www.roavs.com EISSN: 2223-0343
RESEARCH OPINIONS IN ANIMAL & VETERINARY SCIENCES
Research article DOI: 10.20490/ROAVS/16-002

# Effect of feeding protected soybean fat supplement and Salbutamol administration on growth performance, nutrient digestibility and carcass characteristics of Iranian *Bahmaei* feedlot lambs

**Forouzmand M*[1], Ghasemi H[2] and Rowghani E[3]**

[1]Department of Animal Sciences, Yasouj University, Yasouj, Iran; [2]Animal Sciences, Yasouj University, Yasouj, Iran; [3]Department of Animal Sciences, Darab Branch, Islamic Azad University, Darab, Iran

Article history
Received: 10 Dec, 2015
Revised: 2 Feb, 2016
Accepted: 15 Feb, 2016

## Abstract

This study was conducted to evaluate the effect of feeding protected soybean fat and beta-adrenergic agonist Salbutamol on growth performance, nutrients digestibility and carcass characteristics of Iranian *Bahmaei* feedlot lambs. Twenty male lambs (mean age 90±7 days, mean weight of 29±1.7 kg) were used in a completely randomized design with four treatments (five replicates per treatment) for 80 days. The treatments were: Control (basal diet), F, experimental diet containing 5% protected soybean fat supplement, S, basal diet plus Salbutamol (4 mg/kg of DMI) and FS, experimental diet containing 5% protected soybean fat supplement and administration of Salbutamol (4 mg/kg of DMI). Treatments were similar in terms of energy, protein, NDF contents and forage to concentrate ratio. At the end of the experiment, the results showed that although feeding fat supplement increased fat and ash digestibility, but had no significant effect on body weight change, average daily gain and feed conversion ratio, DM, OM, NDF and ADF digestibility. Salbutamol did not affect lamb performance and nutrient digestibility however, improved carcass characteristics by increasing weight and percentage of thigh, shoulders, carcass without fat tail and decreased fat tail weight and percentage. Simultaneous use of fat supplement and beta agonist Salbutamol significantly increased weight and percentage of carcass tail fat and reduced carcass without tail fat weight compared to the control ($P<0.05$). Carcass weight and visceral components were not affected by treatments ($P>0.05$). Therefore, based on the results of this study, administration of Salbutamol (4 mg/kg of DMI) is recommended to improve carcass characteristics but simultaneous use of protected supplemental fat and beta agonist Salbutamol is not recommended.

**Keywords:** Carcass characteristics, Lambs, Performance, Protected fat, Salbutamol

**To cite this article:** Forouzmand M, H Ghasemi and E Rowghani, 2016. Effect of feeding protected soybean fat supplement and Salbutamol administration on growth performance, nutrient digestibility and carcass characteristics of Iranian *Bahmaei* feedlot lambs. Res. Opin. Anim. Vet. Sci., 6(1): 7-12.

## Introduction

Growth rate is an important economic factor of beef livestock industry. Unfortunately, the feed sources available for feeding to livestock are often have a lack of energy and/or protein, so decreasing growth rate and increasing the feedlot period. Fats have 2.5 times more energy than the other nutrients which can be used as high energy source to promote animal performance. Oils and fats are often used to enhance the value of dietary metabolizable energy of ruminants (Clapperton and Steele, 1983) because these nutrients have low heat

***Corresponding author:** Forouzmand M, Department of Animal Sciences, Yasouj University, Yasouj, Iran.
Email: forouzmand@yu.ac.ir

increments, but feeding free fats can cause some problems such as reduced fiber digestibility and disturbance of rumen ecosystem (Johnson and Mc Clure, 1973). Many of these problems can be solved, if the animals fed with protected fat. Palmquist and Jenkins (1980) reported that we can add calcium to the diet while using fat in order to avoid reduction of forage digestibility, because when calcium is added to supplemental fat, insoluble soap will be produced in the rumen that diminish the negative effects of free fatty acids on forage fermentation. In the study of Reddy et al. (2003) calcium salts of palm fatty acids was used as much as 10% of the diet (DM basis), and demonstrated that supplemental protected fat improved dry matter intake. Benchaar and colleagues (2007) reported that supplemental fat did not affect nutrient digestibility however, growth rate and carcass fat percentage increased. In recent years, demand for low-fat meat has increased because of increased awareness of people about relationship between animal fat and cardiovascular disease.

