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Technical Note

Antioxidant and Bacteriostatic Effects of the Addition of Extract of Quillay Polyphenols (*Quillaja saponaria*) in the Marinade of Broiler Chicken

■Author(s)

Fellenberg MA
Espinoza A
Peña I
Alarcón J

Departamento de Ciencias Animales
Facultad de Agronomía e Ingeniería Forestal
Pontificia Universidad Católica de Chile

■Mail Adress

MA Fellenberg
Departamento de Ciencias Animales
Facultad de Agronomía e Ingeniería Forestal
Pontificia Universidad Católica de Chile
Av. Vicuña Mackenna 4860
Macul
Santiago, Chile

E-Mail: mafellen@uc.cl

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ABSTRACT

The nutritional and sensorial characteristics of chicken meat can be affected by oxidative rancidity, process of oxidation of lipids in the meat that constitutes one of the main forms of food deterioration. This problem may be prevented or reduced by adding antioxidants to the meat during the process of marination. In the present study, the addition of a polyphenol-rich quillay extract (QLPerm®) at 5 levels (0, 0.05, 0.10, 0.15, and 0.20%) to the marinade of chicken meat was evaluated. The marinated meat was stored under refrigeration (6 °C) for 0, 2, 4, 6, and 8 days. Basal and induced lipid oxidation was evaluated by TBARS analysis. Microbiological quality was assessed by total coliforms and mesophillic aerobe counts. The application of this natural antioxidant reduced, in some cases, meat lipidic oxidation, improved its microbiological quality, and did not leave any perceivable residues as analyzed by a sensorial evaluation panel.

INTRODUCTION

During the last few decades, chicken meat has been massively consumed at global level (Magdelaine *et al*., 2008; Lee *et al*., 2008; Liu y Niu, 2008), partly due to its excellent nutritional and sensorial qualities. However, depending on the dietary fat source, lipids in meat may be more or less susceptible to oxidation (Grau *et al*., 2001). Oxidative rancitidy (OR) or lipid oxidation is not only one of the main causes of food spoilage, including chicken meat (Pearson *et al*., 1977; Sheehy *et al*., 1993; De Winne & Dirinck, 1996; Morrisey *et al*., 1997), but also reduced meat nutritional value due to the loss of important fatty acids, and may pose a health risk to humans resulting from the accumulation of oxidation products (Gray *et al*., 1996). Moreover, OR has deleterious effects on meat texture, flavor, and color (Gray *et al*., 1996), affecting its sensorial quality.

This problem may be reduced by including antioxidants (AOX) in broiler feeds (Fellenberg & Speiski, 2006). The dietary addition of vitamin E at levels higher than the nutritional requirements (200 ppm) results in higher meat oxidative stability (De Winnie & Dirink, 1996; Grau *et al*., 2001), but increases production costs. The dietary inclusion of AOXs of plant origin has also been evaluated (Lopez-Bote *et al*., 1998; Ruiz *et al*., 2001; Botsoglu *et al*., 2004, Fellenberg *et al*., 2008); however, in addition of increasing feeding costs, the effect on meat oxidative stability have been quite variable. The application of AOXs directly to the meat may prevent meat oxidation, as they would capture compounds that initiate lipid oxidation or stop the chain (Fellenberg & Speisky, 2006). Synthetic AOXs may used for that purpose, but their application and safety have been questioned (Ito *et al*., 1983; Ito *et al*., 1985; Kahl & Kappus, 1993; Iverson, 1995). Natural AOXs can also

be used, and their origin provides some guarantee of their safety.

Another cause of chicken meat spoilage is microbial contamination, which can derive from the carcass itself or acquired during processing. Chilling is a mandatory step in the line of broiler carcass processing as it is necessary to lower internal carcass temperature to 4°C within the first four hours of slaughter (Dickens & Ingrams, 2001). In this sense, Pietzsch & Levertzow (1974) reported that carcasses were washed in the beginning of chilling, but at the end of this stage, carcasses are contaminated with bacteria that remain in the water of the chiller.

