Table . Corn Oil: Effect of Phytosterols, Design Type 1, Design Type 3 and Analytical Studies

Author/ Year	De-sign Type	Class	Quality (+,-,Ø)	Purpose/ Population Sample Size	Regimen	Primary Outcome Measures Results	Author's Conclusions/ *Reviewer's Comments (Italicized)*
Ostlund et al., 2002	**RCT, DB, CO**	**A**	**+**	**Purpose:** To determine effect of commercial corn oil, purified corn oil and purified corn oil with added corn oil phytosterols on chol absorption **Sample:** 25 healthy volunteers (20 females, 5 males) **Inclusions:** Healthy **Exclusions:** Medical and surgical illnesses; prescription meds	**Run-in Period:** None **TX/Duration:** Breakfast test meal with diff types of corn oil used; subj consumed each breakfast once (2 breakfasts total for each study) Chol absorption measured twice (2-wk interval) **Dose/Form:** STUDY 1 (N=10): 1) 35 g commercial (unpurified) corn oil (270 mg intrinsic corn oil sterols) then 2) 35 g purified corn oil triacylglycerol STUDY 2 (N=5): 1) 30 g purified corn oil triacylglycerol then 2) 30 g purified corn oil triacylglycerol + 150 mg corn oil phytosterols STUDY 3 (N=10): 1) 30 g corn oil triacylglycerol then	**Outcome Measures:** Chol absorption **Results:** Chol absorption 38.0 $\pm$ 10.2% higher after sterol-free corn oil than after unpurified corn oil (P<0.005) % change in chol absorption compared with purified sterol-free corn oil: Unpurified corn oil (270 mg sterols): -27.5 $\pm$ 7.4 (P<0.01) Purified corn oil with 150 mg sterols: -12.1 $\pm$ 3.7 (P=0.03) Purified corn oil with 300 mg sterols: -27.9 $\pm$ 9.1 (P=0.01)	**Author's Conclusions*:*** "Phytosterols comprising < 1% of commercial corn oil substantially reduced cholesterol absorption and may account for part of the cholesterol-lowering activity of corn oil previously attributed solely to unsaturated fatty acids" ***Reviewer's Comments:*** *None*

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					2) 30 g purified corn oil triacylglycerol + 300 mg corn oil phytosterols **Dietary Intake During Study:** Test meal (breakfast): 120 g sterol-free pudding containing skim milk powder, cornstarch, sugar, water and vanilla extract mixed with corn oil preparation; kcals (413-457) **Dietary Intake Assessment/Frequency:** NA **Study Visits/ Measurements:** Fasting plasma collected before and 4-5 d after consumption of test breakfast **Washout Period:** 2 wk		
Howell et al., 1998	**RCT, CO**	**A**	**+**	**Purpose:** To examine whether phytosterols in polyunsaturated oils account for their	**Run-in Period:** None **TX/Duration:** 3 diet TX of 10 d each	**Outcome Measures:** Plasma lipids Free cholesterol fractional synthetic rates Deuterium incorporation rates into	**Author's Conclusions:** "These results suggest that phytosterols are partly

