Fat malabsorption produced by dairy calcium.

Lorenzen JK Kristensen M & Astrup A

Regulation of adiposity by dietary calcium

MICHAEL B. ZEMEL,*,1 HANG SHI,* BETTY GREER,* DOUGLAS DIRIENZO,† AND PAULA C. ZEMEL*

The FASEB Journal. 2000;14:1132-1138

Data from the National Health and Nutrition Examination Survey - NHANES III

Table 4. Effects of dietary calcium, and dairy intake on the risk of being in the highest quartile of body fat for women

Quartile of calcium and dairy consumption	Calcium intake (mg/day; mean ± SEM)	Dairy consumption (servings/month) mean ± SEM	Odds ratio of being in the highest body fat quartile
1	255 + 20	14.4 + 1.9	1.00
2	484 + 13	38 + 1.3	0.75 (0.13, 4.22)[b]
3	773 + 28	57.2 + 1.0	0.40 (0.04, 3.90)[b]
4	1346 + 113	102.8 + 3.6	0.16 (0.03, 0.88)[b]

a Model is controlled for race/ethnicity and activity level, with age and caloric intake as continuous covariates.
b 95% Confidence interval in parentheses

Calcium Intake and Body Weight

K. MICHAEL DAVIES, ROBERT P. HEANEY, ROBERT R. RECKER,JOAN M. LAPPE, M. JANET BARGER-LUX, KAREN RAFFERTY, AND SHARILYN HINDERS

J Clin Endocrinol Metab **85:** 4635–4638, 2000

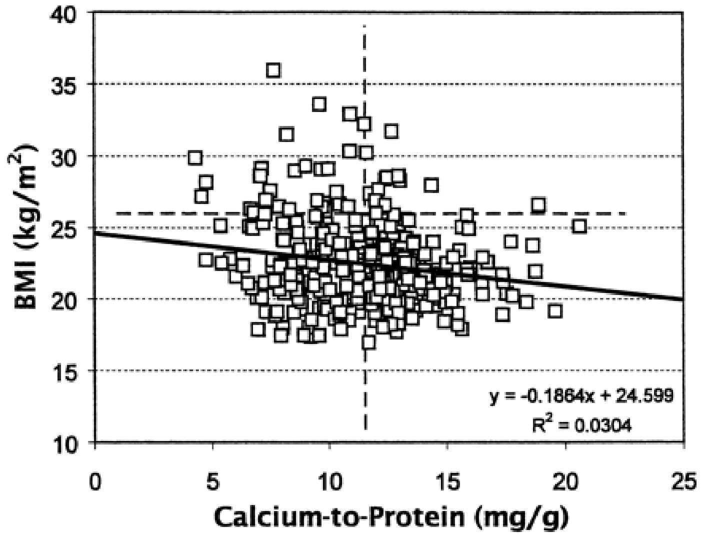


Figure 1. Plot of baseline BMI values (kg/m2) against entry calcium to protein ratio (mg/g) in 348 3rd decade women. The *horizontal dashed line* represents the boundary between normal and overweight, and the *vertical line* represents the median intake ratio for these young women. (Copyright 2000, Robert P. Heaney; used with permission.)

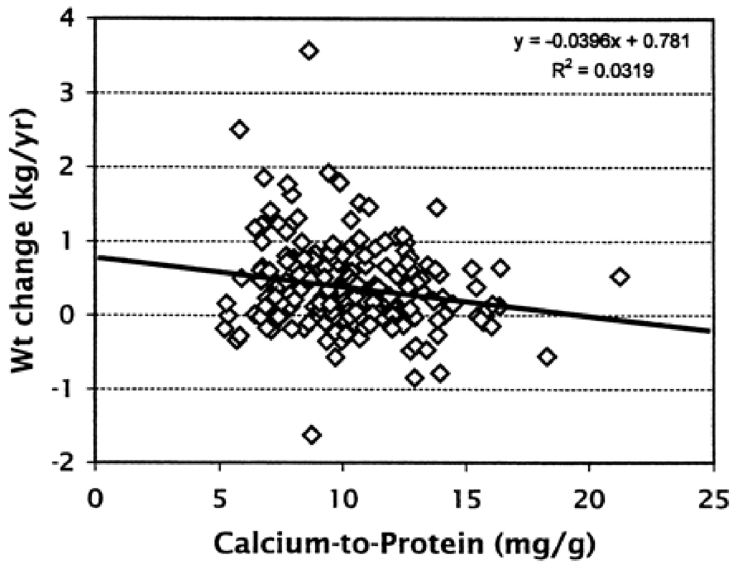


Figure 2. Plot of weight change (kg/yr) against average calcium to protein ratio (mg/g) in 216 middle-aged women. (Copyright 2000, Robert P. Heaney; used with permission.)

Estimates of the relationship indicate that a 1000-mg calcium intake difference is associated with an 8-kg difference in mean body weight and that calcium intake explains ;3% of the variance in body weight.

