Analysis of the temperature stability of essential oils and their effects when applied to fermented sausages

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I. INTRODUCTION

Maintaining consistent temperature and humidity in the fermentation chamber is crucial for the optimal growth of starter fungi until the fermented sausage reaches full maturity. Certain fungal species, such as *Cladosporium cladosporioides*, can negatively impact the quality of fermented sausages by producing off-flavors, inducing specific color changes, and forming hairy mycelium. Essential oils, which contain volatile aromatic compounds, possess antibacterial and antifungal properties, thereby enhancing food safety. This study focuses on evaluating the antifungal activity of essential oils, including clove, marjoram, basil, black pepper, and rosemary, against common molds found in fermented sausages, aiming to identify the most effective natural substance for mold reduction during production.

II. MATERIALS AND METHODS

Temperature resistance testing was conducted at 4, 10, 15, and 20°C to assess the stability of essential oils commonly used in fermented sausage production. These oils were subjected to a 2-hour exposure at each temperature, followed by application onto paper discs inoculated with fungal spore suspensions. The inhibition zone size was measured after culturing at 25°C for 3-5 days. For making fermented sausage, the manufacturing process consists of three methods: i) addition: dry clove powder is added to the dough mixture at a concentration of approximately 20 g/kg. ii) spray: clove extract, obtained using the method mentioned earlier, is evenly sprayed onto the surface of fermented sausages filled with about 5 ml. iii) immersion: fermented sausages are adequately immersed in 2 liters of clove extract solution, ensuring it does not exceed 1 min.

III. RESULTS AND DISCUSSION

The results indicated that, irrespective of temperature conditions, clove consistently exhibited inhibitory effects of over 36 mm on average. According to another study, clove oil demonstrated significant inhibitory effects of over 40 mm against *P. oxalicum*, *P. commune*, and *C. cladosporioides*, irrespective of temperature conditions. However, overall average results across strains for essential oils did not show significant differences with temperature ($P > 0.05$). Additionally, regression analysis revealed an r-square values for each essential oil ranged from 0.00 to 0.12, indicating a very low level of correlation. This suggests that their efficacy remains well preserved during fermentation, refrigeration, and consumption, making them suitable for application.

