Food Chemistry 148 (2014) 276–283

Contents lists available at ScienceDirect

Food Chemistry

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

The effect of antioxidants, packaging type and frozen storage time on the quality of cooked turkey meatballs

Mirosława Karpińska-Tymoszczyk *

Department of Human Nutrition, University of Warmia and Mazury, Olsztyn, Poland

ARTICLE INFO

Article history:
Received 28 May 2013
Received in revised form 9 October 2013
Accepted 10 October 2013
Available online 21 October 2013

Keywords:
Turkey meatballs
Antioxidants
Packaging method
Frozen storage
Lipid oxidation
Colour
Sensory quality

ABSTRACT

Oil-soluble rosemary extract (OR) and butylated hydroxytoluene (BHT) were added individually and in mixture (MIX) to raw turkey meatballs. After cooking and chilling, samples were air- and vacuum-packaged and frozen stored for 90 days. The synthetic antioxidant, the natural antioxidant and their mixture significantly decreased TBA values. Lipid oxidation was most effectively inhibited by a mixture of BHT and OR during storage in the air, and by BHT in vacuum-packaged samples. A lower rate of the hydrolytic process was observed in BHT samples. All additives stabilized the red colour of turkey meatballs, but samples with a mixture of natural and synthetic antioxidants showed higher a^* values than OR samples. Vacuum-packaged turkey meatballs were darker in colour, and the contribution of redness in these samples continued to increase until day 80. OR added alone or in combination with BHT maintained the quality of turkey meatballs during frozen storage, but samples with the synthetic antioxidant were characterized by a non-typical flavour after a longer time of storage.

1. Introduction

Poultry meat is one of the most popular food products worldwide. Poultry meat consumption has increased over the last several decades in many countries due to, among others, it is relatively low cost of production, low fat content and high nutritional value.

Freezing is one of the most important preservation methods for meat and meat products since, compared with other methods, it leads to a minimal loss of quality during long-term storage. However, poultry meat is particularly prone to lipid oxidation during frozen storage due to its high polyunsaturated fatty acid content (Soyer, Özalp, Dalmış, & Bilgin, 2010). The auto-oxidation of lipids during storage affects the colour, flavour, texture and, in particular, the nutritional value of foods (Morrissey, Sheehy, Galvin, Kerry, & Buckley, 1998). Synthetic antioxidants, such as butylated hydroxyanisole (BHA) or butylated hydroxytoluene (BHT) and *tert*-butyl hydroquinone (TBHQ), are widely used in the food industry because they are effective and cheaper than natural antioxidants. However, there has been a growing concern over the possible carcinogenic effects of synthetic antioxidants in foods (Juntachote, Berghofer, Bauer, & Siebenhandl, 2006). Yet, the potential health risks have restricted their extensive use and increased interest in natural antioxidants (Mohamed, Mansour, Diaa El-Din, & Farag, 2011), including rosemary extracts, which have been increasingly used for the preservation of food materials in recent years. It is important to compare the antioxidant activities of plan extracts which may contain more than one antioxidant, with those of individual pure antioxidants, in order to determine a possible synergistic interaction among the antioxidants (Erkan, Ayranci, & Ayranci, 2008). Plants, including herbs and spices, contain many phytochemicals which are potential sources of natural antioxidants, e.g. phenolic diterpenes, flavonoids, tannins and phenolic acids (Dawidowicz, Wianowska, & Baraniak, 2006). The antioxidant activity of rosemary extracts has been associated with the presence of several phenolic diterpenes such as carnosic acid, carnosol, rosmanol, rosmariquinone and rosmaridiphenolo, which break free radical chain reactions by hydrogen donation (Basaga, Tekkaya, & Acitel 1997). Numerous researchers have reported the effectiveness of rosemary extracts for retarding lipid oxidation in various foods (Mohamed et al. 2011; Sebranek, Sewalt, Robbins, & Houser, 2005). Several authors have demonstrated that some of the compounds present in rosemary extracts possess antibacterial properties (Djenane, Sánchez-Escalante, Beltrán, & Roncalés, 2002; Fernández-López, Zhi, Aleson-Carbonell, Pérez-Alvarez, & Kuri, 2005).

This study was designed to investigate the stabilizing effect of a commercial rosemary antioxidant and a mixture of BHT and rosemary extract on turkey meatballs, in comparison with BHT and a control treatment without antioxidants.

* Address: 10-726 Olsztyn, Plac Cieszyński 1, Poland. Tel./fax: +48 89 523 49 91.
E-mail address: mikar@uwm.edu.pl

0308-8146/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.foodchem.2013.10.054

2. Materials and methods

2.1. Materials

Thigh muscles of male British United BIG-6 turkeys (Frednowy, Poland) were purchased from the Indykpol Company (Olsztyn, Poland), oil-soluble rosemary extract (0791 Stabilotion OR) containing 30% phenolic diterpenes (carnosic acid, carnosol, rosmanol and rosmarinic acid) was purchased from the RAPS GmbH & Co., KG Company (Kulmbach, Germany), and butylated hydroxytoluene (BHT) was purchased from Sigma–Aldrich.

