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Effect of Pudina (*Mentha piperita)* Supplementation on Nutrient Utilization and Blood Biochemical Parameters of Sheep

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ABSTRACT

The present study was undertaken to evaluate the effects of Pudina *(Mentha piperita*),a herbal feed additive, on the nutrient balance and blood biochemicals in sheep.Ten male adult Bakerwal sheep were divided in to control (T_0) and treatment (T_1) groups. The complete ration for T_1 was fortified with herb *Mentha piperita* @3%. Intake of DM, OM and body weight was observed. Digestibility coefficients of DM, OM, CP and EE showed significant (P<0.05) differences where as non-significant (P<0.05) differences were observed in digestibility coefficients of NFE, NDF, ADF and HC. Significant (P<0.05) increase in DCP and TDN were recorded in T_1 group as compared to T_0 group. Nitrogen, calcium and phosphorus balance were comparable between two groups and were positive in both the groups. Among haemato-biochemical parameters blood glucose, Hb, PCV and total serum proteins, differed non-significantly (P≤0.05) between the groups, both before and after experimental feeding except the BUN, which was found significantly (P≤0.05) higher in herb supplemented group. It was concluded that Pudina could be used as feed additive @3% of diet for enhancing digestibility in sheep without any negative effect on body weight, nitrogen balance or blood biochemical parameters.

Key words: Bakerwal sheep, Haemato-biochemical, *Mentha piperita*, Nutrient utilization

INTRODUCTION

Antibiotics use as growth promoters has revolutionized the livestock and poultry sector in terms of growth and production in developed nations. But at the same time, it has threatened the health sector with the problem of antibiotic resistance and development of super bugs. As a consequence, the use of antibiotics as a livestock feed additive has been banned in many countries (Russell and Houlihan, 2003).Nowadays non-antibiotic growth promoters are receiving due attention and researchers are focusing on natural herbal additives as alternative to antibiotic growth promoters (Wanapat *et al.,* 2008). India being rich in natural medicine and feed additives, is receiving due attention of researchers for providing alternatives to antibiotics and other hazardous chemicals. Phytobiotics or phytogenic feed additives are the natural bioactive compounds of plant origin incorporated into animal feed to enhance livestock productivity through the improvement of digestibility, nutrient absorption and elimination of resident pathogens in the animal gut (Athanasiadou *et al.,* 2007) with the aim to improve production performance and the quality of food derived from animals (Windisch *et al.,* 2008).The application of herbal feed additives in livestock ration has tremendous potential for improvement in nutrient utilization as well as growth and production (Balunas and Kinghorn, 2005).

Mentha piperita, locally known as Pudina, belongs to family*Lamiaceae*. It is used as digestive, carminative, chloretic, antispasmodic, diuretic, antiemetic, mild sedative, diaphoretic, antiseptic, antiviral, and is widely used in many mixtures for treatment of indigestion, colic, cough and cold remedies (Robers and Tyler, 1999). Peppermint oil, as feed additive has been used as a rumen fermentation modifier and has been reported to decrease methane production with simultaneous improvement in digestibility of protein and ether extract (Agarwal *et al.* 2009). Bhat *et al.,* (2017a) reported that incorporation of Mentha piperita at 3% in the substrate enhanced digestibility and rumen fermentation *in vitro*. Based upon the encouraging results of *in vitro* experiment, the present study was

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Table-1: Chemical composition of complete feed, feed additives and feed ingredients (% DM basis)

