af frie fedtsyrere i blodet (**Figure 6**), serum insulin og HOMA-IR (**Figure 7**) i grise i sammenligning med 4-måneder modnet cheddar.

Indtag af 14-måneder modnet cheddar forårsagede lavere koncentration i blod af frie fedtsyrer hvorimod koncentrationen af insulin og HOMA-IR ikke var signifikant forskellig fra den for den 4-måneder modnede cheddar. Forskellen i modningstid påvirkede ikke fedtfordøjelighed, kropsvægt eller koncentrationerne af total kolesterol, HDL-kolesterol, LDL-kolesterol, triglycerider eller glukose i grisenes blod.

Resultater:

Table 3: Nutrient composition of the 21-day run-in butter diet and of the 14-day 4-MRC, 14-MRC, and 24-MRC diets fed to the three-month old female pigs.

	Run-in butter diet	4-MRC diet	14-MRC diet	24-MRC diet
Energy, MJ/kg diet	15.1	15.3	15.0	15.2
Cheddar, g/kg diet	-	350	350	350
Butter, g/kg	143	-	-	-
Potato protein, g/kg diet	105	-	-	-
Wheat, g/kg diet	301	299	299	299
Water, g/kg diet	99.0	-	-	-
Barley, g/kg diet	322	322	322	322
Chalk, g/kg	11.0	11.0	11.0	11.0
Mono calcium phosphate, g/kg	8.0	8.0	8.0	8.0
Feed salt, g/kg	3.0	3.0	3.0	3.0
Micromineral/ vitamin mix[1], g/kg	2.0	2.0	2.0	2.0
Celite marker, g/kg	5.0	5.0	5.0	5.0
Fat, energy %	32.5	33.8	32.8	32.8
Protein, energy %	15.6	15.6	15.8	16.1
Carbohydrate, energy %	51.9	50.6	51.4	51.1

[1]g/kg finished diet: retinol acetate=0.003; cholecalciferol=0.00003; all-rac-α-tocopheryl acetate=0.06; menadione=0.0022; thiamin=0.0022; riboflavin=0.0055, pyridoxine=0.0033; d-pantothenic acid=0.017; niacin=0.022; folic acid=0.0017; biotin=0.0002 cyanocobalamin=0.0002; BHT=0.06, Fe=0.10; Zn=0.15; Mn=0.028; Cu=0.00002; I=0.0003; Se=0.0003. Abbreviations: 4-MRC, 4 month ripened cheddar; 14-MRC, 14 month ripened cheddar; 24-MRC, 24 month ripened cheddar.

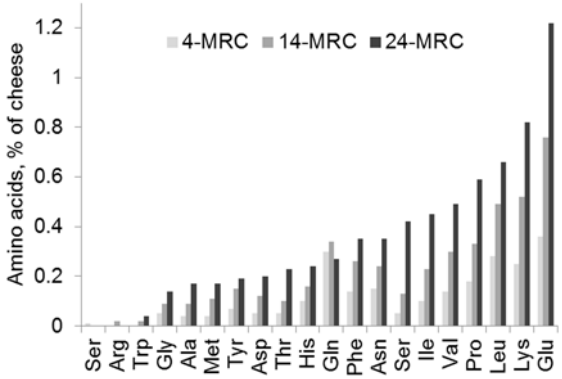


Figure 4. Amino acids concentrations in the 4-MRC, 14-MRC and 24-MRC cheeses used in the tree intervention diets fed to three-month old female pigs for 14 days. n=2. Abbreviations: 4-MRC, 4 month ripened cheddar; 14-MRC, 14 month ripened cheddar; 24-MRC, 24 month ripened cheddar.

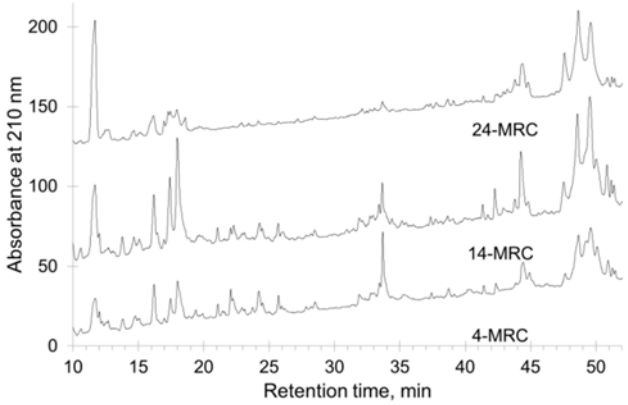


Figure 5. Chromatograms of peptides in the 4-MRC, 14-MRC and 24-MRC cheeses used in the three 14-day intervention diets fed to three-month old female pigs. Abbreviations: 4-MRC, 4 month ripened cheddar; 14-MRC, 14 month ripened cheddar; 24-MRC, 24 month ripened cheddar.

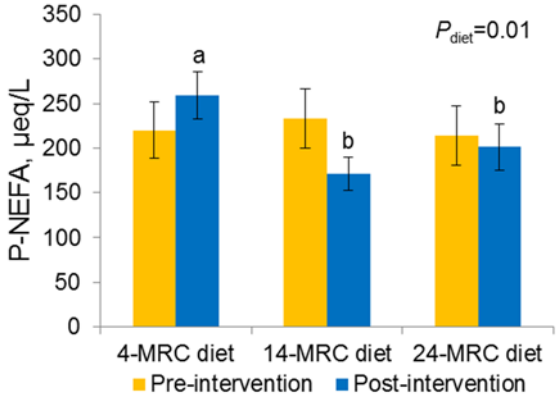


Figure 6. Plasma NEFA concentrations in three-month old female pigs before and after consuming the 4-MRC, 14-MRC, and 24-MRC diet for 14 days. Values are means ± SEM, n=12. Labeled means without a common letter differ, *P*<0.05. Abbreviation: NEFA, non-esterified fatty acids; P, plasma; 4-MRC, 4 month ripened cheddar; 14-MRC, 14 month ripened cheddar; 24-MRC, 24 month ripened cheddar.

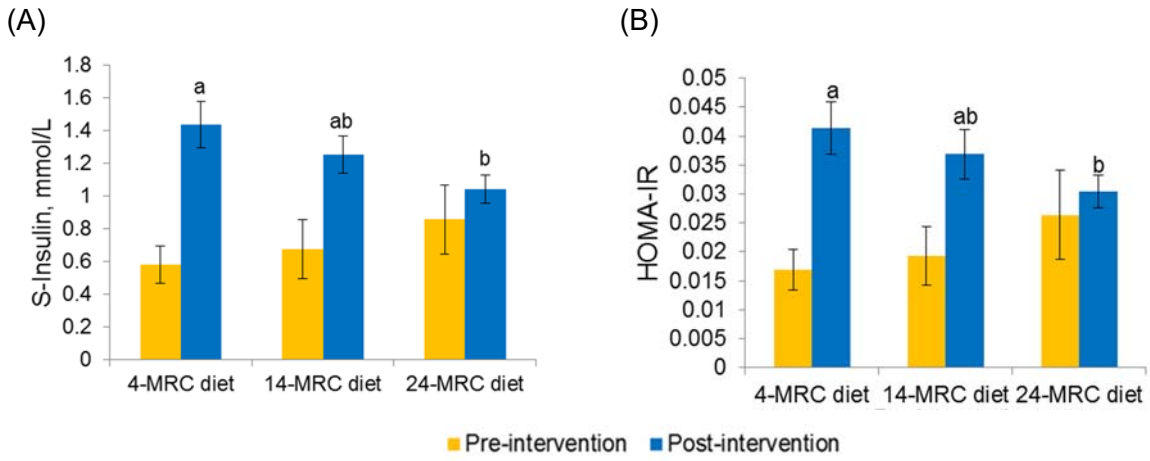


Figure 7. Serum insulin concentrations (A) and HOMA-IR (B) in three-month old female pigs before and after consuming the 4-MRC, 14-MRC, and 24-MRC diet for 14 days. Values are means ± SEM, n=12. Labeled means without a common letter differ, *P*<0.05. Abbreviations: HOMA-IR, homeostasis model assessment of insulin resistance; S, serum; 4-MRC, 4 month ripened cheddar; 14-MRC, 14 month ripened cheddar; 24-MRC, 24 month ripened cheddar.

