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RESEARCH ARTICLE

The Effect of Different Transport Distances and Season on Meat Quality Characteristics of Broiler Chicken in Commercial Slaughter Conditions

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ABSTRACT

The aim of the study was to determine the effect of season and transport distance on meat quality characteristics of broiler chicken in commercial transport and slaughter conditions. The study was carried out on Ross 308 broiler chickens reared under similar commercial conditions from three different seasons (summer, autumn and winter) and three different transport distances at 40 km, 70 km and 130 km. Meat samples were taken on July, October, and December for summer, autumn and winter seasons, respectively during 2018. Broilers in trucks were waited in holding barn for 1 h. A total of 135 broilers, 15 samples per transport distance, were randomly selected to determine meat quality characteristics, (3 seasons × 3 transport distances × 15 samples). Meat colour parameters, pH_{4h}, drip loss, cooking loss and Warner Bratzler shear force (WBSF) was determined. In winter, pH_{4h}, a^*_{24h} and b^*_{24h} were higher than other seasons, while L^*_{24h}, drip loss and WBSF were lower than other seasons. The incidence of pale, soft and exudative (PSE) meat was the highest in summer (26.67%), while the incidence of dark, firm and dry (DFD) meat was the highest in winter (53.33%). The lowest incidence of normal breast meat was in winter season. In conclusion, incidence of normal breast meat decreased when broiler chickens were transported in winter. However, incidence of PSE meat was the highest in summer season. Transport distance affected adversely some meat quality characteristics and this effect was most pronounced in summer season. In order to improve the meat quality, as much as possible, transportation of broiler chickens should be carried out within thermal comfort zone ranges and avoided from long-distance transports especially in summer.

Keywords: Animal welfare, DFD meat, meat quality, PSE meat, transportation

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Ticari Kesim Koşullarında Etlik Piliçlerde Farklı Nakil Mesafelerinin Ve Mevsimin Et Kalitesine Etkisi

ÖZ

Bu araştırma ticari nakil ve kesim koşullarında etlik piliçlerin et kalite özellikleri üzerine mevsimin ve nakil mesafesinin etkisini belirlemek amacıyla yapılmıştır. Bu araştırma benzer ticari koşullar altında yetiştirilen 3 farklı mevsim (yaz, sonbahar ve kış) ve 3 farklı nakil mesafesinde (40 km, 70 km ve 130 km) kesimhaneye nakledilen Ross 308 hattı etlik piliçler üzerinde yürütülmüştür. Et örnekleri 2018 yılında yaz, sonbahar ve kış mevsimleri için sırasıyla Temmuz, Ekim ve Aralık aylarında alınmıştır. Etlik piliçlere nakil aracı içinde 1 saat dinlenme süresi uygulanmıştır. Her mevsimde her bir nakil mesafesi için 15'er örnek olmak üzere toplam 135 etlik piliç (3 mevsim × 3 nakil mesafesi × 15 örnek) et kalite özelliklerinin belirlenmesi için rastgele seçilmiştir. Et rengi, pH_{4h}, damlama kaybı, pişirme kaybı ve Warner Bratzler kesme kuvveti (WBSF) belirlenmiştir. Kış mevsiminde pH_{4h}, a^*_{24h} ve b^*_{24h} değeri diğer mevsimlerden daha yüksek iken L^*_{24h}, damlama kaybı ve WBSF değeri diğer mevsimlerden daha düşük bulunmuştur. PSE (soluk, yumuşak, sulu) etin insidensi yaz mevsiminde en yüksek iken (%26.67), DFD (koyu, sert, kuru) etin insidensi ise kış mevsiminde en yüksek olarak tespit edilmiştir (%53.33). En düşük normal et insidensi kış mevsiminde bulunmuştur. Sonuç olarak, kış mevsiminde etlik piliçlerin nakli normal et insidensinin düşmesi ile sonuçlanmıştır. Diğer taraftan, PSE etin insidensi ise en yüksek yaz mevsiminde bulunmuştur. Nakil mesafesinin artışı bazı et kalite özelliklerini olumsuz olarak etkilemiş ve en çok bu etki yaz mevsiminde gözlenmiştir. Etlik piliçlerin et kalite özelliklerinin olumsuz olarak etkilenmemesi için termal konfor zonu aralıklarında naklin yapılması ve özellikle yaz mevsiminde uzun mesafe nakillerden kaçınılması önerilmektedir.