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				differential action on lipid metabolism compared with monounsaturated oils **Sample:** 16 normolipidemic subj (8 females; 8 males) **Inclusions:** Plasma TC levels <4.9 mmol/L, LDL <3.0 mmol/L and TG <2.4 mmol/L; BMI <27 **Exclusions:** Smoker; use of meds known to affect lipid metabolism	separated by washout period Solid food diet (50% TE as CHO, 35% fat and 15% PRO) with 2/3 fat as either: 1) Corn oil 2) Olive oil 3) Olive oil + phytosterol mixture **Dose/Form:** 1) Corn oil (56.8% of total fat PUFA, 27.8% MUFA, 13.9% SFA, 830 mg/100 phytosterols) 2) Olive oil (9.3% of total fat PUFA, 72.9% MUFA, 17.8% SFA, 225 mg/100 phytosterols) 3) Olive oil plus phytosterol mixture (0.4 g phytosterol/1000 kcal – double that contained in corn oil mixture) **Dietary Intake During Study:** Total fat: 35% TE with 2/3 fat as test oil PUFA (% TE): Corn oil: 17.0 Olive oil: 4.3	esterified chol **Results:** TC conc (mmol/L) higher after olive oil diets (*P*=0.0001) than corn oil diet: Corn oil: 3.32±0.11 Olive oil: 3.71±0.15 Olive oil + phytosterol: 3.65±0.13 NS diff bet olive oil and olive oil + phytosterol diets (mean diff: 0.06 mmol/L; 95% CI, -0.13 to 0.25 mmol/L) LDL conc (mmol/L) higher after olive oil diet (*P*<0.05) than corn oil diet: Corn oil: 1.99±0.12 Olive oil: 2.17±0.12 Olive oil + phytosterol: 2.11±0.12 (NS diff from corn diet or olive oil diet) Plasma TG conc (mmol/L) higher after olive oil diet (*P*<0.05) than corn oil diet: Corn oil: 0.70±0.04 Olive oil: 0.85±0.07 Olive oil + phytosterol: 0.80±0.06 (NS diff from corn diet or olive oil diet)	responsible for the differences in plasma cholesterol levels and synthesis observed between polyunsaturated and monounsaturated oils" ***Reviewer's Comments:*** *None*

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					SFA: ~7% TE Chol: 129 mg/1000 kcal **Dietary Intake Assessment/Frequency:** Meals provided by metabolic research unit **Study Visits/ Measurements:** Wt measured daily Fasting blood samples collected on d 9 and 10 of each dietary phase **Washout Period:** Habitual ad lib diet consumed for ≥ 2 wk	NS diff bet HDL conc after any diets Females had consistently higher (P=0.03) plasma HDL conc than males over each TX period, but both genders responded similarly to diet TX with no within-group diff Fractional synthetic rates after corn oil TX (0.061±0.009 pools/d) higher (P<0.05; 0.034 pools/d; 95% CI, 0.008 to 0.059 pools/d) than those after olive oil TX (0.028±0.004 pools/d), but NS diff from olive oil + phytosterol TX Deuterium incorporation rates into esterified chol NS diff bet TX **% change not provided**	
Kohlmeier et al., 1988	**RCT, CO**	**A**	**+**	**Purpose:** To examine effect of typical fat-modified diets on serum lipids, lipoproteins and apolipoproteins and to compare efficacy of 2 commonly used oils with high linoleic acid content, sunflower oil and corn oil	**Run-in Period:** 2-wk dietary intakes monitored (self-transcribed and dictated protocol methods) **TX/Duration:** Randomized to fat-modified diets of either corn oil or sunflower oil TX then CO to other TX	**Outcome Measures:** Lipids Lipoproteins Apolipoproteins Fecal sterol balance **Results:** % median relative diff bet normal and fat-modified diets: TC: -21.6 (P≤0.001) LDL: -23.3 (P≤0.001) TG: 5.7 (NS)	**Author's Conclusions:** "While changes of all measured parameters pointed in the same direction, serum total and LDL cholesterol levels were significantly lower with corn oil than with the sunflower oil"