A systematic review of the effects of calcium supplementation on body weight

Rebecca Trowman1, Jo C. Dumville1, Seokyung Hahn2, David J. Torgerson1

British Journal of Nutrition (2006), 95: 1033-1038

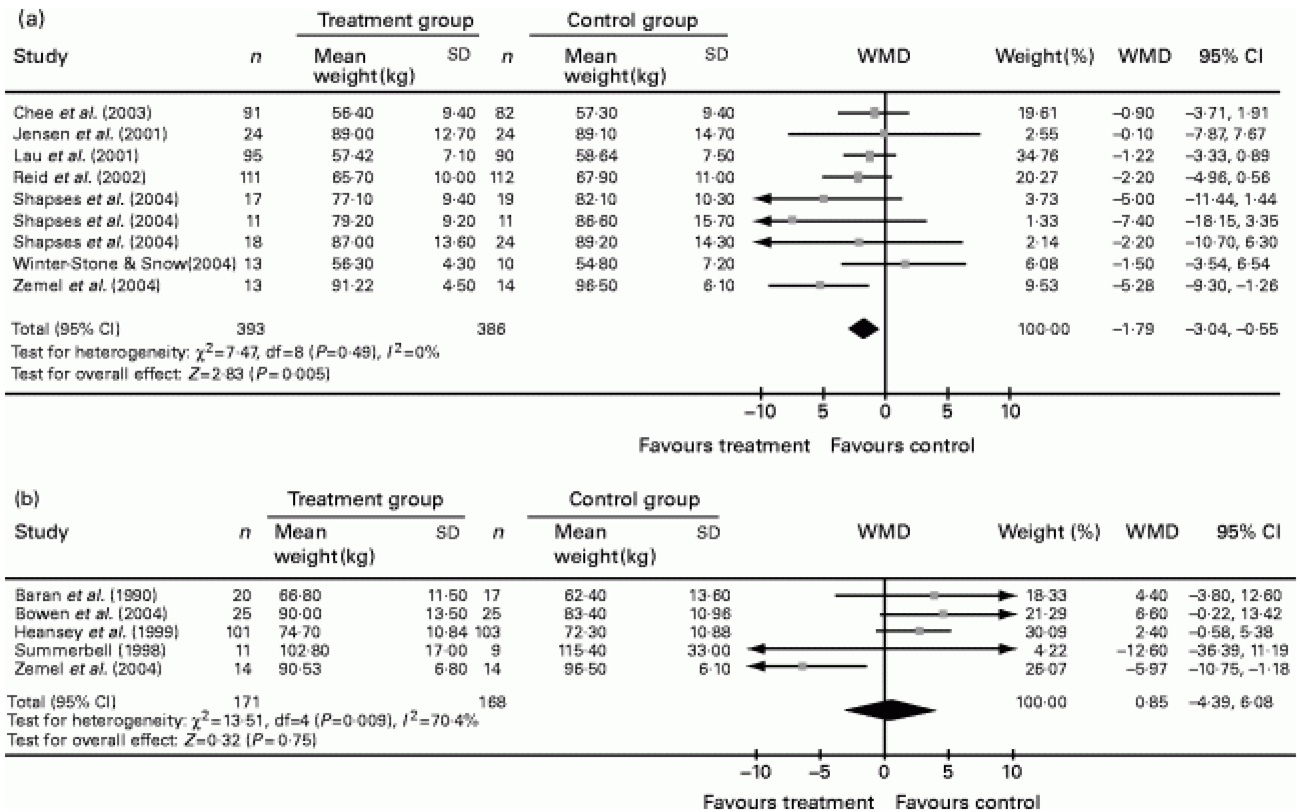


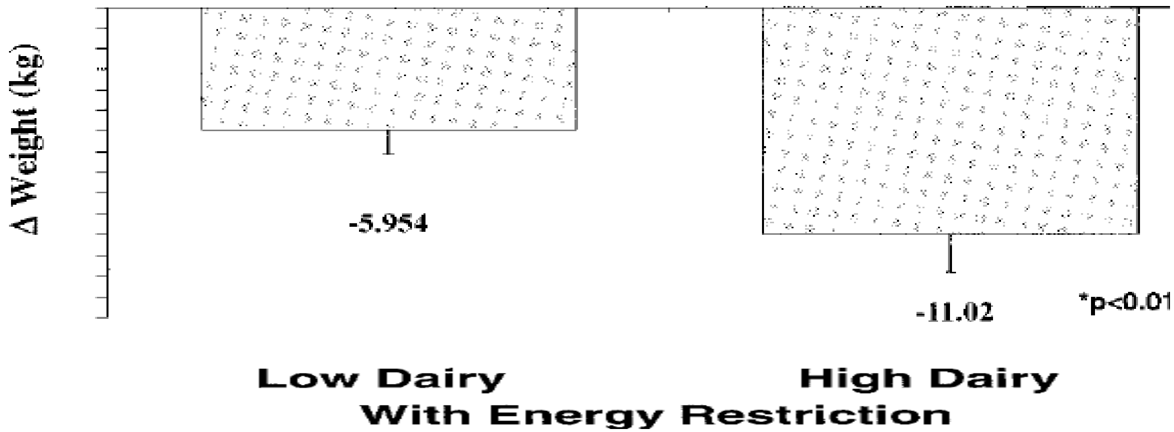
Figure 1. (a) Association between calcium supplementation and final weight. (b) Association between dairy supplementation and final weight. WMD, weighted mean difference; df, degrees of freedom; I^2, proportion of total variability explained by heterogeneity; Z, z score

Effects of Calcium and Dairy on Body Composition and Weight Loss in African-American Adults

Michael B. Zemel, Joanna Richards, Anita Milstead, and Peter Campbell

OBESITY RESEARCH Vol. 13 No. 7 July 2005

- 29 subjects with low habitual calcium intake
- Energy restristed diet (- 500 kcal/d) with:
  - low calcium (500 mg7d)/low dairy (<1 serving/d)
  - high calcium (1200 mg Ca/d)/high dairy (3 servings7d of dairy).
- 24 wk



International Journal of Obesity (2005), 1–10

0307-0565/05 $30.00
www.nature.com/ijo

PAPER

Effect of short-term high dietary calcium intake on 24-h energy expenditure, fat oxidation, and fecal fat excretion

R Jacobsen[1], JK Lorenzen[1], S Toubro[1], I Krog-Mikkelsen[1] and A Astrup[1]*

[1]*Department of Human Nutrition, Centre for Advanced Food Studies, The Royal Veterinary and Agricultural University, DK-1958 Frederiksberg C, Denmark*

BACKGROUND: Observational studies have shown an inverse association between dietary calcium intake and body weight, and a causal relation is likely. However, the underlying mechanisms are not understood.
OBJECTIVE: We examined whether high and low calcium intakes from mainly low-fat dairy products, in diets high or normal in protein content, have effects on 24-h energy expenditure (EE) and substrate oxidation, fecal energy and fat excretion, and concentrations of substrates and hormones involved in energy metabolism and appetite.
DESIGN: In all, 10 subjects participated in a randomized crossover study of three isocaloric 1-week diets with: low calcium and normal protein (LC/NP: 500 mg calcium, 15% of energy (E%) from protein), high calcium and normal protein (HC/NP: 1800 mg calcium, 15E% protein), and high calcium and high protein (HC/HP: 1800 mg calcium, 23E% protein)

To examine whether high and low calcium intakes from mainly low-fat dairy products, in diets high or normal in protein content, have effects on fecal energy and fat excretion.

Design

Randomized cross-over study

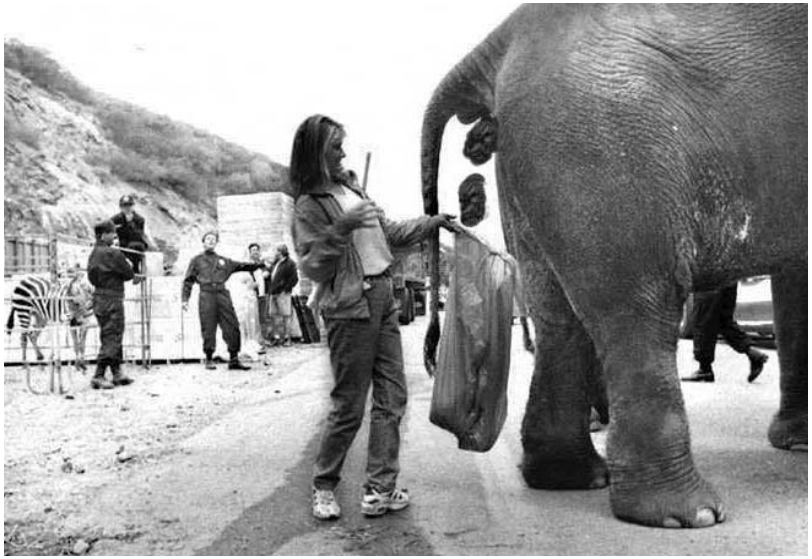
Subjects: 10 (8 female/2 male)

Three isocaloric one-week (adjusted for the subjects energy requirement) diets with:

HC/NP: High calcium (174mg/MJ) normal protein (15E%)
HC/HP: High calcium (187mg/MJ) high protein (23E%)
LC/NP: Low calcium (47mg/MJ) normal protein (15E%)

3 days feces collection:

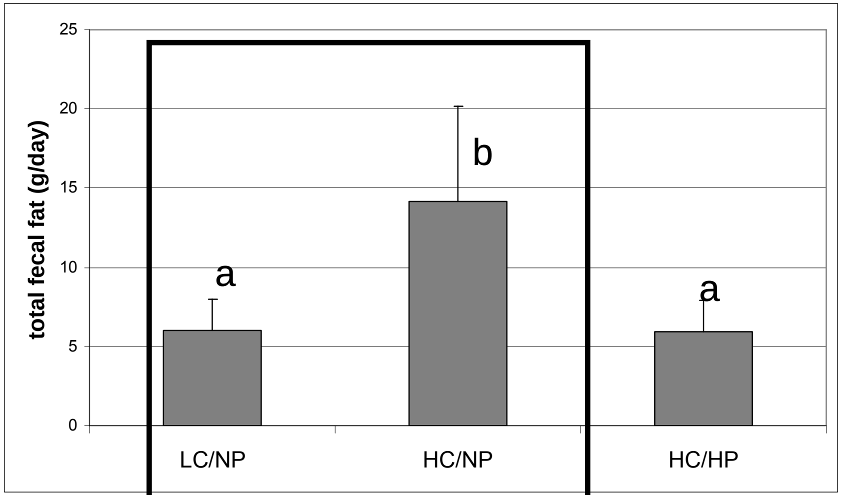
- calcium
- total fat
- total energy

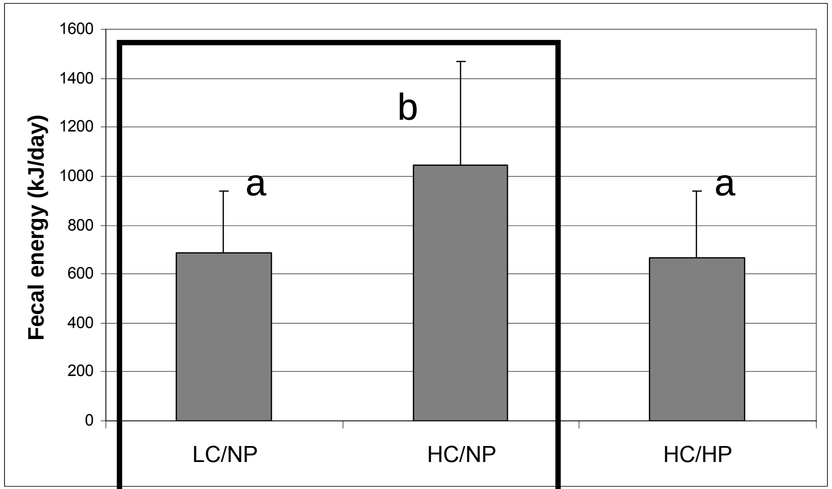


24 h urine collection:

- calcium
- nitrogen

Fecal fat and energy excretion





Values with different superscript letter are significantly different ($p<0.05$)

↑~137%

↑~50%

↑ 312 kJ ~86% ↑ 361 kJ

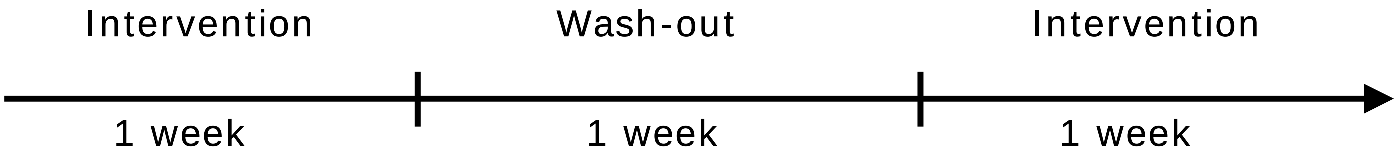
Design

Randomized cross-over study

Subjects: 11 (6 female/ 5 male)

