EFFECTS OF DIETARY VITAMIN E SUPPLEMENTATION AND POST-SLAUGHTER ADDITION OF ROSEMARY EXTRACT ON OXIDATIVE STABILITY OF IRRADIATED MINCED BEEF

Z. Formanek[a], **J.P. Kerry**[b], **K.Galven**[c], **D.J. Buckley**[b], **J. Farkas**[a],

[a]Department of Refrigeration and Livestock Products Technology, University of Horticulture and Food Industry, Ménesi út 45, H 1118 Budapest, HUNGARY; [b]Department of Food Technology and [c] Department of Nutrition, University College Cork, Cork, IRELAND.

Keywords: antioxidants, minced beef, gamma irradiation, oxidative stability

Background and Objectives

Contamination of foods, including meats, with pathogenic microorganisms continues to be a major public health problem and is of economic importance. Radiation processing with gamma rays or accelerated electrons in the dose range of 1 to 4 kGy is one of the technologies, which may help to alleviate this problem (Fu et al., 1995). However, irradiating meat may affect quality by inducing oxidation of myoglobin and lipids, leading to discolouration, rancidity and other off-flavours, especially, when the extended microbiological shelf-life of such products is considered. Ground meats are particularly sensitive because of their greater surface area.
Several researchers found that dietary supplementation of vitamin E (VE) to animals for prior to slaughter could delay lipid oxidation and improve colour/pigment stability by suppressing metmyoglobin formation in muscle foods (Liu et al., 1995). Antioxidants added during processing may prevent oxidation in locations not occupied by α-tocopherol and act synergistically in line with the "radical cascade process" as defence against damage from free radical attack and lipid peroxidation. Patterson and Stevenson (1995) demonstrated that irradiation-induced off-odour in raw chicken could be very much reduced by supplementation of feedstuffs with α-tocopherol and ascorbic acid. It is also known that extracts of certain spices, particularly rosemary, mainly due to phenolics, impart a potent antioxidative effect in foods (Lindberg Madsen and Bertelsen, 1995). Therefore, our present study aimed to investigate the possibility of suppressing oxidative changes in refrigerated and irradiated ground beef by combining dietary vitamin E supplementation and post-slaughter incorporation of a rosemary extract.

Methods

Friesian cattle (n=10) were diwided into two groups (n=5) and were fed control (20) and supplemented (2000 IU/head/day)for 50 days. The animals were slaughtered at Keepak Co., Meath, Ireland, and the meat taken to the University College Cork, where further processing and investigations were performed.

Semitendinosus muscles were taken and minced with a stainless-steel meat mincer (Crypto model AE 22). A part of the dietary VE supplemented batch was mixed with 0.25% (based on total meat weight) water soluble rosemary antioxidant powder (Quest International Ireland Ltd., Cork). Each experimental batch was portioned onto plastic trays, wrapped aerobically with oxygen-permeable polyvinyl chloride film (6000-8000 $cm^3/m^2/24$ hours).
Irradiation was done with 0, 1, 2, 3 and 4 kGy dose, in the Gammabeam 650 Co-60 facility (Nordion International Inc., Kanata, Canada) of the Queen's University, Belfast, Northern Ireland. The temperature during irradiation was 1-4 °C. Samples were transported between Cork and Belfast in return in frozen state. After returning to Cork, all ground beef samples were stored under illumination in a retail display cabinet at 4 °C for 8 days.
The α-tocopherol content was measured before radiation processing and storage by the HPLC method of Bieri et al. (1979). Surface colour was investigated by minolta Chromameter CR-300 instrument. Thiobarbituric acid reactive substances (TBARS) according to Newburg and Concon (1980), and pH of the mince were estimated periodically during storage. Fatty acid profile determinations were carried out using gas-chromatography (Slover and Lanza, 1979) on days 0 and 8. Sensory testing consisted of scoring odour and surface colour using a 5-point descriptive scale by 10 panelists.

Results and Discussion

The initial α-tocopherol content of samples determined from 20 replicates was 0.21 ± 0.05 mg/kg and 0.34 ± 0.05 mg/kg for the control dietary VE supplementation, respectively.
Results of duplicate measurements for Hunter tristimulus values are shown in Table 1.
Characteristic changes during storage could be noted in the a* (redness) values. Table 1 shows that at the commencement of storage, and during the entire storage period, VE-supplemented samples had higher a* values than those of control batch, and the combination of VE-supplementation and the rosemary extract reduced further discolouration. VE-supplemented and antioxidatively combined treated samples had also somewhat lighter colour (higher L* values) than the controls. Under the aforementioned conditions, radiation treatment at the applied doses seemed to have little effect on the colour characteristics.
Fig 1. illustrates the effects of VE-supplementation, rosemary extract and radiation treatment on TBARS levels. The figure clearly shows that the increased endogenous VE level reduced the formation of TBARS both during radiation treatment and storage as compared to the controls. Additional enhancement of the antioxidant capacity of the VE-supplemented ground beef aws found using the rosemary extract. The TBARS in the unirradiated and low-dose (1-2 kGy) treated samples were reduced considerably at medium (3-4 kGy) dose levels. The proportions of the saturated fatty acids and the monounsaturated fatty acids in the fatty acid profile were in the range of 41-47 % and 46-53%, respectively, and they did not show considerable changes as a function of irradiation and storage, whereas the dominant, C18:2, fatty acid decreased significantly in the control samples during storage, and its decrease was somewhat greater in the medium-dose treated samples.

