

# Capítulo 11

# Conclusiones

Sólo sé que no sé nada.  
*Sócrates*



De los resultados expuestos en la presente memoria de tesis doctoral se pueden extraer las siguientes conclusiones:

1. A medida que el nivel de poliinsaturación dietético se incrementa, tanto el contenido como la proporción de ácidos grasos poliinsaturados en muslo y pechuga aumenta de manera exponencial. La proporción de ácidos grasos poliinsaturados en estos tejidos se deposita a un ritmo fraccional inferior cuando la grasa dietética aporta mayor contenido de ácidos grasos saturados y monoinsaturados.
2. A medida que se incrementa la cantidad de ácidos grasos poliinsaturados del pienso (g/kg), bien sea variando el tipo o el nivel de grasa añadida al pienso, el contenido de ácidos grasos saturados y monoinsaturados se reduce de forma lineal a un ritmo de 0,4-0,7 g/kg, respectivamente, en el muslo y de 0,9-1,0 g/kg, respectivamente, en la pechuga de pollo.
3. El depósito estimado de ácidos grasos procedentes exclusivamente de la síntesis endógena disminuye al aumentar el nivel de grasa dietética de 0 a 10%, situándose para muslo y pechuga entre 37,8 y 17,8% y entre 39,2 y 23,3%, respectivamente, para los ácidos grasos saturados y entre 48,5 y 8,0% y entre 42,6 y 9,8%, respectivamente, para los ácidos grasos monoinsaturados.
4. La suplementación con acetato de  $\alpha$ -tocoferol a dosis inferiores o iguales a 400 mg/kg no afecta al contenido de ácidos grasos del muslo y de la pechuga.
5. La concentración tisular de  $\alpha$ -tocoferol en muslo y pechuga es directamente proporcional a su contenido en la dieta, y su depósito no se satura a dosis iguales o inferiores a 400 mg  $\alpha$ -TA/kg.
6. El depósito de  $\alpha$ -tocoferol en los tejidos de las aves se reduce al aumentar el grado de poliinsaturación dietético, siendo atribuido principalmente al contenido en ácidos grasos poliinsaturados de la dieta, y en menor medida al del propio tejido. Para alcanzar un depósito de  $\alpha$ -tocoferol en la carne concreto (40 mg/kg), por cada gramo de ácidos grasos poliinsaturados en el pienso, se necesita aumentar la cantidad de  $\alpha$ -tocoferol de la ración alrededor de 3-4 mg para contenidos dietéticos de ácidos grasos poliinsaturados bajos (15-20 g/kg) y más de 12 mg para contenidos de ácidos grasos poliinsaturados en la dieta altos (superiores a 55 g/kg).
7. En términos generales, el depósito de ácidos grasos y de  $\alpha$ -tocoferol en la pechuga es menos influenciado a través de modificaciones de la dieta que el del muslo con piel.

8. El consumo de diferentes niveles de acetato de  $\alpha$ -tocoferol no modifica el perfil de estereoisómeros del  $\alpha$ -tocoferol en el hígado y muslo. Ambos tejidos muestran un perfil de estereoisómeros similar dependiente del perfil de estereoisómeros de la dieta. Cuando el animal consume una mezcla racémica de  $\alpha$ -tocoferol se favorece el depósito de las formas 2R.
  
9. La susceptibilidad a la oxidación (valorada en términos de TBA) de la carne de pollo es directamente proporcional al contenido de ácidos grasos poliinsaturados de la misma, y se hace más evidente durante su procesado y posterior conservación en refrigeración.
  
10. El  $\alpha$ -tocoferol reduce la oxidación lipídica de la carne de pollo, siguiendo un modelo de saturación. La estabilidad oxidativa de ésta no se ve afectada por un aumento en el nivel de  $\alpha$ -tocoferol dietético de 200 a 400 mg/kg.

Capítulo 12  
**Bibliografía**



## A

- Addis PB. Occurrence of lipid oxidation products in foods. *Food Chem Toxic* **1986**; 24(10/11):1021-1030.
- Addis PB, Emanuel HA, Bergmann SD, Zavoral JH. Capillary GC quantification of cholesterol oxidation products in plasma lipoproteins of fasted humans. *Free Radical Biol Med* **1989**; 7:179-182.
- Addis PB, Park PW, Guardiola F. Analysis and health effects of cholesterol oxides. En: Food lipids and Health. McDonald RE, Min DB, Eds. Marcel Dekker, Inc. New York, EUA, **1996**; 199-240.
- Ahn DU, Wolfe FH, Sim JS, Kim DH. Packaging cooked turkey meat patties while hot reduces lipid oxidation. *J Food Sci* **1992**; 57(5):1075-1077.
- Ahn DU, Ajuyah AO, Wolfe FH, Sim JS. Oxygen availability affects prooxidant catalyzed lipid oxidation of cooked turkey patties. *J Food Sci* **1993a**; 58(2):278-291.
- Ahn DU, Wolfe FH, Sim JS. Prevention of lipid oxidation in pre-cooked turkey meat patties with hot packaging and antioxidant combinations. *J Food Sci* **1993b**; 58(2):283-287.
- Ahn DU, Wolfe FH, Sim JS. Dietary  $\alpha$ -linolenic acid and mixed tocopherols, and packaging influences on lipid stability in broiler chicken breast and leg muscle. *J Food Sci* **1995**; 5 :1013-1018.
- Ahn DU, Lutz S, Sim JS. Effects of dietary  $\alpha$ -linolenic acid on the fatty acid composition, storage stability and sensory characteristics of pork loin. *Meat Sci* **1996**; 43(3-4):291-299.
- Ahn DU, Sell JL, Jo C, Chen X, Wu C, Lee JI. Effects of dietary vitamin E supplementation on lipid oxidation and volatiles content of irradiated, cooked turkey meat patties with different packaging. *Poult Sci* **1998**; 77:912-920.
- Ahn DU, Lee JI, Jo C, Sell JL. Analysis of cholesterol oxides in egg yolk and turkey meat. *Poult Sci* **1999**; 78:1060-1064.
- Ajuyah AO, Lee KH, Hardin RT, Sim JS. Changes in the yield and in the fatty acid composition of whole carcass and selected meat portions of broiler chickens fed full-fat oil seeds. *Poult Sci* **1991**; 70:2304-2314.
- Ajuyah AO, Hardin RT, Sim JS. Dietary antioxidant and storage affect chemical characteristics of  $\omega$ -3 fatty acid enriched broiler chicken meats. *J Food Sci* **1993a**; 58(1):43-46.

- Ajuyah AO, Hardin RT, Sim JS. Effect of dietary full-fat flax seed with and without antioxidant on the fatty acid composition of major lipid classes of chicken meats. *Poult Sci* **1993b**; 72:125-136.
- Aletor VA, Hamid II, Nieb E, Pfeffer E. Low-protein amino acid-supplemented diets in broiler chickens: effects on performance, carcass characteristics, whole-body composition and efficiencies of nutrient utilisation. *J Sci Food Agric* **2000**; 80:547-554.
- Ang CYW. Comparisons of broiler tissues for oxidative changes after cooking and refrigerated storage. *J Food Sci* **1988**; 53(4):1072-1075.
- Ang CYW, Lillard HS, Searcy GK. Effect of refrigeration and microbial contamination of raw broiler tissues on thiobarbituric acid values and headspace gas chromatographic analysis of cooked and stored breast and leg meat. *Poult Sci* **1989**; 68:1470-1477.
- Ang CYW. Reheating effect on thiobarbituric acid reactive substances of refrigerated stored, cooked broiler meat. *J Food Prot* **1992**; 55(11):924-926.
- AOAC. Official Methods of Analysis (16th Ed.). Association of Analytical Chemists, Ed. Washington DC, EUA **1995**.
- Applegate TJ, Sell JL. Effect of dietary linoleic to linolenic acid ratio and vitamin E supplementation on vitamin E status of poults. *Poult Sci* **1996**; 75:881-890.
- Asghar A, Lin CF, Gray JI, Buckley DJ, Booren AM, Flegal CJ. Effects of dietary oils and  $\alpha$ -tocopherol supplementation on membranal lipid oxidation in broiler meat. *J Food Sci* **1990**; 55 (1):46-50.
- Atkinson A, Van der Merwe RP, Swart LG. The effect of high levels of different fish meals, of several antioxidants and poultry byproduct meal on the flavour and fatty acid composition of broilers. *Agroanimalia* **1972**; 4:63-68.
- Atteh JO, Leeson S. Response of laying hens diets to dietary saturated and unsaturated fatty acids in the presence of varying dietary calcium levels. *Poult Sci* **1985**; 64:520.
- Aubourg SP. Review: Interaction of malondialdehyde with biological molecules- new trends about reactivity and significance. *Int J Food Sci Technol* **1993**; 28:323-335.
- B**
- Badinga L, Selberg KT, Dinges AC, Comer W, Miles RD. Dietary conjugated linoleic acid alters hepatic lipid contents and fatty acid composition in broiler chickens. *Poult Sci* **2003**;



82:111-116.

