Journal of Anatolian Environmental and Animal Sciences
(*Anadolu Çevre ve Hayvancılık Bilimleri Dergisi*)
DOI: https://doi.org/10.35229/jaes.1112687

JAES
Year: 7, No: 3, 2022 (367-373)
AÇEH
Yıl: 7, Sayı: 3, 2022 (367-373)

ARAŞTIRMA MAKALESİ RESEARCH PAPER

The Effect of Season and Feed Withdrawal Duration on Meat Quality Characteristics of Broiler Chicken in Commercial Slaughter Conditions [*]

Bahri ÇOLAK[1] **Bülent TEKE**[2*]

[1] *Republic of Turkey Ministry of Agriculture and Forestry, Ulubey Directorate of District Agriculture and Forestry, Ordu, Türkiye*
[2] *Ondokuz Mayis University, Faculty of Veterinary Medicine, Department of Animal Breeding and Husbandry, Samsun, Türkiye*

Geliş/Received: *05.05.2022* ***Kabul/Accepted:*** *06.07.2022* ***Yayın/Puplished:*** *30.09.2022*

How to cite: **Çolak, B. & Teke, B. (2022).** The Effect of Season and Feed Withdrawal Duration on Meat Quality Characteristics of Broiler Chicken in Commercial Slaughter Conditions. *J. Anatolian Env. and Anim. Sciences, 7*(3), 367-373.
Atıf yapmak için: **Çolak, B. & Teke, B. (2022).** Ticari Kesim Koşullarında Etlik Piliçlerde Mevsim ve Açlık Süresinin Et Kalite Özelliklerine Etkisi. *Anadolu Çev. ve Hay. Dergisi, 7*(3), 367-373.

*: https://orcid.org/0000-0002-1091-643X
: https://orcid.org/0000-0002-7567-921X

***Corresponding author's:**
Bülent TEKE
Ondokuz Mayis University, Faculty of Veterinary Medicine, Department of Animal Breeding and Husbandry, Samsun, Türkiye
✉: bulentteke@gmail.com

Abstract: The aim of the study was to determine the effect of season and withdrawal duration on meat quality characteristics of broiler chicken in commercial slaughter conditions. The study was carried out on Ross 308 broiler chickens reared under similar commercial conditions from two different seasons (autumn and winter) and three different withdrawal duration (8, 10 and 12 hours). A total of 180 broilers, 10 samples per transport distance were randomly selected to determine meat quality characteristics, (2 seasons × 3 withdrawal durations × 10 samples × 3 repeats). Meat colour parameters, pH_4, pH_{24}, drip loss and cooking loss were determined. In this study, pH_4 value increased ($p<0.001$) and L^*_{24} value decreased ($p<0.001$) as the withdrawal duration increased. Broiler chicken transported in winter had more dark, red and yellow meat colour than autumn season. As the withdrawal duration increased, the differences between two seasons about meat quality characteristics increased (L^*_0, L^*_{24}, a^*_0, a^*_{24}, b^*_0, b^*_{24}). In addition, as the withdrawal duration increased sensor characteristics of broiler chicken meat increased. In conclusion, the withdrawal duration and season affected significantly meat quality characteristics. The adverse effect occurred especially during winter condition and long withdrawal duration. Cold weather condition and long withdrawal duration result in increased pH meat but the increase did not cause the DFD meat. Therefore it is recommended that up to 12 hours of withdrawal duration can be applied to broiler chickens not only in autumn conditions but also in winter conditions.

Keywords: Broiler, meat quality, season, sensory analysis, withdrawal duration.

Ticari Kesim Koşullarında Etlik Piliçlerde Mevsim ve Açlık Süresinin Et Kalite Özelliklerine Etkisi

***Sorumlu yazar:**
Bülent TEKE
Ondokuz Mayıs Üniversitesi, Veteriner Fakültesi, Zootekni Anabilim Dalı,Samsun, Türkiye
✉: bulentteke@gmail.com

