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Review

Natural antioxidants in meat and poultry products

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ABSTRACT

In response to recent claims that synthetic antioxidants have the potential to cause toxicological effects and consumers' increased interest in purchasing natural products, the meat and poultry industry has been seeking sources of natural antioxidants. Due to their high phenolic compound content, fruits and other plant materials provide a good alternative to conventional antioxidants. Plum, grape seed extract, cranberry, pomegranate, bearberry, pine bark extract, rosemary, oregano, and other spices functions as antioxidants in meat and poultry products. Pomegranate, pine bark extract, cinnamon, and cloves have exhibited stronger antioxidant properties than some synthetic options. Plum products, grape seed extract, pine bark extract, rosemary, and some spices all have been shown to affect the color of finished meat or poultry products; however, in some products such as pork sausage or uncured meats, an increase in red color may be desired. When selecting a natural antioxidant, sensory and quality impact on the product should be considered to achieve desired traits.

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1. Introduction

Antioxidants are substances that at low concentrations retard the oxidation of easily oxidizable biomolecules, such as lipids and proteins in meat products, thus improving shelf life of products by protecting them against deterioration caused by oxidation. The use of antioxidants in food products is controlled by regulatory laws of a country or international standards. Although there are many compounds that have been proposed to possess antioxidant properties to inhibit oxidative deterioration, only a few can be used in food products. In the United States the use of antioxidants is subject to regulation under the Federal Food, Drug and Cosmetic Act, Meat Inspection Act, Poultry Inspection Act, and other state laws (Mikova, 2001; Shahidi & Zhong, 2005). In the European Union, regulation of antioxidants is stipulated by the European Parliament and Council Directive No. 95/2/EC of 20 February 1995 on food additives other than color or

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sweeteners. Another organization that regulates the use of antioxidants is the *Codex Alimentarius*, which is a collection of internationally adopted standards. *Codex Alimentarius* permits only the use of those antioxidants which have been evaluated by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) and these may be used only in foods standardized by *Codex* (Mikova, 2001).

Synthetic antioxidants such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), *tert*-butylhydroquinone (TBHQ), and propyl gallate (PG) have been used as antioxidants in meat and poultry products (Biswas, Keshri, & Bisht, 2004; Formanek et al., 2001; Jayathilakan, Sharma, Radhakrishna, & Bawa, 2007), but synthetic antioxidants have fallen under scrutiny due to potential toxicological effects (Naveena, Sen, Vaithiyanathan, Babji, & Kondaiah, 2008; Nunez de Gonzalez, Hafley, Boleman, Miller, Rhee, & Keeton, 2008; Raghavan & Richards, 2007).

In response to recent demand for natural products and consumers' willingness to pay significant premiums for natural foods (Sebranek & Bacus, 2007), the meat and poultry industry is actively seeking natural solutions to minimize oxidative rancidity and increase products' shelf-life (Naveena, Sen, Kingsly, Singh, & Kondaiah, 2008). Recent investigation has focused towards identification of novel antioxidants from natural sources. Due to their high content of phenolic compounds, fruits and other plant materials are a good source of natural antioxidants and provide an alternative to currently used conventional antioxidants (Nunez de Gonzalez, Boleman, Miller, Keeton, & Rhee, 2008). Many natural antioxidants such as rosemary and spice extracts have been reported to be more active than synthetic antioxidants and the food application of these compounds needs to be explored. In 2010, the European Union authorized the use of rosemary extracts as new food additives for use in foodstuffs under Directive 95/2/EC and assigned E 392 as its E number (European Union directives 2010/67/EU and 2010/69/EU) and the applications specified by the directives include meats. With the approval of carnosic acid and carnosol-based rosemary extract as a safe natural alternative to synthetic antioxidants, a new trend for "natural products" has emerged.

Lipid oxidation, one of the major causes of quality deterioration, is also important (Raghavan & Richards, 2007) because it can negatively affect sensory attributes such as color, texture, odor, and flavor as well as the nutritional quality of the product (Nunez de Gonzalez, Boleman, et al., 2008). These issues leave the meat and poultry industry in need of economical and effective natural antioxidants that can replace synthetic antioxidants without negatively affecting the quality of finished products and consumer perceptions; therefore, the objective of this paper is to review published natural antioxidant research on how natural ingredients with antioxidant properties may be used in meat and poultry products.

A natural product in the meat and poultry industry is defined by United States Department of Agriculture's Food Safety and Inspection Service (USDA/FSIS) as a product that does not contain "any artificial flavor, coloring ingredient or chemical preservative, or any other artificial or synthetic ingredient; and the product and its ingredients are not more than minimally processed" (USDA, 2005). Some of the natural antioxidants we will discuss may not fit this definition but have been obtained from natural sources and processed prior to incorporation into meat or poultry products.

