ANTIOXIDANT EFFECT OF WINE RESIDUES ON LIPID OXIDATION AND COLOUR OF FROZEN STORED CHICKEN MEAT

Carmen J. Contreras-Castillo[1 *], Miriam M. Selani[1], Viviane G. Packer[1], Tâmara Z. Silva[1] and Gerson B. Mourão[2]

[1]Departamento de Agroindústria, Alimentos e Nutrição, Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Av. Pádua Dias, 11, 13418-900, Piracicaba, SP, Brazil

[2]Departamento de Zootecnia, Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Av. Pádua Dias, 11, 13418-900, Piracicaba, SP, Brazil

[*]Corresponding author (phone: +55-19-3429-4150; fax: +55-19-3429-4288; e-mail: ccastill@esalq.usp.br)

Abstract—**Chicken meat has desirable nutritional features such as low lipid content and relatively high concentration of unsaturated fatty acids. However, the high instauration level accelerates lipid oxidation, which affects flavour, odour, colour and texture of foods. Due to the possible toxicity of synthetic antioxidants, the use of natural antioxidants represents an alternative in the prevention of lipid oxidation. The aim of this study was to evaluate the effect of Isabel (IGE) and Niagara (NGE) grape seed and peel extracts on lipid oxidation, instrumental colour, pH and sensory properties of raw and cooked processed chicken meat stored at -18°C for 9 months. The pH of raw and cooked samples was not affected by the addition of grape extracts. IGE and NGE were effective in inhibiting the lipid oxidation of raw and cooked chicken meat, with results comparable to synthetic antioxidants. The extracts caused alterations in colour, as evidenced by the instrumental (darkening and lower intensity of red and yellow colour) and sensory results of cooked samples. These findings suggest that the IGE and NGE are effective in retarding lipid oxidation and have great potential for use as natural antioxidants in chicken meat in the food industry.**

Index Terms— **grape seed and peel extract, lipid oxidation, natural antioxidants, processed chicken meat.**

I. INTRODUCTION

Chicken meat, especially its industrial products, presents serious problems of processing and storage. Unsaturated lipids, fine grinding, incorporation of air, haem pigments, metal contact and high temperature during processing contribute to lipid oxidation (Field, 1988), which is the main process that results in loss of quality after microbial deterioration (Gray, Gomaa & Buckley, 1996) Lipid oxidation generates undesirable products from the sensory point of view, making them unfit for consumption. In addition, it causes the degradation of fat soluble vitamins and essential fatty acids, and it interferes with the integrity and security of foods through the formation of potentially toxic compounds (Silva, Borges & Ferreira, 1999).

In an attempt to control this process, food industries use synthetic additives with antioxidant properties. However, due to reports of possible toxic effects from synthetic antioxidants and to increasingly demanding consumer preferences for natural products and health benefits, the interest for alternative methods to retard lipid oxidation in foods, such as the use of natural antioxidants, has increased. These methods include plant extracts, fruit juice concentrates and seed extracts (Rhee, Ziprin, Ordonez & Bohac, 1988).

Residues from the wine industry account for approximately 30% of the total volume of grapes used for wine production. These by-products, such as seeds and peels, are rich in phenolic compounds with polymeric tannins and monomeric flavonoids, such as catechin and epicatechin, which are responsible for their high antioxidant activity (Guendez, Kallithraka, Makris & Kefalas, 2005). The possibility of using this residue as a natural antioxidant in the food industry, allowing not only reduction in environmental impact but also higher food utilisation rate, has attracted considerable attention.

The objective of this study was to evaluate the effects of IGE and NGE grape seed and peel extracts (*Vitis Labrusca* L.) on lipid oxidation and colour of raw and cooked chicken meat that was vacuum-packed and stored at -18°C for 9 months.

