Tropical Animal Health and Production (2021) 53: 380
https://doi.org/10.1007/s11250-021-02817-w

REGULAR ARTICLES

Fatty acid profilies and some meat quality traits at different slaughter weights of Brown Swiss bulls

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Received: 11 March 2021 / Accepted: 18 June 2021 / Published online: 30 June 2021

Abstract

This research was done to detect some meat quality traits and tissue fatty acid combination of the longissimus dorsi thoracis (LT) muscle of Brown Swiss bulls at the different slaughter weights (SW). The animal material of the study comprised 20 Brown Swiss bulls. In the study, Brown Swiss bulls were divided into two groups according to their SW as low (LSW ($n=10$); 431–503 kg) and high (HSW ($n=10$); 504–583 kg). In the study, the LSW group showed the lowest final pH value (pH_F) (5.44) ($P<0.05$). As the SW increase, the L* (lightness) value decreased in the LT muscle of Brown Swiss bulls ($P>0.05$). In the research, the differences observed between the SW groups considering a* (redness) and C (chroma) values were found significant ($P<0.05$). LT muscle water holding capacity (PL) decreased ($P<0.01$) with increasing slaughter weight. In the study, the differences observed between SW groups in terms of drip losses (DL) after 3-day (DRP3) and 7-day (DRP7) storages and cooking losses (CL) determined were found insignificant ($P>0.05$). Freeze–thaw loss (FL) and ether extract (PEE) were found 4.35% and 1.01% higher, respectively, in the HSW group than the LSW group ($P<0.05$). Cholesterol content was determined as 66.15 and 70.68 mg 100 g^{-1} meat in LSW and HSW groups, respectively. The ratios of n-6/n-3 ($P<0.05$) and PUFA/SFA ($P>0.05$) in the LT muscle decreased with the increase of SW. As a result, when LSW and HSW slaughter weight groups were evaluated considering the water losses causing financial losses in meat and fatty acids having beneficial effects on human health, it was seen that the LSW group came to the fore.

Keywords Brown Swiss · Slaughter weights · Meat quality · Fatty acids · Cholesterol

Introduction

It has been reported that a healthy person should consume at least 1 g of protein for each kilogram of her/his total body weight (BW) every day and 42% of the protein consumed should be of animal origin (Saygın and Demirtaş 2018). Red meat ranks first among animal proteins, which are crucial for individuals' healthy and balanced diets (Onurlubaş et al. 2018). Cattle are one of the sources used in red meat production in Turkey. Depending on the population rise, the demand for red meat in Turkey increases day by day (Akın et al. 2020). This demand acceleration can be met by improving the genetic structure of existing breeds, preventing young and breeding animal slaughter, improving the care and feeding conditions in the breeding establishments, and increasing the carcass weight obtained from each animal. Yield development studies have been carried out to raise the low yield per animal since the early Republic years. During these studies, Brown Swiss cattle were imported from Austria and Hungary in 1925 and used in breeding local

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breeds (Yılmaz et al. 2012). Some of the farmers in Turkey because it has the ability to adapt to various climates prefer Brown Swiss cattle. So, Brown Swiss cattle are grown in all regions in Turkey according to farmers' preferences. Brown Swiss cattle are reared for meat and milk production. Brown Swiss cattle that are not used for breeding are used for meat production as their daily live weight gain in fattening is better than domestic cattle. Today, as a result of the animal breeding works, out of the total cattle population of 18.426.219 in Turkey, 8.74% of cattle are local breed, 42.83% are culture crossbred, and 48.43% are the culture breed. In Turkey's 1,201,469 tons of red meat production, the share of cattle beef is 89.51% with 1,075,479 tons of red meat production (TurkStat 2021). Today, because of the changing and updated consumer preferences, besides efforts to increase red meat production, the meat quality has become very significant (Aksoy and Ulutaş 2016; Şireli 2018). Besides consumers, also producers pay increasing importance to the quality concept in red meat in Turkey (Özkaya and Kayaardı 2018). Various researchers have reported that the final pH (pH_F) value, color, various periods PL, cooking loss, texture, and chemical combination are the main quality traits in red meats (Ma et al. 2013; Şireli 2018). Among these quality criteria, pH_F is the most important criterion because it affects meat's color, hardness, and water retention capacity (Uğurlu et al. 2017). Properties related to meat water holding capacity are particularly significant in terms of shelf life, appearance, and prevention of financial losses in meat. However, the most important factor affecting consumer preference among these quality criteria is color (Uğurlu et al. 2017; Saçlı 2018; Sarı et al. 2019). Generally, consumers characterize those with light shiny appearances as soft and young animal meat. The appeal of beef with this type of tint is high during the sales (Sarı et al. 2019). Today, the consumers prefer the meat to be not tough, easy to cook, and has little waste, and the cooking loss criterion is gaining importance as one of the meat quality parameters. Due to the low PUFA ratio and high SFA ratio, especially ruminant animal meats are continuously criticized for the risks they carry for cardiovascular health (Razmaite et al. 2020). It has been notified that omega-3 (n-3) series fatty acids (FAs), one of the PUFAs, reduce the amount of cholesterol and low-density lipoprotein (LDL) and specifically protect vascular and heart health (Öztürk 2014; Aksoy et al. 2021). Because of the biogenization in the rumen, ruminants' tissue fatty acid (FA) composition is less affected by diet than monogastric animals (Church 1993; Öztürkcan et al. 1996). For this reason, fatty acid composition and cholesterol content in red meats constitute one of the meat quality characteristics that researchers mostly emphasize. Many researchers have reported that SW affects the meat quality and tissue fatty acid profilies in cattle (Nogalski et al. 2014a; Mottin et al. 2020). In this context, tissue fatty acid combinations and some meat quality traits of Brown Swiss bulls in different slaughter weights were determined in this study.

