2013 Georgia Poultry Conference: Processing Session

White Striping in Processed Broiler Muscle Tissue – A Growing Problem?

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Condition is not isolated to breast meat

White Striping

- White stripes on breast meat and thighs
- Various degrees
- Run parallel to the direction of muscle fibers
- Cause currently unknown

Condition is not isolated to broilers

Turkey
Thighs

Condition is wide spread across broiler industry

Boneless / Skinless Breast Meat

Importance in the Industry

- ***Consumer acceptance of visual appearance of broiler breast meat with varying degrees of white striping*** V.A. Kuttappan , Y.S. Lee , G.F. Erf , J.-F.C. Meullenet , S.R. McKee and C.M. Owens
  -Poultry Science 91(5): 1240-1247, May 2012
- Research shows that consumer purchase of meat is significantly influenced by physical appearance
- Consumer acceptance significantly decreases as white striations increase
- Results of study indicate consumers rejected fillets with white striping at a significant rate, as they were perceived to be high in fat

White Striping Classification

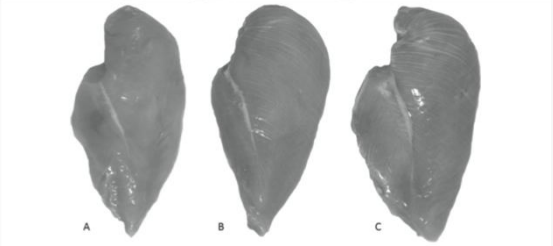


Figure 1. White striping classification of broiler breast meat: A) normal (NORM) breast fillet (no striping), B) breast fillet exhibiting moderate (MOD) degree of white striping, and C) breast fillet exhibiting severe (SEV) degree of white striping.

(Kuttappan et al., 2012)

Deficiency Symptoms

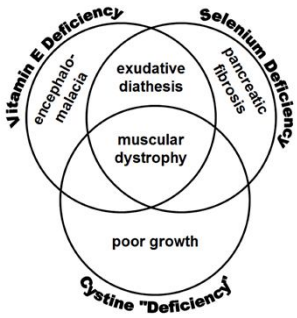
Table 17-3 The symptoms of vitamin E and selenium deficiency diseases in poultry.

	Responds to:			
Symptom	**Vitamin E**	**Se**	**Cystine**	**Antioxidants**
Encephalomalacia	+			
Testicular degeneration	+			
Red blood cell hemolysis	+			
Pancreatic fibrosis		+		
Exudative diathesis	+	+		
Gizzard myopathy (turkeys and ducks)	+	+		
Muscular dystrophy	+	+	+	
Loss of apetite	+	+		+
Reduced growth	+	+		+

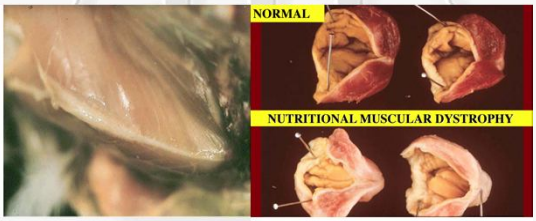
Researched Explanations

- Postulated explanations for white striations in literature:
  - **Vitamin E Deficiency** (Dam et al., 1952)
- *Muscular degeneration (white striation of muscles) in chicks reared on Vitamin-E deficient*, low fat diets. H. Dam, I. Prange and E. Sondergaard
- *ACTA PATHOLOGICA ET MICROBIOLOGICA SCANDINAVICA* 31(2):172-184 1952

Deficiency Interactions



1960's Muscular Dystrophy Chicken Breast Muscle Turkey Gizzards



Researched Explanations

- Postulated explanations for white striations in literature:
  - **Association with Growth Rates** (Kuttappan, et. al, 2012)
  - **Processing Age** (Bauermeister et. al, 2009)
  - **Muscle Damage & Myopathic Changes** (Kuttappan, 2011)
  - **Thicker, heavier fillets** (Kuttappan et al., 2009)

Influence of growth rate on the occurrence of white striping in broiler breast fillets

- ***Poultry Science 91(10): 2677-2685, October 2012***
- *V.A. Kuttapan, V. B. Brewer, J. K. Apple, P. W. Waldroup, and C. M. Owens (University of Arkansas)*