Öz: Bu araştırma etlik piliçlerin et kalite özellikleri üzerine mevsimin ve açlık süresinin ticari kesim koşullarında etkisini belirlemek amacıyla yapılmıştır. Bu araştırma benzer ticari koşullar altında yetiştirilen 2 farklı mevsim (sonbahar ve kış) ve 3 farklı kesim öncesi açlık süresi (8, 10 ve 12 saat) uygulanan Ross 308 hattı etlik piliçler üzerinde yürütülmüştür. Her nakil için rastgele 10 örnek olmak üzere (2 mevsim × 3 açlık süresi × 10 örnek × 3 tekrar) toplam 180 etlik piliç et örneği seçilmiştir. pH_4, pH_{24}, et rengi, damlama kaybı ve pişirme kaybı gibi et kalite özellikleri analiz edilmiştir. Bu araştırmada açlık süresinin artmasıyla birlikte pH_4 değerinin attığı ($p<0,001$), L_{24}^* değerinin düştüğü ($p<0,001$) tespit edilmiştir. Kış mevsiminde nakledilen etlik piliçlerin, sonbaharda nakledilenlere kıyasla daha koyu, daha kırmızı ve daha sarı renkte göğüs etine sahip olduğu belirlenmiştir. Açlık süresi arttıkça iki mevsim arasında et kalite özellikleri (L^*_0, L^*_{24}, a^*_0, a^*_{24}, b^*_0, b^*_{24}) arasındaki farklılığın da arttığı tespit edilmiştir. Açlık süresinin artışıyla birlikte piliç eti duyusal özelliklerinin arttığı belirlenmiştir. Araştırma sonucunda et kalite özellikleri açlık süresi ve mevsimden önemli derecede etkilenmiştir. Olumsuz etkinin özellikle kış mevsimindeki uzun açlık süresinde daha çok ortaya çıktığı belirlenmiştir. Soğuk hava şartları ve uzun açlık süresinin pH artışına neden olduğu fakat bu artışın DFD et oluşturmayacak düzeyde olduğu belirlenmiştir. Bu yüzden sadece sonbahar koşullarında değil aynı zamanda kış koşullarında da etlik piliçlere 12 saate kadar açlık süresinin uygulanabileceği sonucuna varılmıştır.

Anahtar kelimeler: Açlık süresi, DFD et, duyusal analizler, et kalitesi, mevsim, piliç.

[*] *This study was produced from the master thesis.*

INTRODUCTION

Broilers are exposed to various stress factors in the last moments of its life before slaughter. These stress factors include starving, catching, placing in crates and loading on the transport vehicle, then transporting them to the slaughterhouse under different seasonal conditions, and resting in the slaughterhouse before slaughter under these seasonal conditions. It has been reported by various researchers that catching broilers, crating, loading into transport vehicles and transporting are very stressful stages for broilers (Elrom, 2000; Knowles & Broom 1990; Mitchell & Kettlewell, 1998; Von Borrell, 2001). Each of these processes adversely affects animal welfare to varying degrees, increases corticosterone levels in plasma, and reduces energy stores in the muscles of broiler chickens, and damages meat quality. In addition, the body temperature of the chicken increases and the liver glycogen stores decrease during the fasting period (Warris et al., 1999). Fasting is a routine practice of broilers for a certain period of time before slaughter. Broilers are taken from the feeders and starved a few hours before catching in order to reduce the risk of carcass contamination, mainly *Salmonella* and *Campylobacter*. If the fasting period is less than 6-7 hours, since the gastrointestinal tract will still be filled with food, the intestines will occupy most of the cylindrical abdominal cavity during this process, and increasing the possibility of leakage of gastrointestinal contents during the evacuation of the internal organs (Nortcutt, 2000). Although it is recommended to apply a total fasting period of 8-10 hours before slaughter (Wabeck, 1972), sometimes this period may be longer depending on the slaughter plan in the slaughterhouse. In some studies, it has been determined that the optimum fasting period for broilers is 8-12 hours, in which carcass contamination is reduced to the lowest level and meat quality characteristics are increased (Lyon et al., 1991; Veerkamp, 1986).

Meat pH is an important parameter that affected the pre-slaughter fasting period. The glycogen content in the muscle tissue of the broiler determines the extent and rate of the pH drop at the onset of rigor mortis (Hwang et al., 2003). It is necessary to have sufficient glycogen in the muscles of the chicken before slaughter in order to obtain broiler chicken meat that is suitable for production and preferred by the consumer, therefore, the appropriate feeding plan should be applied to the animal before slaughter (Lyon & Buhr, 1999).

Seasonal conditions during transport may also affect meat quality characteristics. The water holding capacity and meat colour of the breast meat of broilers transported in cold weather conditions are adversely affected (Barbut et al., 2005; Dadgar et al., 2010), on the other hand, drip loss, cooking loss and L* value is high in breast meat of broilers transported at hot weather conditions (Bianchi et al., 2005; Petracci et al., 2004). It has been reported by some researchers that the season in which the broiler is transported does not have a significant effect on meat quality characteristics (Debut et al., 2003; Sandercock et al., 2001).