Materials and methods

This investigation was made under commercial company conditions in the province of Kırşehir in the Central Anatolia area of Turkey. It has been reported that the altitude of the province is 985 m and the annual temperature varies between − 0.3 (January) and 22.8 °C (July), with an average of 11.3 °C (Anonymous 2021). The animal material of the research formed 20 heads of Brown Swiss bulls. In the study, Brown Swiss bulls were separated into two experimental groups according to their SW as low (LSW; 431–503 kg) and high (HSW; 504–583) SW. In the research, ten Brown Swiss bulls of each SW group were slaughtered in a licensed slaughterhouse to determine the meat quality characteristics. The slaughtering process in the slaughterhouse was made according to TSI (1987). In the research, 24-h postmortem pH (pH_F) and CIE Lab color parameters were found. Drip losses in the samples were determined by the tests performed on the third day (DRP3) and seventh day (DRP7). Cooking and thawing losses, the chemical composition A (ash), PEE (ether extract), CP (crude protein) and M (moisture) FA content, and cholesterol levels of the samples were determined. For this purpose, *M. longissimus dorsi thoracis* (LT) sample was obtained from a level between the 11th and 13th ribs and cleaned from fat and connective tissues to determine meat quality characteristics. LT muscle samples were protected at − 20 °C for thawing and cooking losses and chemical composition determination and − 80 °C for determination of cholesterol content and fatty acid profilies until the analysis day.

Meat quality traits

The LT muscle pH_F value was determined by using a Testo 205 brand (Germany) immersion-type meat pH device, which was inserted 2–3 cm into the LT muscle between the 12th and 13th ribs of the carcasses kept during 24-h postmortem in the slaughterhouse at + 4 °C (Ramirez and Cava 2007; Aksoy et al. 2021).

This research, LT muscle lightness (L*), redness (a*), and yellowness (b*) color parameter values were obtained by Konica Minolta CR95 400 brand (Japan) spectrocolorimeter according to CIE Lab (Aksoy and Ulutaş 2016; Aksoy et al. 2021). C (Chroma) (Formula 1) and H° (Hue) (Formula 2) values were determined using the a* and b* values determined 24-h postmortem in the LT muscle (Önenç 2003; Aksoy and Ulutaş 2016).

$$C = \sqrt{a^{*2} + b^{*2}} \quad (1)$$

$$H^{\circ} = \tan^{-1}\frac{b*}{a*} \quad (2)$$

LT muscle 24-h postmortem PL value was detected by the press procedure (Grau and Hamm 1956; Aksoy and Ulutaş 2016). The connective and adipose tissues were cleaned, and approximately 60-g LT muscle was taken and turned into mincemeat by Aura Type-103 brand (Turkey) mini chopper. One-gram homogenized meat sample was taken and placed between two filter papers of 125-mm diameter and pressed with 2.250-kg weight for 5 min. After the process, the press loss (PL%) value was calculated according to the formula (3).

$$PL(\%) = \frac{(a-b)}{a}x100 \quad (3)$$

In the equality, a is the specimen weightiness pre-press (g) and b is the specimen weightiness post-press (g).