Two isocaloric one-week diets (adjusted for the subjects energy requirement) with:

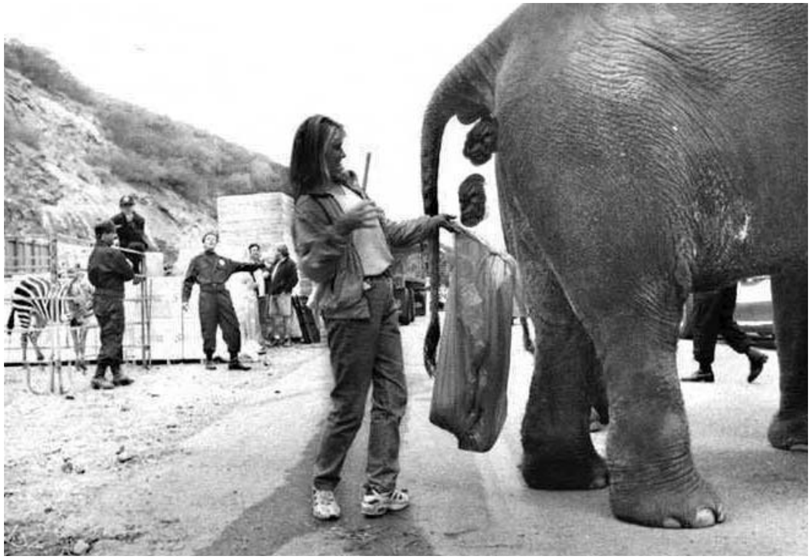
HC/NP: high calcium (177mg/MJ) and normal protein (15E%)
LC/NP: low calcium (57 mg/MJ) and normal protein (15E%)



published on http://www.bbc.co.uk

5 days feces collection:

- calcium
- total fat
- energy
- FA composition



24 h urine collection:

- calcium

Calcium intake and excretion

	Diet		P
	High-Ca	Low-Ca	Difference: ~1600 mg/d
Dietary Ca intake (mg/d)[1]	2287 ± 150	698 ± 46	
Fecal Ca (mg/d)[1]	2082 ± 211	650 ± 38	<0.0001
Urinary Ca (mg/d)[2]	109 ± 72	80 ± 55	0.0340
	96%	**105%**	

Values are presented as means ± SE. [1]n=11. [2]n=10.

Fecal fat and energy excretion

	Diet		
	High-Ca	Low-Ca	P
Total fat			
Dietary intake (g/d)	99.9 ± 6.4	93.8 ± 6.2	
Fecal excretion (g/d)			
unadjusted	11.5 ± 1.4	5.4 ± 0.5	<0.0001
adjusted for fat intake	11.1 ± 0.6	5.9 ± 0.6	<0.0001
Dietary fat excreted (%)	11.2 ± 0.8	5.7 ± 0.3	<0.0001
Total FA			
Dietary intake (g/d)	80.7 ± 5.2	83.1 ± 5.5	
Fecal excretion (g/d)			
unadjusted	8.0 ± 1.1	2.4 ± 0.3	<0.0001
adjusted for FA intake	8.1 ± 0.5	2.3 ± 0.5	<0.0001
Dietary fat excreted (%)	9.5 ± 0.8	2.9 ± 0.2	<0.0001
Energy			
Dietary intake (kJ/d)	12 902 ± 835	12 274 ± 806	
Fecal excretion (kJ/d)			
unadjusted	1 201 ± 148	946 ± 94	<0.01
adjusted for energy intake	1156 ± 40	991 ± 40	<0.01
Dietary energy excreted (%)	9.0 ± 0.6	7.6 ± 0.3	<0.01
Fecal dry weight (g/d)	55 ± 7	44 ± 4	<0.01
Fecal wet weight (g/d)	236 ± 38	197 ± 23	NS