- Barroeta A, King AJ. Effect of carotenoids on lipid oxidation in stored poultry muscle. *Poult Sci* **1991**; 70(Sup. 1):11.
- Bartov I, Lipstein B, Bornstein S. Differential effects of dietary acidulated soybean oil soapstock, cottonseed oil soapstock and tallow on broiler carcass fat characteristics. *Poult Sci* **1974**; 53:115-124.
- Bartov I. Lack of effect of dietary ascorbic acid on stability of carcass fat and meat of broilers. *Br Poult Sci* **1977a**; 18:553-555.
- Bartov I. Pro- and antioxidants in the diets of broilers and their effects on carcass quality: copper, selenium and acidulated soybean-oil soapstock. *Poult Sci* **1977b**; 56(3):829-835.
- Bartov I, Bornstein S. Stability of abdominal fat and meat of broilers: Effect of duration of feeding antioxidants. *Br Poult Sci* **1978**; 19:129-135.
- Bartov I. Nutritional factors affecting quantity and quality of carcass fat in chickens. *Fed Proc* **1979**; 38:2627-2630.
- Bartov I, Bornstein S. Stability of abdominal fat and meat of broilers: Combined effect of dietary vitamin E and synthetic antioxidants. *Poult Sci* **1981**; 60(8):1840-1845.
- Bartov I, Frigg M. Effect of high concentrations of dietary vitamin E during various age periods on performance, plasma vitamin E and meat stability of broiler chicks at 7 weeks of age. *Br Poult Sci* **1992**; 33:393-402.
- Bjorneboe A, Bjorneboe GEA, Drevon CA. Absorption, transport and distribution of vitamin E. *J Nutr* **1990**; 120:233-242.
- Blanch A, Barroeta AC, Baucells MD, Serrano X, Puchal F. Utilization of different fats and oils by adult chickens as a source of energy, lipid and fatty acids. *An Feed Sci Technol* **1996**; 61:335-342.
- Botsoglou NA, Florou-Paneri P, Christaki E, Fletouris DJ, Spais AB. Effect of dietary oregano essential oil on performance of chickens and on iron-induced lipid oxidation of breast, thigh and abdominal tissues. *Br Poult Sci* **2002**; 43:223-230.
- Botsoglou NA, Grigoropoulou SH, Botsoglou E, Govaris A, Papageorgiou G. The effects of dietary oregano essential oil and  $\alpha$ -tocopheryl acetate on lipid oxidation in raw and cooked turkey during refrigerated storage. *Meat Sci* **2003**; 65:1193-1200.

- Bou R, Guardiola F, Grau A, Grimpa S, Manich A, Barroeta A, Codony R. Influence of dietary fat source,  $\alpha$ -tocopherol, and ascorbic acid supplementation on sensory quality of dark chicken meat. *Poult Sci* **2001**; 80:1-8.
- Bou R, Guardiola F, Tres A, Barroeta AC, Codony R. Effect of dietary fish oil, and  $\alpha$ -tocopheryl acetate, and zinc supplementation on the composition and consumer acceptability of chicken meat . *Poult Sci* **2004**; 83:282-292.
- Bramley PM, Elmadfa I, Kafatos A, Kelly FJ, Manios Y, Roxborough HE, Schuch W, Sheehy PJA, Wagner K-H. Vitamin E. *J Sci Food Agric* **2000**; 80:913-938.
- Brandon S, Morrissey PA, Buckley DJ, Frigg M. Influence of dietary  $\alpha$ -tocopheryl acetate on the oxidative stability of chicken tissues. Proceedings of the 11<sup>th</sup> European Symposium on the Quality of Poultry Meat, Tours, Francia, **1993**; 397-403.
- Brue RN, Latshaw JD. Energy utilization by the broiler chicken as affected by various fats and fat levels. *Poult Sci* **1985**; 64:2119-2130.
- Buckley DJ, Morrissey PA. Vitamin E and meat quality. *F Hoffmann-La Roche Animal Production Highlights* **1991**.
- Burton GB, Ingold KU. Vitamin E as in vitro and in vivo antioxidant. *Ann N Y Acad Sci* **1989**; 570:7-22.
- Burton GB, Traber MG. Vitamin E: antioxidant activity, biokinetics and bioavailability. *Annu Rev Nutr* **1990**; 10:357-382.
- Burton GW, Ingold KU, Zahalka H, Dutton P, Hodgkinson B, Hughes L, Foster DO, Behrens WA. Biodiscrimination of tocopherols. En: Vitamin E. Its usefulness in health and in curing diseases. Mino M, Nakamura H, Diplock A, Kayden HJ, Eds. Japan Scientific Societies Press. Tokyo, Japón, **1993**: 51-61.

## C

- Cahaner A, Nitsan Z, Nir I. Weight and fat content of adipose and nonadipose tissues in broilers selected for or against abdominal adipose tissue. *Poult Sci* **1986**; 65:215-222.
- Calabotta DF, Cherry JA, Siegel PB, Jones DE. Lipogenesis and lipolysis in fed and fasted chicks from high and low body weight lines. *Poult Sci* **1985**; 64 :700-704.
- Carrapiso AI, Timón ML, Petróon MJ, Tejeda JF, García C. In situ transesterification of fatty acids from Iberian pig subcutaneous adipose tissue. *Meat Sci* **2000**; 56:159-164.

Chang MH, Chen TC. "Hotness" stability of chicken hot-wing products as affected by preparation methods and storage. *Poult Sci* **1998**; 77:627-631.

Chanmugam P, Boudreau M, Boutte T, Park RS, Hebert J, Berrio L, Hwang DH . Incorporation of different types of n-3 fatty acids into tissue lipids of poultry. *Poult Sci* **1992**; 71:516-521.

Chen KH, Yang SC, Su JD. The cholesterol oxidation products contents of chicken meat as affected by different heating methods. Proceedings of the 11<sup>th</sup> European Symposium on the Quality of Poultry Meat, Tours, Francia, **1993**; 412- 422.

Cherian G, Wolfe FW, Sim JS. Dietary oils added tocopherols: Effects on egg or tissue tocopherols, fatty acids, and oxidative stability. *Poult Sci* **1996**; 75:423-431.

Clough RH, Yee BG, Foote CS. Chemistry of singlet oxygen. XXX. The unstable primary product of tocopherol photooxidation. *J Am Chem Soc* **1979**; 101:683-686.

Corl BA, Barbano DM, Bauman DE, Ip C. *Cis*-9, *trans*-11 CLA derived endogenously from *trans*-11 18:1 reduces cancer risk in rats. *J Nutr* **2003**; 133:2893-2900.

Crespo N, Esteve-García E. Dietary fatty acid profile modifies abdominal fat deposition in broiler chickens. *Poult Sci* **2001**; 80:71-78.

Crespo N, Esteve-García E. Dietary polyunsaturated fatty acids decrease fat deposition in separable fat depots but not in the remainder carcass. *Poult Sci* **2002a**; 81:512-518.

Crespo N, Esteve-García E. Nutrient and fatty acid deposition in broilers fed different dietary fatty acid profiles. *Poult Sci* **2002b**; 81:1533-1542.

