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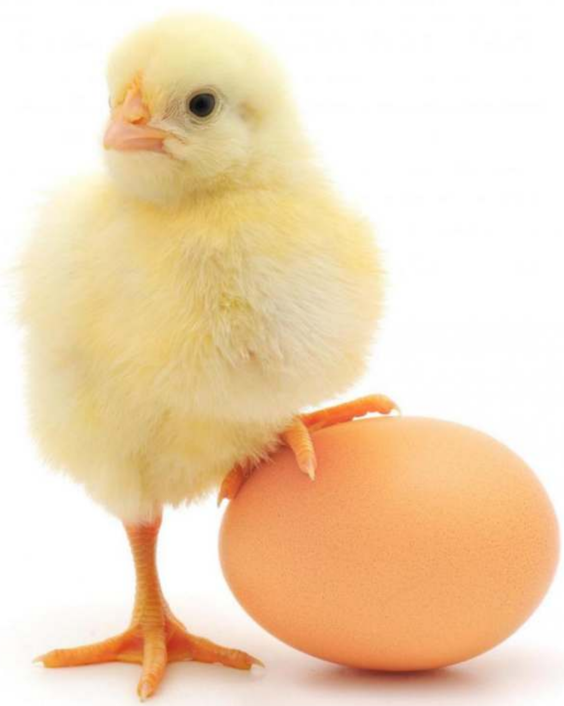

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Effect of Sex, Bird Size and Marination on Duck Breast Meat Quality

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Abstract: Several factors may affect poultry breast meat quality, both intrinsic characteristics (age, sex, size and strain) and external influences (carcass aging time postmortem before deboning, fillet marination and cooking method). Commercial duck processors are now expanding into the deboned breast meat markets but very little research is available on duck meat quality as compared to other poultry species. Therefore, the following study was conducted to determine the effect of duck sex, size and fillet marination on breast meat quality. Duck rearing, processing and carcass deboning were conducted at a commercial facility. Carcasses were kept separate by sex and were then sized to 1.6 kg (S), 2.0 kg (M) and 2.5 kg (L) after chilling. After 6 h aging on the carcass, breast fillets were removed and half of the fillets from each sex-size category were marinated while the other half of the fillets (unmarinated) were held as controls. A total of 360 fillets were produced, 30 in each of 12 categories (2 sexes X 3 sizes X 2 treatments). At the laboratory, fillets were weighed, evaluated for raw color, cooked, reweighed, evaluated for cooked color and sheared via Warner-Bratzler (WB). Uncooked and cooked fillet weights were significantly affected by bird size ($p<0.05$). Marination increased fillet cook yield compared to control fillets (73.5% versus 69.1%, respectively) and decreased WB shear values (2.2 kg versus 3.2 kg, respectively). Less force was required to shear the first slice using WB as compared to the second WB slice (2.4 and 3.0 kg, respectively). Lightness (L*) and yellowness (b*) values were lower in uncooked fillets from females than males ducks and marination decreased raw fillet L* values and cooked b* values for both sexes. Results showed that sex, carcass size and marination affect duck breast meat quality.

Key words: Duck breast, carcass size, marination, meat quality

INTRODUCTION

In the U.S., the duck processing industry is relatively small compared to the broiler or turkey processing industries. In 2000, U.S. duck processors generated just over 160 million pounds and they have consistently produced nearly the same amount of meat every year for over a decade, predominately marketing whole carcasses (USDA, 2011). More recently duck processors have entered new markets of more convenient yet value-added products. Deboned duck breast fillets, both fresh and marinated are sold in the U.S., supplementing the traditional sale of whole duck. Overall meat quality, especially color and texture, is important for these newer product types especially considering the products are priced at a premium. Duck processors have reported receiving complaints of fillet toughness, which is unfortunate since texture is one of the primary considerations for customers after appearance or color (Acton and Dick, 1986; Fletcher, 2002).

Intrinsic factors that may affect duck meat appearance, texture and meat yields are breed and sex and carcass aging time prior to deboning. Prior research found that differences existed between duck breeds (Pekin, Muscovy, Hinny and Mule) for breast meat color, cooking loss and shear values (Chartrin *et al.*, 2006). Duck meat texture (tenderness) may be affected by sex as breast meat from Pekin duck males was more tender than breast meat from females (Omojola, 2007). Minor differences in breast meat quality due to sex were observed for Muscovy and mule ducks (Baeza *et al.*, 1998; Baeza *et al.*, 2000).