Feed	DM	OM	CP	EE	CF	NFE	TA	NDF	ADF	HC	Ca	P
Complete Feed	91.7	90.9	13.8	6.10	32.4	38.5	9.15	63.6	42.3	21.3	1.42	0.73
Ingredients												
Maize	91.5	94.6	8.60	3.10	3.60	79.3	5.40	14.4	5.45	8.91	0.15	0.22
Wheat bran	90.5	91.3	14.5	4.21	11.3	61.4	8.70	39.7	17.3	22.3	0.14	0.97
Rice bran	89.6	90.6	9.90	2.30	23.5	54.9	9.40	61.5	35.6	25.9	0.59	1.22
Mustard cake	91.5	91.3	34.6	7.60	14.4	34.7	8.70	31.4	16.5	14.9	0.60	1.05
Mineral mixture	98.1	-	-	-	-	-	100	-	-	-	26.22	13.65
Common salt	96. 5	-	-	-	-	-	100	-	-	-	-	-
Oats straw	92.1	90.3	3.40	1.03	51.2	34.6	9.70	69.5	48.6	20.9	0.20	0.07
Mentha piperita	93.4	90.2	15.9	3.21	12.6	58.5	9.76	43.6	22.6	20.9	1.20	0.56

undertaken to evaluate the *in vivo* effect of *Mentha piperita* L. (Pudina) as feed additive in complete ration of sheep.

MATERIALS AND METHODS

The study was carried out at Mountain Research Centre for Sheep and Goat, Shuhama, SKUAST-Kashmir, India. Pudina leaves (*Mentha piperita)* were collected from surroundings as it grows in wild. Leaves were collected before flowering stage and dried and ground to uniform size prior to mixing with feed. Ten male adult Bakerwal sheep (about 17-20 months of age and 28±2 kg body weights) were randomly allotted on body weight basis into two equal groups (n=5) namely, control (T_0) and treatment (T_1) group. Complete ration with concentrate mixture and oats straw in 40:60 ratios was provided to all the animals as per ICAR (2013). The complete ration for treatment group (T_1) was supplemented with 3% *Mentha piperita*.The concentrate mixture was formulated containing maize, rice bran, wheat bran mustard cake, mineral mixture and salt in the ratio of 25, 17, 25, 30, 02 and 01 per cent, respectively.The animals were fed twice daily with free access to water. Feed offered and residues were recorded daily from each ram before the addition of fresh feed next day during the experimental period of 30 days. Body weight was recorded at fortnightly interval. To assess the digestibility of nutrients and balance of nitrogen and minerals (calcium and phosphorus), a metabolism trial of 7 days duration was conducted. The chemical composition of complete ration, ingredients and Pudina used in experiment was analysed as per procedures of AOAC (2000), Van soest *et al.* (1991) and Talapatra *et al.* (1948).

Blood samples were drawn from the jugular vein of the experimental animals at the start and end of the experiment. Haemoglobin was estimated by Sahli's haemoglobinometer (Edwin and Howard, 1923), PCV by Microhematocrit method (Brian *et al.,* 2000), total protein by Biuret method (Murtuza, 1998) and blood glucose by O-toludine method (Marks, 1959). BUN was estimated as per method described by Skeggs (1957).

Data were subjected to analysis of variance

(ANOVA) for completely randomized design, using the Statistical Package for the Social Sciences, Base 14.0 (SPSS Software products, Marketing Department, SPSS Inc. Chicago, USA). The Comparison among means was done by the least significant difference (LSD) test of Duncan.

RESULTS AND DISCUSSION

The complete ration formulated contained 91.65% DM, 90.85% OM, 13.80% CP, 6.10% EE, 38.53% NFE, 9.15% TA, 63.56% NDF, 42.25% ADF, 21.31% hemicelluloses (HC), 1.42% calcium (Ca) and 0.73% phosphorus (P). Pudina composed chemically of 90.24% OM, 15.89% CP, 3.21% EE, 58.54% NFE, 9.76% TA, 1.2% Ca and 0.56% P, respectively. Mainasara *et al.,* (2018) reported that dried peppermint contained 56.31% carbohydrates, 7.69% protein, 5% lipid, and 22% ash.The analysis of *Mentha piperita* revealed that it contained 43.56% NDF, 22.63% ADF and 20.93% hemicellulose. Wanapat *et al.,* (2013) reported that Pudina has 92.4% DM, 87.5% OM, 1.20% CP, 3.30% NDF, 17.3% ADF, 1.20% EE and 7.2 % essential oil. Hosoda *et al.* (2005) reported similar results in peppermint powder except that their samples contained lower amount of CP. The variation in composition may