After slaughtering, about 25 g of LT muscle meat samples was taken, nestled in vacuum bags, and then vacuumed. Drip losses on day 3 (DRP3) and day 7 (DRP7) were determined in LT muscle samples stored at + 4 °C for 3 and 7 days (Aksoy et al. 2021). The drip losses (DL%) at the end of storage were determined according to the formula (4).

$$DL(\%) = \frac{(c-d)}{c}x100 \quad (4)$$

In the equality, c is the sample weight before storage (g) and d is the sample weight after storage (g).

After slaughter, approximately 30 g of meat sample was taken from LT muscle and preserved in vacuum bags at − 20 °C till the investigation day. Before the analysis, the muscle samples were excluded from the deep freezer and were entirely defrosted by keeping the vacuum bags in a water bath at + 17 °C (Honikel 1997). Subsequent to thawing, the freeze–thaw loss (FL%) value was determined according to formula (5).

$$FL(\%) = \frac{(e-f)}{e}x100 \quad (5)$$

In the equality, e is the sample weight before deep freeze (g) and f is the sample weight after thawing (g).

The cooking loss (CL) value was determined in LT muscle meat samples after freezing and thawing. For this purpose, after thawing, the meat samples were vacuumed again in vacuum bags and cooked in a hot water container at + 80 °C temperature (for about 1 h) (Aksoy et al. 2021). Later, the meat samples were received from the hot water process and were chilled to + 25 °C with a cold water bath. The CL (%) value was determined according to the formula (6).

$$CL(\%) = \frac{(f-g)}{f}x100 \quad (6)$$

In the equality, f is the sample weight after thawing (g) and g is the sample weight after cooking (g).

In the study, LT muscle chemical composition was detected in a meat sample. The M, A, and CP contents in LT muscle chemical composition were detected according to AOAC (1990). PEE levels was detected using the ANKOM XT10 Extractor device (Spain) using petroleum ether (approximately 500 ml, 90-min hot extraction) (Aksoy and Ulutaş 2016).

Fatty acid profilies and cholesterol content

Triacylglycerides in the lipid obtained by cold extraction from the LT muscle were transformed to FAME (fatty acid methyl esters) according to ISO (2011) (ISO 12,966–2: 2011 method). Perkin Elmer Auto system GLX (USA) brand gas chromatography system (GC) was used to define FAME. The SP™-2380 silica capillary column (100 m × 0.25 mm I.D. × 0.25 µm film thickness) and the Supelco 37 FAME mix (C4-C24) (USA) were utilized as a criterion for identification of fatty acid methyl esters through the GC. LT muscle cholesterol content was determined with the same model GC utilizing SE-54 column (5% phenyl-1% vinyl-methyl-polysiloxane, 30 m × 0.32 mm × 0.25 µm film thickness). The cholesterol content in the study was performed according to ISO (1999) as reported by Dağ et al. (2015).

Analysis

The research data were evaluated via SPSS (2016) package program utilizing the GLM (general linear model) procedure. T test was utilized to compare group averages.

Results

In the research, some meat quality traits of LT muscle of Brown Swiss bulls in different SW groups are given in Table 1. In the study, the lowest pH_F value was found in the LSW group ($P < 0.05$). L* value in Brown Swiss bulls was similar in LSW and HSW groups ($P > 0.05$). As the SW increased, the a* value of the LT muscle decreased. In the study, the variations between the SW groups were determined insignificant ($P > 0.05$) in terms of b* and H° values. PL value was lower in LSW group (20.55%) than HSW group (23.72%) ($P < 0.01$). In the study, the determined drip loss differences between SW groups after 3 and 7 days of

Table 1 According to HSW (504–583) and LSW (431–503) slaughter weight groups meat quality traits of LT muscle

Traits	SW group (kg)		SEM	Sig
	431–503	504–583		
pH_F	5.44	5.51	0.021	*
Color of *longissimus dorsi thoracis* (LT) muscle				
L*	38.62	38.19	0.234	-
a*	17.72	15.13	0.579	**
b*	6.56	4.93	0.590	-
C	18.93	15.81	0.735	**
H^o	18.84	16.69	1.253	-
Water holding capacity (%)				
3rd day drip loss	11.98	13.32	0.474	-
7th day drip loss	14.90	16.47	0.557	-
Press loss	20.55	23.72	0.689	**
Freeze–thaw and cooking loss (%)				
Freeze–thaw loss	13.23	17.58	0.640	***
Cooking loss	35.02	35.09	0.361	-