Publikation: Tanja K. Thorning, Nathalie T. Bendsen, Søren Krogh Jensen, Ylva Ardö, Tine Tholstrup, Arne Astrup, and Anne Raben. **Cheddar cheese ripening affects plasma non-esterified fatty acids and serum insulin concentrations in grow-ing pigs.** *J Nutr 2015 Jul;145(7):1453-8.*

Delprojekt C

Betydning af kosttyper med fed ost, fedt kød eller kulhydrater for markører for hjertekarsygdom i overvægtige postmenopausale kvinder.

Sammendrag: Kosttyper med ost og kød som primære kilder til mættet fedt (**Tabel 4**) forårsagede ikke forskellige koncentrationer af LDL-kolesterol i postmenopausale kvinder sammenlignet med en kosttype med lavere fedtinghold og højere kulhydratindhold (**Table 5**). Dette kan muligvis forklares med den totale udskillelse af galdesyrer i fæces som var højere på kosten med ost og kød som primære kilder til mættet fedt i sammenligning med kosten med lavere fedtindhold og højere kulhydratindhold (**Table 6**).

Kosttyperne med ost og kød forårsagede højere koncentrationer af HDL-kolesterol og apo-A1, og synes derfor at være mindre atherogene end en kost med lavere fedtindhold og højere kulhydratindhold.

Vores fund bekræftede at en kost med ost øger den fækale fedtudskillelse i sammenligning med en kost med kød som primær kilde til mættet fedt og i sammenligning med en kost med lavere fedtindhold og højere kulhydratindhold.

Resultater:

Table 4. Nutrient composition of the three 2-wk intervention diets[1]

	CHEESE diet	CARB diet	MEAT diet
Energy (kJ)[2]	10,008 (11,070)	10,002 (10,469)	10,004 (10,516)
Protein (E%)	15.3	15.0	15.1
Carbohydrate (E%)	48.7	61.9	48.5
Sugar (E%)	7.5	8.9	6.9
Dietary fiber (g/d)[3]	35.8	37.0	36.6
Fat (E%)	36.0	23.0	36.4
SFA (% of fat)	49.9 (52.1)	49.8 (50.8)	49.8 (51.6)
MUFA (% of fat)	35.0 (36.6)	34.2 (35.2)	35.8 (35.9)
PUFA (% of fat)	15.1 (11.3)	16.0 (14.1)	14.4 (12.5)
Calcium (mg/d)[3]	1278	434	401
Phosphorous (mg/d)[3]	1679	1278	1375
Sodium (mg/d)[3]	2997	2887	2814
Cholesterol (mg/d)[3]	199	142	185

[1] Nutrient content estimated by Dankost 3000 dietary assessment software (Danish Catering Center) [2] Content assessed by duplicate analysis is shown in brackets [3] Content per 10 MJ diet

Table 5. Pre- and post-intervention blood parameters on the three 2-wk intervention diets

	CHEESE diet	CARB diet	MEAT diet	P_{diet}
Fasting concentrations				
TC (mmol/L)				
Pre-intervention	5.98 ± 0.21	6.21 ± 0.23	6.23 ±0.23	NS
Post-intervention	5.79 ± 0.29	5.74 ± 0.24	5.96 ± 0.21	
LDL-C (mmol/L)				
Pre-intervention	3.64 ± 0.18	3.86 ± 0.21	3.84 ± 0.19	NS
Post-intervention	3.58 ± 0.23	3.68 ± 0.22	3.82 ± 0.18	
HDL-C (mmol/L)				
Pre-intervention	1.56 ± 0.08	1.53 ± 0.07	1.55 ± 0.07	0.002
Post-intervention	1.39 ± 0.07[a]	1.30 ± 0.06[b]	1.42 ± 0.07[a]	
TAG (mmol/L)				
Pre-intervention	1.18 ± 0.14	1.08 ± 0.06	1.26 ± 0.11	NS
Post-intervention	1.21 ± 0.12	1.13 ± 0.10	1.10 ± 0.09	
LDL-C: HDL-C (ratio)				
Pre-intervention	2.43 ± 0.17	2.62 ± 0.20	2.56 ± 0.18	NS
Post-intervention	2.66 ± 0.21	2.93 ± 0.22	2.79 ± 0.19	
TC: HDL-C (ratio)				
Pre-intervention	3.94 ± 0.20	4.16 ± 0.23	4.11 ± 0.20	NS
Post-intervention	4.25 ± 0.25	4.52 ± 0.24	4.31 ± 0.22	
Apo-B (g/L)				
Pre-intervention	0.98 ± 0.04	1.03 ± 0.05	1.03 ± 0.05	NS
Post-intervention	0.97 ± 0.05	1.00 ± 0.05	1.01 ± 0.05	
Apo-A1 (g/L)				
Pre-intervention	1.37 ± 0.05	1.38 ± 0.05	1.40 ± 0.04	0.002
Post-intervention	1.27 ± 0.05[a]	1.19 ± 0.04[b]	1.26 ± 0.04[a]	
Apo-B: Apo-A1 (ratio)				
Pre-intervention	0.73 ± 0.04	0.77 ± 0.05	0.75 ± 0.04	0.028
Post-intervention	0.78 ± 0.05[a]	0.85 ± 0.05[b]	0.81 ± 0.05[b]	
Insulin (pmol/L)				
Pre-intervention	73.6 ± 8.3	76.1 ± 7.3	77.0 ± 7.4	NS
Post-intervention	77.8 ± 10.4	70.0 ± 7.0	72.3 ± 8.7	
Glucose (mmol/L)				
Pre-intervention	5.71 ± 0.12	5.77 ± 0.12	5.64 ± 0.11	NS
Post-intervention	5.18 ± 0.36	5.38 ± 0.09	5.53 ± 0.08	
HOMA-IR				
Pre-intervention	2.72 ± 0.34	2.81 ± 0.30	2.82 ± 0.27	NS
Post-intervention	2.65 ± 0.41	2.58 ± 0.32	2.42 ± 0.24	
Postprandial concentrations[1]				
TC (mmol/L)				
Post-intervention	5.69 ± 0.25	5.96 ± 0.26	6.02 ± 0.20	NS
LDL-C (mmol/L)				
Post-intervention	3.45 ± 0.21	3.74 ± 0.22	3.76 ± 0.17	NS
HDL-C (mmol/L)				
Post-intervention	1.39 ± 0.06	1.39 ± 0.07	1.41 ± 0.06	NS
TAG (mmol/L)				
Post-intervention	1.90 ± 0.21	1.59 ± 0.15	1.52 ± 0.14	0.089
Insulin (pmol/L)				
Post-intervention	161.8 ± 20.3	202.5 ± 26.5	179.2 ± 27.7	0.073
Glucose (mmol/L)				
Post-intervention	5.29 ± 0.11	4.97 ± 0.20	5.31 ±0.12	0.067

Values are means ± SEMs, n=14. *P*-diet reports the overall effect by ANCOVA where post-intervention was modeled as the dependent variable while diet, pre-intervention (when available), period, and diet x period were modeled as fixed variables, and the subject number was modeled as a random variable. $P>0.05$ for pre-intervention differences and for diet x period interactions for all dependent variables. NS is defined as $P>0.10$. Means not sharing a common superscript letter are significantly different at $P<0.05$, based on post hoc pairwise comparisons using t-tests. CHEESE: intervention diet containing cheese, MEAT: a non-dairy control diet with a high content of high-fat processed and unprocessed meat in amounts matching the saturated fat content from cheese in the CHEESE diet, CARB: a non-dairy low-fat control diet where the energy from cheese fat and protein was iso-calorically replaced by carbohydrates and lean meat. [1]measured 3 hours after intake of a breakfast meal with a macronutrient and food composition similar to the intervention period just completed.

