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Microbial Biotransformation in a Soy-Based Cheese Model: Integrated Physicochemical and Flavor Modulation

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Abstract

The increasing demand for sustainable protein sources has accelerated interest in plant-based foods, particularly soybean-derived products due to their high protein content [1]. Fermentation might be an effective and environmentally friendly approach for structural modification and the targeted removal of off-flavors [2]. This study evaluated the metabolic efficacy of various bacterial and yeast starter cultures in modifying the physicochemical and flavor profile of a coagulated soy protein base, and explored the relationship between the metabolites and human sensory perception.

Solid-state fermentation was conducted using monocultures of spore-forming bacteria and selected yeasts. The biotransformation process was comprehensively characterized via targeted metabolite profiling (HPLC, GC-MS), texture profile analysis, and sensory evaluation.

Results demonstrated that strain-specific metabolism properties were closely related to structural degradation and flavor generation. Strains exhibiting intense proteolytic activity like *Bacillus subtilis* and *Yarrowia lipolytica* drove a massive accumulation of free amino acids that imparted pronounced umami and bitter tastes. Concurrently, this extensive enzymatic cleavage of the protein network resulted in dramatic structural softening, increased adhesiveness, and a significant loss of elasticity. Conversely, *Heyndrickxia coagulans* engaged in homofermentative metabolism, lowering the pH via lactic acid accumulation to impart a pleasant sourness. For *H. coagulans* and some yeasts yielded limited protease, the matrix preserved its initial hardness and cohesiveness. Furthermore, lipid metabolism significantly diversified the sensory profile. Targeted lipolysis and esterification by *G. candidum* created pronounced fruity aromas alongside moderate structural softening, whereas incomplete β-oxidation by *Y. lipolytica* led to the accumulation of hexanoic acid, contributing pungent, blue cheese-like notes.

These findings revealed the interrelationships between chemical, structural, and flavor dynamics during microbial fermentation. Such comprehensive understanding provides a mechanistic basis for rational co-culture strategies designed to balance texture and flavor in the innovation of highly acceptable, probiotic-enriched plant-based foods.

References

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