- insignificant. *$P > 0.05$; **$P < 0.01$; ***$P < 0.001$

SW slaughter weight; *LSW* low slaughter weight; *HSW* high slaughter weight

storage were insignificant ($P > 0.05$). For LSW and HSW groups, the cooking losses were determined as 35.02% and 35.09%, respectively. Only PEE differences in the chemical composition of LT muscle in Brown Swiss bulls SW groups were significant in the study ($P < 0.05$; Table 2). Cholesterol content was determined as 66.15 mg and 70.68 mg 100^{-1} meat in LSW and HSW groups, respectively ($P < 0.01$). In Table 3, the LT muscle FA profiles of the Brown Swiss bulls are presented. In this study, with the increase in SW weight, the oleic acid ratio (C:18:1n-9c) of monounsaturated fatty acids (MUFA) decreased ($P > 0.05$). Except for eicosatrienoic acid (C20:3n-3) of PUFAs, the differences in terms of other fatty acids were found insignificant ($P > 0.05$). In the study, the n-6/n-3 and the PUFA/SFA ratios of LT muscle decreased with the SW increase. In the study, although the differences observed between the LSW and the HSW groups in terms of PUFA/SFA value were insignificant ($P > 0.05$), the differences observed in the n-6/n-3 proportion were determined significant ($P < 0.05$).

Discussion

Meat quality traits

The final pH (pH_F) value of meat is significant in meat formation quality as it affects thawing loss, water holding capacity, storage, cooling, firmness, and meat color (Sarı et al. 2019). In the study, the postmortem pH_F values for LSW and HSW groups of Brown Swiss bulls were determined 5.44 and 5.51, respectively, and the pH_F value dissimilarities between the SW groups were detected important ($P < 0.01$). Çatıkkaş and Koç (2017) observed the postmortem pH_F value of Brown Swiss bulls at 512-kg SW as 5.94. In a study performed on Brown male calves (Cerdeño et al. 2006a), the LT muscle pH_F value at 400-kg, 407-kg, and 472-kg SW was determined as 5.67, 5.65, and 5.61, respectively. Besides, in another study with the same muscle, sex, and genotype parameters, Cerdeño et al. (2006b) found the pH_F value as 5.61, 5.65, and 5.66 at the 200-kg, 250-kg, and 450-kg SW, respectively. The pH_F values obtained in this research were found lower than the values determined in studies performed on Brown male calves (Cerdeño et al. 2006a, 2006b). The pH_F value determined for the HSW group in the study was found close to the value found by Tagliapietra et al. (2018) for Brown Swiss bulls.

Meat color is the most significant agent affecting consumer choice in the visual assessment of meat. The meat color in beef is desired to be bright cherry red, and deviations from this color negatively affect consumer decisions (Mancini and Hunt 2005; Aksoy et al. 2021). In the study, the L* (brightness) value measured 24-h postmortem was found higher in the LSW (38.62) group than the HSW (38.19). Many researchers have reported the meat color becomes darker with the increase in the slaughter weight (Önenç 2003; Aksoy and Ulutaş 2016; Aksoy et al. 2021). Many researchers have suggested that the rise in slaughter

Table 2 Chemical combination (%) and cholesterol content (mg 100 g^{-1} meat) of LT muscle for SW groups

SW groups	Contents				
	Protein (CP)	Ash (A)	Moisture (M)	Ether extract (PEE)	Cholesterol
431–503 kg	23.49	0.96	68.79	6.53	66.15
504–583 kg	23.78	0.96	71.23	7.54	70.68
SEM	0.498	0.000	0.457	0.333	0.206
Sig	-	-	-	*	**

- insignificant. $P > 0.05$; *$P < 0.05$; **$P < 0.01$

SW slaughter weight; *LSW* low slaughter weight; *HSW* high slaughter weight

Table 3 LT muscle fatty acid profilies according to HSW (504–583) and LSW (431–503) slaughter weight (wt.%)

Fatty acids	SW (kg)		SEM	Sig
	431–503	504–583		
C10:0	0.050	0.047	0.005	-
C12:0	0.055	0.056	0.005	-
C14:0	2.561	2.781	0.155	-
C15:0	0.334	0.367	0.027	-
C16:0	24.971	26.280	0.445	-
C17:0	0.985	0.855	0.045	-
C18:0	16.120	16.750	0.590	-
C20:0	0.097	0.100	0.003	-
C21:0	0.231	0.492	0.108	-
SFA	45.400	47.730	0.049	*
C14:1	0.556	0.694	0.138	-
C16:1	2.894	2.852	0.145	-
C18:1 n-9t	0.942	0.773	0.101	-
C18:1 n-9c	38.660	37.810	0.940	-
C20:1	0.170	0.146	0.006	*
C18:3 n-3	0.155	0.150	0.017	-
C21:0	0.231	0.492	0.108	-
MUFA	43.220	44.270	0.995	-
C18:2 n-6c	2.995	2.564	0.195	-
C18:3 n-3	0.155	0.150	0.017	-
C20:3 n-3	0.044	0.061	0.005	*
C20:4 n-6	0.102	0.166	0.030	-
PUFA	3.326	2.971	0.230	-
UFA	46.550	45.240	0.905	-
PUFA/SFA	0.073	0.062	0.004	-
n-6	3.097	2.730	0.210	-
n-3	0.199	0.211	0.019	-
n-6/n-3	16.250	13.120	0.840	*