Different researchers have studied natural products that could reduce bacterial contamination. For instance, Lis-Balchin *et al*. (1998), Hao *et al*. (1998) y Dickens & Ingram (2001) reported bacterial count reduction in chicken meat treated with different plant extract. It was determined that polyphenols, molecules frequently present in plants, have bactericidal or bacteriostatic effects (Cowan, 1999). Bose (1958) observed that anthemic acid, a phenolic acid extracted from chamomile, had bactericidal effects on *M. tuberculosis*, *S. typhimorium* y *S. aureus*, which was later confirmed by Scheel (1972) and Hamburger & Hostettmann (1991). Moreover, Vijaya *et al*. (1995) and Toda *et al*. (1992) found that catechins present in green tea reduced Shigella and Vibrio counts, respectively, and Hunter & Hull (1993) reported that phloretin, derived from a flavonoid extracted from a wild apple, reduced general bacterial counts.

Quillay (*Quillaja saponaria*) is a native tree of Chile that is being rationally exploited to obtain saponins, which are used as adjuvants in animal and human vaccines (Wu *et al*., 1992; Kensil, 1996). One of the byproducts of quillay extraction is a polyphenol mixture that after extraction and purification (QLPerm®) may have antioxidant and antimicrobial effects. Commercial marination is a process of broiler processing when a solution of water, salt, and other ingredients are added to the meat by immersion, tumbling or injection (Smith & Acton, 2001), which main objective is to improve meat sensorial characteristics (texture, flavor, tenderness). Therefore, the inclusion of quillay polyphenol extract (which is approved as human food additive by the CODEX ALIMENTARIUS[1]) to chicken meat marinade could improve its oxidative and microbiological quality. The present study aimed at evaluating the effect of the application of a quillay polyphenol extract in chicken meat marinade on meat oxidative rancidity, bacterial count, and sensorial quality.

1 - Quillay extract I y II, SIN numbers 999(i) and 999(ii).

MATERIALS AND METHODS

Quillay polyphenol extract

QLPerm®, manufactured by a Chilean company, was used. QLPerm® characteristics are shown in Table 1.

Table 1 - QLPerm® characteristics.

QLPerm® characteristics	
Polyphenols[1]	7.16%
Tannins[2]	1.84%
Polysaccharides[1, 2]	18.60%
CAOX	70% free-radical inhibition using 0.2 mole of polyphenol derived from QLPerm®/mole DPPH. 5.21g of the product to inhibit 75% of 1mMole DPPH

1 - Segarra *et al*., 1995. 2 - Molina, 2000.

Marination and refrigeration of meat samples

Broilers were slaughtered in a commercial processing plant. Marinade was prepared with the brine solution typically used in the processing plant (phosphates and polyphosphates 60%, salt 27%, carragenin 10%, and guar gum 3%), to which QLPerm® was added according to the quantities shown in Table 2. After the solutions were prepared, 60 carcasses per treatment, totaling 300 carcasses, were marinated by injection, with 10% marinade retention. Carcasses were cut up to obtain breasts and thighs, totaling 120 half breasts and 120 thighs per treatment (5 marinade solutions), which were placed in plastic ziploc® bags, and refrigerated at 6°C for 0, 2, 4, 6, or 8 days, with 24 half breasts and 24 deboned thighs per treatment and per refrigeration day. Out of the 24 half breast and 24 thigh samples, 4 were submitted to lipid oxidation analysis, 4 to microbiological analysis, and 16 to sensorial evaluation.

Table 2 - QLPerm® concentration in the marinade brine.

Brine	QLPerm® addition (g/100L solution)	Final concentration (%)	pH
1	50	0.05	8.28
2	100	0.10	8.25
3	150	0.15	8.23
4	200	0.20	8.21
Control	0	0.00	8.31

Laboratory analyses

Basal lipid oxidation and susceptibility to lipid oxidation

Basal lipid oxidation and susceptibility to lipid oxidation analyses were carried out according to

Fellenberg *et al*. (2008). Tissue simples weighing 1,000mg were homogenized with 10mL phosphate buffer at pH 7.4. Total homogenates were divided in two 5-mL flasks. To one flask, 50µL $FeCl_3$ at 5.05mM and 50µL buffer to the other. Flasks were incubated for 0 (basal lipid oxidation) and 20min (susceptibility to lipid peroxidation induced by temperature and Fe + temperature) in water bath (37°C) with slow agitation. A volume of 600µL total homogenate was added to a tube containing 100µL TCA at 60% and EDTA at 2mM, agitated, and centrifuged at 12,000xg for 5min at 24°C. Then, 500µL of the supernatant was mixed with 1,000µL thiobarbituric acid (TBA-Sigma) at 0.67% in HCl at 0.3M, incubated in water at 100°C for 10min, and the absorbance was read at 535nm. Results were expressed as absorbance at 535nm/g tissue.

