Meat Science 83 (2009) 528–533

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Antioxidative effect of dietary grape pomace concentrate on lipid oxidation of chilled and long-term frozen stored chicken patties

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ARTICLE INFO

Article history:
Received 10 August 2008
Received in revised form 3 March 2009
Accepted 26 June 2009

Keywords:
Grape pomace concentrate
Lipid oxidation
Free radical scavenging
Chicken breast

ABSTRACT

Grape pomace concentrate (GPC) is a natural source of phenolic compounds with high antioxidant capacity. The effect of a diet containing GPC on lipid peroxidation levels (TBARS) and antioxidant capacity (ABTS method) of raw and cooked chicken breast meat patties stored in chilled conditions (4 °C) for 0, 3, 6, 13 and 20 days, and long-term frozen storage (6 months) was investigated. Chickens were fed GPC at levels of 0, 30 and 60 mg/kg from 3 to 6 weeks of age. Dietary GPC did not affect chicken performance. Lipid oxidation (TBARS value) was significantly increased by the storage time (0–20 days and 6 months of storage, respectively) in raw and cooked samples. Dietary GPC significantly caused an inhibitory effect on lipid oxidation of raw and cooked breast chicken patties compared with samples obtained from birds fed the control diet at 20 days and long-term frozen storage (6 months). Radical scavenging capacity was significantly increased at 20 days in cooked samples and significantly reduced at 6 months of storage in raw and cooked samples. The higher concentration of dietary GPC increased the ABTS values only in the raw samples. These results indicated that dietary grape pomace concentrate could be effective in inhibiting lipid oxidation of chilled and long-term frozen stored chicken patties.

1. Introduction

Chicken meat and products are widely consumed all over the world. They have many desirable nutritional characteristics such as low lipid contents and relatively high concentrations of polyunsaturated fatty acids, which can be further enhanced by specific dietary strategies (Bourre, 2005). However, a high degree of polyunsaturation accelerates oxidative processes leading to deterioration in meat flavor, color, texture and nutritional value (Mielnick, Olsen, Vogt, Adeline, & Skrede, 2006). The most common strategies for preventing lipid oxidation are the use of antioxidants and restriction of access to oxygen during storage by vacuum-packaging (Tang, Kerry, Sheehan, Buckley, & Morrissey, 2001a). Antioxidant additives are added to fresh and further processed meats to prevent oxidative rancidity, retard development of off-flavors and improve color stability (Ahn, Grun, & Fernando, 2002). Synthetic antioxidants such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) have been used to control lipid oxidation in meat. However, the use of these synthetic antioxidants is restricted in some countries because of their toxic or carcinogenic effects (Hirose et al., 1998; Pokorny, 1991). The oxidative stability of poultry meat depends largely on the α-tocopheryl acetate added to the diet (Wen, Morrisey, Buckley, & Sheehy, 1997). However, this presents a number of drawbacks which include its synthetic origins and low bioefficiency (Allard, Kurian, Aghdassi, Muggli, & Royall, 1997). In view of these drawbacks, there has been considerable growth of interest in the use of natural antioxidants in the last decade. Grape pomace accounts for about of the 20% of the weight of the grape processed into wine (Llobera & Canellas, 2007). Grape pomace is a rich source of flavonoids including monomeric phenolic compounds, such as (+)-catechins, (−)-epicatechin, and (−)-epicatechin-3-*O*-gallate and dimeric, trimeric, and tetrameric procyanidins. Studies have shown that flavonoids have the capacity to act as powerful antioxidants by scavenging free radicals and terminating oxidative reactions (Yilmaz & Toledo, 2004). Previous reports (Brenes et al., 2008; Goñi et al., 2007) indicate that the intake of grape pomace increases antioxidant capacity in breast and thigh meat of broiler chickens, in the same way as added vitamin E in experimental diets. Grape seed extract and other plant extracts have been shown to have an antioxidative effect on beef (Ahn et al., 2002), turkey (Lau & King, 2003; Mielnick, Olsen, Vogt, Adeline, & Skrede, 2006) and chicken meat (Mitsumoto, O'Grady, Kerry, & Buckley, 2005).

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doi:10.1016/j.meatsci.2009.06.038

The aim of this study was to evaluate the effect of a dietary grape pomace concentrate on the stability of raw and cooked chicken meat patties stored for 0, 3, 6, 13 and 20 days in chilled conditions (4 °C) and during long-term frozen stored (6 months at −20 °C).

2. Materials and methods

2.1. Grape pomace concentrate composition

Grape pomace concentrate (*Vitis vinifera*, var Cencibel, La Mancha, España) is a grape by-product consists mainly on peels, stems and seed. It was used as source of dietary fiber and polyphenols in chicken diets. The proximate composition of GPC is shown in Table 1.

2.2. Birds and diets

A total of 70 one-day-old male broiler chicks (Cobb strain) were obtained from a commercial hatchery. The birds were housed in electrically heated stainless steel starter battery brooders in an environmentally controlled room with 23 h constant overhead fluorescent lighting during 3 weeks and were fed on a commercial broiler starter diet from 1 to 21 days. At the end of week 3, 54 chickens were weighed and moved to grower–finisher batteries from 21 to 42 days. Chicks were allocated to 9 cages, each cage containing six chicks, to receive three dietary treatments with 3 replicates of each treatment. Diets in mash form and water were provided for *ad libitum* consumption. All diets were formulated to meet or exceed the minimum (NRC, 1994) requirements for broiler chickens. At the end of the experiment period, birds were weighed, and feed consumption was recorded for feed efficiency computation. All housing and handling were approved by the University Complutense of Madrid Animal Care and Ethics Committee in compliance with the Ministry of Agriculture, Fishery and Food for the Care and Use of the Animals for Scientific Purpose. Ingredients and nutrient composition of diets are shown in Table 2. The source of dietary fiber on control diet was cellulose. Cellulose was replaced (50% or 100%) by GPC on test diets (30 GPC and 60 GPC, respectively).

