ANSC/NUTR) 618

LIPIDS & LIPID METABOLISM

Dietary fat and Cardiovascular Disease

I. Investigations in humans relating dietary fat intake to serum cholesterol

  A. Ansel Keys: the Keys Formula

  ΔCholesterol = 1.35*(2ΔS – ΔP) + 1.5 ΔZ

Where:

  ΔCholesterol = predicted change in serum cholesterol

  ΔS = % calories provided by saturated fat

  ΔP = % calories provided by polyunsaturated fat

  ΔZ = square root of the mg of dietary cholesterol per 1,000 calories

  B. Conclusions from Keys' research

     1. Saturated fatty acids increase plasma cholesterol (factor of 2).

     2. Polyunsaturated fatty acids decrease plasma cholesterol (factor of -1).

     3. Dietary cholesterol increases cholesterol (square root factor)

 C. A small proportion of the population is sensitive to dietary cholesterol.
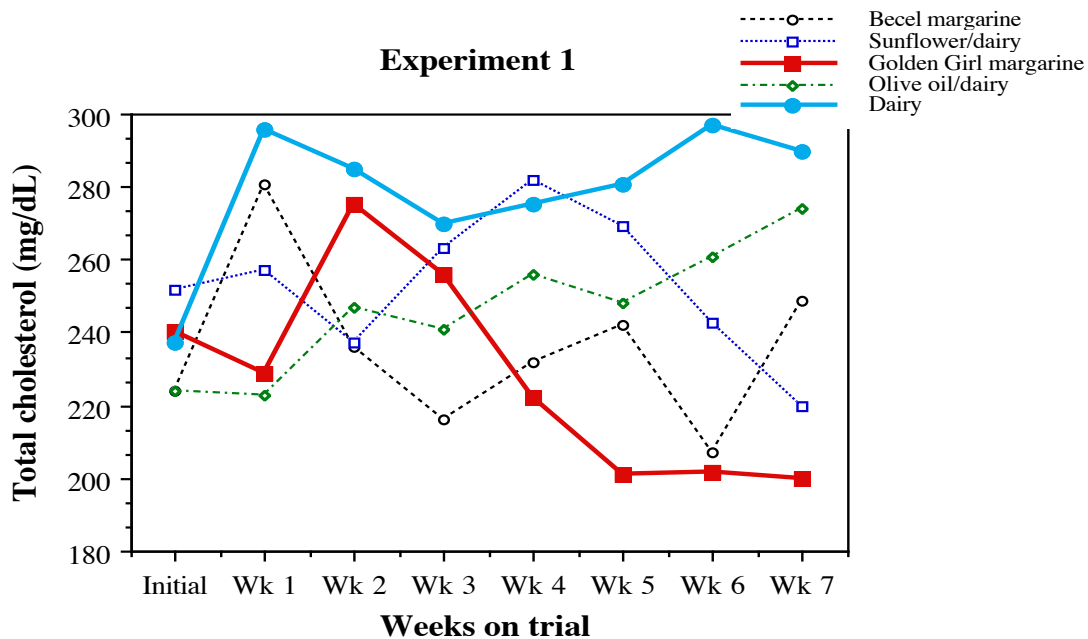
Changes in total cholesterol for SBS in response to diets varying in fatty acid composition. Oils were provided at 40% energy. The dairy diet was high in short-chain saturated fatty acids whereas the Golden Girl margarine was high in linoleic acid.

II. Human intervention trials – dietary oils

   A. Dietary oil supplements (a review by Kris-Etherton & Yu, 1997)

       1. Lauric, myristic, and palmitic acid increase total, LDL, *and* HDL cholesterol.

       2. *trans*-18:1 fatty acids increase total and LDL cholesterol and decrease HDL
          cholesterol.

       3. Stearic acid decreases total and LDL cholesterol but has no effect on HDL cholesterol
          (one study only – Grundy, 1988)

