LIPID OXIDATION AND CHANGES IN FATTY ACIDS PROFILE RELATED TO BROILER BREAST MEAT COLOUR ABNORMALITIES

AL Soares[1], DF Marchi[1], M Matsushita[2], PD Guarnieri[3], AD Droval[1], EI Ida[1], M Shimokomaki[1,3*]

[1]Graduate Program in Food Science, Department of Food Science and Technology, Agricultural Sciences Centre, Londrina State University, P. O. Box, 6001, CEP 86051-970 Londrina, PR, Brazil; [2]Maringá State University, Maringá, PR, Brazil, and [3]Graduate Program in Food Science, Faculty of Pharmaceutical Sciences, São Paulo University, São Paulo, Brazil. Email: mshimo@uel.br

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Introduction

The considerable variation in breast fillet colour is a continuing problem for the broiler meat industries. In a recent survey carried out at a Brazilian commercial plant a figure of 20.0-25.0% of the flock presented broiler breast PSE (Pale, Soft, Exudative) meat and 0.30-6.0% as DFD-like (Dark, Firm and Dry) meat (Soares et al., 2003a). These results are the consequence of several factors including mostly pre-slaughtering management (Guarnieri et al., 2004) and animal nutrition (Olivo, et al., 2001). The main substrates involved in the oxidative decomposition are unsaturated fatty acids, components of phospholipids and triglycerides of cell membranes. Recently, we postulated that thermal stress enhancess higher mitochondrial phospholipase A2 (PLA2) activity in the presence of higher concentrations of Ca^{2+} and that this may be the triggering factor in initiating the characteristic symptoms leading to broiler PSE meat formation (Soares et al., 2003b). PLA2 is a lypolytic enzyme which acts upon membrane phospholipids liberating arachidonic acid (AA) (Murakami and Kudo, 2002).

Objectives

The aim of this work was to determine quantitatively the lipid oxidation and fatty acid profiles of broiler breast samples either with PSE or DFD-like and related them to the meat colour characteristics.

Materials and Methods

Chickens of Cobb lineage, 42 days old were used and they were sacrificed according to routine commercial plant procedures. Sample pH and colour values were determined after 24h storage at 4ºC as described in Olivo et al. (2001). Samples were classified based on the previous established parameters such as L*> 53.0 as PSE, L*< 44.0 as DFD-like and 44.0 ≤ L*≤ 53.0 as control (Soares, et al. 2002). Lipid oxidation and fatty acid profile analyses were carried out in samples after 30 days of storage at –18°C. Lipid oxidation was carried out according to Tarladgis et al. (1964). Fatty acid profile was determined using Shimadzu 14A (Japan) gas chromatograph equipped as described in Ruiz et al. (2005). Statistical analyses were performed using the STATISTICA software and Tukey test was applied for comparison of mean values among three groups: PSE, DFD-like and non-PSE breast meat (Statsoft, 1995).

Results and Discussion

In Table 1 are shown the results of pH values and colour measurements for characterization of PSE, control and DFD-like broiler breast meat. PSE meat samples presented the lowest pH values and DFD-like was higher than control meat samples (p£0.05). As expected, the Minolta L* values were the highest in the PSE group indicating paler meat in comparison sequentially to that of control and DFD-like samples. The a* values were significantly lower for PSE meat samples in relation to control and DFD meat while b* values did not show any significant differences. In relation to lipid oxidation, PSE meat samples were 27.0% more lipid oxidized than control samples and 41.0% more oxidized in relation to DFD-like meat (p£0.05).

Table 1 – pH, colour values and lipid oxidation for PSE, control and DFD-like broiler breast meat

Samples	pH	L*	a*	b*	TBARS (mg/kg of samples)
PSE	$5.87^{c} \pm 0.09$	$57.54^{a} \pm 4.20$	$1.94^{b} \pm 1.06$	$7.25^{a} \pm 2.18$	$0.44^{a} \pm 0.11$
Control	$5.95^{b} \pm 0.11$	$49.11^{b} \pm 1.96$	$3.85^{a} \pm 1.55$	$6.58^{a} \pm 1.89$	$0.32^{b} \pm 0.07$
DFD-like	$6.10^{a} \pm 0.12$	$43.74^{c} \pm 1.03$	$4.17^{a} \pm 0.67$	$5.92^{a} \pm 1.46$	$0.26^{b} \pm 0.04$

Means within columns with different superscript are significantly different (p£0.05)

Table 2 shows the total saturated fatty acid (SFA) and monounsaturated fatty acid (MUFA) were not significantly different among the three samples. However, the content of polyunsaturated fatty acid (PUFA) was

the highest in the PSE compared to control and DFD- like meat samples (p£0.05). Myristic acid (14:0) and arachidonic acid (20:4 n6) were highest in PSE meat that in control and DFD-like meat (not shown). The ratio of PUFA/SFA was highest in PSE compared to control and DFD-like meat of 0.736, 0.713 and 0.694, respectively.

Table 2– Fatty acid composition for PSE, control and DFD-like broiler breast meat samples

Fatty acid	PSE	Control	DFD-like
SFA*	$32.382^{a} \pm 2.551$	$31.443^{a} \pm 0.914$	$31.481^{a} \pm 0.455$
MUFA**	$42.075^{a} \pm 4.795$	$45.258^{a} \pm 0.917$	$45.939^{a} \pm 2.054$
PUFA***	$24.147^{a} \pm 0.773$	$22.793^{ab} \pm 0.563$	$21.768^{b} \pm 0.718$
PUFA/SFA	$0.736^{a} \pm 0.014$	$0.713^{ab} \pm 0.014$	$0.694^{b} \pm 0.010$

Means within columns with different superscript are significantly different (p£0.05)
*SFA – Saturated fatty acid = (C14:0 + C16:0 + C18:0 + C22:0), **MUFA – Monounsaturated fatty acid = (C17:1 + C18:1 + C20:1), ***PUFA – Polyunsaturated fatty acid = (C18:2 + C18:3 + C20:2 + C20:3 + C20:4 + C22:4)

Thermal stress promotes a higher intracellular PLA2 activity in the presence of higher concentration of Ca^{2+}. As originally proposed by Cheah et al. (1986) in pigs and by Soares et al. (2003b) in broiler, this enzymatic reaction might be the triggering factor to initiate the formation of PSE meat. As we previously reported, the enhanced intracellular Ca^{2+} concentration activates some enzymes, in particular, mitochondrial PLA2 and as consequence PSE samples present a higher percentage of AA than samples from control- and DFD-like meat samples. These results are consistent with those reported by Duthie et al. (1992) where a higher percentage of this fatty acid was found in malignant hyperthermia-susceptible pigs muscle homogenates compared to resistant pigs. This enzyme acts upon phospholipid membranes liberating arachidonic acid (Murakami and Kudo, 2002) and this condition may influence the sarcoplasmatic reticulum Ca^{2+} release (Cheah, et al., 1986).

Conclusions

Broiler breast meat colour abnormalities have their origin in several biochemical and physiological causes among which lipid oxidation seems to play a fundamental role. Our results emphasize the importance of phospholipase A2 activity under elevation of Ca^{2+} as a triggering factor initiating intracellular degenerative processes within poultry skeletal muscle.

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