EFFECT OF ADDITION OF TEA CATECHINS AND VITAMIN C ON SENSORY EVALUATION, COLOUR AND LIPID STABILITY IN COOKED OR RAW BEEF AND CHICKEN PATTIES

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Background

Colour and lipid stability in retail meats are very important quality characteristics, which influence consumer acceptability. Minced meats undergo oxidative changes and develop rancidity more quickly than intact muscle since grinding exposes more of the muscle surface to air and microbial contamination. Many attempts have been made to reduce pigment and lipid oxidation in meats through endogenous and exogenous treatment with antioxidants, in particular, vitamin E and vitamin C. Mitsumoto (2000) reported that dietary vitamin E supplementation for several weeks decreased oxidation of meat or fat in poultry, pork and beef and that exogenous vitamin C addition retarded pigment and lipid stability in ground pork and beef. In an increasingly competitive market, meat processors constantly strive to produce more healthy meat products. Tea catechins are polyphenolic antioxidants found in green tea, which possess a range of health promoting properties. Meat products containing natural antioxidants, as opposed to synthetic derivatives, are more desirable from a consumer viewpoint.

Tang et al. (2000) found that supplementation of poultry diets with tea catechins (300 mg/kg feed) retarded lipid oxidation in chicken meat compared to controls and dietary vitamin E (200 mg/kg feed) supplemented meat. To date, it is unknown whether tea catechin addition to meat products is as effective in maintaining meat quality as vitamin C.

Objectives

The aim of this study was to compare the effects of addition of tea catechins and vitamin C on the colous, lipid stability and sensory quality in cooked and raw beef as well as chicken patties.

Materials and methods

Fresh beef striploin and chicken breast muscles (~10 kg of each) were obtained from a local meat processing unit. Meat samples were vacuum packaged and stored at 0ºC for approximately 3 days prior to commencement of each trial. Tea catechins (TC) (80.15%) were obtained from Kinglong Natural Plant Products Industry Ltd., Changsha, Hunan, China. Sodium ascorbate (Vitamin C: VC) (99.0-101.0%) was obtained from Pfizer Ireland Pharmaceuticals, Ringaskiddy, Co. Cork.

Cooking and packaging

Beef and chicken samples were minced twice through a plate with 4 mm holes (mincer model P114L, Talsa, Valencia, Spain) following removal of all external fat and connective tissue. Following mincing, beef and chicken were assigned to one of the following five treatments: CNTRL, control meat; TC200, meat plus 200mg TC/kg muscle; TC400, meat plus 400mg TC/kg muscle; VC200, meat plus 200mg VC/kg muscle, VC400, meat plus 400mg VC/kg muscle. Sodium chloride (1%) was added to all samples.

Minced beef and chicken (125 g portions) were formed into patties using a meat former (Ministeak burger maker, O. L. Smith Co. Ltd., Italy) and stored overnight at 0ºC. Patties were cooked in a fan-assisted oven (model 10GN1/1, Zanussi Professional, Conegliano, Italy) at 180ºC until an internal meat temperature of 72ºC was reached, and subsequently held at 180ºC for a further 15 minutes. After chilling, cooked patties were placed in low oxygen permeable ($<1cm^3/m^2/24hr/atm$) polystyrene/ethylvinylalcohol (EVOH)/ polyethylene (PE) trays and flushed with 30% CO_2 : 70% N_2 using a vacuum sealing unit (VS 100, Gustav Müller & Co. KG, Homburg, Germany) equipped with a gas mixer (Witt-Gasetechnik GmbH & Co. KG, Witten, Germany). Trays were covered and heat-sealed with a low oxygen permeable ($3cm^3/m^2/24hr$) laminated barrier film with a polyolefin heat sealable layer. Fresh raw beef and chicken patties were stored in 80% O_2 : 20% CO_2. All samples were stored for up to 7 days under fluorescent lighting (approximately 700 lux) at 4°C.