Administration of beta agonists is one of the newest ways to enhance growth pattern of farm animals (Johnson and Chung, 2007). These compounds bind to beta-adrenergic receptors of target cells and can increase lipolysis in fat cells and/or stimulate hypertrophy of muscle fibers. In the study of Zare Shahneh et al. (2001) using metaproterenol resulted in increased body protein percentage but decreased fat tail mass. In another study, it was found that feeding Ractopamine hydrochloride and Zilpaterol hydrochloride for 42 days improved carcass characteristics and linearly decreased dorsal fat thickness by increasing levels of zilpaterol hydrochloride (Lopez-Carlosa et al., 2010). The aim of this study was to investigate the effect of protected soybean fat supplement and Salbutamol as a beta agonist on growth performance, nutrient digestibility and carcass characteristics of Bahmaei feedlot lambs.

## Materials and Methods

Twenty male lambs (*Bahmaei*, average age 90±7 days, mean weight 29 ± 1.7 kg) were housed in individual pens and assigned to a completely randomized design with four treatments (five replicates per treatment) for 80 days (20 and 60 days for adaptation and experimental periods, respectively). The treatments were: (C) Control (basal diet), (F) Experimental diet containing 5% protected soybean fat supplement, (S) Basal diet plus administration of Salbutamol (4 mg/kg of DMI) and (FS) experimental diet containing 5% protected soybean fat and administration of Salbutamol (4 mg/kg of DMI). Diets were formulated according to NRC (1985) recommendations (Table 1) and had similar energy, protein, neutral detergent fiber content and forage to concentrate ratio (Table 2). Lambs were fed twice daily (8 am and 16 pm) and had free access to water, TMR and salt rock. Every morning feed was collected separately, weighed, and dry matter intake of previous day was calculated.

Feed, orts and faeces samples were taken twice on day 30 and 60 of the experiment and frozen at -17℃ for later analysis. At the end of experiment, all the samples were oven dried to a constant weight at 55°C, ground to pass a 1 mm screen using laboratory hammer mill and analyzed for organic matter (OM), Ash, acid detergent fibre (ADF) and ether extract (EE) as described by AOAC (2003). Crude protein was measured by Kjeldahl procedure on automatic distillation apparatus

**Table 1: Feed ingredients of experimental diets (DM basis)**

| Item (% DM) | Experimental diets[1] | | | |
|---|---|---|---|---|
| | C | F | S | FS |
| Chopped alfalfa | 48.5 | 39 | 48.5 | 39 |
| Wheat straw | 4 | 14.5 | 4 | 14.5 |
| Ground barley | 37.5 | 21.5 | 37.5 | 21.5 |
| Soybean meal | 6.5 | 10.5 | 6.5 | 10.5 |
| Wheat bran | 1.5 | 7.5 | 1.5 | 7.5 |
| Soybean protected fat[2] | 0 | 5 | 0 | 5 |
| Vitamin premix | 1.5 | 1.5 | 1.5 | 1.5 |
| Mineral premix | 0.5 | 0.5 | 0.5 | 0.5 |
| Salbutamol (mg/kg of DMI) | 0 | 0 | 4 | 4 |
| Total | 100 | 100 | 100 | 100 |
| Forage ratio | 52.5 | 53.5 | 52.5 | 53.5 |
| Concentrate ratio | 47.5 | 46.5 | 47.5 | 46.5 |

[1]Experimental diets: (C) control (basal diets), (F) Experimental diet containing 5% (DM basis) protected Soybean fat, (S) basal diet containing 4mg/Kg of DMI Salbutamol (beta agonist), (FS) Experimental diet containing 5% (DM basis) protected Soybean fat and 4 mg/kg of DMI Salbutamol (beta agonist); [2]Soybean protected fat supplement (calcium salts of Soybean fatty acids), product of Behparvaran Nami Naghshe Jahan, Isfahan, IRAN. (www.behparvaran.com).

