

Carotenoid-microbiota dynamics: *in vitro* analysis of gut modulation and associated health benefits

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Carotenoids are bioactive compounds with recognized health benefits, yet their full potential is limited by poor bioaccessibility and complex interactions within the gastrointestinal tract. This study aimed to investigate the digestion, absorption, and gut microbiota modulation of three carotenoids (β -carotene, lutein, lycopene), a mixed carotenoid solution, and the red alga *Osmundea pinnatifida*. Using a simulated gastrointestinal digestion model (INFOGEST), combined with dialysis and *in vitro* fecal fermentation, we evaluated carotenoid recovery, antioxidant capacity, antidiabetic and antimutagenic activities, and short-chain fatty acid (SCFA) production. Results demonstrated low carotenoid recovery and structural transformation during digestion, with the mixed carotenoid solution exhibiting the highest antioxidant activity. Lutein and the mixed group also showed significant α -glucosidase inhibition, suggesting antidiabetic potential. Fermented samples increased the production of SCFAs and significantly modulated the gut microbiota, enhancing beneficial taxa such as Lachnospiraceae. These findings highlight the potential of carotenoids and *O. pinnatifida* in supporting gut health and preventing noncommunicable diseases through microbiota-mediated mechanisms.

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