ISSN 1819-1878

Asian Journal of Animal Sciences

http://knowledgiascientific.com

Knowledgia SCIENTIFIC
A Place to Publish Outstanding Research

OPEN ACCESS Asian Journal of Animal Sciences

ISSN 1819-1878
DOI: 10.3923/ajas.2020.69.74

Research Article
Effect of *Saccharomyces cerevisiae* Fermentation Products on Productive Performance of Ardi Goat

A.A. Alshanbari, S.B. Al-Suwaiegh, Y.M. Al-Yousef and T. A. Al-Shaheen

Department of Animal and Fish Production, King Faisal University, P.O. Box 402, Al-Ahsa, 31982, Kingdom of Saudi Arabia

Abstract

Background and Objective: Goats are one of the major range animals reared for milk and meat production in Saudi Arabia. These animals are capable to survive under highly drought and feed stress conditions. To achieve high milk and meat production, this study was conducted to determine the effect of SCFP on the productive performance of Ardi goats. **Materials and Methods:** The study utilized different inclusion rates of SCFP on 20 lactating goats by following a Randomized Complete Block Design (RCBD). Five SCFP rates namely 0 (control) 2.5, 3.5 and 4.5 g/h/day were tested with 3 to 4 replications. Animals were quarantined for two weeks to acclimatize the metabolic crates and new ration. Milk yield was recorded daily for 90 days. Two experiments were conducted on 20 adult and 20 goat kids for treatment evaluation. Data were analyzed statistically by following appropriate methods for treatment evaluation. **Results:** Milk production, feed efficiency conversion rates and milk fat increased for groups three and four with inclusion rate of 3.5 and 4.5 g/h/day of SCFP, respectively, but without affecting milk protein and lactose concentration. The difference between Total Digestion Nutrients (TDN) and digestibility of Organic Matter (OM) was not significant between the control and other treatments. However, a significant difference was found between the control and other groups in Crude Protein (CP) digestibility. **Conclusion:** Supplementation of SCFP did not show any effect on milk production of Ardi goats, but it improved the FCR and milk fat yield. Also, ADF digestibility improved without any effect on OM and NDF digestibility. Besides, supplementing SCFP reduced the CP digestibility. Overall, the performance of Ardi goats improved with SCFP supplementation.

Key words: Goats, milk production, Saccharomyces cerevisiae fermentation products (scfp), cp digestibility, milk fat, milk protein

Citation: A.A. Alshanbari, S.B. Al-Suwaiegh, Y.M. Al-Yousef and T. A. Al-Shaheen, 2020. Effect of *Saccharomyces cerevisiae* fermentation products on productive performance of ardi goat. Asian J. Anim. Sci., 14: 69-74.

Corresponding Author: S.B. Al-Suwaiegh, Department of Animal and Fish Production, King Faisal University, P.O. Box 402, Al-Ahsa, 31982, Kingdom of Saudi Arabia Tel: 0096567059059

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

According to the Ministry of Environment, Water and Agriculture statistical report around 3.5 million goats were found in Saudi Arabia[1]. Among these, Ardi goats are the most common and widely spread in the Kingdom due to their unique adaptation behavior for low feed quality and quantity, harsh environmental conditions and water scarcity as reported by Aljumaah[2] and El-Nouty *et al.*[3].

Livestock in Saudi Arabia depends on pelleted feed produced in local feed mills, which mainly use concentrate feed mixed with finely chopped fibers. Furthermore, due to inadequate natural pastures, local livestock breeders and producers face multiple nutritional disorders that results in feeding animals on those pelleted feed alone. The main cause of which is the abolition of natural role of rumination that requires sufficient effective fibers in the ration of animals. *Saccharomyces cerevisiae* Fermentation Products (SCFP) are widely used as a feed additive in ruminant nutrition to improve rumen digestibility and lactating performance. They provide soluble growth factors (i.e., organic acids, B vitamins and amino acids) that stimulate growth of ruminal bacteria to utilize lactate and digest cellulose[4,5], improve milk production[6-8] and feed efficiency[9,10]. Whereas, other studies did not find any response for the application of SCFP[11-13]. Therefore, it was assumed that SCFP would improve the lactating performance and digestibility for one of the local goat breeds (Ardi goats) in Saudi Arabia. The main objective of this study was to determine the effect of *Saccharomyces cerevisiae* Fermentation Products (SCFP) on the productive performance of Ardi goats.