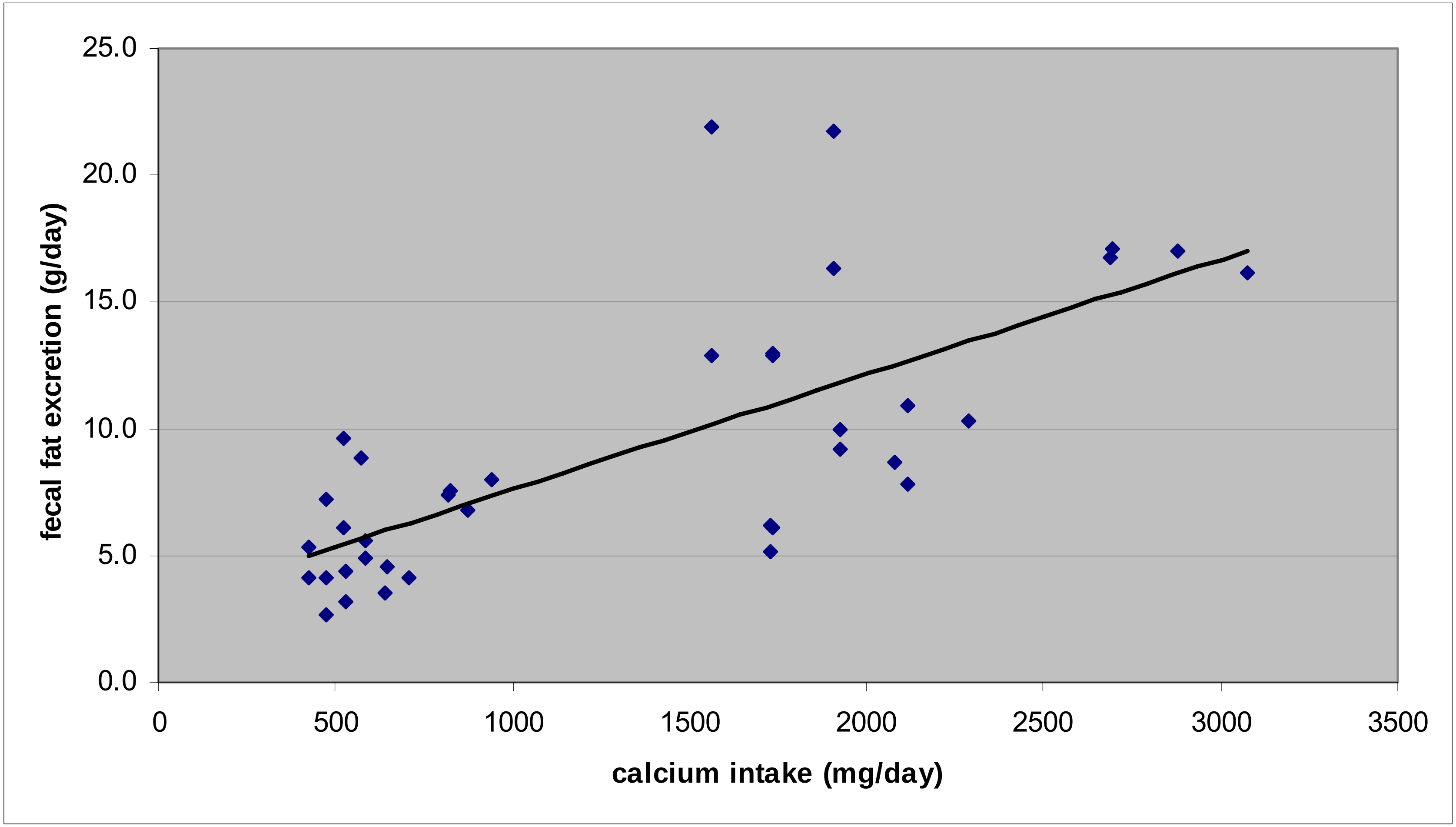
Values are means ± SE

↑ 232 kJ/d
↑ 6.1 g/d

↑ 5.6 g/d

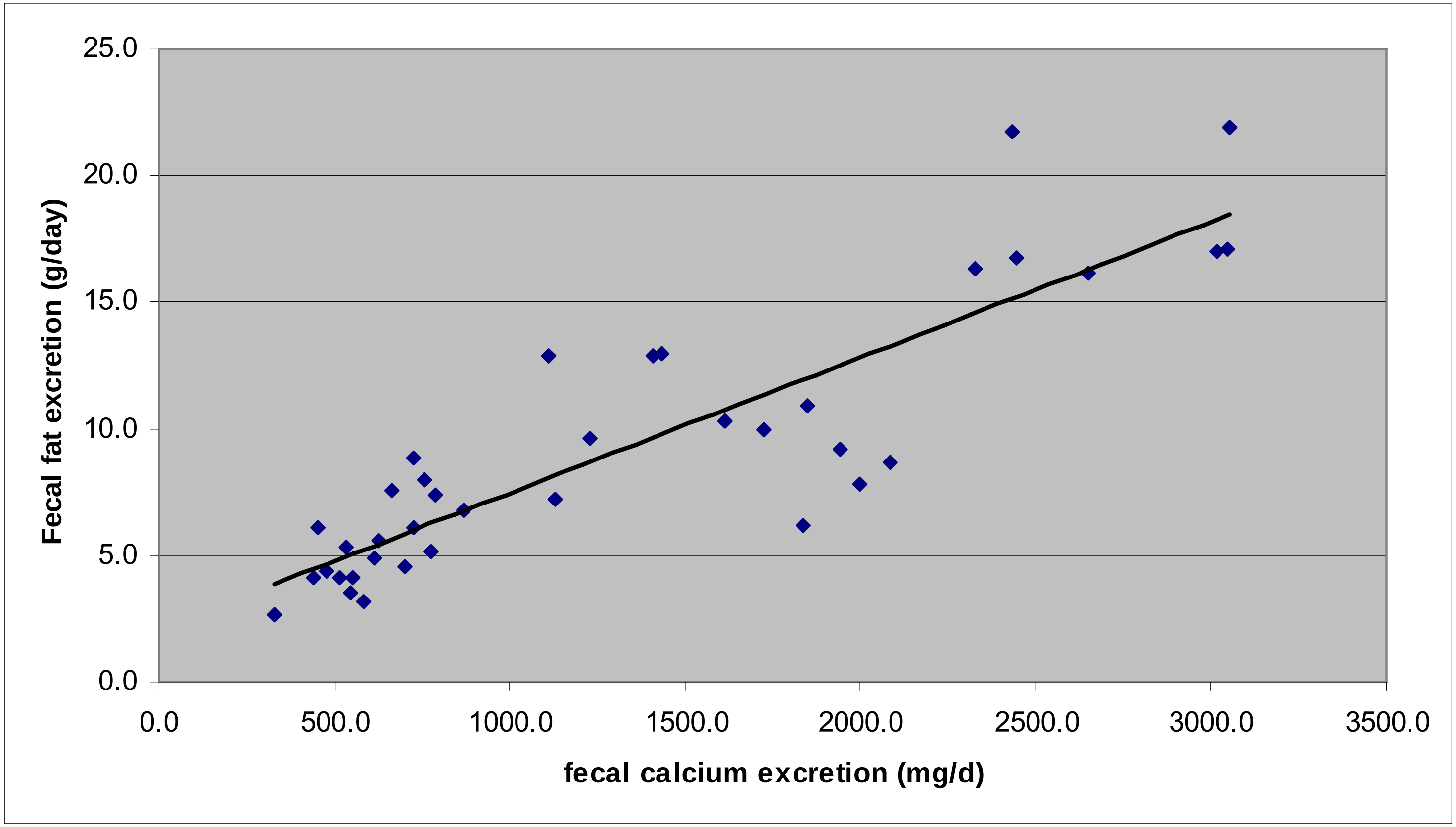
↑ 255 kJ/d

92%
91%



r= 0.713 P<0.0001

R^2=0.509



r= 0.873 P<0.0001

R^2=0.762

High Dietary Calcium Reduces Body Fat Content, Digestibility of Fat, and Serum Vitamin D in Rats

Emilia Papakonstantinou, William P. Flatt,* Peter J. Huth,† and Ruth B.S. Harris**

Obes Res. 2003;11:387–394.

Design

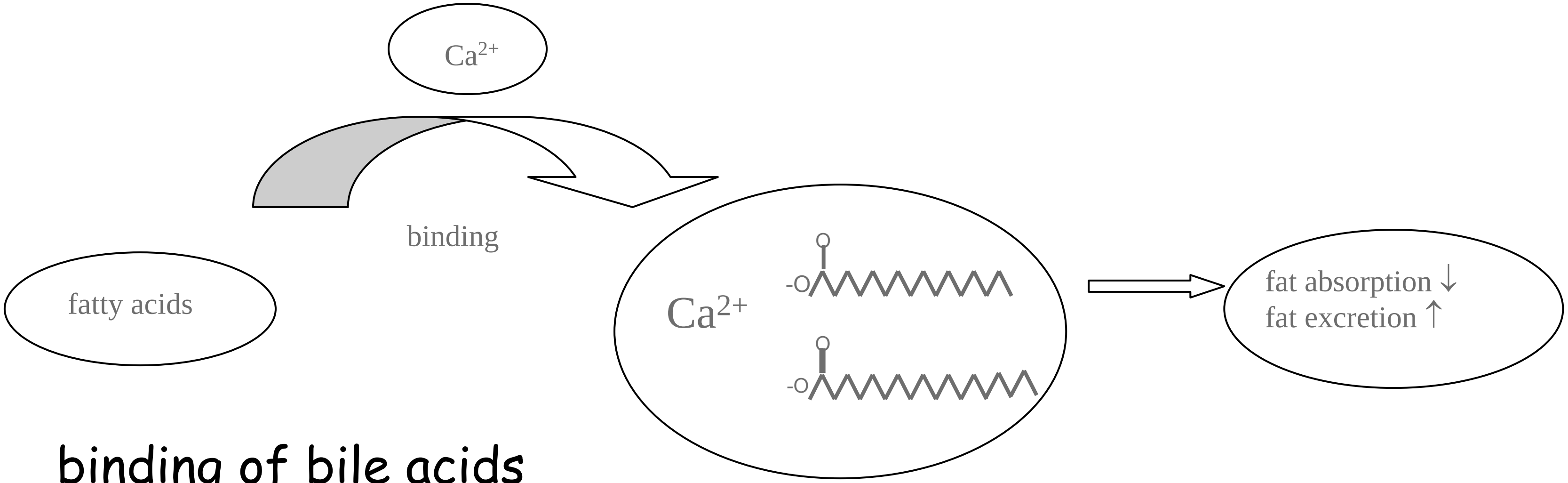
- 24 male Wistar rats
- high or low dairy calcium diet (25E% fat, 14E% protein)
- 85 days

Table 3. Fecal analysis

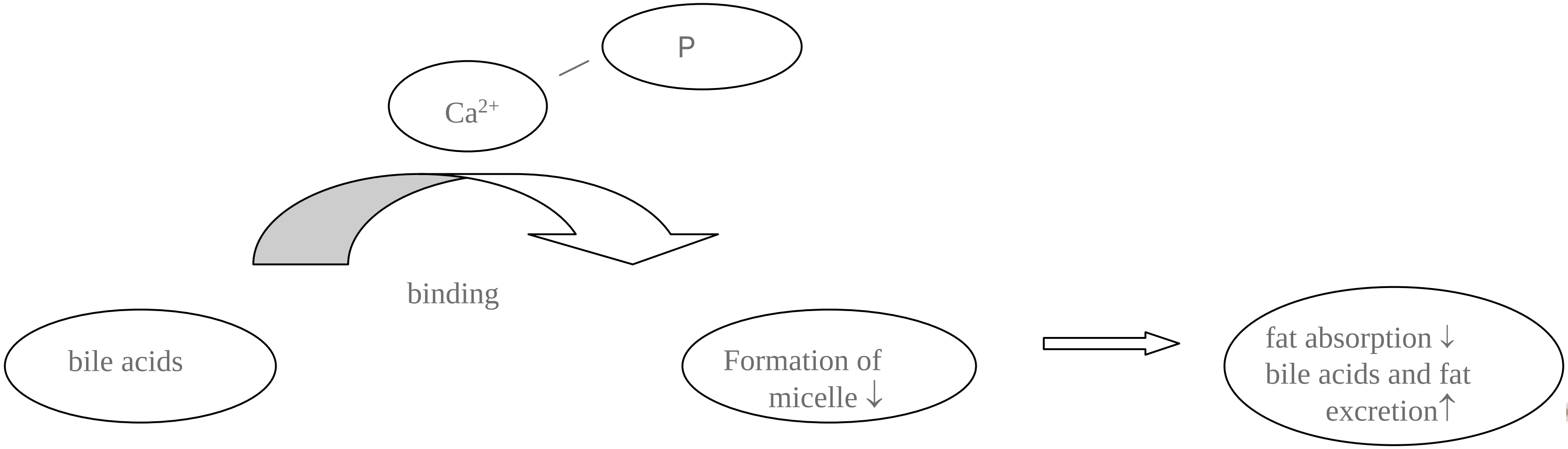
	Control	High-calcium	Statistical significance
Fecal weight (g/5 days)	8.9 ± 0.6	15.9 ± 0.6	$p < 0.01$
Fecal fat (%)	0.11 ± 0.01	0.13 ± 0.02	
Fecal fat (g/5 days)	0.95 ± 0.11	2.04 ± 0.25	$p < 0.001$
Fecal ash (%)	0.12 ± 0.001	0.37 ± 0.005	$p < 0.001$
Fecal ash (g/5 days)	1.1 ± 0.1	5.8 ± 0.2	$p < 0.001$

The feces from each rat were pooled from Days 48 to 52 of the experiment. Values are means ± SEM for groups of 12 rats. Statistically significant differences were determined by unpaired Student's *t* test, assuming equal variance.