In recent years, interest on meat quality characteristics of pre-slaughter fasting period has increased, and various studies have been carried out to determine the optimum range of pre-slaughter fasting period. However, among these studies, it was determined that the number of studies in which different pre-slaughter fasting periods applied in different seasons was quite low. This research was carried out to determine the effects of 2 different seasons (autumn and winter) and 3 different pre-slaughter fasting periods (8, 10 and 12 hours) on meat quality characteristics of broiler chickens.

MATERIAL AND METHOD

***Animals, Study Design and Slaughter Process*:** The animal material of this study consisted of Ross 308 line broiler chickens, which were selected from three similar size and design coop of the same company in the same commercial conditions in Bafra, Samsun. Broiler chickens were given three different feeds during the study. Broilers started for the first 11 days with beginning (HP: 23.5%; ME: 2850 kcal/kg), reared between 12-22 days (HP: 22%; ME: 2950 kcal/kg) and finished until sent to slaughter (HP: % 20; ME: 3010 kcal/kg). Feed and water were given ad libitum and 23 hours of light and 1 hour of darkness were applied. On the slaughter day, 8, 10 and 12 hours of fasting periods were applied to the first, second and third coop, respectively. The time of catching the broilers and placing them in the crates (2 hours), the transport period (2 hours 30 minutes) and the resting period before slaughter (1 hour) were included the fasting period, and their feed was withdrawn from the feeders according to the fasting period to be applied. Water was given until the animals were caught. They were loaded onto a separate transport vehicle for each coop after placing the broilers in 80 cm length × 45 cm width × 30 cm height boxes at the density recommended by FAWC (1991). The transport vehicles with 320 loading crates in each of the 9 transport vehicles, 3 transport vehicles from each poultry house, travelled 125 km at a constant speed of approximately 50 km/h on average and reached the slaughterhouse in 2 hours and 30 minutes. The transport vehicles completed the transport without stopping, without sudden acceleration or deceleration during the transport. The broiler chickens were slaughtered after resting in the slaughterhouse for 1 hour. Meat samples were taken from randomly selected 10 chickens from each transport vehicle and 90 chickens were utilized for each season (3 fasting times x 10 samples x 3 repeats). A total of 180 chicken meats

were used throughout the research (the autumn and winter seasons). In addition, the average temperature and humidity values on the slaughter day were obtained from the meteorology, and the slaughter age and average body weight of broiler chickens were obtained from the slaughterhouse. These recorded values are given in Table 1.

Table 1. Averages and standard errors of some transportation, slaughter characteristics, temperature and humidity values of slaughter day ($\overline{X} \pm S\overline{x}$)

Traits	Autumn	Winter
Stocking density (m^2/chicken)	0.041±0.001	0.040±0.001
Slaughter weight (kg)	2.38±0.05	2.30±0.05
Slaughter age (d)	41	41
Temperature (°C)	11.30±0.26	-1.00 ± 0.26
Humidity (%)	91.90±0.77	85.40±0.62

In the research, transportation and slaughtering was took place at night, autumn season data were collected in November 2019 and winter season data were collected in January 2020, the broilers were unloaded from the crates and hung upside down on the slaughter line following the rest periods in the slaughterhouse. Electric current were given the broilers before slaughtering and they were cut by hand, then the blood flow was provided. They were passed through a hot water tank at 60°C and their feathers were automatically plucked. The carcasses were taken to the relevant sections for cooling after the internal organs were removed automatically. A total of 180 broiler chickens (30 samples x 3 fasting periods x 2 seasons) were randomly selected to determine their meat quality characteristics.

Meat Quality Analysis: M. *pectoralis major* was removed from the 15 carcasses. The pH of this muscle was measured by a pH meter (Testo 205) 4 hours and 24 hours after slaughter and the result was recorded as pH_{4h} and $pH_{24h.}$

Drip Loss Measurement: Samples were obtained from M. pectoralis major was dried with a paper towel, the samples were weighed (HT-1000NH+ model, Dikomsan, Istanbul) and the results were recorded as the initial weight ($W_{initial}$). The samples was placed in a nylon bag in such a way that it would not touch the nylon bag and was weighed after it was kept at 4°C for 24 hours (W_{last}). Drip loss (DL) is calculated using the below formula (Honikel, 1998):

$$DL\ (\%) = [(W_{initial} - W_{last}) / W_{initial}] \times 100$$

Meat Colour Measurement: Meat colour measurements (L*, a* and b* values) was measured by a device (Minolta CR 400) according to the CIE (1972) standards. The device was calibrated with a white plate (Y=93.8; x=0.316; y=0.3323) and D65 was used as the light source. Measurements were made from three different places of M. *pectoralis major* for colour analysis. The first measurement of sample was made as soon as the sample was obtained. Afterwards, the sample was maintained in a refrigerator at 4°C for 24 hours and then a second colour measurement was obtained. The colorimeter was set so that it averaged three reading. The mean was recorded as colour value for each sample.