II. MATERIALS AND METHODS

A. Preparation of grape extracts: Residues (seeds and peels) were dried in an oven with forced air circulation at 40°C for 24 h and ground in an analytical mill to a grain diameter of less than 0.5 mm. Twenty grams of dried and ground

residue were macerated with 100 ml of ethanol 80% (v/v) under constant mechanical agitation on a rotary shaker at room temperature and protected from light for 48 h. The extract was filtered (12.5 mm qualitative filter paper), and the filtrate obtained was concentrated in a vacuum rotary evaporator at 65°C until the solvent was evaporated. The residues were dissolved in water to a final volume of 50 ml. These grape seed and peel extracts were stored in amber glass bottles and kept under refrigeration (4°C - 8°C).

B. Preparation of chicken samples: Boneless and skinless chicken thighs and drumsticks were ground (0.8 cm plate) separately in a grinder and divided into 5 treatments as follows: 1) IGE (concentration of 60 mg total phenolic compounds (TPC)/kg of meat); 2) NGE (concentration of 60 mg TPC/kg meat); 3) BHT (0.01% according to Decree No 1004 of the Secretariat of Health Surveillance, Brazil) dissolved in 5 ml of soybean oil without antioxidant; 4) SE (0.37%, which is the concentration usually employed in industry) dispersed in salt; and 5) control without addition of antioxidants. In all treatments, sodium chloride (1.5%) was added. Immediately after the addition of ingredients, the treatments were homogenised in a cutter. From the homogenised meat mixture, 25 g portions were shaped in the form of meatballs. Some of the samples were cooked in a hot plate until the internal temperature reached 72°C for 5 min. Raw and cooked samples were packaged separately and stored under freezing temperatures (-18°C) for 9 months. The procedure was performed in triplicate.

C. Analysis of samples:
Thiobarbituric acid reactive substances (TBARS): The TBARS values were determined in duplicate using an extraction method described by Vyncke (1970), Vyncke (1975) and Sorensen and Jorgensen (1996) with modifications
Colou evaluation: The instrumental colour was determined in triplicate with a colorimeter using the following parameters: L* (lightness), a* (redness) and b* (yellowness) (CIELAB). For sensory evaluation of colour, a trained panel of 12 panellists evaluated the product in 2 replications. Five samples per session were presented to the panellists that were coded with random numbers of 3 digits. For the analysis of colour alteration, whole samples were presented with only the surface layer removed of the product for better visualisation of the inner colour. The panellists evaluated the samples for colour alteration using a 10 point unstructured scale ranging from absent (0) to intense (10). All tests were carried out after processing and after 3, 6 and 9 months of frozen storage.

E. Statistical analysis: This experiment was designed as randomised complete blocks with a 5 x 4 complete factorial arrangement of treatment factors (control, BHT, IGE, NGE and SE) and storage times (0, 3, 6 and 9 months). The experiment was performed in triplicate. The experimental results were submitted for analysis of variance (ANOVA) considering the treatment model, storage time and interaction of treatment and storage time. The comparison of treatment means was performed using the Tukey test ($p < 0.05$).

III. RESULTS AND DISCUSSION

A. Thiobarbituric acid reactive substances (TBARS)

The treatments had a significant effect on the lipid oxidation of cooked samples ($p<0.05$), and no significant effect was observed for the storage period ($p>0.05$). The control treatment had significantly higher TBARS values ($p<0.05$) when compared to other treatments with antioxidants (Figure 1a). There was no significant difference ($p>0.05$) between treatments with synthetic antioxidants (BHT and SE) and treatments with natural extracts (IGE and NGE), demonstrating the efficiency of grape seed and peel extracts as antioxidants in chicken meat. According to Lu and Foo (1999), the grape seed extract obtained from wine and juice processing is rich in proanthocyanidins, which has multiple mechanisms for its antioxidant activity and the abilities to sequestrate radicals, chelate metals and synergise with other antioxidants.

