71st ICoMST
GIRONA - CATALONIA - SPAIN
3rd-8th August - 2025

EFFECTS OF THE USE OF RASPBERRY LEAF EXTRACT IN THE CURING PROCESS OF MEAT WITH A REDUCED AMOUNT OF SODIUM NITRITE ON THE NITROSYL PIGMENT CONCENTRATION AND COLOUR OF HEAT-TREATED SMOKED MEAT PRODUCTS

Szymański P.*, Okoń A., Łaszkiewicz B., Siekierko U.

Department of Meat and Fat Technology, prof. Waclaw Dabrowski Institute of Agricultural and Food Biotechnology – State Research Institute, Warsaw, Poland

*Corresponding author email: piotr.szymanski@ibprs.pl

I. INTRODUCTION

There is a growing consumer demand for food products with fewer additives, driven by the perception that they are healthier. Nitrite plays a key role in meat curing by stabilizing colour, inhibiting harmful bacteria, enhancing flavour and aroma, and acting as an antioxidant. However, its use remains a subject of public concern [1]. Legislative measures within the European Union are focused on reducing nitrite levels in meat processing. A significant reduction in the amount of sodium nitrite may compromise the effectiveness of curing, colour stability, product quality, and shelf life. These challenges are particularly relevant for small-scale producers using traditional methods without chemical additives to support the curing process. Raspberries (*Rubus idaeus L.*) are rich in bioactive compounds, including polyphenols, organic acids, vitamins, minerals, and anthocyanins with strong antioxidant properties [2]. Raspberry extracts have been explored for their potential to inhibit lipid oxidation in meat products [3]. Raspberry leaves, a byproduct of fruit cultivation, contain bioactive compounds similar to those found in the fruit [3]. Due to their antioxidant content, raspberry leaf extracts may offer a natural alternative to support meat curing with reduced nitrite levels, potentially improving product quality and stability. Therefore, the study aimed to evaluate the effect of raspberry leaf extract on nitrosyl pigment concentration and colour formation in heat-treated, smoked model meat products cured with a reduced amount of sodium nitrite. Additionally, the physicochemical and microbiological properties of the products were assessed.

II. MATERIALS AND METHODS

Preparation of extract: 5 g of dried raspberry leaves (*Rubus idaeus L.* POLANA) 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: 4 meat batter treatments were prepared: (C) treatment with a 2.0% NaCl and $NaNO_2$—150 mg/kg;(T0) treatment with a 2.0% NaCl and $NaNO_2$—50 mg/kg, (T1) treatment with a 2.0% NaCl, $NaNO_2$—50 mg/kg and 1% of raspberry extract; (T3) treatment with a 2.0% NaCl, $NaNO_2$—50 mg/kg and 3% of raspberry 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 parameters were measured: pH and redox potential (Delta 350 pH meter), contents of nitrosyl pigments (Horsney method), contents of nitrates and nitrites (EN 12014–4:2005), colour parameters (CIE *L*a*b**, Minolta CR-300), 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). The experiment was performed at 3 replications (n=3). A two-way ANOVA was applied to assess the effects of treatment (C, T0, T1, T3) 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 addition of raspberry leaf extract had no significant effect on the pH of the products immediately after production ($P > 0.05$). However, after storage, a significant decrease in pH was observed in all treatments ($P < 0.05$), likely due to bacterial metabolic activity and organic acid production. The lowest redox potential values after production were recorded in the T1 and T3 treatments ($P < 0.05$), which may be attributed to the antioxidant properties of compounds present in raspberry leaf extract. The highest concentration of residual nitrites was detected in the C treatment, corresponding with the higher initial dose of $NaNO_2$. No significant differences in nitrite content were found between the T0, T1, and T3 treatments ($P > 0.05$). Residual nitrite levels decreased significantly in all treatments during

storage ($P < 0.05$), which is consistent with their reduction over time. Nitrate concentrations were significantly lower in T1 and T3 treatments after production ($P < 0.05$), suggesting an enhanced reduction of nitrates formed from nitrites via dismutation reactions, likely influenced by components of the raspberry extract. Both after production and after storage, the T1 and T3 treatments showed significantly higher concentrations of nitrosyl myoglobin (MbNO) compared to T0 ($P < 0.05$), reaching levels similar to the control (C). This indicates that raspberry leaf extract may enhance the reductive capacity of the meat system and support nitrosylation of haem pigments. The concentration of MbNO is closely related to the redness parameter (a^*). Treatments T1 and T3 exhibited significantly higher a^* values than T0 ($P < 0.05$), similar to the C treatment. Additionally, these treatments generally showed lower brightness (L^*) and yellowness (b^*) values compared to C and T0. After 35 days of storage, all treatments displayed noticeable colour changes, including a reduction in redness (a^*) and increases in both brightness (L^*) and yellowness (b^*). Microbiological analysis confirmed the absence of pathogenic bacteria in all samples. Total viable counts after storage remained stable across treatments, at approximately 10^2 CFU/g.