Anahtar Kelimeler: DFD et, et kalitesi, hayvan refahı, nakil, PSE et.

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INTRODUCTION

The rapid increase in the human population in the world has closely associated with an increase in protein demand leading to nutritional problems (Makkar et al. 2014). Animal products due to important essential amino acids contents constantly increasing thus, the breeding of animals where animal proteins can be obtained at the lowest price and in the a short time have gained popularity (Altınel 1999). Chicken meat has a very important role in human nutrition because of its low cholesterol and fat levels, high protein and calcium content, sufficient amount of essential amino acids and being cheaper than red meat. In addition, it is economical to breed because it can be produced in the short term, the feed conversion rate is good, and more products can be obtained in a unit area than other animals (Çınar 2007, Öztürk 2016).

Turkey provides 60% of its total meat production from poultry meat. Chicken meat production was 163 thousand tons in 1990 in Turkey, has reached 2 million tons with an increase of 12 times in 2019 and has a share of 2% in the world (Anonymous 2019).

Farm animals can show different reactions to the stress depending on their specific genetic structures during the transport process. Chickens are one of the most sensitive species to stress among farm animals (Isabel Guerrero 2010). They may face with risk and the extent of economic damage become more important considering that chickens are the most transported farm animals in the world (EFSA 2004).

Transport of poultry from farm to slaughterhouse is a multifactorial process. This process includes pre-slaughter stages with varying degrees of stress, such as the start of loading, leaving the social environment, movement, sudden acceleration and stopping, exposure to a new unfamiliar environment, noise, high or low ambient temperature (Appleby 2008). Catching, crating and transporting broilers are the most traumatic events among these stages (Elrom 2000). Pre-slaughter stress factors can cause varying degrees of immune system damage, bone fractures, injuries in different regions, deterioration in meat quality, and even death in broilers. Pre-slaughter stress factors such as transport time and distance, vehicle riding quality, unloading of broilers from the transport vehicle and dispatching to slaughter, pre-slaughter rest period have been studied by various researchers (Warriss et al. 1992, Mitchell and Kettlewell 1998, Knierim and Gocke 2003; Nijdam et al. 2004). Among these factors, especially transport distance and heat stress at pre-slaughter is a significant threat to bird welfare. Heat or cold stress has a negative effect on meat quality and increases the mortality rate. Thus, it can cause great economic loss (Mitchell and Kettewell 1998, Lara and Rostagno 2013).

The most important factor increasing the fear level of the transported broilers is the transportation time (Cashman et al. 1989). Long-distance transport negatively affects both animal welfare and meat quality. Long transports cause fatigue in broilers, especially when they are hungry for a long time, and decrease the glycogen stores in the body. In addition, broilers exposed to heat stress expose to dehydration in long-distance transportation. The stress caused by the negative effects of long transports brings about significant economic losses by damaging the welfare and meat quality of broilers. Therefore, it has been reported that the transport time should be reduced (Burgess and Pickett 2006).

Seasonal conditions of transport may affect meat quality characteristics. The water holding capacity, WBSF and meat color are negatively affected when broilers are exposed to cold weather conditions (Barbut et al. 2005, Dadgar et al. 2010, 2011). Broiler meats exposed to hot weather conditions have more drip loss, cooking loss and pale meat colour with WBSF value (McKee and Sams 1997, Petracci et al. 2004, Bianchi et al. 2005, Langer et al. 2009). On the other hand, it has been reported that the season does not have a significant effect on meat quality characteristics in some studies (Holm and Fletcher 1997, Sandercock et al. 2001, Debut et al. 2003).

