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# Effect of fat levels in early phase on growth performance and meat characteristics in twin lambs

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**Abstract:** This experiment aims to study the effects of dietary fat level during the suckling period on growth performance and meat characteristics in twin lambs. Thirty pairs of male twin Hu lambs were divided into two groups, namely high fat (HF) and normal fat (NF). Lambs in HF group were fed milk replacer and starter containing 26.89% and 5.07% of fat, whereas those in NF group were fed milk replacer and starter containing 15.15% and 2.80% of fat, respectively, from eight to 60 days of age. From 60 to 120 days of age, all lambs were fed a starter feed containing 2.80% fat. The results showed that lambs fed HF diet had higher body weight (12.78 kg versus 11.63 kg, $P = 0.020$), average daily gain (162.4 g/day versus 141.1 g/day, $P = 0.019$), apparent digestibility of organic matter ($P = 0.018$) and gross energy ($P < 0.001$). No difference was observed between HF and NF group in slaughter performance during eight to 60 days of age. Lambs fed HF diet had higher body weight at 120 days of age ($P = 0.035$). However, no difference was observed in nutrient digestibility, slaughter performance or meat quality at 120 days of age. In summary, HF diet in the suckling period showed long-lasting beneficial effects on the growth performance of lambs.

**Keywords:** fat level; meat quality; twin lamb; nutrient digestion

The dietary manipulation in early life could influence later body growth and development. However, early nutrition was ignored because it could not provide an income for producers in the lamb stage. Studies showed that high-energy density diets positively influence productive indicators in lambs (do Nascimento Barreto et al. 2019). However, dietary energy cannot be calculated directly. Dietary fat is the main energy source. Its levels not only affect the energy supply of lambs but also link to the early development of the digestive tract, the solid food intake, and the digestion and absorption of other nutrients (Broudiscou et al. 1994). Also, feeding a starter feed with high fat helped to attenuate the slump in growth at weaning in calves raised on intensive feeding programs (Araujo et al. 2014). The study of Ghasemi et al. (2016) showed that the change of fat content in muscle varied with the type of dietary fat. Therefore, in this study, we will make upward adjustments of fat in diet (both milk replacer and starter) for determination of growth performance and meat characteristics in lambs.

Hu sheep is a famous and popular breed in China and in the world. Their reproduction rate is greater

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than 200%, and reproduction frequency is lambing twice a year or three times in two years (Wang et al. 2018). In this trait, twin lambs were chosen to maintain a consistent genetic background (Danso et al. 2016). At present, there are many literary sources about fat nutrition focus on monogastric animals and cattle, but limited data related to sheep, especially newborn twin lambs, are available. The study investigated the effects of high fat diet on the body weight gain, nutrient digestibility, dressing rate and physicochemical properties of the *longissimus dorsi* muscle using thirty pairs of twin lambs.

## MATERIAL AND METHODS

### Experimental design and animal processing

All animals in the experiment were managed in accordance with the Guidelines for Experimental Animals established by the Ministry of Science and Technology (Beijing, China). Animal welfare issues were approved by the Science Research Department (in charge of animal welfare issues) of the Institute of Animal Sciences, Chinese Academy of Agriculture Science (Beijing, China).

Thirty pairs of male twin Hu lambs with 4.22 ± 0.56 kg (birth weight ± SD) were selected and separated from ewes at day 7. All the lambs were assigned to two groups using a matched-pairs design, which meant that 30 paired twins were divided into two treatments. Each treatment had 10 replicates, and three lambs as one replicate were fed in individual pens. The two treatments were fed high fat (HF) and normal fat (NF) diet that were designed using NRC (2007). During the experimental period, the HF group was fed milk replacer (MR) and starter containing 26.89% and 5.07% fat, respectively, whereas the lambs in the NF group were fed milk replacer and starter containing 15.15% and 2.80% fat. All lambs were fed MR at 2% of body weight (BW) between day 7 and 50 and 1.5% of BW from day 50 to 60. The MR was fed at 06:00, 12:00 and 17:30, and the fresh starter was provided daily. Clean water and starters were provided *ad libitum*. The amount of MR was adjusted every seven days according to the weight of lambs. The formula of milk replacer was prepared by cooling the boiling water to 50–60 °C hot water. The ratio of MR to water in 7–50 days old lambs was 1 : 6, and that of 50–60 days old lambs was 1 : 7. After brewing, the mixture was evenly stirred and cooled to 38 ± 2 °C. From 61 to 120 days of age, all lambs were fed the same starter containing 2.80% fat to better detect effects of dietary energy in early life on later performance. During the whole experiment, the starter and water were taken freely.

