Effect of Added Grape Seed and Skin on Chicken Thigh Patties during Chilled Storage

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Introduction

By-products from the winemaking industry are widely available in Mediterranean countries. In many cases, these products cause an important environmental problem in terms of storage, processing or disposal (Brenes et al., 2016). However, grape pomace (seeds, skin, and stems) contains a wide range of polyphenols and is one of the major sources of phenolic compounds (Yildrim et al., 2005; Brenes et al., 2016). Many positive effects on human health have been described for these compounds including anti-inflammatory, anti-carcinogenic, cardio protective and vasodilatory properties (Georgiev et al., 2014). A positive effect on animal health has also been described by Brenes et al. (2016). The antioxidant and antimicrobial properties of grape polyphenols have been widely reported (Etxeberria et al., 2013; Georgiev et al., 2014). Polyphenols often act as free radical scavengers and stop radical chain reactions that occur during the oxidation of triglycerides. Today the meat industry is interested in replacing traditionally used synthetic antioxidants (BHT, BHA, TBHQ, etc.) which are potentially toxic and harmful to health with natural products or ingredients of plant origin containing bioactive compounds with potential health benefits (Ayo et al., 2007; Rojas & Brewer, 2008). This is particularly important for the meat industry which is anxious to improve its image which has been tarnished over the last decade (Jiménez-Colmenero et al., 2010).

Lipid oxidation and color are important factors for consumer acceptance of meat and meat products. Several studies have found a reduction in oxidation in different meats (pork, beef, lamb, chicken and goat) after the addition of different natural compounds such as those found in oregano, sage, rosemary, thyme, marjoram, caraway, basil, ginger, kinbow, pomegranate, cereal, walnut and seaweed (Botsoglou et al., 2003; Naveena et al., 2008; Ayo et al., 2007; López-López et al., 2009; Devatkal et
Preparation of patties

Three formulations were used to prepare patties consisting of 85.4% meat, 6.8% whole egg, 1% salt and 6.8% breadcrumbs in the control sample (PC), 4.8% breadcrumbs and 2% grape seed in the PGS sample and 4.8% breadcrumbs and 2% grape skin in the PSS sample following the formulation of Sáyago-Ayerdí et al. (2009). The ground meat was blended in a bowl mixer (Hobart, Model N50, USA) for 60 s and then the salt was added and mixed a further 30 s. The eggs and breadcrumbs were then put into the mixer and mixed for 60 s. A total of 25 patties were made from the mixture (~50g per patty) for every treatment using a conventional burger maker (Mini steak burger maker, O.L. Smith Co. Ltd., Italy). The patties were placed in high oxygen barrier vacuum bags (nylon/polyethylene, 9.3 ml O2/m²/24 h at 0ºC, Koch Kansas City, MO). Each bag contained 2 patties which were refrigerated at 4ºC. The patties were analyzed on day 0 and after 3, 6 and 9 days of storage.

Proximate analysis

Moisture and ash were analyzed in meat and patties in quadruplicate according to AOAC methods (2005). Fat content was evaluated in triplicate according to the Bligh and Dyer (1959) method. Protein content was measured in quadruplicate using a Nitrogen Determinator LECO FP-2000 (Leco Corporation, St Joseph, MI, USA). Protein content was analyzed in GS and SS. The crude fiber of these ingredients was also analyzed according to AOAC methods (2005).

Color measurement

Color (CIE-LAB tristimulus values, lightness (L*), redness (a*) and yellowness (b*)) was measured on the surface of raw patties using a CR-400 Chroma Meter (Konica Minolta Business Technologies, Tokyo, Japan). Ten measurements were taken per sample.

Determination of total extractable polyphenols compounds

Total Extractable Polyphenols (TEP) was extracted from GS and SS, raw and cooked patties (prepared in an electric pan 1.5 min per side at 210 ± 4°C) by means of double aqueous-organic extraction according to the method of Sáyago-Ayerdí et al. (2009). Extractable polyphenols were determined by the Folin–Ciocalteu procedure using gallic acid (Sigma-Aldrich, St. Louis, MO) as standard. Results were expressed as gallic acid equivalents (mg GAE/kg of sample).