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				Sample: 15 nonobese, healthy men **Inclusions:** Middle-aged men; higher than ave plasma chol levels (5.2-6.7 mmol/L) **Exclusions:** Liver, kidney or metabolic disorder; habitual alcohol consumption >30 g/d	4 wk each TX diets alternated with 4 normal diet periods 6 wk each **Dose/Form:** 1) TX 1: 35 g corn oil, 40 g corn-oil margarine and 35 g hidden fat 2) TX 2: 35 g sunflower oil, 40 g sunflower-oil margarine and 35 g hidden fat Test fats used by subj in normal manner of cooking or as bread spread Subj given list of permitted foods **Dietary Intake During Study:** Total fat (g/d): Corn oil: 117 Sunflower oil: 119 Normal diet: 96-111 PUFA (g/d): Corn oil: 36.3 Sunflower oil: 34.7 SFA (g/d): Corn oil: 13.4	VLDL: -18.5 (NS) HDL (electrophoresis): -25.5 ($P \leq 0.001$) HDL (precipitation): -3.7 (NS) % median relative diff bet normal and corn oil diets: TC: -25.0 ($P \leq 0.001$) LDL: -29.3 ($P \leq 0.001$) TG: -3.6 (NS) VLDL: -5.0 (NS) HDL (electrophoresis): -14.8 ($P \leq 0.001$) HDL (precipitation): 0.3 (NS) % median relative diff bet normal and sunflower oil diets: TC: -18.2 ($P \leq 0.001$) LDL: -17.3 ($P \leq 0.01$) TG: -1.5 (NS) VLDL: -3.7 (NS) HDL (electrophoresis): -20.5 ($P \leq 0.001$) HDL (precipitation): -2.1 (NS) % median relative diff bet sunflower and corn oil diets: TC: -6.8 ($P \leq 0.01$) LDL: -12.0 ($P \leq 0.01$) TG: 5.4 (NS) VLDL: 0 (NS) HDL(electrophoresis): 2.3 (NS) HDL (precipitation): 0 (NS) Apolipoprotein A-I and A-II NS diff bet each diet	***Reviewer's Comments:*** *Counseling always included spouses to assure assistance in meal preparation, compliance and monitoring of intake*

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					Sunflower oil: 11.6 Chol (mg/d): Corn oil: 179 Sunflower oil: 166 Normal diet: 343-536 **Dietary Intake Assessment/Frequency:** Self-transcribed and dictated protocol methods throughout study 24-h recall method used repeatedly **Study Visits/ Measurements:** Fasting blood samples collected at end of each diet period along with intravenous fat-tolerance test	Fecal bile acid excretion NS diff at end of normal and fat-modified diets Fecal sterol balance more negative with use of corn oil than with sunflower oil ($P \leq 0.05$)	
Haust and Beveridge, 1963	**Non-ran-dom-ized trial**	**C**	**-**	**Purpose:** To examine changes in fecal elimination of 3 β-hydroxysterols when using formula rations free from chol **Sample:** 2 adult males (1 healthy; 1 diabetic)	**Run-in Period:** None **TX/Duration:** Fat free formula diet for 8 d then switched to corn oil formula diet for another 8 d **Dose/Form:** 1) Fat free formula diet:	**Outcome Measures:** Plasma chol Sterol content of feces **Results:** Consumption of fat-free diet in case of both subj led to decr in level of plasma chol that dropped further as result of isocaloric substitution of corn oil for CHO	**Author's Conclusions:** "These data…demonstrate that the overall increase in sterol excretion observed when subjects are transferred from a fat-free diet to one high in corn oil is due in large

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				Inclusions: Not provided **Exclusions:** Not provided	skim milk powder and sucrose 2) Corn oil formula diet: 60% TE corn oil (replacing equicaloric amt of CHO); 0.93% of digitonin-precipitable sterol **Dietary Intake During Study:** Not provided **Dietary Intake Assessment/Frequency:** None **Study Visits/ Measurements:** Feces collected last 4 d of each diet Fasting plasma chol levels determined on d 0, 4, 8, 12 and 16	Chol levels in both subj: Fat free diet: 1st subj: From 209 mg/100 mL to 120.1 and 145.4 mg/100 mL on d 4 and 8, respectively 2nd subj: From 165.0 mg/100 mL to 113.0 and 108.5 mg/100 mL on d 4 and 8, respectively Corn oil diet: 1st subj: From 209 mg/100 mL to 109.6 and 107.3 mg/100 mL on d 4 and 8, respectively 2nd subj: From 165.0 mg/100 mL to 82.2 mg/100 mL on d 4 and 8 Large incr in amt of fecal unsaponifiable matter excreted by subj on last 4 d of corn oil period due to 3 β-hydroxysterols Fraction of fecal fecal 3 β-hydroxysterols accounted for nearly 80% of sitosterol ingested in corn oil **% change not provided**	part to an increase in the output of sterols derived from endogenous sources. The association of significant increases in the elimination of endogenous sterol with decreasing plasma cholesterol levels suggests that these 2 phenomena are causally related" ***Reviewer's Comments:*** *Small sample size (N=2); short period (8 d); little info provided on dietary protocol*
Grande et al., 1958	**Non-ran-dom-ized trial**	**C**	**Ø**	**Purpose:** To determine whether corn oil contains special chol-lowering substance not accounted for as FA	**Run-in Period:** 6 wk on standard "house diet" **TX/Duration:** Switchback design; low fat	**Outcome Measures:** Chol **Results:** Change in chol values (mg/100 mL) for corn oil minus other oils	**Author's Conclusions:** "Comparison of corn oil with 4 other oils of the linoleic-oleic acid type consistently