- Used a visual scoring system to assess the severity of striping as NORM, MOD, or SEV
- Used proximate and fatty acid composition of breast fillets to examine the differences of the varying degrees of striated muscles
- Included two series of diets, a low- (LED) or high-energy (HED) diet

Experimental Diets

Table 1. Composition (% DM) of the low- (LED) and high-energy (HED) diets

	0 to 18 d		18 to 32 d		32 to 54 d	
Item	LED	HED	LED	HED	LED	HED
Ingredient						
Yellow corn	63.638	51.217	66.254	55.579	69.351	53.914
Poultry oil	0.496	6.013	0.515	5.903	0.503	6.065
Soybean meal	32.360	39.199	30.012	35.201	27.066	36.919
Limestone	0.274	0.175	0.246	0.197	0.270	0.168
Defluorinated phosphate	1.735	1.882	1.528	1.679	1.360	1.455
Feed-grade salt	0.244	0.227	0.269	0.252	0.290	0.277
MHA-84%[1]	0.290	0.349	0.261	0.303	0.237	0.318
L-Threonine	0.060	0.063	0.041	0.041	0.041	0.041
L-Lysine HCl	0.203	0.175	0.174	0.148	0.182	0.143
Waldroup vitamins[2]	0.500	0.500	0.500	0.500	0.500	0.500
Mintrex P_Se[3]	0.100	0.100	0.100	0.100	0.100	0.100
Coban 90[4]	0.050	0.050	0.050	0.050	0.050	0.050
BMD-50[5]	0.050	0.050	0.050	0.050	0.050	0.050
Total	100.000	100.000	100.000	100.000	100.000	100.000
Nutrient content						
CP (%)	21.53	23.91	20.53	22.24	19.31	22.96
Calcium (%)	0.90	0.95	0.81	0.86	0.74	0.79
Nonphytate P (%)	0.44	0.47	0.40	0.43	0.036	0.39
Methionine (%)	0.61	0.68	0.57	0.62	0.54	0.64
TSAA (%)	0.94	1.05	0.90	0.97	0.85	0.99
Lysine (%)	1.27	1.42	1.18	1.29	1.11	1.33
ME (kcal/kg)	3,002.95	3,205.71	3,025.00	3,250.00	3,063.54	3,250.90

[1]Methionine hydroxy analogue calcium salt (Novus International, St. Louis, MO).
[2]Provided 7,715 IU of vitamin A (from vitamin A acetate); 5,511 IU of cholecalciferol; 16.53 IU of vitamin E (from DL-α-tocopheryl acetate); 0.013 mg of vitamin B_{12}; 6.6 mg of riboflavin; 39 mg of niacin; 10 mg of pantothenic acid; 1.5 mg of menadione (from menadionedimethylpyrimidinol); 0.9 mg of folic acid; 1,000 mg of choline; 1.54 mg of thiamine (from thiamine mononitrate); 2.76 mg of pyridoxine (from pyridoxine HCl); 0.066 mg of D-biotin; and 125 methoxyquin per kilogram of diet.
[3]Provided 40 mg of Mn (as manganese methionine hydroxy analog complex); 40 mg of Zn (as zinc methionine hydroxy analog complex); 20 mg of Cu (as copper methionine hydroxy analog complex); and 0.3 mg of Se (as selenium yeast) per kilogram of diet (Novus International Inc., St. Louis, MO).
[4]Elanco Animal Health division of Eli Lilly & Co., Indianapolis, IN.
[5]Bacitracin methylene disalicylate granule (Alpharma Inc., Bridgewater, NJ).