       4. Oleic and linoleic acid decrease total and LDL cholesterol and oleic acid increases
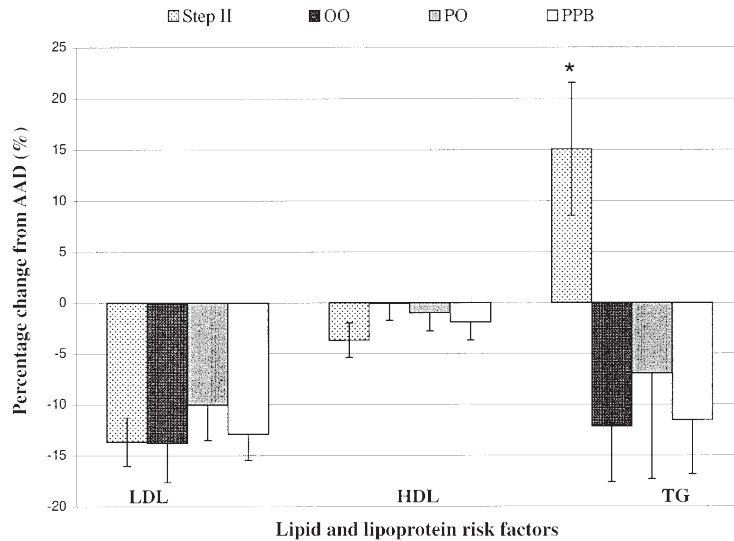   HDL cholesterol.
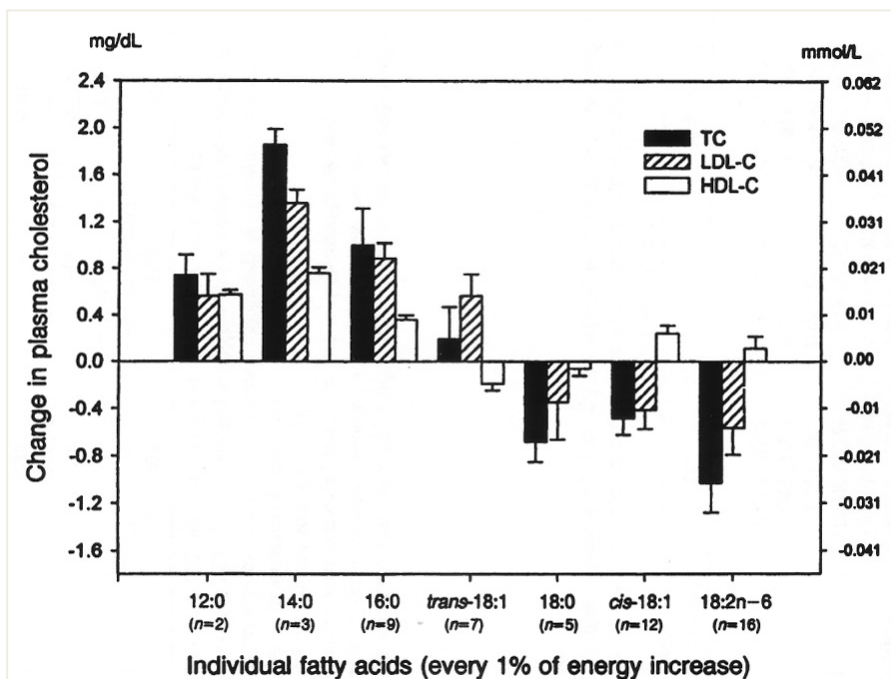
Changes in plasma cholesterol fractions in response to dietary fatty acids (all intervention trials reviewed)

Kris-Etherton and Yu, Am. J. Clin. Nutr. 1997

   B. Dietary oil supplements – Intervention trial (Kris-Etherton et al., 1997)

       1. Compared to the average American diet (AAD):

          a. Step II, olive oil, peanut oil, and peanut/peanut butter diets decreased LDL
          cholesterol and had no effect on HDL cholesterol

          b. Olive oil, peanut oil, and peanut/peanut butter diets decreased plasma TAG.

       2. *These results are similar to effects seen with dietary linoleic acid.*

Effects of four cholesterol-lowering diets [Step II, olive oil diet (OO), peanut oil diet (PO), peanut and peanut butter diet (PPB)] on LDL-cholesterol, HDL-cholesterol, and triacylglycerol (TG) concentrations ($n = 22$) compared with an average American diet (AAD). Kris-Etherton et al., Am. J. Clin. Nutr. 1999

III. Human intervention trials – dietary meats

   A. Comparison of lean chicken and lean beef (Scott et al., 1994)

      1. Composition of lean chicken and lean beef

         a. Chicken (100 g serving): 2.2 g SFA, 3.5 g MUFA, 1 g PUFA, 86 mg cholesterol

         b. Beef (100 g serving): 3.6 g SFA, 4.0 g MUFA, 0.4 g PUFA, 90 mg cholesterol

      2. Both chicken and lean beef lowered LDL cholesterol.

      3. Both chicken and lean beef lowered HDL cholesterol. This effect was greater after the chicken intervention.

   B. Comparison of lean beef to the Habitual American Diet (HAD) to the Beef in an Optimal Lean Diet (BOLD), BOLD+, and the Dietary Approaches to Stop Hypertension (DASH) diet (Roussell et al., 2012 – from Kris-Etherton's group)