Crespo N, Esteve-García E. Dietary linseed oil produces lower abdominal fat deposition but higher de novo fatty acid synthesis in broiler chickens. *Poult Sci* **2002c**; 81:1555-1562.

## D

Dawson PL, Sheldon BW, Larick DK, Ball HR. Changes in the phospholipid and neutral-lipid fractions of mechanically deboned chicken meat due to washing, cooking, and storage. *Poult Sci* **1990**; 69:166-175.

De Groote G, Reynstens N, Amich-Gali J. Fat studies 2. The metabolic efficiency of energy utilization of glucose, soybean oil and different animal fats by growing chicks. *Poult Sci* **1971**; 50(3):808-819.

De Winne A, Dirinck P. Studies on vitamin E and meat quality. 2. Effect of feeding high

- vitamin E levels on chicken meat quality. *J Agric Food Chem* **1996**; 44:1691-1696.
- Deaton JW, McNaughton JL, Reece FN, Lott BD. Abdominal fat of broilers as influenced by dietary level of animal fat. *Poult Sci* **1981**; 60:1250-1253.
- Deaton JW, Lott BD. Age and dietary energy effect on broiler abdominal fat deposition. *Poult Sci* **1985**; 64:2161-2164.
- Decker EA, Xu Z. Minimizing rancidity in muscle foods. *Food Technol* **1998**; 52(10):54-59.
- Donaldson WE. Lipogenesis and body fat in chicks: Effects of calorie-protein ratio and dietary fat. *Poult Sci* **1985**; 64:1199-1204.
- Drevon CA. Absorption, metabolism, and excretion of vitamin E. En: Vitamin E. Its usefulness in health and in curing diseases. Mino M, Nakamura H, Diplock A, yden HJ, Eds. Japan Scientific Societies Press. Tokyo, Japón **1993**: 65-83.
- Drotleff AM, Ternes W. Determination of RS,E/Z-tocotrienols by HPLC. *J Chromatogr A* **2001**; 909:215-223.
- Du M, Ahn DU, Nam KC, Sell JL. Volatiles profiles and lipid oxidation of irradiated cooked chicken meat from laying hens fed diets containing conjugated linoleic acid. *Poult Sci* **2001a**; 80:235-241.
- Du M, Hur SJ, Nam KC, Ismail H, Ahn DU. Volatiles, color, and lipid oxidation of broiler breast fillets irradiated before and after cooking. *Poult Sci* **2001b**; 80(1748):1753.
- Du M, Ahn DU. Effect of dietary conjugated linoleic acid on the growth rate of live birds and on the abdominal fat content and quality of broiler meat. *Poult Sci* **2002**; 81:428-433.
- Dutta-Roy AK, Gordon MJ, Campbell FM, Duthie GG, James WPT. Vitamin E requirements, transport, and metabolism: role of  $\alpha$ -tocopherol-binding proteins. *J Nutr Biochem* **1994**; 5:562-570.

## E

- Emanuel HA, Hassel CA, Addis PB, Bergmann SD, Zavoral JH. Plasma cholesterol oxidation products (oxysterols) in human subjects fed a meal rich in oxysterols. *J Food Sci* **1991**; 56(3):843-847.
- Engberg RM, Lauridsen C, Jensen SK, Jakobsen K. Inclusion of oxidized vegetable oil in

broiler diets. Its influence on nutrient balance and on the antioxidative status of broilers. *Poult Sci* **1996**; 75:1003-1011.

Erickson MC. Lipid oxidation of muscle foods. En: Food lipids. Chemistry, Nutrition and Biotechnology. Akoh CC, Min DB, Eds. Dekker Inc. New York, EUA; **1998**: 297-332.

Esterbauer H, Schaur RF, Zollner H. Chemistry and biochemistry of 4-hydroxynonenal, malonaldehyde and related aldehydes. *Free Radical Biol Med* **1991**; 11:81-128.

## F

Flachowsky G, Engelman D, Sünder A, Halle I, Sallmann HP. Eggs and poultry meat as tocopherol sources in dependence on tocopherol supplementation of poultry diets. *Food Res Int* **2002**; 35:239-243.

Frankel EN. Recent advances in lipid oxidation. *J Sci Food Agric* **1991**; 54:495-511.

Frankel EN. Foods. En: Lipid oxidation. The Oily Press Ltd., Dundee, Scotland, **1998**: 187-225.

Frigg M, Prabucki AL, Banken L, Schwere B, Häuser A, Blum JC. Effect of dietary vitamin E supplies in broilers. 1. Report: Evaluation of parameters related to oxidative stability of broiler meat. *Arch Geflügelk* **1991**; 55(5):201-207.

Fry JL, Van Wallegghem P, Waldroup PW, Harms RH. Fish meal studies. 2. Effects of levels and sources on "Fishy flavor" in broiler meat. *Poult Sci* **1965**; 44:1016-1019.

## G

Gallo-Torres R. Obligatory role of bile for the intestinal absorption of vitamin E. *Lipids* **1970**; 5:379-384.

Gallo-Torres R, Weber F, Wiss O. The effect of different dietary lipids on the lymphatic appearance of vitamin E. *Int J Vitam Nutr Res* **1971**; 41:504-515.

Galvin K, Morrissey PA, Buckley DJ, Frigg M. Influence of oil quality and  $\alpha$ -tocopheryl acetate supplementation on  $\alpha$ -tocopherol and lipid oxidation in chicken tissues. Proceedings of the 11<sup>th</sup> European Symposium on the Quality of Poultry Meat, Tours, Francia, **1993**; 423-429.

Galvin K, Morrissey PA, Buckley DJ. Influence of dietary vitamin E and oxidised sunflower oil on the storage stability of cooked chicken muscle. *Br Poult Sci* **1997**; 38:499-504.

- González-Esquerro R, Leeson S. Effects of menhaden oil and flaxseed in broiler diets on sensory quality and lipid composition of poultry meat. *Br Poult Sci* **2000**; 41:481-488.
- Grau A. Oxidación lipídica en carne de pollo: Influencia del grado de insaturación de la dieta y de su suplementación con ácido ascórbico y alfa-tocoferol. Tesis doctoral, Universitat de Barcelona, Facultat de Farmàcia, **2000**.
- Grau A, Guardiola F, Boatella J, Barroeta AC, Codony R. Measurement of 2-thiobarbituric acid values in dark chicken meat through derivative spectrophotometry: Influence of various parameters. *J Agric Food Chem* **2000a**; 48:1155-1159.
- Grau A, Guardiola F, Boatella J, Baucells MD, Codony R. Evaluation of lipid ultraviolet absorption as a parameter to measure lipid oxidation in dark chicken meat. *J Agric Food Chem* **2000b**; 48:4128-4135.
- Grau A, Guardiola F, Bou R, Codony R. Influencia de la dosis y el tiempo de suplementación del pienso con acetato de  $\alpha$ -tocoferol en la calidad de la carne de pollo. *Alimentación, Nutrición y Salud* **2000c**; 7(4):91-98.
- Grau A, Guardiola F, Grimpa S, Barroeta AC, Codony R. Oxidative stability of dark chicken meat through frozen storage: Influence of dietary fat and  $\alpha$ -tocopherol and ascorbic acid supplementation. *Poult Sci* **2001a**; 80:1630-1642.
- Grau A, Codony R, Grimpa S, Baucells MD, Guardiola F. Cholesterol oxidation in frozen dark chicken meat: influence of dietary fat source, and  $\alpha$ -tocopherol and ascorbic acid supplementation. *Meat Sci* **2001b**; 57:197-208.
- Gray JI, Goma EA, Buckley DJ. Oxidative quality and shelf life of meats. *Meat Sci* **1996**; 43 (Suppl.):111S-123S.
- Griffiths L, Leeson S, Summers JD. Influence of energy system and level of various fat sources on performance and carcass composition of broilers. *Poult Sci* **1977**; 56:1018-1026.
- Guardiola F, Codony R, Addis PB, Rafecas M, Boatella J. Biological effects of oxysterols: current status. *Food Chem Toxic* **1996**; 34(2):193-211.
- Gurr MI. Types of fats in the body and their functions. En: Role of fats in food and nutrition. Elsevier Applied science publishers, London, UK, **1984**; 5-17.
- Gutteridge JMC. The use of standards for malonyldialdehyde. *Anal Biochem* **1975**; 69:518-526.