***Cooking Loss Analysis*:** The samples (the remaining part of M. pectoralis major) were weighed and vacuumed, then vacuum packed samples were warmed in a water bath at 80°C for 20 minutes. Afterwards, the samples cooled under running water until their internal temperature reached room temperature. All samples were maintained in a refrigerator at 4°C for 24 hours. The samples were removed from vacuum bags. The liquid on the sample was dried with paper towels and weighed to obtain their weights after cooking. The difference between pre- and post-cooking weights divided by the precooked weight for cooking loss (%) (Honikel, 1998).

***Sensory Analysis*:** Thigh meats of broiler chicken which were applied 3 different fasting periods in the autumn season cooked in the oven until the temperature in the centre reached 80°C. Afterwards, they were presented to the panellists for their evaluation. A consumer panel consisting of 12 people was arranged and cooked thigh meat was scored between 1-8 in terms of juiciness, tenderness and flavour.

***Statistical Analysis*:** One way ANOVA test was used to determine the effect of pre-slaughter fasting period on meat quality characteristics, and a t-test was used to compare meat quality characteristics between two seasons. Tukey's multiple range tests was used to determine the significance of the difference between fasting periods. Friedman Test was applied to determine the effect of pre-slaughter fasting time on sensory characteristics.

RESULTS

The mean and significance levels of meat quality characteristics belonging to the fasting period groups are given in Table 2. Accordingly, pH_4, L^*_0, L^*_{24} and cooking loss were significantly affected by the fasting period. The pH_4 value increased ($p<0.001$). L^*_0 and L^*_{24} values decreased ($p<0.01$ and $p<0.001$, respectively) with increasing fasting period. The cooking loss decreased as the fasting period increased ($p<0.05$). Other meat quality characteristics did not change with the increase of the fasting period.

The averages and significance levels of meat quality characteristics according to the season are given in Table 2. Accordingly, most of the meat quality characteristics (pH_4, L^*_0, L^*_{24}, a^*_0, a^*_{24}, b^*_0, b^*_{24}) were significantly affected by the season ($p<0.001$). The averages and significance levels of meat quality characteristics of the fasting duration groups in the seasons are given in Table 3. Accordingly, the effect of fasting time was significant on pH_4 at $p<0.001$, on a^*_0 at $p<0.01$, on a^*_{24} at $p<0.05$ and on cooking loss at $p<0.05$ level in the autumn season. The number of affected parameters increased in winter, when the effect of fasting period on meat quality characteristics was compared with the autumn season. Among these parameters, the pH_{24} ($p<0.05$), L^*_0 ($p<0.001$), L^*_{24} ($p<0.001$), b^*_0

(p<0.01) and cooking loss (p<0.001) was significantly affected by fasting period. Comparison of meat quality characteristics according to fasting groups between two seasons and their significance levels are given in Table 4. According to this, as the fasting time increased, the number of affected meat quality parameters increased. All colour parameters (L^*_0, L^*_{24}, a^*_0, a^*_{24}, b^*_0, b^*_{24}) significantly different (p<0.001) between the two seasons in the 12-hour fasting group.

Table 2. Mean values and significance levels of meat quality trait values belonging to season and fasting period groups