The experimental diets were formulated according to the NRC (2007), and their composition is presented in Table 1. The MR was formulated with milk fat in NF group, and in HF group MR was added coconut oil and palm oil (the ratio of coconut oil and palm oil was 1 : 1) based on NF group.

### Growth performance

Body weight was measured on day 7, 60, and 120 before morning feeding. The starter and orts were recorded daily and used to calculate the intake of each pen as experimental unit.

### Apparent nutrient digestibility

From 50 to 60 days and 110 to 120 days of age, digestibility trials were conducted using nine lambs from each group. The lambs were moved from their floor pens into 80 × 50 cm$^2$ individual metabolism crates in which faeces and urine were separately collected for five days after five days of adaptation. All faecal and urinary samples were collected and recorded daily before morning feeding. After thorough and uniform mixing, 10% of the total faeces were collected and mixed with 10 ml of 10% $H_2SO_4$. These samples were separately mixed for each animal. Starter, urine, and faeces samples were kept frozen at −20 °C for later analysis.

### Slaughter performance

Nine pairs of twin lambs from the two groups were slaughtered at 60 and 120 days of age, respectively. Feed was withheld for 16 h before slaughtering. Live body weight (LBW) was measured before slaughtering. The lambs were exsanguinated via severing the carotid artery and jugular vein, then the empty body weight (EBW) was calculated as the BW minus the weight of the content of the gastrointestinal tract. The hot carcass weight (HCW) was recorded after the removal of non-carcass components. The pH of the *longissimus dorsi* muscle was recorded using

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Table 1. Ingredients and nutritional composition of milk replacer and starter (%)

| Items | Milk replacer | | Starter | | |
|---|---|---|---|---|---|
| | normal fat | high fat | normal fat | high fat | IS |
| **Ingredients** (air dry basis) | | | | | |
| Corn (%) | – | – | 47.25 | 50.00 | 55.00 |
| Soybean meal (%) | – | – | 28.70 | 31.48 | 19.00 |
| Wheat bran (%) | – | – | 20.00 | 10.00 | 7.60 |
| *Leymus chinensis* (%) | – | – | 0.00 | 0.00 | 6.00 |
| Fat (%) | – | – | 0.00 | 4.34 | 0.00 |
| Mountain flour (%) | – | – | 2.56 | 2.44 | 1.60 |
| Salt (%) | – | – | 0.43 | 0.44 | 0.35 |
| Anhydrous calcium hydrogen phosphate (%) | – | – | 0.52 | 0.30 | 0.45 |
| Premix[1] | – | – | 1.00 | 1.00 | 1.00 |
| Total | – | – | 100.00 | 100.00 | 100.00 |
| **Nutrient levels** | | | | | |
| Dry matter (% as feed) | 94.77 | 95.04 | 93.48 | 93.44 | 86.79 |
| Gross energy (MJ/kg of DM) | 19.57 | 21.77 | 16.63 | 17.01 | 17.69 |
| Crude protein (% of DM) | 23.12 | 23.53 | 20.97 | 21.01 | 15.35 |
| Ether extract (% of DM) | 15.15 | 26.89 | 2.80 | 5.07 | 2.81 |
| Neutral detergent fibre (% of DM) | – | – | 15.20 | 12.91 | 21.07 |
| Acid detergent fibre (% of DM) | – | – | 5.18 | 4.52 | 2.48 |
| Ash (% of DM) | 6.06 | 6.54 | 7.06 | 7.06 | 6.63 |
| Ca (% of DM) | 1.12 | 1.15 | 1.04 | 1.03 | 1.06 |
| P (% of DM) | 0.63 | 0.67 | 0.52 | 0.48 | 0.45 |

DM = dry matter; IS = identical starter (feeding the same feed after weaning)

[1]1 kg of premix contained the following: Fe 22.1 g, Mn 9.82 g, Cu 2.25 g, Zn 27.0 g, Se 0.19 g, I 0.54 g, Co 0.09 g, vitamin A 3.20 g, vitamin D 30.80 g, vitamin E 0.4 g

a digital pH meter (Testo 205; Testo SE & Co. KGaA, Titisee-Neustadt, Germany). The *longissimus dorsi* muscle was sampled between the 11$^{th}$ and the 12$^{th}$ rib and divided into two parts: one for physicochemical parameter measurement and the other for chemical composition determination.

