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

MUSCLE TYPE AND POSTMORTEM AGEING INFLUENCE TASTE-ACTIVE METABOLITES IN BEEF

Zhenzhao Li[1], Michael G. Leeming[1], Melindee Hastie[1], Robyn Warner[1]

[1] Faculty of Science, The University of Melbourne, Australia

*Corresponding author email: lee.li1@unimelb.edu.au

I. INTRODUCTION

Both taste and aroma contribute to the flavour of beef and much research has been conducted on the aroma of beef. In contrast, there is less understanding of the factors contributing to the taste of beef, which is associated with the perception of taste-active compounds on the taste buds, including free amino acids (FAAs), nucleotides, peptides, and organic acids [1]. Bovine muscles are composed of different percentages of oxidative (type I) and glycolytic (type II) fibres. The oxidative and glycolytic fibres have distinctive metabolism [2], which could impact the profile of taste-active metabolites in muscles containing high proportions of either fibre type. In addition to muscle type, the profile of taste-active metabolites is known to be influenced by the postmortem ageing [3]. During ageing, FAAs are released due to proteolysis, and nucleotides degrade into nucleosides or other secondary metabolites [3]. The effect of ageing on taste-active metabolites could potentially depend on the predominant muscle type in beef muscles. However, the interaction between muscle type and ageing has not been previously studied in beef. We hypothesised that muscle type and ageing influence the taste-active metabolites in beef. To test our hypothesis, we used model muscles beef *masseter* (100% type I) and *cutaneous trunci* (92% type II) [4]. The concentration of taste-active metabolites in these two muscles were measured before and after 14-days ageing.

II. MATERIALS AND METHODS

Masseter (n = 24) and *cutaneous trunci* (n = 24) were collected from both sides of 12 beef carcasses within 1 hr after the animals were processed in a commercial abattoir. The muscles were transported to The University of Melbourne under refrigeration, stored in the dark, and processed at approximately 12 hr postmortem. *Masseter* and *cutaneous trunci* from one side of each individual carcass were processed the same day that fresh samples (day 0) were obtained. Muscles from the other side were vacuum packed, then stored in the dark at 0 ± 1 ˚C for 14 days and processed as aged samples (day 14). A 15 g subsamples were taken from each muscle (day 0 and 14), freeze-dried, and stored at – 20 ˚C until extraction of taste-active metabolites. For the extraction of metabolites, freeze-dried muscles (50 ± 5.0 mg) were ground manually, and homogenised in 800 µL of methanol/chloroform (1:1, v/v). Then 400 µL of MilliQ water was added and the tubes were homogenised again for 1 min. The samples were centrifuged to collect the upper phase, which was then dried under a gentle flow of nitrogen and stored at - 80 ˚C until further analysis. The concentration of taste-active metabolites in beef was analysed using liquid chromatography tandem mass spectrometry. The samples were injected into a Shimadzu Nexera X2 liquid chromatography unit coupled to a Shimadzu 8050 triple quadrupole mass spectrometer. The metabolites were separated on a Kinetex 2.6 µm F5 100 Å 150 × 2.1 mm column. A mixed standard containing FAAs, dipeptides, and nucleotides were used to construct the calibration curve and quantify the taste-active metabolites in beef.

III. RESULTS AND DISCUSSION

Table 1 shows the effect of muscle type and ageing on the concentration of taste-active compounds in the beef muscles. The concentration of free amino acids in beef was influenced by the interaction between muscle type and ageing ($P < 0.001$ for all). The concentrations of glutamic acid, aspartic acid, and methionine were higher in the fresh *masseter* than in the fresh *cutaneous trunci* ($P < 0.001$ for all). It is well-established that type I fibres take up more FAAs, as metabolic substrates, compared to type II fibres [2]. During aging, the concentration of all FAAs increased ($P < 0.001$ for all). FAAs in *masseter* increased to a larger extent compared to in *cutaneous trunci* ($P < 0.001$ for all). FAAs are released by exopeptidases during the postmortem proteolysis of beef [3]. Therefore, it is likely that *masseter*, which is high in type I fibres, had higher exopeptidase activity than *cutaneous trunci,* which is high in type II fibres. However, this speculation needs to be tested in future studies. Free amino acids, especially glutamic and aspartic acids, contribute to the umami taste and hence play an important role in the flavour liking of beef [1]. We hence postulate that beef high in type I fibres had higher umami taste caused by FAAs.