Temperature stress can cause inappropriate changes in meat quality parameters such as pale, soft and exudative (PSE) or dark, firm and dry (DFD) meat (Langer et al. 2009). Most of the consumers do not prefer this type of meat because of their colour and low meat quality (Fletcher 1999). Recently, it has been reported by many researchers that there is a close relationship between uncooked breast meat color and defective meat problems (Qiao et al. 2001, Bianchi et al. 2005). It has been reported by some researchers that the brightness value (L*) can be used as an indicator of PSE or DFD meat, as well as to predict the incidence of meat defects (Barbut 1997, Wilkins et al. 2000, Soares et al. 2002, Galobart and Moran 2004, Petracci et al. 2004).

This research was carried out to determine the effect of season and transport distance on meat quality characteristics of broiler chickens under commercial transport and slaughter conditions.

MATERIAL and METHODS

Animals, study design and slaughter process

The study was carried out three different seasons (summer, autumn and winter) and three different transportation distances (short, medium and long distance) reared under the similar commercial conditions in Samsun. The animal material of this study consisted of Ross 308 line broilers. The short distance transportation was determined as 40 km, medium distance transportation was 70 kilometers and long distance transportation was 130 kilometers. In the research, data were collected for the summer, autumn and winter seasons in July, October and December in 2018. A total of 135 broiler chickens (3 seasons × 3 transport distances × 15 samples) were randomly selected to determine meat quality characteristics.

In the hens, 23 hours of light and 1 hour of darkness were applied, and feed and water were given ad libitum by the producers. Broilers in all poultry houses were starved 8 hours before transport throughout the study. The dimensions of the loading crates used for transport are 80 cm long × 45 cm wide × 30 cm high. The type of trailers was similar and there were 320 crates in each vehicle. Stocking densities in the crates for all transfers were within the range recommended by Anonymous (2011). Average vehicle speed was approximately 40 km/h. The transport vehicles completed the transport without stopping, without sudden acceleration or deceleration during the transport. A temperature and humidity recording device (Testo 174H, Testo Instrument Co. Ltd., Germany) was installed outside the slaughterhouse to record the ambient temperature and humidity. The recorded values throughout the research are given in Table 1.

Table 1. Certain transportation and slaughter characteristics by season ($\overline{X} \pm S\overline{x}$)

Items	Summer	Autumn	Winter
Stocking density (m^2/bird)	0.043±0.001	0.042±0.001	0.040±0.001
Slaughter weight (kg)	2.13±0.05	2.10±0.05	2.14±0.05
Slaughter age (d)	40.89±0.62	40.02±0.36	39.08±0.74
Temperature (^oC)	16.61±0.75	4.16±0.45	0.34 ± 0.33
Humidity (%)	90.11±2.54	88.33±0.85	96.89±0.63

The slaughtering process took place between 23:30 and 08:00, depending on the workload in the slaughterhouse. The rest period before slaughter was applied as 1 hour for all transport vehicles. Broilers were unloaded from the crates and hung upside down on the slaughter line at the end of this period. Broilers were stunned electrically at 50 Volt for 10 sec before slaughtering, afterward they were cut by hand, after 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. Laboratory analyzes of meat quality were carried out at Istanbul University-Cerrahpasa, Faculty of Veterinary Medicine, Department of Animal Breeding and Husbandry, Meat quality laboratory.

Meat quality analysis

M. *pectoralis major* was removed from the 15 carcasses for each application. The pH of this muscle was measured 4 hours after slaughter using a Testo 205 pH meter (Testo Instrument Co. Ltd., Germany) and the result was recorded as pH_{4h}.