## Chemical analysis

Feed, orts, and faeces were oven-dried at 65 °C for 72 h, ground to pass through a 1 mm screen for analysing dry matter (DM) (method 930.15, AOAC 1990), ether extract (EE) (method 920.85, AOAC 1990), and ash (method 924.05, AOAC 1990). The gross energy (GE) of feed was measured with a bomb calorimeter (6400; Parr Instrument Company, Moline, IL, USA). The neutral detergent fibre (NDF) and acid detergent fibre (ADF) of feed were measured according to Van Soest et al. (1991). Total phosphorus of feed was analysed by the molybdovanadate colorimetric method (method 965.17, AOAC 1990) using a spectrophotometer (UV-6100; Mapada Instruments Co., Ltd., Shanghai, China). Calcium of feed was analysed using an atomic absorption spectrophotometer (M9W-700; Perkin-Elmer Corp., Norwalk, CT, USA) (method 968.08, AOAC 1990).

## Proximate composition, colour, pH, drip loss, and shear force measurement

Samples of the *longissimus dorsi* muscle for measurement of physicochemical parameters were used to detect drip loss, shear force, and cooking loss. The contours of the *longissimus dorsi* muscle between the first and the second rib were depicted using sulphuric acid paper and the contour area of the rib eye area was calculated. The $pH_{45min}$ of the *longissimus* sample was measured using an insertion

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probe (Testo 205; Testo SE & Co. KGaA, Titisee-Neustadt, Germany) after the probe was calibrated in buffer at pH 4.0 and pH 6.88. Surface colour values [International Commission on Illumination (CIE)], lightness (L*), redness (a*), and yellowness (b*) were measured by a CR-100 Chroma Meter (Konica Minolta, Inc., Osaka, Japan) equipped with an 8.0 mm aperture and illuminant C, which was calibrated with a piece of white paper. CIE L*, CIE a*, and CIE b* were recorded as described by Obeidat et al. (2019), and the averages were used in the statistical analysis. The *longissimus dorsi* samples were cut into blocks and weighed before and after cooking in a plastic bag in an 80 °C water bath for 1 h, and cooking loss was calculated and recorded. A rectangular cross-section of the *longissimus dorsi* sample was cut with the fibre orientation parallel to the long axis for the shear force measurement. The muscle samples were cut into cubes (5 cm × 3 cm × 2 cm) and suspended in the refrigerator for 24 h at 4 °C. The drip loss was determined. The remaining *longissimus dorsi* samples were collected and stored in a −20 °C refrigerator and then treated with freeze drying. Moisture, crude protein, and crude fat contents were determined according to the methods of the Association of Official Analytical Chemists (AOAC 1990).

### Statistical analysis

The results were analysed using a paired *t*-test (SAS/STAT® v9.4; SAS Institute Inc., Cary, NC, USA) with individual lambs as experimental units. Statistical significance was declared at $P < 0.05$ and statistical trends at $0.05 < P < 0.10$.

## RESULTS

### Growth performance

The initial body weight at seven days of age (Table 2) was not different between the two groups ($P = 0.877$), demonstrating the homogeneity and efficiency in the distribution of the animals. After 53 days, although there was no difference in dry matter intake (DMI) between the two groups ($P > 0.05$), lambs consuming HF diet had higher BW ($P = 0.020$) and average daily gain (ADG) ($P = 0.019$) compared to NF lambs. The HF group tended ($P = 0.056$) to have a lower feed conversion ratio (F/G = DMI/ADG). Lambs fed HF diet had higher BW and DMI ($P = 0.035$ and $P < 0.001$) at 120 days of age. No difference in ADG or F/G was observed between the two groups of lambs.

Table 2. Intake and growth performance of lambs fed diets with different fat levels

| Items | Treatment | | SEM | *P*-value |
|---|---|---|---|---|
| | normal fat | high fat | | |
| Initial body weight (kg) | 4.15 | 4.17 | 0.13 | 0.877 |
| **Day 60** | | | | |
| Body weight (kg) | 11.63 | 12.78 | 0.409 | 0.020 |
| Average daily gain (g/day) | 139.55 | 161.61 | 7.75 | 0.019 |
| Dry matter intake (g/day) | 233.12 | 237.04 | 12.55 | 0.762 |
| Feed intake/daily gain | 2.03 | 1.69 | 0.10 | 0.056 |
| **Day 120** | | | | |
| Body weight (kg) | 29.28 | 31.40 | 0.91 | 0.035 |
| Average daily gain (g/day) | 277.09 | 286.96 | 9.97 | 0.339 |
| Dry matter intake (g/day) | 907.30 | 957.17 | 7.67 | < 0.001 |
| Feed intake/daily gain | 3.73 | 4.10 | 0.25 | 0.163 |

