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ARTICLE

Incidence of White Striping and Its Effect on the Quality Traits of Raw and Processed Turkey Breast Meat

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Abstract The aim of this study is to evaluate the incidence of white striping abnormality and its consequences on the quality traits of raw and processed turkey breast (chemical composition, color traits, and water holding capacity). In total, about 2300 breasts from 22 flocks were used to assess the incidence and 60 breasts to evaluate the quality traits. Our study showed that the total incidence of moderate and severe white striping was 61.3% out of them, moderate cases were 49.4%. Severe white striped turkey breast exhibited significantly lower protein content (21.1 vs. 23.2 and 23.16%, $p<0.05$) and higher fat content (2.3 vs. 0.77 and 1.76%, $p<0.05$) if compared to normal and moderate white striped breast respectively. Moreover, moderate and severe white striped meat showed significantly higher redness (a*) (2.98 and 3.14 vs. 1.48, $p<0.05$) and yellowness (b*) indexes (7.27 and 7.95 vs. 4.05, $p<0.05$) than normal meat, respectively.

Keywords white striping, turkey, breast, quality, incidence

Introduction

Huge efforts in genetic selections have been exerted in the last decades to optimize the growth of poultry broilers. In addition, genetic selection has led to improvements in fat reduction, breast size, and feed conversion (Barbut et al., 2008). Accordingly, some current hybrid birds exhibited breast yield more than 20% if compared with pure breeds (Havenstein et al., 2003). Chicken and turkey breast meat have functional characteristics such as their contents of bioactive peptides, long-chain n-3 polyunsaturated fatty acids (PUFA), conjugated linoleic acid (CLA), vitamins and antioxidants (Gibbs et al., 2010; Ryan et al., 2011). Moreover, it is well known that breast meat has low fat content. On the contrary, recent studies showed that the nutritional profile of chicken meat was not similar as in the past. In this context, currently produced chicken meat is characterized with high fat content if compared with that produced some years ago (Crawford et al., 2010; Wang et al., 2009).

Several studies showed that the incidence of muscle abnormalities increased as a consequence of intensive genetic selections to optimize the growth of broilers (Dransfield and Sosnicki, 1999; Mahon, 1999). In this context, the most familiar muscle abnormalities in poultry sector are: deep pectoral muscle disease (Bianchi et al., 2006) and PSE-like meat (pale, soft, and exudative-like condition). Recent muscle abnormalities have also been observed such as white striping (Bauermeister et al., 2009; Kuttappan et al., 2009) and wooden breast (Sihvo et al., 2014). *Pectoralis major* muscle containing white striations in parallel to muscle fibers was defined as white striping abnormality (Kuttappan et al., 2009).

The effect of several farming factors on incidence of white striping have been evaluated by previous studies. Petracci et al. (2013) studied the effect of genotypes (high and standard breast yield hybrids) on the incidence of white striping and it was found that high breast hybrids exhibited higher incidence of white striping than standard breast yield hybrids. Kuttappan et al. (2013b) found that male birds exhibited higher incidence of white striping than female birds. The same authors also found that high energy diet increased the incidence more than low energy diet. Kuttappan et al. (2012b) found that the incidence of white striping reached to 50% while the estimation of white striping incidence was 12% by Petracci et al. (2013). Even the etiological origin of white striping is still unknown, but several authors showed that white striping abnormality was companied by different histological lesions such as disappearance of cross striations, differences in fiber size, fibers degeneration/regeneration, fibrosis and lipidosis, and signs of inflammation (Kuttappan et al., 2013a; Shivo et al., 2014).

Most of previous studies were focused to evaluate the incidence of white striping and its consequences on the quality traits of chicken breast meat from different genotypes reared under different farming factors. The available knowledge about the effect of white striping on turkey breast meat is very limited. Therefore, the aim of this study is to evaluate the incidence of white striping in turkey breast as well as it is effect on the quality traits of raw and processed meat products.