The retardation of lipid oxidation in meat due to the use of grape residue extracts was verified in cooked and refrigerated turkey meat (Lau & King, 2003), cooked and refrigerated chicken meat (Rababah, Ereifej, Mahasneh & Rababah, 2006; Shirahigue et al., 2010), cooked and refrigerated beef (Ahn, Grun & Mustapha, 2007; Rojas & Brewer, 2007), cooked and frozen pork (Sasse, Colindres & Brewer, 2009) and cooked and refrigerated pork (Carpenter, O'Grady, O'Callaghan, O'Brien & Kerry, 2007; Rojas et al., 2007). These reports confirm the efficiency of the grape seed extract for use as a natural antioxidant in cooked meat.

A significant effect ($p<0.05$) of treatments and storage times was observed in raw samples. The BHT treatment was the only treatment that significantly differed ($p<0.05$) from the control with the lowest TBARS values. IGE and NGE treatments had no significant difference ($p>0.05$) when compared to the control or from the treatments with synthetic antioxidants (Figure 1b). These results indicate that IGE and NGE are comparable to commercial antioxidants and that their action is more effective in cooked samples, in which oxidation is induced by cooking.

For the storage period, the TBARS values increased over time with an average of 0.13 mg MDA/kg meat at the beginning of the experiment and an average of 0.74 mg MDA/kg meat at the end of the experiment (9 months). Similar results were reported by Brannan (2008) that observed an increase in the TBARS values of chicken meat during refrigerated storage. According to Grau, Guardiola, Boatella and Codony (2000), the development of oxidative rancidity occurs even during the storage of frozen chicken meat. While the rate of the deteriorative reactions (microbiological and

enzymatic) can be inhibited with the use of low temperatures, lipid oxidation still occurs normally, although at low rates.

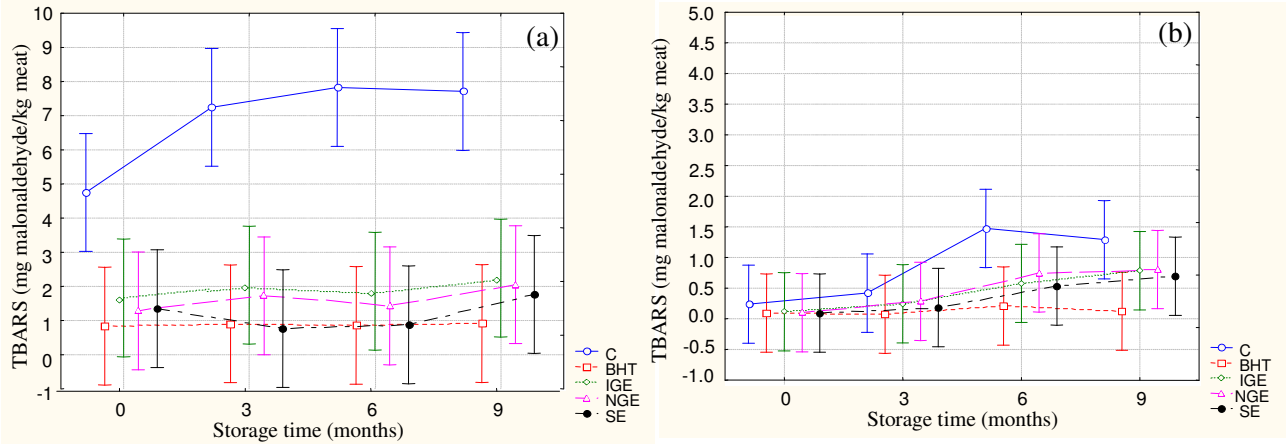

Figure 1. Effect of treatments on the TBARS values of cooked (a) and raw (b) chicken meat, stored at -18°C, during 9 months.

B. Colour evaluation

Intrumental colour

The results of colour analysis suggested that the treatments had a significant effect ($p<0.05$) and indicated that the addition of grape seed and peel extract in cooked chicken promoted changes in the 3 parameters evaluated (L*, a* and b*). The IGE treatment promoted the most significant change in the L* value, which caused darkening of the chicken meat, and the IGE treatment differed significantly ($p<0.05$) from the control and BHT treatments. The reduction in L* values may have been caused by addition of the extracts, especially IGE, which has dark colour. The darkening of samples with the addition of grape extract was also reported in precooked chicken meat (Brannan, 2009) and in cooked pork (Sasse et al., 2009).