Table 3. Effects of dietary fat levels on the nutrient apparent digestibility of Hu lambs

| Items | Treatment | | SEM | *P*-value |
|---|---|---|---|---|
| | normal fat | high fat | | |
| **Day 50~60** | | | | |
| Dry matter (%) | 83.46 | 84.24 | 0.36 | 0.073 |
| Organic matter (%) | 82.90[b] | 85.71[a] | 0.88 | 0.018 |
| Gross energy (%) | 77.16[b] | 86.30[a] | 1.04 | < 0.001 |
| Crude protein (%) | 82.17 | 84.71 | 1.21 | 0.080 |
| Ether extract (%) | 87.51 | 90.88 | 1.65 | 0.088 |
| Neutral detergent fibre (%) | 54.16 | 48.61 | 3.60 | 0.227 |
| Acid detergent fibre (%) | 35.32 | 39.53 | 3.59 | 0.286 |
| Ca (%) | 53.51 | 48.56 | 2.72 | 0.118 |
| P (%) | 63.83 | 65.22 | 2.67 | 0.621 |
| **Day 110~120** | | | | |
| Dry matter (%) | 73.34 | 72.54 | 1.83 | 0.676 |
| Organic matter (%) | 75.45 | 75.20 | 1.67 | 0.885 |
| Gross energy (%) | 77.69 | 77.04 | 1.92 | 0.748 |
| Crude protein (%) | 73.98 | 73.91 | 1.92 | 0.973 |
| Ether extract (%) | 80.19 | 80.18 | 1.58 | 0.995 |
| Neutral detergent fibre (%) | 38.10 | 38.06 | 1.22 | 0.976 |
| Acid detergent fibre (%) | 28.65 | 26.93 | 1.25 | 0.219 |
| Ca (%) | 38.57 | 36.22 | 1.35 | 0.133 |
| P (%) | 51.80 | 51.66 | 1.70 | 0.939 |

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### Apparent nutrient digestibility

The apparent digestibility of organic matter (OM) ($P$ = 0.018) and GE ($P$ < 0.001) of the lambs in the HF group was greater than that of the lambs in the NF group between 50 and 60 days of age (Table 3). Lambs fed HF diet during 50 and 60 days of age tended to have a higher apparent digestibility of DM ($P$ = 0.073), CP ($P$ = 0.080), and EE ($P$ = 0.088) compared to those fed NF diet. The apparent digestibility of NDF, ADF, Ca, and P was not affected by the dietary fat level ($P \geq 0.118$). No difference in apparent digestibility was observed between 110 and 120 days of age.

### Slaughter performance

At 60 days of age, HCW ($P$ = 0.048) and rib eye area ($P$ = 0.001) were higher while LBW tended to be higher ($P$ = 0.096) for lambs in HF group (Table 4). At 120 days of age, LBW ($P$ = 0.028), EBW ($P$ = 0.025), and HCW ($P$ = 0.022) were higher in HF group than in NF group.

### Chemical composition and physicochemical parameters of the *longissimus dorsi* muscle

The chemical composition and physicochemical parameters of the *longissimus dorsi* muscle are shown in Table 5. The CIE L* ($P$ = 0.006) was higher, while shear force ($P$ = 0.003) and cooking loss ($P$ = 0.024) were lower for lambs in HF group at 60 days of age than for lambs in NF group. At 120 days of age, the CIE b* ($P$ = 0.001) and cooking loss ($P$ = 0.006) were lower in the *longissimus dorsi* muscle of lambs fed HF diet compared to those fed NF diet. Lambs fed HF diet had higher crude fat in the *longissimus dorsi* muscle at both 60 ($P$ = 0.011) and 120 ($P$ = 0.026) days of age.