Table 2. Effect of Pudina (*Mentha piperita*) on feed intake, body weight, digestibility and nutrient utilization in sheep

Attributes	Control (T_0)	Treatment (T_1)
Feed intake (g/d)		
DMI	887.60^{a}±4.28	942.40^{c}±4.11
OMI	824.20^{a}±3.05	889.00^{b}±3.29
Initial body weight (kg)	28.05^{a}±2.10	28.07^{a}±2.16
Final body weight (kg)	29.61^{a}±2.18	30.03^{b}±2.21
Total gain (kg)	1.56	1.96
Digestibility (%)		
DM	57.82^{a}±1.70	66.39^{b}±0.64
OM	57.36^{a}±1.50	64.38^{b}±1.33
CP	60.10^{a}±1.06	66.07^{b}±1.60
EE	55.92^{b}±1.29	66.11^{b}±0.97
NFE	66.27±1.06	68.35±0.72
NDF	48.80±0.98	50.43±0.56
ADF	39.83±0.83	41.45±1.46
HC	58.76±0.71	59.29±1.34
Nutritive value (%)		
DCP	8.30^{a}±0.15	9.12^{b}±0.22
TDN	65.18^{a}±0.58	69.13^{b}±0.73
NR	6.86±0.16	6.6±0.18
DE (kcal/g)	2.45^{a}±0.02	2.60^{b}±0.03
ME (kcal/g)	2.02^{a}±0.16	2.14^{b}±0.02
Nutrient intake (g/d)		
DDM	524.80^{a}±1.71	561.60^{b}±3.98
DOM	508.40^{a}±1.94	542.80^{b}±3.72
DCP	73.63^{a}±1.53	85.92^{b}±2.01
TDN	578.59^{a}±5.76	651.42^{b}±7.26

Means superscripted with different letters in a row differ significantly (P<0.05)

be due to difference in Pudina species according to different geographical areas. The source of variation may also be Pudina *per se,* in the present experiment, wild grown varieties were used, unlike cultivated Pudina no fertilizers or nutrients were applied. Besides leaves were collected at growing stage which may be the reason for variation too.Lemon grass and Pudina have been reported as feed additives to improve production performance of beef and dairy cattle (Hosoda *et al.,* 2005; Yang *et al.,* 2007) and to enhance rumen fermentation efficiency (Kongmun *et al.,* 2010). The average values of dry matter and organic matter intake in terms of g/d were significantly (P<0.05) higher in treatment (T_1) than control group (T_0) as depicted in table 2. Atta-Elmnan *et al.* (2013) similarly reported increase in DM intake from 622 to 955 g/day at 5% fenugreek seed inclusion level. Ganai *et al.* (2011) also reported higher intake of feed containing *Eclipta alba* as feed additives in complete ration of goats. Bhat *et al,* (2017b) reported similar results in sheep supplemented with *Artemisia absinthium*. The increase in feed intake may be due the presence of active compounds such as essential oils that stimulate appetite and improve the digestion by suppressive action on gastrointestinal disorders (Asadi *et al.,* (2017). Ismail (2000) ascribed increase in feed intake to saponin content in herbs in growing Barki lambs. In contrast, Wanpat *et al.,* (2013) reported no effect on DM intake on herb supplementation. Average digestibility coefficients of DM, OM, CP and EE were found to be significantly