2. Natural antioxidants

2.1. Fruits

Fruits have gathered interest from the public and scientific communities because of their health promoting properties. The benefits of fruits have been attributed to their high phenolic compound content, which acts as antioxidants (Zuo, Wang, & Zhan, 2002). Numerous studies have been conducted on the antioxidant potential of many fruits (plum, grape seed extract, cranberry, pomegranate, and bearberry) in meat and poultry products (Brannan, 2008; Lee, Reed, & Richards, 2006; Nunez de Gonzalez, Boleman, et al., 2008; Pegg, Amarowicz, & Barl, 2001).

2.1.1. Plum

Food ingredients derived from plums function as antioxidants, antimicrobials, fat replacers, and flavorants (Nunez de Gonzalez, Hafley, et al., 2008). Plums have demonstrated antioxidant properties in products such as irradiated turkey, precooked pork sausage, and roast beef (Lee & Ahn, 2005; Nunez de Gonzalez, Boleman, et al., 2008; Nunez de Gonzalez, Hafley, et al., 2008); however, Nunez de Gonzalez, Hafley, Boleman, Miller, Rhee, and Keeton (2009) reported that use of plum in sliced ham increased cook loss, shear force values, and redness (a^* values). Nunez de Gonzalez, Boleman, et al. (2008) evaluated raw and cooked pork sausage patties (32% fat) treated with 3% and 6% dried plum puree, 3% and 6% dried plum and apple puree (California Dried Plum Board, Sunsweet Growers Inc., Yuba City, CA), and butylated hydroxyanisole (BHA)/butylated hydroxytoluene (BHT) at 0.02% (based on sausage fat content). Sausages were cooked to an internal temperature (I.T.) of 71.1 °C and vacuum-packaged. Samples were either stored at 4 °C for 28 d or frozen at −20 °C for 90 d.

After 28 d of storage (4 °C), precooked pork sausage patties treated with 3% and 6% dried plum puree, or 3% and 6% dried plum and apple puree showed a reduction ($p<0.05$) in TBARS values compared with the control (untreated). TBARS values of the control, 3% dried plum puree, and 6% dried plum samples were 1.00, 0.44, and 0.34 mg MDA/kg sample, respectively. The 3% and 6% dried plum and apple puree samples resulted in TBARS values higher than the samples treated with dried plum puree, and 3% dried plum and apple puree sample had a TBARS value higher than the control. The 3% and 6% dried plum puree treatments were not different ($p>0.05$) from the BHA/BHT treated sample, which had a TBARS value of 0.39 mg MDA/kg sample.

Control precooked pork sausage patties stored for 90 d (−20 °C) also had a significantly higher TBARS value (1.98 mg MDA/kg sample) compared with patties with 3% dried plum (0.95 MDA/kg sample), 6% dried plum puree (0.46 MDA/kg sample), and 3% dried plum and apple puree (1.46 mg MDA/kg sample). The BHA/BHT treatment had a TBARS value of 1.05 mg MDA/kg sample and was found to be higher ($p<0.05$) than the 6% dried plum treated sample.

Lee and Ahn (2005) found that plum extract (California Dried Plum Board, Sunsweet Growers Inc., Yuba City, CA) used at 3% in irradiated (3 kGy) turkey breast rolls reduced ($p<0.05$) lipid oxidation. TBARS value for the control product was 0.95 mg MDA/kg meat, and the 3% plum extract sample had a reduced ($p<0.05$) TBARS value of 0.84 mg MDA/kg meat after 7 d of storage at 4 °C.

Nunez de Gonzalez, Hafley, et al. (2008) found that lipid oxidation was reduced ($p<0.05$) in precooked roast beef when treated with fresh plum juice concentrate, dried plum juice concentrate, and spray-dried plum powder (California Dried Plum Board, Sunsweet Growers, Inc., Yuba City, CA). Beef top rounds were brine-injected (20% by weight of raw product) with the above plum products added at 2.5% and 5% to the brine. Samples were cooked to an endpoint temperature of 62.8 °C and stored at <4 °C for 10 wk. The 5% fresh plum juice concentrate treatment (0.16 mg MDA/kg) was found to have the lowest TBARS value of all the treatments. The TBARS value of the control was 0.62 mg MDA/kg.

Nunez de Gonzalez et al. (2009) reported that hams injected with (20% w/w) brine solutions containing fresh plum juice concentrate, dried plum juice concentrate, spray-dried plum powder at 2.5 or 5% (California Dried Plum Board, Sunsweet Growers, Inc., Yuba City, CA) and no plum ingredients (control), had similar TBARS values. Hams were cooked to an endpoint temperature of 71.1 °C, vacuum-packaged, stored at <4 °C, and evaluated at 2-wk intervals for 10 wk.

Yildiz-Turp and Sedaroglu (2010) reported the effect of using different amounts of plum puree (PP) on low fat (5–6%) beef patties. Puree