- insignificant, $P > 0.05$; *$P < 0.05$

SEM standard error of mean, *LSW* low slaugher weight; *HSW* high slaugher weight

weight and age will improve in meat pigment density and, consequently, the meat color will darken (Sañudo et al. 2007; Aksoy et al. 2021). Although it was insignificant ($P > 0.05$) in the study, the lowest L* value was found in the HSW group, similar to the literature reports. Cerdeño et al. (2006a) determined the L* value in 400-kg, 407-kg, and 472-kg SW Brown Swiss male calves as 36.1, 39.5, and 37.4, respectively. In another study (Cerdeño et al. 2006b) performed on Brown Swiss male calves, the L* value was determined as 41.5, 38.4, and 39.5 for 200-kg, 250-kg, and 400-kg SW, respectively. In another study performed on cattle with 506-kg SW of the same breed, the L* value was found 35.90 (Tagliapietra et al. 2018). Çatıkkaş and Koç (2017) determined the value 33.78 for Brown Swiss bulls with 512-kg SW. The L* values detected in the current study for both SW groups were lower than the values declared by Vieira et al. (2005) and Cerdeño et al. (2006b) and higher than the findings found by Tagliapietra et al. (2018), Çatıkkaş and Koç (2017), and Cerdeño et al. (2006a) studies. For LSW and HSW groups, a* (redness) value was determined as 17.50 and 15.09 respectively, and as the SW increased, the redness (a*) value decreased. The redness (a*) value in both SW groups in this search was found higher than the values determined in various examinations (Cerdeño et al. 2006a, 2006b; Tagliapietra et al. 2018). In the study, the redness (a*) value observed in the HSW group was like to the result found by Çatıkkaş and Koç (2017) for Brown Swiss bulls (512-kg SW). In the current study, the HSW group redness (a*) value observed was found close to the research Cerdeño et al. (2006a) for Brown Swiss bulls with 400 kg SW. The LSW group redness value of this research was found higher than the results determined by some studies (Cerdeño et al. 2006a, 2006b). In this study, the b* (yellowness) value was found higher in LSW (6.56) and HSW (4.94) groups. The b* value was determined as 12.9, 12.1, and 10.8 in Brown Swiss male calves at 400-kg, 407-kg, and 472-kg SW, respectively (Cerdeño et al. 2006a). The b* value determined in both SW groups in this research was found higher than the values determined for the different SW, the same genotype (Cerdeño et al. 2006b; Çatıkkaş and Koç 2017), and lower than the value observed for the Brown Swiss cattle (Cerdeño et al. 2006a; Tagliapietra et al. 2018). The HSW group b* value is lower than the values reported for Brown Swiss male calves (Vieira et al. 2005) and is approximate to the value determined for LSW in Vieira et al.'s (2005) finding. PL affects both the sensory quality and economic value of meat (Modzelewska-Kapituła et al. 2015). In present investigation, the highest PL value was found in the HSW group. Therefore, the PL value increased due to the increase in SW. Similar to the research findings, Vieira et al. (2005), Cerdeño et al. (2006b), and Kul et al. (2020) reported that the PL value in meat increased with the increase of SW. Kul et al. (2020) determined the water holding capacity of Holstein bulls at 450- to 520-kg SW and 521- to 580-kg SW, 25.33% and 26.98%, respectively. In the current study, the PL values detected in both SWs were found lower than the values found in Holstein bulls (Kul et al. 2020). The research findings were higher than the value determined in Brown Swiss cattle (Cerdeño et al. 2006b) and Grey cattle (Soysal 2012). The difference in the research findings from other research results might have occurred because of the variation in the procedure employed to identify the PL value as well as the breed, breeding system, and slaughter weight.

