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INFLUENCE OF REPLACING SALT WITH *SALICORNIA RAMOSISSIMA* ON THE PRESERVATION OF BEEF HAMBURGERS

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I. INTRODUCTION

Meat is a vital source of high-quality protein in the human diet, with global consumption steadily increasing [1,2]. However, ground meat products, such as hamburgers, are highly perishable due to the increased surface area exposed during processing, leading to rapid microbial growth and quality deterioration [3]. The food industry is actively seeking natural alternatives to synthetic additives to enhance food safety and extend shelf life [4]. This study evaluated the potential of *Salicornia ramosissima* (salicornia) powder in Mertolenga D.O.P. beef hamburgers. *S. ramosissima* is a seasonal halophytic plant that grows in saltwater around much of the Mediterranean coast. Its aerial parts are widely used both as traditional medicine and as an edible vegetable [5–7]. More recently, the use of halophytes has been suggested as an alternative natural solution to reduce the sodium content of food products. Additionally, *S. ramosissima* has a good nutritional profile, being a source of mineral and fiber, but also bioactive compounds, including vitamin C and carotenoids [5,8]. As one of the most salt-tolerant species, *Salicornia* is equipped with a powerful antioxidant system and produces diverse secondary metabolites with several therapeutic properties [6,7]. The primary aim was to investigate whether this natural additive could improve the sensory and microbiological quality of hamburgers, thereby extending their shelf life.

II. MATERIALS AND METHODS

Mertolenga D.O.P. beef hamburgers were prepared and divided into five experimental groups: control, 1% salt, and salicornia (1%, 1.5% and 2% salicornia). The beef used was sourced from three male animals, specifically the *semitendinosus* and *semimembranosus* muscles (4 days *post mortem*). The hamburgers were individually packaged in modified atmosphere (70% O2: 30% CO2) and stored at 2°C. Microbiological (total mesophilic and psychrotrophic populations, *Enterobacteriaceae*, *Pseudomonas* spp., *Brochothrix thermosphacta*, lactic acid bacteria, fungi, *Salmonella* spp., *L. monocytogenes* and *E. coli*), physicochemical (pH, water activity, and instrumental color – L*a*b* parameters), and sensory analyses [9], were conducted on days 1, 3, 5, 7, and 10, on fresh hamburgers.

III. RESULTS AND DISCUSSION

Microbiological analysis revealed microbial growth (mesophiles, psychrotrophs, *Enterobacteriaceae*, *Pseudomonas* spp., *B. thermosphacta*, lactic acid bacteria, and fungi) throughout the storage period across all tested conditions, with no significant differences observed between the control, salt, and salicornia treatments. Despite the observation that the control samples recorded the highest initial and final pH values, and the salicornia samples the lowest, statistical analysis revealed no significant differences between the control, salicornia, and salt treatments.

All samples containing salicornia consistently showed lower a_w values, when compared to the control samples. Notably, significant differences between conditions were present at time point 5 ($p < 0.05$), indicating differences between the 2% salicornia sample and all other conditions. At time point 10, significant differences ($p < 0.001$) were also evident between all salicornia conditions and the control. Furthermore, samples with 2% salicornia also differed significantly from both the salt and the 1% salicornia samples. The lower a_w observed in the Salicornia samples is likely due to the high ion concentration within the Salicornia powder. The inclusion of salicornia in the hamburger samples led to a statistically significant decrease ($p < 0.05$) in the L* value, indicating a darkening effect compared to the other conditions. Regarding the a* parameter (redness), salicornia negatively impacted this value, resulting in darker colored samples ($p < 0.001$). The control samples showed the highest positive a* value, followed by the salt treatment, and then the salicornia samples, with the 2% salicornia concentration having the lowest a* values. Additionally, salicornia's stabilizing effect on the b* parameter led to higher values in these samples compared to the control, with no significant differences noted. Salicornia added to 1% decreased the deteriorated smell in the last analyzed time when compared to the control ($p > 0.05$).

Spoilage thresholds were reached around day 6 for the control, salt, and 1% salicornia samples. However, for the 1.5% and 2% salicornia samples, spoilage occurred earlier, before day 5. This indicates that higher salicornia concentrations led to a decrease in shelf life of at least one day compared to the other treatments (as shown in Figure 1). This negative effect on shelf life at higher salicornia levels is supported by significant differences in the overall freshness evaluation compared to the control and salt samples, and is likely linked to the undesirable color changes observed.

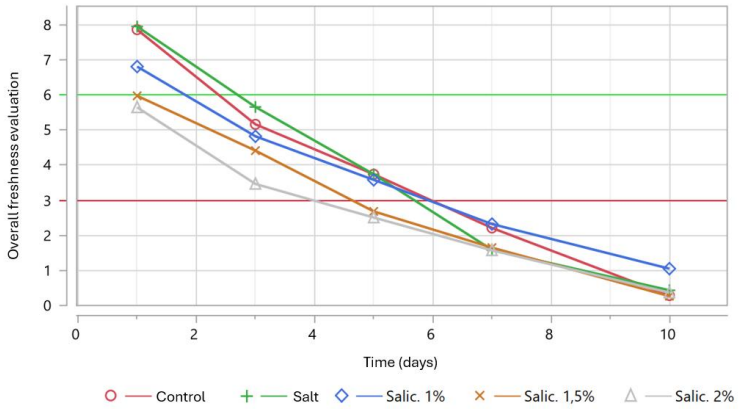


Figure 1. Overall Freshness Evaluation evolution in hamburgers under different treatments (control, salt, salicornia 1%, 1.5% and 2%), with freshness category thresholds marked by green (fresh/semi-fresh) and red (semi-fresh/spoiled) lines.

IV. CONCLUSION

The incorporation of salicornia powder at concentrations exceeding 1% presented a challenge in balancing Mertolenga D.O.P. beef hamburgers. While it negatively impacted organoleptic properties and reduced acceptability, its ability to lower water activity suggests a potential for salt replacement, which is desirable from a human health perspective due to the benefits of sodium reduction. The observed undesirable darkening effect, however, significantly affected sensory acceptability. Future studies must focus on carefully balancing the concentration of salicornia to maximize its potential for sodium reduction and preservation, thereby contributing to healthier food options, while concurrently minimizing negative impacts on product quality.

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