The extracts of both grape varieties caused a significant reduction ($p<0.05$) in the redness of cooked chicken meat compared to other treatments. Treatment with SE had the greatest a* value and gave greater stability to the samples with regard to red discolouration. Significant changes in a* values were also observed in chicken meat, beef and pork (Brannan, 2009; Ahn et al., 2007; Carpenter et al., 2007); however, these authors reported an increase in a* values of samples with grape seed extract, which was different from what we observed. This variation in results may be due to different colourations of the grape extracts used, which may have interfered in the meat colour in different ways.

The b* value was also affected by the addition of the extracts, which significantly decreased ($p<0.05$) the yellowness of the cooked samples. Similar results were observed in cooked beef (Ahn et al., 2007) and in precooked chicken meat (Brannan, 2009).

No colour parameter was affected by the storage period of the cooked product ($p>0.05$), i.e., the samples were maintained without significant changes during the 9 months of frozen storage.

In raw samples, the results were satisfactory because no significant change was observed ($p>0.05$) in the L*, a* and b* colour parameters in all of the treatments. Rojas and Brewer (2008) observed that the instrumental colour of raw and frozen pork samples with natural antioxidants, including grape seed extract, was similar to the colour of the control samples. Furthermore, Sasse et al. (2009) reported that the addition of grape seed extract did not change the a* and b* values of raw pork.

During the storage period of samples, only the a* colour parameter was significantly affected ($p<0.05$), with a more evident reduction in this value from the BHT treatment. These results indicate that even though the BHT synthetic antioxidant is effective in lipid oxidation retardation, it is too unstable to maintain the red colour of raw chicken products stored under freezing temperatures.

Sensory evaluation of colour

It was observed that the treatment with natural antioxidants had significantly higher ($p<0.05$) colour alterations compared to control and synthetic antioxidant treatments. In regards to colour, the results of the sensory evaluation corroborate with the results of the instrumental evaluation, in which colour alterations were observed in cooked samples with grape seed and peel extract. This colour alteration of samples, as previously mentioned, may be due to the addition of the extracts, especially IGE, which has a dark colour. Significant colour alterations of samples with grape seed extract (meat darkening) were also observed by Brannan (2009) in precooked and refrigerated chicken meat and by Lau et al. (2003) in turkey meat.

IV. CONCLUSION

The addition of IGE and NGE in raw and cooked chicken meat promoted a satisfactory effect on lipid oxidation, with results comparable to the BHT and SE antioxidants. However, the natural extracts promoted alterations in the

colour of the cooked product, which was evidenced by the results of the sensory and instrumental measures. The use of residues from the wine industry as natural antioxidants, combined with the use of vacuum packaging and storage under freezing temperatures, may be considered an effective method to retard lipid oxidation in both raw and cooked processed chicken meat.

ACKNOWLEDGEMENT

The authors acknowledge the "Fundação de Amparo à Pesquisa do Estado de Sao Paulo" (FAPESP), Brazil, for financial support, Cryovac® - Brazil for the supply of packaging and IBRAC for the supply of additives.

REFERENCES

Ahn, J., Grun, I. U., & Mustapha, A. (2007). Effects of plant extracts on microbial growth, color change, and lipid oxidation in cooked beef. *Food Microbiology, 24*(4), 7-14.

Brannan, R.G. (2008). Effect of grape seed extract on physicochemical properties of ground, salted, chicken thigh meat during refrigerated storage at different relative humidity levels. *Journal of Food Science, 73*(1), C36-C40.

Brannan, R.G. (2009). Effect of grape seed extract on descriptive sensory analysis of ground chicken during refrigerated storage. *Meat Science, 81*(4), 589-595.

Carpenter, R., O´Grady, M. N., O´Callaghan, Y. C., O´Brien, M. N., & Kerry, J.P. (2007). Evaluation of the antioxidant potential of grape seed and bearberry extracts in raw and cooked pork. *Meat Science, 76*(4), 604-610.