## H

Halliwell B, Gutteridge JMC. Role of free radicals and catalytic metal ions in human disease: an overview. *Methods Enzimol* **1990**; 186:1-85.

Halliwell B, Chirico S. Lipid peroxidation: its mechanism, measurement, and significance. *Am J Clin Nutr* **1993**; 57 suppl(7):15S-25S.

Halliwell B, Murcia A, Chirico S, Aruoma OI. Free radicals and antioxidants in food and in vivo: what they do and how they work. *Crit Rev Food Sci Nutr* **1995**; 35(1&2):7-20.

Hargis PS, Van Elswik ME. Manipulating the fatty acid composition of poultry meat and eggs for the health conscious consumer. *World's Poult Sci J* **1993**; 49:251-264.

Herrera E. Metabolismo de la vitamina E. *Nutrición y Obesidad* **2000**; 3:4-16.

Herrera E, Barbas C. Vitamin E: action, metabolism and perspectives. *J Physiol Biochem* **2001**; 57(1):43-56.

Higgins FM, Kerry JP, Buckley DJ, Morrissey PA. Effect of dietary  $\alpha$ -tocopheryl acetate supplementation on  $\alpha$ -tocopherol distribution in raw turkey muscles and its effect on the storage stability of cooked turkey meat. *Meat Sci* **1998**; 50(3):373-383.

Higgins FM, Kerry JP, Buckley DJ, Morrissey PA. Effects of  $\alpha$ -tocopheryl acetate supplementation and salt addition on the oxidative stability (TBARS) and warmed-over flavour (WOF) of cooked turkey meat. *Br Poult Sci* **1999**; 40(59):64.

Hosomi A, Arita M, Sato Y, Kiyose C, Ueda T, Igarashi O, Arai H, Inoue K. Affinity for  $\alpha$ -tocopherol transfer protein as a determinant of the biological activities of vitamin E analogs. *FEBS Lett* **1997**; 409:105-108.

Hrdinka C, Zollitsch W, Knaus W, Lettner F. Effects of dietary fatty acid pattern on melting point and composition of adipose tissues and intramuscular fat of broiler carcasses. *Poult Sci* **1996**; 75:208-215.

Hulan HW, Ackman RG, Ratnayake WMN, Proudfoot FG. Omega-3 fatty acid levels and performance of broiler chickens fed redfish meal or redfish oil. *Can J Anim Sci* **1988**; 68:533-547.

Hulan HW, Ackman RG, Ratnayake WMN, Proudfoot FG. Omega-3 fatty acid levels and general performance of commercial broilers fed practical levels of redfish meal. *Poult Sci* **1989**; 68:153-162.

Husveth F, Manilla HA, Gaal T, Vajdovich P, Balogh N, Wagner L, Loth I, Nemeth K. Effects of saturated and unsaturated fats with vitamin E supplementation on the antioxidant status of broiler tissues. *Acta Vet Hung* 2000; 48(1):69-79.

## I

Infante JP. A function for the vitamin E metabolite  $\alpha$ -tocopherol quinone as an essential enzyme cofactor for the mitochondrial fatty acid desaturases. *FEBS Lett* 1999; 446:1-5.

Ingold KU, Burton GW, Foster DO, Hughes L. Is methyl-branching in  $\alpha$ -tocopherol's "tail" important for its in vivo activity? Rat curative myopathy bioassay measurements of the vitamin E activity of three 2RS-n-alkyl-2,5,7,8-tetramethyl-6-hydroxychromans. *Free Radic Biol Med* 1990; 9:205-210.

## J

Jakobsen K, Engberg RM, Andersen JO, Jensen SK, Lauridsen C, Sorensen P, Henckel P, Bertelsen G, Skibsted LH, Jensen C. Supplementation of broiler diets with *all-rac*- $\alpha$ - or a mixture of natural source RRR- $\alpha$ -, $\gamma$ -, $\delta$ -tocopheryl acetate. 1. Effect on vitamin E status of broilers in vivo and at slaughter. *Poult Sci* 1995; 74:1984-1994.

Jensen C, Skibsted LH, Jakobsen K, Bertelsen G. Supplementation of broiler diets with *all-rac*- $\alpha$ - or a mixture of natural source RRR- $\alpha$ -, $\gamma$ -, $\delta$ -tocopheryl acetate. 2. Effect on the oxidative stability of raw and precooked broiler meat products. *Poult Sci* 1995; 74:2048-2056.

Jensen C, Enberg R, Jakobsen K, Skibsted LH, Bertelsen G. Influence of the oxidative quality of dietary oil on broiler meat storage stability. *Meat Sci* 1997; 47(3/4):211-222.

Jensen C, Lauridsen C, Bertelsen G. Dietary vitamin E: Quality and storage stability of pork and poultry. *Trends Food Sci Technol* 1998a; 9:62-72.

Jensen LS, Schumaier GW, Latshaw JD. "Extra coloric" effect of dietary fat for developing turkeys as influenced by calorie-protein ratio. *Poult Sci* 1970; 49:1697-1704.

Jensen SK, Jensen C, Jakobsen K, Engberg RM, Andersen JO, Lauridsen C, Sorensen P, Skibsted LH, Bertelsen G. Supplementation of broiler diets with retinol acetate,  $\beta$ -carotene or canthaxanthin: Effect of vitamin status and oxidative status of broiler in vivo and on meat stability. *Acta Agric Scand* 1998b; 48:28-37.



Jensen SK, Engberg RM, Hedermann MS. *All-rac- $\alpha$ -tocopherol acetate is a better vitamin E source than all-rac- $\alpha$ -tocopherol succinate for broilers. *J Nutr* 1999; 129:1355-1360.*

Jeun-Horng L, Yuan-Hui L, Chun-Chin K. Effect of dietary fish oil on fatty acid composition, lipid oxidation and sensory property of chicken frankfurters during storage. *Meat Sci* 2002; 60:161-167.

## K

Kagan VE, Quinn PJ. The interaction of alpha-tocopherol and homologues with shorter hydrocarbon chains with phospholipid bilayer dispersions. A fluorescence probe study. *Eur J Biochem* 1988; 171:661-667.

Kamal-Eldin A, Appelqvist LA. The chemistry and antioxidant properties of tocopherols and tocotrienols. *Lipids* 1996; 31(7):671-701.

Kanatt SR, Paul P, D'Souza SF, Thomas P. Lipid peroxidation on chicken meat during chilled storage as affected by antioxidants combined with low-dose gamma irradiation. *J Food Sci* 1998; 63(2):198-200.

Kaneko K, Kiyose C, Ueda T, Ichikawa H, Igarashi O. Studies of the metabolism of  $\alpha$ -tocopherol stereoisomers in rats using [5-methyl- $^{14}\text{C}$ ]SRR- and RRR- $\alpha$ -tocopherol. *J Lipid Res* 2000; 41:357-367.

Kanner J, Harel S. Initiation of membranial lipid peroxidation by activated metmyoglobin and methemoglobin. *Arch Biochem Biophys* 1985; 237:314-321.

Kanner J, German JB, Kinsella JE. Initiation of lipid peroxidation in biological systems. *Crit Rev Food Sci Nutr* 1987; 25:317-364.

Keren-Zvi S, Nir I, Nitsan Z, Cahaner A. Effect of dietary concentrations of fat and energy on fat deposition in broilers divergently selected for high or low abdominal adipose tissue. *Br Poult Sci* 1990; 31:507-516.

King AJ, Uijttenboogaart TJ, Vries AW.  $\alpha$ -Tocopherol,  $\beta$ -carotene and ascorbic acid as antioxidant in stored poultry muscle. *J Food Sci* 1995; 60:1009-1012.