Passive Water Loss Measurement

Samples were taken from M. *pectoralis major* approximately 20 g for passive water loss measurement. After the moisture on the outer surfaces of the samples taken for this purpose was carefully dried with a paper towel, it was weighed on a precision balance sensitive to 0.01 g (HT-1000NH+ model, Dikomsan, Istanbul) and recorded as the initial weight ($W_{initial}$). The sample taken was placed in a transparent bag in such a way that it would not touch the bag and was weighed again after it was kept at 4°C for 24 hours. Passive water loss (PWL) is calculated with the following formula, which expresses the ratio of passive water loss resulting from hanging for 24 hours to the initial sample weight (Honikel 1998):

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

Meat Colour Measurement

A color measuring device (Minolta CR 400, Konica Minolta Sensing, Inc., Osaka, Japan) measuring with L*, a*, b* coordinate system was used for meat color measurement. The standards reported by CIE (1976) were applied in the measurements, and D65 was used as the light source. The device was calibrated according to the standard white plate (Y=93.8; x=0.316; y=0.3323). Measurements were made from three different places (the bone-facing surface of M. *pectoralis major*, from the lean and undamaged parts of the median line) by means of a colorimeter for color analysis. Samples taken for color measurement were placed on a plastic plate and the first measurement was made as soon as the sample was taken. Afterwards, the samples were kept in a refrigerator at 4°C for 24 hours and then a second color measurement was performed. The colorimeter is set to take three measurements per command and calculate their average. The average value was accepted as the color value of that sample.

Cooking loss analysis

The remaining part of M. *pectoralis major* was used for cooking loss and texture analysis. The samples were weighed, packed with vacuum, and baked in a water bath at 80^{o}C for 20 minutes before cooking At the end of this period, the samples were removed from the water bath and cooled under running water until their internal temperature reached room temperature. The samples were then kept in a refrigerator at 4^{o}C for 24 hours. Afterwards, the samples were taken out of their bags, dried with paper towels and weighed to determine their weights after cooking. Cooking loss (%) was calculated as the ratio of the difference between pre- and post-cooking weights to the initial weight (Honikel 1998).

Texture analysis

Warner-Bratzler blade connected to Instron 3343 device (Instron, Norwood, USA) was used for WB shear force analysis. The samples used in the cooking loss measurement were used in the WBSF analysis. Three sub-samples from each cooked meat samples were cut parallel to the muscle fibres with a cross section of 1×1 cm and 2.5-3 cm length. The average value was accepted as the value of that sample (Pekel et al. 2012).

Classification of Samples

Breast meat samples were classified as PSE, DFD or normal meat according to L^*_{24h} value. Accordingly, if $L^*_{24h} \geq 49.0$ is considered PSE, if $L^*_{24h} \leq 44.0$ is DFD and $44.0 < L^*_{24h} < 49.0$ is considered normal (Barbut 1997, Soares et al. 2002).

Statistical Analysis

Chi-square test was used to compare DFD, normal and PSE meat incidences by season. GLM test was performed to determine the effect of season and transport distance on meat quality characteristics. Season and transport distance were used as the main factors in the model, and the interaction effect of season and transport distance was calculated. Tukey's multiple range tests was used to determine the significance of the difference when the effect of season, transport distance or interaction of both were significant.

RESULTS

The Effect of Season on Meat Quality Characteristics

Average values for meat quality characteristics according to season and transportation distance are shown in Table 2. In this study, the effect of the season on meat quality characteristics was significant (P<0.01 and P<0.001) except b^*_0, while the effect of transport distance on pH_{4h}, L^*_0 and L^*_{24} values was insignificant (P>0.05). The value of pH_{4h}, a^*_0 and a^*_{24} were the lowest in summer, and the highest L^*_{24h} and b^*_{24h} among meat quality characteristics. In addition, it was determined that drip loss, cooking loss and WBSF value were higher in summer than broilers transported in other seasons. On the other hand, it was determined that the effect of the season × transport distance interaction on meat quality characteristics became significant except L^*_0, b^*_0, drip loss and WBSF value (P>0.05).

