Effects of birth weight and feeding system on fattening performance and feeding behaviour of Karayaka male lambs

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Abstract

To determine effects of birth weight (BtW) and feeding system on fattening performance and behavioural responses of lambs, after birth 28 Karayaka male lambs were divided into two BW groups, namely a low BtW (4.1±0.06 kg) and high BtW (5.0±0.09 kg). After weaning (90 days of age), seven lambs in each of these groups were fed individually ad libitum with total mixed ratio (TMR), consisted of 80% of a compound feed and 20% of roughage based on a dry matter basis (140 g crude protein and 2550 kcal ME/kg) and the other seven lambs were fed on the same ingredients as that of TMR but each of the lambs were allowed to choose feeding, FCF). Therefore the lambs were offered free-choice of food (free choice feeding, FCF) factorial design. Live weight gains and intakes of dry matter, dry matter (P<0.05), protein and energy (P<0.01) of FCF-fed lambs were higher than those of TMR-fed lambs. FCF-fed lambs consumed less alfalfa hay, wheat bran and barley than TMR-fed lambs (P<0.01). The FCF increased ruminating (P<0.01) and tend to rest more (P<0.05) compared to the TMR. The study suggests that FCF system can assist in enhancing the live weight gain by promoting the protein and energy intakes and by improving the welfare of lambs.

Introduction

It has been observed that under commercial managemental regimes, fattening lambs are raised on concentrate-based diets to achieve maximum growth rates, better feed efficiency, leading to increased profit opportunities and thereby enhancing profitability from the system (Bodas et al., 2007; Dikmen et al., 2009), however this is usually carried out without considering their nutritional preferences and welfare or feeding behaviour. When fattening lambs are fed concentrate-based diets, forage intake is usually very low (Rodríguez et al., 2007), large variation occurs in the feed intake, which would cause digestive disturbance, abnormal or erratic feeding behaviour and subsequent decrease in their growth performance (Askar et al., 2006). A cafeteria feeding system or offering free-choice of food (free choice feeding, FCF) may be a practical alternative that offers some advantages over conventional compound feeding of fattening lambs (Fedele et al., 2002; Dikmen et al., 2009). Indeed it has been indicated that sheep, reared in a controlled environment can successfully select a diet of adequate intake from a suitable pair of feeds to match their nutritional requirements and have a feed efficiency and body growth rate similar or better than those achieved with conventional feeding system (FS) (Sahin et al., 2003; Askar et al., 2006; Rodríguez et al., 2007, 2008; Dikmen et al., 2009). Behavioural responses such as feeding and welfare behaviours are very important in connection with feed intake and feeding management, since it has direct effects on consumption patterns, feedstuff availability and selection of feeds (Keskin et al., 2004; Kaya, 2011). Keskin et al. (2004) determined that FCF-fed lambs had higher eating, ruminating, resting and spent less time standing and walking compared to total mixed ratio (TMR)-fed animals. Kaya (2011) reported that TMR-fed lambs reared outdoors in hot climate showed less rate of ruminating but more rate of lying behaviour, while FCF-fed lambs consumed more amount of concentrate feed ingredients, such as full fat soya and wheat bran without changing their behaviour patterns. However, Meier et al. (2012) reported that the use of FCF systems need to be optimized because an important limitation of such experiments is that the results are only valid for the specific situation tested and cannot be generalized. To optimize the use of FCF system, the influence of FCF system with same ingredients as in TMR on feeding behaviour such as eating, ruminating and drinking, other welfare behaviours such as standing, playing and resting as well as diet selection and fattening performance requires further study.

Birth weight (BtW) of the lamb is one of the most important factors influencing the growth of the neonate as there is a positive correlation between the BtW and subsequent live weight development and fattening performances in small ruminants (Saiuud et al., 1998; Sušić et al., 2005). The BtW is an easily measured and says little about the quality of that growth or fattening performance (Gardner et al., 2007). Indeed there is scanty information on how lambs with different BtW in the FCF system affects diet selection and subsequently the performance of the animal, in addition to its feeding behaviour. Accordingly, the objectives of the present study were to verify fattening performance of Karayaka male lambs with different BtW fed FCF system and to investigate the changes in their diet selection, feeding and welfare behaviours.