**Table 2: Chemical composition of Experimental diets (% DM)**

| Item | Experimental diets[1] | | | |
|---|---|---|---|---|
| | C | F | S | FS |
| Metabolizable Energy (Mcal/kg) | 2.5 | 2.5 | 2.5 | 2.5 |
| Crude protein | 14 | 14 | 14 | 14 |
| Neutral detergent fibre | 45.9 | 44.9 | 45.9 | 44.9 |
| Acid detergent fibre | 22.11 | 20.33 | 22.11 | 20.33 |
| Calcium | 0.5 | 0.5 | 0.5 | 0.5 |
| Phosphorus | 0.25 | 0.25 | 0.25 | 0.25 |
| Vitamin A (IU) | 1100 | 1100 | 1100 | 1100 |
| Vitamin D (IU) | 15 | 15 | 15 | 15 |

[1]Experimental diets: (C) control (basal diets), (F) Experimental diet containing 5% (DM basis) protected Soybean fat, (S) basal diet containing 4 mg/kg of DMI Salbutamol (beta agonist), (FS) Experimental diet containing 5% (DM basis) protected Soybean fat and 4 mg/kg of DMI Salbutamol (beta agonist).

(WD 40). Neutral detergent fibre and acid detergent fibre were determined by filter bags technique according to the suggested method by ANKOM Corporation. To calculate nutrients digestibility, acid insoluble ash (AIA) was used as an internal marker.

Lambs were weighed and recorded on day 20, 50 and 80 of the experiment (after 24 hours of feed withdrawn) and total live weight gain, average daily gain and feed conversion ratio (FCR) was calculated. On day 80, lambs were weighed and slaughtered then weight of hot carcass, thighs, shoulders, eye ribs area, fat tail and visceral components were recorded after dressing and removal of offal parts.

**Statistical analysis**

Statistical analyses of the data were done by GLM procedure of SAS version 9.1 and comparison between the four dietary treatments was made using Duncan's multiple range tests.

## Results

The data related to the effects of treatments on some growth performance traits of feedlot lambs is presented in Table 3. Although there were no significant effects of experimental treatments on dry matter intake, total weight gain, average daily gain and feed conversion ratio (P>0.05) but supplemental fat and/or Salbutamol administration did not depress feed intake in this study.

As seen in Table 4, there were no significant effect of experimental treatments on DM, OM, NDF and ADF digestibility but EE and ash digestibility were affected significantly (P<0.05). In the current study, EE increased significantly (P<0.05) in F while ash content decreased significantly in F and FS groups.

The data of treatments effect on carcass characteristics of feedlot lambs are presented in Table 5. As the results showed, Salbutamol beta agonist administration alone (S) increased (P<0.05) thigh weight, thighs percentage, eye ribs area weight, eye ribs area percentage, carcass without fat tail weight, carcass without fat tail percentage and decreased (P<0.05) fat tail weight and fat tail percentage compared with the control.

In this study, fat supplementation did not improve carcass characteristics compared to the control, in addition, simultaneous use of supplemental fat and beta agonist Salbutamol (Treatment FS) decreased weight of carcass without fat tail and increased fat tail weight and percentage compared to the control treatment. Also, the results of this experiment revealed that the impact of treatments on weight of visceral components (Table 6) were not significant (P>0.05).

## Discussion

In the present study, there were no significant effects of protected fat supplement on lamb performance that were similar to the results of Reddy et al. (2003), Manso (2005) and Salinas et al. (2006). Supplemental fat had no significant effect on BWG, AWG and FCR. It has been well known that fat supplementation increases the secretion of satiety hormone (cholecystokinin) and reduces ruminal motility and subsequently suppress feed intake.