Effect of Transport Distance on Meat Quality Characteristics

Mean meat quality characteristics (±SEM) of different transportation distances are given in Table 3 according to the seasons. Accordingly, it has been determined that meat quality characteristics from different transportation distances are greatly affected in the summer season. It was determined that meat quality characteristics were partially affected or the difference was insignificant at different transportation distances in other seasons.

Incidence of DFD, normal and PSE meat

DFD, normal and PSE meat incidences according to the seasons are given in Table 4. According to these findings, it was determined that DFD meat incidence was highest in winter (53.33%) and lowest in summer (6.66%). The highest incidence of PSE meat was observed in the summer (26.67%) and PSE meat was not found in the winter season. In addition, normal meat incidence was the lowest (46.67%) in winter.

Table 2. Means and importance levels of meat quality characteristics of seasonal and transport distance groups

Meat Quality Characteristics	Seasons (S)			Transport Distance (TD)				Significance		
	Summer	Autumn	Winter	Short	Medium	Long	SEM	S	TD	SxTD
pH_{4h}	6.06^{c}	6.35^{b}	6.50^{a}	6.35	6.31	6.26	0.03	***	ns	***
L^*_0	46.48^{b}	43.37^{a}	44.51^{b}	44.52	45.23	44.61	0.57	***	ns	ns
L^*_{24}	46.67^{a}	44.57^{b}	43.92^{b}	45.37	45.06	44.72	0.23	***	ns	*
a^*_0	2.59^{b}	3.13^{a}	3.03^{a}	2.67^{b}	2.84^{ab}	3.25^{a}	0.12	**	**	**
a^*_{24}	2.58^{b}	2.79^{ab}	3.03^{a}	2.51^{b}	2.80^{ab}	3.09^{a}	0.12	**	*	***
b^*_0	4.92	5.01	4.84	5.30^{a}	4.87^{ab}	4.60^{b}	0.18	ns	*	ns
b^*_{24}	5.29^{ab}	4.74^{b}	5.61^{a}	5.62^{a}	5.28^{ab}	4.74^{b}	0.18	**	**	**
Dropping loss (%)	2.87^{a}	2.17^{b}	1.46^{c}	2.12	2.21	2.17	0.07	***	ns	ns
Cooking loss (%)	19.44^{a}	15.34^{c}	17.54^{b}	17.81^{ab}	17.90^{a}	16.62^{b}	0.37	***	*	*
WBSF (kg)	2.37^{a}	1.61^{b}	1.33^{b}	1.87	1.76	1.68	0.09	***	ns	ns

S: Season, TD: Transport Distance, ns: Non 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. Means and significance levels of meat quality characteristics at different transportation distances according to the seasons ($\overline{X} \pm S\overline{x}$)

Characteristics	Summer				Autumn				Winter			
	Short	**Medium**	**Long**	**Sig.**	**Short**	**Medium**	**Long**	**Sig.**	**Short**	**Medium**	**Long**	**Sig.**
pH_{4h}	6.06±0.03	6.10±0.02	6.03±0.05	ns	6.45±0.05^{a}	6.22±0.05^{b}	6.37±0.05^{ab}	**	6.52±0.06^{ab}	6.61±0.05^{a}	6.38±0.06^{b}	*
L^*_0	47.10±0.20^{a}	47.25±0.59^{a}	45.09±0.59^{b}	**	41.37±2.70	44.59±0.48	44.14±0.25	Ns	45.07±0.36	43.86±0.27	44.61±0.61	ns
L^*_{24}	47.21±0.27^{a}	47.28±0.58^{a}	45.51±0.54^{b}	*	44.50±0.33	44.65±0.41	44.56±0.25	Ns	44.41±0.30	43.25±0.21	44.08±0.52	ns
a^*_0	2.16±0.13	2.17±0.27	3.44±0.26	***	2.94±0.13	2.99±0.17	3.45±0.24	Ns	2.89±0.15	3.34±0.24	2.86±0.22	ns
a^*_{24}	2.12±0.15	2.13±0.27	3.49±0.28	***	2.57±0.12	2.76±0.16	3.02±0.18	Ns	2.83±0.18	3.51±0.27	2.75±0.21	ns
b^*_0	5.75±0.28	4.71±0.24	4.30±0.40	**	4.82±0.39	5.30±0.22	4.89±0.31	Ns	5.32±0.32	4.60±0.24	4.59±0.31	ns
b^*_{24}	6.25±0.27	5.05±0.28	4.55±0.35	***	4.40±0.34	5.25±0.23	4.51±0.30	Ns	6.21±0.31	5.44±0.31	5.04±0.32	*
Dropping loss (%)	2.78±0.12	3.07±0.09	2.77±0.15	ns	2.12±0.14	2.19±0.15	2.19±0.12	Ns	1.47±0.06	1.36±0.07	1.55±0.05	ns
Cooking loss (%)	19.45±0.55^{ab}	21.32±0.70^{a}	17.55±0.82^{b}	**	15.61±0.82	15.38±0.59	15.04±0.39	Ns	18.36±0.59	17.01±0.39	17.26±0.73	ns
WBSF (kg)	2.59±0.23	2.30±0.28	2.23±0.18	ns	1.54±0.06	1.72±0.13	1.57±0.08	Ns	1.49±0.11	1.25±0.07	1.25±0.08	ns

