THE EFFECT OF PLANT EXTRACTS ON LIPID OXIDATION AND OXYMYOGLOBIN OXIDATION IN BEEF MUSCLE MODEL SYSTEMS

L. McGovern*[1], M.N. O'Grady[1], S.A. Aherne[1], E. Ryan[1], N.M. O'Brien[1] and J.P. Kerry[1]

[1]*Department of Food & Nutritional Sciences, University College Cork, Cork, Ireland*.
*Email: lr_McGovern@yahoo.com

Key words: Plant extracts, antioxidants, lipid oxidation.

Introduction

Colour and lipid oxidation are important factors affecting the quality of fresh beef. The muscle pigment myoglobin is responsible for the colour of fresh beef. Lipid oxidation is a major quality deteriorative process in muscle foods resulting in a variety of breakdown products which produce off-odours and flavours. The processes of colour and lipid oxidation in beef are linked (O'Grady et al., 2001). In recent years, concerns regarding safety and toxicity of synthetic antioxidants prompted a surge of interest in the use of health promoting natural antioxidants derived from plant sources. The functional properties of many plant extracts have been investigated for their potential use as novel nutraceuticals. Nutraceuticals are believed to modulate the aetiology of many chronic diseases such as coronary heart disease, cancer and diabetes. Rosemary (*Rosmarinus officinalis* L.), oregano (*Origanum vulgare* L.) and sage (*Salvia officinalis* L.) are members of the *Lamiaceae* family and contain antioxidant compounds such as carnosol, carnosic acid and rosmarinic acid (Capecka et al., 2005). Compounds present in rosemary and sage possess anti-cancer (Cheung and Tai, 2007) and memory boosting properties, respectively. Extracts of oregano inhibited the growth of *H. pylori* a stomach ulcer inducing bacterium (Chun et al., 2005). Echinacea (*Echinacea purpurea* L.), a member of the *Asteraceae* family, contains compounds such as chlorogenic acid, cynarin, caffeic acid and cichoric acid. Echinacea has immuno-stimulatory and free radical scavenging properties (Facino et al., 1995). The aim of this study was to assess the influence of rosemary (R), oregano (O), sage (S) and echinacea (E) on oxymyoglobin and lipid oxidation in 25% *M. longissimus dorsi* (LD) in order to determine plant extract levels suitable for inclusion in beef and beef products.

Materials and Methods

Longissimus dorsi (LD) homogenates (25%) were prepared in 0.12 M KCl 5mM histidine buffer pH 5.5 using an Ultra Turrax tissue homogeniser. Lipid oxidation in 50 ml LD homogenate samples, held at 4ºC, was initiated by the addition of 45µM $FeCl_3$/sodium ascorbate (1:1). The concentrations of R, O, S and E added to the LD homogenates were based on the IC_{50} value (concentration of plant extract that inhibited caco-2 cell growth by 50%) for each plant extract. The IC_{50} values were R, 123 µg/ml; O, 318 µg/ml; S, 214 µg/ml and E, 1421 µg/ml (Aherne et al., 2007). R, O, S and E (solubilised in distilled water) were added to LD homogenates at the following concentrations: R, 100 µg/ml, 200 µg/ml, 300 µg/ml; O, 200 µg/ml, 400 µg/ml, 600 µg/ml; S, 200 µg/ml, 400 µg/ml, 600 µg/ml; E, 500 µg/ml, 1000 µg/ml, 2000 µg/ml. LD homogenates with and without $FeCl_3$/ascorbate were run simultaneously as controls. Lipid oxidation and oxymyoglobin (oxyMb) oxidation was measured in samples held at 4ºC for up to 24 hours. Lipid oxidation in LD homogenates was measured following a modification of the 2-thiobarbituric acid reactive substances (TBARS) procedure of Siu and Draper (1978). Lipid oxidation was expressed in units of absorbance at 532 nm (Abs_{532}). OxyMb oxidation in 25% LD homogenates was measured in the supernatant obtained after centrifuging, filtering and re-centrifuging 7 ml of LD homogenate at 13,000 rpm for 15 minutes at 4ºC. The relative portion of oxyMb (% total myoglobin) in LD homogenates was calculated using absorbance measurements at selected wavelengths (730, 572, 565, 545 and 525 nm) as described by Krzywicki (1982). Each experiment was performed three times and all analysis was carried out in duplicate.

Results and Discussion

Following $FeCl_3$/ascorbate addition, lipid oxidation increased over the 24 hour storage period (Table 1). The increase in lipid oxidation was accompanied by an increase in oxyMb oxidation. The relationship between oxyMb oxidation and lipid oxidation in 25% LD homogenates has been previously reported by O'Grady et al. (2001). Graded addition of each plant extract reduced lipid oxidation relative to controls. Lipid oxidation decreased with increasing concentration of each plant extract and antioxidant potency followed the order: S > R > O > E. The antioxidant efficacy of R, O, S and E correlated well with their corresponding IC_{50} values. The antioxidant properties of R has been previously demonstrated in beef (Formanek et al., 2001). OxyMb oxidation decreased with increasing plant extract concentration and trends observed were similar to those for lipid oxidation.

