Lipid oxidation of raw and cooked turkey breast meat during refrigerated storage

Lipoxidation von rohem und gegartem Putenbrustfleisch während gekühlter Lagerung

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Introduction

Lipid oxidation is one of the major problems encountered in meat processing, cooking, and refrigerated storage. Chilled raw meat is usually oxidatively stable but mincing, cooking and other processes prior to refrigerated storage disrupt muscle cell membranes facilitating the interaction of unsaturated fatty acids with prooxidant substances such as non-heme iron, and thereby accelerating lipid oxidation that leads to rapid quality deterioration and development of rancidity (TICHIVANGANA and MORRISSEY, 1985). Poultry meat, in particular, is very sensitive to oxidative deterioration because of its very high content of polyunsaturated fatty acids (IGENE and PEARSON, 1979; MERCIER et al., 2001; CORTINAS et al., 2005).

Lipid peroxidation, the oxidative deterioration of the polyunsaturated lipids of food leads through formation of hydroperoxides to short-chain aldehydes, ketones, and other oxygenated compounds, which are considered to be responsible for the development of rancidity in stored foods (GRAY, 1978; MELTON, 1983; WONG, 1989). The oxidative reactions influence the colour, the flavour, the smell and decrease the nutritional quality and safety of the meat (PEARSON et al., 1983; GRAY et al., 1996; BOU et al., 2001).

Modern trends towards production of pre-cooked, refrigerated ready-to-eat products have made the control of lipid oxidation increasingly important (MIELCHE and BERTELSEN, 1994; CORTINAS et al., 2004, 2005). Moreover, supplementation of chicken and turkey diets with antioxidants increased resistance of refrigerated and cooked poultry meat to lipid peroxidation (SURAI and SPARKE, 2000; VARA-UBOL and BOWERS 2001; YU et al., 2002).

Malondialdehyde (MDA), a major degradation product of lipid hydroperoxides, has attracted much attention as a marker for assessing the extent of lipid peroxidation (BICHILE, 1994; DRAPER and HADLEY, 1990; RAHARZO et al., 1993). This compound is of particular concern since it has been shown to be mutagenic (BASU and MARNETT, 1984), carcinogenic (SHAMBERGER et al., 1974) and implicated in other pathological processes such as the formation of fluorescent pigments typical of cellular aging (TROMBLY and TAPPEL, 1975).

The purpose of present work was to study the effect of storage time on susceptibility of raw and cooked (boiled and roasted) turkey breast meat to lipid oxidation during refrigerated storage (4°C).

Material and methods

Chemicals

Butylated hydroxytoluene, 2-thiobarbituric acid and 1,1,3,3-tetraethoxypropane, the precursor of MDA, were obtained from Sigma while trichloroacetic acid and n-hexane were from Merck. All chemicals used were of analytical grade.

Sampling procedure

Nine day-old female broiler turkeys from a commercial strain (Nicholas White, Europoult LTD, UK) were fed for a period of 84 days, according to nutrient requirements of turkeys as given by NRC (1994). All birds were cared for according to applicable recommendations of U.S. National Research Council (NRC, 1996). At the end of the feeding period, all turkeys had feed removed for 18 h (water was allowed), and were slaughtered under commercial conditions. Carcasses from the nine birds were immediately trimmed for breast meat by removing skin, bones and connective tissue. Following trimming, right breast meat of each bird was individually sliced to three samples of 200 g for raw, boiled and roasted lipid oxidation studies, respectively; then each sample was sliced again into four sub-samples of 50 g, one for each measurement day of refrigerated storage.

