Antioxidant properties of β-carotene in poultry meat as affected by its concentration in feed during chilled storage.

J.A. Ruiz, A.M. Pérez-Vendrell and E. Esteve-García

Institut de Recerca i Tecnologia Agroalimentàries (I.R.T.A.), Department of Animal Nutrition, Centre de Mas Bové, Apartat 415, 43280 Reus, Spain.

Abstract

A study was carried out to compare the possible antioxidant properties of β-carotene with α-tocopherol as feed supplements. A basal maize-soy diet containing 6 % olive oil and 20 ppm α-tocopheryl acetate was supplemented with either 200 ppm α-tocopheryl acetate, 15 or 50 ppm β-carotene and no-supplementation. Vitamin E supplementation increased α-tocopherol tissue levels compared to the control, improving the oxidative stability of leg meat as shown by reduced TBARS values in iron-induced and non-induced TBARS analysis of fresh, cooked and stored meat. The effects of β-carotene were variable depending on its concentration in feed, α-tocopherol tissue levels and chilled storage during 7 days. At low concentrations (15 ppm) it seemed to act as an antioxidant, but at high concentration (50 ppm), and mainly in chilled meat, it acted as a pro-oxidant. This suggests that vitamin E tissue concentrations and chilled storage may influence the antioxidant properties of β-carotene.

Objective

To determine the effect of different 'natural' antioxidant, namely vitamin E and β-carotene at different concentrations, supplemented in the diet of broiler chickens fed a monounsaturated fat (olive oil) on the oxidative stability of chicken legs to compare with the results previously obtained with saturated fat (lard) and polyunsaturated fat (sunflower oil) added to poultry feed.

Introduction

α-Tocopherol supplemented to animal diets is deposited in tissue and improves some quality characteristics of meat, such as colour, flavour, texture, nutritive value and safety, which are related to oxidative stability (Morrissey et al., 1994). Antioxidant properties of β-carotene depend on its concentration, O_2 pressure and the presence of other antioxidants. At low O_2 pressure, as the physiological level found in tissues, and at low concentration, β-carotene could act as an antioxidant (Burton and Ingold, 1984; Kennedy and Liebler, 1992). *In vitro*, other antioxidants, such as α-tocopherol and vitamin C, improve antioxidant properties of β-carotene (Palozza and Krinsky, 1992). However, there is no clear information about its effects in meat, when supplemented in feed (King et al., 1995; Leibovitz et al., 1990). An experiment was carried out to test if β-carotene added to poultry feed supplemented with olive oil acted as an antioxidant in leg meat, in order to compare its possible antioxidant characteristics with the well-known properties of α-tocopherol. This experiment belongs to a series of experiments where different dietary fat varying in degree of unsaturation are added to feed . In a previous experiment (Ruiz et al., 1997) β-carotene seemed to act as an antioxidant at low concentration (15 ppm) when sunflower oil was used while it acted as a pro-oxidant at high concentration (50 ppm) and lard as supplemental fat.

Materials and Methods

A basal maize-soy diet containing 6 % olive oil and 20 ppm α-tocopheryl acetate was supplemented with either 200 ppm α-tocopheryl acetate, 15 or 50 ppm β-carotene or non-supplementated. The amount of α-tocopherol was measured without saponification after extraction with hexane by HPLC, in leg meat. The oxidative stability was assessed measuring TBARS by colorimetric methods (for non-induced TBARS, Vyncke, 1975; and for iron-induced TBARS Kornbrush and Mavis, 1980).

Results and Discussion

Vitamin E supplementation increased tissue levels of α-tocopherol above the control. It is interesting to note that β-carotene 50 ppm reduced them below the level observed with the basal diet (Table 1), possibly as a result of competition between two antioxidants during absorption (Yin and Cheng, 1997). α-tocopherol reduced non-induced TBARS values (Table 2) and iron-induced TBARS values (Figure 1) with respect to the control. β-carotene at low concentration decreased induced TBARS values as shown in Figure 1 and it seemed to show an antioxidant effect in non-induced TBARS compared with the basal diet. On the other hand, β-carotene at 50 ppm did not show any antioxidant effect rather tended to show a pro-oxidant effect in leg meat after 7 days of chilled storage, which could be caused by destruction of vitamin E during regeneration of β-carotene radicals developed during oxidation. Palozza and Krinsky (1992) showed that α-tocopherol protects β-carotene from autoxidation *in vitro*. This protection is dose-dependent and occurs only at sufficient concentration of α-tocopherol. When α-tocopherol concentration decreased below a certain level, β-carotene showed no effect, and even in some cases a pro-oxidant effect (in chilled storage during 7 days). These results

emphasize the need for a greater level of vitamin E in the presence of β-carotene, in order to obtain an antioxidant effect of β-carotene, as shown in a previous experiment with lard and sunflower oil as supplemental fat in feed (Ruiz et al, 1997). However, further studies are needed to confirm this synergistic behaviour *in vivo* between α-tocopherol and β-carotene, specially in chilled storage.