Field, R. A. (1988). Mechanically separated meat, poultry and fish. In: A. M. Pearson, & T. R. Dutson, *Edible meat by-products* (pp. 83-128). London: Elsevier.

Grau, A., Guardiola, F., Boatella, J., & Codony, R. (2000). Measurement of 2-thiobarbituric acid values in dark chicken meat through derivative spectrophotometry: influence of various parameters. *Journal of Agriculture and Food Chemistry, 48*(4), 1155-1159.

Gray, J. L., Gomaa, E. A., & Buckley, D. J. (1996). Oxidative quality and shelf life of meats. *Meat Science, 43*, S111-S123.

Guendez, R., Kallithraka, S., Makris, D. P., & Kefalas, P. (2005). An analytical survey of the polyphenols of seeds of varieties of grape (*Vitis vinifera* sp.) cultivated in Greece: implications for exploitation as a source of value-added phytochemicals*, Phytochemical Analysis, 16*(1), 17–23.

Lau, D. W., & King, A. J. (2003). Pre- and post-mortem use of grape seed extract in dark poultry meat to inhibit development of thiobarbituric acid reactive substances. *Journal of Agriculture and Food Chemistry, 51*(6), 1602-1607.

Lu, Y. R., & Foo, L. Y. (1999). The polyphenol constituents of grape pomace. *Food Chemistry, 65*(1), 1-8.

Rababah, T.M., Ereifej, K.I., Mahasneh, A.A., & Rababah, A.A. (2006). Effect of plant extracts on physicochemical properties of chicken breast meat cooked using conventional electric oven or microwave. *Poultry Science, 85*(1), 148-154.

Rhee, K. S., Ziprin, Y. A., Ordonez, G., & Bohac, C. E. (1988). Fatty acid profiles of the total lipids and lipid oxidation in pork muscles as affected by canola oil in the animal diet and muscle location. *Meat Science, 23*(3), 201-210.

Rojas, M. C.; & Brewer, M.S. (2007). Effect of natural antioxidants on oxidative stability of cooked, refrigerated beef and pork. *Journal of Food Science, 72*(4), S282-S288.

Rojas, M. C., & Brewer, M. S. (2008). Effect of natural antioxidants on oxidative stability of frozen, vacuum-packaged beef and pork. *Journal of Food Quality, 31*(2), 173-188.

Sasse, A., Colindres, P., & Brewer, M. S. (2009). Effect of natural and synthetic antioxidants on the oxidative stability of cooked, frozen pork patties. *Journal of Foods Science, 74*(1), S30-S35.

Shirahigue, L. D., Plata-Oviedo, M., Alencar, S. M., Regitano-D'Arce, M.A.B., Vieira, T.M.F.S., Oldoni, T.L.C., Contreras-Castillo, C.J. (2010). Wine industry residue as antioxidant in cooked chicken meat. *International Journal of Food Science and Technology*, doi:10.1111/j.1365-2621.2010.02201.x.

Silva, F.A. M., Borges, M. F. M., & Ferreira, M. A. (1999). Métodos para avaliação do grau de oxidação lipídica e da capacidade antioxidante. *Química Nova, 22*(1), 94-103.

Sorensen, G., & Jorgensen, S.S. (1996). A critical examination of some experimental variables in the 2-thiobarbituric acid (TBA) test for lipid oxidation in meat products. *Zeitschrift fur Lebensmittel Untersuchung und-forschung, 202*(3), 205-210.

Vyncke, W. (1970). Direct determination of the thiobarbituric acid value in trichloracetic acid extracts of fish as a measure of oxidative rancidity. *Fette Seifen Anstrichnittel, 72*(12), 1084-1087.

Vyncke, W. (1975). Evaluation of direct thiobarbituric acid extraction method for determining oxidative rancidity in mackerel (*Scomber scombrus* L.). *Fette Seifen Anstrichmittel, 77*(6), 239-240.