Table 3. Effect of Pudina *(Mentha piperita)* on balance of nutrients in sheep

Parameters	Control (T_0)	Treatment (T_1)
N intake (g/d)	20.37^a ±0.68	23.40^b ±0.34
Excretion		
Faeces (g/d)	7.19±0.04	7.09±0.06
Urine (g/d)	5.36±0.34	6.03±0.20
Balance		
(g/d)	7.81^a ±0.37	10.27^b ±0.20
% of intake	38.30^a ±0.63	43.88^b ±0.60
% of absorbed	59.39^a ±0.97	63.00^b ±0.82
Ca intake (g/d)	11.15^a ±0.18	12.56^b ±0.12
Excretion		
through faeces (g/d)	4.47^a ±0.12	5.25^b ±0.10
through urine (g/d)	2.29±0.03	2.37±0.07
Balance		
g/d	4.38^a ±0.16	4.94^b ±0.24
% of intake	39.35^a ±1.15	39.32^a ±1.64
% of absorbed	65.61^a ±0.88	67.49^b ±1.58
P intake (g/d)	7.27^a ±0.08	7.62^b ±0.09
Excretion		
through faeces (g/d)	2.26±0.03	2.44±0.05
through urine (g/d)	2.11±0.03	1.92±0.05
Balance		
g/d	2.90^a ±0.02	3.25^b ±0.03
% of intake	39.76^a ±0.45	42.70^b ±0.70
% of absorbed	57.80^a ±0.27	62.80^b ±0.75

Means superscripted with different letters in a row differ significantly (P<0.05)

($P<0.05$) higher in T_1 as compared to T_0.Atta-Elmnan *et al.* (2013) and Abo El Nor *et al.,* (2007) reported increase in nutrient digestibility in Nubian goats and lactating buffaloes on fenugreek supplementation, respectively. The higher values for digestibility in T_1 may be due to improvement in liver function (Zong *et al.,* 2011), strong anti-oxidant (Tsai *et al.,* 2013) and anti-bacterial activity (Kapp, 2015). Essential oils (EOs) appear to suppress harmful microorganisms, stimulate beneficial microbes such as Lactobacillus spp., regulate the activity of enzymes and protect gut villi. They beneficially affect the ecosystem of gastrointestinal microflora by controlling potential pathogens, alleviating the oxidative stress caused by them and stabilizing gut microbiota (Simitzis, 2017). Moreover, digestive secretions (saliva, bile, mucus, *etc.*) and enzyme (trypsin, amylase, lipase, *etc.*) activity are enhanced partially through the irritation of the epithelial tissues, resulting in an increased gastric retention time of the ingested feed and a better nutrient absorption (Patel and Srinivasan, 2004). The percent digestibility of CF,NFE, NDF, ADF and HCwas found to be statistically non-significant ($P<0.05$) between experimental groups.The present results of no change of fibre digestibility were consistent with the previous findings of Hosoda *et al.* (2006), Atta-Elmnan *et al.* (2013), Pattanaik *et al.* (2009) and Ganai *et al.* (2011).However, Ando *et al.* (2003) reported that supplementation with peppermint could increase nutrient digestibility which contradicts with the present findings.

Significant ($P<0.05$) positive effect was seen in the treatment group for nitrogen, calcium and phosphorus balance. The results are in agreement with the findings of Bhat *et al,* (2017b), Atta Elmnan *et al.* (2013) and Ganai *et al.* (2011) who reported increase in nitrogen, calcium and phosphorous retention in ruminants when supplemented with herbs. Fernandez *et al.* (1997) used a commercial blend of EO compounds to manipulate rumen fermentation, inhibiting the breakdown of protein, thus potentially increasing the dietary protein available to the ruminant.The phytoactives of Pudina increases the digestibility of dry matter, which in turn may be reflected in more retention of nitrogen and minerals in treatment group. Any beneficial effects of EO on protein metabolism may have to be balanced against possible detrimental effects on fiber breakdown (McIntosh *et al.,* 2003).The fact that constituents of peppermint oil appear in the urine indicates that it must eventually cross the intestinal epithelium and would therefore be capable of exerting actions on secretory mechanisms as well as influencing absorption when it is present at the luminal surface (Beesley *et al.,* 1996). Braun *et al.,* (2019) reported that essential oils may not only influence ruminal fermentation but also modulate the absorption of cations like Na^+, Ca^{2+} and NH_4^+ across ruminal epithelia of cattle and sheep through direct interaction with epithelial transport proteins, such as those of the transient receptor potential family. Intriguingly, EO have been shown to enhance the transport of Ca^{2+} and other cations across numerous preparations (Nilius and Szallasi, 2014).