2.2. Sample preparation

After cutting and chilling, 1 kg portions of turkey meat were packaged in polyethylene bags and deep-frozen at –25 °C at the "Indykpol" Poultry Processing Plant in Olsztyn. After three days, the material was transported to the laboratory at the University of Warmia and Mazury and placed in a refrigerator at 3 °C, where it was defrosted over 20 h and assigned to the experiment. Defrosted meat was cut into 4–6 cm pieces and ground in a meat grinder, type MMU-10Z (Nakło, Poland) with a 4 mm mesh. Ground turkey meat was divided into four groups. Following the addition of wheat flour roll soaked in water (13%), beaten eggs (5%), flour (2%) and salt (1% relative to the total mass weight) to meat (80%), the mass was mixed in a multifunctional food processor (Bauknecht, Warsaw Poland). Experimental treatments were as follows: no additives (control-C), butylated hydroxytoluene (BHT) – 0.3 g/kg of the total mass weight, oil-soluble rosemary extract (OR) – 0.3 g/kg and a mixture of OR and BHT (MIX) – 0.15 g/kg and 0.15 g/kg, respectively. Oil-soluble rosemary extract was mixed with part of the meat mass before mixing with the total mass. Butylated hydroxytoluene was dissolved in ethanol, and it was slowly added to the meat mass while mixing. While preparing a mixture of BHT and OR, the ingredients were added individually. Next the mass was formed into 90 g + 1 g meatballs (8 cm in diameter, 1 cm in thickness).

2.3. Cooking

A hundred and twenty meatballs randomly selected from each treatment were placed on the oven tray (twelve meatballs at a time) and were cooked in the BECK FCV 4 EDS steam-convection oven (BECK GmbH, Jagsthausen, Germany) with a measuring probe. Steam and hot air were used for heat treatment (air temperature −180 °C, steam saturation – 30%). The treatment was continued until a temperature of 82 °C was reached inside the product. The patties analyzed after cooking were stored overnight at 0 °C.

2.4. Storage study

Cooked turkey meatballs were air-packaged using the Vacsy Bag welding machine (Zepter International, Poland) and vacuum-packaged with the TEPRO TP packaging unit (Koszalin, Poland) into bags of a five-layer PE-LD/adh/PA/ADH/PE-PD film (total thickness – 0.08 mm, PA layer thickness – 0.024 mm, oxygen permeability – 40 cm^3/m^{-2} 24 h^{-1} bar^{-1}, water vapour permeability – 10 g m^{-2} 24 h^{-1} bar^{-1}). The samples were stored at −20 °C + 2 °C for 10, 20, 30, 40, 50, 60, 70, 80 and 90 days.

2.5. Analytical methods

Frozen samples were thawed at 4 °C prior to analysis.

2.5.1. Lipid oxidation analysis

Lipid oxidation was assessed in 10 g of turkey meatballs by the 2-thiobarbituric acid (TBA) method of Tarladgis, Watts, and Younathan (1960) modified by Pikul, Dennise, Leszczyński, and Kummerow (1989). TBARS values were calculated from the standard curve of malondialdehyde and expressed as mg malondialdehyde kg^{-1} product. TBARS determination was conducted in triplicate on each of three samples per treatment.

2.5.2. Acid value (AV)

The acid value (AV) indicates how much free fatty acid has accumulated as a result of lipolysis. It was determined in fat extracted from the products in accordance with Polish Standard PN-EN ISO 660 (Animal and vegetable fats and oils, 2005). Samples of around 10 g were dissolved in 50 ml of ethanol: diethyl ether mixture (1:1, v/v), and were titrated with 0.1 N potassium hydroxide solution using phenolphthalein as an indicator. Analyses were carried out in triplicate on each of three samples per treatment. The acid value was the number of mg KOH required to neutralize 1.0 g of fat.

2.5.3. pH

For pH determination, 10 g samples of the products and 90 ml of distilled water were homogenized in a blender (type MPW-302) for 60 s. The pH of the mixture was measured using a pH-meter; model ATC PICCOLO 2 (Woonsocket USA), standardized at pH 4 and pH 7. pH was measured directly after homogenization and it was read after stabilization. pH determination was conducted in triplicate on each of three samples per treatment.

2.5.4. Colour evaluation

A MiniScan XE Plus Hunter Lab with a D65 illuminate and a 10ş standard observer was used to measure CIE Lab colour parameters, L^*, a^*, and b^*. Colour was measured on the meat surface 30 min after the package had been opened. The measurement was repeated at eighteen randomly selected points on each of three samples per treatment.

2.5.5. Sensory quality

Meatballs were subjected to a sensory evaluation by the flavour profile method (Meilgaard, Civille, & Carr, 1999). The assessment was performed by five experienced panelists selected from among the University staff and graduate students who had prior experience with poultry product sensory tests. Descriptor selection was carried out based on the experience of all panellists. A training session was held prior to testing so that each panellist could thoroughly discuss and clarify each attribute to be evaluated. The following flavour attributes of cooked meatballs were assessed: meaty, typical of poultry meat, fatty, aromatic, typical of roasted meat, spicy-rosemary, WOF, and non-typical. Standard samples with a very strongly noticeable perception of WOF were prepared from poultry patties which were cooked in boiling water until a temperature of 82 °C was reached inside the product, cooled at room temperature, packaged into polyethylene bags and stored at 4 °C for 3 days. Using a standardized lexicon of meat descriptors for WOF (Love, 1988), the judges described the standard sample off-flavours with the terms "boiled fish" or "stale", and off-odours with the terms "painty" or "cardboardy". For flavour evaluation, two meatballs per treatment were cut into approximately uniform pieces. Samples were served in random order to each panellist on a white porcelain dish, coded with random numbers. Two sensory evaluation sessions were conducted per day. The 2nd session comprised the replicates of the 1st session. The sessions were conducted at one-hour intervals. At the beginning of each session, the panel was presented with the reference samples for the extremes of scales of the flavour attributes to be measured. The intensity