Lipid oxidation evaluation

Lipid oxidation was determined by measuring the Thiobarbituric Acid Reactive Substances (TBARS) described by Lópezo-López et al. (2009). A calibration curve was plotted with 1,1,3,3-tetraethoxypropane (Sigma Chemical Co., St. Louis, MO, USA) to Measure Malonaldehyde (MDA). TBARS determinations were performed in triplicate. Values were expressed as mg of malondi aldehyde/kg of sample.

Sensory evaluation

Patties were assessed by a 15-member panel of individuals who regularly consume these types of products. The panel was selected after preliminary training (two sessions) on the products and terminology. Samples were cooked in an electric pan 1.5 min per side at 210 ± 4°C. Patties were cut into pieces of uniform size (2 x 2 cm) and were then immediately presented to the judges who were instructed to evaluate color, flavor, hardness, juiciness and general acceptability. All parameters were measured on unstructured scales (0 = dislike very much, 10 = like very much) except general acceptability which was
measured on a hedonic scale rating test. Sensory analysis was performed 2 days after preparation of the patties.

Statistical Analysis

Data was analyzed using SPSS V.13.0 software (SPSS Institute Inc., Cary, NC). The experimental design was done in duplicate. Differences between the two replicates were not significant (P < 0.05). Results were expressed by mean values and standard error of the mean of three or more separate determinations. One-way and two-way Variance Analysis (ANOVA) was used to determine the effect of formulation and storage time on the physico-chemical and sensorial properties of chicken thigh patties. Comparison of means was performed using the Tukey HSD test and differences were declared at P < 0.05.

Results and Discussion

Proximate analysis

The proximate composition of SS and GS is shown in Table 1. Protein content was similar for both ingredients. The main difference was observed in the polyphenolic content. Grape seed showed higher TEP and crude fiber content (approximately 4 and 2 times respectively) than grape skin. Similar results were reported by Ky et al. (2014).

Table 1: Proximate composition (%) and total extractable polyphenols expressed as (g of Gallic Acid Equivalents (GAE)/100 g of Grape Seed (GS) and Grape Skin (SS)).

| Parameters | GS      | SS      |
|------------|---------|---------|
| Protein    | 19.64 ± 0.41 | 16.27 ± 0.01 |
| Fiber      | 25.28 ± 1.87 | 14.40 ± 1.33 |
| Total extractable polyphenols | 8.23 ± 0.16 | 2.35 ± 0.14 |

Note: Means ± SD. GS: grape seed and SS: grape skin.

Table 2 shows the proximate composition of the chicken patties. No significant differences were found in moisture, fat, or protein. The addition of grape seed and skin resulted in higher (P < 0.05) ash content compared to the control sample due to the presence of grape by-product powder in the treatments. Similar results were found in ground chicken thigh meat treated with grape seed extract (Brannan, 2008).

Table 2: Proximate analysis (%) of different chicken thigh patties.

| Parameters | PC       | PGS      | PSS      |
|------------|----------|----------|----------|
| Moisture   | 68.80 ± 0.09 a | 69.99 ± 0.27 b | 69.08 ± 0.02 b |
| Protein    | 18.30 ± 0.33 a | 18.72 ± 0.06 a | 18.44 ± 0.02 a |
| Fat        | 6.45 ± 0.45 a | 6.16 ± 0.34 a | 6.25 ± 0.18 a |
| Ash        | 1.90 ± 0.04 a | 2.04 ± 0.01 a | 2.03 ± 0.08 a |

Note: Sample denomination: PC (patties Control); PGS (patties Grape Seed); PSS (patties Grape Skin)
Means ± SD. Different letters in the same row (a, b) indicate significant differences (P < 0.05).

pH

Table 3 shows the pH of the different chicken thigh patties during chilled storage. Initial pH levels were equal to or higher than 6.20 in all samples, the lowest levels being observed in the PSS. These results are similar to those obtained for chicken patties by other authors (Calliari et al., 2015) and in cooked chicken patties elaborated with extract of kin now rind, pomegranate rind and pomegranate seed powder (Devatkal et al., 2010).

During storage time, a significant decrease in the pH was observed, with lower levels in samples containing GS (PGS) and SS (PSS). pH decreased significantly in all samples during storage time. The lowest pH levels were detected in PGS and PSS samples. Other authors (Lorenzo et al., 2014) also found that the addition of grape seed extract leads to lower pH values in pork patties. This lower pH is associated with microbial growth, mainly lactic acid bacteria (Triki et al., 2013), and the polyphenol content of these grape by-products.