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				glyceride, presumably in unsaponifiable fraction **Sample:** 93 healthy schizophrenic men (39-66 y of age) **Inclusions:** Physically healthy **Exclusions:** Acute illness; body wt changes of 2 kg in dietary period or 3 kg in entire experiment	diet with 100 g experimental fat added (ave 28% of total calories) EXPERIMENT N: 1) TX 1: Group W – Low fat diet with safflower oil (3 wk) then corn oil (3 wk) 2) TX 2: Group X – Low fat diet with corn oil (3 wk) then safflower oil (3 wk) 3) TX 3: Group Y – Not described 4) TX 4: Group Z – Not described EXPERIMENT O: 1) TX 1: Group A – low fat diet + 100 g mixture of cottonseed and safflower oils + 1.7 g/d unsaponifiable corn oil concentrate (wk 1-3) 2) TX 2: Group B – low fat diet + 100 g mixture of cottonseed and safflower oils + 1.7 g/d unsaponifiable corn oil concentrate (wk 3-6) Diets adjusted as needed to keep body wt constant	(observed/predicted): Olive oil: -27.2 ±3.6/-17.3 Cottonseed oil: -19.3±4.2/-11.3 Sunflower seed oil: -9.3±2.8/ +2.5 Safflower oil: +2.7±2.2/+9.1 Magnitude of discrepancy with corn oil observed change vs predicted change substantially same in all experiments, 6.4 to 11.8 mg/100 mL Every man showed considerable fall in serum chol in changing from "house diet" to either imitation corn oil alone or that oil plus unsaponifiable fraction, grand ave change -42.5 mg chol/100 mL Something present in corn oil but absent from other fats results in ave serum chol about 9 mg% lower than expected when 100 g corn oil ingested daily Feeding unsaponifiable corn oil fraction assoc with trivial diff, 3.2 mg%, compared with oil mixture alone (*P*=0.17) **% change not provided**	indicated that corn oil in the diet produced slightly lower serum cholesterol values than those predicted, on the basis of fatty acid composition….It is concluded that the unsaponifiable matter of 100 g of corn oil lowers serum cholesterol by something between 6 and 12 mg/100 mL" ***Reviewer's Comments:*** *References provided further detail about diets*

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					Dose/Form: STUDY N: 1) 100 g corn oil (15% SFA, 26% MUFA, 59% PUFA) 2) 100 g safflower oil (12% SFA, 10% MUFA, 78% PUFA) **Dietary Intake During Study:** Total fat: about 40 g/d PUFA: STUDY N: Corn oil: 59% Safflower oil: 78% STUDY O: Imitation corn oil: 64% Cottonseed oil: 29.7% Safflower oil: 34.3% SFA: STUDY N: Corn oil: 15% Safflower oil: 12% STUDY O: Imitation corn oil: 18.7% Cottonseed oil: 13.4% Safflower oil: 5.3% **Dietary Intake Assessment/Frequency:** Plate rejections recorded		