	Season (S)		Fasting Period (F)			Significance	
Meat Quality Characteristics	**Autumn**	**Winter**	**8 h**	**10 h**	**12 h**	**S**	**F**
pH_4	5.95±0.01^b	6.02±0.01^a	5.92±0.01^b	6.01±0.01^a	6.04±0.01^a	***	***
pH_{24}	6.00±0.01	5.99±0.01	5.97±0.01	6.01±0.01	6.00±0.01	ns	ns
L^*_0	50.28±0.18	49.95±0.20	50.24±0.22^{ab}	50.60±0.23^a	49.54±0.23^b	ns	**
L^*_{24}	49.41±0.24^a	48.05±0.26^b	49.01±0.32^a	49.43±0.28^a	47.79±0.33^b	***	***
a^*_0	2.08±0.06^b	3.75±0.09^a	3.02±0.14	2.93±0.13	2.80±0.15	***	ns
a^*_{24}	2.55±0.09^b	3.76±0.09^a	3.29±0.14	3.13±0.12	3.05±0.15	***	ns
b^*_0	1.96±0.12^b	6.48±0.17^a	4.69±0.37	4.11±0.32	3.86±0.33	***	ns
b^*_{24}	3.13±0.19^b	6.46±0.17^a	5.18±0.34	4.65±0.28	4.56±0.30	***	ns
Drip Loss (%)	2.38±0.11	2.56±0.09	2.60±0.16	2.34±0.09	2.46±0.11	ns	ns
Cooking Loss (%)	17.59±0.32	17.79±0.29	18.39±0.32^a	16.99±0.30^b	17.69±0.45^{ab}	ns	*

ns: Not significant (P>0.05) a, b, c Mean values in the same row with different letters differ significantly (P<0.05).
* P<0.05 **P<0.01 ***P<0.001

Table 3. Mean values and significance levels of meat quality characteristics of fasting duration groups in the seasons

	Autumn				Winter			
Meat Quality Characteristics	**8 h (n=30)**	**10 h (n=30)**	**12 h (n=30)**	**Sig**	**8 h (n=30)**	**10 h (n=30)**	**12 h (n=30)**	**Sig**
pH_4	5.90±0.01^b	5.97±0.02^a	5.99±0.02^a	***	5.94±0.01^b	6.04±0.01^a	6.08±0.01^a	***
pH_{24}	5.98±0.02	6.04±0.02	5.98±0.03	ns	5.97±0.01^b	5.99±0.01^{ab}	6.01±0.01^a	*
L^*_0	50.13±0.30	50.58±0.26	50.15±0.34	ns	50.35±0.31^a	50.61±0.38^a	48.94±0.29^b	***
L^*_{24}	49.37±0.52	49.68±0.31	49.18±0.41	ns	48.66±0.36^a	49.18±0.46^a	46.40±0.38^b	***
a^*_0	2.21±0.10^a	2.22±0.10^a	1.83±0.10^b	**	3.83±0.16	3.65±0.16	3.77±0.09	ns
a^*_{24}	2.80±0.19^a	2.65±0.13^{ab}	2.22±0.14^b	*	3.77±0.16	3.61±0.17	3.88±0.17	ns
b^*_0	2.25±0.21	2.09± 0.21	1.56±0.12	ns	7.14±0.33^a	6.12±0.27^b	6.17±0.23^b	**
b^*_{24}	3.44±0.35	3.17±0.34	2.80±0.32	ns	6.91±0.37	6.13±0.23	6.33±0.25	ns
Drip Loss (%)	2.53±0.30	2.34±0.13	2.28±0.11	ns	2.68±0.12	2.34±0.12	2.64±0.19	ns
Cooking Loss (%)	18.48±0.36^a	17.65±0.33^{ab}	16.68±0.77^b	*	18.29±0.54^a	16.32±0.49^b	17.79±0.29^a	***

ns: Not significant (P>0.05) a, b, c Mean values in the same row with different letters differ significantly (P<0.05).
Sig: Significance
* P<0.05 **P<0.01 ***P<0.001

Table 4. Comparison of meat quality characteristics between two seasons according to fasting period groups

Meat Quality Characteristics	**8 h**	**10 h**	**12 h**
pH_{4h}	*	***	***
pH_{24h}	ns	*	ns
L^*_0	ns	ns	**
L^*_{24}	ns	ns	***
a^*_0	***	***	***
a^*_{24}	***	***	***
b^*_0	***	***	***
b^*_{24}	***	***	***
Drip Loss (%)	ns	ns	ns
Cooking Loss (%)	ns	*	*

ns: Not significant (P>0.05)
* P<0.05 **P<0.01 ***P<0.001

Sensory analysis values and significance levels according to fasting period are given in Table 5. Accordingly, it was determined that the preference of all sensory properties (juiciness, tenderness and flavour) by the panellists increased with the increase of the fasting time. The biggest difference between the fasting period groups was felt in the tenderness trait (p<0.001), while the smallest difference was felt in the juiciness trait (p<0.05) in terms of the effect of fasting period on sensory characteristics.