Total extractable polyphenolic compounds

Initial levels of total extractable polyphenolic compounds were highest (P < 0.05) in the Patties with Grape Seed (PGS) and lowest in the control sample (Table 3). These results coincide with the polyphenol content of GS and SS, which was highest in the GS (Table 2). Similar results were obtained by other authors (Thorngate & Singleton, 1994; Zhao et al., 1999; Yilmaz et al., 2015). Thorngate & Singleton (1994) estimated approximately 60 – 70% of grape polyphenols in grape seeds and about 5% in the skin. However, the phenolic composition of grapes and different grape parts depends on multiple factors, including climate, degree of ripeness, grape size, grapevine variety and viticulture practices (Rodriguez-Montealegre et al., 2006).

Polyphenol content observed in the control patties and in those formulated with grape by-products was similar to that found by other authors in patties enriched with fruit extracts (Devatkal et al., 2010) and in the thigh meat of broilers fed wild grapes (Yong et al., 2013). However, polyphenol content in the patties of this study was lower than that observed by other authors in low-salt meat pork emulsion containing seaweed (López-López et al., 2009) and walnut (Ayo et al., 2007).

An increase in the levels of polyphenolic compounds in all the samples was observed during storage, the highest levels found in PGS samples followed by PSS in relation with initial levels. A similar pattern of total phenolic content increase during chilled storage was observed in chicken patties elaborated with extract of kin now rind, pomegranate rind and pomegranate seed powder and in cooked chicken patties treated with pomegranate juice and rind extract (Naveena et al., 2008; Devatkal et al., 2010).

In order to evaluate the effect of heat treatment on polyphenol levels, only an initial study was conducted on the second day of patty storage to simulate consumer behavior. Polyphenol levels in the cooked patties were higher (P < 0.05) in the sample with grape seed PGS (739.1 mg GAE/kg) compared with PSS (527.9 mg GAE/kg) and the control (435.9 mg GAE/kg) samples. This was in relation with the polyphenolic content of raw patties (Table 3). As expected, the polyphenol levels were higher in cooked patties compared to the raw ones due to decreased moisture after cooking. The fact that patties maintain their polyphenol content after cooking suggests that this product could have health benefits for consumers.
Grape Seed and Skin on Chicken Thigh Patties

Table 3: pH, Total Extractable Polyphenols (TEP) and Thiobarbituric Acid-Reactive Substances (TBARS) values of different chicken thigh patties during chilled storage (4 ºC).

| Parameters                      | Sample | Storage (days at 4 ºC) |
|---------------------------------|--------|------------------------|
|                                 |        | 0          | 3          | 6          | 9          |
| pH                              |        |            |            |            |            |
| PC                              | 6.64 ± 0.01a1 | 6.39 ± 0.06a2 | 5.30 ± 0.05a3 | 4.99 ± 0.03a4 |
| PGS                             | 6.52 ± 0.01a1 | 6.26 ± 0.01a2 | 5.12 ± 0.01a3 | 4.78 ± 0.05a4 |
| PSS                             | 6.20 ± 0.01a1 | 6.05 ± 0.01a2 | 5.14 ± 0.01a3 | 4.83 ± 0.02a4 |
| PC                              | 387.9 ± 0.6a3 | 397.8 ± 0.6a3 | 424.6 ± 0.5a2 | 642.6 ± 1.4a1 |
| TEP (mg gallic acid equivalents/kg) |        |            |            |            |            |
| PGS                             | 575.5 ± 0.6a3 | 597.1 ± 1.3a3 | 955.5 ± 0.6a2 | 1148.1 ± 1.0a1 |
| PSS                             | 400.1 ± 1.0a3 | 411.2 ± 0.4a3 | 577.0 ± 1.3a2 | 841.8 ± 0.2a1 |
| PC                              | 0.96 ± 0.12a3 | 0.39 ± 0.03a1 | 0.67 ± 0.01a2 | 0.70 ± 0.01a2 |
| TBARS (mg malondialdehyde/kg)    |        |            |            |            |            |
| PGS                             | 0.57 ± 0.06a3 | 0.21 ± 0.04a1 | 0.39 ± 0.01a2 | 0.46 ± 0.01a2 |
| PSS                             | 0.64 ± 0.04a3 | 0.40 ± 0.03a3 | 0.49 ± 0.01a2 | 0.57 ± 0.01a2 |

Note: Sample denomination: PC (patties Control); PGS (patties Grape Seed); PSS (patties Grape Skin)

Means ± SD. Different letters in the same column (a, b, c) and numbers in the same row (1, 2, 3) indicate significant differences (P < 0.05).