**Table 3: Effect of experimental treatments on performance of feedlot lambs**

| Item (% DM) | Experimental Treatments[1] | | | | Treatments effect | SE |
|---|---|---|---|---|---|---|
| | C | F | S | FS | | |
| Dry matter intake (kg/day) | 1.80 | 1.65 | 1.66 | 1.69 | NS | 0.09 |
| Total weight gain (kg) | 14.91 | 14.75 | 14.18 | 15.24 | NS | 0.77 |
| Average weight gain (g/day) | 233.16 | 230.63 | 221.47 | 238.05 | NS | 12 |
| Feed conversion ratio | 7.69 | 7.27 | 7.58 | 7.26 | NS | 0.36 |

NS. Not significant (P>0.05); [1]Experimental diets: (C) control (basal diets), (F) Experimental diet containing 5% (DM basis) protected Soybean fat, (S) basal diet containing 4 mg/kg of DMI Salbutamol (beta agonist), (FS) Experimental diet containing 5% (DM basis) protected soybean fat and 4 mg/kg of DMI Salbutamol (beta agonist)

**Table 4: Effect of experimental treatments on nutrients digestibility**

| Item (% DM) | Experimental Treatments[1] | | | | Treatments effect | SE[2] |
|---|---|---|---|---|---|---|
| | C | F | S | FS | | |
| DM | 73.14 | 73.54 | 72.20 | 70.34 | NS | 2.3 |
| OM | 74.75 | 76.41 | 74.10 | 72.98 | NS | 2.3 |
| CP | 78.21 | 81.24 | 78.05 | 80.68 | NS | 1.9 |
| NDF | 66.10 | 64.05 | 64.34 | 62.06 | NS | 3.4 |
| ADF | 55.05 | 51.02 | 52.00 | 52.51 | NS | 3.7 |
| EE | $73.46^{b}$ | $85.47^{a}$ | $73.39^{b}$ | $64.51^{b}$ | * | 3.75 |
| Ash | $59.3^{a}$ | $45.62^{b}$ | $55.3^{ab}$ | $44.00^{b}$ | * | 3.5 |

NS. Not significant (P>0.05), * significant difference (P<0.05); a, b, values in the same row that share different superscript (s) are statistically different (P<0.05); [1]Experimental diets: (C) control (basal diets), (F) Experimental diet containing 5% (DM basis) protected Soybean fat, (S) basal diet containing 4 mg/kg of DMI Salbutamol (beta agonist), (FS) Experimental diet containing 5% (DM basis) protected Soybean fat and 4 mg/kg of DMI Salbutamol (beta agonist); SE= standard error of the mean.

**Table 5: Effect of Experimental treatments on some carcass characteristics**

| Item | Experimental Treatments[1] | | | | Treatments | SE[2] |
|---|---|---|---|---|---|---|
| | C | F | S | FS | effect | |
| Hot carcass weight (kg) | 24.17 | 23.12 | 24.51 | 24.67 | NS | 1.20 |
| Dressing percentage | 48.48 | 47.19 | 48.82 | 49.21 | NS | 1.15 |
| Thighs weight (kg) | 5.93$^{b}$ | 5.95$^{b}$ | 7.45$^{a}$ | 6.20$^{b}$ | * | 0.29 |
| Thighs percentage | 24.59$^{b}$ | 25.83$^{b}$ | 30.51$^{a}$ | 25.17$^{b}$ | * | 0.62 |
| Shoulders weight (kg) | 3.49 | 3.44 | 3.72 | 3.70 | NS | 0.14 |
| Shoulders percentage | 14.44 | 14.95 | 15.25 | 15.08 | NS | 0.34 |
| Eye ribs area weight (kg) | 3.30$^{ab}$ | 3.18$^{ab}$ | 3.64$^{a}$ | 2.97$^{b}$ | * | 0.19 |
| Eye ribs area percentage | 13.68$^{ab}$ | 13.73$^{ab}$ | 14.98$^{a}$ | 12.06$^{b}$ | * | 0.55 |
| Fat tail weight (kg) | 4.67$^{b}$ | 4.85$^{b}$ | 4.14$^{c}$ | 5.70$^{a}$ | * | 0.13 |
| Fat tail percentage | 19.45$^{bc}$ | 21.13$^{b}$ | 17.07$^{c}$ | 24.98$^{a}$ | * | 0.87 |
| Carcass Without fat tail weight (kg) | 19.49$^{ab}$ | 18.28$^{ab}$ | 20.38$^{a}$ | 17.16$^{b}$ | * | 0.99 |
| Carcass Without fat tail percentage | 80.54$^{ab}$ | 78.86$^{ab}$ | 82.91$^{a}$ | 75.01$^{c}$ | * | 0.87 |