Significant ($P<0.05$) differences were observed between control (T_0) and treatment group (T_1) in terms of DCP and TDN content of the diets with non-

Table 4. Effect of Pudina (*Mentha piperita*) on blood biochemical parameters

Attributes	Control (T_0)		Treatment (T_1)	
	0 day	30th day	0 day	30th day
Hb (g/dl)	10.52±0.07	10.90±0.06	10.66±0.09	11.11±0.10
PCV (%)	28.12±0.23	29.08±0.30	28.18±0.42	29.00±0.27
Blood glucose (mg/dl)	56.77±1.00	58.57±1.05	56.33±0.67	57.29±±0.66
Total proteins (g/dl)	6.24±0.20	7.09±0.07	6.28±0.18	7.16±0.10
BUN (mg/dl)	19.68±0.62	20.84±0.63	19.71[a]±0.71	22.94[b]±0.25

Means superscripted with different letters in a row differ significantly ($P<0.05$)

significant effect on NR. The improvement in DCP content on dietary supplementation of herb might be due to better microbial protein synthesis in T_1. There was higher (P<0.05) DDMI, DOMI, DCPI and TDNI in treatment (T_1) group than control (Table 2), as also reported by Kraszewski *et al.* (2002) and Gupta *et al.* (2005).

Blood biochemical parameters were within the normal ranges mentioned by Constable *et al,* (2017) (Table 4). The mean values of Hb, PCV, blood glucose and total serum protein concentration did not differ significantly (P>0.05) in animals among different groups. Values of BUN were significantly (P<0.05) higher in treatment group (T_1) as compared to control (T_0). It may be due to increase in ammonia fermenting bacteria, which in turn lead to more urea production. Khattab *et al.* (2011) reported similar results on feeding of phytogenic feed additives in small ruminants.

CONCLUSION

The current study concludes that Pudina (*Mentha piperita)* can be used as feed additive @3% of diet for enhancing digestibility in sheep without any negative effect on body weight, nitrogen balance or blood biochemical parameters.

REFERENCES

Agarwal, N., Shekhar, C., Kumar, R., Chaudhar, L.C. and Kamra, D.N. 2009. Effect of peppermint *Mentha piperita* oil on *in vitro* methanogenesis and fermentation of feed with buffalo rumen liquor. *Anim. Feed Sci. Technol.*148: 321-327.

Allam, S.M., El-Hosseiny, H.M., Abdel-Gawad, A.M., El-Saadany, S.A and Zeid, A.M.M. 1999. Medicinal herbs and plants as feed additives for ruminants, I-Effect of using some medicinal herbs and plants as feed additive on zaraibi goat performance. *Egyptian. J. Nutr. Feeds.* 2: 349-365.

AOAC, 2000. *Official Methods of Analysis*. 16th edn. Association of official Analytical Chemists. Virginia State, USA.

Atta Elmnan, A.B., Rewais, F.A.,FadelElseed, A.M.A., Mahala, A.G. and Amasiab, E.O. 2013. Effect of supplementation of fenugreek (*Trigonella foenum - graecum*) seeds on feed intake, digestibility, N-balance and rumen environment of Nubian Goats. *Int. J. Develop. Sustain.* 2: 1214-1223.

Beesley, A., Hardcastle, J., Hardcastle, P.T. and Taylor, C.J. 1996.Influence of peppermint oil on absorptive and secretory processes in rat small intestine. *Gut.* 39: 214-219.