Table 1 - The pH, redox potential, nitrites and nitrates content, nitrosyl pigment concentration and colour parameters (L^*, a^*, b^*) of the experimental model meat products.

Parameter	Storage time (days)	Treatment (n=3)				
		C	T0	T1	T3	ANOVA
pH	0	6.20 ± 0.14^{aB}	6.19 ± 0.10^{aB}	6.17 ± 0.02^{aB}	6.17 ± 0.02^{aB}	S***
	35	6.02 ± 0.06^{bA}	6.05 ± 0.08^{bA}	6.05 ± 0.03^{bA}	5.93 ± 0.08^{bA}	
Redox (mV)	0	315.0 ± 12.9^{bA}	308.3 ± 14.5^{bA}	290.2 ± 7.6^{aA}	288.2 ± 6.5^{aA}	T*** S***
	35	340.8 ± 5.0^{cB}	327.7 ± 7.1^{bB}	308.5 ± 6.1^{aB}	307.3 ± 4.5^{aB}	
$NaNO_2$ (mg/kg)	0	45.7 ± 4.7^{bB}	22.9 ± 2.4^{aB}	21.9 ± 0.6^{aB}	19.6 ± 0.7^{aB}	TxS***
	35	15.0 ± 0.6^{bA}	8.1 ± 0.9^{aB}	7.8 ± 1.1^{aA}	7.4 ± 0.6^{aA}	
$NaNO_3$(mg/kg)	0	6.7 ± 1.2^{bA}	7.3 ± 1.2^{bA}	3.8 ± 0.4^{aA}	4.0 ± 0.3^{aA}	TxS*
	35	9.4 ± 1.5^{bA}	5.7 ± 2.0^{aA}	7.8 ± 1.1^{aB}	5.3 ± 0.6^{aB}	
MbNO (ppm)	0	18.5 ± 0.5^{bcA}	16.3 ± 1.0^{aB}	17.8 ± 0.7^{bA}	18.8 ± 1.2^{cA}	T*** S*
	35	17.4 ± 1.7^{bA}	14.3 ± 1.1^{aA}	17.6 ± 3.8^{bA}	18.3 ± 1.4^{bA}	
L^*	0	65.3 ± 0.8^{bA}	65.9 ± 0.9^{cA}	64.8 ± 0.8^{aA}	64.4 ± 0.8^{aA}	T*** S***
	35	65.9 ± 0.8^{bB}	$66.1\pm.0.5^{bA}$	65.7 ± 0.8^{bB}	65.2 ± 0.5^{aB}	
a^*	0	7.2 ± 0.4^{bB}	6.8 ± 0.4^{aB}	7.2 ± 0.3^{bB}	7.3 ± 0.2^{bB}	T*** S***
	35	6.7 ± 0.4^{bA}	6.0 ± 0.3^{aA}	6.8 ± 0.3^{bA}	6.7 ± 0.2^{bA}	
b^*	0	9.7 ± 0.2^{cA}	9.4 ± 0.3^{bA}	9.2 ± 0.3^{abA}	9.1 ± 0.4^{aA}	TxS***
	35	10.0 ± 0.2^{cB}	10.3 ± 0.3^{dB}	9.7 ± 0.4^{bB}	9.4 ± 0.3^{aB}	

Means followed by the different lowercase letters (a-d) 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; *$P < 0.05$; ***$P < 0.001$.

IV. CONCLUSION

The use of raspberry leaf extract in the curing process with a reduced amount of sodium nitrite enhanced nitrosyl pigment formation and improved redness (a^*) of the meat products, achieving levels comparable to the standard nitrite dose. All products maintained good microbiological quality after 35 days of storage. These results suggest that raspberry leaf extract may be an effective natural additive to support nitrite reduction in meat processing.

ACKNOWLEDGEMENTS

This research was funded by the Ministry of Agriculture and Rural Development Republic of Poland. Decision No. DRE.prz.070.1.2025

REFERENCES

1. Zhang, Y., Zhang, Y., Jia, J., Peng, H., Qian, Q., Pan, Z., & Liu, D. (2023). Nitrite and nitrate in meat processing: Functions and alternatives. *Current Research in Food Science*, *6*, 100470.
2. Luo, T., Chen, S., Zhang, H., Jia, S., Wang, J. (2020). Phytochemical composition and potential biological activities assessment of raspberry leaf extracts from nine different raspberry species and raspberry leaf tea. Journal of Berry Research, 10, 295-309.
3. de Oliveira, A.S., dos Santos, B.A., Farias, C.A.A., Correa, L.P., Cordeiro, M.W.S., Pinton, M.B., Barcia, M.T., Wagner, R., Cichoski, A.J.; Barin, J.S. (2023). Raspberry Extract as a Strategy to Improve the Oxidative Stability of Pork Burgers Enriched with Omega-3 Fatty Acids. Foods, 12, 1631.