Mesophilic aerobe count (MAC) and total coliform count (TC)

Ten g were taken from each sample, added to 90mL peptone water at 0.1% (Oxoid), and homogenized for 2min, and then were submitted to serial dilutions. The Petrifilm 3M technique (Blackburn *et al*., 1996) was used for mesophilic aerobe and total coliform counts. All samples were analyzed in duplicate.

Sensorial evaluation

Sensorial evaluation was carried out by the Tasting Panel of the Department of Agroindustry and Enology of the University of Chile. Quality parameters were evaluated by a descriptive method with 12 trained evaluators (Watts *et al*., 1992), utilizing a 0- to 15cm non-structured scale. Appearance, color, lightness, and aroma were evaluated in raw meat, and appearance, flavor and aroma in cooked meat (Pedrero & Pangborn, 1989; Watts *et al*., 1992). Acceptability was measured by the hedonic scale method (Watts *et al*., 1992) using a a 0- to 15cm non-structured scale and 24 evaluators. The sensorial evaluation was carried out in a properly equipped room, with individual boots, positive air pressure, and red light to mask color differences.

Statistical analysis

A completely randomized experimental design was applied, with five level for each factor, determining a 5*5 factorial arrangement (5 AOX inclusion levels * 5 refrigeration periods). Three replicates for each combination of levels were considered. Means were compared by the test of Tukey at each refrigeration level when interactions were significant. If no interaction was significant, the increasing AOX concentration level within the mean response to refrigeration level was evaluated.

RESULTS

Lipid oxidation

Breast meat. Basal lipid oxidation increased with refrigeration time and was lower in the meat marinated with QLPerm® (Table 3). There was no protective effect of QLPerm® against lipid oxidation induced by incubation at 37°C. When lipid oxidation was induced by incubation at 37°C plus Fe addition, the interaction between factors was significant. At refrigeration days 0 and 4, the meat marinated with the three lowest doses of QLPerm® showed lower lipid oxidation than the control meat, whereas at refrigeration day 2, the meat marinated with 0.1 and 0.15% QLPerm® presented lower lipid oxidation than the control meat.

On refrigeration day 8, there were no significant differences between the control treatment and the breast meat which marinade included quillay extract.

Thighs. There were no significant differences among treatments as to basal lipid oxidation. When lipid oxidation was induced by temperature, there was interaction between factors. In this case, TBARS were lower in the meat with QLPerm® at refrigeration day 6 (0.05% QLPerm®), refrigeration days 2 and 6 (0.1% QLPerm®), and refrigeration day 4 (0.15 and 0.2% QLPerm®). When lipid oxidation was induced by Fe and temperature, the meat marinated with the control brine presented lower TBARS concentrations than those marinated with QLPerm®.

Microbiology

MAC (Figure 1) was lower in at least one order of magnitude in the meat marinated with QLPerm® as compared to the meat marinated in traditional brine, and similar in all meats marinated up to four days of refrigeration, after which, the difference between meats marinated in the control brine or with QLPerm®.

TC (Figure 2) in thigh and breast meat was also lower in the meat marinated with QLPerm®.

Sensorial evaluation

The quality parameters appearance, color, lightness, and aroma were not different between raw meats marinated with QLPerm® or control marinade (Table 5). However, in cooked breast, aroma was considered better in the meat marinated with QLPerm® than that marinated in the control brine. Acceptability of

Table 3 - Lipid oxidation in chicken breast.

