探討乾式熟成與接種微生物之牛肉品質與風味變化

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大綱

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摘要

乾式熟成牛肉以其獨特的風味和口感長期受到消費者青睞，但其品質與微生物變化之間的關聯性研究較為有限，且自然熟成技術也面臨週期長、成本高、品質不穩定、損耗大、缺乏標準化等挑戰，而如何穩定及促進熟成製程成為重要的課題，故本研究目的旨在探討乾式熟成對於肉品品質、風味及微生物組成之變化，並為熟成發酵劑開發提供理論依據。本研究選用牛肉在溫度 1-4℃，相對溼度 75-90% 的條件下，分別進行為期 21、26、40 天的乾式熟成，並分析品質、游離胺基酸、揮發性風味化合物及微生物。結果顯示以接種真菌的方式較自然熟成更能顯著加速表面真菌生長，並提高揮發性風味化合物和油酸含量，增強牛肉的「入口即化」口感及風味。在微生物分析結果顯示，*Staphylococcus* spp. 和 *Macrococcus* spp. 與肉品的咀嚼性、硬度相關，也與 octanal、heptanal 密切相關，賦予牛肉獨特風味，是乾式熟成牛肉品質的關鍵微生物。並從熟成 40 天後的牛肉中分離出三種產蛋白酶的真菌，*Yarrowia hollandica* (D4 和 D11)、*Penicillium oxalicum* (D5)及 *Meesziomyces ophidis* (D20)。其中 *Penicillium oxalicum* 在蛋白質降解及風味化合物生成上表現最為突出，其揮發性成分含量也最高，並與發酵過程中 phenylalanine、tyrosine 和 tryptophan 的生物合成途徑密切相關。綜上所述，接種適合的微生物不僅能加速熟成過程，還能提升肉品品質並增強揮發性風味化合物的生成。

Investigation of beef quality and flavor changes during dry aging and microbial inoculation

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Outline

1. Introduction
2. Effects of inoculation of fungal flora on the quality and flavor of dry-aged beef
3. Effects of dry-aging on beef quality and microbial composition
4. Protein hydrolysis and related metabolic pathways of fungi isolated from dry-aged beef
5. Conclusion

Abstract

Consumers have long favored dry-aged beef for its unique flavor and texture. However, research on the relationship between meat quality and microbial changes during dry aging remains limited. Additionally, traditional dry-aged methods face challenges such as long processing time, high cost, inconsistent quality, significant losses, and lack of standardization. Stabilizing and improving the aging process has thus become a key focus. This study aimed to investigate the effects of dry aging on meat quality, flavor, and microbial composition, providing a theoretical basis for developing aging starter cultures. Beef samples were aged at 1-4°C with a relative humidity of 75-90% for 21, 26, and 40 days, followed by analysis of quality, free amino acids, volatile flavor compounds, and microbiota. The results showed that inoculation with fungi significantly accelerated fungal growth on the surface, increased the production of volatile compounds and oleic acid, and enhanced the "melt-in-the-mouth" texture and flavor. Microbial analysis revealed that *Staphylococcus* spp. and *Macrococcus* spp. were closely related to beef chewiness, hardness, octanal, and heptanal, contributing to its distinctive flavor and key microorganisms for dry-aged beef quality. Additionally, three protease-producing fungi were isolated from beef aged for 40 days: *Yarrowia hollandica* (D4 and D11), *Penicillium oxalicum* (D5), and *Meesziomyces ophidis* (D20). Among them, *Penicillium oxalicum* exhibited the strongest performance in protein degradation and flavor compound generation, with the highest volatile content and strong associations with the biosynthesis pathways of phenylalanine, tyrosine, and tryptophan. In conclusion, inoculating suitable microorganisms not only accelerates the aging process but also enhances meat quality and the formation of volatile flavor compounds.

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