Conclusions

- α-tocopherol supplemented to diet, increased vitamin E tissue levels, and increased oxidative stability of fresh, cooked and stored leg meat.
- β-carotene has antioxidant properties depending on dietary concentration. β-carotene can act as an antioxidant at low concentration (15 ppm) and show no effect or a pro-oxidant effect at high concentration (50 ppm) or during chilled storage, possibly due to a reduction of vitamin E tissue concentration.
- TBARS during chilled storage does not give the same pattern of response as iron-induced TBARS, as shown by the results of β-carotene. Therefore, iron-induced TBARS may not be a good predictor of oxidative status during storage.

References

Burton, G.W. and Ingold, K.U. (1984). Science, 224: 569-573.
Kennedy, T.A. and Leibler, D.C. (1992). Journal of Biological Chemistry, 267: 4658-4663.
King, A.J.; Uijttenboogaart, T.G. and Devries, A.W. (1995). Journal of Food Science, 60: 1009-1012.
Kornsbrust, D.J. and Mavis, R.D. (1980). Lipids, 15: 315-322.
Leibovitz, B.; Hu, M.L. and Tappel, A.L. (1990). Journal of Nutrition, 120: 97-104
Morrissey, P.A.; Buckley, D.J.; Sheehy, P.J.A. and Monahan, F.J. (1994). Proceeding of the Nutrition Society, 53: 289-295.
Palozza, P. and Krinsky, N.I. (1992). Archives of Biochemistry and Biophysics, 297: 184-187.
Ruiz, J.A.; Pérez-Vendrell, A.M. and E. Esteve-García. In: 11th European Symposium on Poultry Nutrition, page 301-303. August 24-28, 1997. Faaborg. Denmark.
Vyncke, W. (1975). Fette Seifen Anstrichmittel, 77: 239-240.
Yin, M.C. and Cheng, W.S. 1997 Journal of Food Science, 62: 1095-1097

Table 1.- Vitamin E tissue levels (mg/g tissue)

Treatment	Day 0	Cooked	Day 7
Basal	3.20^{b}	2.79^{b}	3.19^{b}
Vitamin E 200 ppm	13.17^{a}	13.13^{a}	11.75^{a}
β-carotene 15 ppm	3.49^{b}	2.16^{bc}	2.60^{b}
β-carotene 50 ppm	2.15^{c}	2.00^{c}	1.90^{c}
SE	*0.57*	*0.50*	*0.30*

Means in the same column followed by different superscripts are significantly different (P<0.05)

Table 2.- TBARS tissue levels (mmol MDA/Kg tissue)

Treatment	Day 0	Cooked	Day 7
Basal	0.91^{a}	2.97^{a}	4.61^{b}
Vitamin E 200 ppm	0.52^{b}	1.21^{c}	2.43^{c}
β-carotene 15 ppm	1.10^{a}	2.13^{b}	3.57^{bc}
β-carotene 50 ppm	1.10^{a}	2.97^{a}	10.46^{a}
SE	*0.12*	*0.22*	*1.41*

Means in the same column followed by different superscripts are significantly different (P<0.05)

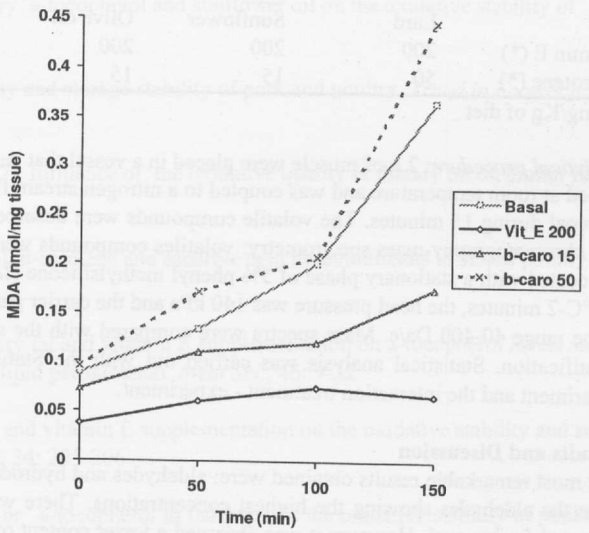

Figure 1.- Iron-induced TBARS of leg muscles