Table 4. Effects of dietary fat levels on the slaughter performance of Hu lambs (day 60 and day 120)

| Items | Treatment | | SEM | *P*-value |
|---|---|---|---|---|
| | normal fat | high fat | | |
| **Day 60** | | | | |
| Live body weight (kg) | 9.58 | 11.57 | 1.54 | 0.096 |
| Empty body weight (kg) | 7.46 | 8.58 | 0.86 | 0.238 |
| Hot carcass weight (kg) | 4.33 | 5.41 | 0.03 | 0.048 |
| Dressing percentage (%) | 44.83 | 46.69 | 1.93 | 0.277 |
| Rib eye area ($cm^2$) | 8.43 | 10.29 | 0.26 | 0.001 |
| **Day 120** | | | | |
| Live body weight (kg) | 30.00 | 32.72 | 0.12 | 0.028 |
| Empty body weight (kg) | 21.19 | 23.19 | 0.73 | 0.025 |
| Hot carcass weight (kg) | 14.17 | 15.65 | 0.08 | 0.022 |
| Dressing percentage (%) | 47.05 | 47.72 | 1.21 | 0.207 |
| Rib eye area ($cm^2$) | 19.11 | 20.44 | 0.76 | 0.119 |

## DISCUSSION

The performance of animals' production potential is subject to factors such as feeding level,

Table 5. Meat quality and chemical composition of the *longissimus dorsi* muscle from Hu lambs fed at different fat levels (day 60 and day 120)

| Items | Treatment | | SEM | *P*-value |
|---|---|---|---|---|
| | normal fat | high fat | | |
| **Day 60** | | | | |
| **Physico-chemical parameter** | | | | |
| pH | 6.71 | 6.67 | 0.09 | 0.685 |
| CIE L* | 38.16 | 39.85 | 0.46 | 0.006 |
| CIE a* | 11.19 | 11.57 | 0.42 | 0.147 |
| CIE b* | 8.58 | 8.09 | 0.59 | 0.423 |
| Shear force (N) | 39.79 | 38.37 | 0.33 | 0.003 |
| Drip loss (%) | 4.92 | 4.55 | 0.44 | 0.422 |
| Cooking loss (%) | 37.57 | 36.02 | 0.561 | 0.024 |
| **Chemical composition** | | | | |
| Moisture (%) | 75.96 | 75.54 | 0.24 | 0.126 |
| Ash (%) | 1.53 | 1.78 | 0.27 | 0.385 |
| Crude protein (%) | 19.52 | 19.77 | 0.28 | 0.403 |
| Crude fat (%) | 3.39 | 4.12 | 0.22 | 0.011 |
| **Day 120** | | | | |
| **Physico-chemical parameter** | | | | |
| pH | 6.78 | 6.71 | 0.08 | 0.374 |
| CIE L* | 38.62 | 37.62 | 0.50 | 0.104 |
| CIE a* | 13.63 | 13.60 | 0.50 | 0.955 |
| CIE b* | 8.08 | 7.25 | 0.16 | 0.001 |
| Shear force (N) | 42.65 | 41.60 | 0.61 | 0.127 |
| Drip loss (%) | 3.21 | 4.04 | 0.41 | 0.109 |
| Cooking loss (%) | 36.60 | 34.90 | 0.46 | 0.006 |
| **Chemical composition** | | | | |
| Moisture (%) | 76.09 | 76.03 | 0.56 | 0.923 |
| Ash (%) | 1.40 | 1.52 | 0.12 | 0.322 |
| Crude protein (%) | 19.58 | 19.55 | 0.49 | 0.950 |
| Crude fat (%) | 3.71 | 4.43 | 0.26 | 0.026 |

CIE a* = redness; CIE b* = yellowness; CIE L* = lightness

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genotype, sex, age, and productive aptitude (NRC 2007). The plane of nutrition during the early age of lamb influences the post-weaning performance. In the present study, we evaluated the growth performance, apparent nutrient digestibility, slaughter performance, and chemical composition and physicochemical parameters of weaned lambs under different dietary fat levels.

## Growth performance

The growth rate of lambs in the pre- and post-weaning phase of experiment was within the range of moderate to high growth potential as observed in earlier reports (Karim et al. 2007; Tripathi et al. 2007). In this study, lambs fed HF diet before day 60 had improved growth performance in terms of BW and ADG at both 60 and 120 days of age. Similarly, the study showed that the higher plane of nutrition in the form of milk replacer feeding during the pre-weaning period and rumen inert fat-supplemented feed during the post-weaning period to grow ram lambs enhances their growth (Kumar et al. 2014). High energy feeding is required for the rapid growth of young lambs as high energy diets are used more efficiently in the growth promotion of young animals (Mahgoub et al. 2000). Previous experiments also showed that high-fat diet promoted the growth in calves (Wijayasinghe et al. 1984), high-producing dairy cows (Havlin et al. 2015), and Holstein bull calves (Tikofsky et al. 2001). It can be seen that the level of dietary fat before weaning has an effect on the growth performance at the later stage.

