RESEARCH ARTICLE Asian Journal of Dairy and Food Research, Volume 42 Issue 3: 292-297 (September 2023)

Qualitative Analysis of Apple Pomace based Maize Silage for Animal Feeding

Ngahanyui Kengoo[1], Rohit Bishist[1], Sunita Devi[2], Krishan Lal Gautam[1], S. Khalandar[3]

10.18805/ajdfr.DR-1878

ABSTRACT

Background: Himachal Pradesh is one of the important apple producing state in India and a substantial quantity of apple fruit is utilized in processing for the preparation of juice and the left-over apple pomace remains a pollutant owing to the un-hygienic nature of apple pomace and its quick bio-degradability. Only a small fraction of apple pomace is traditionally being utilized in animal feeding due to the rapid spoilage of the wet pomace. The utilization of apple pomace in animal feeding remains a challenge and thus an attempt was made to ensile the maize through incorporation of apple pomace.

Methods: The study was conducted to evaluate the nutritive value of maize silage incorporated with different levels of apple pomace and to study the effect of feeding silage on milk performance of crossbred cows. In the experiment apple pomace was incorporated in maize silage at 10, 20 and 30 per cent level.

Result: On studying the proximate composition of different silage it was found that silage (T3) containing 80 per cent maize, 10 per cent apple pomace and 10 per cent mulberry leaves showed promising results. In T3 the proximate principles *viz*. dry matter, crude protein, crude fibre, ether extract, neutral detergent fibre acid detergent fibre, total ash, acid insoluble ash and pH were in ideal range and was at par with the silage formed by ensiling of sole maize crop. In the animal feeding trial, on feeding of apple pomace based maize silage 10.21 per cent higher milk yield was recorded with significantly higher milk fat, SNF and proteins. The net return on feeding of apple pomace based maize silage to crossbred cows was ` 149.00 which was higher than the control group (` 143.00 cow^{-1} day^{-1}).

Key words: Apple pomace, Milk composition, Mulberry, Silage.

INTRODUCTION

India being an agricultural country with nearly 70 per cent of the population living in rural areas and rely upon agriculture and animal husbandry for their sustenance. Livestock farming has been considered as one of the mainstay of the rural economy and is an important sub sector of the agriculture in Indian economy with a contribution of about 4.9 per cent of the total GDP of the country (Anonymous, 2020). Unavailability of green fodder in the lean period is the major constraint in dairy production in the country which has emphasized on conservation of green fodder.

Apple (*Malus domestica* Borkh.) is a climacteric fruit cultivated in temperate regions of the world (Luby, 2003) with an annual production of 75.9 million tonnes (FAO, 2019). Himachal Pradesh is also called as “Apple bowl of India” with the annual production of 4.46 lakh metric tonnes under an area of 1.12 lakh hectare (Anonymous, 2018 and 2019). The residue left after extraction of juice from apple fruit is called apple pomace which is an industrial waste and an environmental pollutant. Apple pomace is traditionally utilized as an animal feed ingredient; however, only a small fraction of apple pomace is used due to the rapid spoilage of the wet pomace. Apple pomace are highly succulent moist feed, providing a good source of digestible fibre that can be used as either a forage extender or concentrate feed. High moisture and fermentable sugar content of fresh apple pomace owes to rapid spoilage of the pomace and therefore requires either ensilage or dehydration of the pomace for longer preservation (Shalini *et al.,* 2010; Crawshaw, 2004). Fresh apple pomace has an average of 4.5 per cent CP content and it could be effectively used as an alternative animal feed resource in heifer ration (Chandel *et al.,* 2015).

Mulberry foliage is an excellent source of crude protein (20-24%) and is utilized in animals feeding in lean period. In order to increase the CP content of silage Ba *et al.* (2005) advocated the use of mulberry foliage in the form of silage

[1]Department of Silviculture and Agroforestry, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan-173 230, Himachal Pradesh, India.
[2]Department of Basic Sciences, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan-173 230, Himachal Pradesh, India.
[3]Department of Social Sciences, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan-173 230, Himachal Pradesh, India.