Table 6. Fecal excretion of fat, energy and bile acids on the three 2-wk intervention diets

	CHEESE diet	CARB diet	MEAT diet	P_{diet}
Fecal fat excretion (g/d)	5.8 ± 0.4[a]	3.9 ± 0.2[b]	4.9 ± 0.4[c]	0.001
Fecal energy excretion (kJ/d)	679.6 ± 53.4	631.7 ± 36.3	736.1 ± 46.7	NS
Fecal total bile acid excretion (µmol/d)	206.1 ± 24.8[a]	155.3 ± 16.2[b]	225.9 ± 30.7[a]	0.018
taurine-conjugated bile acids (µmol/d)	84.2 ± 15.4[a]	57.2 ± 5.7[b]	56.6 ± 5.8[b]	0.025
glycine-conjugated (µmol/d)	52.2 ± 10.5	50.8 ± 9.0	71.4 ±12.8	NS
total conjugated bile acids (µmol/d)	133.0 ± 19.0	107.0 ± 11.2	120.1 ± 17.0	NS
total deconjugated bile acids (µmol/d)	73.1 ±9.7[a]	48.3 ± 6.7[b]	105.8 ± 16.6[c]	<0.001

Values are means ± SEMs, n=13. *P*-diet reports the overall effect of diet by ANCOVA, where diet, period and diet x period was modeled as fixed variables, and the subject number was modeled as a random variable. *P*>0.05 for pre-intervention differences and fir diet x period interactions for all dependent variables. NS is defined as P>0.10. Means not sharing a common superscript letter are significantly different at P<0.05, based on post hoc pairwise comparisons using t-tests. CHEESE: intervention diet containing cheese, MEAT: a non-dairy control diet with a high content of high-fat processed and unprocessed meat in amounts matching the saturated fat content from cheese in the CHEESE diet, CARB: a non-dairy low-fat control diet where the energy from cheese fat and protein was iso-calorically replaced by carbohydrates and lean meat.

Publikation: Tanja K. Thorning, Farinaz Raziani, Nathalie T. Bendsen, Arne Astrup, Tine Tholstrup, and Anne Raben. **Diets with high-fat cheese, high-fat meat or carbohydrate on cardiovascular risk markers in overweight postmenopausal women: a randomized cross-over trial.** *Am J Clin Nutr 2015 Jul Sep;102(3): 573-81.*

Delprojekt D

High intake of regular-fat cheese compared with reduced-fat cheese does not affect LDL cholesterol or risk markers of the metabolic syndrome: a randomized controlled trial.

Sammendrag:

Et dagligt indtag af 64-112 g (**Tabel 7**) fuldfed ost i 12 uger forårsagede ikke forskellige koncentrationer af LDL-C sammenlignet med samme mængde af fedtreduceret ost eller kulhydratrige fødevarer i en population med risikofaktorer for det metaboliske syndrom (**Tabel 8+9**). Det samme gjorde sig gældende for andre metaboliske parametre som eksempelvis kropsvægt, insulinresistens og blodtryk (**Tabel 10**). Dette var på trods af et signifikant højere indtag af mættet fedt i gruppen, der indtog fuldfed ost (**Tabel 11**). Der var en tendens mod højere værdier af HDL-C koncentrationer efter indtagelse af fuldfed ost sammenlignet med kulhydratrige fødevarer.

Resultater:

Table 7. Nutrient composition of the test foods (per day)[1,2]

	REG		RED		CHO	
	Riberhus	Cheddar	Cheasy	Cheddar	Bread	Jam
Daily amount (g)[2]	40	40	40	40	90	25
Energy (kJ/d)	528	666	378	614	954	219
Energy density (kJ/100 g)	3.2	3.9	2.3	3.7	2.5	2.1
Fat						
(g/d)	10.2	13.2	5.4	9.6	1.8	0.1
Saturated fat (g/d)	6.3	8.1	3.3	5.6	0.2	-
Monounsaturated fat (g/d)	2.8	4.6	1.3	3.3	-	-
Polyunsaturated fat (g/d)	0.3	0.7	0.1	0.3	-	-
Protein						
(g/d)	8.8	10	10.4	15.2	6.3	0.1
Carbohydrates						
(g/d)	0.2	-	0.2	-	45	12.5
Total sugar (g/d)	-	-	-	-	0.9	11.3
GI (48)	-	-	-	-	71	51
GL	-	-	-	-	35.5	25.5
Calcium (mg/d)	267	285	309	285	33	25
Sodium (g/d)	0.6	0.7	0.6	0.7	0.9	-

[1]per 10 MJ diet

[2]Nutrition information provided by the manufacturer. Abbreviations: CHO, carbohydrate control; GI, glycemic index; GL, glycemic load; RED, reduced-fat cheese; REG, regular-fat cheese.

Table 8. Baseline characteristics of the 139 subjects who completed the intervention[1]

	REG (n=45)	RED (n=48)	CHO (n=46)
Sex [n (%)]			
Women	28 (62)	34 (71)	30 (65)
Men	17 (38)	14 (29)	16 (35)
Age (y)	54.6 ± 13.4	52.1 ± 12.3	55.3 ± 10.6
BMI (kg/m^2)	29.4 ± 3.8	28.2 ± 3.5	28.7 ± 3.6
Smoking [n (%)]	1 (2)	4 (8)	1 (2)
Energy requirement (MJ/d)	10.5 ± 1.8	10.4 ± 2.0	10.3 ± 2

Mean ± SD (all such values). Abbreviations: REG, regular-fat cheese; RED, reduced-fat cheese; CHO, carbohydrate control.

Table 9. Fasting blood values at week 12 and changes from baseline[1]

	REG (n=50)		RED (n=51)		CHO (n=49)		REG vs. RED	REG vs. CHO
	Week 12	Change from baseline	Week 12	Change from baseline	Week 12	Change from base-line	*P*	*P*
LDL-C (mmol/l)	3.51 ± 0.11	0.17 ± 0.07	3.45 ± 0.13	0.09 ± 0.08	3.43 ± 0.11	0.03 ± 0.06	0.42	0.17
HDL-C (mmol/l)	1.45 ± 0.06	0.06 ± 0.02	1.46 ± 0.04	0.05 ± 0.02	1.46 ± 0.05	0.01 ± 0.03	0.86	0.07
TC (mmol/l)	5.40 ± 0.14	0.18 ± 0.07	5.28 ± 0.15	0.03 ± 0.09	5.24 ± 0.13	0.00 ± 0.08	0.14	0.11
TAG (mmol/l)	1.42 ± 0.11	0.11 ± 0.09	1.23 ± 0.07	-0.03 ± 0.07	1.30 ± 0.10	0.11 ± 0.06	0.11	0.88
FFA (µmol/l)	510 ± 31	28 ± 25	494 ± 24	-42 ± 34	503 ± 25	6 ± 21	0.34	0.54
LDL-C: HDL-C	2.54 ± 0.12	0.02 ± 0.05	2.49 ± 0.13	-0.04 ± 0.05	2.47 ± 0.13	-0.01 ± 0.05	0.06	0.69
TC: HDL-C	3.92 ± 0.18	0.01 ± 0.10	3.76 ± 0.15	-0.14 ± 0.06	3.72 ± 0.13	-0.05 ± 0.06	0.23	0.71
Insulin (pmol/l)	90.0 ± 8.3	11.7 ± 4.2	81.2 ± 8.2	7.5 ± 4.5	78.2 ± 8.0	9.8 ± 5.4	0.72	0.57
Glucose (mmol/l)	5.78 ± 0.08	0.01 ± 0.06	5.81 ± 0.10	0.04 ± 0.06	5.78 ± 0.08	-0.05 ± 0.05	0.39	0.88
HOMA-IR	3.43 ± 0.35	0.51 ± 0.20	3.13 ± 0.36	0.33 ± 0.20	2.96 ± 0.31	0.34 ± 0.19	0.68	0.46
CRP (mg/L)	2.39 ± 0.30	0.54 ± 0.28	2.17 ± 0.30	0.44 ± 0.17	1.75 ± 0.27	0.05 ± 0.25	0.80	0.12

[1]All values are mean ± SEM. Statistical differences between groups is based on linear mixed models with baseline values as co-variates and adjustments for age, sex, BMI and Δ body fat. Pairwise comparisons were made using *post hoc* t-test on the linear mixed model with p-values adjusted for multiplicity. Abbreviations: CHO: carbohydrate control; CRP, C-reactive protein; FFA, free fatty acids; HDL-C, high density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol; RED: reduced-fat cheese; REG: regular-fat cheese; TC: total cholesterol.