ns: Non 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 4. The incidence of DFD, normal and PSE meat by season

Traits	Summer (n=45)		Autumn (n=45)		Winter (n=45)		Overall (n=135)		Sig.
	N	%	n	%	N	%	n	%	
DFD	3	6.66[c]	11	24.44[b]	24	53.33[a]	38	28.15	***
Normal	30	66.67[b]	34	75.56[a]	21	46.67[c]	85	62.96	***
PSE	12	26.67[a]	0	0[b]	0	0[b]	12	8.89	***

a, b, c: Incidence values in the same row with different letters differ significantly (P<0.05).
Sig.: Significance, *** (P < 0.001).

DISCUSSION

Poultry is more sensitive to stress than other animal species, especially ruminants. Therefore, meat quality problems are more common in poultry compared to cattle and sheep (Warriss et al. 1992). It has been reported that pre-slaughter stress factors such as pre-slaughter fasting period, environmental temperature and humidity, and pre-slaughter resting conditions may affect the meat quality of broiler chickens (Mitchell and Kettlewell 1998).

The Effect of Season on Meat Quality Characteristics

In this study, broilers transported in summer were more pale (+2.75 L^*_{24h} units), less red (−0.45 a^*_{24h} units), and less yellow (−0.32 b^*_{24h} units) compared to those transported in winter, WBSF value and drip loss increased breast meat. In most of the studies, it has been reported that broilers transported in summer were a decrease in pH, a decrease in red color (a*), drip loss, cooking loss and lightness (L*) compared to cold weather conditions. In addition, it has been reported by the researchers that the WBSF value increases when broilers are exposed to pre-slaughter heat stress (Bianchi et al. 2007). It has been reported that exposure of broilers to pre-slaughter heat stress accelerates the formation of rigor mortis and causes protein denaturation. It has been stated that if there is a rapid decrease in pH in the early postmortem period when the carcass temperature is high, undesirable results such as PSE meat (pale, soft and exudative) may occur (Mitchell et al. 2001). These results are in accordance with those reports by Petracci et al. (2001), Petracci et al. (2004), Bianchi et al. (2006) and Bianchi et al. (2007). However, it has been reported by some researchers that heat stress did not have a significant difference on meat quality characteristics of broiler chickens (Sandercock et al. 2001, Debut et al. 2003). Differences between studies may be due to differences in ambient temperature, resting period before slaughter or starvation period before slaughter. On the other hand, it has been stated that cold weather conditions before slaughter may also cause stress in broilers and adversely affect meat quality. It has been reported by many researchers that breast meat has less drip loss, more shear force, darker meat color and higher pH compared to optimum weather conditions of broilers exposed to cold stress (Dadgar et al. 2010, 2011). Similar results were also recorded in this study. Broilers exposed to seasonal cold stress during transport use some of the glycogen in the muscles to keep their body temperature constant. Therefore, it is thought that less glycogen is converted to lactic acid and the pH of meat remains high (Warriss et al. 1999).