Table 5. Sensory analysis values and significance levels according to fasting times

Sensory characteristics	**8 h of fasting MR Value**	**10 h of fasting MR Value**	**12 h of fasting MR Value**	**Significance**
Juiciness	1.79	1.71	2.50	*
Tenderness	1.88	1.38	2.75	***
Flavour	2.21	1.29	2.50	**

MR: Mean Rank * p<0.05 **P<0.01 ***p<0.001

DISCUSSION

In the study by Komiyama et al. (2008), four different pre-slaughter fasting periods (4, 8, 12 and 16 hours) were applied to broilers before slaughter and the effect of fasting on meat quality characteristics was investigated. The pH values of broiler chickens which were fasted for 4, 8 and 12 hours were 5.87, 5.87 and 6.04, respectively, and the pH value increased as the fasting period increased. As the fasting period increased, the L*

(lightness) value decreased (51.39, 46.98, 46.31 and 46.54, respectively), a* (redness) value increased (2.51, 3.06, 3.30 and 3.02, respectively). It was reported that the differences between fasting time groups regarding both colour parameters were significant, but the b* (yellowness) value was not affected by the fasting period. Drip loss and cooking loss values were determined as 5.17 and 28.48, 5.37 and 27.38, 5.11 and 29.07, 2.38 and 24.31 for 4, 8, 12 and 16 hours pre-slaughter fasting times, respectively. As a result of the research, it was reported that the pre-slaughter fasting period significantly affected the meat quality characteristics. Haslinger et al. (2007) examined the long fasting period and broiler chickens were divided into 6 groups as 0, 2, 4, 8, 16 and 24 hours before slaughter. It was reported that immediately after slaughter and post-mortem 24-hour pH values increased slightly (0.17-0.34) with the increase of fasting time, and the postmortem 24-hour pH value reached similar levels in all groups. It was determined that the slight increase in pH value was not at a level that would enable the development of DFD meat. In a study (Schedle et al., 2006), pre-slaughter fasting period groups were divided into 6 groups (0, 2, 4, 8, 16 and 24 hours), pH values immediately after slaughter (pH_1) and postmortem 24 hours (pH_2) was measured by researchers. It was determined that as the fasting period increased, the pH_1 value increased slowly from 6.30 to 6.50. The maximum value was 6.00 in the 16-hour fasting group while pH_2 was 5.80 in the group without fasting, and the difference was found to be statistically significant ($p<0.05$). As fasting period was increased, both pH values increased, but the increase did not cause the DFD meat. Savenije et al. (2002), half of the broiler chickens were starved for 5 hours before slaughter, and the other half were allowed to reach the feed until they were transported. At the end of the study, it was reported that the effect of pre-slaughter fasting period on breast meat pH, water holding capacity, L* and b* values was not significant. In the study of Kotula & Wang (1994), broilers were slaughtered after 0, 3, 6, 12, 18, 24 and 36 hours of fasting. It was determined that the pH and glycogen levels in breast meat and thigh meat decreased with the increase in the fasting period, and the fasting period did not affect the colour characteristics of breast and thigh meat. Lyon et al. (2004) applied a fasting period of 0-8 hours to broilers aged between 42-52 days and the effect of this fasting period on meat quality characteristics was investigated. According to the research findings, it was reported that as the fasting period increased, the breast meat L* value increased (lighter), a* value decreased (less red), and b* value increased (more yellow). In current study, it was determined that the pH_4 value increased ($p<0.001$) and the L_{24}* value decreased ($p<0.001$) with the increase in the fasting period. The results of the current study are similar to the results of most researchers (Haslinger et al., 2007; Komiyama et al., 2008; Schedle et al., 2006). However, it was reported by some researchers that the fasting period was not significant effect on the pH and L* values of broiler chickens (Kotula & Wang, 1994; Savenije et al., 2002) or the L* value increased with the increase of the fasting period (Lyon et al., 2004). The differences between studies may be due to differences in the length of fasting period.

In this study, the breast meat of broiler transported in winter was darker (- 1.36 L^*_{24} units), redder (+ 1.21 a^*_{24} units) and yellower (+ 3.33 b^*_{24} units) colour compared to those transported in autumn. In addition, it was determined that the difference between two seasons increased (L^*_0, L^*_{24}, a^*_0, a^*_{24}, b^*_0, b^*_{24}) as the fasting period increased related to meat quality characteristics. In studies on the transportation of broilers under cold weather conditions (Dadgar et al., 2010; 2011), it was reported that breast meats obtained from these chickens were darker and higher pH than those transported under optimum weather conditions. Similar results were obtained in current study. Birds have the ability to keep their body temperature constant and they use some of the glycogen in their muscles to maintain their body temperature when transported in cold weather conditions. It is thought that the rate of conversion of glycogen to lactic acid increases with the prolongation of the fasting period in winter conditions, and therefore the pH remains high (Warriss et al., 1999). In this study, it was determined that the increase in pH value was not at a level that would provide DFD meat formation.