Table 10. Fasting values of anthropometric measurements, body composition and blood pressure at week 12 and changes from baseline[1]

	REG (n=50)		RED (n=51)		CHO (n=49)		REG vs. RED	REG vs. CHO
	Week 12	Change from baseline	Week 12	Change from baseline	Week 12	Change from baseline	*P*	*P*
Body weight	85.6 ± 1.9	0.1 ± 0.2	84.1 ± 2.0	0.1 ± 0.2	84.6 ± 2.2	0.1 ± 0.2	0.80	0.85
WC (cm)	99.0 ± 1.4	0.1 ± 0.4	97.3 ± 1.6	0.2 ± 0.4	97.0 ± 1.5	0.1 ± 0.4	0.88	0.62
BMI (kg/m^2)	29.3 ± 0.5	0.0 ± 0.1	28.1 ± 0.5	0.03 ± 0.1	28.7 ± 0.5	0.1 ± 0.1	0.74	0.93
Fat Mass (kg)	31.9 ± 1.2	-0.1 ± 0.2	32.4 ± 1.2	0.3 ± 0.2	32.1 ± 1.3	-0.3 ± 0.2	0.30	0.56
Fat percent (%)	37.6 ± 1.1	-0.2 ± 0.2	38.5 ± 0.9	0.2 ± 0.2	38.0 ± 1.2	-0.4 ± 0.2	0.17	0.57
Lean Body Mass (kg)	50.4 ± 1.5	0.3 ± 0.2	48.4 ±1.3	-0.1 ± 0.2	49.2 ± 1.6	0.2 ± 0.2	0.16	0.71
Systolic BP (mmHg)	130.5 ± 1.9	-1.1 ± 1.4	125.2 ± 2.2	-3.2 ± 1.3	127.7 ± 1.8	-2.0 ± 1.5	0.17	0.21
Diastolic BP (mmHg)	83.3 ± 1.1	-1.4 ± 0.7	81.1 ± 1.3	-2.0 ± 0.7	83.1 ± 1.1	-1.9 ± 0.7	0.50	0.77

[1]All values are mean ± SEM. Statistical differences between groups is based on linear mixed models with baseline values as co-variates and adjustments for age, sex, BMI and Δ body fat. Pairwise comparisons were made using *post hoc* t-test on the linear mixed model with p-values adjusted for multiplicity. Abbreviations: BP; blood pressure; CHO: carbohydrate control; RED: re-duced-fat cheese; REG: regular-fat cheese; WC; waist circumference.

Table 11. Average daily consumption of energy and macronutrients for the REG, RED and CHO diet during the 12 weeks intervention[1]

	REG (n=39)	RED (n=46)	CHO (n=44)
Total energy (kJ)	9098 ± 362	9073 ± 429	8000 ± 340
Energy density (kcal/g)	0.9 ± 0.1	0.8 ± 0.1	0.8 ± 0.1
Fat (% of energy)	36.6 ± 1.1	32.2 ± 0.8**	29.8 ± 1.0***
Fat (g)	90.8 ± 5.2	78.5 ± 4.0 †,**	65.4 ± 3.7 ***
Saturated fat (g)	34.3 ± 2.3	27.4 ± 1.2†††,**	19.1 ± 1.4***
Monounsaturated fat (g)	30.1 ± 2.1	27.1 ± 1.6	23.9 ± 1.6**
Polyunsaturated fat (g)	13.7 ± 1.0	13.0 ± 0.8	13.3 ± 0.9
Carbohydrate (% of energy)	40.5 ± 1.4	43.2 ± 1.1†††	49.4 ± 1.2***
Dietary Fiber (g/d)	23.2 ± 1.3	22.7 ± 1.2	22.4 ± 1.6
Protein (% of energy)	19.2 ± 0.6	20.6 ± 0.6 ††	18.4 ± 0.6
Alcohol (g)	11.5 ± 1.8	12.9 ± 1.7	7.1 ± 1.6
Calcium (mg)	1281 ± 70	1328 ± 55†††	728 ± 33***

[1]All values are means ± SEMs, n= 129 because 10 subjects had dietary records considered nonsufficient and were therefore removed from the model. Data were assessed by using 3-d weighted dietary record estimated using Dankost 3000 dietary assessment software (Dankost). Statistical differences were based on linear mixed models with values for average daily consumption at week 0 for all variables included as covariates. Pairwise comparisons were based on *post hoc* t- test. *,**,*** Significantly different from REG diet: $^{*}P < 0.05$, ** $P < 0.01$, *** $P < 0.001$. †,††,††† Significantly different from CHO: $^{\dagger}P < 0.05$, $^{\dagger\dagger}P < 0.01$, $^{\dagger\dagger\dagger}P < 0.001$. Abbreviations: CHO: carbohydrate control; RED: reduced-fat cheese; REG: regular-fat cheese.

Publikationer:

Farinaz Raziani, Tine Tholstrup, Marlene D Kristensen, Matilde L Svanegaard, Christian Ritz, Arne Astrup, Anne Raben. **High intake of regular-fat cheese compared with reduced-fat cheese does not affect LDL cholesterol or risk markers of the metabolic syndrome: a randomized controlled trial**. *Am J Clin Nutr 2016; 104:973-981*

Delprojekt D -Substudie 1

Postprandial glycaemia, insulinemia, and lipidemia after 12 weeks' cheese consumption: a sub-study from a randomized controlled trial.

Sammendrag:

Formålet med substudie 1 var at sammenligne effekten af måltider indeholdende hhv. fuldfed ost med måltider indeholdende fedtreduceret ost eller kulhydratrige fødevarer (**Tabel 12**) på postprandialle ændringer i glukose, insulin, TAG, og frie fedtsyrer, samt subjektiv appetit følelse, efter 12 ugers tilvænning af fødevarerne. En 4-timers måltidstest blev udført i en subgruppe af 37 forsøgsdeltagere. Postprandialle koncentrationer af glukose, insulin, TAG, og FFA blev målt før og 30, 60, 90, 120, 180 og 240 minutter efter påbegyndelse af morgenmåltidet. Fuldfed

ost ikke fører til forhøjede postprandielle glukose og insulin koncentrationer (**Figur 8+9**), men resulterer i forhøjede postprandielle TAG koncentrationer efter 240 min sammenlignet med tilsvarende mængde fedtreduceret ost (**Figur 10**).

Resultater:

Table 12 Composition of the three breakfast meals[1]

	REG	RED	CHO
Energy (kJ)	2001	1787	2000
Meal weight (g)	430	430	465
Energy density (kcal/g)	4.5	4.5	4.3
Fat			
(% of energy)	46.4	33.7	6.5
(g)	25.1	16.3	3.5
Saturated fat (g)	14.6	4.6	0.4
Carbohydrate			
(% of energy)	33	37	83.4
(g)	38.1	38	96
Protein			
(% of energy)	20.6	29.3	10.1
(g)	24.2	30.8	11.9
Dietary Fiber (g)	1.8	1.8	1.8

[1]Nutrition information provided by the manufacturer (Arla, Lactalis, Kohberg, and Fynbo). Abbreviations: CHO, carbohydrate control; RED, reduced-fat cheese; REG, regular-fat cheese.