Materials and Methods

Evaluation of the prevalence of white striping

The prevalence of white striping was carried out in Palestinian slaughterhouse near Tulkarm city (Palestine) during the period of May to September 2018. About 2,300 turkey breasts (from 20-week old tom turkey birds) were randomly collected from 22 flocks. The incidence of white striping was evaluated on the processing line after deboning by 16–18 h. From each flocks about 100 breast muscles were selected to evaluate the incidence of white striping. The classification of white striping was based on the presence and thickness of white striations on the cranial area of breast where breast scored as severe case when the white striations thickness is more than 1 mm and moderate case when the thickness of white striations is less than 1 mm. Normal breast was scored when there is no any whole white striations on the cranial area (Kuttappan et al., 2012c).

Samples selection for quality analysis

To evaluate the effect of white striping on the quality traits of raw and processed turkey breast, 60 the *pectoralis major* muscles of 20-week old tom turkey birds were randomly selected based on the appearance of white striations from local Palestinian slaughterhouse near Tulkarm city (Palestine). The same previously mentioned approach to classify the degree of white striping was followed. The samples were classified into three groups (n=12/group): normal, moderate, and severe. The experiment was carried out in two replicates.

Analysis of quality traits of raw breast meat

Color traits (CIE L*= lightness, a*= redness and b*= yellowness) were assessed in triplicate by the using a Chroma Meter

CR-410 (Konica Minolta, Japan) considering the skin-side surface of each fillet from cranial area. For each raw fillet, proximate composition (moisture, protein, ash and lipid contents) has been determined according to the official methods of AOAC (1990). For pH, it was measured by using method described by Jeacocke (1977). To determine the thawing loss, a parallel rectangles meat sample (60 × 40 × 20 mm) were removed from the cranial area and stored at –18°C for two months then the samples were defrosted on plastic strain overnight in refrigerator at 4°C. The difference in weights before and after defrosting has been recorded to determine thawing loss.

Analysis of quality traits of marinated breast meat

From each breast, a cut (10 × 5 × 3 cm) has been excised from the cranial area to evaluate purge loss, marinade uptake, yield and cooking loss. All meat samples from three groups were marinated and tumbled by using a small- scale vacuum tumbler (MGH-20, Vakona Qualitat, Lienen, Germany) for 25 min (speed 20 rpm, 500 rounds) at pressure of 0.95 bars.

The marinade solution containing 7.5% of sodium chloride and 2% sodium tripolyphosphate (STPP) were used to achieve 1.5% and 0.4% for sodium chloride and sodium tripolyphosphate (STPP) in finished product after marination, respectively. The weight of meat samples was measured after marination to determine marinade uptake, the samples were stored in refrigerator at 2°C to 4°C for 48 h, and then the samples were weighted to calculate purge loss. After 48 h, samples were vacuum-packed and cooked in water bath at 80°C for 24 min until the core temperature arrived 80°C. After the samples has been cooled to room temperature, they were removed from bags and reweighed to measure cook loss, as well as total yield based on weight before marination.

Statistical analysis

The effect of different levels of white striping (normal, moderate, and severe) on the quality traits of turkey breast was evaluated by ANOVA. General linear model (GLM) model was used to test the main effects of WS levels (normal, moderate, or severe) and replication, as well as the interaction term using the (SAS, 1988) on meat quality traits. Means were separated using Duncan test with $p<0.05$ considered as significant.