NS. Not significant (P>0.05), * significant difference (P<0.05); a,b:value in the same row that share different superscript(s) are statistically different (P<0.05); [1]Experimental diets: (C) Control (basal diets), (F) Experimental diet containing 5% (DM basis) protected Soybean fat, (S) basal diet containing 4mg/Kg of DMI Salbutamol (beta agonist), (FS) Experimental diet containing 5% (DM basis) protected Soybean fat and 4mg/Kg of DMI Salbutamol (beta agonist); SE= standard error of the mean

**Table 6: Effect of Experimental treatments on weight of carcass visceral components (g)**

| Item (g) | Experimental Treatments[1] | | | | Treatments | SE[2] |
|---|---|---|---|---|---|---|
| | C | F | S | FS | effect | |
| Abdominal fat | 458 | 426 | 375 | 453 | NS | 91.50 |
| Kidneys | 126 | 125 | 125 | 129 | NS | 6.93 |
| Liver | 675 | 616 | 689 | 703 | NS | 40.67 |
| Lungs | 508 | 456 | 569 | 485 | NS | 35.29 |
| Heart | 189 | 174 | 190 | 186 | NS | 10.51 |

NS. Not significant (P>0.05); [1]Experimental diets: (C) Control (basal diets), (F) Experimental diet containing 5% (DM basis) protected Soybean fat, (S) basal diet containing 4 mg/kg of DMI Salbutamol (beta agonist), (FS) Experimental diet containing 5% (DM basis) protected Soybean fat and 4 mg/kg of DMI Salbutamol (beta agonist); SE= standard error of the mean

Lambs performance was not affected by Salbutamol administration in this experiment. The result was similar to the findings of Lopez Carlosa et al. (2010), Avendano-reyes et al. (2011) and Zare Shahneh et al. (2002). The response to beta agonists varies with animal species, dose and duration (Zare Shahneh et al., 2001; Moody et al. (2000), absorption and half-life in body tissue and fluids (Murdoch et al., 2006). In some studies, feed intake decreased due to the effects of beta agonist administration (Mersmann, 1989; Ricks et al., 1984). Most of the nutrients digestibility parameters were not affected by Salbutamol administration that was similar with the results of Lopez-Carlosa et al. (2010). Results showed that carcass characteristics improved significantly by Salbutamol alone. These results were similar to the results of Carlos Lopez et al. (2010), Malucelli et al. (1994) and Zare Shahneh (2001).

Some studies (Koohmaraie and Shackelford, 1991; Sainz et al., 1993) showed that beta agonists (u-Calpain) decreased the protease activity and/or increased the protease inhibitors (Calpastatin). Reduction of protease activity and increasing inhibitors may increase the concentration of tissues protein and ultimately, weight of carcass would be increased. Also, it has been reported that using beta agonists increased amount of mRNA and its transcription (Koohmaraie et al., 1991), leading to hypertrophy of muscle cells and muscle mass. Increasing muscle mass eventually leads to an increase of carcass weight. Kornegay (1996) demonstrated that beta agonists increased adenosine mono-phosphate cyclase (cAMP) by increasing the concentration of hormone-sensitive lipase, leading to increase triglyceride degradation of fat cells. Also, it has been found that beta agonists increased the numbers of fat cells sizing from 60 to 69µm and reduced the number of cells with the size of 90 to 99µm, resulting in reduced fat mass (Hu et al., 1988).