Refrigerated-storage-induced lipid oxidation

To study the effect of storage time on lipid oxidation, all breast meat sub-samples of each raw sample were wrapped in transparent oxygen-permeable polyvinyl chloride film (6000-8000 cm² m⁻² 24 h⁻¹), and placed in a non illuminated refrigerated cabinet at 4°C for up to 5 days. The progress of lipid oxidation in the raw meat samples during storage was determined after 0, 1, 3 and 5 days, respectively. A similar experiment was carried out with boiled and roasted meat. For this purpose, the two others raw breast meat samples were separately boiled at 85°C and roasted in an oven at 220°C. After 30 min of boiling and when the temperature in the centre of roasted samples reached 75°C samples were cooled under tap water, placed in a non illuminated refrigerated cabinet at 4°C, and the
progress of lipid oxidation was determined after 0, 1, 3 and 5 days of storage.

**Determination of lipid oxidation**

Lipid oxidation was assessed on the basis of the MDA formed during refrigerated storage. MDA, the compound used as an index of lipid peroxidation, was determined by a rapid, sensitive and selective thioarbituric acid method based on the third-order derivative spectrophotometric method (Botsoglou et al., 1994). In brief, 2 g of samples were thoroughly homogenized with aqueous trichloroacetic acid (8 ml, 5%) and butylated hydroxytoluene in hexane (5 ml, 0.8%), and the mixture was centrifuged. A 2.5-ml aliquot from the bottom layer was mixed with 1.5 ml of 0.8% aqueous 2-thiobarbituric acid to be further incubated at 70°C for 30 min. Following incubation, the mixture was submitted to conventional spectrophotometry (Shimadzu, Model UV-1601, Tokyo, Japan) in the range of 400-650 nm. Third-order derivative spectra was produced by digital differentiation of the normal spectra using a derivative wavelength difference setting of 21 nm. The concentration of MDA (ng/g wet tissue) in analysed extracts was calculated on the basis of the height of the third-order derivative peak at 521.5 nm by referring to slope and intercept data of the computed least-squares fit of standard calibration curve prepared using 1,1,3,3-tetraethoxypropane.

**Statistical analysis**

All data were subjected, as repeated measurements, to analysis of variance (ANOVA) where the experimental unit was any individual turkey. The statistical significance of the differences between means from different treatments at individual time points was determined by Tukey’s test (Steel and Torrie, 1980).

**Results and discussion**

The susceptibility of raw and cooked (boiled and roasted) turkey breast meat to lipid oxidation during refrigerated storage at 4°C is illustrated in Figure 1. Refrigerated storage increased levels of MDA in raw, boiled and roasted breast samples (Table 1). The extent of lipid oxidation of raw turkey breast meat, as measured by MDA formation, was significantly different (P<0.05) among the zero time of refrigeration (155 ng/g) and the first (547 ng/g), third (613 ng/g) and fifth (1185 ng/g) day of storage (Table 1). MDA concentration was also higher (P<0.05) in the fifth day of storage than the first and third day. Furthermore, MDA values of boiled and roasted meat samples were significantly higher (P<0.05) at the third and fifth day of refrigerated storage than the respective zero time of refrigeration and the first day of storage.

No differences occurred in MDA concentration in raw, boiled and roasted breast samples within the first day of storage and in boiled and roasted breast samples within the third and fifth day of storage (Table 1). However, in the third and fifth day of storage boiled and roasted breast samples exhibited higher (P<0.05) MDA values than the raw turkey breast samples. The mean concentration of MDA in boiled and roasted meat was 4043 and 4679 ng/g, respectively, at the fifth day of refrigerated storage.

The increase of MDA values during refrigerated storage of turkey meat shows that oxidative deterioration started earlier in cooked than in raw breast meat.

![Figure 1. MDA concentrations (ng/g) in raw, boiled and roasted turkey breast meat](image)

Table 1. MDA differences in raw, boiled and roasted turkey breast meat (ng/g)

<table>
<thead>
<tr>
<th>Day</th>
<th>Raw meat (n=9)</th>
<th>Boiled meat (n=9)</th>
<th>Roasted meat (n=9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>155(^a) ± 67.3</td>
<td>155(^d) ± 67.3</td>
<td>155(^d) ± 67.3</td>
</tr>
<tr>
<td>1</td>
<td>547(^b) ± 96.4</td>
<td>452(^d) ± 115</td>
<td>333(^d) ± 123</td>
</tr>
<tr>
<td>3</td>
<td>613(^b) ± 95.4</td>
<td>439(^b) ± 256</td>
<td>510(^b) ± 434</td>
</tr>
<tr>
<td>5</td>
<td>1185(^c) ± 147</td>
<td>4043(^b) ± 335</td>
<td>4679(^b) ± 275</td>
</tr>
</tbody>
</table>

\(^1\) Values represent mean±SE.