Results and Discussion

The incidence of white striping is shown in Fig. 1. It was found that total incidence was 61.3% including moderate and severe white striping. In particular, the incidence of moderate white striping was 49.4% while the incidence of severe cases was 11.9%. In this context, there are no available studies about the incidence of white striping abnormality in turkey breast but there were several studies evaluated the incidence of white striping in chicken breasts. In this context, Lorenzi et al. (2014) found that the total incidence of white striping was 43% in chicken breast meat from different breeds chicken. Kuttappan et al. (2012b) found that the total incidence of white striping in chicken breast was 50.7% (out of them 36.7 moderate and 14% severe cases). In 2013, the same authors observed that the total incidence of WS was 55.8%. Moreover, Russo et al. (2015) found that medium and heavy-weight broilers exhibited overall prevalence of WS 70.2% and 82.51% respectively. In general, the occurrence rates of white striping in chicken breast were associated by different factors such as age, sex, body weight, growth rate, and genotype (Kuttappan et al., 2012a; Kuttappan et al., 2012b). Further studies are needed to evaluate the effect of previous factors on the incidence of white striping in turkey breast.

The results of quality parameters (thawing loss, pH, a*, b*, L*, and calories content) and proximate chemical composition

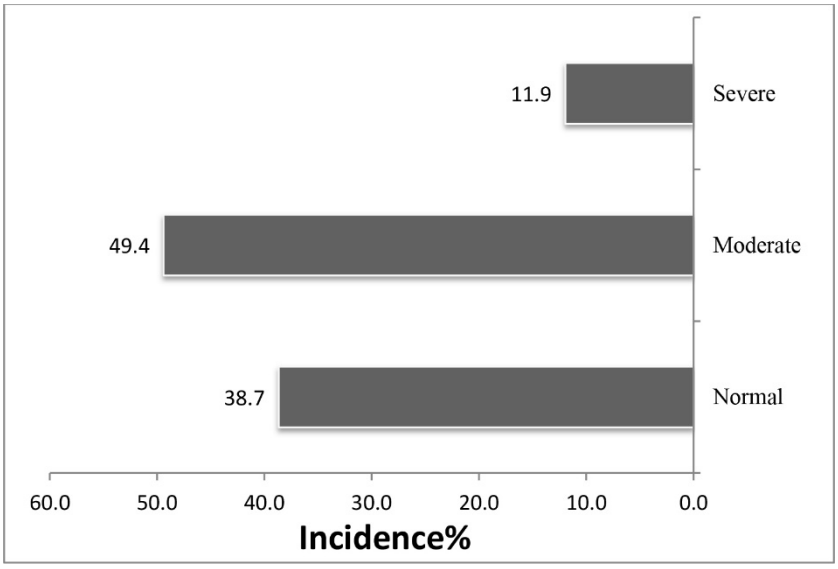

Fig. 1. The incidence of white striping in turkey breast meat classified as normal, moderate, and severe where the levels of white striping was classified according to Kuttappan et al. (2012c).

(moisture content, protein content, fat content, and ash content) of raw turkey breast meat are shown in Table 1. Our finding showed that the presence of white striping defects changed some chemical properties of breast meat. In this context, severe white striped turkey breast exhibited significantly lower protein contents (21.08 vs. 23.17 and 23.16%, $p<0.05$) and higher fat contents (2.25 vs. 0.77 and 1.47%, $p<0.05$) if compared to normal and moderate white striped breast respectively. The low content of proteins can be attributed to degeneration of muscle fibers which have been observed in histological evaluation from previous studies (Shivo et al., 2014). Moreover, several researchers observed that myodegeneration was companied by fibrosis and adiposis which may explain the high fat content (Kuttappan et al., 2009; Shivo et al., 2014). On another hand,

Table 1. Physical (thawing loss, pH, L*, a*, b*, and calories content) and chemical (moisture content, protein content, fat content, and ash content) characteristics of raw turkey breast meat