Effect of Transport Distance on Meat Quality Characteristics

In this study, it was determined that meat quality characteristics were affected more in summer than other seasons in different transportation distances in different seasons. Three different transport times (15 km, 50 km and 150 km) and season (autumn, winter and summer) stress on broilers were investigated by Elsayed (2014). In this study, it was determined that as the transport distance increased, glucose and LDH, decreased, while H:L and corticosterone increased. In addition, it has been reported that corticosterone increased in all seasons at 50 km, especially in long transport (150 km). Stress of broiler chickens increased in summer season. Nijdam et al. (2005) reported an increase in plasma corticosterone level of broiler chickens after 3 hours of transportation. Zhang et al. (2009) reported that the plasma glucose level increased slightly in the first 45 minutes and then decreased within 3 hours. Oba et al. (2009) investigated the effect of three different transport distances (30 min, 90 min and 180 min) on meat quality characteristics under hot weather conditions (33 ^{o}C). At the end of the study, it was reported that the a* value increased while the L* value decreased with the increase in the transportation period. Yalçin and Güler (2012) investigated the effects of three different transport distances (65 km, 115 km and 165 km) on blood metabolites and meat quality. At the end of the study, it was reported that long-distance transport (165 km) has a negative effect not only on animal welfare, but also on meat quality as well as slaughter weight is an important factor in the occurrence of this negative effect. A study in turkeys (Owens and Sams 2000) reported that turkeys transported for 3 hours had a significantly lower breast meat L* value compared to turkeys that were not transported. It was reported that there was a negative correlation between L* value and breast meat pH when the correlation between meat quality characteristics was examined. The results found in this study regarding transportation distance and meat quality characteristics are similar to the research findings of Yalçın and Güler (2012). Transport is the most important source of environmental stress for broilers (Mitchell and Kettlewell 1998). The extent of this stress is highly dependent on transport distance and ambient temperature (Warriss et al. 1992, Kannan et al. 1997, Warriss et al. 2005). It was reported that transportation longer than three hours causes increased mortality, increased carcass injuries and decreased carcass quality (Warriss et al. 1992). Since poultry are more sensitive to stress than other animal species, it is recommended that the transport time should be shorter (Warriss et al. 1993, 1999). It is thought that deteriorate in meat quality parameters due to the decrease in muscle glycogen stores when transport distance increase.

On the other hand, in the study by Vosmerova et al. (2010), three different ambient temperatures (25-35 ^{o}C, 10-20 ^{o}C and -5-5 ^{o}C) and four different transport distances (0 km, 10 km, 70 km and 130 km) were compared according to stress conditions of broilers transported. As a result of the research, it was reported that broiler chickens in short distance and cold weather conditions had the highest corticosterone level. Yue et al. (2010) used two different transport distances and two different rest periods (45 min transport and 45 min rest, 45 min transport and 3 hours rest, 3 hours transport and 45 min rest, 3 hours transport and 3 hours rest). Biochemical properties and meat quality parameters were compared between the groups. As a result of the research, there were biochemical changes between the groups, but it was reported that there was no significant change in breast meat quality characteristics other than the a* value. In another study, the same transport times and the same rest periods were applied (45 min transport and 45 min rest, 45 min transport and 3 hours rest, 3 hours transport and 45 min rest, 3 hours transport and 3 hours rest) (Zhang et al. 2009). It has been reported that short transport time and short resting time cause an increase in a* value. Bianchi et al. (2006), three different transport distances were applied (<40 km, between 40-210 km and >210 km) and meat quality characteristics were compared. It was reported that there was a significant difference only among a* values. The a* value was higher in broilers transported <40 km than in the other two transport groups. The results of current study on the effect of transport distance on meat quality characteristics are different from the results of some researchers (Bianchi et al., 2006; Zhang et al. 2009, Vosmerova et al. 2010; Yue et al. 2010). It is thought that the differences between the studies may be due to the differences in environmental temperature, resting period before slaughter, starvation period before slaughter, and transportation distances.