      1. Composition of diets

         a. HAD: SFA, 12%; MUFA, 11%; PUFA, 7%; 287 mg cholesterol

         b. DASH: SFA, 6%; MUFA, 9%; PUFA, 8%; 188 mg cholesterol

         c. BOLD: SFA, 6%; MUFA, 11%; PUFA, 7%; 168 mg cholesterol

         d. BOLD+: SFA, 6%; MUFA, 12%; PUFA, 7%; 193 mg cholesterol

      2. Compared to the HAD diet:

         a. The BOLD, BOLD+, and DASH diets decreased LDL and HDL cholesterol.

         b. None of the diets affected plasma TAG.

Table 4. Plasma Lipid Levels at Baseline and Beginning and End of 5-Week Test*

Lipid	Baseline†	End of Stabilization Diet‡	End of Test Diets§	Lowering During Test Diets‖
Total cholesterol, mmol/L (mg/dL)				
Beef	6.66±0.33 (257.5±12.7)	6.98±0.47 (269.8±18.3)	6.44±0.56 (249.1±21.7)	0.54±0.40 (20.7±15.5)
Chicken	6.62±0.67 (255.9±25.8)	6.81±0.78 (263.4±30.1)	6.11±0.74 (236.1±28.6)	0.70±0.52 (27.3±20.1)
HDL cholesterol, mmol/L (mg/dL)				
Beef	1.27±0.29 (49.2±11.0)	1.25±0.28 (48.3±10.9)	1.19±0.27 (46.0±10.3)	0.06±0.11 (2.3±4.1)
Chicken	1.16±0.21 (44.9±8.1)	1.18±0.22 (45.4±8.4)	1.06±0.18 (40.8±6.9)	0.12±0.15 (4.6±6.0)
Triglyceride, mmol/L				
Beef	1.58±0.63	1.74±0.70	1.72±0.63	0.02±0.54
Chicken	1.56±0.56	1.54±0.59	1.46±0.55	0.08±0.28
LDL cholesterol, mmol/L (mg/dL)				
Beef	4.66±0.36 (180.4±13.9)	4.93±0.35 (190.6±13.7)	4.47±0.42 (172.7±16.4)	0.46±0.43 (17.9±16.4)
Chicken	4.74±0.48 (183.3±18.6)	4.93±0.68 (190.8±26.2)	4.38±0.63 (169.6±24.5)	0.55±0.35 (21.2±13.5)

*HDL indicates high-density lipoprotein; LDL, low-density lipoprotein. Values are mean±SD.
†Average of weeks 0 and 1.
‡Average of weeks 7 and 8.
§Average of weeks 12 and 13.
‖Average of weeks 7 and 8 minus average of weeks 12 and 13; this was calculated for each subject, then the means and SDs were calculated.

Effects of lean beef and chicken dietary interventions on total cholesterol, HDL cholesterol, plasma TAG, and LDL cholesterol in hypercholesterolemic men. Values are means ± SEM (n = 19 per treatment). Scott et al., Arch. Intern. Med. 1994
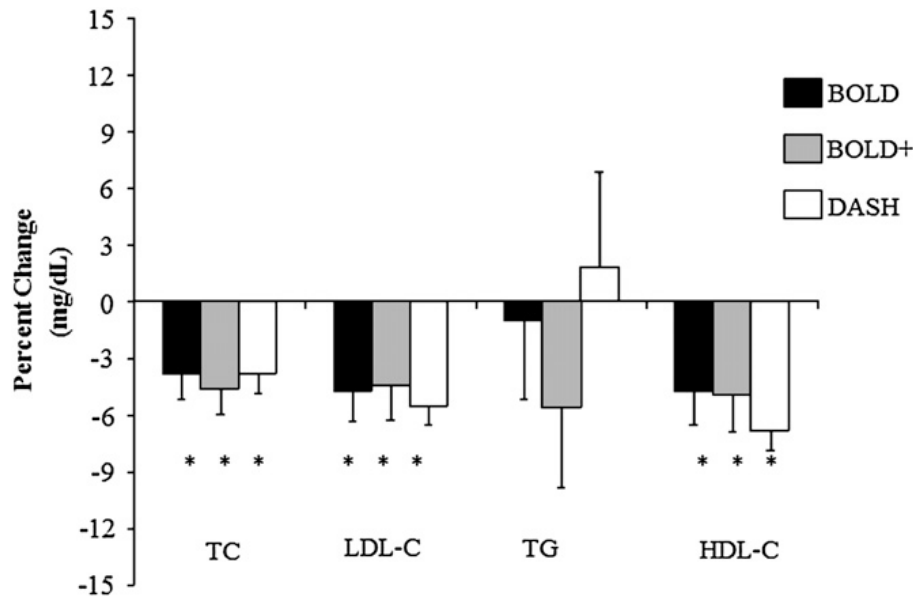