Figure 8

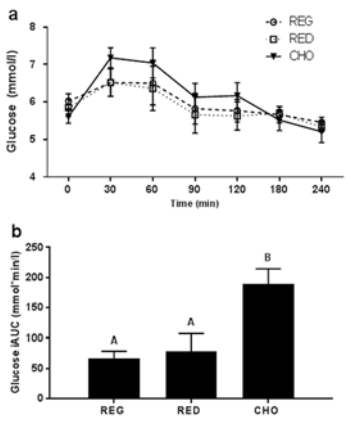


Figure 9

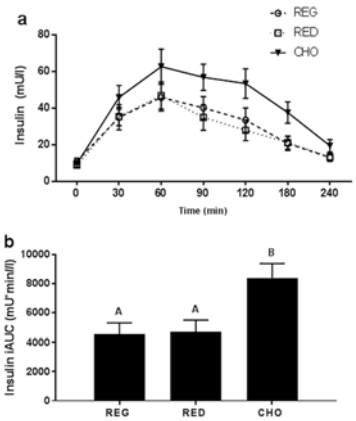
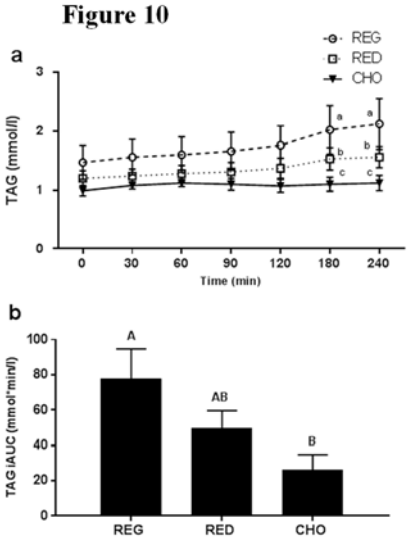


Figure 8. Mean ± SEM (n=37) changes of postprandial blood glucose concentrations (a) and incremental area under the glucose curve (b) after a regular-fat cheese (REG), a reduced-fat cheese (RED), and a carbohydrate control (CHO) meal. Linear mixed model showed significant differences of the treatment ($P < 0.01$) with post hoc differences between REG and CHO ($P < 0.01$) and between RED and CHO ($P < 0.01$). Values not sharing a common superscript in (b) are significantly different ($P < 0.05$). Model was adjusted for baseline outcome, age, sex, BMI, and included subjects as random effects.

Figure 9. Mean ± SEM (n=37) changes of postprandial serum insulin concentrations (a) and incremental area under the glucose curve (b) after a regular-fat cheese (REG), a reduced-fat cheese (RED), and a carbohydrate control (CHO) meal. Linear mixed model showed significant differences of the treatment (P < 0.001) with post hoc differences between REG and CHO (P < 0.001) and between RED and CHO (P < 0.001). Values not sharing a common superscript in (b) are significantly different (P < 0.05). Model was adjusted for baseline outcome age, sex, and BMI and included subjects as random effects.



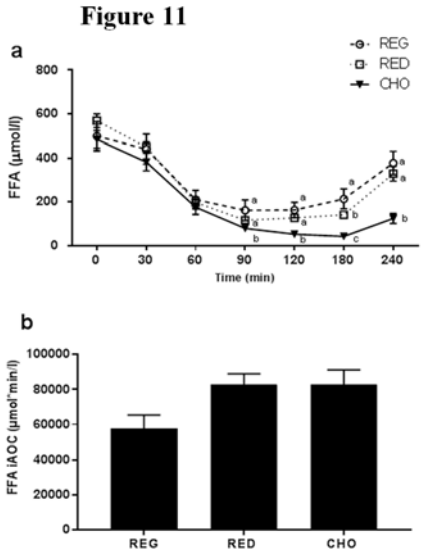


Figure 10. Mean ± SEM (n=37) changes of postprandial triacylglycerol concentrations (a) and incremental area under the glucose curve (b) after a regular-fat cheese (REG), a reduced-fat cheese (RED), and a carbohydrate control (CHO) meal. Linear mixed model showed significant time-by-treatment interaction (P < 0.001). Values not sharing a common superscript are significantly different (P < 0.05). Model was adjusted for baseline outcome, age, sex, BMI, and included subjects as random effects.

Figure 11. Mean ± SEM (n=37) changes of postprandial free fatty acid concentrations (a) and incremental area under the glucose curve (b) after a regular-fat cheese (REG), a reduced-fat cheese (RED), and a carbohydrate control (CHO) meal. Linear mixed model showed significant time-by-treatment interaction (P < 0.001). Model was adjusted for baseline outcome, age, sex, BMI, and included subjects as random effects. Values not sharing a common superscript are significantly different (P < 0.05). Post hoc testing showed no difference in iAUC between meals.

Publikationer:

Farinaz Raziani, Tine Tholstrup, Rosa Caroline Jullie Rudnicki, Christian Ritz, Arne Astrup, Anne Raben. **Postprandial glycaemia, insulinemia, and lipidemia after 12 weeks' cheese consumption: a sub-study from a randomized controlled trial**. *Re-Submission to relevant journal*

Delprojekt D -Substudie 2

Sammendrag:

Formålet med substudie 2 var at sammenligne effekten af fuldfed ost med fedtreduceret ost og en isokalorisk mængde kulhydratrige fødevarer på fordelingen af LDL partikel størrelse. I alt indgik en subgruppe af 85 i de statistiske analyser. Resultaterne fra substudie 2 viste, at fuldfed ost ikke ændrede LDL partikelstørrelsesfordelingen sammenlignet med fedt-reduceret ost (**Tabel 13**). Vores resultater tydede dog på, at lipoprotein responset er kønsspecifikt. Subanalyser i mænd viste at fuldfed ost reducerede antallet af LDL partikler sammenlignet med fedtreduceret ost (**Tabel 14**), mens antallet af LDL partikler havde en tendens til at være højere i kvinder der havde spist fuldfed ost sammenlignet med fedtreduceret ost (**Tabel 15**).

Resultater:

Table 13 Lipoprotein particle number and cholesterol content at wk 12 and changes from baseline in men and women[1]

	REG (n=30)		RED (n=26)		CHO (n=29)		REG vs. RED	REG vs. CHO
	Week 12	Change from baseline	Week 12	Change from baseline	Week 12	Change from baseline	*P*	*P*
VLDL-P (nmol/l)	148.4 ± 14.1	-3.6 ± 15.3	129.5 ± 9.4	-6.0 ± 8.8	126.1 ± 13.8	3.4 ± 6.7	0.56	0.67
IDL-P (nmol/l)	73.3 ± 6.9	-4.5 ± 6.9	68.5 ± 6.5	-6.1 ± 5.0	68.2 ± 7.0	2.1 ± 4.3	0.62	0.81
LDL-P (nmol/l)								
Total	1322 ± 60.0	26.2 ± 41.3	1265 ± 78.8	7.9 ± 50.2	1363 ± 55.5	-2.9 ± 39.1	0.43	0.99
LDL_{1+2}	415.9 ± 21.4	22.2 ± 15.1	444.2 ± 23.0	-13.3 ± 19.3	453.2 ± 22.4	-29.3 ± 14.7	0.82	0.16
LDL_{3+4}	403.2 ± 20.6	9.9 ± 22.4	414.9 ± 31.6	15.9 ± 19.5	403.3 ± 22.2	-10.8 ± 18.1	0.98	0.76
LDL_{5+6}	487.7 ± 43.1	-12.7 ± 20.5	391.1 ± 43.6	-7.7 ± 25.7	479.6 ± 49.3	32.0 ± 19.0	0.39	0.35
VLDL-C (mg/dl)								
Total	16.5 ± 2.2	-0.5 ± 2.4	13.2 ± 1.6	-1.3 ± 1.3	12.8 ± 2.4	0.7 ± 1.2	0.47	0.68
$VLDL_{1+2}$	7.3 ± 1.2	0.7 ± 1.1	4.9 ± 0.9	-0.5 ± 0.6	5.0 ± 1.3	0.1 ± 0.1	0.26	0.56
$VLDL_{3+4}$	6.7 ± 1.0	-1.2 ± 1.3	5.6 ± 0.7	-1.0 ± 0.7	5.4 ± 1.0	-0.2 ± 0.5	0.67	0.87
$VLDL_{5+6}$	2.1 ± 0.1	-0.1 ± 0.1	2.0 ± 0.1	0.0 ± 0.1	2.0 ± 0.1	0.7 ± 0.7	0.96	0.68
IDL-C (mg/dl)	7.0 ± 1.1	-0.2 ± 0.9	6.7 ± 1.1	-1.5 ± 1.3	7.1 ± 1.3	0.1 ± 0.7	0.28	0.81
LDL-C (mg/dl)								
Total	118.2 ± 5.4	3.7 ± 4.4	117.3 ± 7.3	3.8 ± 4.9	122.6 ± 4.5	-2.6 ± 3.9	0.69	0.70
LDL_{1+2}	42.8 ± 2.5	2.7 ± 1.7	46.6 ± 2.6	-0.5 ± 2.3	47.2 ± 2.4	-3.2 ± 1.9	0.51	0.19
LDL_{3+4}	38.2 ± 2.2	0.9 ± 2.1	40.0 ± 3.1	2.3 ± 2.1	38.7 ± 2.2	-1.7 ± 1.8	0.72	0.57
LDL_{5+6}	36.2 ± 3.1	-0.5 ± 1.4	29.6 ± 3.4	0.2 ± 2.0	35.7 ± 3.5	2.1 ± 1.5	0.88	0.21
HDL-C (mg/dl)								
Total	56.0 ± 2.9	2.2 ± 1.0	56.5 ± 2.5	2.4 ± 1.3	55.9 ± 2.3	-0.6 ± 1.3	0.84	< 0.05
HDL_{1+2}	27.1 ± 2.7	1.0 ± 0.8	27.5 ± 2.1	0.6 ± 1.0	28.6 ± 2.0	0.1 ± 1.1	0.68	0.23
HDL_{3+4}	29.4 ± 0.8	1.2 ± 0.6	29.4 ± 0.9	1.6 ± 0.7	27.8 ± 0.9	-0.8 ± 0.6	0.95	<0.05
LDL-C:HDL-C ratio	2.2 ± 0.1	0.0 ± 0.1	2.2 ± 0.2	0.0 ± 0.1	2.3 ± 0.1	0.0 ± 0.1	0.62	0.81
Apo-B:Apo-A1 ratio	0.6 ± 0.0	0.0 ± 0.0	0.6 ± 0.0	0.0 ± 0.1	0.7 ± 0.0	0.0 ± 0.0	0.67	0.16