Bhat, A.R., Ganai, A.M., Ishfaq, A., Masood, D., Sheikh, G.G. and Beigh, Y.A. 2017a. Effects of *Mentha piperita* on in vitro fermentation and digestibility of complete rations for small ruminants growth. *Indian J. Anim. Nutr.* 34: 173-177.

Bhat, A.R., Ishfaq, A., Ganai, A.M., Beigh, Y.A., Sheikh, G.G. and Masood, D. 2017b. Effect of *Artemisia absinthium* (Titween) on nutrient intake, digestibility, nutrient balance and blood biochemical of sheep. *Indian J. Anim. Res.* DOI: 10.18805/ijar.B-3321.

Brian, S.H. 2000. *Procedure for Determining Packed Cell Volume by the Microhematocrit Method: Approved Standard*, 3rd ed.NCCLS Wayne, Pennsylvania, USA. pp:1-24.

Braun, H.S., Schrapers, K.T., Mahlkow-Nerge, K., Stumpff, F. and Rosendahl, J. 2019. Dietary supplementation of essential oils in dairy cows: evidence for stimulatory effects on nutrient absorption. *Animal.* 13: 518-523.

Constable, P.D., Hinchcliff, K.W., Done, S.H. and Walter GruNberg, W.2017.*Veterinary Medicine: A Textbook of the Diseases of Cattle, Horses, Sheep, Pigs and Goats,* Eleventh edition, Elsevier 3251 Riverport Lane St. Louis, Missouri 63043.

Edwin, E.O. and Howard, D.H. 1923. A new permanent standard for estimation of haemoglobin by the acid hematin method. *J. Biol. Chem.,*1: 107-110.

Fernandez, M., Serrano, E., Frutos, P., Giraldez, F. J., Mantecon, A.R. and Llach, J.R. 1997. Effect of Crina HC supplement upon the rumen degradative activity in sheep. *Inf. Tech. Econ. Agraria.* 18: 60-162.

Ganai, A.M., Sharma, T. and Dhuria, R.K. 2011. Effect of bhringraj (*Ecliptaalba*) herb on in vitro fermentation characteristics of bajra straw and bajra straw-based complete feed. *Appl. Biol. Res.* 13: 38-42.

Gupta, N., Kumar, A. and Tiwari, D.P, 2005. Effect of herbs as feed additive on haemato-biochemical constituents in growing crossbred heifers fed paddy straw based ration. *Indian J. Anim. Sci*., 76: 528-531.

ICAR.2013. *Nutrient Requirements of Sheep, Goat and Rabbit.* Indian Council of Agricultural Research, New Delhi. India.

Kapp K. 2015. *Polyphenolic and Essential Oil Composition of Mentha and Their Antimicrobial Effect*. Academic Dissertation. Faculty of Pharmacy of the University of Helsinki. p. 90.

Khattab, H.M., El Basiony, A.Z., Hamdy, S.M. and Marwan, A.A. 2011. immune response and productive performance of dairy buffaloes and their offspring supplemented with black seed oil. *Iranian J. Appl. Anim. Sci.*1: 227-234.

Kim, J.H., Kim, C.H. and Ko, Y.D. 2002. Influence of dietary addition of dried worm wood (Artemisia) on the performance and carcass characteristics of hanwoo steers and the nutrient digestibility of sheep. *Asian Australas. J. Anim. Sci.* 15: 390-395.

Kim, D.H., Kim, K.H., Nam, I.S., Lee, S., Choi, C.W., Kim, W., Kwon, E.G., Lee, K.Y., Lee, M.J. and Oh, Y.K. 2013. Effect of indigenous herbs on growth, blood metabolites and carcass characteristics in the late fattening period of hanwoo steers *Asian Australs. J. Anim. Sci.* 26: 1562-1568.