Kuttapan et al, 2012
Experimental Design

- 280 straight run, 1 day old chicks of the Cobb 500 strain
- Assigned to either the LED (low energy diet) or HED (high energy diet)
- 28 birds/treatment and 5 replicates of each treatment
- Bird weights and feed intake recorded after starter, grower, and finisher
- Chickens were processed at 54 days of age and meat collected after scalding
- Right pectoralis major collected for proximate analysis
- Carcasses prechilled (75 minutes) and deboned 2 hrs postmortem
- Severity of white striping was scored as either NORM, MOD, or SEV

Experimental Diets

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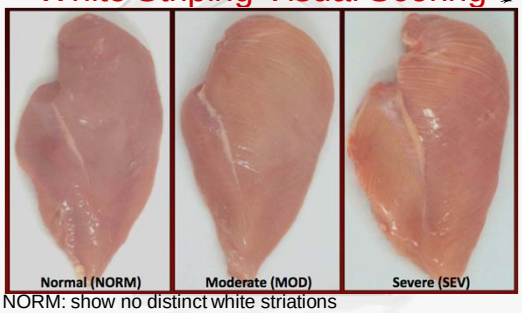
Mintrex P_Se[3]	0.100	0.100
Coban 90[4]	0.050	0.050
BMD-50[5]	0.050	0.050
Total	100.000	100.000
Nutrient content		
CP (%)	21.53	23.91
Calcium (%)	0.90	0.95
Nonphytate P (%)	0.44	0.47
Methionine (%)	0.61	0.68
TSAA (%)	0.94	1.05
Lysine (%)	1.27	1.42
ME (kcal/kg)	3,002.95	3,205.71

White Striping Visual Scoring



NORM: show no distinct white striations
MOD: small, thin lines of striping
SEV: thick, white striations covering most of the surface area

Live Body Weights and Feed Conversion

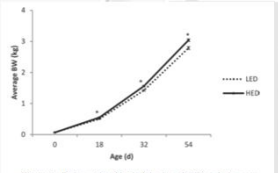


Figure 1. Body weight of birds fed a low- (LED) or high-energy diet (HED) during the starter (0 to 18 d), grower (18 to 32 d), and finisher (32 to 54 d) periods. Within a feeding period, an asterisk (*) indicates a difference ($P < 0.05$) between the 2 dietary treatments.

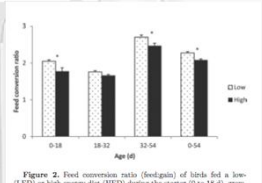


Figure 2. Feed conversion ratio (feed:gain) of birds fed a low- (LED) or high-energy diet (HED) during the starter (0 to 18 d), grower (18 to 32 d), finisher (32 to 54 d), and overall (0 to 54 d) feeding periods. Within a feeding period, an asterisk (*) indicates a difference ($P < 0.05$) between the 2 dietary treatments.

Average Body Weight vs. Age in LED & HED diets

Feed Conversation Ratio vs. Age in LED & HED diets

Experimental Diets

Feed Efficiency

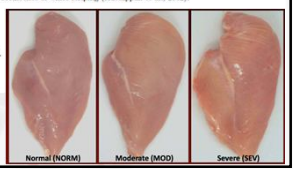
	0-18 D	18-32 D	0-54 D
Cobb500 Standard	1.18	1.54	2.00
Low Energy Diet	2.11	1.81	2.33
High Energy Diet	1.79	1.68	2.11

Proximate Analysis Results

Table 3. Comparison of broiler breast meat from birds with 3 degrees of white striping

Parameter	Degree of white striping[1] NORM (n = 13)	MOD (n = 14)	SEV (n = 8)
Live weight (g)	2,987.54[b] ± 78.92	3,095.79[b] ± 71.95	3,108.00[a] ± 103.16
Fillet weight[2] (g)	266.77[b] ± 12.60	300.80[ab] ± 10.96	321.88[a] ± 13.49
Fillet yield[2,3] (%)	8.89[b] ± 0.23	9.71[a] ± 0.24	10.36[a] ± 0.26
Moisture (g/100 g)	82.39[a] ± 0.93	81.30[a] ± 0.90	81.99[a] ± 1.20
Ash[4] (g/100 g)	4.58[b] ± 0.03	4.6[b] ± 0.03	4.54[b] ± 0.04
Fat content[4] (g/100 g)	3.03[b] ± 0.44	4.47[ab] ± 0.42	5.56[a] ± 0.56
Calories from fat[4,5] (kcal/100 g)	27.26[b] ± 3.92	40.2[ab] ± 3.78	50.04[a] ± 5.00
Protein content[4] (g/100 g)	90.03[b] ± 0.57	88.93[ab] ± 0.55	87.73[b] ± 0.73
Calories from protein[4,6] (kcal/100 g)	360.12[a] ± 2.28	355.71[ab] ± 2.20	350.9[b] ± 2.91
Fat:protein	0.08[b] ± 0.01	0.11[ab] ± 0.01	0.14[a] ± 0.01
Total calorie[4,7] (kcal/100 g)	387.38[b] ± 2.95	395.91[ab] ± 2.85	400.94[a] ± 3.76

