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

EFFECT OF PLANT POLYPHENOLS WITH DIFFERENT M-HYDROXY AND O-HYDROXY GROUPS ON THE INHIBITION OF HETEROCYCLIC AMINES FORMATION IN ROASTED MEAT

Xiaoyue Yang[1,2], Chongxin Liu[1,3], Christophe Blecker[2], Huan Liu[1], Dequan Zhang[1] and Zhenyu Wang[1*]

[1] Institute of Food Science and Technology, Chinese Academy of Agricultural Sciences, Beijing 100193, P. R. China

[2] Laboratory of Food Science and Formulation, Gembloux Agro-Bio Tech, University of Liège, Gembloux, B-5030, Belgium

[3] School of Agriculture and Food Science, University College Dublin, Belfield, Dublin, Ireland

*Corresponding author email: caasjgsmeat2021_1@126.com

I. INTRODUCTION

Heterocyclic amines (HAs) are easily produced when high-protein foods such as fish and meat are heated at high temperatures and have been widely concerned for their carcinogenic and mutagenic effects [1]. The addition of polyphenols has been widely considered to be a remarkably effective method to control the production of HAs [2]. Many studies have shown that the main mechanisms of polyphenols, especially flavonoids, to inhibit the HAs, are due to the scavenging of free radicals and trapping active carbonyl compounds [3,4]. Moreover, polyphenolic compounds are closely related to the quantity and location of hydroxyl structures in exerting antioxidant activity and inhibiting the formation of HAs [5]. Polyphenols with different structures have different inhibitory effects on HAs, but there is still a lack of systematic research on which structural polyphenols have a strong effect on the inhibition of which HAs, and also a lack of the study of the inhibitory mechanism of other structural polyphenols except for flavonoids against different kinds of HAs. Therefore, this study investigated the effects of nine different categories of polyphenols on the types and content of HAs in electric roasted lamb meat. And summarized the inhibitory effects of different structures of polyphenols on different HAs.

II. MATERIALS AND METHODS

20 ± 0.1 g minced meat from *Longissimuss lumborum* (LL) muscles of small-tailed Han lambs with 0.1 mmol polyphenols powder was prepared into a round patty with a thickness of 0.8 cm and a diameter of 5.5 cm. Nine different categories of polyphenols (Figure 1) are from five different classes (flavonoids, phenolic acids, stilbenes, coumarins, chalcones) and covering three different structures (only with o-hydroxyl structure, only with m-hydroxyl structure, both o-hydroxyl and m-hydroxyl). All patties were left to marinate for 8 h at 4°C, then roasted on a 250-300°C electric oven for 10 min (each side takes 5 min). Then the content of HAs were measured by UPLC-MS/MS. The Duncan test and one-way ANOVA analysis were used to determine the multi-group comparison hypothesis test.

III. RESULTS AND DISCUSSION

The variation in the total HAs content in Table 1 showed that polyphenols can effectively inhibit the production of HAs and there are differences in the inhibition effect of different types of polyphenols. Overall, phenolic acid compounds were the least effective in inhibiting the production of HAs, with an inhibition rate of only 10.88%. Flavonoids inhibited HAs production by 44.05%-64.87%. Chalcone, coumarin, and stilbene compounds had higher inhibition rates, of 69.59%, 70.41%, and 72.30% respectively. Among the flavonoids, quercetin and genistein had stronger inhibitory effects than luteolin.

Table 1 – Effects of different structure polyphenols on the formation of HAs in electric roasted lamb patties.

Groups		Harman	Norharman	Trp-P-2	MeAαC	PhIP	MeIQx	Total HAs
	Normal	3.62±0.18^{a}	7.42±0.97^{a}	0.58±0.09^{a}	0.60±0.08^{a}	5.83±0.14^{a}	11.55±1.18^{a}	29.60±0.27^{a}
	Quercetin	2.00±0.45^{bc}	2.89±0.53^{bc}	0.47±0.06^{ab}	0.48±0.06^{ab}	4.35±0.79^{abc}	4.23±0.42^{bc}	14.41±0.55^{e}
	Naringenin	1.87±0.08^{bc}	3.46±0.29^{c}	0.31±0.02^{cd}	0.31±0.02^{cde}	4.10±0.14^{bcd}	5.42±0.05^{b}	15.47±0.29^{de}
flavonoid	Epicatechin	0.84±0.03^{e}	2.12±0.15^{bc}	0.30±0.02^{d}	0.30±0.01^{de}	2.68±0.51^{cd}	9.97±1.06^{a}	16.22±0.25^{d}
	Luteolin	2.15±0.02^{bc}	5.64±0.91^{b}	0.44±0.04^{bc}	0.45±0.04^{bc}	5.83±0.89^{a}	3.40±0.48^{cd}	17.89±0.50^{c}
	Genistein	1.57±0.08^{cd}	2.22±0.11^{bc}	0.39±0.04^{bcd}	0.43±0.06^{bcd}	2.65±0.12^{cd}	3.14±0.23^{cd}	10.40±0.24^{f}
phenolic acid	Gallic acid	2.52±0.13^{b}	6.69±0.67^{ab}	0.42±0.00^{bcd}	0.41±0.02^{bcd}	4.99±0.51^{ab}	11.36±0.47^{a}	26.38±0.58^{b}
stilbenes	Resveratrol	0.84±0.06^{e}	1.59±0.26^{d}	0.33±0.02^{cd}	0.25±0.02^{e}	2.91±0.48^{cd}	2.27±0.38^{de}	8.20±0.17^{g}
coumarin	Aesculetin	1.82±0.50^{bc}	2.03±0.55^{c}	0.29±0.01^{d}	0.30±0.01^{de}	3.31±0.55^{cd}	1.00±0.12^{e}	8.76±0.39^{g}
chalcone	Phloretin	1.01±0.02^{de}	1.41±0.16^{d}	0.34±0.03^{bcd}	0.34±0.03^{bcde}	2.59±0.41^{d}	3.30±0.09^{cd}	9.00±0.15^{g}