Colour determination
Surface colour measurements were determined using a CR-300 Chroma Meter (Minolta Co., Osaka, Japan) which consisted of a measuring head (CR-300), with an 8 mm diameter measuring area, and a data processor (DP-301). The chroma meter was calibrated on the Hunterlab colour space system using a white tile (D_{65}: Y = 94.4, x = 0.3172, y = 0.3339). Hunter L^* (lightness), a^* (redness) and b^* (yellowness) values were measured on days 1, 3 and 6 for cooked meats and on days 2 and 7 for raw beef and chicken.

Measurement of lipid oxidation
Lipid oxidation was measured by the 2-thiobarbituric acid distillation method of Tarladgis et al. (1960) as modified by Ke et al. (1977) and results were expressed as 2-thiobarbituric acid reactive substances (TBARS) in mg malonaldehyde (MDA)/kg meat.

Sensory evaluation
An untrained sensory panel of 8 to 11 people evaluated cooked beef and chicken patties after 1, 3 and 6 days of storage. Patties were placed on paper plates, reheated using a microwave oven at high power (800 W) for 30 sec and served to the panellists individually. Panellists were asked to evaluate sample colour, flavour, taste and tenderness on an 8-point scale ranging from extremely desirable (8) to extremely undesirable (1). In addition, panellists were asked to rank samples, in order of preference from best (1) to worst (5) separately for beef and chicken, in terms of overall acceptability.

Statistical analysis
Data were analyzed by the General Linear Models procedure of SAS (1988).

Results and discussion

Cooked patties
Both tea catechins treatments (TC200 and TC400) showed low ($P<0.05$) sensory colour scores (Fig. 1) and Hunter b^* values (10.2 and 9.9, respectively) in cooked meat patties compared to controls (b^* values: 13.2) and both vitamin C treatments (VC200 and VC400) (b^* values: 12.6 and 12.5, respectively). Tea catechins treatment (TC200) had low ($P<0.01$) Hunter a^* values (1.2) in cooked meat patties compared to controls (2.9) and both vitamin C treatments (VC200 and VC400) (3.3 and 3.0, respectively). Tea catechins treatments resulted in no significant differences ($P>0.10$) in the sensory flavour, taste, tenderness and Hunter L^* value in cooked meat compared to controls and both vitamin C treatments. Tea catechins treatments had no effects ($P>0.10$) on overall acceptability in cooked beef patties, but decreased ($P<0.001$) acceptability in cooked chicken meat during display compared to controls and vitamin C treatments. Neither of the vitamin C treatments significantly affected ($P>0.05$) sensory traits and Hunter colour values in cooked meat compared to controls. Tea catechins and vitamin C treatments effectively reduced ($P<0.001$) lipid oxidation in cooked meat patties compared to controls (Fig. 2).

Raw patties
Tea catechins treatment, TC400, showed lower ($P<0.01$) Hunter *b* values (6.6) in raw meat patties compared to controls (7.4). In contrast, the vitamin C treatment (VC200) resulted in the highest Hunter *b* values (7.7). Both tea catechins treatments (TC200 and TC400) greatly suppressed ($P<0.01$) lipid oxidation in raw meat patties compared to controls, and TC400 resulted in the lowest TBARS values (Fig. 3). Vitamin C treatments (VC200 and VC400) did not significantly reduce ($P>0.05$) lipid oxidation in raw meat patties compared to controls (Fig. 3).

Tea catechins have been recognized as efficient antioxidants by scavenging free radicals and chelating metal ions (Shahidi and Wanasundara, 1992; Tang et al., 2002). In the current study, tea catechins caused discoloration possibly by binding with the iron component of myoglobin, and delayed lipid oxidation by reacting with free radicals. Discoloration caused by tea catechins clearly reduced the visual appearance and overall acceptability of the meat patties by panellists. Maher et al. (2002) reported that addition of tea catechins (1000 mg/kg muscle) and rosemary (1000 mg/kg muscle) to minced beef greatly improved the colour and lipid stability under aerobic and modified atmosphere conditions compared controls. Tang et al.

