



13-14 November 2025

PORK SAUSAGES REFORMULATED BY REPLACING CURED MEAT WITH ROSEHIP WASTE POWDER: EFFECTS ON THEIR QUALITY

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Abstract: Rosehip waste powder (Rp), rich in bioactive compounds, was tested as a functional ingredient in pork sausages by partially replacing cured meat. The addition of Rp reduced moisture and protein levels, increased carbohydrate, polyphenol, and carotenoid contents, and lowered pH and easily hydrolysable nitrogen, indicating preservative potential. Sausages showed improved red and yellow colour tones and acceptable sensory quality, confirming Rp as a sustainable ingredient for meat product reformulation.

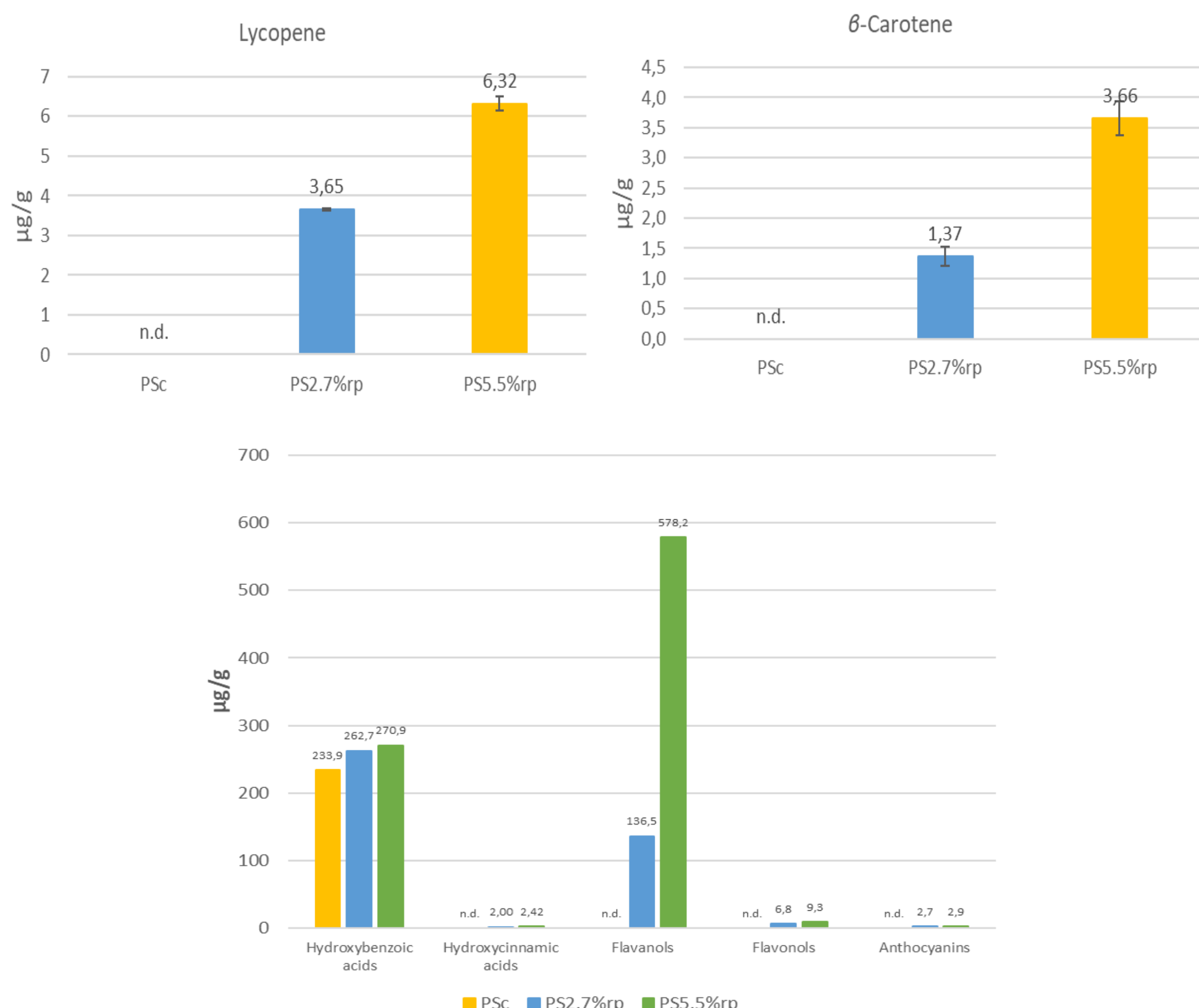
• Introduction

Rosehip waste powder contains high levels of fibres, polyphenols, and carotenoids. Given the preservative and antioxidant properties of polyphenols (Borsa et al. 2025), the natural colouring capacity of carotenoids, and the powder's inherently low pH, this ingredient shows potential for use in meat products, either as a natural alternative to synthetic nitrites or to extend shelf life. Valorising such by-products supports sustainable food production and aligns with circular economy principles.