Water drip loss causes financial losses in meat, especially during cooling and storage, depending on the meat's water holding capacity. Besides, low PL can have a high drip loss, and corrupts the visuality of such meat. Therefore, this situation may negatively affect the preferences of consumers

prioritizing visuality in meat (Jama et al. 2008; Aksoy et al. 2021). In this search, the drip loss was detected higher in the HSW group than the LSW group in both periods after storage, but it was insignificant ($P > 0.05$). In the research, the DRL3 and DRL7 value found for Brown Swiss bulls were lower than the value observed by Kul et al. (2020) for Holstein bulls 450- to 520-kg SW (14.06 and 15.81%) and 521- to 580-kg SW (15.60 and 17.75%).

It has been reported that cell membranes are damaged when meat is frozen. In this case, water holding capacity decreases in frozen and thawed meats, and cooking loss becomes higher than fresh meats (Lagerstedt et al. 2008). Cooking loss, one of the meat quality parameters, occurs as thawing, dripping, and evaporation. Therefore, cooking losses have been stated to cause high economic losses in the beef industry and increase the loss of essential nutrients in some meat products (Jama et al. 2008). In the investigation, the CL values determined in the frozen-thawed meat samples of SW groups of Brown Swiss bulls were similar. In the study, the CL value determined in both experimental groups was higher than the value observed for Brown Swiss bulls in various studies (Cerdeño et al. 2006a, 2006b; Çatıkkaş and Koç 2017) in different SW groups. This situation may be due to the various methods applied to determine the CL value after freezing and thawing.

The amount of M, PEE, and CP in the meat content is another significant criterion used in determining the meat quality (Şireli, 2018). In the study, the differences in PEE value between SW groups of Brown Swiss bulls were found significant ($P < 0.05$). In the study, the PEE value of each SW group in Brown Swiss bulls was higher than the value of Brown Swiss male calves reported by Cerdeño et al. (2006a) for 400-kg, 407-kg, and 472-kg SW and Cerdeño et al. (2006b) for 200-kg, 250-kg, and 450-kg SW. Besides, in the study, the PEE value detected in the LSW group was found coherent with the value declared for Brown Swiss × Dajal crossbred heifers (Fayyaz et al. 2004). In the study, although it was not significant ($P > 0.05$), the CP amount in the HSW group was higher than the LSW. In the research, the CP value determined for LSW and HSW groups showed a resemblance to the values declared by Cerdeño et al. (2006a) for 407-kg (23.62%) and 472-kg (23.43%) SW and Cerdeño et al. (2006b) for 250-kg and 450-kg SW.

The value A of Brown Swiss cattle, Brown Swiss × Dajal Cross, Holstein, Charolais × Holstein–Friesian cross (slaughtered between 200 and 510 kg) varied between 1.02 and 1.26% (Fayyaz et al. 2004; Cerdeño et al. 2006a, 2006b; Nogalski et al. 2018). Kul et al. (2020) reported that the value A of the Holstein bulls 450- to 520-kg and 521- to 580-kg SW were 0.95% and 0.97%, respectively. The value A detected in the LSW and HSW groups in the current research was compatible with the value declared by Kul et al. (2020).

Fatty acid profiles and cholesterol content

This study determined that among the SFAs, palmitic (C16:0) and stearic acid (C18:0) were at the highest level in the LT muscle in SW groups. It was seen that while the HSW group had the highest C16:0 content value, the LSW had the lowest, and the difference between the group averages was also insignificant ($P > 0.05$). No difference was detected in the C18:0 content of both SW groups. It was reported that the contents of SFAs C18:0 and C16:0 in M. longissimus dorsi (Karabacak et al. 2012) of Brown Swiss bulls of 544-kg SW and Holstein bulls of 535-kg SW were considerable. In their study, Mottin et al. (2020) found the C16:0 content in the male Brown Swiss × Nellore crossbreeds of 450-kg, 469kg-, 491-kg, and 513-kg SW as 27.93%, 28.83%, 27.52%, and 28.06%, respectively. In the study, the C16:0 values determined for each SW were higher than the values found in Hungarian Simental (Holló et al. 2001) and Brown Swiss × Nellore crossbred cattle (Mottin et al. 2020).

In the study, the C16:0 value detected in the LSW group was found compatible with the value stated in the study by Filipčík et al. (2011) for the Charolais bulls 581- to 640-kg SW and 641- to 700-kg SW. The C18:0 values detected in this investigation were found close to the results detected for male Brown Swiss × Nellore crossbreeds at 450-kg, 469kg-, 491-kg, and 513-kg SW (Mottin et al. 2020). Besides, the research finding (C18:0) was found higher than the value stated by Vieira et al. (2005) for Brown Swiss male calves. In the study, the values of C18:0 in both slaughter weights were found lower than the values stated by several searchers (Holló et al. 2001; Filipčík et al. 2011; Kul et al. 2020) for Hungarian Simmental, Holstein, and Charolais cattle of 401- to 700-kg SW (18.40–22.90%).

