

Almonds and Their Impact on Gastrointestinal Physiology, Luminal Microbiology and Gastrointestinal Function: A Randomized Controlled Trial

Alice Creedon,¹ Eirini Dimidi,¹ Estella Hung,¹ Mark Scott,² Christopher Probert,³ Sarah Berry,¹ and Kevin Whelan¹

¹King's College London; ²Queen Mary University; and ³University of Liverpool

Objectives: The objective of this study was to investigate the impact of almonds, and almond form (whole, ground) on fecal *Bifidobacteria* (primary outcome) and gut microbiology, physiology, and symptoms in healthy adults.

Methods: Eighty-seven healthy adults with moderate fiber intake (<22g/d) were randomized to receive whole almonds (56 g/d), ground almonds (56 g/d) or a control muffin (2/d) in place of their habitual snacks for 4 weeks. Fecal *Bifidobacteria*, gut microbiota composition and diversity (16S rRNA sequencing), short-chain fatty acids (SCFA; gas-chromatography), volatile organic compounds (gas-chromatography mass-spectrometry), gut transit time (wireless motility capsule), and stool output and symptoms (7-day diary) were measured at baseline and at end of intervention. Differences between groups were assessed by analysis of covariance (ANCOVA) or a non-parametric

equivalent and corrected for multiple testing (Bonferroni (p) or Benjamini-Hochberg FDR (q)) where appropriate.

Results: There were no differences in relative abundance of fecal *bifidobacteria* following 4-weeks consumption of whole almonds (8.7%, SD 7.7), ground almonds (7.8%, SD 6.9) or control (13.0%, SD 10.2; $q = 0.613$). There was no effect of almonds on gut microbiota at the phylum level or on diversity. At the genus level, almonds (whole and ground pooled) increased relative abundance of *Lachnospiraceae_NK4A136_group*, *Phascolarctobacterium* and decreased *Tyzerella* (all $p < 0.05$), however these were no longer significant following FDR adjustment. Pre-specified analysis comparing almonds (whole and ground pooled) demonstrated higher concentrations of butyrate (24.1 $\mu\text{mol/g}$, SD 15.0) versus control (18.2, SD 9.1; $p = 0.046$). There was no effect of almonds on gut transit time, stool consistency or gut symptoms. Almond form as either whole (low nutrient bioaccessibility) or ground (higher nutrient bioaccessibility) did not affect any outcome.

Conclusions: Almonds are a high fibre snack that can be incorporated into the diet of moderate fibre consumers with no adverse gastrointestinal symptoms. Almonds do not have major impact on global microbiota composition but may exert a prebiotic effect on microbial metabolism in healthy adults.

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