Harman, Norharman, PhIP and MeIQx are not only the main HAs determined in electric roasted lamb meat but also the focus of researchers. Therefore, further cluster analysis was conducted on the results of different structural polyphenols inhibition of major HAs and shown in Figure 1. The results indicated that there is a similar inhibitory condition on PhIP, Norharman, and Harman by polyphenols and epicatechin, resveratrol, and phloretin with strong inhibition effects on these three HAs all contain meso-dihydroxy structure, indicating that active carbonyl capturing might be the main way for the inhibition of Harman, Norharman and PhIP production by polyphenolic compounds. aesculetin had the best inhibitory effect on MeIQx compared to resveratrol and phloretin which was just the opposite of the other three HAs suggests that polyphenolic compounds may inhibit MeIQx production mainly by scavenging free radicals.

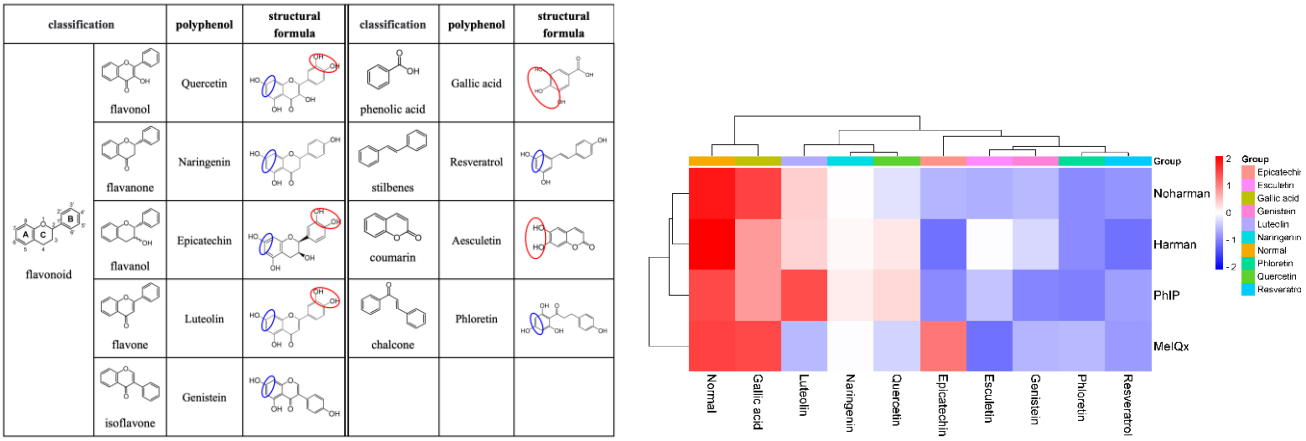


Figure 1. The selected five classes of polyphenols with different structures in this study (left, the red circle shows the o-hydroxyl group and the blue circle shows the m-hydroxyl group); Heatmap analysis of the inhibitory effects of polyphenols with different structures on different major HAs (right)

IV. CONCLUSION

Stilbene, coumarin and chalcone had a better inhibitory effect on HAs than flavonoids. These four polyphenolic classes above presented a stronger effect than phenolic acids. Besides, polyphenols with m-hydroxyl structures have a stronger inhibition of PhIP, Harman and Norharman by capturing the reaction intermediate carbonyl compounds. Polyphenols with the o-hydroxyl group had a stronger inhibitory effect on MeIQx by scavenging free radicals. This study can not only speculate the inhibition mechanism of different HAs through the structure of unknown polyphenols, but also further provides a theoretical basis for effectively controlling the formation of HAs and reducing their harm to human beings.

ACKNOWLEDGEMENTS

This work was financially supported by Beijing Innovation Consortium of Agriculture Research System (BAIC06-2024), and Agricultural Science and Technology Innovation Program (CAAS ASTIP-2024-IFST).

REFERENCES

1. Barzegar, F.; Kamankesh, M.; Mohammadi, A. (2019). Heterocyclic aromatic amines in cooked food: A review on formation, health risk-toxicology and their analytical techniques. Food Chemistry, 280: 240-254.
2. Dong, H.; Xian, Y.; Li, H.; Bai, W.; Zeng, X. (2020). Potential carcinogenic heterocyclic aromatic amines (HAAs) in foodstuffs: Formation, extraction, analytical methods, and mitigation strategies. Comprehensive Reviews in Food Science and Food Safety, 19(2): 365–404.
3. Vitaglione, P.; Fogliano, V. (2004). Use of antioxidants to minimize the human health risk associated to mutagenic/carcinogenic heterocyclic amines in food. Journal of Chromatography. B, Analytical Technologies in the Biomedical and Life Sciences, 802(1): 189–199.
4. Cheng, K. W.; Wong, C. C.; Chao, J.; Lo, C.; Chen, F.; Chu, I. K.; Che, C. M.; Ho, C. T.; Wang, M. (2009). Inhibition of mutagenic PhIP formation by epigallocatechin gallate via scavenging of phenylacetaldehyde. Molecular Nutrition & Food Research, 53(6): 716–725.
5. Hidalgo, F. J., Aguilar, I., & Zamora, R. (2017). Model studies on the effect of aldehyde structure on their selective trapping by phenolic compounds. Journal of agricultural and food chemistry, 65(23): 4736–4743.