[a,b]Least squares means (±SE) with different superscripts within a row differ ($P < 0.05$).
[1]Breast fillets with normal (NORM), moderate (MOD), or severe (SEV) occurrence of white striping (Kuttappan et al., 2012).
[2]Left fillet (single).
[3]Yield as percentage of live weight.
[4]Dry matter basis.
[5]Energy from fat (kcal/100 g) = amount of fat (in g/100 g) × 9.
[6]Energy from protein (kcal/100 g) = amount of protein (in g/100 g) × 4.
[7]Total energy = calories from fat + calories from protein.

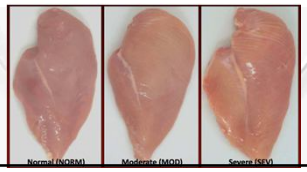


Experiment Results

Table 2. Live weight, fillet weight and yield, and the frequency of occurrence of 3 degrees of white striping in breast fillets from broilers fed either a low- (LED) or high-energy diet (HED)

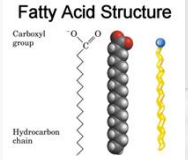
Feed treatment	Live weight (g)	Fillet weight[1] (g)	Fillet yield[1,2] (%)	Degree of white striping[3] NORM n	NORM %	MOD n	MOD %	SEV n	SEV %	WS[4] n	WS %
LED (n = 137)	2,787.1[b] ± 30.6	260.4[b] ± 4.0	9.3[a] ± 0.1	65[a]	47.45[a]	70[b]	51.09[a]	2[b]	1.46[b]	72[b]	52.55[a]
HED (n = 138)	3,041.9[a] ± 30.5	289.8[a] ± 4.0	9.5[a] ± 0.1	35[b]	25.36[b]	91[a]	65.94[a]	12[a]	8.70[a]	103[a]	74.64[a]

[a,b]Least squares means (±SE) lacking a common superscript within a column differ ($P < 0.05$).
[1]Left fillet (single).
[2]Yield as percentage of live weight.
[3]Counts (percentages calculated on row total) of breast fillets with normal (NORM), moderate (MOD), or severe (SEV) occurrence of white striping (Kuttappan et al., 2012).
[4]Fillets showing either MOD or SEV degrees of white striping (WS).



Fatty Acid Analysis

Fatty Acid Analysis was done to calculate the amount of saturated fatty acids (SFA), mono-unsaturated fatty acids (MUFA), and poly-unsaturated fatty acids



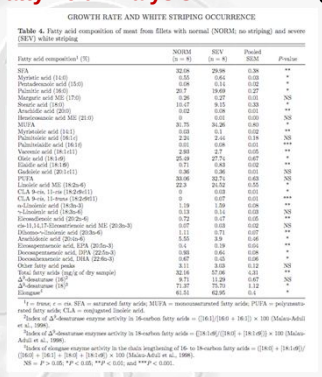

GROWTH RATE AND WHITE STRIPING OCCURRENCE

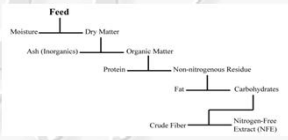
Table 4. Fatty acid composition of meat from fillets with normal (NORM; no striping) and severe (SEV) white striping