Table 1. Minolta L*(lightness), a*(redness) and b*(yelowness) values at various days (d) of refrigerated storage

Batch	Radiation dose (kGy)	Time														
		L*					a*					b*				
		0 d	2 d	4 d	6 d	8 d	0 d	2 d	4 d	6 d	8 d	0 d	2 d	4 d	6 d	8 d
Control	0	33	36	37	36	34	9	4	3	4	5	7	7	7	6	6
	1	35	38	37	38	37	8	5	5	4	3	7	7	7	8	7
	2	34	36	37	38	36	6	5	4	3	3	7	7	7	8	7
	3	35	38	38	38	37	8	2	4	4	3	7	8	8	8	3
	4	36	37	38	39	39	9	5	4	4	3	7	7	8	8	8
VE-supplem.	0	39	41	41	40	39	12	5	5	6	5	10	8	8	8	8
	1	40	42	43	44	43	8	7	6	4	4	9	9	9	9	9
	2	38	41	41	43	42	9	5	4	3	3	9	8	9	10	8
	3	40	41	43	43	42	11	6	5	3	4	9	9	9	10	9
	4	38	41	42	42	42	11	7	6	6	3	8	9	9	9	10
VE-supplem. + rosemary	0	40	42	43	43	40	11	9	4	6	6	9	9	9	8	8
	1	40	43	43	43	45	10	9	9	4	4	9	9	9	9	8
	2	41	43	43	44	43	9	9	8	4	4	9	9	9	10	9
	3	40	41	44	43	44	12	10	7	5	4	10	9	9	9	9
	4	39	43	42	42	43	12	9	9	9	6	9	9	9	10	9
LSD95%				0.9					0.5					0.4		

The retention of residual PUFA levels was improved by the antioxidants as illustrated in Table 2, showing both the C18:2 percentage and the PUFA/SFA ratio.

Only a minor decrease of pH (initial range: 5.51-5.56, after 8 days storage: 5.31-5.48) was observed. Although some values for L*, a* and b* colour measurements were different (Table 1), no significant differences ($P>0.05$) in sensory colour or odour scores were detected by panelists.

Conclusions

Increased endogenous α-tocopherol concentration by dietary VE supplementation and its combination with a commercial rosemary extract as natural antioxidant additive resulted in a colour-stabilising and lipid protecting effect in ground beef muscle. Although the irradiation in the studied dose range can cause a significant decrease in α-tocopherol levels (Lakritz et al., 1995), the combined antioxidative activity observed is very promising in minimising unwanted quality changes when the use of ionising radiation is considered for improved microbiological safety and extended shelf-life of this important product.

Acknowledgements

These experiments were carried out under a co-operation agreement between the University College Cork, Ireland, and the University of Horticulture and Food, Budapest, Hungary. The first author wishes to thank for the invaluable assistance of his Irish hosts and the FEFA Foundation, Hungary, for the financial support.

Pertinent literature

Bieri, J.G., T.J. Tolliver and G.L. Catignani. 1979. Am. J. Clin. Nutrit. 32: 2143.

Fu, An-Hung, J.G. Sebranek and E.A. Murano. 1995. J. Food Sci. 60: 972.

Lakritz, L., J.B. Fox Jr., J. Hampson, R. Richardson, K. Kohout and D.W. Thayer. 1995. Meat Sci. 41:261.

Lindberg Madsen, H. and G. Bertelsen. 1995. Trends Food Sci. Technol. 6: 271.

Liu, Q., M.C. Lanari and D.M. Schaefer. 1995. J. Anim. Sci. 73: 3131.

Newburg, D.S. and J.M. Concon. 1980. J. Food Sci. 45: 1681.

Patterson, R.L.S. and M.H. Stevenson. 1995. Brit. Poultry Sci. 36: 425.

Slover, H.T. and E. Lanza. 1979. J. Am. Oil Chem. Soc.

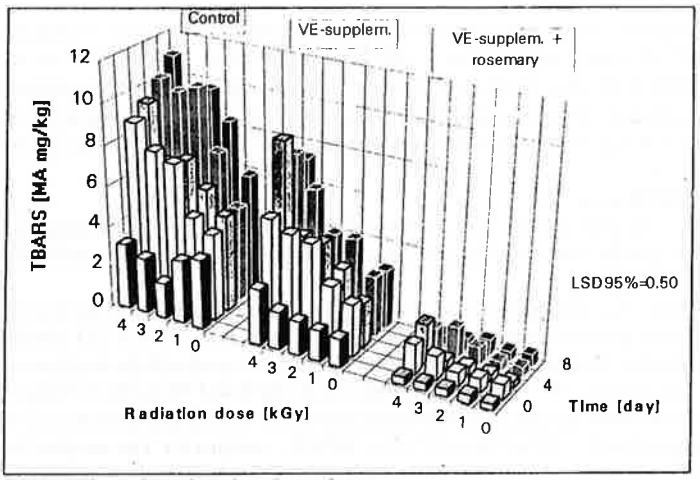

Fig 1. TBARS values as affected by radiation dose and storage time

Table 2. The concentrations of the dominant polyunsaturated fatty acid (C18:2) and ratios of PUFA/SFA in the fatty acid contents

Batch	C18:2 as percentage of total fatty acids						PUFA/SFA ratio in fatty acid profile					
	0 day	8 days					0 day	8 days				
	0 kGy	0 kGy	1 kGy	2 kGy	3 kGy	4 kGy	0 kGy	0 kGy	1 kGy	2 kGy	3 kGy	4 kGy
Control	7.3	3.4	3.5	3.3	3.2	2.4	0.23	0.11	0.11	0.11	0.11	0.07
VE supplem.	4.0	2.8	3.2	3.4	3.2	2.9	0.13	0.09	0.10	0.11	0.10	0.10
VE supplem. + rosemary	3.7	3.4	4.5	3.4	4.2	5.3	0.19	0.13	0.14	0.14	0.14	0.18