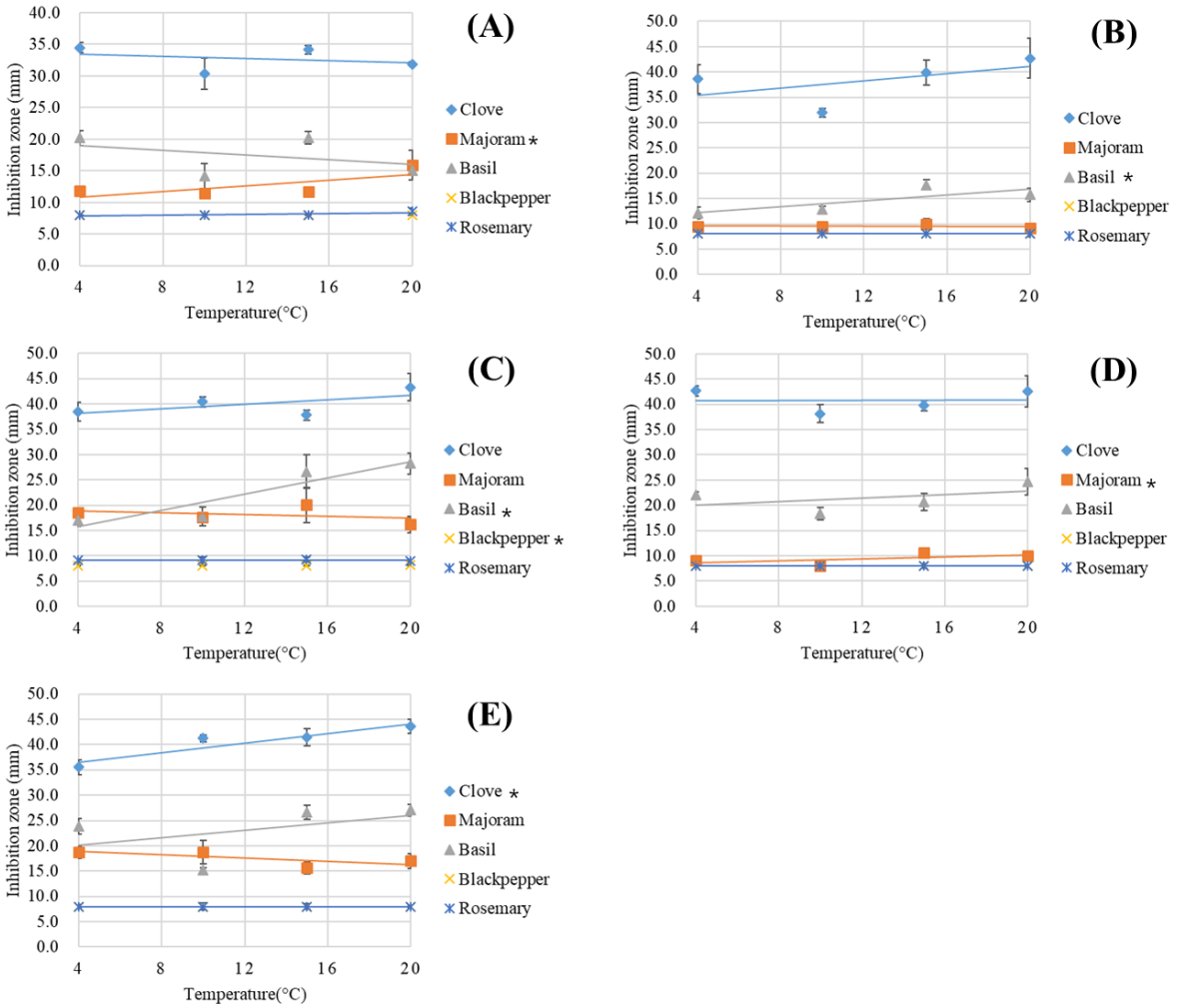

Figure 1. Analysis of antifungal activity according to temperature resistance of essential oils. * indicate that temperature has a significant ($P < 0.05$) effect on antifungal inhibition of essential (A) *P. commune*, (B) *P. chrysogenum*, (C) *C. cladosporioides*, (D) *P. oxalicum*, (E) *P. solitum*

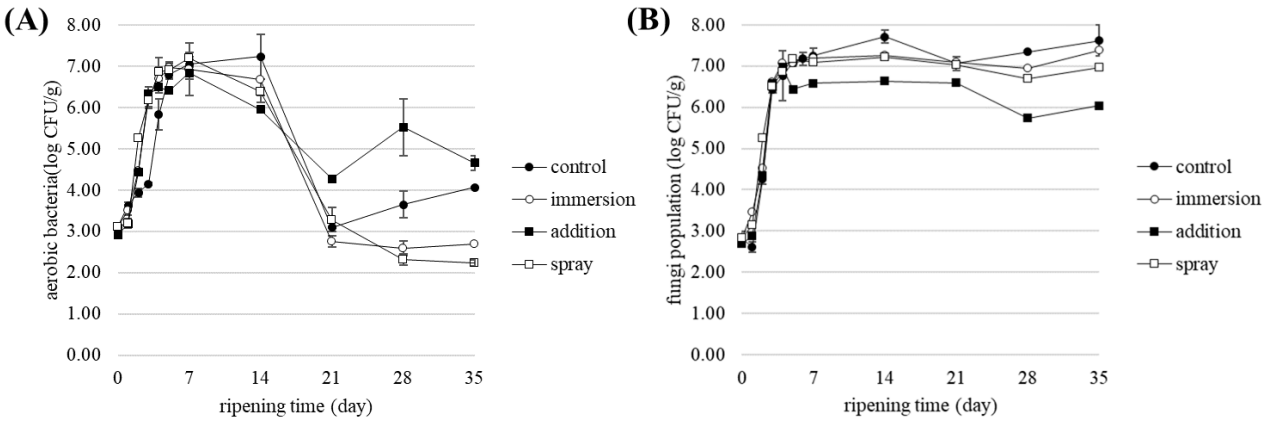

Figure 2. Changes in aerobic bacteria and fungi count during the ripening period of fermented sausages according to clove treatment methods.

IV. CONCLUSION

Clove has good potential for inhibiting growth of *Penicillium* spp., and *C. cladopsporioides* in fermented sausages. Clove ethanol extract has relatively lower antibacterial effects compared to its oil

counterpart, but ethanol extraction method was employed for easy application in small-scale farms. Therefore, to confirm whether the antifungal ability of clove remains consistent due to the characteristics of fermented meat products exposed to various temperatures during the manufacturing process, temperature stability analysis was conducted. The results showed consistent antifungal ability at 4, 10, 15, and 20°C, with a very low correlation observed in the regression analysis (r-square < 0.12). As a result, with both spraying and dipping treatments, there was an average reduction of 1.2 log CFU/g for general bacteria, and 0.3 log CFU/g for fungi, respectively. Ultimately, considering economic factors (amount of extract used, worker convenience), antimicrobial effects, and quality characteristics, spraying treatment was deemed suitable for utilization during manufacturing.

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