Beerman (1993) stated that beta agonists reduced insulin binding to fat cells by reducing the number of insulin receptors so using beta agonists reduce plasma insulin levels and/or the number of insulin receptors and subsequently reduce lipogenesis and increase lipolysis (Hu et al., 1988; Mersmann, 1989).

In this study, fat supplementation did not improve carcass characteristics compared to the control. Manso (2005) and Garrett et al. (1976) also reported no beneficial effect of fat supplementation on carcass characteristics.

Frenzel et al. (2011) and Zare Shahneh et al. (2002) reported that there was no significant effect of beta agonist on visceral components also, the other studies (Kott et al., 2003; Seabrook, 2011 and Dutta et al., 2007) showed the results similar to our data for the effect of feeding fat supplements on visceral components.

## Conclusion

The results showed feeding protected fat had no significant effect on performance, DM, OM, NDF and ADF digestibility and carcass characteristic. Salbutamol significantly improved carcass characteristics weight and percentage of thigh, shoulders, carcass without tail fat and decreased weight and percentage of tail fat. Therefore, based on the results of this study, administration of Salbutamol (4 mg/kg of DMI) is recommended to improve carcass characteristics but simultaneous use of protected supplemental fat and Salbutamol are not recommended.

## References


AOAC (2003) Official methods of analysis of the association of official's analytical chemists, 17th edition. Association of analytical chemists, Arlington, Virginia.

Avendano-reyes L, Macias-Cruz U, Alvarez-Valenzuela FD, Aguila-Tepato Torrentera-Olivera E, Soto-Navarro SA (2011) Effect of zilpaterol hydrochloride on growth performance, carcass characteristics, and wholesale cut yield of hair-breed ewe lambs consuming feedlot diets under moderate environmental conditions. J Anim Sci 3904 (Abstract).

Beerman DH (1993) The endocrinology of growth, development, and metabolism in vertebrates. Acadmemic Press Inc New York, pp. 345-364.

Benchaar C, Petit HV, Berthiaume R, Ouellet DR, Chiquette J, Chouinard PY (2007) Effects of essential oils on digestion, ruminal fermentation, rumen microbial populations, milk production and milk composition in dairy cows fed Alfalfa silage. J Dairy Sci 90: 886-897.

Clapperton JL, Steele W (1983) Fat supplementation in animal production-ruminants. Proceed Nutr Soc 42: 343-350.

Doreu M, Chilliard Y (1997) Digestion and metabolism of dietary fat in farm animals. Bri J Nutr 78: 15-35.

Dutta M, Agnihotri K, Rao SBN (2007) Effect of supplemental palm oil on nutrient utilization, feeding economics and carcass characteristic in post-weaned Muzafarnagari lambs under feedlot condition. Small Rumin Res 78: 66-73.

Frenzel A, Harp M, Lambert D, Cadle M, Garcial L (2011) Effect of ractopamineHydrochloride on Growth and Carcass Characteristics of Lightweight Swine. J Agric Nat Res 24: 74-82.

Garrett WN, Yang YT, Dunkly WL, Smith LM (1976) Energy utilization, feedlot performance and fatty acid composition of beef steers fed protein encapsulated tallow or vegetable oils. J Anim Sci 42: 1522-1533.

Hu CY, Suryawan A, Forsberg NE, Dalrymple RH, Ricks CA (1988) Effect of cimaterol on sheep adipose tissue metabolism. J Anim Sci 66: 1393-1400.

Jenkins TC, Palmquist DL (1982) Effect of added fat and calcium on in vitro formation of insoluble fatty acid soap and cell wall digestibility. J Anim Sci 55: 957.

Johnson BL, Chung KY (2007) Alterations in the growth physiology of cattle with growth-enhancing compounds. Vet Clin Food Anim 23: 321-332.

Johnson R, Clure MC (1973) High fat rations for ruminants. II. Effects of fat added to corn plant material prior to ensiling on digestibility and voluntary intake of the silage. J Anim Sci 36: 397-404.