• Material and method

Three pork sausage formulations were prepared: a control sample (PSc) without rosehip powder and two reformulated variants containing 2.7% (PS2.7%rp) and 5.5% (PS5.5%rp) rosehip waste powder. Samples were analysed during storage for physicochemical characteristics (moisture, protein, carbohydrates, pH, and easily hydrolysable nitrogen), colour (L^* , a^* , b^* parameters), texture (hardness, gumminess, chewiness), sensory properties, and the content of polyphenols and carotenoids.

➤ Content of individual carotenoids and polyphenols in pork sausages



• Results and discussions

➤ Changes in proximate composition, energy value, pH, and easily hydrolysable nitrogen content of pork sausages during refrigerated storage.

Parameter/ Energy value	PSc				PS2.7%rp				PS5.5%rp			
	1st storage day	12th storage day	19th storage day	26th storage day	1st storage day	12th storage day	19th storage day	26th storage day	1st storage day	12th storage day	19th storage day	26th storage day
Moisture (%)	60.83±0.206 ^{ab}	49.34±0.031 ^{ba}	40.01±0.207 ^{ca}	37.61±0.507 ^{ca}	57.83±0.250 ^{ab}	41.29±0.300 ^{ab}	37.28±0.297 ^{ab}	27.97±0.070 ^{ab}	55.79±0.648 ^{ab}	39.73±0.433 ^{ab}	27.20±0.121 ^{bc}	21.49±0.159 ^{bc}
pH	6.13±0.007 ^{ab}	6.15±0.007 ^{ab}	6.20±0.0 ^{ab}	6.23±0.007 ^{ab}	5.97±0.007 ^{ab}	5.97±0.007 ^{ab}	5.96±0.007 ^{ab}	5.84±0.0 ^{ab}	5.68±0.0 ^{ab}	5.70±0.0 ^{ab}	5.69±0.007 ^{bc}	5.60±0.0 ^{bc}
EHN (mg NH3/100 g)	24.61±1.218 ^a	31.44±1.211 ^{ab}	31.44±1.199 ^{ab}	33.14±1.204 ^a	21.18±1.128 ^{ab}	31.44±1.200 ^{ab}	32.29±2.402 ^{ab}	33.12±1.202 ^a	16.92±0.082 ^{ab}	27.19±0.0 ^{ab}	33.98±0.007 ^{ab}	29.74±1.207 ^{ab}

Data are expressed as mean ± standard deviation values of four measurements. Different lowercase letters within a row indicate significant differences between storage times ($p < 0.05$, Tukey's test), and different uppercase letters show significant differences between pork sausage formulations ($p < 0.05$).

➤ Changes in colour properties of pork sausages during refrigerated storage.

Colour attribute	PSc				PS2.7%rp				PS5.5%rp			
	1st storage day	12th storage day	19th storage day	26th storage day	1st storage day	12th storage day	19th storage day	26th storage day	1st storage day	12th storage day	19th storage day	26th storage day
L^*	60.15±2.108 ^{ab}	52.58±3.892 ^{ab}	46.23±2.434 ^{ab}	52.28±1.387 ^{ab}	59.49±1.422 ^{ab}	48.15±3.145 ^{ab}	47.10±2.565 ^{ab}	40.80±4.954 ^{ab}	54.91±1.627 ^{ab}	46.92±3.092 ^{ab}	42.84±2.644 ^{ab}	41.48±3.199 ^{ab}
a^*	10.01±1.107 ^{ab}	7.39±0.721 ^{ab}	6.15±0.611 ^{bc}	7.43±0.819 ^{ab}	10.61±1.731 ^{ab}	8.40±0.731 ^{ab}	8.07±1.208 ^{ab}	12.71±1.976 ^{ab}	11.82±1.294 ^{ab}	10.00±0.928 ^{ab}	10.41±1.375 ^{ab}	13.40±2.111 ^{ab}
b^*	10.24±0.689 ^{ab}	10.72±1.287 ^{ab}	9.50±1.409 ^{ab}	11.83±1.068 ^{ab}	15.63±3.134 ^{ab}	14.38±0.980 ^{ab}	15.16±2.367 ^{ab}	24.89±6.677 ^{ab}	22.06±2.359 ^{ab}	15.07±3.259 ^{ab}	19.84±4.527 ^{ab}	26.28±5.821 ^{ab}
ΔE^*	0.77±0.082 ^{ab}	0.97±0.052 ^{ab}	0.99±0.032 ^{ab}	1.01±0.026 ^{ab}	0.99±0.070 ^{ab}	1.04±0.022 ^{ab}	1.08±0.024 ^{ab}	1.09±0.059 ^{ab}	1.08±0.049 ^{ab}	0.97±0.081 ^{ab}	1.08±0.068 ^{ab}	1.09±0.040 ^{ab}
ΔE^*	14.79±1.429 ^{ab}	13.04±1.317 ^{ab}	11.32±1.491 ^{ab}	13.98±1.294 ^{ab}	18.62±2.981 ^{ab}	16.66±1.172 ^{ab}	17.18±2.626 ^{ab}	27.99±6.770 ^{ab}	25.06±2.409 ^{ab}	18.14±3.064 ^{ab}	22.45±4.513 ^{ab}	29.52±6.084 ^{ab}
ΔE^*	-	-	-	-	6.21	7.01	7.61	19.54	13.33	8.67	12.76	19.83