Ko Y.D., Kim, J.H., Adesogan, A.T., Ha, H.M. and Kim, S.C. 2006. The effect of replacing rice straw with dry wormwood (*Artemisia sp.*) on intake, digestibility, nitrogen balance and ruminal fermentation characteristics in sheep. *Anim. Feed Sci. Technol.* 125: 99-110.

Kraszewski, J., Wawrzynczak, S. and Wawrzynski, M. 2002. Rearing of cattle on diets containing various proportions of herb mixture. *Reczniki Nau. Zootech.,*29: 145-164.

Marks, 1959. O-Toluidine method. *Clin. Chem. Acta.* 4: 395.

McIntosh, F. M., Williams, P., Losa, R., Wallace, R. J., Beever, D. A. and C. J. Newbold, C. J. 2003. Effects of essential oils on ruminal Microorganisms and their protein metabolism. *Appl. Environ. Microbiol.* 69: 5011-5014.

Murtuza, M.D. 1998. *Practical Biochemistry*. 1st edition, Alpha Publishers, Patna. pp. 59-61.

Nilius, B. and Szallasi, A. 2014. Transient receptor potential channels as drug targets: from the science of basic research to the art of medicine. *Pharmacol. Rev.* 66: 676-814.

Owens, F.N. and Goetsch, A.L. 1986. Digesta passage and microbial protein synthesis. In: *Control of Digestion and Metabolism in Ruminants* (Eds. Millgan, L.P., Grovum, W.L., Dobson, A.). Prentice-Hall, Englewood Cliffs, NJ 07632, pp. 196-223.

Pattnaik, A.K., Dutta, N., Sharma, K., Kumar, Puneet, Singh, M. and Singh, A. 2009. Influence of *Tinospora-cordifolia* as a functional feed additive on nutrient metabolism, metabolic profile, antioxidant status and immune response of rams. *Proc. Anim. Nutr. Assoc.World Conf.*, 14-17 Feb., New Delhi, India, pp. 189.

Patel, K. and Srinivasan, K. 2004. Digestive stimulant action of spices: A myth or reality? *Indian J. Med. Res.* 119: 167-179.

Russel, J.B. and Houlihan, A.J. 2003. Ionophore resistance of ruminal bacteria and its potential impact on human health. *FEMS Microbiol. Rev.* 27: 65-74.

Simitzis, P. E. 2017. Enrichment of animal diets with essential oils-a great perspective on improving animal performance and quality characteristics of the derived products. *Med. (Basel).* 4: 35.

Skeggs. 1957. *Physiological Chemistry*. Edition reprint-1979, New Delhi, pp. 1039.

Talapatra, S.K., Ray, S.C. and Sen, K.C. 1948. The analysis of mineral contents in biological materials. Estimation of phosphorus, calcium, magnesium, sodium, and potassium in foodstuffs. *Indian J. Vet. Sci. Anim. Husb.* 10: 243-258.

Tsai, M.L., Wu, C.T., Lin, T.F., Lin, W. C., Huang, Y.C. and Yang, C.H.2013.Chemical composition and biological properties of essential oils of two mint species. *Trop. J. Pharm. Res.* 12: 577-582.

Van Soest, P.J., Robertson, J.B. and Lewis, B.A. 1991. Methods of dietary fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition. *J. Diary Sci.* 74: 3583-3597.

Wanapat, M., Khejorsart, P., Pakdeeand P. and Wanapat, S. 2008. Effect of supplementation of garlic powder on rumen ecology and digestibility of nutrients in ruminants. *J. Sci. Food Agric.* 88: 2231-2237.

Zong, L., Qu, Y., Luo, D.X., Zhu, Z.Y., Zhang, S., Su, Z., Shan, J.C., Gao, X.P., and Lu, L. G. 2011.Preliminary experimental research on the mechanism of liver bile secretion stimulated by peppermint oil. *J. Dig. Dis.* 12: 295-301.

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