Quality parameters	Level of white striping[1)]			p
	Normal	Moderate	Severe	
Color indexes				
L^*_r	66.60±2.50	64.11±4.30	64.39±3.97	0.67
a^*_r	1.48±1.15	2.98±1.62	3.14±1.46	<0.05
b^*_r	4.08±1.70^b	7.27±2.89^a	7.95±1.86^a	<0.05
pH	6.10±0.09^b	6.16±0.06^a	6.20±0.06^a	<0.05
Moisture (%)	75.48±1.15	76.07±1.55	75.52±1.19	0.53
Protein (%)	23.17±2.01^a	23.16±1.46^a	21.08±1.67^b	<0.05
Fat (%)	0.77±0.51^b	1.47±1.67^{ab}	2.25±1.14^a	<0.05
Ash (%)	2.25±1.31	1.73±0.42	1.57±0.25	0.18
Calories	130.00±10.38	122.61±10.01	128.61±6.47	0.30
Freeze loss	2.27±0.47	1.88±0.33	2.05±0.54	0.18

[1)] The levels of white striping were classified into normal, moderate and severe according to Kuttappan et al. (2012c).
[a,b] Means within a row followed by different superscript letters differ significantly ($p<0.05$).

there were no significant differences in moisture, ash, and calories contents between groups. Moderate and severe white striped meat had pH significantly higher (6.16 and 6.20 vs. 6.10, $p<0.5$) than normal meat, respectively. Tijare et al. (2016) and Mudalal et al. (2014) found similar results where white striped meat had higher pH than normal meat. It was found that white striping defect had significant impact on color traits. Moderate and severe white striped meat showed significantly higher redness (a*) (2.98 and 3.14 vs. 1.48, $p<0.05$) and yellowness (b*) indexes (7.27 and 7.95 vs. 4.08, $p<0.05$) than normal meat, respectively. Similar findings have been observed in chicken breast meat from several researchers (Mudalal et al., 2014; Sihvo et al., 2014). The high values of redness (a*) and yellowness (b*) were seen in chicken breast meat in previous studies and were explained due to high pH values and high fat content, respectively (Petracci et al., 2014; Sihvo et al., 2014; Tijare et al., 2016). There were no significant differences in lightness (L*) between groups but all values of lightness were in range of Pale Soft Exudate breast meat (L*>53). For freezing loss, there were no significant differences between groups.

Quality parameters of marinated (marinade up take, drip loss and, L*, a*, b*) and cooked (cooking loss, yield, and color indexes) turkey breast meat are shown in Table 2. After marination, there were no significant differences in color indexes. Similarly, cooked breast meat did not show any significant differences in L* and b* values. Moderate and severe white striped cooked breast had higher b*-values (13.75 and 13.04 vs. 11.92, $p<0.05$) than normal meat. This result can be attributed due to high fat content. The presence of white striping had no effect on marinade uptake, drip loss, cooking loss, and yield. These results were partially in agreement with previous studies (Bauermeister et al., 2009; Kuttappan et al., 2009).

The effect of processing (raw, marination, and cooking) on the color traits (L*, a*, and b*) of normal, moderate, and severe white striping turkey breast meat was shown in Table 3. In general, marination and cooking did no exhibit any significant effect on redness index (a*) for normal, moderate, and severe white striping meat. Lightness (L*) significantly decreased after marination (66.60 vs. 58.56, $p<0.05$; Normal, 64.11 vs. 59.28, $p<0.05$; moderate, and 64.39 vs. 61.16, $p<0.05$; severe) and increased after cooking (66.60 vs. 88.28, $p<0.05$; Normal, 88.53 vs. 64.11, $p<0.05$; moderate, and 88.61 vs. 61.16,

Table 2. Quality parameters of marinated (marinade up take, drip loss, L*, a*, and b*) and cooked (cooking loss, yield, and color indexes) turkey breast meat