Corresponding Author: Krishan Lal Gautam, Department of Silviculture and Agroforestry, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan-173 230, Himachal Pradesh, India. Email: krishanlalgautam99@gmail.com

How to cite this article: Kengoo, N., Bishist, R., Devi, S., Gautam, K.L. and Khalandar, S. (2023). Qualitative Analysis of Apple Pomace based Maize Silage for Animal Feeding. Asian Journal of Dairy and Food Research. 42(3): 292-297. doi: 10.18805/ajdfr.DR-1878.

Submitted: 24-01-2022 **Accepted:** 18-04-2022 **Online:** 12-05-2022

without addition of additives like molasses. Due to the acute scarcity of green fodder during winters and extreme summers in Himachal Pradesh, the conservation of fodder in the form of silage holds a great potential to meet the nutritional demands of the ever growing livestock population of the state. The concept of silage making is very common in dairy states like Punjab (Brar *et al.,* 2019) where it's been used for animal feeding during lean periods. Silage is the product formed when grasses or other fodder crops with sufficient moisture and soluble carbohydrate content (*e.g.,* sorghum and forage corn) are stored under anaerobic conditions in a structure known as silo. During ensilage, the fodder undergoes an acid fermentation in which bacteria produce lactic, acetic and butyric acids from sugars present in the raw material. The net result is a reduction in the pH which prevents the growth of spoilage microorganisms, the majority of which are intolerant to acidic conditions (Singh and Neelakantan, 2007). Different studies (Rodrigues *et al.,* 2008 Nazir, 2017) have been conducted to utilize apple pomace in the form of silage and it has been reported that apple pomace could be effectively ensiled using wheat straw in different proportions. However, to our knowledge no study is available, where apple pomace and mulberry leaves have been utilized with corn to prepare the silage. Therefore, the study was undertaken to evaluate the nutritive value of mulberry and apple pomace based maize silage and its utilization in animal feeding.

MATERIALS AND METHODS

The study was conducted at the Dairy Farm of Department of Silviculture and Agroforestry, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during the year 2018-2019 with the objective to evaluate the nutritive value of maize silage incorporated with different levels of apple pomace and mulberry leaves and to evaluate the effect of feeding mulberry and apple pomace based maize silage on milk performance of cross bred dairy cows. In the first experiment, fodder maize (Var. African tall) was harvested from the university field at milk stage. Fresh mulberry leaves were lopped from the university agroforestry farm and the fresh apple pomace was procured from HPMC Parwanoo, HP. The nutritive value of fodder maize, apple pomace and mulberry leaves are presented in Table 1. Silage was prepared by chopping the maize and Mulberry leaves in lengths of about 1-1.5 inches by using the chaff cutter and subsequently filling in the silage bags. The ingredients were mixed in different ratio (Fresh weight basis) with following treatment details *i.e.* T1 (100% maize silage), T2 (85% apple pomace + 15% wheat straw), T3 (80% maize + 10% apple pomace + 10% mulberry leaves), T4 (70% maize + 20% apple pomace + 10% mulberry leaves) and T5 (60% maize + 30% apple pomace + 10% mulberry leaves). The experiment was conducted using randomized block design with four replications under each treatment. The silage bags were sealed in air tight conditions and it was made sure that no air is trapped inside the silage bags. These bags were covered, sealed and stored for a period of 60 days. The representative samples were collected from silage bags after 60 days storage and pH, dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF), neutral detergent fibre (NDF), acid detergent fibre (ADF), nitrogen free extract (NFE), total ash (TA) and acid insoluble ash (AIA) were determined according to the methods of Association of Official Analytical Chemists (AOAC, 1990). The recorded data were analysed by using OPSTAT statistical software.

In the second experiment, after analysing the nutritive value of the silage formed under different treatment groups the best silage (T3 on the basis of CP) was incorporated in the diets of lactating jersey crossbred cows maintained at the university dairy farm to study the milk performance of cows. In the experiment of 90 days duration, twelve crossbred cows were selected on the basis of their milk yield and were divided into two equal groups of six animals each. Animals in the control group were fed with the standard feeding practices of the farm *i.e.* concentrate @ 4 kg d^{-1}, wheat straw @ 5 kg d^{-1} and *Grewia optiva* tree fodder @ 5 kg d^{-1}. Whereas, each animal in treatment group was given 5 kg silage d^{-1} in addition to the standard feeding practices adopted in the farm. The daily milk yield of the animals in both the groups were recorded and the representative milk samples were taken at fortnightly interval for analysing the milk composition *viz.* milk fat, specific gravity, milk acidity, solid not fat (SNF), total solids and milk protein (FSSAI, 2012). The data obtained was analysed using OPSTAT Statistical Software.