The effect of muscle type and ageing on nucleotides in beef is also shown in Table 1. Both 5'-guanosine monophosphate (GMP) and 5'-insoine monophosphate (IMP) were higher in *cutaneous trunci* compared to in *masseter* before ageing ($P < 0.05$ for both). Nucleotides, including IMP and GMP, play important roles in the

glycolytic metabolism of type II fibres, where an increase signals the activation of glycogenolysis [2]. Therefore, muscles high in type II fibres may synthesise more IMP and GMP compared to muscles high in type I fibres. During ageing, a larger percentage of IMP and GMP degraded in *masseter* than in *cutaneous trunci* ($P < 0.05$ for both). The degradation of IMP in *masseter* is further supported by the increase in hypoxanthine ($P < 0.05$), which is the end product of IMP degradation [1]. GMP and IMP are known to have umami taste in beef, whereas hypoxhanthine has been shown to cause a bitter taste [1]. Therefore, we tentatively speculate that ageing of muscles high in type I fibres could lead to a decrease in umami taste and increase in bitter taste due to the degradation of nucleotides and the resultant accumulation of hypoxanthine. However, this hypothesis needs to be confirmed in future studies by sensory assessment.

Similar to nucleotides, the concentration of carnosine was much higher in *cutaneous trunci* compared to in *masseter*, before and after ageing ($P < 0.05$ for both). Carnosine acts as a buffer against the lactic acid produced in anaerobic glycolysis in type II fibres [5]. Carnosine has been shown to cause bitter or umami taste, depending on the concentration of other taste-active compounds, such as free amino acids, in beef [1]. Therefore, the high level of carnosine could affect the taste of beef that is high in type II fibres, although the specific effect remains unclear.

Table 1 – Effect of muscle type [*Masseter* (M) vs. *Cutaneous trunci* (CT)] and postmortem ageing (day 0 vs. day 14) on taste-active metabolites (µg/g dry matter) in beef

	M		CT		SED[a]	P-values		
	Day 0	Day 14	Day 0	Day 14		Muscle	Ageing	Muscle × ageing
Amino acids								
Cysteine + cystine	1.46	7.37	1.21	5.03	0.440	<0.001	<0.001	<0.001
Methionine	54.7	166	29.8	156	7.360	0.005	<0.001	0.171
Glutamic acid	160	559	59.9	158	15.59	<0.001	<0.001	<0.001
Aspartic acid	44.2	97.9	12.1	33.4	4.220	<0.001	<0.001	<0.001
Dipeptides								
Carnosine	417	493	5690	6381	164.0	<0.001	0.011	0.009
Anserine	188	396	112	226	14.35	<0.001	<0.001	<0.001
Nucleotides and their metabolite								
5'-guanosine monophosphate	90.3	41.9	115.6	83.4	5.860	<0.001	<0.001	0.053
5'-inosine monophosphate	1436	368	4013	2141	171.0	<0.001	<0.001	0.001
Hypoxanthine	954	2124	236	1114	51.15	<0.001	<0.001	<0.001

[a]SED: standard error of difference for interaction

IV. CONCLUSION

Our results show that muscle type not only influenced the initial level of taste-active metabolites in beef but also impacted the formation of free amino acids and the degradation of nucleotides during postmortem ageing. *Masseter* and *cutaneous trunci* had disparate profiles of taste-active metabolites before and after ageing, which reflects the distinctive metabolism of type I and type II fibres. Based on our findings, it is postulated that the taste of beef is affected by the muscle type and ageing. However, this hypothesis needs to be tested in future studies using sensory assessments.

REFERENCES

1. Schlichtherle-Cerny, H.;Grosch, W. (1998) Evaluation of taste compounds of stewed beef juice. Zeitschrift für Lebensmitteluntersuchung und -Forschung A, 207: 369-376.
2. Schiaffino, S.;Reggiani, C. (2011) Fiber Types in Mammalian Skeletal Muscles. Physiological Reviews, 91: 1447-1531.
3. Iida, F., et al. (2016) Changes in taste compounds, breaking properties, and sensory attributes during dry aging of beef from Japanese black cattle. Meat Science, 112: 46-51.
4. Vaskoska, R., et al. (2021) Thermal denaturation of proteins in the muscle fibre and connective tissue from bovine muscles composed of type I (masseter) or type II (cutaneous trunci) fibres: DSC and FTIR microspectroscopy study. Food Chemistry, 343: 128544.
5. Sewell, D.A., et al. (1992) Estimation of the carnosine content of different fibre types in the middle gluteal muscle of the thoroughbred horse. The Journal of Physiology, 455: 447-453.