(2001) reported that lipid oxidation in cooked chicken meat was more effectively controlled by the addition of tea catechins (300 mg/kg meat) than that in cooked beef, and that inhibition of lipid oxidation resulting from tea catechins was greater than that for vitamin E. In this study, tea catechins caused meat discoloration but inhibited lipid oxidation to a greater extent than vitamin C.

Meat

Beef was more susceptible ($P<0.01$) to oxidation as either cooked or raw than chicken meat. Raw meat stored in high oxygen conditions (80% O_2 : 20% CO_2) was more prone to lipid oxidation than cooked meat stored in anaerobic conditions (30% CO_2 : 70% N_2). Tea catechins and vitamin C treatments were effective ($P<0.001$) for lipid oxidation in cooked beef but not ($P>0.10$) in cooked chicken meat. Tea catechins treatments were effective ($P<0.05$) for lipid oxidation in raw beef compared to the control and vitamin C treatments but not ($P>0.10$) in raw chicken meat. Since chicken meat was very stable for lipid oxidation compared to beef in this study, neither tea catechins nor vitamin C could act well as antioxidants for lipid oxidation in cooked or raw chicken meat patties.

Conclusions

Addition of tea catechins caused discoloration in cooked beef and chicken patties, but effectively reduced lipid oxidation in cooked and raw beef patties. Further studies are necessary to elucidate the antioxidant mechanisms of tea catechins in muscle systems.

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References

AOAC (1990). Official methods of analysis. 15th Ed. Association of Official Analytical Chemists, Washington DC.

Ke, P. J., Ackman, R. G., Linke, B. A. and Nash, D. M. (1977). Differential lipid oxidation in various parts of frozen mackerel. Journal of Food Technology, 12, 37-47.

Maher, M., O'Grady, M. N., Buckley, D. J., Troy, D., Moloney, A. P. and Kerry J. P. (2002). Effect of dietary supplementation and direct addition of tea catechins and rosemary on the oxidative stability of beef. In: Proceedings of the 48th International Congress of Meat Science and Technology. (pp. 500–501). Rome, Italy.

Mitsumoto, M. (2000). Dietary delivery versus exogenous addition of antioxidants. Chapter 12. In Antioxidants in Muscle Foods, Decker, E. A., Faustman, C. and Lopez-Bote, C. J. (eds.), 315-343. John Wiley & Sons, Inc. U.S.A.

Mitsumoto, M., Ozawa, S., Mitsuhashi, T. and Koide, K. (1998). Effect of dietary vitamin E supplementation for one week before slaughter on drip, colour and lipid stability during display in Japanese Black steer beef. Meat Science, 49, 165-174.

SAS. (1988). SAS/STAT User's Guide (6.03 Ed.). SAS Inst. Inc., Cary, NC. U.S.A.

Shahidi, F. and Wanasundara, P. K. J. P. D. (1992). Phenolic antioxidants. CRC Food Science and Nutrition, 32, 67–103.

Tang, S. Z., Kerry, J. P., Sheehan, D., Buckley, D. J. and Morrissey, P. A. (2000). Dietary tea catechins and iron-induced lipid oxidation in chicken meat, liver and heart. Meat Science, 56, 285-290.

Tang, S., Kerry, J. P., Sheehan, D. and Buckley, D. J. (2001) A comparative study of tea catechins and α-tocopherol as antioxidants in cooked beef and chicken meat. European Food Research and Technology, 213, 286-289.

Tang, S. Z., Kerry, J. P., Sheehan, D. and Buckley, D. J. (2002). Antioxidative mechanisms of tea catechins in chicken meat systems. Food Chemistry, 76, 45-51.

Tarladgis, B. G., Watts, B. M., Younathan, M. T. and Dudan, L. Jr. (1960). A distillation method for the quantitative determination of malonaldehyde in rancid foods. Journal of the American Oil Chemists' Society, 37, 44-48.