Kingston ER, Monahan FJ, Buckley DJ, Lynch PB. Lipid oxidation in cooked pork as affected by vitamin E, cooking and storage conditions. *J Food Sci* 1998; 63(3):386-389.

Kinsella JE, Lokesh B, Stone RA. Dietary n-3 polyunsaturated fatty acid and amelioration of cardiovascular disease: possible mechanism. *J Food Sci* 1990; 52:1-28.

- Kirchgessner M, Risitic M, Kreuzer M, Roth FX. Einsatz von fetten mit hohen anteilen an freien fettsauren in der broilermast. 2. Wachstum sowie qualitat von schlachtkorper, fleisch und fett bei stufenweisem austausch von gesattigten durch ungesattigte fettsauren. *Arch Geflügelk* **1993**; 57(6):265-274.
- Kiyose C., Muramatsu R., Kameyama Y., Ueda T., Igarashi O. Bodiscrimination of  $\alpha$ -tocopherol stereoisomers in humans after oral administration. *Am J Clin Nutr* **1997**; 65:785-789.
- Kiyose C, Muramatsu R, Ueda T, Igarashi O. Change in the distribution of  $\alpha$ -tocopherol stereoisomers in rats after intravenous administration. *Biosci Biotech Biochem* **1995**; 59(5):791-795.
- Klauss AM, Fuhrmann H, Sallmann HP. Peroxidative and antioxidative metabolism of the broiler chicken as influenced by dietary linoleic acid and vitamin E. *Arch Geflügelk* **1995**; 59(2):135-144.
- Knapp HP. Effects of dietary fatty acids on blood pressure: epidemiology and biochemistry. En: Health Effects of Dietary Fatty Acids. Nelson GJ, Eds. American Oil Chemistry Society, Champaign, **1991**: 94-106.
- Kondjoyan N, Berdagué JL, Denoyer C. Analysis of the volatile compounds of cooked meat: comparison between different species. Proceedings of the 11<sup>th</sup> European Symposium on the Quality of Poultry Meat, Tours, France, **1993**; 347-354.
- Krauss RM, Eckel RH, Howard B, Appel LJ, Daniels SR, Deckelbaum RJ, Erdman JW, Kris-Etherton P, Goldberg IJ, Kotchen TA, Lichtenstein AH, Mitch WE, Mullis R, Robinson K, Wylie-Rossett J, Jeor SS, Suttie J, Tribble DL, Bazzare TL. Revision 2000: Statement for healthcare professionals from the nutrition committee of the american heart association. *J Nutr* **2001**; 131:132-146.
- Kubo K, Saito M, Tadokoro T, Maekawa A. Changes in susceptibility of tissues to lipid peroxidation after ingestion of various levels of docosahexaenoic acid and vitamin E. *Br J Nutr* **1997**; 78:655-669.
- Kuhlenkamp J, Ronk M, Yusin M. Identification and purification of a human liver cytosolic tocopherol binding protein. *Prot Exp Purific* **1993**; 4:382-389.

## L

- Labuza TP. Kinetics of lipid oxidation in foods. *Crit Rev Food Technol* **1971**; 2:355-405.

- Lauridsen C, Buckley DJ, Morrissey PA. Influence of dietary fat and vitamin E supplementation on  $\alpha$ -tocopherol levels and fatty acid profiles in chicken muscle membranal fractions and on susceptibility to lipid peroxidation. *Meat Sci* **1997**; 46(1):9-22.
- Lauridsen C, Hedemann MS, Jensen SK. Hydrolysis of tocopheryl and retinyl esters by porcine carboxyl ester hydrolase is affected by their carboxylate moiety and bile acids. *J Nutr Biochem* **2001**; 12:219-224.
- Lauridsen C, Engel H, Jensen SK, Craig AM, Traber MG. Lactating sows and suckling preferentially incorporate RRR- over *All-rac*- $\alpha$ -tocopherol into milk, plasma and tissues. *J Nutr* **2002**; 132:1258-1264.
- Leclercq B, Saadoun A. Selecting broilers for low or high abdominal fat: Comparison of energy metabolism of the lean and fat lines. *Poult Sci* **1982**; 61(1799):1803.
- Leclercq B, Escartin R. Further investigations on the effects of metabolisable energy content of diet on broiler performances. *Arch Geflügelk* **1987**; 51(3):93-96.
- Legrand P, Mallard J, Bernard-Griffiths MA, Douaire M, Lemarchal P. Hepatic lipogenesis in genetically lean and fat chickens. *In vitro* studies. *Comp Biochem Physiol* **1987a**; 87B(4):789-792.
- Legrand P, Mallard J, Bernard-Griffiths MA, Douaire M, Russeil P, Lemarchal P. Lipid biosynthesis and deposition in genetically lean and fat chickens. Comparative *in vivo* studies with <sup>14</sup>C acetate. *Comp Biochem Physiol* **1987b**; 86B(4):791-796.
- Leonard SW, Terasawa Y, Farese JRV, Traber MG. Incorporation of deuterated RRR- or *all-rac*- $\alpha$ -tocopherol in plasma and tissues of  $\alpha$ -tocopherol transfer protein-null mice. *Am J Clin Nutr* **2002**; 75:555-560.
- Leskanich CO, Noble RC. Manipulation of the n-3 polyunsaturated fatty acid composition of avian eggs and meat. *World's Poult Sci J* **1997**; 53:155-183.
- Leyton J, Drury PJ, Crawford MA. Differential oxidation of saturated and unsaturated fatty acids in vivo in the rat. *Br J Nutr* **1987**; 57:383-393.
- Lin CF, Gray JI, Asghar A, Buckley DJ, Booren AM, Flegal CJ. Effects of dietary oils and  $\alpha$ -tocopherol supplementation on lipid composition and stability of broiler meat. *J Food Sci* **1989a**; 54(6):1457-1460.
- Lin CF, Asghar A, Gray JI, Buckley DJ, Booren AM, Crackel RL, Flegal CJ. Effects of oxidised dietary oil and antioxidant supplementation on broiler growth and meat stability.

*Br Poult Sci* **1989b**; 30:855-864.

Liu Y, Jensen SK, Eggum BO. The influence of seed size on digestibility and growth performance of broiler chickens fed full-fat rapeseed. *J Sci Food Agric* **1995**; 67:135-140.

Lopez-Bote CJ, Rey AI, Sanz M, Gray JI, Buckley DJ. Dietary vegetable oils and  $\alpha$ -tocopherol reduce lipid oxidation in rabbit muscle. *J Nutr* **1997**; 127:1182-1997.

Lopez-Bote CJ, Gray JI, Gomaa EA, Flegal CJ. Effect of dietary oat administration on lipid stability in broiler meat. *Br Poult Sci* **1998a**; 39 :57-61.

Lopez-Bote CJ, Gray JI, Gomaa EA, Flegal CJ. Effect of dietary administration of oil extracts from rosemary and sage on lipid oxidation in broiler meat. *Br Poult Sci* **1998b**; 39:235-240.

Lopez-Bote CJ, Isabel B, Ruiz J, Daza A. Effect of vitamin E supplementation and partial substitution of poly- with mono-unsaturated fatty acids in pig diets on muscle, and microsome extract  $\alpha$ -tocopherol concentration and lipid oxidation. *Arch Anim Nutr* **2003**; 57:11-25.

Losowsky MS, Kelleher J, Walker BE, Davies T, Smith CL. Intake and absorption of tocopherol. *Ann N Y Acad Sci* **1972**; 203:212-222.

López-Ferrer S, Baucells MD, Barroeta AC, Grashorn MA. Influence of vegetable oil sources on quality parameters of broiler meat. *Arch Geflügelk* **1999a**; 63(1):29-35.

López-Ferrer S, Baucells MD, Barroeta AC, Grashorn MA. N-3 enrichment of chicken meat using fish oil: Alternative substitution with rapeseed and linseed oils. *Poult Sci* **1999b**; 78:356-365.

López-Ferrer S, Baucells MD, Barroeta A., Grashorn MA. PUFA losses after cooking of chicken meat. Proceedings of the XIV European Symposium on the Quality of Poultry Meat, Bolonia, Italia, **1999c**; 197-202.