	DO/g tissue					
	Concentration (%)					
Refrig. (days)	**0**	**0.05**	**0.1**	**0.15**	**0.2**	**Mean**
A.- Basal lipid oxidation						
0	0.085	0.018	0.035	0.020	0.042	0.040
2	0.110	0.029	0.040	0.038	0.076	0.058
4	0.113	0.062	0.040	0.053	0.064	0.066
6	0.144	0.070	0.047	0.060	0.102	0.084
8	0.106	0.096	0.120	0.055	0.083	0.091
Mean	0.112A	0.055B	0.056B	0.045B	0.074B	
B,- Lipid oxidation induced by incubation at 37°C for 20min						
0	0.077	0.040	0.060	0.034	0.051	0.052
2	0.119	0.107	0.093	0.060	0.178	0.111
4	0.117	0.087	0.065	0.097	0.103	0.093
6	0.083	0.064	0.065	0.075	0.052	0.067
8	0.158	0.141	0.094	0.107	0.096	0.119
Mean	0.111 ^{A}	0.088 ^{A}	0.075 ^{A}	0.075 ^{A}	0.096 ^{A}	
C,- Lipid oxidation induced by incubation at 37°C for 20min and addition of $FeCl_3$						
0	2.427 ^{A}	0.205 ^{B}	0.320 ^{B}	0.323 ^{B}	0.348 ^{B}	0.725
2	1.669 ^{A}	1.395 ^{AB}	0.410 ^{B}	0.460 ^{B}	2.179 ^{A}	1.223
4	0.967 ^{A}	0.127 ^{B}	0.203 ^{B}	0.415 ^{B}	0.578 ^{AB}	0.458
6	0.129 ^{B}	0.101 ^{B}	0.133 ^{B}	0.103 ^{B}	1.024 ^{A}	0.298
8	0.354 ^{A}	0.189 ^{A}	0.071 ^{A}	0.165 ^{A}	0.140 ^{A}	0.184
Mean	1.109	0.403	0.227	0.293	0.854	

A,B,C - Differences among treatments (columns)($p<0.05$). Each result is the average of three samples.

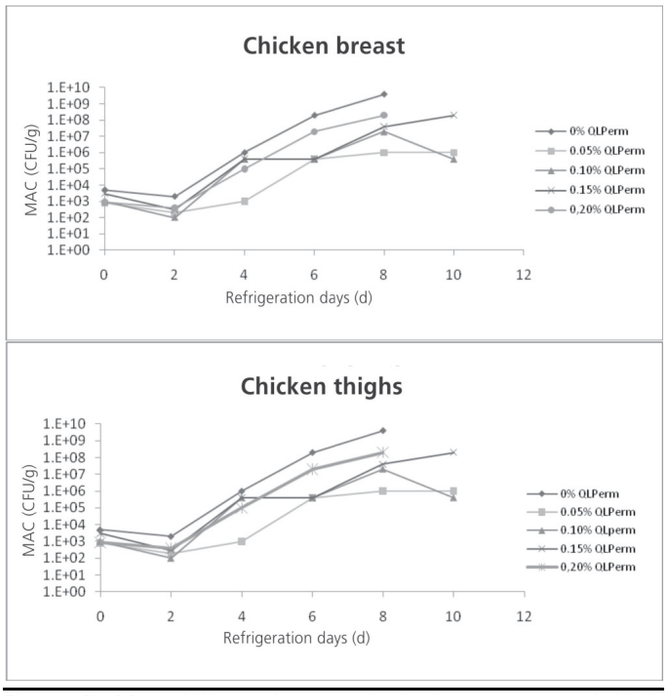

Figure 1 - Mesophilic aerobe count in the breast meat and thigh meat of chicken carcasses marinated with different QLPerm® concentrations.

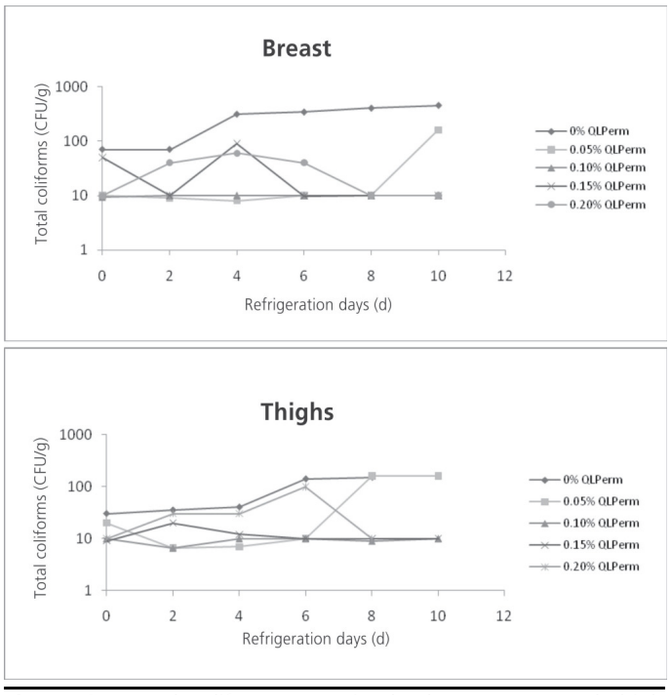

Figure 2 - Total coliform count in the breast meat and thigh meat of chicken carcasses marinated with different QLPerm® concentrations.