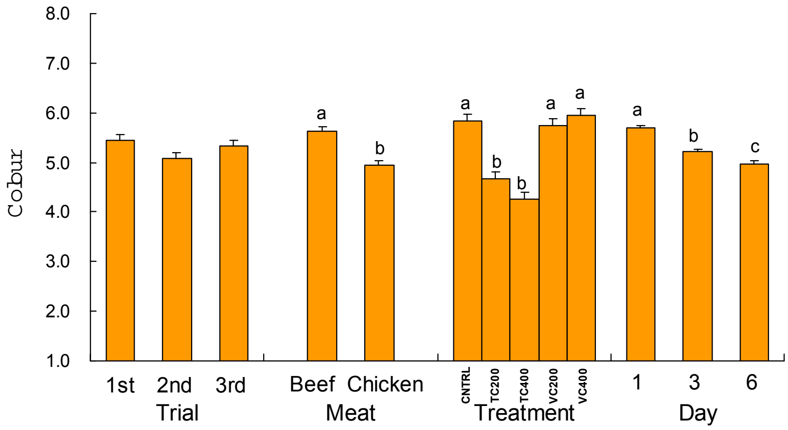

Fig. 1 Effect of meat, treatment and day on sensory colour scores in cooked beef and chicken meat patties. Least-squares means and standard error bars are shown. a,b,c: within main effects, means with no common letters differ (P<0.05).

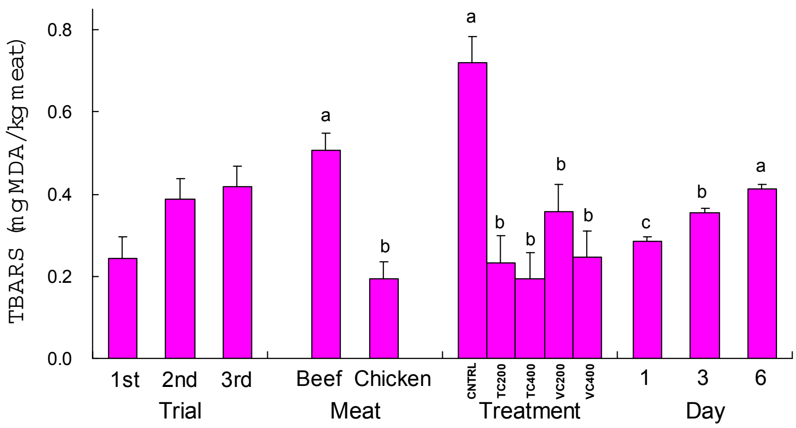

Fig. 2 Effect of meat, treatment and day on TBARS value in cooked beef and chicken meat patties. Least-squares means and standard error bars are shown. a,b,c: within main effects, means with no common letters differ (P<0.05).

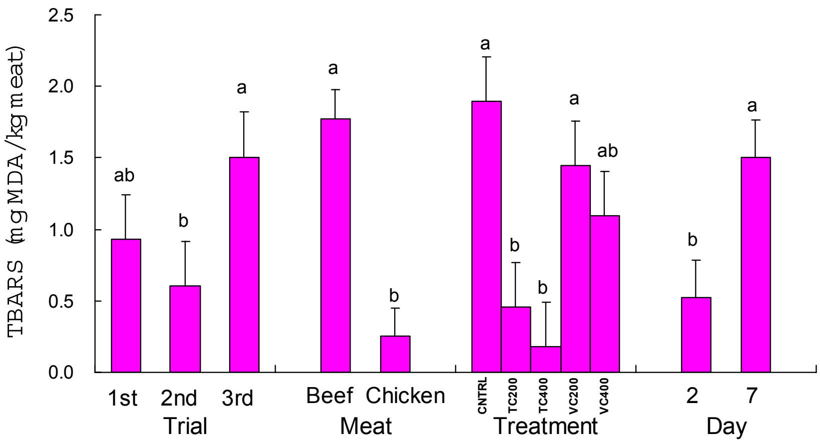

Fig. 3 Effect of meat, treatment and day on TBARS value in raw beef and chicken meat patties. Least-squares means and standard error bars are shown. a, b: within main effects, means with no common letters differ (P<0.05).