López-Ferrer S, Baucells MD, Barroeta AC, Grashorn MA. N-3 enrichment of chicken meat. 1. Use of very long-chain fatty acids in chicken diets and their influence on meat quality: Fish oil. *Poult Sci* **2001**; 80:741-752.

## **M**

Machlin LJ, Gabriel E, Brin M. Biopotency of  $\alpha$ -tocopherol as determined by curative myopathy bioassay in the rat. *J Nutr* **1982**; 112:1437-1440.

Malczyk E, Kopec W, Smolinska T. Influence of oil and vitamin E (alfa-tocopherol)

- supplementation on lipid oxidation and flavor of poultry meat. Proceedings of XIV European Symposium on the quality of poultry meat, Bologna, Italia, **1999**; 167-172.
- Maraschiello C, Sárraga C, García Regueiro JA. Glutathione peroxidase activity, TBARs, and  $\alpha$ -tocopherol in meat from chicken fed different diets. *J Agric Food Chem* **1999**; 47:867-872.
- Marion JE, Woodroof JG. The fatty acid composition of breast, thigh, and skin tissues of chicken broilers as influenced by dietary fats. *Poult Sci* **1963**; 48:1202-1207.
- Mateos GG, Mendez J. Influencia de la nutrición sobre la calidad de la canal del broiler: Deposición de grasa. *VII Curso de especialización Avances en nutrición y alimentación animal FEDNA*, Madrid **1991**.
- Mercier Y, Gatellier P, Viau M, Remington H, Renerre M. Effect of dietary fat and vitamin E on colour stability and on lipid and protein oxidation in turkey meat during storage. *Meat Sci* **1998**; 48(3/4):301-318.
- Mielnik MB, Aaby K, Skrede G. Commercial antioxidants control lipid oxidation in mechanically deboned turkey meat. *Meat Sci* **2003**; 65:1147-1155.
- Miller D, Robisch P. Comparative effect of herring, menhaden, and safflower oils on broiler tissues fatty acid composition and flavor. *Poult Sci* **1969**; 48:2146-2157.
- Miller EL, Huang YX. Improving the nutritional value of broiler meat through increased n-3 fatty acid and vitamin E content. Proceedings of the 11<sup>th</sup> European Symposium on the Quality of Poultry Meat, Tours, France, **1993**; 404-411.
- Min DB, Lee BJ. Chemistry of lipid oxidation. En: Food lipids and health. McDonald RE, Min DB, Eds. Marcel Dekker, Inc., New York, EUA **1996**; 241-268.
- Morrissey PA, Brandon S, Buckley DJ, Sheehy PJA, Frigg M. Tissue content of  $\alpha$ -tocopherol and oxidative stability of broilers receiving dietary  $\alpha$ -tocopheryl acetate supplement for various periods pre-slaughter. *Br Poult Sci* **1997**; 38:84-88.
- Mourot J, Hermier D. Lipids in monogastric animal meat. *Reprod Nutr Dev* **2001**; 41:109-118.
- Muggli R. Physiological requirements of vitamin E as a function of the amount and type of polyunsaturated fatty acid. *World Rev Nutr Diet* **1994**; 75:166-168.
- Myers SJ, Harris ND. Effect of electronic cooking on fatty acids in meats. *J Am Diet Assoc* **1975**; 67:232-234.

## N

Nam K, Lee H, Min B, Kang C. Influence of dietary supplementation with linseed and vitamin E on fatty acids,  $\alpha$ -tocopherol and lipid peroxidation in muscles of broiler chicks. *An Feed Sci Technol* **1997**; 66:149-158.

National Research Council. *Nutrient Requirement for Poultry*. 9<sup>th</sup> rev ed. National Academy Press. Washington DC, EUA **1994**.

Neely WC, Martin JM, Barker SA. Products and relative reaction rates of the oxidation of tocopherols with singlet molecular oxygen. *Photochem Photobiol* **1988**; 48:423-428.

Niki E, Tsuchiya J, Kawakimi A, Saito M, Yamamoto Y, Kamiy Y. Effects of phytyl side chain of vitamin E and its antioxidant activity. *J Biol Chem* **1985**; 260:2191-2196.

Niki E. Function of vitamin E as antioxidant in the membranes. En: Vitamin E. Its usefulness in health and in curing diseases. Mino M, Nakamura H, Diplock A, Kayden HJ, Eds. Japan Scientific Societies Press, Tokyo, Japón **1993**; 23-30.

Niki E.  $\alpha$ -Tocopherol. En: Handbook of Antioxidants. Cadenas E, Packer L, Eds. Marcel Dekker, Inc., New York, EUA, **1996**; 3-26.

Nitsan Z, Dvorin A, Zoref Z, Mokady S. Effect of added soyabean oil and dietary energy on metabolisable and net energy of broiler diets. *Br Poult Sci* **1997**; 38:101-106.

Nitta C, Hayashi K, Ueda T, Igarashi O. Distribution of  $\alpha$ -tocopherol stereoisomers in rats. *Biosci Biotech Biochem* **1993**; 57(8):1406-1407.

## O

O'Neill LM, Galvin K, Morrissey PA, Buckley DJ. Comparison of effects of dietary olive oil, tallow and vitamin E on the quality of broiler meat and meat products. *Br Poult Sci* **1998a**; 39:365-371.

O'Neill LM, Galvin K, Morrissey PA, Buckley DJ. Inhibition of lipid oxidation in chickens by carnosine and dietary  $\alpha$ -tocopherol supplementation and its determination by derivative spectrophotometry. *Meat Sci* **1998b**; 50(4):479-488.

O'Neill LM, Galvin K, Morrissey PA, Buckley DJ. Effect of carnosine, salt and dietary vitamin E on the oxidative stability of chicken meat. *Meat Sci* **1999**; 52:89-94.

Olomu JM, Baracos VE. Influence of dietary flaxseed oil on the performance, muscle protein deposition, and fatty acid composition of broiler chicks. *Poult Sci* **1991**; 70:1403-1411.

## P

Pan DA, Storlien LH. Dietary lipid profile is a determinant of tissue phospholipid fatty acid composition and rate of weight gain in rats. *J Nutr* **1993**; 123:512-519.

Pan PR, Dilworth BC, Day EJ, Chen TC. Effect of season of the year, sex, and dietary fats on broiler performance, abdominal fat, and preen gland secretion. *Poult Sci* **1979**; 58:1564-1574.

Parks E, Traber MG. Mechanisms of vitamin E regulation: Research over the past decade and focus on the future. *Antioxidants and Redox Signaling* **2000**; 2(3):405-411.

Patterson LK. Studies of Radiation-induced peroxidation in fatty acids micelles. En: Oxygen and oxy-radicals in chemistry and biology. Rodgers MAJ, Powers EL, Eds. Academic Press, New York, EUA **1981**; 89-95.

Pesti GM, Bakalli RI, Qiao M, Sterling KG. A comparison of eight grades of fat as broiler feed ingredients. *Poult Sci* **2002**; 81:382-390.

Piironen VI, Liljeroos AI, Koivistoinen PE. Transfer of  $\alpha$ -tocopherol stereoisomers from feeds to eggs. *J Agric Food Chem* **1991**; 39:99-101.

Pikul J, Leszczynski DE, Betchel PJ, Kummerow FA. Effects of frozen storage and cooking on lipid oxidation in chicken meat. *J Food Sci* **1984**; 49:838-843.

Pinchasov Y, Nir I. Effect of dietary polyunsaturated fatty acid concentration on performance, fat deposition, and carcass fatty acid composition in broiler chickens. *Poult Sci* **1992**; 71:1504-1512.

## R

Ratnayake WMN, Ackman RG, Hulan HW. Effect of redfish meal enriched diets on the taste and n-3 PUFA of 42-day-old broiler chickens. *J Food Sci Food Agric* **1989**; 49:59-74.

Regulska-Illow B, Illow R. Comparison of the effects of microwave cooking and conventional cooking methods on the composition of fatty acids and fat quality indicators in herring. *Nahrung/Food* **2002**; 46 (6):383-388.