MATERIALS AND METHODS

Experimental site: The experiments were conducted at The Research and Training Station, King Faisal University, Saudi Arabia from January-March, 2019. The average temperature during the experimental period was 19°C.

Animals and experimental design

Lactating trial: Twenty lactating Ardi goats were utilized in a Randomized Complete Block Design (RCBD) experiment, divided to four groups with 5 replicates. Animals were randomly assigned within block to one of the four dietary treatments i.e., 0 (control), 2.5, 3.5 and 4.5 g/h/day of SCFP (Table 1). Animals in each group were fed individually in a crate located under semi-shed yard.

Table 1: Experimental design

	Groups			
	1	2	3	4
Lactating goats	5	5	5	5
Goat kids	3	3	3	3
SCFP (g/h/day)	0	2.5	3.5	4.5

SCFP: *Saccharomyces cerevisiae* fermentation products (Original XPC, Diamond V Mills, Inc., Cedar Rapids, IA)

Table 2: Ingredients and chemical composition of the experimental diet

Items	Content
Ingredient (DM%)	
Alfalfa hay	50.0
Wheat bran	7.5
Barley	38.5
Soybean meal	0.2
Dicalcium phosphate	1.0
Limestone	2.1
Salt	0.6
[1]Vitamin and mineral Premix	0.1
Chemical composition (DM%)	
DM	88.80
CP	13.90
EE	2.29
CF	18.90
NDF	35.06
ADF	33.45
Ca	1.41
P	0.51
Ash	6.17

DM: Dry matter, CP: Crude protein, EE: Either extract, CF: Crude fiber, NDF: Natural detergent fiber, ADF: Acid detergent fiber, [1]Vit. and min. premix contains Vitamin A: 10.000.000 IU, Vitamin D3:1,000,000 IU, Vitamin E:100,000 mg, Manganese: 50,000 mg, Zinc: 45,000 mg, Iron: 80,000 mg, Copper: 6000 mg, Cobalt: 800 mg, Iodine: 2500 mg, Selenium: 100 mg (per kg premix)

Digestibility trial: Twelve Ardi goat kids were utilized in a randomized complete block design experiment, divided to four groups with 3 replicates. Animals were randomly assigned within block to one of the four dietary treatments i.e., 0 (control), 2.5, 3.5 and 4.5 g/h/day of SCFP (Table 1). Goats were adapted to the metabolic crates for two weeks followed by the collection period lasting 8 days. Feed was offered at 8:00 AM during the trial. The quantity of feed offered and refusal were weighed and recorded daily.

Experimental diet: Feeding ration was formulated for goats according to NRC[14]. The ingredients used in formulating the experimental diets and their chemical composition are presented in Table 2. The SCFP was top dressed, mixed by hand with the concentrates and then mixed with Alfalfa as a Total Mixed Ration (TMR).

Sample collection

Lactating trial: Goats were milked once a day at 8 am. Milk samples of each goat were collected every other week and

analyzed using LactoStar device, a fully automatic device for chemical milk analysis (Funke-Dr.N.Gerber Labortechnik GmbH, Germany).

Digestibility trial: Feed and refusal were sampled daily and approximately 150-200 g was composted until the end of the collection period for further analysis. Daily fecal excretions were collected at 7:00 am and weighed. A sample of feces was collected daily from each animal (15-20%) and dried in a forced air oven at 60°C for 48 h to determine the Dry Matter (DM) percentage. Digestion coefficients were calculated for Organic Matter (OM), Crude Protein (CP), Ether Extract (EE), Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) as a difference between nutrient intake and nutrient excreted in the feces divided by nutrient intake and then multiplied by 100.