Quality parameters	Level of white striping[1)]			p
	Normal	Moderate	Severe	
Color indexes				
L^*_m	58.55±2.62	59.28±2.51	61.16±3.45	0.10
a^*_m	2.10±0.93	2.84±1.50	3.30±1.65	0.25
b^*_m	2.95±2.01	3.98±2.45	5.10±1.75	0.07
Color indexes				
L^*_c	89.27±2.83	88.53±3.39	88.60±3.25	0.82
a^*_c	2.69±0.85	2.88±1.22	2.91±1.41	0.88
b^*_c	11.92±0.94[b]	13.75±0.82[a]	13.04±1.65[a]	<0.05
Marinade uptake	15.93±3.63	15.56±3.41	13.74±2.39	0.56
Drip loss (%)	7.51±1.38	6.35±2.84	6.78±1.26	0.76
Cooking loss (%)	18.65±1.78	17.96±1.51	18.35±2.51	0.56
Yield (%)	94.36±3.00	95.10±2.36	92.96±3.81	0.26

[1)] The levels of white striping were classified into normal, moderate and severe according to Kuttappan et al. (2012c).
[a,b] Means within a row followed by different superscript letters differ significantly ($p<0.05$).

Table 3. Color traits (L*, a*, and b*) of raw, marinated, and cooked turkey breast affected by different levels of white striping

Quality parameters	Level of white striping[1)]			p
	Raw	Marinated	Cooked	
Normal				
Color indexes				
L*	66.60±2.50[b]	58.55±2.62[c]	89.27±2.83[a]	<0.05
a*	1.48±1.15	2.10±0.93	2.69±0.85	0.53
b*	4.08±1.70[b]	2.95±2.01[c]	11.92±0.94[a]	<0.05
Moderate				
Color indexes				
L*	64.11±4.30[b]	59.28±2.51[c]	88.53±3.39[a]	<0.05
a*	2.98±1.62	2.84±1.50	2.88±1.22	0.89
b*	7.27±2.89[b]	3.98±2.45[c]	13.75±0.82[a]	<0.05
Severe				
Color indexes				
L*	64.39±3.97[b]	61.16±3.45[c]	88.60±3.25[a]	<0.05
a*	3.14±1.46	3.30±1.65	2.91±1.41	0.89
b*	7.95±1.86[b]	5.10±1.75[c]	13.04±1.65[a]	<0.05

[1)] The levels of white striping were classified into normal, moderate and severe according to Kuttappan et al. (2012c).
[a–c] Means within a row followed by different superscript letters differ significantly ($p<0.05$).

$p<0.05$; severe) for all groups respectively. For all groups, breast meat exhibited significantly lower values of yellowness (b*) after marination (4.08 vs. 2.95, normal; 7.27 vs. 3.98, moderate; 7.95 vs. 5.10, severe) if compared with raw meat.

After cooking, yellowness index (b*) increased significantly (11.92 vs. 4.08, normal; 13.75 vs. 7.27, moderate; 13.04 vs. 7.95, severe) in all groups. Generally, there were no agreement on the effect of marination and cooking on color indexes between previous studies. Young et al. (2005) did not find differences in color indexes after marination except for b* values in marinated fillets were lower when compared to non-marinated fillets. It was found that marinated poultry muscles exhibited lower red (a*) and yellow (b*) values when compared to non-marinated meat (Lyon et al., 1998). In another study, there was slight significant decrease after marination in L* and a* values (Smith and Young, 2007). Some previous studies showed that both a* and b* values decreased in marinated fillets (Young and Lyon, 1997; Allen et al., 1998).

The marinated cooked samples exhibited lighter (higher L*) and more yellow (higher b*) whereas a* (red color) increased as temperature and cooking time increased (Resurreccion, 2004). The high values of lightness (L*) values after cooking may be explained due to increase in light scattering and reflection as result of fiber shrinkage after cooking (Alvarado and Sams, 2003).

In conclusion, the prevalence of white striping in turkey breast was relatively high. Moreover, white striping abnormality had adversely affect some of the quality traits of turkey breast meat which was more characterized with high fat and low protein contents as well as different color indexes (a* and b*).

Conflicts of Interest

The authors declare no potential conflict of interest.

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Author Contributions

The article is prepared by a single author.

Ethics Approval

This article does not require IRB/IACUC approval because there are no human and animal participants.

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