Rhee KS, Anderson LM, Sams AR. Lipid oxidation potential of beef, chicken, and pork. *J Food Sci* **1996**; 61(1):8-12.

Riss G, Kormann AW, Glinz E, Walther W, Ranalder UB. Separation of the eight stereoisomers of *all-rac*- $\alpha$ -tocopherol from tissues and plasma: Chiral phase high-

performance liquid chromatography and capillary gas chromatography. *Methods Enzymol* **1994**; 234:302-310.

Robey W, Shermer W. The damaging effects of oxidation. *Feed Mix* **1994**; 2(5):22-26.

Roth FX, Ristic M, Kreuzer M, Kirchgessner M. Einsatz von fetten mit hohen anteilen an freien fettsäuren in der broilermast. 1.Wachstum sowie qualität von schlachtkörpern, fleisch und fett bei verfütterung isoenergetischer rationen mit unterschiedlichem fettgehalt. *Arch Geflügelk* **1993**; 57(6):256-264.

Rudel LL. Atherosclerosis and conjugated linoleic acid. *Br J Nutr* **1999**; 81:177-179.

Ruiz JA, Pérez-Vendrell AM, Esteve-García E. Effect of  $\beta$ -carotene and vitamin E on peroxidative stability in leg meat of broilers fed different supplemental fats. *J Agric Food Chem* **1999**; 47:448-454.

Ruiz JA, Guerrero L, Arnau J, Guardia MD, Esteve-García E. Descriptive sensory analysis of meat from broilers fed diets containing vitamin E or  $\beta$ -carotene as antioxidants and different supplemental fats. *Poult Sci* **2001**; 80:976-982.

Rule DC, Broughton KS, Shellito SM, Maiorano G. Comparison of muscle fatty acid profiles and cholesterol concentrations of bison, beef cattle, elk, and chicken. *J An Sci* **2002**; 80:1202-1211.

Russell EA, Lynch A, Galvin K, Lynch PB, Kerry JP. Quality of raw, frozen and cooked duck meat as affected by dietary fat and  $\alpha$ -tocopheryl acetate supplementation. *Int J Poult Sci* **2003**; 2(5):324-334.

## S

Saadoun A, Leclercq B. In vivo lipogenesis in genetically fat and lean chickens of various ages. *Comp Biochem Physiol* **1986**; 83B(3):607-611.

Saadoun A, Leclercq B. In vivo lipogenesis of genetically lean and fat chickens: effects of nutritional state and dietary fat. *J Nutr* **1987**; 117(3):428-435.

Saito M, Kubo K, Ikegami S. An assessment of docosahexaenoic acid (DHA) intake with special reference to lipid metabolism in rats. *J Nutr Sci Vitaminol* **1996**; 42:195-207.

Sante VS, Lacourt A. The effect of dietary  $\alpha$ -tocopherol supplementation and antioxidant spraying on colour stability and lipid oxidation of turkey meat. *J Sci Food Agric* **1994**; 65:503-507.



- Sanz M, Flores A, Perez de Ayala P, Lopez-Bote CJ. Higher lipid accumulation in broilers fed on saturated fats than in those fed on unsaturated fats. *Br Poult Sci* **1999a**; 40:95-101.
- Sanz M, Flores A, Lopez-Bote CJ. Effect of fatty acid saturation in broiler diets on abdominal fat and breast muscle fatty acid composition and susceptibility to lipid oxidation. *Poult Sci* **1999b**; 78:378-382.
- Sanz M, Flores A, Lopez-Bote CJ. The metabolic use of energy from dietary fat in broilers is affected by fatty acid saturation. *Br Poult Sci* **2000a**; 41:61-68.
- Sanz M, Lopez-Bote CJ, Menoyo D, Bautista JM. Abdominal fat deposition and fatty acid synthesis are lower and  $\beta$ -oxidation is higher in broiler chickens fed diets containing unsaturated rather than saturated fat. *J Nutr* **2000b**; 130:3034-3037.
- Sanz M, Lopez-Bote CJ, Flores A, Carmona JM. Effect of the inclusion time of dietary saturated and unsaturated fats before slaughter on the accumulation and composition of abdominal fat in female broiler chickens. *Poult Sci* **2000c**; 79:1320-1325.
- SAS Institute. SAS<sup>®</sup>. SAS Institute, Inc. Cary, NC, EUA. **2000**.
- Sato Y, Hagiwara K, Arai H, Inoue K. Purification and characterization of the  $\alpha$ -tocopherol transfer protein from rat liver. *FEBS Lett* **1991**; 288:41-45.
- Sato Y, Arai H, Miyata A, Tokita S, Yamamoto K, Tanabe T, Inoue K. Primary structure of  $\alpha$ -tocopherol transfer protein from rat liver. *J Biol Chem* **1993**; 268(24):17705-17710.
- Scaife JR, Moyo J, Galbraith H, Michie W, Campbell V. Effect of different dietary supplemental fats and oils on the tissue fatty acid composition and growth of female broilers. *Br Poult Sci* **1994**; 35:107-118.
- Scherf H, Machlin LJ, Frye TM, Krautmann BA, Williams SN. Vitamin E biopotency. Comparison of various natural-derived and chemically synthesized alpha-tocopherols. *An Feed Sci Technol* **1996**; 59:115-136.
- Schultz M, Leist M, Petrzika M, Gassmann B, Brigelius-Flohé R. Novel urinary metabolite of  $\alpha$ -tocopherol, 2,5,7,8-tetramethyl-2(2'-carboxyethyl)-6-hydroxychroman, as an indicator of an adequate vitamin E supply? *Am J Clin Nutr* **1995**; 62(Suppl.):1527S-1534S.
- Scott CG, Cohen N, Riggio PP, Weber G. Gas chromatographic assay of the diastereomeric composition of *all-rac*- $\alpha$ -tocopheryl acetate. *Lipids* **1982**; 17:97-101.
- SENBA. Sociedad Española de Nutrición Básica Aplicada. Tablas de composición de los

- alimentos: macronutrientes. [www.senba.es/recursos/pdf/macronutrientes.pdf](http://www.senba.es/recursos/pdf/macronutrientes.pdf) **2003**.
- Sheard PR, Nutte GR, Chappell AG. The effect of cooking on the chemical composition of meat products with special reference to fat loss. *Meat Sci* **1998**; 49(2):175-191.
- Sheehy PJA, Morrissey PA, Flynn A. Influence of dietary  $\alpha$ -tocopherol on tocopherol concentrations in chick tissues. *Br Poult Sci* **1991**; 32:391-397.
- Sheehy PJA, Morrissey PA, Flynn A. Influence of heated vegetable oils and  $\alpha$ -tocopherol acetate supplementation on  $\alpha$ -tocopherol, fatty acids and lipid peroxidation in chicken muscle. *Br Poult Sci* **1993**; 34:367-381.
- Sheldon BW, Curtis PA, Dawson PL, Ferket PR. Effect of dietary vitamin E on the oxidative stability, flavor, color, and volatile profiles of refrigerated and frozen turkey breast meat. *Poult Sci* **1997**; 76:634-641.
- Shimomura Y, Tamura T, Suzuki M. Less body fat accumulation in rats fed a safflower oil diet than in rats fed a beef tallow diet. *J Nutr* **1990**; 120:1291-1296.
- SigmaPlot. SigmaPlot 2002 for Windows version 8.02. Copyright c 1986-2001 SPSS Inc. **2002**.
- Sijben JWC, Schrama JW, Nieuwland MGB, Hovenier R, Beynen AC, Verstegen MWA, Parmentier HK. Interactions of dietary polyunsaturated fatty acids and vitamin E with regard to vitamin E status, fat composition and antibody responsiveness in layer hens. *Br Poult Sci* **2002**; 43:297-305.
- Sirri F, Tallarico N, Melluzzi A, Franchini A. Long-chain n-3 PUFA enrichment of broiler chicken tissues using dehydrated algae *Schizochytrium*. *Arch Geflügelk* **2002**; 66:151.
- Sirri F, Tallarico N, Melluzzi A, Franchini A. Fatty acid composition and productive traits of broiler fed diets containing conjugated linoleic acid. *Poult Sci* **2003a**; 82:1356-1361.
- Sirri F, Minelli G, Melluzzi A, Franchini A. Quality traits and antioxidative stability of n-3 PUFA enriched chicken meat. Proceedings of the XVI<sup>th</sup> European Symposium on the Quality of Poultry Meat, Saint-Brieuc, Francia, **2003b**; 258-264.
- Sklan D, Bartov I, Hurwitz S. Tocopherol absorption and metabolism in the chick and turkey. *J Nutr* **1982**; 112:1394-1400.
- St Angelo AJ. Lipid oxidation in foods. *Crit Rev Food Sci Nutr* **1996**; 36(3):175-224.
- Sukhija PS, Palmquist DL. Rapid method of determination of total fatty acid content and composition of feedstuffs and faeces. *J Agric Food Chem* **1988**; 36:1202-1206.