Koohmaraie M, Shackelford SD (1991) Effect of calcium chloride infusion on the tenderness of lambs fed a B-adrenergic agonist. J Anim Sci 69: 2463-2471.

Kornegay ET (1996) Nutrient Management of Food Animals to Enhance and protect the environment. Evaluation of new technologies for the improvement of nitrogen utilization in ruminants. CRC Press Inc New York.

Kott RW, Hatfield PG, Bergman JW, Flynn CR, Van Wagoner H, Boles JA (2003) Feedlot performance, carcass composition, and muscle and fat CLA concentration of lambs fed diet supplemented with sunflower seed. Small Rumin Res 41: 11-17.

Lopez-Carlosa MA, Ramirez RJ, Aguilera-Sotoa JI, Arechiga CF, Mendez-Liorentea F, Rodrigueza H, Silvaa JM (2010) Effect of ractopamine hydrochloride and zilpaterol hydrochloride on growth, diet digestibility, intake and carcass characteristics of feedlot lambs. Livest Sci 131: 23-30.

Malucelli A, Ellendorff F, Meyer HH (1994) Tissue distribution and residues of clenbuterol, Salbutamol, and terbutaline in tissues of treated broiler chickens. J Anim Sci 72: 1555-1560.

Manso T, Castro T, Mantecon AR, Jimeno V (2005) Effects of palm oil and calcium soaps of palm oil fatty acids in fatting diets on digestibility, performance and chemical body composition of lambs. J Anim Sci 127: 175-186.

Mersmann HJ (1989) Animal Growth Regulation. New York: Plenum, 1989, p. 337–357.

Moody DE, Hancock DL, Anderson BD (2000) Phenethanolamine repartitioning agents. Farm Animal Metabolism and Nutrition CAB International, NY, USA, pp: 65-95.

Murdoch GK, Okine EK, Christopherson RJ (2006) metabolic modifiers in animal nutrition: potential benefits and risks. Biol Nutr Grow Anim, 4: 135-178.

NRC (1985) Nutrient requirements of sheep. Sixth revised edition, National Academy Press, Washington, DC, USA.

Palmquist DL, Jenkins TC (1980) Fat in lactation ration. Review. J Dairy Sci 63: 1-14.

Reddy YR, Krishna N, Rao ER, Reddy TJ (2003) Influence of dietary protected lipids on intake and digestibility of straw based diet in Deccani sheep. Anim Feed Sci Technol 106: 29-38.

Ricks CA, Dalrymple RH, Baker P, Ingle DL (1984) Use of a B-agonist to alter and muscle deposition in steers. J Anim Sci 59: 1274.

Sainz RD, Kim YS, Dunshea FR, Campbell RG (1993) Effects of ractopamine in pig muscle:Histology, Calpains and B-adrenergic receptors. Austr J Agric Res 44: 1441-1448.

Salinas J, Ramirez RG, Dominguez MM, Reyes-Bernal N, Trinidad- Larraga N, Montano MF (2006) Effect of calcium soaps of tallow on growth performance and carcass characteristics of Pelibuey lambs. Small Rumin Res 66: 135–139.

Seabrook RK, Peel T, Engle E (2011) The effects of replacing dietary carbohydrate with calcium salts of fatty acids on finishing lamb feedlot performance, blood metabolites, muscle fatty acid composition, and carcass characteristics. Small Rumin Res 95: 97-103.

Zare Shahneh A, Mataji R, Zamiri MJ, Shahre-Babak M (2001) Effects of beta-adrenergic agonist metaproterenol on carcass characteristics of Varamini ewes. J Agric Sci Technol 5: 157-166.

Zare Shahneh A, Mataji R., Zamiri MJ and Moradi shahre Babak M (2002) Effects of metaproterenol, a beta-adrenergic agonist on growth, feed conversion and carcass composition of varamini ewe lambs. J Sci Technol Agric Nat Res 5: 157-166.