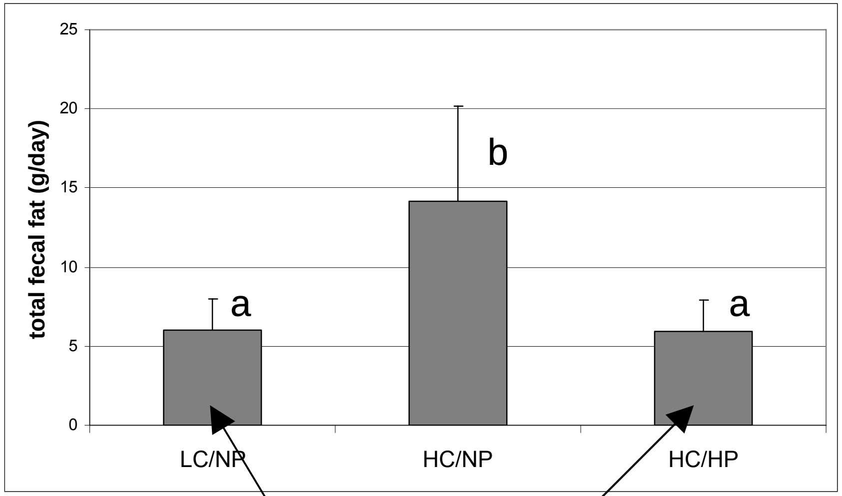
formation of insoluble calcium fatty acid soaps

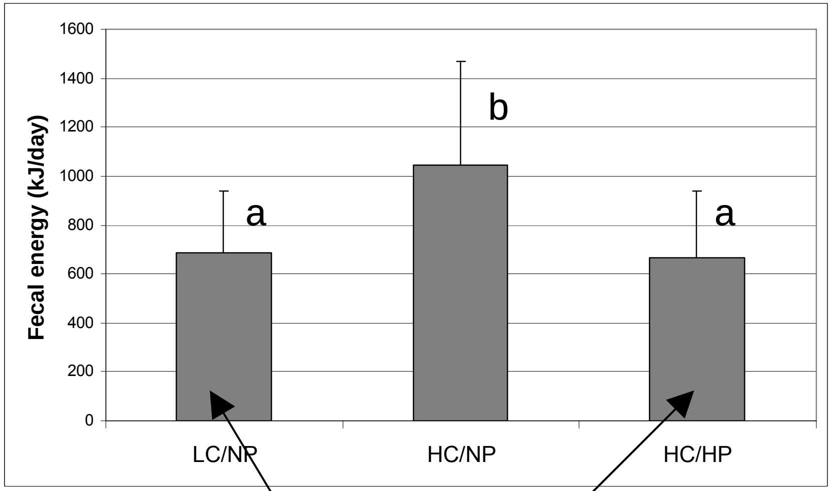


binding of bile acids



Fecal fat and energy excretion





Values with different superscript letter are significantly different ($p<0.05$)

International Journal of Obesity (2007) 1–9

0307-0565/07 $30.00
www.nature.com/ijo

ORIGINAL ARTICLE

An intervention study of the effects of calcium intake on faecal fat excretion, energy metabolism and adipose tissue mRNA expression of lipid-metabolism related proteins

N Boon[1], GBJ Hul[1], JHCH Stegen[1], WEM Sluijsmans[1], C Valle[2,3], D Langin[2,3,4], N Viguerie[2,3] and WHM Saris[1]

Table 1 Energy (MJ/day) and macronutrient composition, PS ratio, dietary fibre (g/day), calcium (mg/day) and vitamin D (μg/day) content of habitual and experimental diets (7 days) ($n=10$)

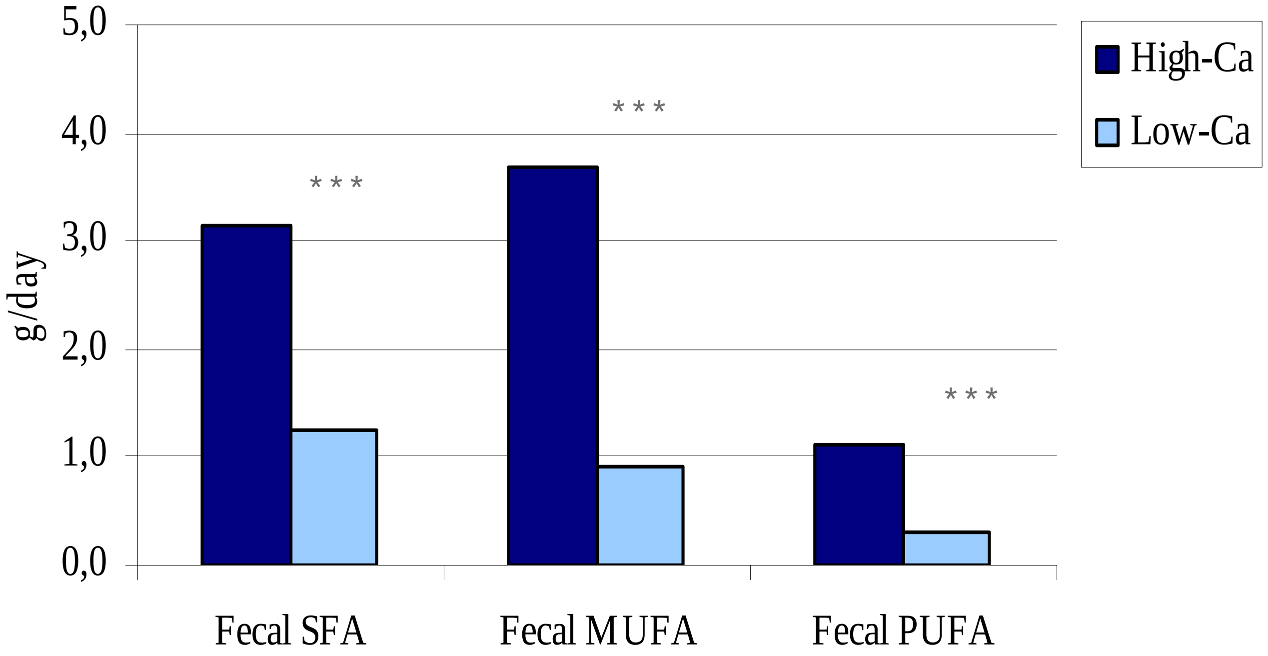
	Diet				
	Habitual	*400 s*	*1200 s*	*2500 s*	*1200 s*
Energy intake	10.2±0.9	10.4±0.4	10.5±0.4	10.4±0.4	10.4±0.4
%PRO	17.4±0.1[a]	20.1±0.1	20.2±0.1	20.5±0.1	20.1±0.2
%CHO	49.4±0.3[a]	45.3±0.3	45.2±0.2	45.0±0.1	45.1±0.2
%Fat	33.3±0.2	34.7±0.2	34.6±0.2	34.4±0.1	34.8±0.2
Dietary fibre	26.0±3.3	33.1±1.2	29.6±1.0	28.5±1.2	32.5±1.2
Calcium	1183±112[b]	348±9[c]	1242±5[d]	2545±13[c]	1242±5[d]
Vitamin D	1.8±0.4[e]	3.2±0.1	3.2±0.1	3.9±0.2	3.0±0.2

Table 3 Faecal energy and fat content

Diet	*Energy (kJ/day)*	*Fat (g/day)*
400 s	571±70	4.8±0.8
1200 s	584±76	7.2±1.1
2500 s	642±85	7.5±1.0
1200 s	631±69	6.7±1.2

All values are mean±s.e.m. Differences between the four diets were tested with a repeated measures ANOVA, a Scheffé test was used for *post hoc* analysis. None of these differences was statistically significant.