Chemical analysis: Chemical analysis was according to AOAC[15] procedures. Composited sample of feed, refusal and feces were analyzed based on DM using forced air oven at 105°C for 24 h. The CP was determined by macro-Kjeldahl procedure method. Ether extract was determined with petroleum ether as the solvent method. The ADF and NDF were determined by using the method described in Tukeys Honestly Significant Difference (HSD) test[16].

Statistical analysis: Statistical analyses of data were carried out using IBM SPSS, statistics (IBM Corp)[17]. The experimental data were subjected to one-way analysis of variance (ANOVA). The treatment means were separated ($p<0.05$) using Tukey's honestly significant difference test[16] to evaluate the effect of feeding SCFP supplementation on milk production and composition, dry matter intake and apparent nutrient digestibility of Ardi goats.

RESULTS AND DISCUSSION

Lactating trial

Dry matter intake and feed efficiency: The results of the study showed a significant decrease ($p<0.05$) in Dry Matter Intake (DMI) by 30 and 21 g/h/day for groups three and four, respectively (Table 3). The decrease in DMI could be due to an increase in ruminal fermentation caused by feeding SCFP as reported by Callaway and Martin[4], Rodriguez[18] and Zhu *et al*., 2017)[5] that would supply the animals with enough energy and make them feel satiation. Similar results were observed in Saudi Arabia for lactating Holstein cows where DMI decreased by 3.4 kg/h/day as observed by Alshaikh *et al*.[6]. The DMI results reflected on Feed Conversion Ratio (FCR) for both studies. However, in this study, FCR was improved in all the treatment groups compared to control ($p<0.05$). But group four with inclusion rate of 4.5 g/h/day of SCFP showed the highest improvement in FCR compared to control (1.64 vs. 2.00 kg DMI/1 kg MY) and other groups (Table 3). Similar results were reported on FCR improvement with SCFP supplementation according to Zhu *et al*.[10] and Acharya *et al*.[8]. Many research studies on sheep and goat showed lot of variation either without any effect on DMI based on the findings of Salama *et al*.[19], Haddad and Goussous[20], Titi *et al*.[21] and Zicarelli *et al*.[22] or increase in DMI according to Stella *et al*.[23] and Osita *et al*.[24]. Similarly, for cows, there was no effect either on DMI according to Hristov *et al*.[13], Ibrahim *et al*.[24] Acharya *et al*.[8] and Zhu *et al*.[5] or increase in DMI as observed by previous researchers[25-27]. A meta-analysis of 36 studies on SCFP supplementation showed an increase in DMI for cows with <70 Days In Milk (DIM) and a decrease in DMI for cows with >70 DIM as stated by Poppy *et al*.[28].

Table 3: Live body weight, dry matter intake, daily milk production and composition of lactating Ardi goats fed SCFP supplementation

	Groups			
Items	1	2	3	4
Initial body weight (kg)	58.80	57.20	56.90	57.40
Final body weight (kg)	62.10	60.80	62.20	60.10
DMI (kg/day)	1.474^{a}	1.467^{a}	1.444^{b}	1.453^{b}
Milk production (kg/day)	0.805	0.794	0.829	0.845
Fat (%)	2.49	2.81	2.62	2.77
Fat yield (g/day)	20.06^{c}	22.35^{ab}	21.75^{b}	23.40^{a}
Protein (%)	3.08	3.07	2.90	2.75
Protein yield (g/day)	24.78	24.38	24.08	23.24
Lactose (%)	4.38	4.46	4.25	4.38
Lactose yield (g/day)	35.22	35.40	35.21	36.97
DMI/1 kg MY (feed conversion ratio)	2.00^{a}	1.86^{b}	1.89^{b}	1.64^{c}

DMI: Dry matter intake, MY: Milk yield, $^{a-c}$Means within a row with different superscript differ ($p<0.05$)