Materials and methods

The study was carried out at the experimental farm of the Gaziosmanpaşa University, Faculty of Agriculture, Tokat, Turkey situated...
were identified by ear tags and were allowed between 4.1±0.06 kg (µ-1 sd) and 5.0±0.09 kg the lambs with low and high BtW spanned month of March. The minimum and maximum male lambs were selected from lambs weigh- the different classes. Thus, 28 one-day-old was the criteria used for grouping them into low and high of BtW±1 sd (standard deviation) was the criteria used for grouping them into the different classes. Thus, 28 one-day-old male lambs were selected from lambs weighing 4.53±0.518 kg (mean ± sd) born in the month of March. The maximum and minimum live weight of the lambs was 3.60 and 5.60 kg, respectively. The average live body weight of the lambs with low and high BtW spanned between 4.1±0.06 kg (µ-1 sd) and 5.0±0.09 kg (µ+1 sd), respectively. The newborn lambs were identified by ear tags and were allowed free suckling to their respective dams. They were penned in stalls with alfalfa hay up to 3 months of age. Thus creep feeding was made available from 3 weeks of age. Prior to weaning, the lambs were drenched with anthelmintic preparation (Triabendazole 12 mg/kg; Levamisole 7.5 mg/kg) before the start of the experiment. All lambs were weaned, weighed using suspended scales weighing from 0 to 50 kg in minimal 50 g increments and shorn at 90 days of age. At the beginning of the experiment, all lambs were penned individually in 100×120×120 cm stalls in a naturally ventilated animal house.

After weaning, the seven lambs of similar body weight in the each of the groups with low and high BtW throughout 60 days of experimen- tional period were fed a TMR ad libitum or the other seven lambs were fed on the same ingredients (FCF) as that of TMR but each ingredient was put in five separate troughs throughout the daily. Therefore the lambs were divided into four comparable groups that con- sisted of seven replicates according to a 2×2 factorial arrangement for 2 (low and high BtW) and 2 (TMR and FCF). The TMR was consisted of 80% of commercial compound feed and 20% of roughage on a dry matter basis (Table 1), and was formulated to provide nutrient require- ments for fattening (NRC, 2007). Vitamin and mineral mixtures, marble powder, dicalcium phosphate, and salt were added equally to each ingredient for the FCF system. The TMR and feed ingredients were used in mash form during the experiment. The animals were allowed an initial training period of 7 days to familiarize the metabolic conse- quences of feed ingredients (Görgülü et al., 1996, 2003). The position of the troughs for each feed was randomly assigned across pens; this order remained unchanged during the experiment.

| Table 1. Composition of experimental ingredients and total mixed ration, as fed. |
|-------------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Dry matter, g/kg | Crude protein, g/kg | Crude fibre, g/kg | ME, kcal/kg |
|-------------------------------------------------|-----------------|-----------------|-----------------|
| Barley | 900 | 110 | 70 | 2850 |
| Corn | 880 | 82 | 29 | 3000 |
| Wheat bran | 870 | 134 | 140 | 2450 |
| Soybean meal | 900 | 460 | 55 | 2750 |
| Alfalfa hay | 900 | 153 | 287 | 1935 |
| TMR | 894 | 140 | 120 | 2550 |

ME, metabolizable energy; TMR, total mixed ration. °The concentrate (per kg dry matter) in the TMR consisted of: barley, 415 g; corn, 100 g; wheat bran, 200 g; soybean meal, 62 g; alfalfa hay, 200 g; marble powder, 15 g; dicalcium phosphate (DCP), 4 g; salt, 2 g; vitamin and mineral mixture, 1 g; each kg vitamin and mineral mixture provided: vitamin A, 20,000,000 U; vitamin D3, 3,000,000; vitamin E, 20 g; vitamin B1, 4 g; vitamin B6, 1 g; vitamin B12, 12 mg; vitamin B12, 5 g; vitamin B1, 50 mg; choline, 200 mg; Mn, 50 g; Fe, 50 g; Zn, 50 g; Cu, 10 g; I, 100 mg; Co, 150 mg; Se, 150 mg. Vitamin and mineral mixtures, marble powder, DCP and salt were added equally to each ingredient for FCF system.