Fecal fatty acid composition



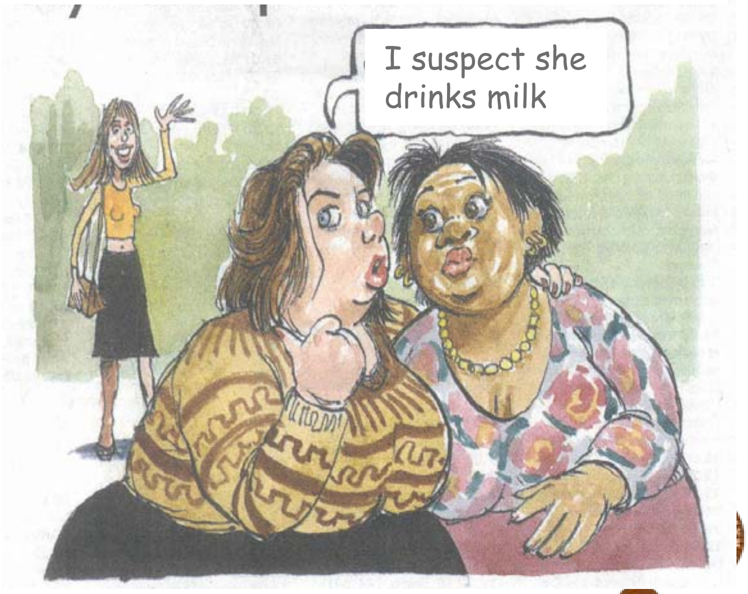
Means are adjusted for intake of SFA, MUFA and PUFA

Does it matter?

An increase in fat excretion of ~6 g/day corresponds to increased excretion of ~230 kJ/d or ~85 MJ/y

Assuming that an increased excretion of 14.64 MJ/year (3500 kcal) will result in a weight loss of about 0.45 kg/year (1 pound)

The increased fat excretion corresponds to a weight loss of ~2.5 kg/y



Original Research Communications

Effect of dairy calcium or supplementary calcium intake on postprandial fat metabolism, appetite, and subsequent energy intake[1–3]

Janne Kunchel Lorenzen, Sanne Nielsen, Jens Juul Holst, Inge Tetens, Jens Frederik Rehfeld, and Arne Astrup

ABSTRACT

Background: High calcium intake has been shown to increase fecal fat excretion.

intake or intake of dairy products and body weight, composition, or both (1–6). On the basis of a reanalysis of data from 4 observational studies, Davies et al (1) concluded that differences in

Am J Clin Nutr 2007;85:678–87.

The aim is to examine whether a high calcium intake from dairy products or from supplements affects postprandial fat metabolism

Design

Randomized cross-over study

Four isocaloric meals with:

HC: high calcium (182mg/MJ) from dairy products
MC: medium calcium (82 mg/MJ) from dairy products
LC: low calcium (15mg/MJ) from dairy products
SUPP: high calcium (182mg/MJ) from calcium supplement (calcium carbonate)

Protein: 15E%, Fat: 39E%, CHO: 46E%

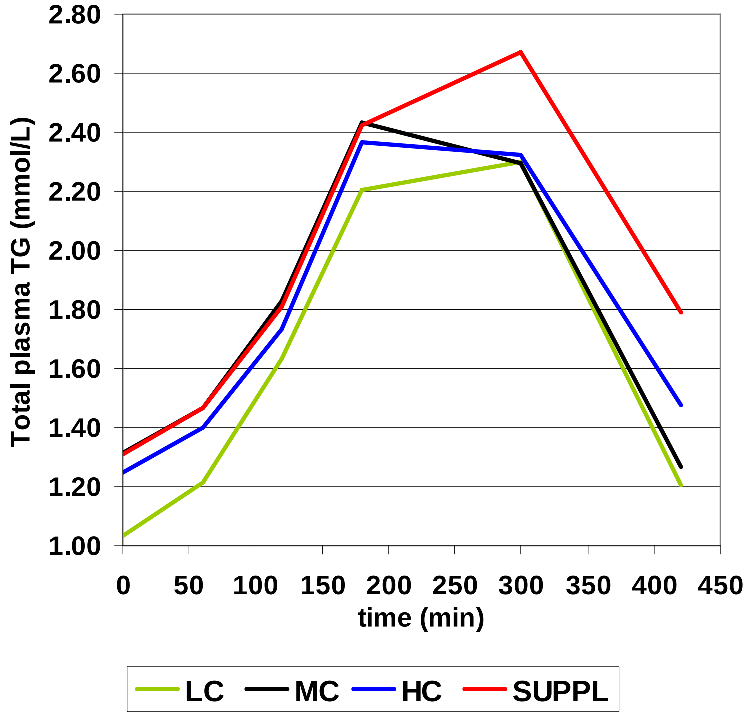
Blood | Intake of meal | Blood | Ad libitum meal

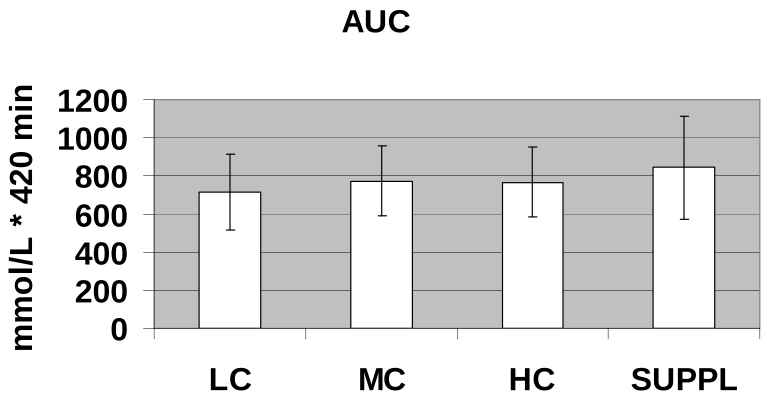
Time=0 | 15 min | Time= 60, 120, 180, 300, 420

Primary endpoints:

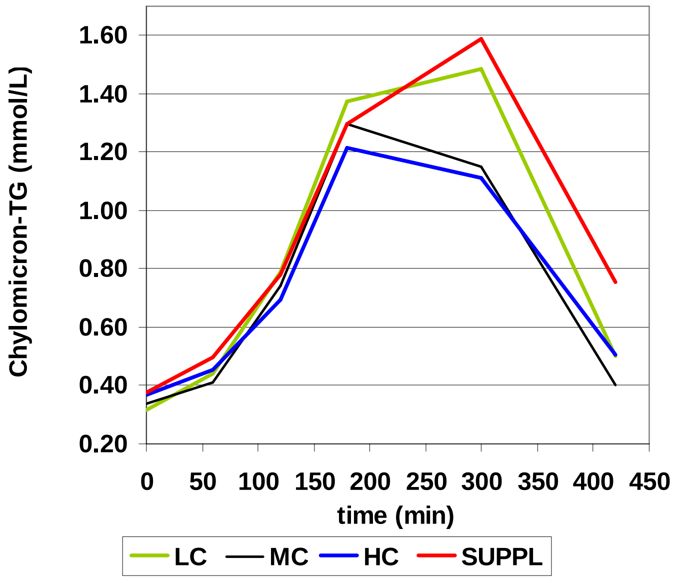
total TG, Chylomicron-TG, cholesterol (total and HDL)

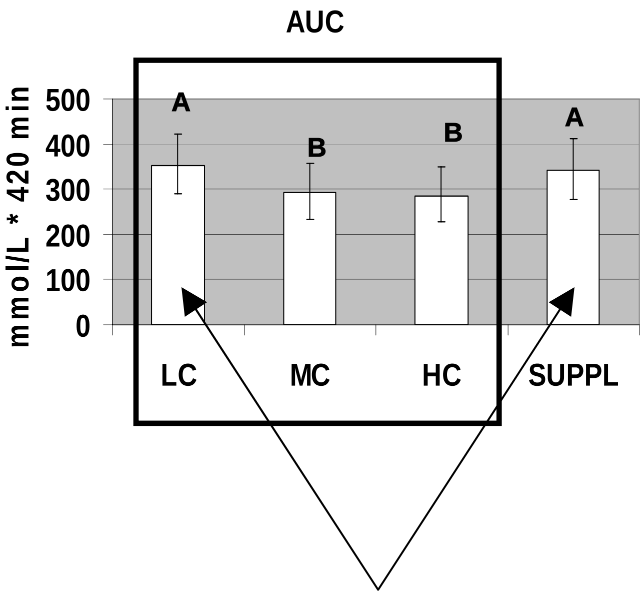
Total plasma triglycerides





Chylomicron triglycerides





Calcium and Dairy Acceleration of Weight and Fat Loss during Energy Restriction in Obese Adults

Michael B. Zemel, Warren Thompson,† Anita Milstead,* Kristin Morris,* and Peter Campbell**

OBESITY RESEARCH Vol. 12 No. 4 April 2004

- 32 obese subjects
- Energy restristed diet (- 500 kcal/d) for 24 wk with:
  - low calcium (400-500 mg/d + placebo)
  - high calcium (low calcium diet + 800 mg calcium carbonate)
  - High dairy (1200-1300 mg/d + placebo)

Table 3. Effects of dietary treatments on body weight and body fat

	Treatment		
	Low calcium	**High calcium**	**High dairy**
Initial body weight (kg)	103.1 ± 6.1[a]	99.8 ± 4.5[a]	101.6 ± 6.8[a]
Initial body fat (kg)	59.4 ± 4.7	48.4 ± 5.3*	50.7 ± 5.0*
Initial trunk fat (kg)	26.0 ± 1.7[a]	22.8 ± 3.1[a]	26.7 ± 3.0[a]
Initial waist circumference (cm)	104.6 ± 3.3[a]	100.6 ± 4.8[a]	103.4 ± 2.8[a]
Weight change (kg)	6.60 ± 2.58[a]	8.58 ± 1.60[b]	11.07 ± 1.63[c]
Weight change (% of initial)	6.4 ± 2.5[a]	8.6 ± 1.1[b]	10.9 ± 1.6
Fat change (kg)	4.81 ± 1.22[a]	5.61 ± 0.98[b]	7.16 ± 1.22[c]
Trunk fat change (kg)	1.38 ± 0.60[a]	2.94 ± 0.73[b]	3.74 ± 0.64[c]

Non-matching letter superscripts in each column denote significant differences ($p < 0.01$).
* Denotes significant difference ($p < 0.05$) in initial body fat.