Lipid oxidation

Initial patty TBARS values were very low (0.57-0.96 mg MDA/kg sample) with significantly lower TBARS levels in the patties formulated with GS and SS (Table 3). These low TBARS were similar to the ones found by other authors (Sáyago-Ayerdi et al., 2009). TBARS generally decreased during storage in all samples. Decreases in TBARS in meat have been described at different stages of storage (Brewer & Wu, 1993; Bhattacharyya et al., 1998; Delgado-Pando et al., 2011; Salcedo-Sandoval et al., 2015), presumably due to intermolecular reactions in the malonaldehyde formed (polymerization) and reactions with other constituents, especially amino acids/proteins (Jamora & Rhee, 2002). This phenomenon is easier to observe due to low oxidation levels in the conservation conditions used (high oxygen barrier vacuum bags). However, in general, the most significant fact of this study is that while low levels of this parameter were found in all samples, the initial differences between the samples with regard to TBARS remained constant during chilled storage with the lowest (P < 0.05) values found in the patties treated with the grape by-products, mainly in the PGS followed by PSS. This effect correlates to the polyphenol content of grape seed and grape skin, i.e. lower TBARS values corresponded to the higher polyphenol content of the reformulated patties (Table 3). Yilmaz et al. (2015) have also described higher antioxidant activity in seed than in skin. The antioxidiant effect of grape polyphenols in ground dark turkey meat, beef, pork, fish and chicken has also been described by many authors (Lau & King, 2003; Brannan, 2008; Brenes et al. 2010; Lorenzo et al. 2014). Flavonoids have the capacity to act as powerful antioxidants by scavenging free radicals and to stop oxidative reactions (Shahidi & Wanasundara, 1992). Grape skin and seed are a rich source of flavonoids including phenolic acids and mono meric compounds such as (+)- catechins, (-)- epicatechin, and (-)- epicatechin-3-O-gallate and oligomeric and polymeric procyanidins. Therefore, the increased effectiveness of GS versus SS in the reduction of lipid oxidation could be due not only to the different concentrations of phenolic compounds present in these by-products, but also to their different phenolic profile. Yilmaz & Toledo (2004) found lower concentrations of gallic acid, monomeric catechin and epicatechin in winery by-product grape skin than in seed due to the possible release of polyphenols contain edin grape skin into the wine during the winemaking process.

In general, chicken thighs are more susceptible to oxidation than breast meat due to the high fatty acid content in the thigh and also the presence of pro-oxidative agents such as Fe-hemo in chicken parts where blood flow is greater. This makes it all the more interesting to include grape by-products in meat products elaborated with these cuts of meat.

Color

Color parameter results (L*, a* and b*) are shown in Figure 1 (a, b and c). The significant changes observed in the color parameters were attributed mainly to the grape by-products added to the patties. The addition of GS and SS in chicken meat caused a significant reduction in L*, and b*, the lowest values found in patties formulated with SS. In this latter case a significant reduction of a* was likewise found but the reduction was not significant between control and PGS patties. A general increase in all the color parameters except b* was observed during the storage period with lower color values for the samples treated with grape by-products compared to control patties (Figure 1). The darkening (mainly a significant reduction in L* and b*) of meat products following the addition of grape extract was also reported in ground chicken thigh and breast meat treated with grape seed extract (Brannan, 2009) and chicken burgers prepared with grape pomace dietary fiber, Sáyago-Ayerdi et al. (2009). This was also the case of cooked chicken meat treated with grape seed and peel extracts (Selani et al., 2011) and cooked pork sausages formulated with grape pomace powder (Ryu et al., 2014). This color reduction in PGS and PSS samples could be due to the dark color of both grape seed and skin. This dark color could be due to polyphenol, mainly anthocyanins, which are responsible for many of the fruit and floral colors, observed in nature. These anthocyanins are water-soluble scarlet, magenta, purple, blue and red pigments. Grapes are among the fruits with the highest levels of phenolic substances with different concentrations of total anthocyanins depending on the variety and the part of the grape (skin, pomace, etc.). In this regard, seeds contain higher levels of polyphenol than skin (Table 1) but have lower concentrations of anthocyanins and phenolic acids than skin as reported by Pinelo et al. (2006). However, despite the vividred color of grape skin and seed used in this study, a reduction of a* was observed in the patties containing these