Milk yield and composition: The results did not show any effect of supplementing SCFP on milk yield for Ardi goats. However, based on the study findings, milk production increased numerically for group three and four compared to control group, but it was not significant with a value of 0.829, 0.845 and 0.805 kg/h/day for group 3, 4 and 1, respectively ($p<0.09$) Table 3. Similar results were reported by Zhu *et al*.[5], who found a linear increase in milk production for cows supplemented with deferent levels of SCFP. Other researchers also reported similar results in cows as observed by Schingoethe *et al*.[9], Robinson[11] and Erasmus *et al*.[12] and goats as found by Salama *et al*.[19] and Zicarelli *et al*.[22]. In contrast to the results of the present study, Alshaikh *et al*.[6]

Table 4: Apparent nutrient digestibility coefficients of Ardi goat kids fed SCFP supplementation

	Groups			
Items (%)	1	2	3	4
Organic matter	77.36	77.66	78.56	78.93
Crude protein	82.80[a]	80.33[b]	80.16[b]	80.40[b]
Neutral detergent fiber	59.50	60.60	58.53	62.36
Acid detergent fiber	64.13[b]	66.10[ab]	63.53[b]	66.73[a]
Fat (EE)	88.76[b]	88.93[ab]	89.76[ab]	89.90[a]
Nutritive value (%)				
Total digestible nutrients	75.12	75.45	76.29	76.60

[a-c]Means within a row with different superscript differ (p<0.05)

showed a significant increase in milk production for cows supplemented with SCFP compared to control group (21.54 vs. 22.84 kg/h/day). Other studies also showed an increase in milk production for cows as reported by Hippen *et al.*[7], Salvati *et al.*[29], Zhu *et al.*[10] and Acharya *et al.*[8]; sheep and goats as investigated by Stella *et al.*[23] and Masek *et al.*[30]. Fat yield increased significantly for groups supplements with SCFP compared to control (Table 3). Milk fat contents were mainly linked with fiber digestibility (Table 4). The results of this study showed an improvement in NDF and ADF digestibility. Furthermore, Callaway and Martin[4] and Zhu *et al.*[5] reported that SCFP supplementation increased the population of cellulolytic bacteria and concentrations of ruminal total Volatile Fatty Acids (VFA) and acetate. Fat yield results of this study were identical to the findings of other studies for cows as stated by Alshaikh *et al.*[6] and Maamouri *et al.*[31] and sheep according to Masek *et al.*[30] both for milk fat percentage or yield. On the other hand, Acharya *et al.*[8] reported a decrease in milk fat percentage for one of the test products of SCFP compared to control group for cows. A decrease in milk fat for goats was reported by Stella *et al.*[23] and Zicarelli *et al.*[22] when supplemented with active *Saccharomyces cerevisiae*. It was also observed that supplementing SCFP did not affect milk lactose and protein in this study except a numerical increase in milk lactose for group four. Acharya *et al.*[8] reported an increase in milk lactose yield for the same group as mentioned earlier. Whereas, an increase in milk lactose were observed for sheep and goats supplemented with ASC as stated by Masek *et al.*[30] and Salvati *et al.*[29]. A number of researchers did not report any effect of supplementing SCFP on milk composition based on the findings of Zhu *et al.*[5], Zhu *et al.*[10], Erasmus *et al.*[12] and Hristov *et al.*[13].