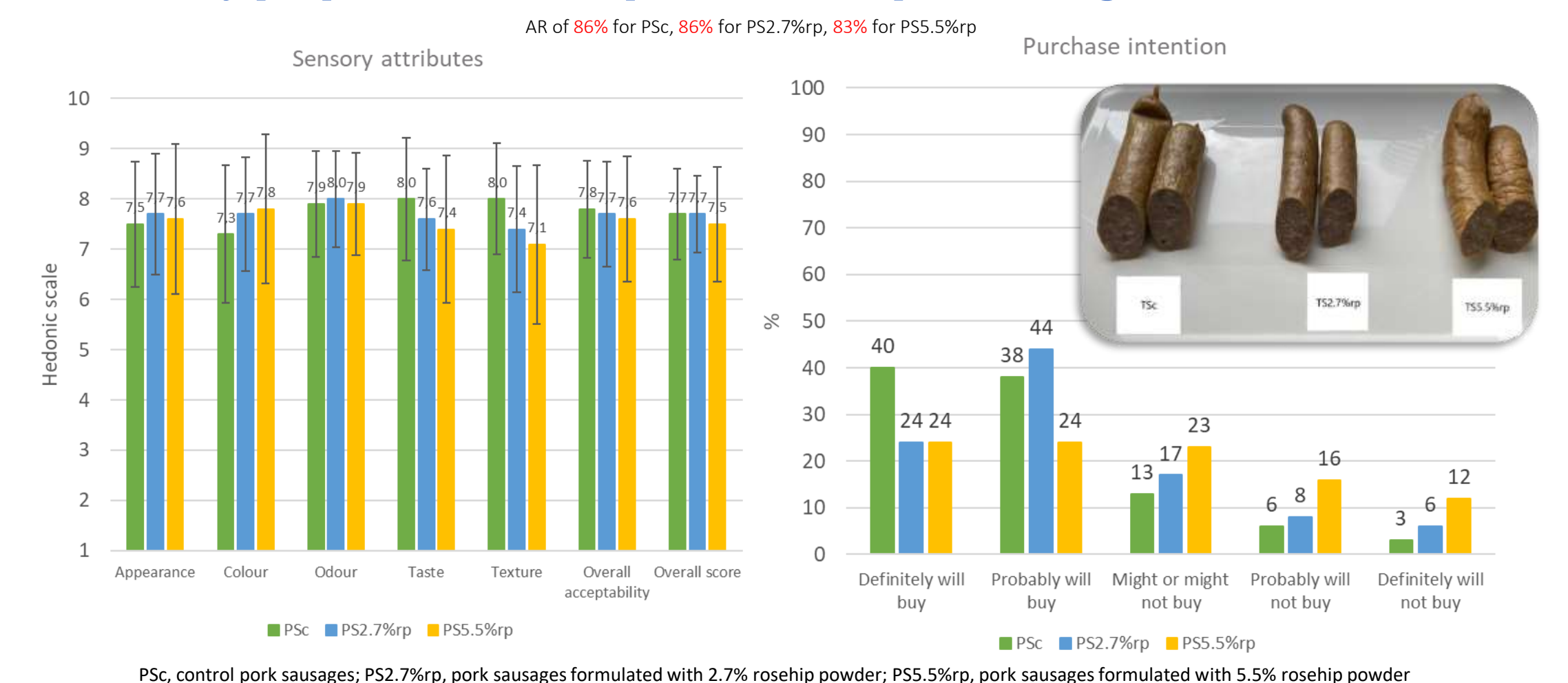
Data are expressed as mean ± standard deviation values of twenty-four measurements. Different lowercase letters within a row indicate significant differences between storage times ($p < 0.05$, Tukey's test), and different uppercase letters show significant differences between pork sausage formulations ($p < 0.05$). $\Delta E^* = 0.0 - 0.5$, a colour difference at the trace level; $\Delta E^* > 0.5 \leq 1.5$, the colour difference is slight; $\Delta E^* > 1.5 \leq 3.0$, the colour difference is noticeable; $\Delta E^* > 3.0 \leq 6.0$, the colour difference is appreciable; $\Delta E^* > 6.0 \leq 12.0$, the colour difference is large; $\Delta E^* > 12.0$, the colour difference is obvious.