Table 4 - Lipid oxidation in chicken thighs.

	DO/g tissue					
	Concentration (%)					
A.- Basal lipid oxidation						
Refrig. (days)	**0**	**0.05**	**0.1**	**0.15**	**0.2**	**Mean**
0	0.056	0.021	0.039	0.037	0.053	0.041
2	0.147	0.068	0.053	0.077	0.112	0.091
4	0.092	0.135	0.087	0.089	0.083	0.097
6	0.187	0.082	0.319	0.166	0.258	0.202
8	0.220	0.208	0.336	0.136	0.280	0.236
Mean	0.140 ^{A}	0.103 ^{A}	0.167 ^{A}	0.101 ^{A}	0.157 ^{A}	
B.- Lipid oxidation induced by incubation at 37°C for 20min						
0	0.149 ^{A}	0.029 ^{A}	0.047 ^{A}	0.077 ^{A}	0.072 ^{A}	0.075
2	0.426 ^{A}	0.171 ^{AB}	0.095 ^{B}	0.226 ^{AB}	0.355 ^{AB}	0.255
4	0.450 ^{A}	0.168 ^{AB}	0.209 ^{AB}	0.102 B	0.091 ^{B}	0.204
6	0.849 ^{A}	0.105 ^{C}	0.485 ^{B}	0.245 ^{BC}	0.311 ^{BC}	0.399
8	0.316 ^{A}	0.316 ^{A}	0.222 ^{A}	0.195 ^{A}	0.385 ^{A}	0.287
Mean	0.438	0.158	0.212	0.169	0.243	
C.- Lipid oxidation induced by incubation at 37°C for 20min and addition of $FeCl_3$						
0	0.594	0.043	0.185	0.263	0.223	0.261
2	1.031	0.534	0.213	0.537	0.816	0.626
4	0.388	0.210	0.094	0.160	0.210	0.212
6	1.073	0.162	0.523	0.276	0.613	0.529
8	0.779	0.382	0.613	0.329	0.654	0.551
Mean	0.773 ^{A}	0.266 ^{B}	0.326 ^{B}	0.313 ^{B}	0.503 ^{B}	

A,B,C - Differences among treatments (columns)($p<0.05$). Each result is the average of three samples.

Table 5A - Sensorial evaluation: Quality.

	Control	QLPerm (%)			
Quality attribute		**0.05**	**0.1**	**0.15**	**0.2**
Raw breast meat					
Appearance	10.79 ^{A}	10.30 ^{A}	10.62 ^{A}	10.40 ^{A}	10.31 ^{A}
Color	7.63 ^{A}	7.87 ^{A}	8.07 ^{A}	7.60 ^{A}	7.85 ^{A}
Lightness	8.60 ^{AB}	8.14 ^{B}	8.81 ^{A}	8.56 ^{AB}	8.74 ^{A}
Aroma	7.04 ^{A}	6.75 ^{A}	6.83 ^{A}	7.19 ^{A}	6.98 ^{A}
Cooked breast meat					
Appearance	10.71 ^{A}	10.71 ^{A}	9.87 ^{A}	10.87 ^{A}	10.91 ^{A}
Flavor	7.72 ^{A}	7.76 ^{A}	7.66 ^{A}	7.95 ^{A}	7.71 ^{A}
Aroma	7.88 ^{A}	7.32 ^{B}	7.17 ^{B}	7.56 ^{AB}	6.97 ^{B}
Raw thigh meat					
Appearance	9.64 ^{A}	9.17 ^{A}	9.06 ^{A}	9.33 ^{A}	8.56 ^{B}
Color	7.80 ^{A}	7.81 ^{A}	7.70 ^{A}	7.97 ^{A}	7.88 ^{A}
Lightness	8.48 ^{A}	8.01 ^{A}	8.36 ^{A}	8.26 ^{A}	8.19 ^{A}
Aroma	6.04 ^{A}	6.05 ^{A}	6.37 ^{A}	6.60 ^{A}	6.71 ^{A}
Cooked thigh meat					
Appearance	9.16 ^{A}	9.22 ^{A}	9.72 ^{A}	9.39 ^{A}	9.64 ^{A}
Flavor	7.66 ^{A}	7.66 ^{A}	7.73 ^{A}	7.34 ^{A}	7.76 ^{A}
Aroma	7.14 ^{A}	7.08 ^{A}	6.89 ^{A}	7.07 ^{A}	7.22 ^{A}

A,B,C - Differences among treatments (columns)($p<0.05$). Each result is the average of three samples. Appearance: 0: bad; 15: excellent. Color: 0: pale; 7.5: typical of chicken meat; 15: dark. Lightness: 0: dull; 15: very shiny. Aroma: 0: no aroma; 7.5: typical of chicken meat; 15: intense. Flavor: 0: no flavor; 7.5: typical of chicken meat; 15: intense.