[1]All values are means ± SEMs. Statistical differences between groups are based on linear mixed models with baseline values as covariates and adjustments for age, sex, BMI and change in body fat. Pairwise comparisons were made using *post hoc* t-test on the linear mixed model with p-values adjusted for multiplicity. Abbreviations: apo, apolipoprotein; CHO: carbohydrate control; HDL-C, high density lipoprotein cholesterol; HDL-P, high density lipoprotein particle number; IDL-P, intermediate density lipoprotein cholesterol, IDL-P, intermediate density lipoprotein particle number; LDL-C, low density lipoprotein cholesterol; LDL-P, low density lipoprotein particle number; RED: reduced-fat cheese; REG: regular-fat cheese; VLDL-C, very low density lipoprotein cholesterol; VLDL-P, very low density lipoprotein particle number.

Table 14 Lipoprotein particle number and cholesterol content at wk 12 and changes from baseline in men[1]

	REG (n=9)		**RED (n=5)**		**CHO (n=9)**		**REG vs. RED**	**REG vs. CHO**
	Week 12	Change from baseline	Week 12	Change from baseline	Week 12	Change from baseline	*P*	*P*
VLDL-P (nmol/l)	178.3 ± 34.0	14.3 ± 21.1	141.3 ± 21.7	12.5 ± 14.8	174.5 ± 28.2	25.2 ± 13.0	0.56	0.12
IDL-P (nmol/l)	83.9 ± 18.5	-3.4 ± 8.2	68.2 ± 19.7	0.1 ± 10.9	78.0 ± 16.0	3.8 ± 7.2	0.61	0.24
LDL-P (nmol/l)								
Total	1275.3 ± 154.4	-81.7 ± 45.5	1381.7 ± 244.9	171.0 ± 150.1	1372.0 ± 86.3	-34.6 ± 48.5	< 0.05	0.68
LDL_{1+2}	336.4 ± 31.8	1.6 ± 21.3	378.1 ± 51.9	-9.6 ± 31.3	355.0 ± 31.3	-44.8 ± 8.6	0.45	0.05
LDL_{3+4}	369.5 ± 53.0	-72.4 ± 32.2	441.8 ± 79.5	84.5 ± 65.9	359.9 ± 40.3	-37.3 ± 21.8	< 0.05	0.53
LDL_{5+6}	571.4 ± 103.3	-21.1 ± 33.9	544.8 ± 156.7	91.8 ± 81.7	639.2 ± 104.8	47.1 ± 46.2	0.06	0.12
VLDL-C (mg/dl)								
Total	22.7 ± 5.4	2.7 ± 4.1	15.1 ± 3.4	1.5 ± 1.7	21.0 ± 5.1	4.1 ± 2.7	0.97	0.22
$VLDL_{1+2}$	10.6 ± 2.6	1.9 ± 2.5	6.7 ± 2.1	0.9 ± 1.0	9.6 ± 2.9	3.0 ± 1.6	0.79	0.28
$VLDL_{3+4}$	9.3 ± 2.7	0.3 ± 1.6	5.7 ± 1.4	0.4 ± 1.4	8.3 ± 2.4	1.1 ± 1.2	0.67	0.19
$VLDL_{5+6}$	2.2 ±0.4	0.1 ± 0.2	1.8 ± 0.1	0.0 ± 0.3	2.4 ± 0.3	0.1 ± 0.2	0.76	0.72
IDL-C (mg/dl)	9.6 ± 3.0	0.7 ± 1.6	4.3 ± 1.5	-1.3 ± 2.3	9.4 ± 3.2	0.8 ± 1.5	0.69	0.55
LDL-C (mg/dl)								
Total	111.0 ± 12.8	-6.9 ± 5.8	127.1 ± 20.1	18.2 ± 15.7	118.3 ± 6.1	-7.8 ± 5.1	< 0.05	0.82
LDL_{1+2}	34.3 ± 3.5	1.0 ± 2.5	40.1 ± 6.0	0.0 ± 4.0	36.8 ± 3.5	-5.1 ± 1.2	0.88	< 0.05
LDL_{3+4}	33.9 ± 5.1	-6.2 ± 3.5	42.5 ± 7.5	8.4 ± 7.2	33.7 ± 4.1	-4.5 ± 2.3	< 0.05	0.76
LDL_{5+6}	42.1 ± 7.3	-1.2 ± 2.3	42.1 ± 11.7	8.6 ± 6.8	47.0 ± 7.0	2.6 ± 3.4	< 0.05	0.29
HDL-C (mg/dl)								
Total	43.8 ± 3.7	1.0 ± 2.0	50.8 ± 5.4	1.0 ± 3.0	48.5 ± 2.5	1.0 ± 1.3	0.72	0.88
HDL_{1+2}	16.4 ± 3.4	0.6 ± 1.4	21.6 ± 3.2	-0.8 ± 1.7	20.8 ± 2.4	1.0 ± 1.0	0.09	0.49
HDL_{3+4}	27.7 ± 1.7	0.4 ± 0.8	29.7 ± 2.3	1.6 ± 1.8	28.1 ± 1.8	0.1 ± 1.0	0.36	0.73
LDL-C:HDL-C ratio	2.7 ± 0.3	-0.2 ± 0.1	2.6 ± 0.4	0.3 ± 0.2	2.5 ± 0.2	-0.2 ± 0.1	<0.001	0.72
ApoB:ApoA1 ratio	0.7 ± 0.1	-0.1 ± 0.0	0.7 ± 0.1	0.0 ± 0.0	0.7 ± 0.1	0.0 ± 0.0	< 0.01	0.96

[1]All values are means ± SEMs. Statistical differences between groups are based on linear mixed models with baseline values as covariates and adjustments for age, BMI and change in body fat. Pairwise comparisons were made using *post hoc* t-test on the linear mixed model with p-values adjusted for multiplicity. Abbreviations: apo, apolipoprotein; CHO:

carbohydrate control; HDL-C, high density lipoprotein cholesterol; HDL-P, high density lipoprotein particle number; IDL-P, intermediate density lipoprotein cholesterol, IDL-P, intermediate density lipoprotein particle number; LDL-C, low density lipoprotein cholesterol; LDL-P, low density lipoprotein particle number; RED: reduced-fat cheese; REG: regular-fat cheese; VLDL-C, very low density lipoprotein cholesterol; VLDL-P, very low density lipoprotein particle number.

