Table 4.9 Studies on coffee drinking and oxidative stress and antioxidant status in non-human mammals in vivo

Species, strain (sex)	Tissue	End-points	Test	Description of exposure[a] and controls	Response[b]/ significance	Comments	Reference
Rat							
Rat, Wistar (M)	Urine	DNA damage, lipid peroxidation	8-OHdG, F2-isoprostanes	3 groups (n = 16 each), instant coffee (0.62%), instant coffee (1.36%), control; 90, 110, 130 days	Coffee vs control increased 8-OHdG [$P < 0.05$] No change in isoprostanes	Coffee dose equival.9 and 20 cups/day	Sakamoto et al. (2003)
Rat, Wistar (M)	Liver	DNA damage, lipid peroxidation, proteomics, mRNA	8-OHdG, F2-isoprostanes	4 groups (n = 6 each), HFD + filtered decaf coffee; HFD + water, ND + filtered decaf coffee, ND + water; 3 months	Coffee HFD vs water HFD: decreased F2-isopr and 8-OHdG [both $P < 0.05$]	Rats with induced NAFLD (HFD for 3 months); coffee dose equivalent to 2 cups of filtered coffee/day	Salomone et al. (2014)
Rat, Sprague-Dawley (M)	Liver, plasma	Lipid peroxidation	TBARS	4 groups, unfiltered coffee (n = 7), unfiltered coffee + CCl_4 (n = 10), CCl_4 (n = 7), control (n = 7); 8 days	No change in TBARS with coffee alone. Coffee+CCl_4 vs control+CCl_4: increased plasma [$P < 0.05$] and liver [$P < 0.01$] TBARS.	CCl_4 used to induce liver damage	Poyrazoglu et al. (2008)
Rat, Wistar (M)	Muscle (anterior tibialis)	Lipid peroxidation, protein oxidation, antioxidant enzymes	Carbonyls, TBARS, SOD and GPx activity	8 groups (n = 8 each): coffee + exercise, decaf + exercise, caffeine + exercise, water + exercise, 4 other controls; 21 days	Caffeinated coffee+ exercise vs water + exercise: decreased carbonyls [$P < 0.05$] and TBARS [$P < 0.05$] No change with decaffeinated coffee or caffeine alone	Coffee dose equivalent to 4 cups (50 ml) coffee/day	Viana et al. (2012)
Rat, Wistar (M)	Liver, serum	Lipid peroxidation, antioxidants	tGSH, GSH/GSSG, FRAP, TBARS	5 groups (n = 6 each): HFD + decaf coffee; HFD + coffee polyphenols; HFD + coffee melanoidins; HFD + water; standard diet + water; 1 month, after 2 months on HFD except control	HFD+Coffee vs HFD+water: serum HFD+decaf coffee TBARS ─25% [$P < 0.05$]	Coffee dose equivalent to 6 cups espresso/day; HFD to develop nonalcoholic steatohepatitis	Vitaglione et al. (2010)

					FRAP ─15% [$P < 0.05$] tGSH ─20% [$P < 0.05$] GSH/GSSG +60% [$P < 0.05$] In liver tissue similar effects, no effects on GST activity, except for HFD+coffee ─15% [$P < 0.05$]		
Rat, Sprague-Dawley (M)	Plasma	Lipid peroxidation, antioxidants, antioxidant enzymes	TBARS, tGSH, SOD	4 groups ($n = 6$ each), coffee, sucrose, coffee + sucrose, water; 12 weeks	Coffee vs water TBARS + 8% [$P > 0.05$] SOD +10% [$P > 0.05$] tGSH + 6% [$P > 0.05$]		Morakinyo et al. (2013)
Rat, Sprague Dawley (M)	Liver	Lipid peroxidation, antioxidants, antioxidant enzymes	PCR, TBARS, tGSH, SOD	4 groups ($n = 8$ each):100 or 300 mg/kg coffee + DMN, DMN only; control; 4 weeks	Coffee + DMN vs DMN only: reduced TBARS [$P < 0.05$]; increased catalase [$P < 0.01$], GSH [$P < 0.05$] and SOD +70% [$P < 0.01$] in liver	DMN induced liver fibrosis	Shin et al. (2010)
Rat, Wistar (M)	Liver	Antioxidant enzymes, antioxidant capacity	SOD, CAT, and GPx activity, ORAC	8 groups ($n = 6$ each), single dose of filtered coffee (2 ml); sacrificed 1, 2, 3, and 4 hours after gavage, dose response 1 hour after gavage (0.5, 1.0. 1.5, 2.0 ml coffee) control: single dose of water (2 ml); sacrificed 1 hour after gavage	Coffee vs control water (1 hour) 2 ml dose, only at 1 hour significantly different GPx increased [$P < 0.05$] SOD increased [$P < 0.05$] CAT increased [$P < 0.05$] No significant change: ORAC	Dose response enzymes: only 1.5–2.0ml significantly different (except for CAT)	Vicente et al. (2011)
Rat, SHR/Izm (spontaneously hypertensive rat) (M)	Thoracic aorta	NAD(P)H oxidase components Nox-2, $p22^{phox}$, $p47^{phox}$	PCR	2 groups ($n = 6$ each), HHQ-free coffee, physiological saline; 8 weeks	HHQ-free coffee vs physiological saline NAD(P)Hox decreased [$P < 0.05$]		Suzuki et al. (2006)