➤ Changes in texture properties of pork sausages during refrigerated storage.

Texture attribute	PSc				PS2.7%rp				PS5.5%rp			
	1st storage day	12th storage day	19th storage day	26th storage day	1st storage day	12th storage day	19th storage day	26th storage day	1st storage day	12th storage day	19th storage day	26th storage day
Surface hardness (N)	23.92±1.872 ^{ab}	31.43±2.344 ^{ab}	19.93±1.145 ^{ab}	23.14±2.800 ^{ab}	23.22±1.506 ^{ab}	54.44±3.444 ^{ab}	19.33±1.597 ^{ab}	42.76±3.566 ^{ab}	22.32±1.800 ^{ab}	89.92±2.278 ^{ab}	36.79±2.581 ^{ab}	45.95±2.340 ^{ab}
Hardness (N)	83.45±5.279 ^{ab}	93.68±3.973 ^{ab}	9.92±0.469 ^{ab}	14.40±0.699 ^{ab}	73.79±5.798 ^{ab}	65.96±5.404 ^{ab}	7.84±1.082 ^{ab}	29.07±2.257 ^{ab}	79.95±5.171 ^{ab}	104.93±6.363 ^{ab}	18.10±1.705 ^{ab}	29.57±4.188 ^{ab}
Cohesiveness	0.76±0.026 ^{ab}	0.61±0.006 ^{ab}	0.36±0.044 ^{ab}	0.42±0.050 ^{ab}	0.70±0.010 ^{ab}	0.70±0.084 ^{ab}	0.60±0.121 ^{ab}	0.39±0.006 ^{ab}	0.68±0.058 ^{ab}	0.66±0.052 ^{ab}	0.26±0.140 ^{ab}	0.43±0.012 ^{ab}
Springiness index	0.85±0.036 ^{ab}	0.84±0.017 ^{ab}	0.65±0.052 ^{ab}	0.94±0.006 ^{ab}	0.86±0.031 ^{ab}	0.81±0.042 ^{ab}	0.96±0.216 ^{ab}	0.92±0.056 ^{ab}	0.80±0.030 ^{ab}	0.76±0.021 ^{ab}	0.51±0.070 ^{ab}	0.95±0.045 ^{ab}
Gumminess (N)	63.51±6.182 ^{ab}	56.73±2.139 ^{ab}	5.20±0.886 ^{ab}	4.17±0.481 ^{ab}	51.79±3.372 ^{ab}	46.24±8.403 ^{ab}	4.76±1.398 ^{ab}	11.24±0.922 ^{ab}	54.31±1.714 ^{ab}	69.41±9.227 ^{ab}	4.64±2.157 ^{ab}	12.88±1.979 ^{ab}
Chewiness (mJ)	368.23±47.184 ^{ab}	311.27±23.001 ^{ab}	20.10±5.059 ^{ab}	27.93±3.323 ^{ab}	293.70±15.936 ^{ab}	247.80±51.321 ^{ab}	27.87±13.395 ^{ab}	74.77±8.138 ^{ab}	285.07±15.219 ^{ab}	333.50±37.726 ^{ab}	17.20±18.669 ^{ab}	86.07±14.951 ^{ab}

Data are expressed as mean ± standard deviation values of four measurements. Different lowercase letters within a row indicate significant differences between storage times ($p < 0.05$, Tukey's test), and different uppercase letters show significant differences between pork sausage formulations ($p < 0.05$).

➤ Sensory properties and acceptance rate of pork sausages



• Conclusions

Rosehip waste powder can partially replace cured meat in pork sausages, enhancing nutritional value, colour, and preservation while maintaining quality. This sustainable approach supports the valorisation of local agro-industrial by-products.

Acknowledgement: This work was supported by the University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, Romania.