Other factors during processing that may affect duck breast meat quality include aging time and marination. Similar to breast meat from other poultry species, duck fillets required 4 or more h of aging on the carcass prior to deboning to reach a moderate level of tenderness (Smith *et al.*, 1992). Marination is used extensively in the poultry further processing industry as a means of improving yield and flavor, with a corresponding increase in tenderness (Smith and Acton, 2010). Previous research has shown that marination can be used to improve duck breast meat tenderness (Smith *et al.*, 1991). Other research on duck meat has shown that lactic acid marination degraded duck meat fibers (Chou *et al.*, 1997), red wine accelerated post mortem degradation of mule duck muscle (Lin *et al.*, 2000) and ginger similarly accelerated degradation of Muscovy duck muscle (Tsai *et al.*, 2012). These same reports also showed that marination improved cooked meat yield from these various duck breeds.

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Prior research has shown that duck breast meat quality may be affected by sex and marination treatment. Therefore the objective of this study was to determine whether sex (with fillet size standardized to reduce influence of size on sex) or marination affected the quality of duck breast meat as measured by color, texture and yield.

MATERIALS AND METHODS

Approximately 4000 Pekin ducks of the same strain were hatched, reared and processed at facilities owned and operated by a commercial producer. Ducks were sexed at 1 d of age and raised in separate pens by sex in the same house. At 35 d of age all ducks were processed in a commercial facility, with sexes identified and kept separate throughout the process. Ducks were transported to the processing facility, manually hung on shackles, then electrically stunned and exsanguinated. All carcasses were scalded, picked, waxed and eviscerated. Carcasses were chilled using cold water immersion for 60 min. Whole carcasses (separated by sex), were categorized for size (weight) with a scale into 1.6 kg (small, S), 2.0 kg (medium, M) and 2.5 kg (large, L). Carcasses were stored in a cooler at the plant for 6 h and then the front halves were harvested and manually deboned. Skin was left on the boneless breast fillets. At least 30 fillets were placed in bags by category of bird sex (male or female) and carcass size (S, M or L). Half of the fillets from each of these categories were left as fresh unmarinated controls (6 bags) while the other half of the fillets from each category were marinated (6 bags). The commercial processing plant conducted marination on the 6 bags of fillets selected for the process. Fillets were vacuum tumbled for 8 min at 25 mm Hg and 3.5 RPM. Marinade solution was added at 5% of the total fillet weight and consisted of 86% water, 8% salt and 6% sodium tripolyphosphate. Thirty fillets were collected in each of the 12 categories (2 sexes X 3 sizes X 2 treatments, control or marinated) for a total of 360 fillets.

The twelve bags of identified fillets were placed in insulated containers with cold packs and shipped. Containers were received the following morning at the laboratory. Fillets were immediately skinned and weighed, evaluated for raw color and cooked in a convection oven to an endpoint temperature range of 77 to 80°C. After cooling for approximately 2 h fillets were reweighed and evaluated for cooked color. Cook yield was determined by dividing the cook weight of each fillet by the raw weight and multiplying by 100.

Color of each duck fillet (surface reflectance, both raw and cooked) was measured using a spectrocolorimeter (HunterLab UltraScan Pro Spectrocolorimeter, Hunter Associate Laboratories, Inc., Reston, VA) for both uncooked and cooked fillets for lightness (L*), redness (a*) and yellowness (b*). All measurements were made on the medial (keel) side of the breast, in the cranial area, where free from fat, bruises, or other features that could have affected color values. Prior to measuring color, the spectrocolorimeter was standardized using both a light trap (complete absence of reflectance color) and a white tile. CIE L*, a* and b* color values were determined to provide a standard for comparison to other color values. Spectral reflectance color was also determined from 350 to 700 nm using a 5 nm optical resolution and reporting interval. Both spectral and CIE reflectance measures were taken using a standard setting to simulate a 2 and 10°C observer.