## Apparent nutrient digestibility

Nutrient digestibility is closely related to the production performance of animals, and it is also a comprehensive expression of the utilization of nutrients. A direct relationship was found between the amount of feed and the apparent digestibility of energy in the diet (Amado et al. 2019). In the present study, the nutrient digestibility criteria corresponded with the growth performance. High fat diet significantly increased OM and GE digestibility of lambs before weaning. This finding is consistent with the result that fat can replace part of the protein decomposition energy supply and improve the animal protein utilization rate. In this study, the digestibility of DM, OM, CP, and EE in lambs before weaning was higher than that in beef cattle (dos Santos Monnerat et al. 2013) and lambs during pre- and post-weaning periods (Saleem et al. 2017). Conversely, in the study of Stokes and Walker (1970) on the nutritive value of fat in the diet of milk-fed lambs, the digestibility of EE was higher than that of lard, butter, and canola oil but lower than that of coconut oil and peanut oil. Nutrient digestibility decreased in the lambs of the two groups fed the same diet after weaning. Lambs were fed the same diets after weaning, the digestibility of DM, OM, CP, and EE in HF group was lower than that of the lambs in NF group. This result may be due to that HF diet stimulates the development of the digestive system and improves the energy supply of the digestive system before weaning. However, the specific mechanism needs further study.

## Slaughter performance

The lambs in HF group were fed a high-fat diet before weaning, which not only improved the growth performance but also increased the carcass weight and rib eye area of the lambs. A previous study showed that the carcass may increase with the increase in energy concentration of the diet in lambs (Bhatt et al. 2009), which is consistent with our findings. Although all lambs were weaned and fed the same diet between 60 to 120 days of age, the LBW, EBW, and HCW of the lambs in HF group were still significantly higher than those of the lambs in NF group at 120 days of age. Qiye Wang et al. (2020) suggested that increasing the dietary energy level can improve the growth performance and slaughter traits in fattening Hu lambs. We suggest that fat should be added to the diet earlier to achieve the effect of fattening later.

## Chemical composition and physicochemical parameters

The appearance of meat, such as colour, has a decisive effect on consumer choice and acceptance (Thornton et al. 2012). In this study, CIE L*, CIE a*, and CIE b* were all within the normal range (33–41 for CIE L*, 11.1–23.6 for CIE a*, and 6.1–11.3 for CIE b*; Muchenje et al. 2009). At 60 days of age, the CIE L*

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of the lambs in HF group was significantly higher than that of the lambs in NF group. However, fat is broken down into glycerol and fatty acids in animals. Carvalho et al. (2014) reported that the inclusion of crude glycerin (12%, 18%) in beef cattle diets increased CIE L*, consistently with the results of the present study. Fat is lighter than muscle; therefore, its presence can contribute to an increase in the luminosity value (Realini et al. 2004).

Cooking loss in the lambs in HF group was significantly higher than that in NF group at 60 and 120 days of age. Moreover, the tenderness and flavour of the lamb muscle in HF group were better than those in the lambs in NF group. The shearing force reflects the tenderness of the muscle. In this study, the shearing force of the lamb muscle in HF group was significantly lower than that in the lambs in NF group. This result corresponds to the cooking loss and proves that the lamb muscles in HF group were relatively tender.

Crude fat is important to ensure the flavour, aroma, and juiciness of the muscle (Hwang and Joo 2017). This experiment is consistent with the previous research results, feeding lambs with high-fat diet can increase the fat content of mutton (Frank et al. 2016; Smith 2016; Ramos-Nieves et al. 2020). The idea that increased levels of marbling correspond to a more acceptable flavour and juiciness is generally accepted (Noidad et al. 2019). In the present study, the crude fat content of the lamb muscles in HF group was significantly higher than that in the lambs in NF group on day 60 and 120. This result indicates when lambs were fed a high-fat diet in the pre-weaning period, the crude fat content in the *longissimus* muscle would increase, and the effect can last for two months post-weaning. Thus the sensory flavour, juiciness, and tenderness would be increased.

## CONCLUSION

It is concluded that the high-fat diet improves growth performance, CIE L* and crude fat content in the *longissimus* muscle of lambs.

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### Conflict of interest

The authors declare no conflict of interest.

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