Digestibility trial: The apparent nutrients digestibility for Adri goats supplemented with SCFP are presented in Table 4. There was no difference in OM and NDF digestibility between treatment and control groups, but a linear increase was observed when the inclusion rate of SCFP was increased. The ADF digestibility increased significantly (p<0.05) for group four (66.73%) compared to control group (64.13%). The difference between group 2 (66.10%) and 3 (63.53%) were not significant. Similar results were reported regarding NDF and ADF digestibility by Titi *et al.*[21] and OM digestibility by Obeidat *et al.*[32]. Whereas, some researchers reported a significant increase in both the NDF and ADF according to findings of Haddad *et al.*[20] and Obeidat *et al.*[32] and OM digestibility as observed by Titi *et al.*[21] and Osita *et al.*[24] for animals supplemented with SCFP compared to control. Goats fed the control group was significantly (p<0.05) higher in CP digestibility compared to the treatment groups. Estimating CP digestibility in ruminants could give inaccurate results due to the presence of a different protein source than the protein in the feed. The protein used by the animal may be from the feed or from the microbes washed from the rumen. Because the amount of each depends on the extent to which dietary protein is degraded in the rumen and on the growth and outflow of microbes from the rumen as found by Moran[33]. Another researcher stated that between 60 and 85% of the total amino acid-nitrogen entering the small intestine is microbial protein and true digestibility of microbial protein in the small intestine appears to be remarkably constant (74-85%) as reported by Meyer *et al.*[34]. The SCFP provides soluble growth factors (i.e., organic acids, B vitamins and amino acids) that stimulate growth of ruminal bacteria and increase microbial population and total volatile fatty acids as found by Callaway and Martin[4] and total gas production according to Rodriguez, *et al.*[18]. These factors suggested that more microbes were washed from the rumen and the fecal CP% for treatment groups was higher than the control group which was reflected on CP digestibility showing a significant increase for control compared to treatment groups (p<0.05).

CONCLUSION

This study finding showed the effect of supplementing SCFP on milk production for Ardi goats, but it improved the FCR and milk fat yield. The ADF digestibility was also improved without any effect on OM and NDF digestibility, but supplementing SCFP decreased the digestibility of Crude Protein (CP).

SIGNIFICANCE STATEMENT

This study discovered that among the different range animals, Ardi goats play a significant role both in meat and milk production in the country. The study showed that the

inclusion rates of SCFP improved the milk production, milk fat, ADF digestibility and Feed Conversion Ratio (FCR) of Ardi goats. Overall, this study will help the researchers to determine the critical level of SCFP application in order to improve the sustainable raring and production of Ardi goats as a beneficial range animal in an arid environment.

ACKNOWLEDGMENTS

The authors express their sincere gratitude and thanks to King Faisal University for financial supporting this research and for providing necessary materials and facilities to conduct the study at The Research and Training Station. I would like to thank Al-Ghadeer feed mill, Al-Ahsa for providing the concentrates feed for the animals in the study. I would also like to thank Al-Safi dairy farm, Al-Kharj for chemical analyses of the research materials.