Palmitoleic and oleic acid are desirable monounsaturated fatty acids in human nutrition due to their positive effect on total cholesterol levels (Denke and Grundy 1992). Although not statistically significant in the study, C16:1 and C18:1 fatty acid content decreased with the SW increase ($P > 0.05$). Differing from the study findings, Kul et al. (2020) (for Holstein bulls) and Holló et al. (2001) (for Hungarian Simmental) reported in their studies that the C16:1 and C18:1 fatty acid content would increase with an SW increase in the cattle. Again, in a research conducted on Polish Holstein–Friesian and Limousin crossbred bulls and steers (Nogalski et al. 2014b), it was reported that C18:1 increased with the SW increase. Similar to the study findings, it was determined that C16:1 fatty acid content decreased with the increase of SW in Holstein (Holló et al. 2001) and Charolais cattle (Filipčík et al. 2011). In the research, the C18:1 contents determined in both SW groups were higher than the value observed for Charolais and Holstein crossbreed cattle in several investigations (Nogalski et al. 2018; Kul et al. 2020) and lower than the value determined for Charolais cattle (Filipčík et al.

2011). In the current investigation, the C18:1 value detected in both SW groups was found similar to the value determined for Holstein–Friesian bulls in semi-intensive and intensive breeding systems (Nogalski et al. 2014a). It was determined that the SFA ratio increased with the increase of SW in LSW and HSW groups, and the dissimilarity between SW groups was also important ($P < 0.05$). Unlike the research findings, some studies (Zawadzki et al. 2015; Mottin et al. 2020) informed that the SFA ratio decreased with the increase of the SW. Mottin et al. (2020) determined the SFA contents of Brown Swiss × Nellore crossbreeds of 450-kg, 469-kg, 491-kg, and 513-kg SW as 49.73%, 50.53%, 49.78%, and 50.06%, respectively. The results stated by Zawadzki et al. (2015) for Angus and Nellore crossbreeds of 443-kg and 500-kg SW, respectively, were lower than the HSW group value and higher than the LSW group value in this search. In this investigation, the SFA content detected in both SW groups was higher than the result detected by Karabacak et al. (2012) for Brown Swiss bulls and lower than the result detected by Vieira et al. (2005) for male calves of the same breed. In this investigation, the PEE value was higher in Brown Swiss bulls in the HSW group ($P < 0.05$). Similarly, a study conducted on Nellore cattle (Pereira et al. 2012) reported that the meat of higher weight animals had a higher PEE content, and this situation was directly related to the percentage of total carcass fat and monounsaturated fatty acid (MUFA). The MUFA value determined in two different slaughter weights in the research was lower than the values determined for the Angus and Nellore crossbred cattle (Zawadzki et al. 2015) of 386-kg, 443-kg, and 500-kg SW (46.8%, 45.9%, and 48.7%, respectively) and higher than the values reported for Purunã bulls (Ito 2010) of 465.1-kg and 469.0-kg SW (41.9%, 41.1%, respectively).

In this research, it was defined that while SW raised, also SFA and MUFA ratio increased and PUFA ratio decreased, and except SFA, the difference between group averages was statistically insignificant ($P > 0.05$). In a study conducted on Simmental bulls of two different SW (401–500 kg and 501–600 kg), it was stated that as the SW weight increased, the ratio of SFA and MUFA increased and PUFA rate decreased, meanwhile the differences between the group averages were found insignificant (Holló et al. 2001). Similar to the findings of this research, in the study conducted on Holstein, Belgian Blue bulls, and Brown Swiss × Nellore crosses, it was reported that as the carcass weight increased, the ratio of SFA and MUFA increased and the PUFA ratio decreased (Smet et al. 2000; Weglarz 2010; Nogalski et al. 2014a; Mottin et al. 2020). In this investigation, the gap between LSW and HSW groups PUFA/SFA ratio in Brown Swiss bulls was detected statistically insignificant ($P > 0.05$). It is suggested that the PUFA/SFA proportion should be 0.4 or higher in foods taken for a healthy life (Razmaite et al. 2020; Aksoy et al. 2021). In this research, PUFA/SFA ratios determined for LSW and HSW groups were lower than the suggested values. Similarly, the PUFA/SFA proportion in Hungarian Simmental and Holstein cattle was determined as 0.6–0.6 and 0.06–0.07, respectively (Holló et al. 2001). These reports show a resemblance to the research findings. In three different slaughter weights in a study, PUFA/SFA values were determined as 0.80%, 0.17%, and 0.11% in Angus and Nellore crossbreeds (Zawadzki et al. 2015). The PUFA/SFA ratios calculated in this investigation were lower than the value stated for Angus × Nellore crosses (Zawadzki et al. 2015) and Purunã bulls (Ito et al. 2010).