Conclusion

An increase in dietary calcium intake, together with a normal protein intake:

- increased fecal fat and energy excretion
- reduced postprandial lipidemia

This is presumably due to formation of insolul
calcium fatty acid soaps and/or binding of
bile acids which impairs the formation of mice

This might contribute to explain why
dairy products may have a beneficial effect
on body weight.

Supplementary calcium carbonate does not extent a similar effect on fat absorption as calcium from dairy products.

This may be due to differences in the chemical form, or co-factors in dairy products

European Journal of Clinical Nutrition (2007), 1–7
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www.nature.com/ejcn

ORIGINAL ARTICLE

Whole flaxseeds but not sunflower seeds in rye bread reduce apparent digestibility of fat in healthy volunteers

M Kristensen[1], TW Damgaard[1], AD Sørensen[1], A Raben[2], TS Lindeløv[3], AD Thomsen[3], C Bjergegaard[4], H Sørensen[4], A Astrup[1] and I Tetens[5]

[1]*Department of Human Nutrition/Centre for Advanced Food Studies, Faculty of Life Sciences, University of Copenhagen, Frederiksberg, Denmark;* [2]*Novo Nordisk A/S, Bagsværd, Denmark;* [3]*Cerealia R&D, Schulstad Bread, Hvidovre, Denmark;* [4]*Department of Natural Sciences, Faculty of Life Sciences, University of Copenhagen, Frederiksberg, Denmark and* [5]*Department of Nutrition, National Food Institute, Technical University of Denmark, Søborg, Denmark*

Objective: The aim of this study was to measure the apparent digestibility of fat and the transit time upon addition of whole sunflower seeds (SU) or flaxseeds (FL) to rye breads consumed as part of a whole diet.
Method: In a randomized crossover study, gross intake and faecal excretion of fat and energy were measured in 11 young healthy men aged 24.6 $\pm$ 2.7 years. During each 7 days intervention periods, the subjects received a basal diet plus 300 g of one of four rye breads: (1) rye bread; (2) rye bread with SU; (3) rye bread with FL; (4) low extraction rate rye bread with SU and FL. Fat binding properties of rye breads (1) and (3) were determined by *in vitro* digestion.
Results: Addition of whole SU or FL to breads increased daily gross intake of fat and energy ($P < 0.001$). The amounts of

The aim was to examine the effect of adding sunflower seeds and flaxseeds to rye bread on digestibility of fat and energy and gut transit time

Design

Randomized crossover study with four 1-wk periods

Subjects:

11 young healthy males

Test diet:

low fiber basal diet + 300 g of one of four test breads per day:

Table 1 Composition of test rye breads (per 100 g bread)

	Rye bread C[a]	*Rye bread SU*[b]	*Rye bread FL*[c]	*Rye bread SU-FL*[d]
Energy (kJ[e])	910	1074	1008	1138
Fat (g[e])	1.8	5.1	4.0	7.3
Dietary fibre (g[e])	8.1	8.1	8.6	6.5
Whole grain rye flour	41	32	33	—
Squeezed whole grain rye	—	—	—	11
Sunflower seeds	—	6.2	—	6.8
Flax seeds	—	—	6.2	6.1

[a]Rye bread C: whole grain rye bread (Control).
[b]Rye bread SU: control + sunflower seeds (SU).
[c]Rye bread FL: control + flaxseeds (FL).
[d]Rye bread SU–FL: low extraction rate rye bread + SU + FL.
[e]The values for the chemical composition are gross values obtained by direct chemical analyses.

Transit markers:

At breakfast on day 4,5 and 6 the subjects were given transit markers

primary endpoints

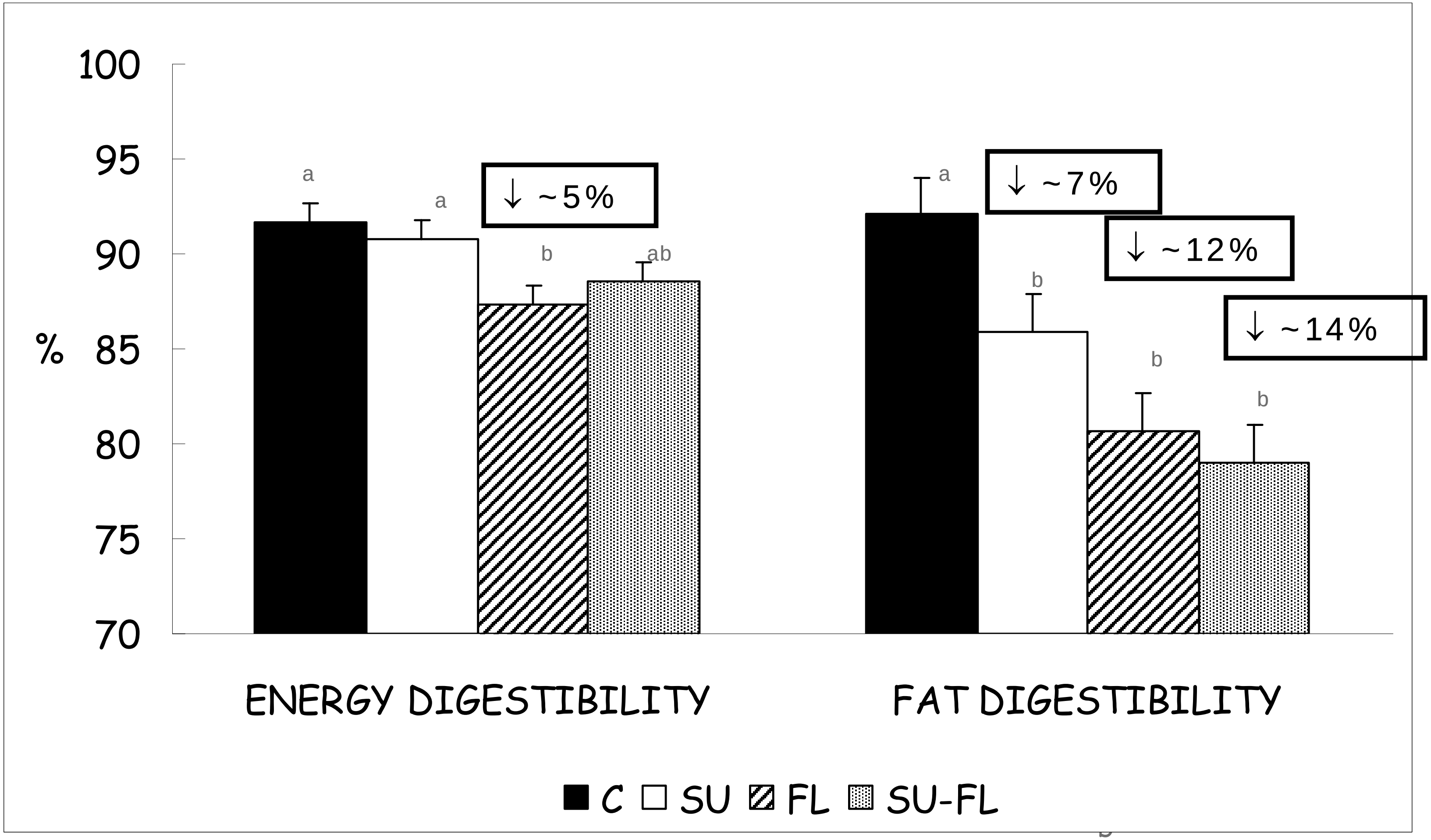
- total fat and energy excretion

(estimated based on transit markers and fat/energy in first stool on the day 7)