Fatty acid composition[1] (%)	NORM (n = 8)	SEV (n = 8)	Pooled SEM	P-value
SFA	32.08	29.98	0.38	**
Myristic acid (14:0)	0.55	0.61	0.03	*
Pentadecanoic acid (15:0)	0.08	0.14	0.02	*
Palmitic acid (16:0)	20.7	19.69	0.27	*
Margaric acid MS (17:0)	0.26	0.27	0.01	NS
Stearic acid (18:0)	10.47	9.15	0.33	*
Arachidic acid (20:0)	0.02	0.08	0.01	**
Heneicosanoic acid MS (21:0)	0	0.01	0.00	NS
MUFA	31.75	34.26	0.83	*
Myristoleic acid (14:1)	0.03	0.1	0.02	**
Palmitoleic acid (16:1)	2.24	2.44	0.18	NS
Palmitoleidic acid (16:1t)	0.01	0.08	0.01	***
Vaccenic acid (18:1v11)	2.93	2.7	0.05	**
Oleic acid (18:1c9)	25.49	27.74	0.67	*
Elaidic acid (18:1t9)	0.71	0.83	0.02	**
Gadoleic acid (20:1c11)	0.36	0.36	0.01	NS
PUFA	33.06	32.71	0.63	NS
Linoleic acid MS (18:2n-6)	22.3	21.52	0.55	*
CLA 9-cis, 11-cis (18:2c9c11)	0	0.03	0.01	*
CLA 9-cis, 11-trans (18:2c9t11)	0	0.07	0.01	***
α-Linolenic acid (18:3n-3)	1.19	1.59	0.08	**
γ-Linolenic acid (18:3n-6)	0.1	0.12	0.01	NS
Eicosadienoic acid (20:2n-6)	0.72	0.57	0.05	**
cis-11,14,17-Eicosatrienoic acid ME (20:3n-3)	0.07	0.03	0.02	NS
Dihomo-γ-linolenic acid (20:3n-6)	1.11	0.71	0.07	**
Arachidonic acid (20:4n-6)	5.55	5.9	0.46	*
Eicosapentaenoic acid, EPA (20:5n-3)	0.4	0.19	0.04	**
Docosapentaenoic acid, DPA (22:5n-3)	0.93	0.61	0.08	*
Docosahexaenoic acid, DHA (22:6n-3)	0.67	0.45	0.06	*
Other fatty acid peaks	3.11	3.03	0.12	NS
Total fatty acids (mg/g of dry sample)	32.16	37.06	4.31	**
Δ^9-desaturase (16)[2]	9.75	11.29	0.67	NS
Δ^9-desaturase (18)[3]	71.37	75.73	1.12	*
Elongase[4]	61.51	62.95	0.4	*

[1]t = trans; c = cis. SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids; CLA = conjugated linoleic acid.
[2]Index of Δ^9-desaturase enzyme activity in 16-carbon fatty acids = ([16:1c9]/[16:0 + 16:1]) × 100 (Malau-Aduli et al., 1998).
[3]Index of Δ^9-desaturase enzymes activity in 18-carbon fatty acids = ([18:1c9]/[18:0] + [18:1c9]) × 100 (Malau-Aduli et al., 1998).
[4]Index of elongase enzyme activity in the chain lengthening of 16- to 18-carbon fatty acids = ([18:0] + [18:1c9])/([16:0] + [16:1] + [18:0] + [18:1c9]) × 100 (Malau-Aduli et al., 1998).
NS = $P > 0.05$, * $P < 0.05$, ** $P < 0.01$, and *** $P < 0.001$.

Proximate Analysis

- **Proximate Analysis**:
  - Most representative samples from each degree of striations chosen
  - Only samples from HED-fed birds further analyzed
  - Moisture %
- Fat, Protein, and Ash contents measured using appropriate ether extraction, combustion, and incineration methods

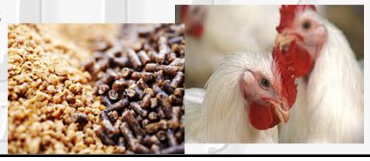


Conclusions

- Feeding HED can produce birds with greater BW and lower feed conversion ratios
- The high growth rate induced by the high calorie diet increases the occurrences of white striping in broiler breast fillets
- High degrees of white striping are associated with higher amounts of lipid and lower amounts of protein, resulting in higher net calorie content of the meat
- There were also differences in the fatty acid composition of NORM and SEV fillets

Possible Future Research Issues

- This study did not suggest or evaluate any differences in male and female striation occurrences
- The many differences in the two diets (energy, protein, fat, Methionine, Lysine, etc.) could be a factor for growth causes or striping differences



Questions?