Table 5B - Sensorial evaluation: Acceptability.

	Control	QLPerm (%)			
		0.05	0.1	0.15	0.2
Cooked breast	8.89 A	9.22 A	9.02 A	8.66 A	8.89 A
Cooked thighs	8.25 A	8.48 A	8.56 A	8.56 A	8.17 A

A,B,C - Differences among treatments (columns)($p<0.05$). Each result is the average of three samples.

the thighs and breasts marinated with QLPerm® was also better than those marinated in the control brine, although not statistically significant.

DISCUSSION

The analysis of basal lipid oxidation shows the degree of oxidation of meat lipids until this process is reduced by sample freezing. Both basal lipid oxidation and lipid oxidation induced by temperature were significantly higher in the thighs as compared to the breast, and the magnitude of the difference was lower at some refrigeration times. The higher lipid oxidation in thighs is due to the fact that its lipid content is higher than in breasts, relatively providing more substrate that can be oxidized (Pikul *et al*., 1985; Salih *et al*., 1989; Liu & Niu, 2008). Moreover, thighs, as compared to breast meat, are rich in inorganic iron and heme proteins (Johns *et al*., 1989; Monahan *et al*., 1993), which catalyze lipid oxidation. On the other hand, when lipid oxidation was induced by Fe and temperature, statistical differences were observed relative to the control treatment at refrigeration days 2, 4, and 6, and in two concentrations on this day (0.1 and 0.2%). The other refrigeration times and quillay extract concentrations did not affect the lipid oxidation of meats induced by Fe and temperature. It is possible that, when Fe was added as an inducer of lipid oxidation, Fe levels became similar in the thigh and the breast. These results indicate the tissue Fe content may be more relevant than lipid content for the occurrence of lipid oxidation.

In the breast marinated with QLPerm®, basal lipid oxidation was significantly lower than that marinated with the control brine. No statistical differences were obtained in the thighs.

As to lipid oxidation induced by temperature, breast meat marinated with QLPerm® was not different from the control meat. Thigh meat presented mixed results, which did not allow us to conclude of the application of QLPerm® in the marinade effectively protected this meat against this type of induced lipid oxidation.

On the other hand, lipid oxidation induced by the addition of Fe and incubation at 37 °C is the most challenging for the antioxidant product, as the meat sample is submitted to highly pro-oxidative conditions. In the case of thigh meat, the addition of QLPerm® to the marinade protected this meat against induced lipid oxidation. In breast meat, protection occurred on refrigeration day 0 for all application levels, refrigeration day 2 (0.1 and 0.15% QLPerm® application), and refrigeration days 4 and 6 for the three lower doses. On refrigeration days 6 and 8, lipid oxidation of the control meat was reduced, reaching statistically similar levels as those of the meat marinated with quillay extract. Although this result was not expected, as oxidation usually increases with storage time, it is possible that, during storage, all substrate required for this evaluation was spent.

There is little information on the effect of the inclusion on natural AOX in the marinade of different meats. Nevertheless, these results partially agree with the findings of Mielnik *et al*. (2008), who evaluated the effect of the incorporation of rosemary, sage, and thyme in turkey thighs, and reported that these antioxidant plant extracts reduced meat TBARS content when added to the marinade as compared to the control meat. McKenna *et al*. (2003) showed that lamb marinated with cranberry and onion oleoresins, black pepper, and rosemary reduced meat lipid oxidation. On the other hand, it was reported that accumulation of heterocyclic amines in meat at the time of heat treatment is related to the presence of free radicals (Skog *et al*., 1998; Arvidsson *et al*., 1999; Skog *et al*., 2000). In this sense, Busquets *et al*. (2006) and Melo *et al*. (2008) mentioned that the incorporation of red wine and red wine and beer, respectively, reduce the accumulation of heterocyclic amines in fried chicken breast and fried beef. The attenuation or reduction of the effect of free radicals on meat systems by reducing lipid oxidation or the production of heterocyclic amines is essential for human health, as well as for preventing the sensorial deterioration caused by these processes. As previously mentioned, information on the effect of natural AOXs included in chicken meat marinades is lacking, warranting further research on their true protective effects.

