Changes in protein fractions of chicken breast meat affected by white striping

S. MUDALAL, E. BABINI, C. CAVANI and M. PETRACCI*

Department of Agricultural and Food Sciences, Alma Mater Studiorum - University of Bologna, Piazza Goidanich 60, 47521 Cesena, Italy
*Corresponding author: m.petracci@unibo.it

White striping striations parallel to muscle fibres direction have been recently observed on the surface of chicken breast which could be ascribed to intensive growth genetic selection. The aim of this study was to evaluate the effect of white striping on protein fractions of chicken breast fillets. Twelve Pectoralis major muscles for both normal and white striping fillets were used to evaluate collagen content (colorimetric method) as well as quantity (Bradford method) and solubility of myofibrillar and sarcoplasmic protein fractions together with water holding capacity of the meat (cooking loss). Pattern of molecular weight protein profile by SDS-PAGE analysis was also assessed. White striped fillets exhibited higher collagen content (1.36 vs. 1.22%; P<0.01) and lower amount of myofibrillar (8.7 vs. 14.0%; P<0.05) and sarcoplasmic (2.6 vs. 3.2%; P<0.001) protein fractions in comparison to normal fillets. White striping defect also resulted in a dramatic decline of total, sarcoplasmic and myofibrillar protein solubility which resulted in a significant increase in cooking loss (33.7 vs. 27.4%; P<0.001). SDS-PAGE analysis evidenced a strong reduction of almost all sarcoplasmic and some major myofibrillar (actin, slow twitch light chain myosin and fast-twitch light chain myosin) proteins. In conclusion, this study revealed that white striping had great detrimental impact on protein profile of chicken breast meat.

Keywords: Chicken breast meat; white striping; Myofibrillar; proteins; SDS-PAGE; solubility

Introduction

Recent myopathy termed as white striping has been macroscopically characterized by appearance of white striations on the surface of chicken breast and histologically by myodenegaration. This myopathy can be attributed due to selection for growth rate and breast yield (Petracci and Cavani, 2012). Breast meat affected by white striping showed low water holding capacity (WHC) (higher drip and cooking losses, and lower marinade uptake) and soft texture (lower shear force) of meat (Petracci et al., 2013). Moreover, the occurrence of white striping under commercial conditions was relatively high in particular in high-breast yield hybrids (Petracci et al., 2013). Meat proteins greatly contribute to processing abilities by imparting specific functionalities. The quality traits of meat and meat products (appearance, texture, and mouth feel) are dependent on protein functionality (Xiong, 2004). It is well known that myofibrillar proteins (i.e. myosin and actin) are mainly responsible for the WHC and textural properties of meat products. Solubility of myofibrillar and sarcoplasmic proteins are highly correlated with WHC (Warner et al., 1997). The aim of this study was to evaluate
the changes in protein fractions of chicken breast meat affected by white striping, by focusing mainly on functional aspects of protein fractions (in particular, myofibrillar and sarcoplasmic proteins) that are related to processing abilities.

Materials and Methods

Twelve samples of normal and severe white striped (WS) boneless breast fillets were collected from same flock of 7-wk-old straight-run after the deboning area in a commercial processing plant. The cranial part was excised from each Pectoralis major muscle, minced, mixed, and kept in freezer at -20°C for further analysis. The meat mixes were used for determination of chemical composition (moisture, protein, lipid, ash, and collagen contents), total quantity of myofibrillar and sarcoplasmic proteins, solubility of sarcoplasmic, myofibrillar and total proteins and molecular protein profile by electrophoresis analysis. Proximate composition (moisture, protein, ash and lipid contents) of breast meat was estimated in three replications for each sample using official methods of AOAC (1990). Collagen content (hydroxyl proline as a measure) was determined using colorimetric method proposed by Kolar (1990). Total contents of myofibrillar and sarcoplasmic proteins were determined by extraction and separation of sarcoplasmic and myofibrillar proteins according to Fritz (1989). Concentration of extracted myofibrillar and sarcoplasmic proteins was measured by Bradford (1976). Protein solubility was estimated according to differences in extractability of proteins in different ionic strength solutions (Warner et al., 1997). Water holding capacity was estimated by cooking loss which was measured according to Van Laack et al. (2000). As for electrophoresis analysis, proteins extraction and separation on SDS-PAGE instrument was conducted as described by Fritz (1989). Myofibrillar protein extract was loaded on 12% Mini-PROTEAN® TGX Stain-Free™ Gel (Bio-Rad, Italy) and sarcoplasmic extract was loaded on Mini-PROTEAN® TGX any kDa Stain-Free™ (Bio-Rad, Italy). The separated protein bands were identified by comparing their mobilities against those of molecular weight markers (Precision plus Standard protein, all blue prestained, Bio-Rad, Italy) made of several purified proteins with 10 different molecular weights (10, 15, 20, 25, 37, 50, 75, 100, 150 and 250 kDa). Point to point (semi-log) regression method was used to calculate the molecular weights.

Statistical analysis was determined by analysis of variance (ANOVA) using the General Linear Model (GLM) to find the differences in quality traits between normal and WS fillets.