REFERENCES

1. Ministry of Agriculture, 2018. Agricultural statistics year book. Kingdom of Saudi Arabia. Pp. 177-199.
2. Aljumaah, R.S., M.M. Musthafa, M.A. Alshaikh, O.M. Badri and M.F. Hussein, 2012. Genetic diversity of ardi goat based on microsatellite analysis. Afr. J. Biotechnol., 11: 16539-1654.
3. El-Nouty, F.D. A.A. Al-Haidary and S.M. Basmaeil, 1990. Physiological responses, feed intake, urine volume and serum osmolality of aardi goats deprived of water during spring and summer. Asian Australas. J. Anim. Sci., 3: 331-336.
4. Callaway, E.S. and S.A. Martin, 1997. Effects of a *Saccharomyces cerevisiae* culture on ruminal bacteria that utilize lactate and digest cellulose. J. Dairy Sci., 80: 2035-2044.
5. Zhu, W., Z. Wei, N. Xu, F. Yang and I. Yoon, 2017. Effects of *Saccharomyces cerevisiae* fermentation products on performance and rumen fermentation and microbiota in dairy cows fed a diet containing low quality forage. J. Anim. Sci. Biotechnol., 10.1186/s40104-017-0167-3
6. Alshaikh, M.A., M.Y. Alsiadi, S.M. Zahran, H.H. Mogawer and T.A. Alshowime, 2002. Effect of feeding yeast culture from different sources on the performance of lactating Holstein cows in Saudi Arabia. Asian Aust. J. Anim. Sci., 15: 352-356.
7. Hippen, A.R., D.J. Schingoethe, K.F. Kalscheur, P.L. Linke, D.R. Rennich, M.M. Abdelqader and I. Yoon 2010. Saccharomyces cerevisiae fermentation product in dairy cow diets containing dried distillers grains plus solubles. Journal of Dairy Sci., 93: 2661-2669.
8. Acharya, S., J.P. Pretz, I. Yoon, M.F. Scott and D.P. Casper, 2018. Effects of *Saccharomyces cerevisiae* fermentation products on the lactational performance of mid-lactation dairy cows. Transl. Anim. Sci., 1: 221-228.
9. Schingoethe, D.J., K.N. Linke, K.F. Kalscheur, A.R. Hippen, D.R. Rennich and I. Yoon, 2004. Feed efficiency of mid-lactation dairy cows fed yeast culture during summer. J. Dairy Sci., 87: 4178-4181.
10. Zhu, W., B.X. Zhang, K.Y. Yao, I. Yoon, Y.H. Chung, J.K. Wang and J.X. Liu, 2016. Effects of supplemental levels of *Saccharomyces cerevisiae* fermentation product on lactation performance in dairy cows under heat stress. Asian-Aust. J. Anim. Sci., 29: 801-806.
11. Robinson, P.H., 1997. Effect of yeast culture (*Saccharomyces cerevisiae*) on adaptation of cows to diets postpartum. J. Dairy Sci., 80: 1119-1125.
12. Erasmus, L.J., P.H. Robinson, A. Ahmadi, R. Hinders and J.E. Garrett, 2005. Influence of prepartum and postpartum supplementation of a yeast culture and monensin, or both, on ruminal fermentation and performance of multiparous dairy cows. Anim. Feed Sci. Technol., 122: 219-239.
13. Hristov, A.N., G. Varga, T. Cassidy, M. Long and K. Heyler *et al*., 2010. Effect of *Saccharomyces cerevisiae* fermentation product on ruminal fermentation and nutrient utilization in dairy cows. J. Dairy Sci., 93: 682-692.
14. NRC., 1981. Nutrient Requirements of Domestic Animals. National Academic Press, Washington, DC., USA., Pages: 91.
15. AOAC., 2002. Official Methods of Analysis of AOAC International. 17th Edn., Association of Official Analytical Chemistry, Gaithersburg, MD, USA.
16. Vogt, W.P., 2015. Tukeys honestly significant difference (HSD) test. In: Dictionary of Statistics and Methodology. Vogt, W.P., SAGE Publications, Inc. California, United States. .
17. IBM Corp., 2019. IBM SPSS Statistics, Version 27.0. Armonk, NY: IBM Corp.
18. Rodriguez, M.P., M.D. Mariezcurrena, M.A. Mariezcurrena, B.C. Lagunas and M.M.Y. Elghandour *et al*., 2015. Influence of live cells or cells extract of *Saccharomyces cerevisiae* on *in vitro* gas production of a total mixed ration. Ital. J. Anim. Sci., Vol. 14, No. 4. 10.4081/ijas.2015.3713.
19. Salama, A.A.K., G. Caja, D. Garin, E. Albanell, X. Sush and R. Casals, 2002. Effects of adding a mixture of malate and yeast culture (*Saccharomyces cerevisiae*) on milk production of murciano-granadina dairy goats. Anim. Res., 51: 295-303.
20. Haddad, S.G. and S.N. Goussous, 2005. Effect of yeast culture supplementation on nutrient intake, digestibility and growth performance of Awassi lambs. Anim. Feed Sci. Technol., 118: 343-348.
21. Titi, H.H., R.O. Dmour and A.Y. Abdullah, 2008. Growth performance and carcass characteristics of awassi lambs and shami goat kids fed yeast culture in their finishing diet. Anim. Feed Sci. Technol., 142: 33-43.
22. Zicarelli, F., L. Addi, R. Tudisco, S. Calabrò, P. Lombardi, M. I. Cutrignelli and G. Moniello, 2016. The influence of diet supplementation with *Saccharomyces cerevisiae* or *Saccharomyces cerevisiae* plus *Aspergillus oryzae* on milk yield of Cilentana grazing dairy goats. Small Ruminant Res., 135: 90-94.