| Table 2. Feed intake, live weight, daily weight gain and feed to gain ratio of lambs with different birth weight reared with different feeding systems. |
|-------------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Live weight, kg | | | | | | |
| At birth | 4.1 | 4.1 | 5.0 | 4.9 | 0.10 | ** |
| At weaning (90 days of age) | 19.9 | 20.3 | 21.0 | 21.2 | 0.81 | ns |
| At 150 days of age (final) | 31.2 | 37.6 | 35.9 | 34.2 | 1.92 | ns |
| Daily weight gain, g | 211 | 233 | 207 | 267 | 12.1 | ns |
| Daily intake, g | | | | | | |
| Total DM | 984 | 1240 | 982 | 1220 | 48.8 | ns |
| Alfalfa hay | 201 | 162 | 201 | 158 | 6.1 | ns |
| Barley | 414 | 345 | 413 | 329 | 13.6 | ns |
| Wheat bran | 201 | 109 | 201 | 75 | 11.6 | ns |
| Soybean meal | 66 | 257 | 65 | 289 | 23.5 | ns |
| Corn | 103 | 367 | 103 | 368 | 26.3 | ns |
| Nutrient consumption | | | | | | |
| Crude protein, g | 138 | 226 | 138 | 224 | 12.3 | ** |
| Metabolizable energy, kcal | 2403 | 3371 | 2408 | 3327 | 142.5 | ** |
| Energy/protein ratio, kcal/g | 18.1 | 15.0 | 18.1 | 14.4 | 0.34 | ** |
| Feed to gain ratio, g DM per g gain | 4.7 | 4.4 | 4.7 | 4.6 | 0.17 | ns |

BtW, birth weight; TMR, total mixed ration; FCF, free choice feeding; FS, feeding system; DM, dry matter. *P<0.05; **P<0.01; ns, not significant.
Feed intake, feed to gain ratio, and data on fattening of lambs with different BW reared on conventional or FCF systems are presented in Table 2. The live weight gains and intakes of daily dry matter, all ingredients and nutrients of the lambs were not affected by the BW and BW x FS interaction (Table 2). The differences between the low and high BW of lambs were not reflected in the live weight at weaning and daily weight gain from days 90 to 150. The average live weight of the low BW and high BW lambs was similar at weaning (20.1±0.92 vs 21.1±1.38 kg per lamb) and at the end of study (34.4±3.13 vs 35.1±2.17 kg per lamb). Similarly, the final live weight of the lambs was not affected (P>0.05) by FCF systems (35.6±3.74 kg for TMR vs 35.9±3.14 kg for FCF). This result corroborated those obtained by Ocak et al. (2005) and Sirin et al. (2011). Ocak et al. (2005) reported that the difference in the BW of lambs from ewes offered different protein levels during late gestation was not reflected in the live weight at weaning. Sirin et al. (2011) noted that the Karayaka female lambs with different BW (2.68 kg vs 4.05 kg) had a similar live weight at day 90 and day 150 of age. On the other hand, results on final live weight were in agreement with the findings of Sahin et al. (2003) and Keskin et al. (2004) who indicated that final live weight did not differ between TMR- and FCF-fed lambs. The improvement in daily weight gain achieved with FCF, especially in lambs with low BW could be attributed to increased total feed intake as was evident with improvements in feed conversion ratio. The results on fattening of lambs in the present study were within the normal range (Olfaz et al., 2005; Sen et al., 2011; Sirin et al., 2011).

The FCF lambs, were given choices among barley, corn, wheat bran, soybean meal and alfalfa hay, selected diets, which allowed them better (P<0.01) daily weight gain compared to the TMR lambs (Tables 2 and 4). This may be related to the number of replicates per treatment was low. Görgülü et al. (1996) and Rodriguez et al. (2008) reported that daily weight gain increased by FCF systems, which is similar to the observations in the present study. However, FCF system in the studies of Sahin et al. (2003) and Keskin et al. (2004) was not associated with increased daily live weight. The difference between the results of our study and the studies of Sahin et al. (2003) and Keskin et al. (2004) may be related to energy intake because the present finding with regard to energy intake is higher than that reported by these authors. Also these different samples of feed ingredients may have been used. The obtained results were in agreement with those obtained by Sahin et al. (2003) and Keskin et al. (2004). These differences may be related to differences in the composition of feed ingredients used. The revealed results confirm that feeding lambs with FCF allowed to use different feed ingredients and the BW and BW x FS interaction did not affect the live weight at weaning. However, the BW x FS interaction was associated with daily weight gain.