The n-3 FAs inhibit the synthesis of LDL (low-density lipoprotein = "bad" cholesterol) from saturated fatty acids in the liver and reduce its formation. Therefore, many researchers reported that the risk of atherosclerosis is prevented or delayed by lowering LDL in the blood (Mol 2008; Çelebi et al. 2017; Aksoy et al. 2021). Although the n-3 value detected in the LSW group in the study was statistically significant ($P < 0.05$), it was lower than the HSW group. Kul et al. (2020) (in Holstein bulls) and Nogalski et al. (2014a) (in Polish Holstein–Friesian × Limousin's bulls crossbreeds), although they found the SW effect on the n-3 fatty acid proportion as insignificant similar to the research findings, unlike the research findings, reported that the n-3 proportion increased with a decrease in SW.

The fatty acid profilies of meat is crucial, especially since n-3 and n-6 fatty acids have many benefits to human health (Simopoulos 2016). Some researchers reported that the ideal n-6/n-3 fatty acid proportion ranges between 5:1 and 1:1 (Kim et al. 2007; Ibrahim et al. 2018; Aksoy et al. 2021). It was declared that this rate is important due to cancer and coronary disease risks caused by unbalanced nutrition (Corpet 2011). In this study, the rates determined for LSW and HSW groups were found higher than ideally reported values. It was detected that the n-6 fatty acid content determined for the LSW group was higher than HSW, and the n-3 value determined in the HSW group was higher than LSW. Therefore, this situation caused the n-6/n-3 proportion to be lower in the HSW group than the LSW group. Similar to the research findings, Holló et al. (2001) declared that the n-6/n-3 decreased in Hungarian Simental cattle with the SW increase, but this rate increased in Holstein. The n-6/n-3 value found in this research was detected higher than the values determined for purebred and crossbred cattle in different breeds and SW groups (465.1- to 600-kg SW) in various investigations (Holló et al. 2001; Ito et al. 2010; Nogalski et al. 2014a).

Cholesterol is crucial for heart health because it causes disorders such as coronary heart diseases in humans (Ma and Shieh 2006). In the study, the cholesterol content detected in the SW groups in Brown Swiss bulls were found similar to the Kul et al. (2020) study findings on Holstein bulls: 450- to 520-kg SW for the LSW group

(65.56 mg 100 g^{-1} meat) and 521- to 580-kg SW for the HSW group (70.25 mg 100 g^{-1} meat). In this study, the cholesterol contents determined in both SW groups were detected higher than the value reported by Soysal (2012) in Grey cattle.

Conclusion

Higher carcass weights should be obtained in cattle breeding considering plenty of factors such as economic conditions, meat prices, red meat deficit, and the share of beef in red meat production in Turkey. This increase will only be possible with the high slaughter weight of cattle. However, the quality concept is significant and should be taken into consideration in today's world, where the primary preference of retailers, industrialists, and consumers is healthy, reliable, and low-loss meat. In this context, the L* value is observed partially darkened in Brown Swiss beef bulls, even though it is not statistically significant when the above preferences are taken into account in the study. DRP3, DRP7 CL (although not statistically significant), and FT values, which cause economic losses in meat, increased with SW increase, and PL value showed a decrease. Again, in terms of its beneficial effects on human health, the highest PUFA/SFA ratio and the lowest cholesterol content were found in the LSW group. LSW group comes to the forefront in the research, especially considering the meat quality characteristics with economic value, PUFA/SFA ratio, and cholesterol content in meat. In the study, the meat and fatty acid profilies of two different SW groups in Brown Swiss bulls were revealed. Considering Brown Swiss bulls are the most significant source of red meat production in Turkey, more studies should be carried out and determined different performances in different SW combinations.

Author contribution Conducting and planning of this investigation was made by AŞ, EU, and YA, and results of the research were evaluated by AŞ, ZU, and EK. This manuscript was written by AŞ and YA.

Funding This project has been supported by Scientific Research Projects Commission of Kırşehir Ahi Evran University as financial (PYO-ZRT.4001.14.002).

Data availability All data obtained or assessed in this investigation had utilized in presently published manuscript.

Declarations

Ethics approval The protocol of this investigation was accepted by the Kırşehir Ahi Evran University local animal ethics committee.

Conflict of interest The authors declare no competing interests.

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