Table 15 Lipoprotein particle number and cholesterol content at wk 12 and changes from baseline in women[1]

	REG (n=21)		RED (n=21)		CHO (n=20)		REG vs. RED	REG vs. CHO
	Week 12	Change from baseline	Week 12	Change from baseline	Week 12	Change from baseline	*P*	*P*
VLDL-P (nmol/l)	135.6 ± 13.5	-11.2 ± 20.0	126.7 ± 10.6	-10.4 ± 10.3	104.4 ± 13.3	-6.4 ± 7.0	0.59	0.25
IDL-P (nmol/l)	68.8 ± 6.1	-4.9 ± 9.3	68.5 ± 6.8	-7.6 ± 5.7	63.7 ± 7.2	1.3 ± 5.5	0.75	0.91
LDL-P (nmol/l)								
Total	1343.0 ± 57.4	72.4 ± 53.1	1238.3 ± 81.0	-30.9 ± 49.4	1359.7 ± 71.9	11.3 ± 52.7	0.08	0.83
LDL_{1+2}	449.9 ± 24.1	31.0 ± 19.6	459.9 ± 25.0	-14.2 ± 23.0	497.4 ± 23.5	-22.3 ± 21.0	0.41	0.68
LDL_{3+4}	471.6 ± 19.2	45.2 ± 25.5	408.4 ± 35.1	-0.5 ± 17.7	422.8 ± 26.2	1.2 ± 24.1	0.24	0.51
LDL_{5+6}	451.8 ± 42.6	-9.1 ± 25.9	354.5 ± 37.7	31.4 ± 23.6	407.7 ± 47.3	25.2 ± 18.8	0.17	0.25
VLDL-C (mg/dl)								
Total	13.8 ± 2.0	-1.9 ± 3.0	12.7 ± 1.8	-2.0 ± 1.6	9.1 ± 2.1	-0.9 ± 1.2	0.65	0.30
$VLDL_{1+2}$	5.8 ± 1.2	0.1 ± 1.2	4.5 ± 1.0	-0.8 ± 0.8	2.9 ± 1.1	-0.4 ± 0.6	0.31	0.21
$VLDL_{3+4}$	5.6 ± 0.8	-1.8 ± 1.7	5.6 ± 0.9	-1.3 ± 0.9	4.1 ± 0.9	-0.7 ± 0.5	0.94	0.51
$VLDL_{5+6}$	2.0 ± 0.1	-0.1 ± 0.2	2.1 ± 0.1	0.0 ± 0.1	1.8 ± 0.1	0.0 ± 0.1	0.62	0.83
IDL-C (mg/dl)	5.9 ± 0.9	-0.6 ± 1.1	7.3 ± 1.3	-1.6 ± 1.6	6.1 ± 1.2	-0.2 ± 0.8	0.83	0.60
LDL-C (mg/dl)								
Total	121.3 ± 5.7	8.3 ± 5.5	114.9 ± 7.9	0.4 ± 4.8	124.6 ± 6.0	-0.3 ± 5.2	0.21	0.79
LDL_{1+2}	46.4 ± 2.9	3.4 ± 2.2	48.2 ± 2.8	-0.6 ± 2.7	51.9 ± 2.5	-2.3 ± 2.2	0.60	0.74
LDL_{3+4}	40.0 ± 2.2	3.9 ± 2.3	39.4 ± 3.4	0.8 ± 1.9	40.9 ± 2.6	-0.4 ± 2.4	0.37	0.53
LDL_{5+6}	33.7 ± 3.2	-0.2 ± 1.7	26.6 ± 3.0	-1.7 ± 1.7	30.7 ± 3.5	2.0 ± 1.5	0.19	0.29
HDL-C (mg/dl)								
Total	61.2 ± 3.2	2.8 ± 1.2	57.9 ± 2.8	2.7 ± 1.4	59.2 ± 2.8	-1.3 ± 1.8	0.73	< 0.05
HDL_{1+2}	31.7 ± 3.1	1.1 ± 1.0	28.9 ± 2.4	0.9 ± 1.1	32.1 ± 2.4	-0.3 ± 1.5	0.77	0.21
HDL_{3+4}	30.1 ± 1.0	1.6 ± 0.8	29.3 ± 1.0	1.6 ± 0.7	27.7 ± 1.0	-1.2 ± 0.7	0.63	< 0.01
LDL-C:HDL-C ratio	2.1 ± 0.1	0.1 ± 0.1	2.1 ± 0.2	-0.1 ± 0.1	2.2 ± 0.1	0.1 ± 0.1	0.20	0.69
Apo-B:Apo-A1 ratio	0.6 ± 0.0	0.0 ± 0.0	0.6 ± 0.0	0.0 ± 0.0	0.6 ± 0.0	0.0 ± 0.0	0.23	0.19

[1]All values are means ± SEMs. Statistical differences between groups are based on linear mixed models with baseline values as covariates and adjustments for age, BMI and change in body fat. Pairwise comparisons were made using *post hoc* t-test on the linear mixed model with p-values adjusted for multiplicity. Abbreviations: apo, apolipoprotein; CHO: carbohydrate control; HDL-C, high density lipoprotein cholesterol; HDL-P, high density lipoprotein particle number; IDL-P, intermediate density lipoprotein cholesterol, IDL-P, intermediate density lipoprotein particle number; LDL-C, low density lipoprotein cholesterol; LDL-P, low density lipoprotein particle number; RED: reduced-fat cheese; REG: regular-fat cheese; VLDL-C, very low density lipoprotein cholesterol; VLDL-P, very low density lipoprotein particle number

Publikation:

Farinaz Raziani, Parvaneh Ebrahimi, Søren Balling, Arne Astrup, Anne Raben, Tine Tholstrup. **Effect of cheese consumption on LDL particle size distribution in individuals with risk markers of the metabolic syndrome: a sub-study from a randomized controlled trial.** *Re-submission to Journal of Nutrition.*

Samlet konklusion

Samlet set kan det konkluderes at der ikke opnås samme effekt af mættet fedt der spises som del af ostematricen som mættede fedt der spises udenfor matricen men sammen med mager ost på blodlipider og fækal fedtudskillelse. Resultaterne fra humanstudierne terne støtter ikke kostanbefalingen om, at en kost med fedtreduceret ost eller en kost med lavere indhold af ost men med flere kulhydrater skulle være mere hjertesund end en kost med fuldfed ost. Desuden tyder resultaterne på at det for de fleste individer med risikomarkører for det metaboliske syndrom, er rimeligt at inkludere fuldfed ost som en del af en sund kost. Endvidere lader langtidsmodnet ost til at kunne forbedre insulinfølsomheden, men resultaterne skal eftervises et randomiseret kontrolleret studie i mennesker.

11. Afvigelser

11.1 Fagligt

Der blev nedsat en styregruppe bestående af forskerne, repræsentanter fra MFF og repræsentanter for de internationale sponsorer der finansierede 50% af projektet. I denne styregruppe blev der truffet en del beslutninger med betydninger for delprojekternes endelige design.

Delprojekt A skulle ifølge den oprindelige projektbeskrivelse have været en sammenligning af forskellige fermenteringsmetoder i forskellige typer ost:" 4 different types of cheese (to be decided among hard cheeses, soft ripened cheeses and others) or similar amounts of fat from butter". I stedet blev det besluttet at dele projekt A op i to studier. Det ene skulle sammenligne forskellige fermenteringslængder indenfor den samme type ost, for at undersøge om der er forskel på kort- og langtidsmodnede oste. Det andet skulle undersøge ostematricens betydning, dvs. fed ost vs. mager ost sammen med smør og smør alene.

De to studier blev gennemført i grise som modeldyr, i stedet for mus, da grises hjerte-kar metabolisme og fordøjelsessystem ligner det humane mere end mus. For delprojekt B stod der i den oprindelige projektbeskrivelse at fokus ville blive besluttet ud fra resultaterne fra Delprojekt: "Based on the results of Study I (A) two types of cheese (with the most dissimilar metabolic effects) will be selected. High-fat as well as low-fat versions of these two types of cheese will be tested in humans". Da de to grisestuder imidlertid ikke fandt forskelle på LDL-kolesterol, som var det primære endepunkt, blev det besluttet at fokusere på en kost med fed ost sammenlignet med en kost med fede kødprodukter og en kost med lavere fedtindhold men højere kulhydratindhold.

Der var ingen faglige afvigelser for delprojekt D.

11.2 Økonomisk
Der har ikke været økonomiske afvigelser i projektet.

11.3 Tidsplan
Projektet er blevet forsinket ift. den oprindelige tidsplan pga. følgende: 8 mdr. pause under barsel; ophør i post doc ansættelse og tid brugt til at finde en løsning herpå (ansættelse af en PhD studerende); udfordringer med ostelevering fra udlandet (delprojekt B); samt udfordringer med at rekruttere tilstrækkelig mange forsøgsdeltagere (delprojekt D).