Haslinger et al. (2007) investigated the effect of fasting time (0, 2, 4, 8, 16 and 24 hours) on sensory characteristics. It was reported that the sensory properties of broiler chickens with a long fasting period were better, and there was a tendency for broiler meats with a longer fasting period, but this difference was reported to be very small and statistically insignificant. In another study (Schedle et al., 2006), the effect of fasting time (0, 2, 4, 8, 16 and 24 hours) on sensory characteristics was examined. Chicken breast meats were evaluated in terms of tenderness, juiciness and flavour in the test panel. It was reported that the panellists preferred broiler meats fasted for a longer period of time, and the length of the fasting period had a significant positive effect on the sensory quality of the meat product. Lyon et al. (2004) investigated the 0-8 hour fasting period on sensory characteristics, and it was reported that the juiciness and tenderness of chicken meats with 0-hour fasting period were lower than those of chickens with 8-hour fasting period. For this reason, it was reported that the panellists preferred the chicken meat subjected to 8 hours of fasting than other fasting periods. It has been reported by many researchers (Haslinger et al., 2007; Lyon et al., 2004; Schedle et al., 2006) that the sensory properties of chicken meat increase with the

increase in fasting time. Similar results were obtained in this study as well. The effect of fasting time (8, 10, 12 hours) on sensory properties was investigated in current study, it was determined that as the fasting time increased, the panellists preferred chicken meat that was kept during a long fasting period.

CONCLUSION

It is a routine practice to fasting broilers for a certain period of time before slaughter. It is mainly applied to reduce the risk of carcass contamination and to improve meat quality. This research was carried out to determine the effects of season (autumn and winter) and fasting period (8, 10 and 12 hours) on chicken meat quality characteristics. As a result of the research, it was seen that the duration of fasting and the season significantly affected the meat quality characteristics. The adverse effect was more effective especially in the winter season and during the long fasting period. It was determined that cold weather conditions and long fasting period caused an increase in pH, but this increase was at a level that did not produce DFD meat. In addition, the results of the sensory meat analysis revealed that the 12-hour fasting period had a significant positive effect on the sensory quality. Therefore, in this study, it was concluded that a fasting period of up to 12 hours could be applied to broiler chickens not only in autumn conditions but also in winter conditions, since meat quality problems did not occur and it did not affect sensory quality.

ACKNOWLEDGEMENTS

The authors also thank Prof. Dr. Bülent EKİZ for assistance in meat quality analysis.

REFERENCES

Barbut, S., Zhang, L. & Marcone, M. (2005). Effects of pale, normal, and dark chicken breast meat on microstructure, extractable proteins, and cooking of marinated fillets. *Poult Science*, ***84***, 797-802.

Bianchi, M., Fletcher, D.L. & Smith D.P. (2005). Physical and functional properties of intact and ground pale broiler breast meat. *Poultry Science*, ***84***, 803-808.

CIE. (1976) Centre Internationale de L'Eclairage. Definition dun space de coleur por deux coordonees de cromaticite et la luminosite. 1976 Supplement 2 to CIE publication no 15 (E-1-3-1) 1971/ (TC-1-3). Cente Internationale de L'Eclairage, Paris.

Dadgar, S., Lee, E.S., Leer, T.L., Burlinguette N., Classen, H.L., Crowe, T.G. & Shand, P.J. (2010). Effect of microclimate temperature during transportation of broiler chickens on quality of the pectoralis major muscle. *Poultry Science*, ***89,*** 1033-1041.

Dadgar, S., Lee, E.S., Leer, T.L.V., Classen, H.L., Crowe, T.G. & Shand, P.J. (2011). Effect of acute cold exposure, age, sex, and lairage on broiler breast meat quality. *Poultry Science*, ***90***, 444-457.

Debut, M., Berri, C.E., Baeza, N., Sellier, C., Arnould, D., Guemene, N., Hehl, B., Boutten, Y., Jego, C. & Beaumont Le Bihan-Duval, E. (2003). Variation of chicken technological meat quality in relation to genotype and pre-slaughter stress conditions. *Poultry Science*, ***82,*** 1829-1838.

Elrom, K. (2000). Handling and transportation of broilers-welfare, stress, fear and meat quality. Part III: fear; definitions, its relation to stress, causes of fear, responses of fear and measurement of fear. *Israel Journal of Veterinary Medicine*, ***55***(3), 1-7.

