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EFFECT OF THE ADDITION OF NETTLE LEAF EXTRACT ON THE OXIDATIVE STABILITY AND PHYSICOCHEMICAL QUALITY OF HEAT-TREATED SMOKED MEAT PRODUCTS

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I. INTRODUCTION

The oxidation of meat and meat products leads to a deterioration in their quality, color, and sensory attributes. Herbal extracts have garnered considerable attention in this context due to their abundant biologically active compounds that contribute positively to human health. In particular, common nettle (*Urtica dioica* L.) is attracting significant interest from researchers not only for its health-promoting properties but also for its potential applications in the food industry [1, 2]. Nettle's biological properties, such as antioxidant and antimicrobial activities, come from various bioactive compounds, including vitamins, minerals, fiber, phenolic compounds, and flavonoids [2]. Research has demonstrated that water extracts of nettle effectively reduce lipid peroxidation while enhancing the quality of meatballs and cured sausages. Furthermore, these extracts have been shown to extend the shelf life of vacuum-packed meat products [2]. Currently, natural antioxidants are increasingly used because they can help compensate for the reduced use of nitrites in meat processing, which are known for their strong antioxidant properties. This shift is important as it addresses the trend of decreasing nitrite addition while still maintaining the antioxidant effects needed to ensure product quality and safety. Therefore, the study aimed to evaluate the effect of nettle leaf extract on oxidative changes and physicochemical quality in heat-treated, smoked model meat products cured with a reduced amount of sodium nitrite. Furthermore, the investigation included an evaluation of the antioxidant activity, fatty acid composition, and microbiological quality of the products.

II. MATERIALS AND METHODS

Preparation of extract: 5g of dried nettle leaves (*Urtica dioica* L.) were weighed into a 1500 mL beaker and infused with 1000 mL of distilled water at 80 °C. The mixture was covered with a watch glass and left to stand for 30 minutes. After cooling to 10 °C, the extract was filtered through filter paper and used for the preparation of meat model products. Meat model products: 5 meat batter treatments were prepared: (C) treatment with a 2.0% NaCl and NaNO2—150 mg/kg;(N0) treatment with a 2.0% NaCl and NaNO2—50 mg/kg, (N1) treatment with a 2.0% NaCl, NaNO2—50 mg/kg and 1% of nettle extract; (N3) treatment with a 2.0% NaCl, NaNO2—50 mg/kg and 3% of nettle extract, (N5) treatment with a 2.0% NaCl, NaNO2—50 mg/kg and 5% of nettle extract. Distilled water was added to each treatment to standardize the mass of the batters. Pork ham (M. semimembranosus) was minced (20 mm), mixed with the respective ingredients, and left to cure for 24 h at 2–4 °C. The meat batter was then stuffed into 65 mm semi-permeable synthetic polymer casings, clipped, smoked with steam (65–70 °C for 30 min) and cooked up to 70 °C in the centre. Finished products were chilled, vacuum-packed, and stored (4–6 °C). In the samples the following values were defined: pH and redox potential, thiobarbituric acid-reactive substance (TBARS), microbiological (total viable counts ISO 4833-2:2013, the presence of *Salmonella* spp. ISO 6579-1:2017, *Listeria monocytogenes* ISO 11290-2:2017 and *Clostridium* spp. PN-A-82055–12), fatty acid profile and determination of the antioxidant activity (ABTS•+). The experiment was performed at 3 replications (n=3). A two-way ANOVA was applied to assess the effects of treatment (C, N0, N1, N3, N5) and storage period (0, 35 days), as well as their interaction. The Fisher's LSD test was used to determine the significance of the mean values for a multiple comparison at $P< 0.05$. The Statistica program, version 13 was used.

III. RESULTS AND DISCUSSION

The pH value of meat and meat products indicates biochemical changes and microbial growth. The addition of nettle leaf extract had no significant effect on the pH of the products immediately after production ($P > 0.05$) (Table 1). However, after storage, a significant decrease in pH was observed in most treatments ($P < 0.05$), probably due to bacterial metabolic activity and organic acid production. In variant N3, we observed a slight increase in pH value after 35 days of storage, probably resulting from the accumulation of alkaline substances caused by proteolysis. The lowest observed redox potential values following production were significantly associated with the variants incorporating nettle extracts N1, N3, and N5 ($P < 0.05$). However, we did not observe a significant difference in