12. Resultaternes betydning, herunder for mejeribruget

Projektets resultater støtter op om fødevarematricen i ost har betydning for det metaboliske respons efter indtagelse af ost. Resultaterne peger på at der ikke er forskel på blodlipid-responset efter indtag af fed og mager ost, og at der derfor ikke er evidens for at anbefale forbrugerne at vælge den magre ost med henblik på at forebygge hjertekarsygdom. Ifølge resultaterne lader det desuden ikke til at man får den samme effekt af at spise mættet fedt udenfor oste-matricen, sammen med en mager ost som hvis fedtet dette er en del af ostematricen. Generelt synes en kost med ost mindre atherogen end en kost med lavere fedtindhold og højere kulhydratindhold, mens der ikke lader til at være stor forskel på en kost med ost og kød, på de målte sundhedsparametre på kort sigt.

Et interessant fund var at langtidsmodnet ost synes at kunne forbedre insulinfølsomheden og niveauet af cirkulerende frie fedtsyrer, og det ville være relevant at bekræfte dette fund i mennesker, samt at undersøge effekten af forskellige typer ostes modningsprofiler.

13. Formidling og vidensdeling vedr. projektet

Artikler i internationale tidsskrifter:
I alt er der publiceret 6 artikler i internationale peer-review tidsskifter baseret på projektets studier, og yderligere 2 manuskripter er under udarbejdelse.

1. Tanja K. Thorning, Anne Raben, Nathalie T. Bendsen, Henry H. Jørgensen, Pia Kiilerich, Ylva Ardö, Janne K. Lorenzen, Karsten Kristiansen, and Arne Astrup. **Importance of fat content of cheese-matrix for blood lipid profile, fecal fat excretion, and gut microbiome in growing pigs.** *International Dairy Journal, 2016;61:67-75*

2. Tanja K. Thorning, Nathalie T. Bendsen, Søren Krogh Jensen, Ylva Ardö, Tine Tholstrup, Arne Astrup, and Anne Raben. **Cheddar cheese ripening affects plasma non-esterified fatty acids and serum insulin concentrations in growing pigs.** *J Nutr 2015 Jul;145(7):1453-8.*

3. Tanja K. Thorning, Farinaz Raziani, Nathalie T. Bendsen, Arne Astrup, Tine Tholstrup, and Anne Raben. **Diets with high-fat cheese, high-fat meat or carbohydrate on cardiovascular risk markers in overweight postmenopausal women: a randomized cross-over trial.** *Am J Clin Nutr 2015 Jul Sep;102(3): 573-81.*

4. Tanja K. Thorning, Farinaz Raziani, Arne Astrup, Tine Tholstrup, and Anne Raben. **Reply to P Marckmann.** *Am J Clin Nutr 2016 Jan;103(1):292-3.*

5. Farinaz Raziani, Tine Tholstrup, Marlene D Kristensen, Matilde L Svanegaard, Christian Ritz, Arne Astrup, Anne Raben. **High intake of regular-fat cheese compared with re-duced-fat cheese does not affect LDL cholesterol or risk markers of the metabolic syn-drome: a randomized controlled trial**. *Am J Clin Nutr 2016; 104:973-981*

6. Farinaz Raziani, Tine Tholstrup, Marlene D Kristensen, Matilde L Svanegaard, Christian Ritz, Arne Astrup, Anne Raben. **Reply to JI Pedersen and B Kirkhus.** *Am J Clin Nutr 2017;105(4):1017.2-1018*

Populærvidenskabelige artikler:
Kort artikel i politikken over resultaterne fra delprojekt B (Tanja K. Thorning).

Kort artikel om delprojekt C i Frederiksberg Lokalavis (Tanja K. Thorning).

Kort artikel om delprojekt D i New York Times (Farinaz Raziani).

Kort artikel om delprojekt D på videnskab.dk (Farinaz Raziani).

Kort artikel om delprojekt D i BT (Farinaz Raziani).

Studenteropgaver:
Farinaz Raziani, specialeprojekt**: Effect of cheese consumption on cardiovascular risk markers – a randomized controlled, cross-over trial**

Mathilde L. Svanegaard, specialeprojekt: **The effect of high cheese consumption on risk markers of type-2 diabetes mellitus**

Indlæg ved faglige kongresser, symposier etc.:

University of Copenhagen Dairy Matrix Expert Meeting 2016 i Charlottenlund. Tanja K. Thorning afholdt en oral præsentation med titlen: “Dairy matrix and fat absorption – implications for body weight regulation and risk of type 2 diabetes and cardiovascular disease”. Heri indgik resultaterne fra Delprojekt A og B.

World Dairy Summit 2016 i Rotterdam. Tanja K. Thorning afholdt en oral præsentation med titlen: “Results of the Copenhagen Cheese Studies: Importance of the matrix.” Heri indgik resultaterne fra Delprojekt A, B, C og D.

Nordic Nutrition Conference 2016 i Gothenburg: Posterpræsentationer med resultater fra Delprojekt A og D (Tanja K. Thorning).

Congress of the European Atherosclerosis Society (EAS) 2015 i Glasgow: Præsentation af poster med resultater fra Delprojekt C (Tanja K. Thorning).

Landbrug og Fødevarer’s Ernæringsfokus symposium 2015 i København: ”D*et vi troede, vi vidste”*. Tanja K. Thorning præsenterede nye studier om mættet fedt inkl. Resultaterne fra Delprojekt C.

Nordic Dairy Congress 2017 i København: Præsentation af poster med resultater fra Delprojekt D (Farinaz Raziani).

Euro Fed Lipid Congress 2014 I Montpellier: Oral præsentation med titlen “High-fat Dairy Consumption and Cardiovascular Disease: Where Do We Stand?”. Heri indgik beskrivelse og formål af Delprojekt D (Farinaz Raziani) .

Mødeindlæg:
Dairy Research Consortium møde 2014 I Paris. Tanja K. Thorning præsenterede resultaterne fra delprojekt A, B og C.

Seminar om ost og sundhed ved Danmarks Mejeritekniske Selskab, 2014. Tanja K. Thorning præsentation af resultaterne for delprojekt A og B.

Tanja K. Thorning præsenterede projektet og resultaterne fra delprojekt A, B og C for studerende og ansatte ved the Human Nutrition Unit, Auckland University, Maj 2014.

Farinaz Raziani præsenterede projektet og resultaterne fra delprojekt D for studerende og ansatte ved Food science and technology, University of Davis, april 2016.

Andet:
Tanja K. Thorning, PhD forsvar: “Cardiometabolic effects of cheese intake - does matrix fat content and ripening duration matter?” KU, Frederiksberg, 20 November 2015.

Farinaz Raziani, PhD forsvar: ”Cheese consumption and risk factors for cardiovascular disease and the metabolic syndrome” KU, Frederiksberg, 15. Marts 2017.

Præsentation af delprojekt A-D i undervisning af 3. års bachelorstuderende samt 1. års specialestuderende (Tanja K. Thorning).

14. Bidrag til kandidat og forskeruddannelse

Projektet har bidraget til to PhD studerendes forskeruddannelser og resultaterne fra projektet indgår således også i to Ph.D. afhandlinger.

Tanja K. Thorning var på et 3 måneders forskerophold i foråret 2014 ved University of Auckland, New Zealand.

Farinaz Raziani var på et 3 måneders udlandsophold på University of Davis i foråret 2016.

15. Nye kontakter/projekter

Projektets resultater har medvirket til finansiering og arrangering af University of Copenhagen Dairy Matrix Expert Meeting, som medførte en konsensusartikel om Mejerimatricen der netop er publiceret i tidsskriftet *Am J Clin Nutr*.

Forståelse af mejerimatrice konceptet bl.a. baseret på projektets resultater har medvirket til et nyt forskningsprojekt omkring mejerimatricestrukturens betydning for postporandiel lipidaemia, finansieret af AFH

16. Underskrift og dato

Projektet er formeldt afsluttet, når projektleder og MFF-repræsentant (fx styre-gruppeformanden for den respektive styregruppe) har underskrevet slutrappor-ten.

Dato: 4. maj 2017 Projektleders underskrift: 

Dato: _____MFF-repræsentants underskrift:_____