Table 3. Description of the recorded behaviours elements during the experimental period.

| Behaviour    | Description                                  |
|--------------|----------------------------------------------|
| Eating       | Act of eating feed or feed ingredients       |
| Ruminating   | Chewing regurgitated food, either in standing or in lying |
| Drinking     | Swallow water from water bucket              |
| Standing     | Standing without any movement or behaviour   |
| Playing      | Different body movements, sounding, jumping, kickng and touching or contacting equipments. |
| Resting      | Act of lying without ruminating activity     |

Table 4. The proportional composition (mean ± SE) of feed ingredients in total mixed ration and diets selected by lambs with different birth weight.

| Ingredients, % | TMR Low BW | Diet selected by lambs with P value |
|----------------|------------|-----------------------------------|
| Barley         | 41.6±0.4   | 27.4±0.74* 26.7±0.39*             |
| Corn           | 10.0±0.3   | 28.8±0.68* 29.5±0.63*             |
| Wheat bran     | 20.9±0.3   | 8.5±0.35* 5.9±0.72*               |
| Soybean meal   | 6.2±0.3    | 20.0±0.99* 22.8±0.87*             |
| Alfalfa hay    | 20.9±0.3   | 13.2±1.03 13.6±0.69*              |

TMR, total mixed ration; BW, birth weight. *Means in the same row with different letter are significantly different; P<0.05.

Results and discussion

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Table 5. The behaviour responses of Karayaka lambs with different birth weight reared on total mixed ratio or free choice feeding systems.

| Behaviour | Low BtW | High BtW | P value |
|-----------|---------|----------|---------|
|           | TMR    | FCF      | TMR    | FCF    |         |
| Feeding, % |         |          |         |        |         |
| Eating    | 16.9    | 18.0     | 18.0    | 17.6   | ns      |
| Ruminating| 14.3*   | 16.1*    | 15.9*   | 13.7** |         |
| Drinking  | 0.6b    | 0.9b     | 0.5b    | 0.5b   |         |
| Welfare, %|         |          |         |        |         |
| Standing  | 28.7*   | 31.6*    | 26.3*   | 31.9*  | *       |
| Playing   | 2.5b    | 3.1b     | 1.9b    | 3.3*   | *       |
| Resting   | 37.1*   | 30.4b    | 37.3*   | 33.0*  | *       |

BtW: birth weight; TMR, total mixed ratio; FCF, free choice feeding. *Means in the same row with different letter are significantly different; *P<0.05; **P<0.01; ns, not significant.

ferences may be due to difference in age, size and diet offered to animals in the studies and may be attributed to differences in genotype, physiology and learning ability (Dikmen et al., 2009; Meier et al., 2012). TMR-fed lambs consumed less total dry matter (P<0.05), metabolizable energy (P<0.01), soybean meal (P<0.01), corn (P<0.01) and crude protein (P<0.01) than FCF-fed lambs whereas FCF-fed lambs consumed less alfalfa hay (P<0.01), barley (P<0.05), wheat bran (P<0.01) and energy to protein ratio (P<0.01) than TMR-fed lambs (Table 2). Because growing ruminants have greater needs for nutrients, especially protein (Villalba et al., 2011), it is likely that this effect enhanced intake of dry matter and protein in the FCF system relative to that in the TMR system. These findings support the idea that lambs offered a choice among an option of feeds (ground barley, cottonseed meal, wheat bran and alfalfa hay) successfully regulated their nutrient intakes and attained better growth performance (Görgülü et al., 1996; Dikmen et al., 2009). However, the results do not confirm that cafeteria or FCF reduces the feed intake of lamb, as it can balance its nutrient requirement well (Sahin et al., 2003; Askar et al., 2006; Rodriguez et al., 2007; Dikmen et al., 2009; Kaya, 2011). These results indicate that the intake regulation mechanism is most probably not specific for BtW of lambs, but it may change when animals are free to choose when and what to eat, or if chemical composition allow them meeting nutritional requirements of the animals (Fedele et al., 2002; Dikmen et al., 2009). Lambs with different BtW, in fact, were able to increase concentrate intake up to 87% of daily dry matter without suffering digestive disorders, balancing the highly degradable carbohydrates with high crude fibre content in the diet, since TMR-and FCF-fed lambs had a similar crude fibre intake, but not energy to protein ratio (Table 2). The display a particular preference for a high caloric and nitrogenous feeds of growing Karayaka lambs indicated that their requirements for dry matter, protein and energy were higher than nutrient requirements provided for fattening by NRC (2007). Thus the FCF system may be given a chance for lambs to tune their energy to protein ratio balance by using, predominantly, either energy or protein source for their energy or protein requirements (Sahin et al., 2003). A higher the daily weight gain may be related to the amounts of ingested protein and energy in the FCF systems was theoretically in excess of nutrient requirements for fattening (NRC, 2007) due to the fact that the FCF system increased the dry matter, energy and protein intakes (Tables 2 and 4). Many factors, such as inherent characteristics of the animal and long- or short-term environmental and managemental conditions have been reported to affect diet selection and behavioural responses as well as fattening performance (Kyriazakis and Oldham, 1997; Sahin et al., 2003; Kaya et al., 2011). Kaya (2011) reported that the performance of lambs in outdoor in hot climate condition could be inferior to that of lambs in a more controlled environment because the outdoor lambs would be exposed to heat stress. In the present study, all lambs were actually exposed to the same climatic conditions because the treatments shared a common research facility, a building that is naturally ventilated. Therefore, the environmental temperature probably had a similar affect on the intakes of dry matter, feed ingredients and nutrients of TMR- and FCF-fed lambs in the present study.

