

### The Effects of Red Meat Intake on Inflammation Biomarkers in Humans: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

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**Objectives:** Red meat is currently implicated to promote inflammation and compromise immune function. However, the consistency of the effects of red meat on these indices requires systematic assessment. Therefore, we conducted a systematic review and meta-analysis to assess the effects of higher versus lower red meat intakes on inflammation and immune biomarkers in humans.

**Methods:** Four researchers independently screened 2957 articles published through May 2021 using PubMed, Scopus, CINAHL, and Cochrane databases. Randomized controlled trials (RCTs) with human participants were eligible for data extraction. We searched the literature for a complete profile of immune and inflammatory biomarkers, but only obtained data for meta-analyses of inflammatory biomarkers including c-reactive protein (CRP, 19 studies, 28 comparisons), interleukin-6 (IL-6, 10 studies, 12 comparisons), tumor necrosis factor-alpha (TNF $\alpha$ , 5 studies, 8 comparisons), leptin (2 studies,

2 comparisons), and anti-inflammatory biomarker adiponectin (5 studies, 5 comparisons).

**Results:** Among all comparisons, higher total red meat intake led to higher blood CRP concentrations [0.12 mg/L (0.04, 0.19), 28 comparisons; weighted mean difference (95% CI), random effects]. This effect of red meat on CRP was also shown in the subgroup with diagnosed diseases [0.20 mg/L (0.08, 0.32), 7 comparisons], but not in the subgroup without diagnosed diseases [−0.04 mg/L (−0.17, 0.10), 12 comparisons]. Similar effects were observed when mixed processed and unprocessed red meat intakes were categorically combined as “mixed red meat” [0.18 mg/L (0.09, 0.27), 17 comparisons], but not for higher intake of unprocessed red meat [−0.07 mg/L (−0.21, 0.07), 11 comparisons]. Higher total red meat intake did not affect CRP when consuming red meat with uncontrolled habitual diets (8 comparisons) or comparing omnivorous to vegetarian or vegan diets (2 comparisons). Blood concentrations of leptin, IL-6, TNF $\alpha$ , or adiponectin were not affected.

**Conclusions:** There is a paucity of RCT-based research on red meat intake and a complete profile of inflammatory and especially anti-inflammatory markers. Results from our meta-analyses of RCTs suggest that total and mixed, but not unprocessed, red meat intakes affected blood CRP concentrations.

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