23. Stella, A.V., R. Paratte, L. Valnegri, G. Cigalino and G. Soncini *et al*., 2007. Effect of administration of live Saccharomyces cerevisiae on milk production, milk composition, blood metabolites and faecal flora in early lactating dairy goats. Small Rumin. Res., 67: 7-13.
24. C.O. Osita, A.O. Ani, N.E. Ikeh, C.E. Oyeagu, E.A. Akuru, I.E. Ezemagu and V.C. Udeh, 2019. Growth performance and nutrient digestibility of West African Dwarf Sheep fed high roughage diet containing *Saccharomyces cerevisiae* Agro-Sci., 10.4314/as.v18i3.5.
25. Al-Ibrahim, R.M., A.K. Kelly, L. O'Grady, V.P. Gath, C. McCarney and F.J. Mulligan, 2010. The effect of body condition score at calving and supplementation with Saccharomyces cerevisiae on milk production, metabolic status and rumen fermentation of dairy cows in early lactation. J. Dairy Sci., 93: 5318-5328.
26. Dann, H.M., J.K. Drackley, G.C. McCoy, M.F. Hutjens and J.E. Garrett, 2000. Effects of yeast culture (*Saccharomyces cerevisiae*) on prepartum intake and postpartum intake and milk production of jersey cows. J. Dairy Sci., 83: 123-127.
27. Hassan, A.A., A.Z.M. Salem, A.E. Kholif, M. Samir and M.H. Yacout *et al*., 2016. Performance of crossbred dairy Friesian calves fed two levels of Saccharomyces cerevisiae: intake, digestion, ruminal fermentation, blood parameters and faecal pathogenic bacteria. J. Agric. Sci., 154 : 1488-1498.
28. Poppy, G.D., A. Rabiee, I.J. Lean, W.K. Sanchez, K.L. Dorton and P.S. Morley, 2012. A meta-analysis of the effects of feeding yeast culture produced by anaerobic fermentation of *Saccharomyces cerevisiae* on milk production of lactating dairy cows. J. Dairy Sci., 95: 6027-6041.
29. Salvati, G.G.S., N.N.M. Júnior, A.C.S. Melo, R.R. Vilela and F.F. Cardoso *et al*., 2015. Response of lactating cows to live yeast supplementation during summer. J. Dairy Sci., 98: 4062-4073.
30. Masek, T., Z. Mikulec, H. Valpotic, N. Antunac and N. Mikulec *et al*., 2008. Influence of live yeast culture (*Saccharomyces cerevisiae*) on milk production and composition and blood biochemistry of grazing dairy ewes during the milking period. Acta Vet., 77: 547-554.
31. Maamouri, O., H. Selmi and N. M'hamdi, 2014. Effects of yeast (Saccharomyces cerevisiae) feed supplement on milk production and its composition in Tunisian Holstein Friesian cows. Sci. Agric. Bohem., 45: 170-174.
32. Obeidat, B.S., K.Z. Mahmoud, M.D. Obeidat, M. Ata and R.T. Kridli *et al*., 2018. The effects of Saccharomyces cerevisiae supplementation on intake, nutrient digestibility and rumen fluid pH in Awassi female lambs. Vet. World, 11: 1015-1020.
33. Moran, J., 2005. Tropical Dairy Farming: Feeding Management for Small Holder Dairy Farmers in the Humid Tropics. Landlinks Press, Victoria, Australia.
34. Meyer, J.H.F., A.C.M. van Nickerk and J.G. van Der Walt, 2014. Ileorectal anastomasis: An animal model for studying protein digestion in the small intestine of ruminants. Asian Australas. J. Anim. Sci., 2: 329-330.