High dietary protein or energy concentration in fattening lamb diets may result in the occurrence of digestive disturbance (Kyriazakis and Oldham, 1997), abnormal or erratic feeding behaviour (Askar et al., 2006; Favreau et al., 2010). In the present study, no occurrence of these problems in FCF-fed lambs was observed probably due to the fact that TMR-and FCF-fed lambs had a similar crude fibre intake. This observation is consistent with the idea that ruminants learn to selected a mixture of feeds that minimizes metabolic imbalance (Kyriazakis and Oldham, 1997). Therefore, an increase in corn and soybean meal proportions of 19 and 15%, respectively, and a decrease in barley, wheat bran and alfalfa hay proportions of 15, 13 and 7%, respectively, in the diet selected by lambs compared to their proportions in the TMR (Table 4) suggests that feeding behaviour of lambs did not depend on specific nutritive effect of each feed, but on their associative effects, as reported by Favreau et al. (2010). Kyriazakis and Oldham (1997) noted that the long-term (daily) diet selection of sheep may be affected by the degree of synchrony of energy and protein to the rumen. Therefore this result indicates that it is safe to prepare a more readily balanced diet including of 23% soybean meal, 27% barley and 30% corn for fattening without affecting the health status of lambs in conditions of the present study. Feeding behaviour such as eating, ruminating and drinking and welfare behaviours such as standing, playing and resting in lambs with different BtW fed TMR or FCF are presented in Table 5. The FCF-fed and TMR-fed lambs in the present study showed different feeding behaviour depending on their BtW, whereas they showed different welfare behaviour, irrespective of the BtW. The FCF-fed lambs with lower BtW and the TMR-fed lambs with higher BtW spent more time (P<0.01) in ruminating compared to those of the TMR-fed lambs with low BtW and the FCF-fed lambs with higher BtW. Surprisingly, ruminating (P<0.01) and drinking (P<0.05) activity was found higher in TMR lambs with low BtW (Table 5). These results indicates that lambs may be adapted their feeding behaviour to the kind of diet they receive, as reported by Abjouadé et al. (2000) and Keskin et al. (2005). Because rumination is considered as a second meal, inducing a regain in digestive and absorptive processes without new ingested food (Tebo et al., 2009), it is clear why it did not influence eating activity but not drinking activity. The some factors, such as diet composition and the amount of dry matter intake can affect drinking behaviour (Keskin et al., 2005). The FCF-fed lambs had higher standing, playing and resting activities compared to the TMR-fed lambs (P<0.05). Therefore our results with respect to feeding behaviours support idea that sheep with greater feed intake and growth rate tend to eat more meals per day and spend more time eating (Cammack et al., 2007). These results may probably be resulted in differences in phys-
iological adaptation of lambs due to the fact that the behavioral responses might be indicators of physiological adaptation of lambs to the living environment (Ailian et al., 2008).

Conclusions

The present study improved the current knowledge on nutritional requirements and behaviour of Karayaka male lambs, and provided in such a way that requirements of lambs are satisfied to an optimum level. Karayaka male lambs are able to select their own diet from a FCF in such a way that their presumed behavioral and nutritional requirements are fulfilled, and hence their performance was improved compared to TMR-fed lambs. Therefore, it may be a challenge to develop selection procedures that have favorable outcomes, such as increasing growth rate without increasing feed intake in improving sheep production in developing or less developed parts or tropic and sub tropical geographical zones of the world. The FCF-fed lambs tend to consume more of corn and soybean meal in comparison to other types of feed and they (irrespective of their body weight) spent more time in standing and playing compared to those of their TMR counterparts, however the reverse was true when it came to resting. This has relevance for improving animal welfare. Accordingly, the FCF system in conditions of the present study has a potential to stimulate intake and improved animal performance by changing behavioral responses.

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