All fillets were kept refrigerated overnight after cooking and sheared via the Warner-Bratzler (WB) method and apparatus (G-R Electrical Mfg. Co., Manhattan, KS). Fillets were allowed to return to ambient temperature while covered. A strip of meat, 19 mm wide, was manually cut from the cooked fillet parallel with the direction of the muscle fibers, roughly from the wing insertion area to the keel. Each strip was sheared twice, both times perpendicular to the fiber direction. The first shear slice was taken approximately 1.0 to 1.5 cm from the keel end of the strip; the second slice was taken approximately 3.0 to 3.5 cm from the keel end, which was closer to the wing insertion end of the strip. The shear values were averaged together and data are reported in kg shear.

Data were analyzed using the ANOVA option of the general linear model (GLM) procedure of SAS for main effects of carcass size, sex and marination treatment (SAS, 2008). The model tested the main effects of sex, size and marination with residual error used as the test term, unless significant interactions were observed, then the interaction term was used as the test term. Means were pooled where no significant interactions were observed and residual error used as the error term. Significance level throughout the analyses was $p<0.05$.

RESULTS AND DISCUSSION

Weights and cook yield: Uncooked and cooked weights are shown in Table 1 and cook yields (as a percent of cook weight divided by raw weight) are shown in Table 2. Raw weights were significantly affected by carcass size, but not by sex or marination treatment ($p>0.05$). Uncooked fillets from large birds were heavier than fillets from medium birds, which weighed more than the small bird fillets (178.8, 142.5 and 108.9 g, respectively). Cooked weights had a similar pattern to the uncooked fillets, with cooked fillets from large birds at 124.9 g, which were heavier than medium fillets at 103.0 g and small fillets with the lightest weight of 78.2 g. Sex of the bird could have affected fillet weights if sexual dimorphism of body and breast weight were evident at 35 d of age. However, the sizing of birds after chilling removed this effect from the sample population. The lack of difference due to marination could have been due to

Table 1: Mean uncooked and cooked duck fillet weights (g) by bird size

Bird size[1]	N	Uncooked weight (g)	Cooked weight (g)
S	120	108.9^{c}	78.2^{c}
M	120	142.5^{b}	103.0^{b}
L	120	178.8^{a}	124.9^{a}
Pooled SEM		1.61	1.13

$^{a-c}$Means in columns without common superscripts are significantly different (p<0.05). [1]S, M, L refers to small (1.6 kg), medium (2.0 kg) and large (2.5 kg) carcasses

Table 2: Percent cook yield and Warner-Bratzler shear force (kg) values of cooked duck breast meat by marination treatment

Treatment	N	Cook yield (%)	Warner-Bratzler shear (kg)
Fresh (control)	180	69.1	3.2
Marinated	180	73.5	2.2
Pooled SEM		0.23	0.06
p-value		<0.0001	<0.0001

the small (5%) of marinade added combined with the 24 h between marination and weighing. Also, skin was removed after marination, which would have absorbed some of the marinade. Cook yield was significantly increased by marination, resulting in 73.5% average yield as compared to the unmarinated control with a cook yield of 69.1%.

Several reports on duck breast cook yield are available, which include in order from lowest to highest: 59.5, 60.4, 62, 65.5 and 66%, respectively (Ali *et al.*, 2008; Smith *et al.*, 1992; Alvarado and Sams, 2000; Ali *et al.*, 2007; Kim *et al.*, 2012). Marination has been previously shown to improve duck breast cook yield from 64.5 to 72.9% (Smith *et al.*, 1991). Cook yield of male Pekin duck breast was found to be significantly higher than yield from female breast meat, 76.3 vs. 70.2% (Omojola, 2007). The present study did not show a sex difference for yield, possibly because the pre-sorting for carcass weight within sex removed the fillet size differences. The present study also did not find that fillet size significantly affected cook yield. One explanation is that the fillets were monitored closely during cooking and were immediately removed from heat once they achieved the endpoint temperature, rather than all fillets cooked to a final time and temperature which can result in overcooking of smaller fillets with subsequent greater yield loss.

Warner-bratzler shear: Warner-Bratzler (WB) shear force, as a measure of objective texture on cooked duck breast meat, was not affected by sex or size of bird (Table 2). Marination significantly reduced shear values as compared to those observed for unmarinated meat (2.2 vs. 3.2 kg, respectively). Neither of these averages would be considered tough by consumers based on sensory panel data correlated with objective shear results (Lyon and Lyon, 1991). The small difference between these significantly different averages also would likely not be noticed by most consumers.