Incidence of DFD, normal and PSE meat

Bianchi et al. (2006) reported that broiler breast meats at <12^{o}C were darker. The a* and b* values were higher than those in other groups from broiler chickens housed at three different ambient temperatures (<12^{o}C, 12-18^{o}C and >18^{o}C). As a result of the study, it was reported that the incidence of PSE meat was 15.3% in housed at >18^{o}C, 13.3% in broilers housed in the 12-18^{o}C temperature range, and 2.8% in housed at <12^{o}C. Petracci et al. (2004) reported that the incidence of PSE meat was 26.7% in broilers sent to slaughter in the summer season, while this rate was 5.9% in the winter season. Dadgar et al. (2010) reported that the incidence of PSE meat was 13% at 20^{o}C ambient temperature while the incidence decreased to 4% at 0^{o}C.

In this study, it was determined that DFD meat incidence was highest in winter and PSE meat incidence was highest in summer. The results of this study were similar by Bianchi et al. (2006), Dadgar et al. (2010) and Petracci et al. (2004). In addition, many researchers (Mc Kee and Sams 1997, Owens and Sams 2000, Van Laack et al. 2000, Petracci et al. 2004, Bianchi et al. 2005) reported that the incidence of PSE meat was high at high ambient temperature while the incidence of DFD meat was high in cold environmental conditions.

This rate in Europe was %10 (Petracci et al. 2009), 5% in Poland (Lesiow et al. 2007), in England 20%, 37-47% in the USA (Woelfel et al. 2002). In this study, the overall incidence of PSE meat was 8.89%. The current results in this study was similar to the results of Petracci et al. (2009), it was lower than the value reported by Wilkins et al. (2000) and Woelfel et al. (2002). It is thought that the reason for the differences among the results may be due to the environmental temperature, the different microclimate conditions of the transport vehicles in different studies, the differences in the slaughter age and weight of the broilers. On the other hand, Lesiow et al. (2007) reported that the incidence of DFD meat was between 18-34%. DFD meat incidence was reported by Dadgar et al (2010) as 8% in broilers transported between −8^{o}C and 0^{o}C. The results obtained for DFD meat incidence in this study were similar to the results of Lesiow et al. (2007), while it was higher than the results of Dadgar et al (2010). Differences may be due to differences in DFD meat classification created by Dadgar et al. (2010) (pH>6.1 and L*<46).

CONCLUSION

Poultry transport from the coop to the slaughterhouse is a multifactorial and extremely stressful process involving many traumatic factors for broilers. This stress is highly dependent on transport distance and ambient temperature. These factors bring about economic loss by causing meat quality problems such as PSE or DFD. In this study, the effect of the season on meat quality characteristics was significant. It was determined that the meat obtained from broilers transported in the summer season was paler, less red, less yellow, higher drip loss and WBSF value than those transplanted in the winter season. In addition, it was determined that broiler chickens exposed to cold environmental conditions had a darker, less drip loss and less WBSF value due to the higher pH value of breast meat compared to other seasons. On the other hand, the highest PSE meat incidence was in summer, while the highest DFD meat incidence was in winter. At the same time, it was determined that the lowest normal meat incidence was in winter.

It was determined that meat quality characteristics were partially affected, as the transport distance increased, but the effect of transport distance was much more evident, especially in the summer season compared to other seasons. Broiler chickens are affected more in winter than other seasons because the DFD meat ratio is the highest and the normal meat incidence is the lowest. In addition, PSE meat incidence was highest in summer and the effect of transport distance was significant, especially in this season. In conclusion, In order to improve the meat quality transportation of broiler chickens should be carried out within thermal comfort zone ranges and avoided from long-distance transports especially in summer.

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