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					Study Visits/ Measurements: Blood samples collected on 2 d near end of each dietary period		
NONHUMAN TRIALS							
Moreau et al., 1999	**Non-ran-dom-ized trial**	**C**	**NA**	**Purpose:** To investigate effect of heat pre-TX of corn fiber on yield and composition of resulting corn fiber oil **Actual Sample:** NA **Inclusions:** Ground corn fiber **Exclusions:** None listed	**Run-in Period:** NA **TX/Duration:** 1) CNTL: 4 g samples of ground corn fiber placed in 25 mm x 150 mm vials x 2 2) Duplicate samples of each placed horizontally for 1 h in: Vacuum oven x 2 Convection oven x 2 Microwave oven x 2 After heating, samples cooled to room temperature Quantitative high-performance liquid chromatography analysis of lipid classes conducted **Dose/Form:**	**Outcome Measures:** Phytosterol fatty acyl esters Ferulate-phytosterol esters Free phytosterols **Results:** Heat pre-TX with either convection or vacuum oven resulted in small changes in yield of oil from corn fiber. With both types of ovens small incr (approx 4%) in yield at 100 and 125° C. Charring of corn fiber occurred at 150 and 175° C; smoke and very low yields (<1%) produced at 200° C Convection oven heat TX showed progressive decr in phytosterol fatty acyl esters (9%), free phytosterols (19%), ferulate-phytosterol esters (4%), and free FA (17%) as temperatures incr to 175° C; γ-tocopherol incr from 0.34 wt % in CNTL to 3.64 wt %	**Author's Conclusions:** "These experiments reveal that heat pretreatment caused (a) a modest reduction in the levels of the phytosterol components and (b) a profound increase in the levels of γ-tocopherol….From an industrial perspective, these experiments have provided evidence that moderate levels of heat pretreatment of corn fiber could be used to dramatically enhance the levels of γ-tocopherol in corn fiber oil, without significantly decreasing its levels

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					4 g samples ground corn fiber **Dietary Intake During Study:** NA **Dietary Intake Assessment/Frequency:** NA	for 175^{o} C pre-TX, and also caused incr in yield of γ-tocopherol (5.4 mg of γ-tocopherol/100 g corn fiber to 52.1 mg of γ-tocopherol/100 g corn fiber. Heat pre-TX incr in α-tocopherol did not exceed 0.1% Vacuum oven pre-TX caused complete loss of free FA at 150 and 175^{o} C and loss of 90% free phytosterols at 175^{o} C. Level of phytosterol-FA esters incr minimally at 125 and 150^{o} C pre-TX; levels of ferulate-phytosterol esters decr gradually with incr temperature; levels of γ-tocopherol incr from 0.34% in CNTL to 2.50 and 2.98% at 100 and 120^{o} C pre-TX and then decr at 2 higher temperatures Microwave pre-TX caused small incr in yield of corn fiber oil; levels of γ-tocopherol incr much less than with convection and vacuum pre-TX (9%); ferulate-phytosterol esters minimally affected (1% incr for 2.5 min TX, 4% decr for 5.0 min TX)	of valuable cholesterol-lowering phytosterol components" ***Reviewer's Comments:*** *None*
Milkova et al., 1977			**NA**	**Purpose:** To determine nature of individual sterols	**Methods:** Corn lecithin obtained by laboratory hydration of	**Outcome Measures:** Sterols	**Author's Conclusions:** None

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				contained in fractions of free sterols, sterol esters and sterol glycosides of raw soya and corn oils and refinement byproducts of these oils, namely technical lecithins and deodorizer distillates **Sample:** NA **Inclusions:** NA **Exclusions:** NA	raw oil Soya and corn deodorizer distillates prepared by laboratory deodorizing of hydrated oils Free sterols, sterol esters, sterol glycosides of raw soya and corn oils, as well as those of technical lecithin and deodorizer distillate of these oils isolated by preparative TLC Composition of isolated sterol derivatives determined	**Results:** Sitosterol, campesterol and stigmasterol main components of all sterol fractions of corn oil and its refinement products Dehydrocampesterol and unknown sterols with molecular wt of 428 and 430 present in free sterols of raw corn oil Some sterol glycosides of soya and corn lecithin esterified with same major FA components of glycerides, palmitic acid being main one FA composition of sterol esters of raw soya and corn oil roughly corresponds to FA composition of oils	***Reviewer's Comments:*** *None*

APPENDIXI2CornOilPhytosterolsTables