Mouse

Mouse, ICR (M)	Liver	DNA damage, 8-OHdG, genes for antioxidant enzymes	8-OHdG, TBARS	4 groups (n = 7–9 each), normal diet + instant coffee, low vitamin diet + instant coffee, low vitamin diet + water, normal diet + water; 8 months	Coffee vs water in normal diet and low vitamin diet No significant change in: 8-OHdG, SOD, TBARS, γGCS, GR1,Trx1, Trx2, TR1, TR2, TPx2, iNOS, CAT (except for decreased GPx1 expression [$P < 0.05$])		Morii et al. (2009)
Mouse B6, transgenic EpRE luciferase (Cgene) (M)	Whole body, organs (liver, kidney, spleen, thymus, brain, muscle, adipose tissue, skin, heart	EpRE activation	Imaging	2 groups (n = 6 each): LPS + coffee (extract in corn oil, Equation 0.6 g coffee bean); control (LPS)	Coffee vs control Luminescence Whole body increased [$P < 0.05$] Liver increased [$P < 0.05$] Thymus decreased [$P < 0.05$]	Probably the dark roasted coffee was used	Paur et al. (2010)
Mouse, $nrf2^{-/-}$, $nrf2^{+/+}$ C57BL/6 (M)	Liver, small and large intestine	Nrf2 transcription	PCR, immunoblot	6 groups (n = 3 each), coffee 3%, coffee 6%, and control for both $nrf2^{-/-}$ and $nrf2^{+/+}$; 5 days	Coffee vs control In $nrf2^{+/+}$ mouse: liver GST↑, NQO1↑; Small intestine and colon NQO1↑, GST ↑and GCLC↑		Higgins et al. (2008)
Mouse Swiss albino (M)	Liver	Sulfhydryl content, GST activity	Cytosolic GST activity spectophotometric with 1-chloro-2,4-dinitrobenzene; sulfhydryls with modified Ellman method	3 groups (n = 5), instant coffee (70 140, 280 mg/kg bw per day), decaffeinated instant coffee (70 140, 280 mg/kg bw per day), water; 10 days	Coffee vs water (control) Caffeinated and decaf coffee increased sulfhydryls, GST activity		Abraham & Singh (1999)

[a] unless otherwise specified, the term coffee is used to mean brewed, caffeinated coffee

[b] +, positive; ─, negative; differences: exposed vs control

8-OHdG, 8-hydroxydeoxyguanisin; AKR, aldo-keto reductase; AOM, azoxymethane; ARE, antioxidant response element; CAT, catalase; CGA, chlorogenic acid; DMN, dimethylnitrosamine; γ-GCL, γ-glutamylcysteine ligase; γ-GCS, γ-glutamylcysteine sunthetase; EpRE, electrophile response element; FRAP, ferric reducing antioxidant potential; GR1, glutathione reductase 1; GPx1, glutathione peroxidase 1; GST, glutathione-S-transferase; HHQ, hydroxyhydroquinone; HFD, high fat diet; iNOS, inducible nitric oxide synthase; LPS, lipopolysaccharide; NAFLD, nonalcoholic fatty liver disease; ND, normal diet; NQO1, NAD(P)H-quinone oxidoreductase; ORAC, oxygen radical absorbance capacity; Prx1, peroxiredoxin 1; TBARS, thiobarbituric acid-reactive substances, Trx, thioredoxin; TR, thioredoxin reductase; TPx, thioredoxin peroxidase

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