

Title: Preparation of bacterial nanocellulose film containing nitrite, aqueous extracts of sumac, and black carrot and investigating its effects on the color, microbial and chemical characteristics of beef ham

Abstract

Today, natural antimicrobials attracted more attention due to consumers' concerns about the negative side effects of synthetic food additives such as sodium nitrite. This study aimed to decrease sodium nitrite levels, extend self-life, and inhibit *Clostridium perfringens* in cooked beef ham by developing the innovative bacterial nanocellulose (BNC) films incorporated with sodium nitrite (SN), sumac extract (SE), and black carrot extract (BCE). The antibacterial activity of SN, and SE were tested using minimum inhibitory concentration (MIC), minimum bactericidal concentration (MBC), and fractional inhibitory concentration (FIC) assays against *Staphylococcus aureus*, *Listeria monocytogenes*, *Escherichia coli* and *Salmonella* Typhimurium. SN showed the lowest MIC value (6 mg/ml) against *Staphylococcus aureus*. FIC index of the combined application of SN and SE was 0.625 against *L. monocytogenes* suggesting a partial synergy. The ham covered with BNC film immersed in SE (10% w/v) + BCE (5% w/v) + SN (125 ppm) (SE₁₀BCE₅SN₁₂₅) exhibited the lowest microbial load (4.39, 4.32, 3.83, and 4.6 log cycles reductions in total viable count, lactic acid bacteria, Enterobacteriaceae, and *C. perfringens*, respectively) and the lowest oxidation rate (70% reduction compared to control) on day 28 of storage. The samples covered with SE₁₀BCE₅SN₁₂₅ film had also the lowest level of residual nitrite (64% lower nitrite compared to positive control). Positive control (ham containing 120 ppm SN) and ham covered with SE₁₀BCE₅SN₁₂₅ film had the highest redness (a*). It was concluded that the films developed in this study have the potential to reduce the use of sodium nitrite in beef ham production.

Keywords: Nanocellulose Film; Ham; Color; Plant Extract; Sumac; Black carrot; Sodium nitrite