\(^a\)\(^c\) Means within a column with no common superscripts are significantly different (P<0.05).

\(^d\)\(^e\) Means within a row with no common superscripts are significantly different (P<0.05).
from the first day and was increased until the fifth day of storage. The increased MDA values of cooked samples compared with the raw ones show that cooking induced lipid oxidation, which is attributed to disruption of muscle cell membranes that facilitate the interaction of unsaturated fatty acids with prooxidant substances (Botsoglou et al., 2003; Tichvangana and Morrissey, 1985).

Comparison of the MDA values found in this study with literature values for poultry meat shows that turkey meat is more sensitive to oxidative deterioration than chicken meat, although these two species present comparable fatty acid compositions (Kompresa et al., 2001ab; 2003). The difference has been attributed primarily to the weaker ability of turkeys to store dietary tocopherol in their tissues compared to chickens (Sklan et al., 1982; Wen et al., 1997). The antioxidant capacity of poultry meat depends largely on the concentration of the contained α-tocopherol, which in turn is dependent on the level of α-tocopheryl acetate added to the diet (Papageorgiou et al., 2003).

The results of this study show that refrigerated storage significantly (P<0.05) increased lipid oxidation in raw and cooked (boiled and roasted) turkey meat. Moreover, the cooking procedure of turkey meat increases lipid oxidation compared with raw meat during refrigerated storage.

Summary

The objective of the study was to find the relation between refrigerated storage up to five days of raw and cooked (boiled and roasted) turkey breast meat and the lipid oxidation process. Lipid oxidation was assessed by monitoring malondialdehyde (MDA) formation in raw and cooked meat after 0, 1, 3 and 5 days of refrigerated storage, through use of third-order derivative spectrophotometric method.

It was found that lipid oxidation of cooked turkey breast meat significantly (P<0.05) increased compared with the raw meat during refrigerated storage. After the third day of storage the maximum increase of MDA at 4398 ng/g and 5109 ng/g at boiled and roasted turkey breast meat, respectively, was observed. However, there was no significant difference between the boiled and roasted turkey breast meat under the same conditions of storage.

Key words

Turkey, breast meat, lipid oxidation, cooked, refrigerated storage

Zusammenfassung

Lipidoxidation von rohem und gegartem Putenbrustfleisch während gekühlter Lagerung

In der vorliegenden Untersuchung wurde der Zusammenhang zwischen der gekühlten Lagerung von rohem und gegartem (gekocht, gebraten) Putenbrustfleisch über bis zu 5 Tage und dem Verlauf der Lipidoxidation untersucht. Der Grad der Lipidoxidation wurde über die Bestimmung der Bildung von Malondialdehyd (MDA) im rohen und gegarten Fleisch nach einer Kühlungsdauer von 0, 1, 3 und 5 Tagen ermittelt. Hierzu wurde eine Spektrophotometrie mit Derivatisierung in dritter Ordnung verwendet.

Die Lipidoxidation des gegarten Putenbrustfleisches nahm im Vergleich zum rohen Fleisch während der kühlen Lagerung signifikant zu (P<0.05). Am dritten Tag der Lagerung wurde beim gekochten (4398 ng/g) und beim gebratenen (5109 ng/g) Brustfleisch der maximale MDA-Wert bestimmt. Allerdings trat zwischen dem gekochten und dem gebratenen Brustfleisch bei denselben Lagerungsbedingungen kein Unterschied auf.

Stichworte

Pute, Brustfleisch, Lipidoxidation, Garen, Kühlung, Lagerung

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