the redox potential depending on the amount of added extract. After 35 days of storage, all treatments showed a significant increase in the redox potential ($P < 0.05$). No significant differences in TBARS values were observed among the variants; however, all variants demonstrated a notable reduction in TBARS levels following 35 days of refrigerated storage. The decrease in MDA content during storage is because secondary lipid oxidation products may be further degraded to other, more stable compounds [1]. Significantly, the higher radical scavenging activity of ABTS•+ was reported in the N3 and N0 samples (Table 2). In our studies, we have shown that a 3% addition of nettle extract significantly increased the antioxidant activity of model products. This indicates that nettle leaf extract can increase the antioxidant capacity and support the oxidative stability of the product. There were no significant differences in the fatty acid profile between treatments ($P > 0.05$). Additionally, all samples exhibited good microbiological quality throughout the storage period, with no detection of *Listeria monocytogenes*, *Salmonella* spp. and *Clostridium* spp..

Table 1 - The pH, redox potential, TBARS value of the experimental model meat products.

Parameter	Storage time (days)	Treatment (n=3)					
		C	N0	N1	N3	N5	ANOVA
pH	0	6.20 ± 0.13^{aB}	6.19 ± 0.09^{aB}	6.21 ± 0.06^{aB}	6.18 ± 0.01^{aA}	6.17 ± 0.04^{aB}	TxS***
	35	6.02 ± 0.05^{aA}	6.07 ± 0.07^{aA}	6.09 ± 0.02^{aA}	6.25 ± 0.06^{bA}	6.04 ± 0.05^{aA}	
Redox (mV)	0	324.3 ± 4.7^{bA}	319.7 ± 5.6^{bA}	285.0 ± 2.2^{aA}	280.0 ± 2.2^{aA}	282.3 ± 0.9^{aA}	TxS***
	35	351.3 ± 2.1^{cB}	327.0 ± 3.7^{bB}	295.7 ± 1.2^{aB}	336.3 ± 5.0^{cB}	320.7 ± 2.5^{bB}	
TBARS (mg MDA/kg)	0	0.53 ± 0.05^{aB}	0.56 ± 0.07^{aB}	0.61 ± 0.08^{aB}	0.51 ± 0.03^{aB}	0.57 ± 0.01^{aB}	S***
	35	0.35 ± 0.04^{aA}	0.33 ± 0.03^{aA}	0.37 ± 0.04^{aA}	0.35 ± 0.04^{aA}	0.30 ± 0.04^{aA}	

Means followed by the different lowercase letters (a-c) between the treatments at the same storage time and capital letters (A-B) between the same treatment at different storage times are significantly different ($P < 0.05$). SD: standard deviation. P: significance of effects treatment-time interaction; NS – not significant; ***$P < 0.001$.

Table 2 – Antiradical effect against ABTS and fatty acid composition (% total fatty acids) of the experimental model meat products after 35 days of cold storage.

Parameter	Treatment (n=3)				
	C	N0	N1	N3	N5
ABTS (%)	9.68 ± 0.46^{a}	12.71 ± 0.44^{d}	11.22 ± 0.25^{c}	12.93 ± 0.39^{d}	10.67 ± 0.24^{b}
Σ SFA (%)	38.77 ± 0.49^{a}	38.87 ± 0.46^{a}	38.90 ± 0.57^{a}	38.97 ± 0.45^{a}	38.83 ± 0.34^{a}
Σ MUFA (%)	47.33 ± 0.29^{a}	47.20 ± 0.16^{a}	47.53 ± 0.12^{a}	47.53 ± 0.21^{a}	47.50 ± 0.14^{a}
Σ PUFA (%)	13.93 ± 0.42^{a}	14.03 ± 0.42^{a}	13.67 ± 0.48^{a}	13.53 ± 0.49^{a}	13.77 ± 0.33^{a}

Means followed by the different lowercase letters (a-c) between the treatments at the same storage time are significantly different ($P < 0.05$). SFA - the sum of saturated fatty acids; MUFA - the sum of monounsaturated fatty acids; PUFA - the sum of polyunsaturated fatty acids; SD: standard deviation.

IV. CONCLUSION

The analysis of the oxidation-reduction potential and secondary lipid oxidation products showed a low ORP value and the amount of MDA in the tested products with the addition of nettle extract. These results were additionally confirmed by the analysis of the ability to capture free radicals (ABTS•+), which allowed us to confirm the high antioxidant properties of meat products with 3% nettle extract. The results suggest that nettle leaf extract may increase the reducing capacity of the muscular system and oxidative stability. However, it is necessary to continue and extend these studies to meat products with higher fat content to confirm this mechanism.

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