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Int J Food Nutr Sci | Volume 4: Issue 2
grape by-products (Figure 1b). In consistent results have been reported regarding the behavior of this parameter. An increase in the value of \(a^*\) has been observed in chicken burgers prepared with grape pomace (Sáyago-Ayerdi et al., 2009). However, other authors have observed a significant decrease in CIE \(a^*\) values in cooked products such as pork sausages reformulated with grape pomace powder (Ryu et al., 2014). This reduction was explained by the loss of anthocyanin present in grape skin when the grape juice was removed (Rababah et al., 2008). Also, Jin et al., (2013) observed a reduction of \(a^*\) in cooked sausage after adding schisandrachinensis powder which is a rich source of polyphenolic compounds, including anthocyanins and flavonols. These authors noted that a reduction in \(a^*\) could be due to the unstable nature of anthocyanins. On the other hand, other authors (Selani et al., 2011) did not observe significant changes in \(L^*, a^*,\) or \(b^*\) color parameters when grape seed and peel extracts were added to chicken or pork meat. These contrasting results could be due to the higher concentration of grape by-products (2%) added in this study compared to other experiments (Rojas & Brewer, 2008) where lower amounts of grape seed extract were added (0.01% - 0.02%). We would further note that the wine making process also affects levels of anthocyanins as does drying, increasing color intensity and the concentration of these phenolic compounds due to the effect of dehydration of grape by-products and diffusion of the colored compounds from the skin to the pulp due to structural alterations of the skin (Mazza, 1995). In our experiment, the reduction of \(a^*\) could be attributed to different factors such as: the limited presence of these substance in animal tissue, their instability in such a medium or possible interferences of the interaction components of GS and SS with the other components in the meat products (proteins, myoglobin, water or fat) influencing the color of meat products (Pietrasik & Janz, 2009).

![Figure 1: Lightness (L*) (1a), Redness (a*) (1b), Yellowness (b*) (1c) of different chicken patties [PC (patties Control); PGS (patties Grape Seed); PSS (patties Grape Skin)] during refrigerated storage at 4 °C.](image)

**Sensory evaluation**

Sensory attributes of different chicken patties are shown in Figure 2. The addition of grape by-products significantly affected the sensorial color and overall acceptability parameters of the patties. No significant differences among treatments were found for other parameters. The color score could be explained by the direct addition of these grape by-products at a concentration of 2% and because of the dark color of these ingredients as already mentioned. In general, the low score (P < 0.05) was observed for the Patties Containing Grape Skin (PSS), improbably because of the darker color of these samples. A very similar observed for the control sample and in Patties with Grape Seed (PGS). All the samples received an acceptable by the judges. In other words, the panel did not negatively evaluate the addition of grape seed powder into the patties. These results coincide with those reported by Sáyago-Ayerdi et al. (2009) and Brannan (2009).

![Figure 2: Sensory evaluation of different cooked chicken patties[PC (patties Control); PGS (patties Grape Seed); PSS (patties Grape Skin)].](image)

**Conclusion**

The use of grape by-products such as skin and seed in the formulation of patties limited the lipid oxidation of these products. Grape seed was considered more effective in retarding
Grape Seed and Skin on Chicken Thigh Patties

lipid oxidation than grape skin. In general, the patties elaborated with grape seed were evaluated as being more similar to the control sample than those elaborated with grape skin. The marketing of these patties could also have a positive effect on human health due to their polyphenolic content. Therefore, these results are relevant for the meat and the agri-food industries. Wine processing by-products were traditionally considered as waste material. However, the use of these grape by-products in the development of meat products could also have positive effects for consumers thanks to their polyphenol content thus opening a new avenue in the development of healthier foods.

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Grape Seed and Skin on Chicken Thigh Patties

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