Change in lipids and lipoproteins. Mean percentage change (± SEM) from the HAD (HAD: n = 33; DASH: n = 35; BOLD: n = 34; and BOLD+: n = 34). *Significantly different from the HAD, P , 0.05. BOLD, Beef in an Optimal Lean Diet; BOLD+, Beef in an Optimal Lean Diet plus additional protein; DASH, Dietary Approaches to Stop Hypertension; HAD, healthy American diet. Roussell et al., Am. J. Clin. Nutr. 2012

C. Comparison of ground beef low in MUFA to ground beef high in MUFA in men (Gilmore et al., 2011)

   1. Composition of diets (per 9.2 MJ/d))

        a. Habitual: 30 g SFA, 26 g MUFA, 10 g PUFA, 353 mg cholesterol

        b. Low MUFA: 39 g SFA, 31 g MUFA, 11 g PUFA, 325 mg cholesterol

        c. High MUFA: 36 g SFA, 32 g MUFA, 12 g PUFA, 325 mg cholesterol
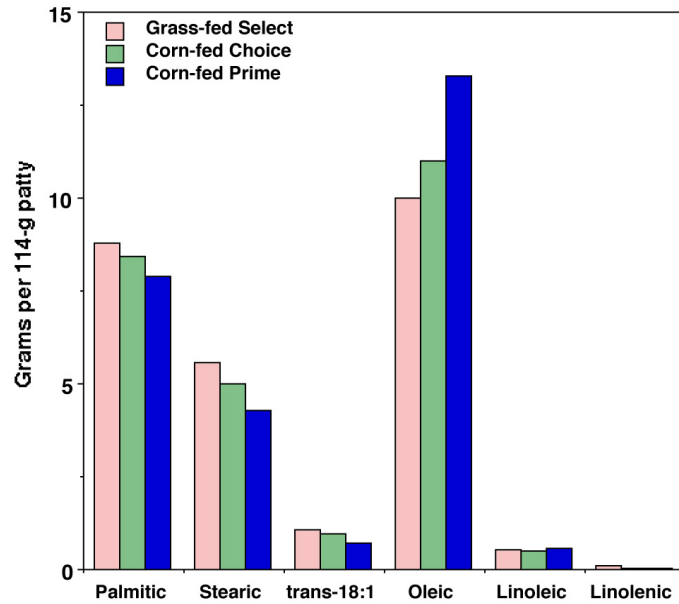
Fatty acid composition of ground beef from grass-fed cattle (USDA Select), cattle fed to USDA Choice, and cattle fed to USDA Prime. The ground beef from the Select and Prime cattle was used in the intervention trial of Gilmore et al., 2011.

    2. Results – Compared to the habitual diet:

        a. Neither ground beef type affected TAG or LDL cholesterol.

        b. The high-MUFA ground beef increased HDL cholesterol.
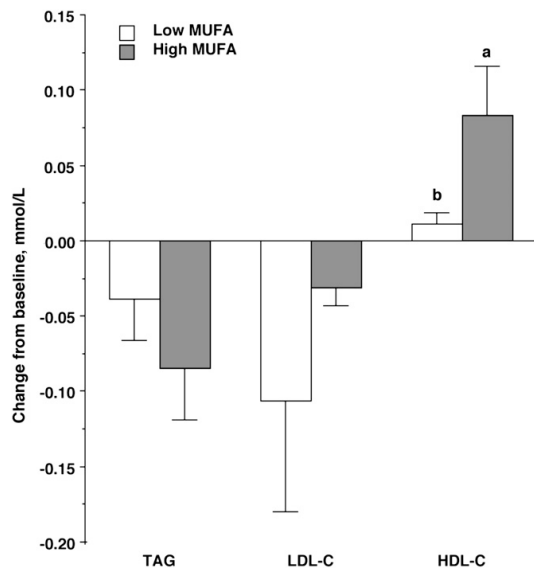
Absolute changes from baseline in serum TG, LDL-C, and HDL-C concentrations of men who consumed ground beef patties that were low or high in MUFA for 5 wk each. Data are means ± SEM, $n = 27$. Means without a common letter differ, $P < 0.05$.