Surai PF, Sparks NHC. Tissue-specific fatty acid and  $\alpha$ -tocopherol profiles in male chickens depending on dietary tuna oil and vitamin E provision. *Poult Sci* **2000**; 79:1132-1142.

Surai PF. Vitamin E. En: Natural antioxidant in avian nutrition and reproduction. Nottingham University Press, UK, **2002**; 27-128.

Szymczyk B, Pisulewski PM, Szczurek W, Hanczakowki P. Effects of conjugated linoleic acid on growth performance, feed conversion efficiency, and subsequent carcass quality in broiler chickens. *Br J Nutr* **2001**; 85:465-473.

## T

Takahashi K, Kawamata K, Akiba Y, Iwata T, Kasai M. Influence of dietary conjugated linoleic acid isomers on early inflammatory responses in male broiler chickens. *Br Poult Sci* **2002**; 43:47-53.

Tanaka K, Ohtani S, Shigeno K. Effect of increasing dietary energy on hepatic lipogenesis in growing chicks. I. Increasing energy by carbohydrate supplementation. *Poult Sci* **1983a**; 62:445-451.

Tanaka K, Ohtani S, Shigeno K. Effect of increasing dietary energy on hepatic lipogenesis in growing chicks. II. Increasing energy by fat or protein supplementation. *Poult Sci* **1983b**; 62:452-458.

Tang SZ, Kerry JP, Sheehan D, Buckley DJ, Morrissey PA. Antioxidant effect of dietary tea catechins on lipid oxidation of long-term frozen stored chicken meat. *Meat Sci* **2001**; 57:331-336.

Tijburg LBM, Haddeman E, Kivits GAA, Weststrate JA, Brink EJ. Dietary linoleic acid at high and reduced dietary fat level decreases the faecal excretion of vitamin E in young rats. *Br J Nutr* **1997**; 77:327-336.

Traber MG, Burton GW, Ingold KU, Kayden HJ. RRR- and SRR- $\alpha$ -tocopherols are secreted without discrimination in human chylomicrons, but RRR- $\alpha$ -tocopherol is preferentially secreted in very low density lipoproteins. *J Lipid Res* **1990**; 31:675-685.

Traber MG, Sies H. Vitamin E in humans: Demand and delivery. *Annu Rev Nutr* **1996**; 16:321-347.

Traber MG, Arai H. Molecular mechanisms of vitamin E transport. *Annu Rev Nutr* **1999**; 19:343-355.

## U

Ueda T, Ichikawa H, Igarashi O. Determination of  $\alpha$ -tocopherols stereoisomers in biological specimens using chiral phase high-performance liquid chromatography. *J Nutr Sci Vitaminol* **1993**; 39:207-219.

USDA. USDA Nutrient Database for Standard Reference, Release 12, **1998**.

## V

van der Berg JJM, Cook NE, Tribble DL. Reinvestigation of the antioxidant properties of conjugated linoleic acid. *Lipids* **1995**; 30(7):599-605.

Vilà B, Esteve-García E. Studies on acid oils and fatty acids for chickens. I. Influence of age, rate of inclusion and degree of saturation on fat digestibility and metabolisable energy of acid oils. *Br Poult Sci* **1996**; 37:105-117.

Villamide MJ, Fraga MJ. Composition of vitamin supplements in spanish poultry diets. *Br Poult Sci* **1999**; 40:644-652.

Villaverde C, Baucells MD, Cortinas L, Galobart J, Barroeta AC. Effects of the dietary fat unsaturation level on body fattening in female broiler chickens. Proceedings of Poultry Science Association Annual Meeting, Madison, EUA, **2003**; 66.

Villaverde C, Cortinas L, Ortego M., Barroeta AC, Baucells MD. Total fatty acid quantification as an estimator of total body fat content in broilers fed unsaturated diets. Proceedings of the XVI European Symposium on the Quality of Poultry Meat, Saint-Brieuc, Francia, **2003**; 265-271.

Villaverde C, Cortinas L, Barroeta AC, Martín-Orúe SM, Baucells MD. Relationship between dietary unsaturation level and vitamin E in poultry. *J An Physiol An Nutr* **2004**.

## W

Weiser H, Vecchi M. Stereoisomers of  $\alpha$ -tocopheryl acetate. II. Biopotencies of all eight stereoisomers, individually or in mixtures, as determined by rat resorption-gestation tests. *Internat J Vit Nutr Res* **1982**; 52:351-370.

Weiser H, Riss G, Kormann AW. Biodiscrimination of the eight  $\alpha$ -tocopherol stereoisomers results in preferential accumulation of the four 2R forms in tissues and plasma of rats. *J Nutr* **1996**; 126:2539-2549.

Wen J, Morrissey PA, Buckley DJ, Sheehy PJA. Oxidative stability and  $\alpha$ -tocopherol

retention in turkey burgers during refrigerated and frozen storage as influenced by dietary  $\alpha$ -tocopheryl acetate. *Br Poult Sci* **1996**; 37:787-795.

Wilkinson AL, Sun Q, Senecal A, Faustman C. Antioxidant effects on TBARS and fluorescence measurements in freeze-dried meats. *J Food Sci* **2001**; 66(1):20-24.

Wilson MD, Blake WL, Salati LM, Clarke SD. Potency of polyunsaturated and saturated fats as short-term inhibitors of hepatic lipogenesis in rats. *J Nutr* **1990**; 120:544-552.

Witting LA, Horwitt MK. Effect of degree of fatty acid unsaturation in tocopherol deficiency-induced creatinuria. *J Nutr* **1964**; 82:19-33.

## Y

Yamauchi K, Nagai Y, Ohashi T. Quantitative relationship between alpha-tocopherol and polyunsaturated fatty acids and its connection to development of oxidative rancidity in chicken skeletal muscle. *Agric Biol Chem* **1982**; 46(11):2719-2724.

Yau JC, Denton JH, Bailey CA, Sams AR. Customizing the fatty acid content of broiler tissues. *Poult Sci* **1991**; 70:167-172.

Yoshida H, Yusin M, Ren I. Identification, purification and immunochemical characterisation of a tocopherol-binding protein in rat liver cytosol. *J Lipid Res* 1992; 33:343-350.

## Z

Zanini SF, Torres CAA, Bragagnolo N, Turatti JM, Silva MG, Zanini MS. Oil sources and vitamin E levels in the diet on the composition of fatty acids in roosters meat. Proceedings of the XVI<sup>th</sup> European Symposium on the Quality of Poultry Meat, Saint-Brieuc, Francia, **2003a**; 199-205.

Zanini SF, Torres CAA, Bragagnolo N, Turatti JM, Silva MG, Zanini MS. Effect of oil sources and vitamin E levels in the diet on the concentration of total lipids, cholesterol, vitamin E in thigh and chest meat of cockerels. Proceedings of the XVI<sup>th</sup> European Symposium on the Quality of Poultry Meat, Saint-Brieuc, Francia, **2003b**; 278-284.

Zollitsch W, Knaus W, Aichinger F, Lettner F. Effects of different dietary fat sources on performance and carcass characteristics of broilers. *An Feed Sci Technol* **1997**; 66:63-73.