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Ionizing Radiation-Assisted Bioconversion of Chicken Feather Waste into Bioactive Peptides via Bacillus Velezensis P45 Fermentation

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Abstract

The valorization of agro-industrial residues through biotechnological processes represents a key strategy within circular economy frameworks aimed at reducing food system losses and waste. Submerged cultivation of chicken feathers using keratinolytic bacteria offers a sustainable route for converting recalcitrant protein-rich byproducts into bioactive compounds with potential food industry applications. The objective of this study was to evaluate the effect of ionizing radiation pretreatment of feather powder on soluble protein yield, proteolytic activity, and selected functional properties of keratin hydrolysates generated during fermentation with *Bacillus velezensis* P45. Feathers were washed, defatted with 70% ethanol, dried and milled to a particle size below 250 µm. The feather powder was vacuum-packed and irradiated in a panoramic Cobalt-60 source at doses of 0 (control), 5, 10, 15, 20, and 25 kGy. For each dose, suspensions containing 10 mg/mL feather powder in a mineral medium (pH 7.0) were incubated for 3 days at 30 °C and 125 rpm. Assays were conducted with and without bacterial inoculum, using three replicates per treatment. Aliquots were collected every 24 h to determine soluble protein (Lowry method), peptide and amino acid concentration (ninhydrin method), proteolytic activity using casein as substrate, antioxidant activity (ABTS and DPPH assays), and reducing power (potassium ferricyanide method). At the end of cultivation, the supernatant was filtered and the remaining solid residue was quantified to estimate substrate degradation. Treatments corresponding to 20 and 25 kGy showed an increase in soluble protein concentration up to 48 h, followed by stabilization or a slight decline, whereas lower-dose treatments continued to increase, albeit at a slower rate, between the second and third day. Peptide and amino acid concentrations significantly increased after 24 h of fermentation, except in the 0 and 5 kGy treatments, where only minor changes were observed. Proteolytic activity and ABTS antioxidant activity exhibited significant differences ($p < 0.05$) between two homogeneous groups: feather meals treated with 0–15 kGy, showing lower activity, and those treated with 20–25 kGy, showing higher activity. No clear irradiation dose-related trend was observed for reducing power or DPPH activity. Solid residue degradation ranged from 74% to

80% at the highest doses, compared to 62% and 64% at 0 and 5 kGy, respectively. These findings indicate that irradiation above 10 kGy enhances keratin denaturation and hydrolysis, facilitating enzymatic access and accelerating the release of bioactive peptides. Integrating controlled radiation pretreatment with microbial fermentation may therefore contribute to the efficient upcycling of poultry processing waste into value-added functional ingredients, supporting more sustainable and resource-efficient food and feed production systems.

Keywords: Keratin bioconversion, gamma irradiation, microbial upcycling, bioactive peptides

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