Table 1. OxyMb oxidation and lipid oxidation in 25% M. *longissimus dorsi* homogenates following the addition of R (100 – 300 μg/ml), O (200 – 600 μg/ml), S (200 – 600 μg/ml) and E (500 – 2000 μg/ml) and storage at 4ºC.

Incubate		μg/ml	Time, hours			
			0		24	
			[1]OxyMb, %	[2]TBARS	OxyMb, %	TBARS
H[3]			86.78 ± 3.95	0.124 ± 0.026	78.71 ± 4.87	0.539 ± 0.097
H+P[4]			73.67 ± 4.24	0.143 ± 0.025	36.32 ± 4.41	1.690 ± 0.061
H+P+						
	R	100	85.87 ± 1.82	0.164 ± 0.066	64.67 ± 11.23	1.043 ± 0.056
		200	87.07 ± 5.88	0.169 ± 0.060	79.23 ± 6.43	0.703 ± 0.057
		300	87.37 ± 4.80	0.155 ± 0.044	82.77 ± 5.35	0.487 ± 0.074
H+P+						
	O	200	76.70 ± 2.16	0.143 ± 0.024	47.83 ± 1.55	1.144 ± 0.030
		400	80.87 ± 3.80	0.142 ± 0.028	60.37 ± 1.50	0.814 ± 0.017
		600	82.77 ± 1.08	0.149 ± 0.024	67.57 ± 2.76	0.601 ± 0.024
H+P+						
	S	200	78.17 ± 5.96	0.102 ± 0.003	57.67 ± 5.44	0.598 ± 0.043
		400	78.85 ± 6.72	0.100 ± 0.004	66.38 ± 6.14	0.280 ± 0.061
		600	76.57 ± 4.51	0.105 ± 0.007	66.89 ± 5.68	0.199 ± 0.056
H+P+						
	E	500	75.90 ± 0.71	0.223 ± 0.047	43.75 ± 1.06	1.483 ± 0.020
		1000	77.20 ± 3.96	0.224 ± 0.061	51.10 ± 1.84	1.243 ± 0.012
		2000	74.80 ± 3.68	0.269 ± 0.079	62.95 ± 2.19	0.853 ± 0.096

[1]Oxymyoglobin, % of total. [2]Abs_{532}. [3]25% LD homogenate. [4]$FeCl_3$/ascorbate.

Conclusions

Health promoting plant extracts demonstrated antioxidant activity in beef muscle model systems. Lipid oxidation decreased with increasing concentrations of all plant extracts and antioxidant potency followed the order: S > R > O > E. Based on the results obtained, suitable plant extract levels were determined for inclusion in beef and beef products.

References

Aherne, S.A., Kerry, J.P., OBrien, N.M. (2007). Effects of plant extracts on antioxidant status and oxidant-induced stress in caco-2 cells. *British Journal of Nutrition*, 97: 321-328.

Capecka, E., Mareczek, A., Leja, M. (2005). Antioxidant activity of fresh and dry herbs of some *Lamiaceae* species. *Food Chemistry*, 93: 223-226.

Cheung, S., Tai, J., (2007). Anti-proliferative and antioxidant properties of rosemary Rosmarinus officinalis. *Oncology Reports*, 17: 1525-1531.

Chun, S.S., Vattem, D.A., Lin, Y.T., Shetty, K. (2005). Phenolic antioxidants from clonal oregano (Origanum vulgare) with antimicrobial activity against Helicobacter pylori. *Process Biochemistry*, 40: 809-816.

Facino, R.M., Carini, M., Aldini, G., Saibene, L., Pietta, P., Mauri, P. (1995). Echinacoside and caffeoyl conjugates protect collagen from free radical-induced degradation: a potential use of Echinacea extracts in the prevention of skin photodamage. *Planta Medica*, 61: 510-514.

Formanek, Z., Kerry, J.P., Higgins, F.M., Buckley, D.J., Morrissey, P.A., Farkas, J. (2001). Addition of synthetic and natural antioxidants to α-tocopheryl acetate supplemented beef patties: effects of antioxidants and packaging on lipid oxidation. *Meat Science*, 58: 337-341.

Krzywicki, K. (1982). The determination of haem pigments in meat. *Meat Science*, 7: 29-36.

O'Grady M.N., Monahan F.J., Brunton N.P. (2001). Oxymyoglobin oxidation and lipid oxidation in bovine muscle – mechanistic studies. *Journal of Food Science*, 66: 386-392.

Siu, G.M., Draper, H.H., (1978). A survey of the malonaldehyde content of retail meats and fish. *Journal of Food Science*, 42: 1147-1149.

Acknowledgement: Funded by the Irish Government under the National Development Plan (NDP) 2000-2006.