2.3. Preparation of meat and patties

At 42 days of age, 6 birds per treatment were slaughtered and carcasses were immediately trimmed for breast meat. Sample of raw breast meat (obtained from 6 birds per treatment; about 2 kg/treatment) was minced twice (4 mm plate) using a grinder (Mainica, Granollers, Spain). The minced meat was salted (NaCl, 1%) and blended in a bowl mixer (Hobart, Model N50, USA) during 3 min, to ensure uniform distribution of the NaCl. The patties obtained were packed in six vacuum high oxygen barrier bags (nylon/polyethylene, 9.3 ml $O_2/m^2/24$ h at 0 °C, Koch Kansas City, MO). Three portions were stored at −20 °C for further analysis after six months. The other three portions were stored at 4 °C. The first day (day 0), the bags were opened for analysis. The rest of the portions were wrapped in a transparent oxygen-permeable polyvinyl chloride film (13,500 cm^3/m^2/day), and stored at 4 °C.

The minced chicken meat (50 g portion) was formed into patties using a meat former (Ministeak burger maker, O.L. Smith Co. Ltd., Italy). Patties were cooked in an electric pan previously greased with olive oil (Plactronic, Selecta, J.P. Selecta, S.A. Barcelona, España) at 170 °C until an internal meat temperature of 72 °C was reached and flattened 30 s with a wood spatula. After 1.5 min patties were turned over to settle for another 1.5 min and cool down for 2 more minutes. The same procedure was repeated to cook the patties after 3, 6, 13 and 20 days of refrigerated storage.

After six months the samples were thawed overnight at 4 °C. The same procedure described above was followed. Raw and cooked patties were analyzed the same day.

Table 1
Proximate composition of grape pomace concentrate (g/kg dry matter).

Protein	138.5 ± 1.20
Soluble sugars	20.7 ± 0.30
Fat	9.87 ± 0.17
Ash	24.1 ± 0.30
Fiber	151.8 ± 0.73
Polyphenols	
Extractable polyphenols	48.7 ± 0.07
Condensed tannins	150.9 ± 0.05
Hydrolysable tannins	26.0 ± 0.05
Antioxidant capacity (ABTS method, μmoL trolox equivalents/g dry matter)	
Extractable polyphenols	377.1 ± 2.44
Condensed tannins	81.40 ± 0.56
Hydrolysable tannins	167.40 ± 3.20

Data are the mean of 4 determinations ± SD.

Table 2
Ingredients and nutrient composition of experimental diets (g/kg as fed).

Ingredients	Control	30 GPC[a]	60 GPC
Corn (8.1% CP[b])	485.9	499.0	509.5
Soybean (48% CP)	336.0	325.7	315.8
Sunflower oil	82.4	80.0	80.0
Cellulose	60.0	30.0	–
GPC (13.8% CP)	–	30.0	60.0
Dicalcium phosphate	15.5	15.5	15.5
Calcium carbonate	10.0	9.6	9.1
Salt	3.0	3.0	3.0
Vitamin mineral premix[c]	5.0	5.0	5.0
DL- Met	1.2	1.2	1.1
Celite[d]	1.0	1.0	1.0
Analyzed composition			
CP	201.5	198.5	200.3
Crude fat	107.7	105.8	106.2
Extractable polyphenols	1.8	3.9	5.2
Hydrolysable polyphenols	14.2	15.3	16.9
Condensed tannins	–	4.51	9.0
Calculated composition			
Average of metabolized energy[e] (kcal/kg)	3000	3000	3000
Met + cystine	7.3	7.3	7.3
Ca	8.7	8.7	8.7
Available P	3.7	3.7	3.7

[a] GPC = Grape pomace concentrate.
[b] CP = crude protein.
[c] Vitamin–mineral mix supplied the following per kilogram of diet: vitamin A, 8250 IU; 8250 UI; cholecalciferol, 1000 IU; vitamin E, 11 IU; vitamin K, 1.1 mg; vitamin B_{12}, 12.5 μg; riboflavine, 5.5 mg; panthothenate, 11 mg; niacin, 53.3 mg; choline cloride, 1020 mg; acid folic, 0.75 mg; biotin, 0.25 mg; delquin, 125 mg; DL-Met, 500 mg; amprol, 1 g; Mn, 55 mg; Fe, 80 mg; Cu, 5 mg; Se, 0.1 mg; I 0.18 mg; and NaCl, 2500 mg.
[d] Celite Corp, Lompoc, CA.
[e] Calculated value (FEDNA Tables, 2003).

2.4. Chemical analysis

2.4.1. Proximate analysis

Dry matter (930.15), crude fiber (978.10), and ash (942.05) were analyzed according to the methods of the AOAC (2000). Crude fat (CF) was determined by extraction in petroleum ether after acidification with 4 N HCl solution (Wiseman, Edmundo, & Shepperson, 1992).

2.4.2. Measurement of lipid oxidation. Thiobarbituric acid index (TBARS)

The extent of lipid oxidation was determined in samples of raw and cooked patties by measuring the TBA-reactive substances at