Results and Discussion

The results for proximate composition and cooking loss of normal and WS fillets are reported in Table 1. White striped fillets showed significantly lower content of protein (18.7 vs. 22.8%; P<0.001) and ash, as well as higher percentage of moisture (75.4 vs. 73.8%; P<0.001), fat (2.15 vs. 0.98%; P<0.01) and collagen (1.36 vs. 1.22%, P<0.01). Moreover, meat affected by white striping exhibited lower content of sarcoplasmic and myofibrillar content than normal meat. These dramatic differences in proximate composition can be likely due to muscular degeneration previously observed in white striped breast muscles (Kuttappan et al., 2013) that can explain the reduction in protein content. In addition, increase of fat accumulation due to lipidosis can explain the higher intramuscular fat content, while higher content of collagen can be explained by fibrosis (Kuttappan et al., 2013). Reduction of both myofibrillar and sarcoplasmic proteins can be explained due to degeneration of muscle in muscular dystrophy which is usually characterized by an extensive loss of sarcoplasmic and
contractile protein with replacement of fat and connective tissue (Stacher et al., 1979). Moreover, increased myofibrillar catabolism can be contribute to this reduction (Hillgartner et al., 1981), while sarcoplasmic protein decline may be a consequence of leakage due to sarcolemma damage and alteration of muscular enzymes (Patnode et al., 1976). In another hand, cooking loss is normally used to measure loss of liquids as a result of protein denaturation and decomposition of cell membranes during cooking. In the current study, WS fillets exhibited higher values of cooking loss (33.7 vs. 27.4%, P<0.001) in comparison to normal fillets.

Table 1 Composition and cooking loss (means ± SEM) of normal and WS chicken breast meat (n=6/group; * = P<0.05; ** = P<0.01; ***= P<0.001).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal</th>
<th>WS</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>73.8±0.24</td>
<td>75.4±0.31</td>
<td>**</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>22.8±0.63</td>
<td>18.7±0.25</td>
<td>***</td>
</tr>
<tr>
<td>Intramuscular fat (%)</td>
<td>0.98±0.23</td>
<td>2.15±0.40</td>
<td>***</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>1.34±0.04</td>
<td>1.14±0.02</td>
<td>***</td>
</tr>
<tr>
<td>Collagen (%)</td>
<td>1.22±0.03</td>
<td>1.36±0.04</td>
<td>**</td>
</tr>
<tr>
<td>Myofibrillar proteins (%)</td>
<td>14.0±1.56</td>
<td>8.68±1.61</td>
<td>*</td>
</tr>
<tr>
<td>Sarcoplasmic proteins (%)</td>
<td>3.20±0.07</td>
<td>2.61±0.12</td>
<td>***</td>
</tr>
<tr>
<td>Cooking loss (%)</td>
<td>27.4±2.14</td>
<td>33.7±0.82</td>
<td>*</td>
</tr>
</tbody>
</table>

The results of protein solubility were in agreement with Warner et al. (1997) who found very wide changes in sarcoplasmic (50-70 mg/g), myofibrillar (55-130 mg/g) and total protein (100-200 mg/g) solubility for meats having different quality defects (like PSE and DFD abnormalities). Several studies showed that myofibrillar and sarcoplasmic protein solubility was highly correlated with some technological properties like WHC (drip loss, moisture uptake, cooking loss) (Warner et al., 1997). The reduction in protein solubility (Figure 1) and cooking loss (Table 1) for WS fillets can be explained by reduction of total protein content and in particular of myofibrillar and sarcoplasmic fractions and to a lesser extent by collagen increase, and not to actual differences in protein solubility.

Figure 1. Sarcoplasmic, myofibrillar, and total protein solubility of normal and WS chicken breast meat (n=6/group; ** = P<0.01; *** = P<0.001).
SDS-PAGE revealed that the absolute concentrations of myofilament proteins such as actin, LC1 slow-twitch light chain myosin and LC3 fast-twitch light chain myosin, which are components of contractile fibres, were decreased (data not shown). Furthermore, the decrease of concentration of specific myofibrillar proteins (actin, LC1 and LC2) may indicate that the degeneration process could be selective in some sites of myofilament. However, it was found a reduction of both absolute and relative concentrations of LC1 slow-twitch and LC3 fast-twitch light chain myosins. Previously, Stracher et al. (1979) reported that myosin from dystrophic chickens contained less LC3 myosin than normal birds and suggested that dystrophic myosin might be embryonic in nature and more susceptible to proteolysis. Most of identified sarcoplasmic proteins exhibited lower absolute concentrations. Previous microscopic examinations on muscle fibers showed that a part of myofibrils had poor functionality of sarcolemma and there was a loss of sarcoplasmic fluids, which contain sarcoplasmic proteins (Stracher et al., 1979).

In conclusion, overall findings revealed that white striping had great detrimental impact on protein profile, proteins functionality and water binding capacity. In addition, white striped meat had different proximate composition characterized by lower protein and higher fat contents.

References