Previous research on duck breast meat has shown that WB shear force ranged from 3.7 to 4.2 kg shear (Ali *et al.*, 2008; Kim *et al.*, 2012). Omojola (2007) found that WB shear of duck breast meat from males (2.6 kg) was significantly more tender than meat from females (3.4 kg). No difference in meat texture due to sex was found in the present study. Due to observations during the study that the second shear slice often contained more connective tissue and appeared tougher than the first shear slice, the averages of the first and second shears were analyzed to determine if the two populations of shear values were equal. The first slice (nearer the keel) had significantly lower shear value (2.4 kg) than the second slice (3.0 kg), which was closer to the wing insertion (n = 360). These data appear to confirm visual observations that connective tissue in the second shear resulted in higher WB values.

Color: Color values (CIE L*, a* and b*) of duck fillets for both uncooked and cooked are shown by sex in Table 3. Uncooked fillets from females had significantly lower L* values than uncooked fillets from males (44.4 versus 46.3). Uncooked fillets from females were also less yellow (lower b* values) compared to uncooked male fillets (11.2 versus 12.4). No differences were observed in the redness of uncooked fillets (average a* value of 12.0). Cooked fillet lightness values were lower in females (58.4) than males (60.4). Redness values were lower for males than females (5.6 versus 6.0, respectively), which was the same pattern for yellowness values (16.2 versus 16.5, respectively).

Marination treatment had a significant effect on uncooked and cooked fillet lightness (data not shown). Uncooked L* values for marinated fillets was lower compared to control fillets (44.4 versus 46.3, respectively). However, cooked marinated L* values were higher for marinated (60.2) as compared to control (58.6) fillets.

Significant but small differences were observed in both uncooked and cooked meat for color values. Overall, however, the averages for color values, even where significant, are not likely to be observed as different by consumers due to the close proximity of these averages. The values found in the current study are generally in agreement with previous research of duck breast meat. Raw duck breast fillet color measurements have been taken from Pekin ducks at 40-44, 49 and 98 d of age. Lightness values ranged from 46.8, to 36.5, to 34.6, respectively; redness values ranged from 15.6 to 13.1 to 13.7, respectively and, yellowness was measured at 0.6, 2.0 and 10.1, respectively (Kim *et al.*, 2012; Smith *et al.*, 1993; Chartrin *et al.*, 2006). A Korean duck breed (Chungdong ori) was processed at 48 d and color

Table 3: Color values (C.I.E. Lightness, L*, redness, a* and yellowness, b*) of uncooked and cooked duck breast fillets by sex

		Uncooked			Cooked		
Sex	N	Lightness (L*)	Redness (a*)	Yellowness (b*)	Lightness (L*)	Redness (a*)	Yellowness (b*)
Female	180	44.4	12.0	11.2	58.4	6.0	16.5
Male	180	46.3	12.0	12.4	60.4	5.6	16.2
Pooled SEM		0.15	0.06	0.09	0.16	0.04	0.08
p-value		<0.0001	0.9516	<0.0001	<0.0001	<0.0001	0.0362

measurements taken from raw fillets, yielding L* of 43.8, a* of 15.5 and b* of 5.4 (Ali *et al*., 2008). Similarly, values taken from raw breast meat of a Cherry berry breed of duck in Korea were 39.7 (L*), 18.2 (a*) and b* of 4.9 (Ali *et al*., 2007). The lowering of L* values of uncooked meat by marination and subsequent increase of cooked L* values has been reported for broiler breast categorized as either normal or light prior to marination (Qiao *et al*., 2002).

Sex, marination and size of carcasses have effects on duck breast meat quality. Uncooked and cooked fillet weights were significantly affected by bird size as would be expected. Larger birds resulted in higher weights than smaller birds for both uncooked and cooked fillets. Cook yield was significantly improved by more than 4% of initial fillet weight by marination. WB shear was also decreased by marination (improved tenderness), while differences were observed between the first and second slices of the shear test. Females had lower lightness (L*) and yellowness (b*) values than males in uncooked fillets. Marination decreased uncooked L* values, but increased cooked L* values.

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