Results

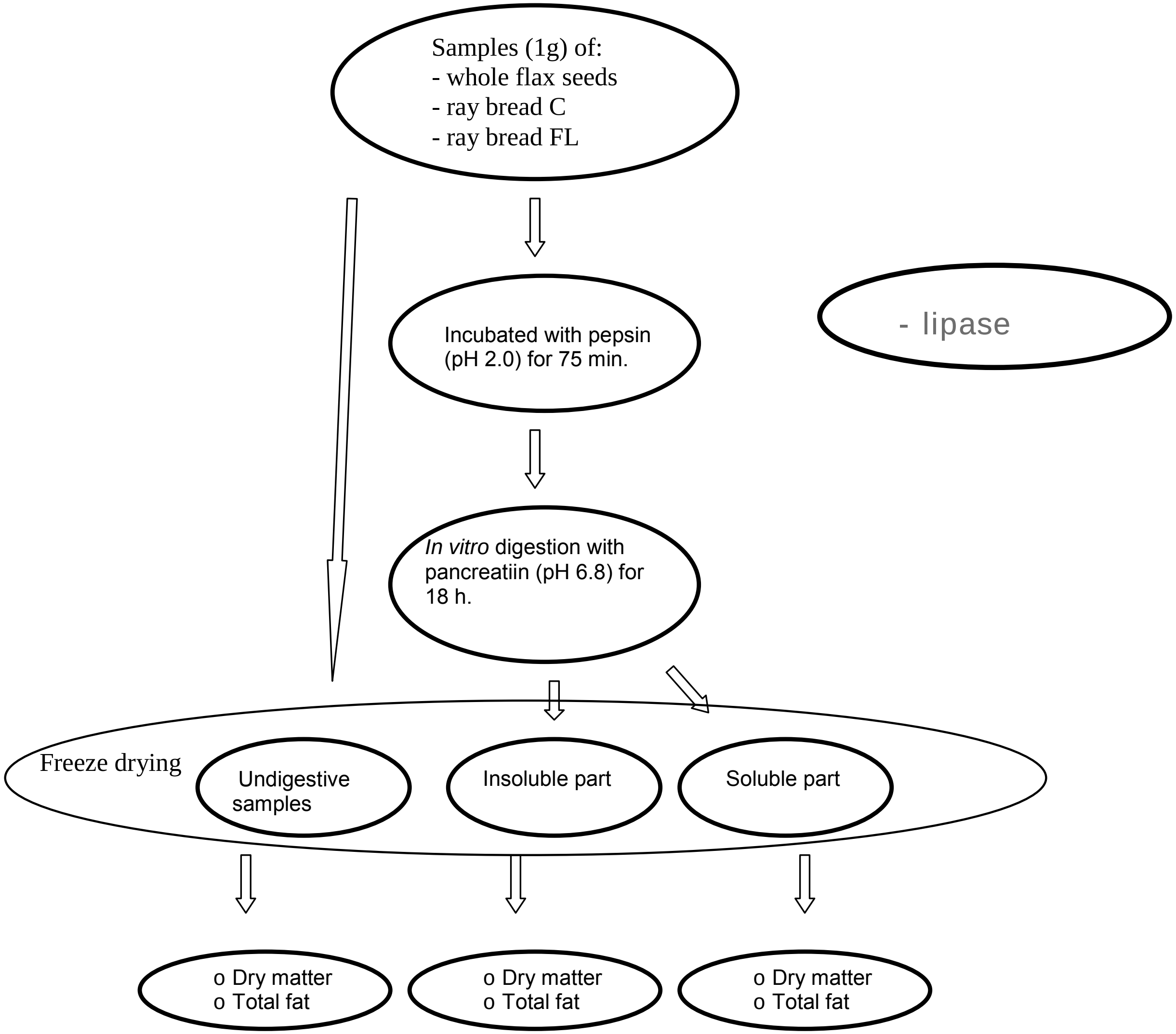
	Basal diet + C bread	Basal diet + SU bread	Basal diet + FL bread	Basal diet + SU-FL bread	p^1
Fecal dry weight, g/d	62.0 ± 6.6^{ac}	61.1 ± 6.6^{ac}	84.0 ± 6.6^{b}	72.5 ± 6.6^{bc}	0.026
Fecal water content, %	77.8 ± 1.01^{a}	74.8 ± 1.01^{b}	74.3 ± 1.01^{b}	70.1 ± 0.94^{c}	< 0.001
$\boxed{\text{Transit time, hours}}$	35.2 ± 2.0	31.6 ± 2.0	33.3 ± 2.0	34.8 ± 2.0	NS

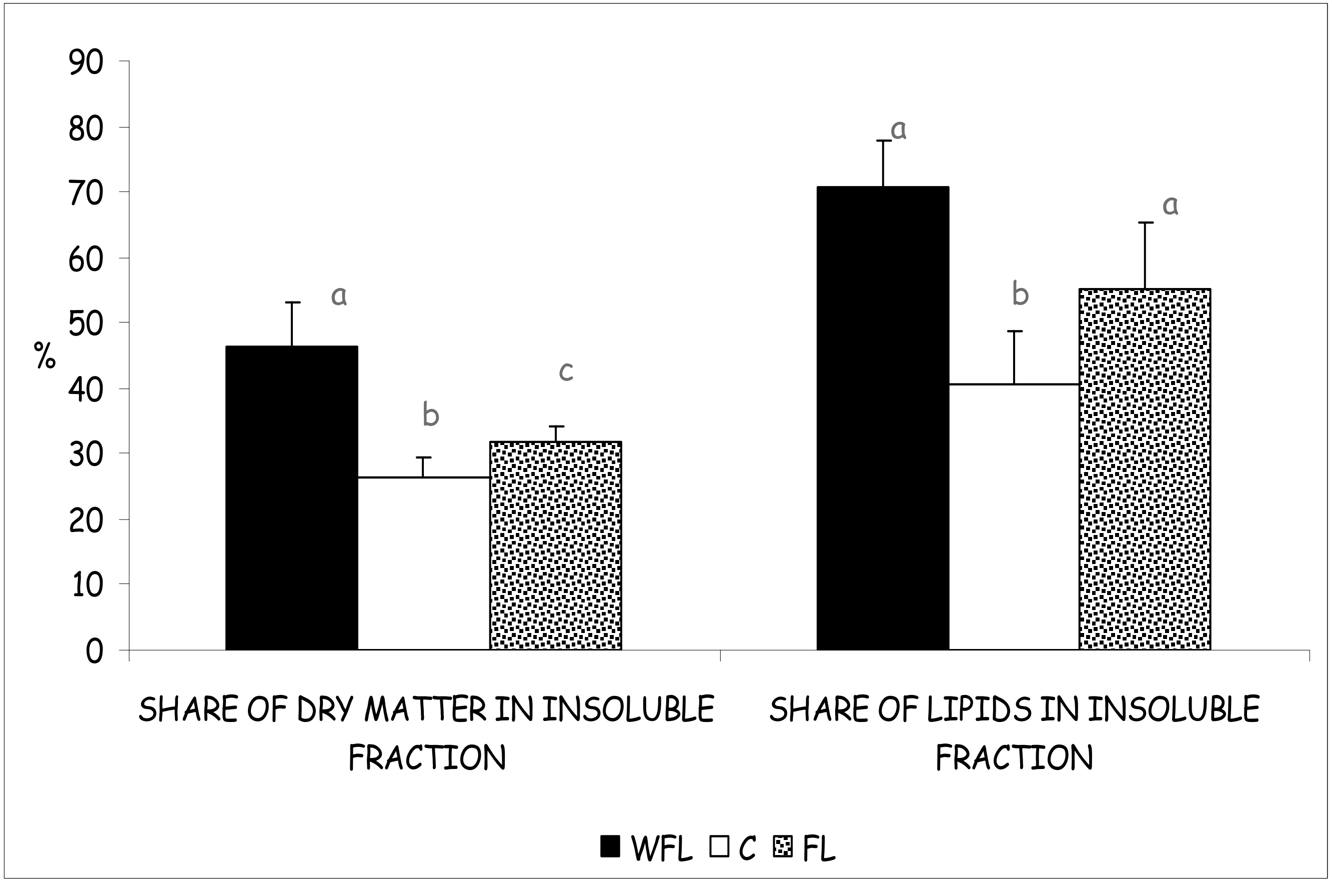
[1] Significant differences between values within a row are indicated with different superscript letters



Values with different superscript letter are significantly different ($p<0.05$)

Two-step *in vitro* digestion





Values with different superscript letter are significantly different ($p<0.05$)

Conclusion

- Flaxseeds and sunflower seeds decreases the fat digestibility
- Flaxseeds seems to have a more pronounced effect than sunflower seeds
- *In vitro* digestibility of whole flaxseeds, rye bread and rye bread with flaxseeds confirms that flaxseed decrease digestibility of fat
- This is presumably due to binding of fat in the gut and not inhabitation of lipase activity

Thank you for your attention

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