FAWC. (1991). Report on the European Commission Proposals on the Transport of Animals. London: MAFF Publications

Haslinger, M., Leitgeb, R., Bauer, F. & Ettle, T. (2007). Windisch, W.M. Slaughter yield and meat quality of chicken at different length of preslaughter feed withdrawal. *Die Bodenkultur*, ***58***(1-4), 67-72.

Honikel, K.O. (1998). Reference methods for the assessment of physical characteristics of meat. *Meat Science*, ***49***, 447-457.

Hwang, I.H., Devine, C.E. & Hopkins, D.L. (2003). The biochemical and physical effects of electrical stimulation on beef and sheep meat tenderness. *Meat Science*, ***65***, 677-691

Knowles, T.G. & Broom, DM. (1990). The handling and transport of broilers and spent hens. *Applied Animal Behaviour Science*, ***28***, 75-91.

Komiyama, C.M., Mendes, A.A., Takahashi, S.E., Moreira, J., Garcia, R.G., Sanfelice, C., Borba, H.S., Leonel, F.R., Almeida Paz, I.C.L. & Balog, A. (2008). Chicken meat quality as a function of fasting period and water spray. *Brazilian Journal of Poultry Science*, ***10***(3), 179-183.

Kotula, K.L. & Wang, Y. (1994). Characterization of broiler meat quality factors as influence by feed withdrawal time. *Journal of Applied Poultry Research*, ***2,*** 103-110.

Lyon, B.G., Smith, D.P., Lyon, C.E. & Savage, E.M. (2004). Effects of diet and feed withdrawal on the sensory descriptive and instrumental profiles of broiler breast fillets. *Poultry Science*, ***83,*** 275-281

Lyon, C.E. & Buhr, R.J. (1999). Biochemical basis of meat texture. In: Poultry Meat Science, (Ed. R. I. Richardson and G. C. Mead) CAB International, Oxfordshire, England, pp. 99-126.

Lyon, C.E., Papa, C.M. & Wilson, R.L. (1991). Effect of feed withdrawal on yields, muscle pH, and texture of broiler breast meat. *Poultry Science*, ***70,*** 1020-1025.

Mitchell, M.A. & Kettlewell, P.J. (1998). Physiological stress and welfare of broiler chickens in transit: solutions not problem**!** *Poultry Science*, ***77***, 1803-1814.

Northcutt, J.K., Savage, S.I. & Vest, L.R. (1997) Relationship between feed withdrawal and viscera condition of broilers. *Poultry Science*, ***76***, 410-414.

Petracci, M., Bianchi, M., Betti, M. & Cavani, C. (2004). Color variation and characterization of broiler breast meat during processing in Italy. *Poultry Science*, ***83***, 2086-2092.

Sandercock, D.A., Hunter, R.R., Nute, G.R., Mitchell, M.A. & Hocking, P.M. (2001). Acute heat stress-induced alterations in blood acid-base status and skeletal muscle membrane integrity in broiler chickens at two ages: Implications for meat quality. *Poultry Science*, ***80,*** 418-425.

Savenije, B., Lambooij, E., Gerritzen, M.A., Venema, K. & Korf, J. (2002). Effects of feed deprivation and transport on preslaughter blood metabolites, early postmortem muscle metabolites, and meat quality. *Poultry Science*, ***81***, 699-708.

Schedle, K., Haslinger, M., Leitgeb, R., Bauer, F., Ettle, T. & Windisch, W. (2006). Carcass and meat quality of broiler chickens at different starving periods before slaughter. *Veterinarija Ir Zootechnika*, ***35***(57), 85-88.

Veerkamp, C.H. (1986). Fasting and yield of broilers. *Poultry Science*, ***65,*** 1299-1304.

Von Borrell, EH. (2001). The biology of stress and its application to livestock housing and transportation assessment. *Journal of Animal Scie*nce, ***79***(e-Suppl.): E260-E267.

Wabeck, C.J. (1972). Feed and water withdrawal time relationship to processing yield and potential fecal contamination of broilers. *Poultry Science*, ***51***, 1119-1121.

Warriss, P.D., Knowles, T.G., Brown, S.N., Edwards, J.E. Kettlewell, P.J., Mitchell, M.A. & Baxter, CA. (1999). Effects of lairage time on body temperature and glycogen reserves of broiler chickens held in transport modules. *Veterinary Record*, ***145***, 218-222.