Gilmore et al., J. Nutr. 2011

C. Comparison of ground beef low in MUFA to ground beef high in MUFA in men (Gilmore et al., 2011)

   1. Composition of diets (per 9.2 MJ/d))

      a. Habitual: 20 g SFA, 15 g MUFA, 8 g PUFA, 202 mg cholesterol

      b. Low MUFA: 24 g SFA, 19 g MUFA, 6 g PUFA, 274 mg cholesterol

      c. High MUFA: 24 g SFA, 22 g MUFA, 8 g PUFA, 240 mg cholesterol

   2. Results − Compared to the habitual diet:

      a. Both ground beef types increased LDL cholesterol, which was increased further by the single bout of exercise.

      b. The high-MUFA ground beef increased HDL cholesterol, which was attenuated by the single bout of exercise.
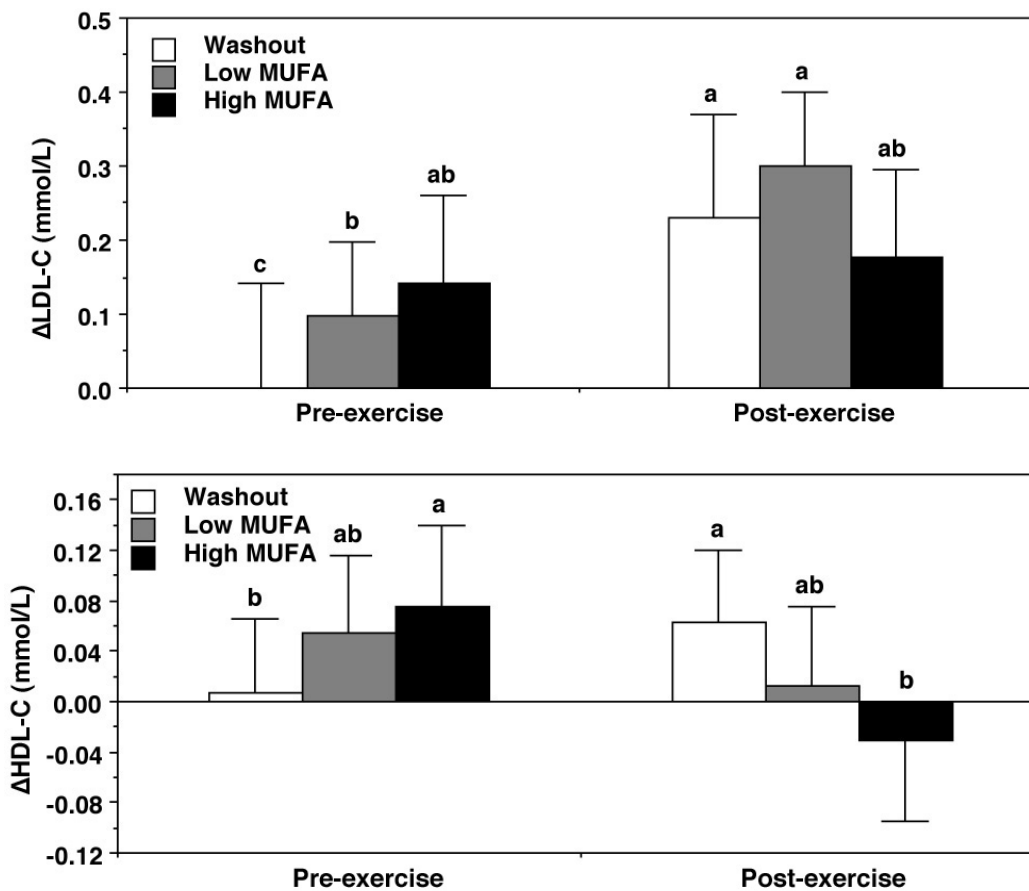
Absolute changes from baseline in plasma LDL-C (top) and HDL-C (bottom) of postmenopausal wome who consumed ground beef patties that were low or high in MUFA for 5 wk each. At the end of 5 wk, subjects participated in a short-term, intense bout of exercise. Data are means ± SEM, n = 17. Means without a common letter differ, $P < 0.05$. Gilmore et al., unpublished