It is known that polyphenols can act as antioxidants or pro-oxidants, depending on their concentration and interactions with the food matrix (Melo *et al*., 2008). Interestingly, in the three lipid oxidation analyses carried out in the present study, the highest QLPerm® inclusion level did not always present antioxidative characteristics, and in some situations, was shown to

be a pro-oxidant (induced lipid oxidation of breast meat at refrigeration days 2 and 6). Botsoglou *et al*. (2004) observed that the application of dehydrated tomato powder to broiler feeds had a clear antioxidant effect in low doses, but was pro-oxidative at the highest inclusion level. Therefore, further investigations are required to determine if inclusion levels higher than 0.20% could have this effect in chicken meat.

It is well known that polyphenols present in some plant extract may have some action against microbial growth (Cowan, 1999; Draughon, 2004). It was shown that flavonoids present in green tea negatively affect bacterial growth (Toda *et al*., 1992; Vijaya *et al*., 1995), that wine phenolic component reduce Listeria monocitogenes growth (Wen *et al*., 2003; Rodríguez-Vaquero *et al*., 2007), and that a polyphenol extract of Geranium sanguineum inhibited the *in vitro* and *in vivo* replication of the H7N1 influenza virus (Serkedjieva, 2003).

Under the experimental conditions of the present study, the application of QLPerm® at all levels (0.05-0.2%) to the marinade of broiler meat reduced in at least one order of magnitude MAC and TC count at some levels. This is consistent with the results of Dickens *et al*. (2000) and Dickens & Ingram (2001), who reported that a plant extract added to the chiller water in broiler processing significantly reduced the counts of mesophilic aerobes, total coliforms, *E. coli*, and *Campilobacter*.

Although polyphenols and their modes of action are still under investigation, some mechanisms of their biocidal or biostatic effects have been elucidated. It was reported that epicatechin (Toda *et al*., 1992) and cinnamic acid (Fernández *et al*., 1996) act by disrupting microbial cell membrane, some flavones inactive enzymes (Brinkworth *et al*., 1992), whereas some tannins bind proteins (Stern *et al*., 1996) or inhibit enzymes (Haslam, 1996). Michalczyk & Zawislak (2008) attempted to relate the antimicrobial activities of tea polyphenols to their antioxidant capacity, but concluded that there was no correlation of these activities in the evaluated green tea, black tea, and pu-erh. Further research is hended to effectively prove that quillay polyphenols indeed have this microbiological effect and to establish the mode of action.

One of the risks of adding additives to chicken meat marinades is that those may result in aromas or flavors that are not characteristic of chicken meat. Sensorial evaluation is considered an adequate method to perceive these differences. In the present study, the application of QLPerm® did not generate any unpleasant aromas or flavors, as perceived by the sensorial evaluation panel. In fact, appearance, color, aroma, and lightness were considered similar in QLPerm®-marinated meat and control meat. This is interesting, as it means that the extract does not leave any residues that may be rejected by future consumers. These results are different from those reported by Mielnik *et al*. (2008), who marinated turkey meat with rosemary, sage, and thyme extracts and reported that an aroma of spices was perceived.

Under the above-described experimental conditions, quillay polyphenol extract reduced basal lipid oxidation of the breast meat of broilers and lipid oxidation induced by Fe and incubation at 37 °C of thigh meat. Lipid oxidation induced by incubation was reduced in three application levels (0.05, 0.1, 0.15) until refrigeration day 4 in thigh meat. Although these results indicate that quillay extract provided the meat with some protection against oxidation, further studies are required to prove this effect. The microbiological analyses (MAC and TC) suggest that quillay extract has a bacteriostatic effect as meat samples marinated at all application doses presented reduction of 1 to 2 orders of magnitude for MAC and of 1 order of magnitude for TC. Quillay extract did not leave perceivable residues in the meat, as flavor and aroma were considered normal by the sensorial evaluation panel. In the present study, the antioxidative effect of quillay extract was not compared with other natural antioxidants, and therefore, further investigation is warranted to evaluate its real contribution as antioxidant and to compare with other natural antioxidants.

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