Table 1: Nutritional value of Mulberry leaves, apple pomace and maize fodder (% DM basis).

Parameters	Mulberry	Apple pomace	Maize fodder
Dry matter (%)	28.94	80.65	15.86
Crude protein (%)	16.90	7.27	8.67
Ether extract (%)	5.8	0.91	5.64
Crude fibre (%)	17.01	33.52	20.70
Neutral detergent fibre (%)	50.17	60.60	54.83
Acid detergent fibre (%)	31.88	37.95	47.21
Nitrogen free extract (%)	46.93	50.51	61.14
Total ash (%)	13.36	7.61	3.85
Acid insoluble ash (%)	2.61	1.04	1.23

RESULTS AND DISCUSSION

The results on nutritive value of maize silage incorporated with apple pomace and mulberry leaves are presented in Table 2. The DM content of silage ranged between 22.91 to 33.20 per cent (Table 2), with the highest DM in corn silage (T1) and lowest in T5 (60% Maize + 30% pomace +10 per cent mulberry leaves). The findings of the study revealed that the DM content decreased with the increasing concentration of apple pomace in silage. The pH in the silage ranged between 3.65 to 4.24 per cent (Table 2) and the minimum pH was observed in T5. The pH content of the silage decreased significantly on addition of apple pomace in silage. Findings of the present study are in agreement to the previous study of Pirmohammadi *et al*. (2006) who compared the ensiled apple pomace with corn silage and reported lower pH in ensiled apple pomace as compared to corn silage (3.4 and 4.6). The CP content in the silage ranged between 6.5 to 8.73 per cent (Table 2). The CP content of silage varied significantly among all treatment groups with the highest CP in T3 (80% maize +10% AP + 10% mulberry leaves). It was observed that with the increasing proportions of the apple pomace in the silage, the CP content of the silage decreased significantly but were higher than that of T1 and T2. The increase in CP content in T3 could be attributed to the fact that addition of mulberry leaves along with maize and low levels of apple pomace has resulted in increase in CP content of the silage. Pirmohammadi *et al.* (2006) and Kara *et al.* (2018) has also reported 7.2 and 6.84 per cent crude protein in the apple pomace silage made without addition of tree leaves in the silage. Chaudhary *et al.* (2016) has also reported 6.1-9.15 per cent CP content in maize silage of different hybrids.

The fibre fractions *i.e.* CF, NDF and ADF contents in the silage decreased significantly with the increasing levels of apple pomace in the silage. The CF content ranged from 21.53 to 27.46 per cent with the minimum CF in T5 and highest in T2. The NDF content ranged between 37.15 to 50.59 per cent with the lowest NDF in T5 and maximum in T2. The ADF content varied between 21.55 to 27.27 with lowest in T1 and highest in T2 treatment group. The CF and NDF contents decreased on increasing proportions of apple pomace in the silage with the highest CF and NDF in the silage prepared by ensiling apple pomace with wheat straw, which may be due to the higher percentage of these fractions in wheat straw. However, the ADF fraction was observed minimum in T1 (corn silage). Findings of the present study are in agreement with the previous studies of Juracek *et al.* (2012) where 18.27 per cent crude fibre content was reported in maize silage. Kara *et al.* (2018) also reported 32.08 per cent crude fibre in apple pomace silage. Similar NDF contents have been reported in apple pomace silage by Abdollahzadeh *et al.* (2010) where 45.3 per cent NDF was observed in apple pomace silage. Islam *et al.* (2018) also reported 42.5 per cent NDF in fermented apple pomace. Kara *et al.* (2018) also reported 30.34 per cent ADF in apple pomace.

The total ash and acid insoluble ash content of the silage followed a decreasing trend on increasing the concentration of apple pomace in the silage. The total ash content was recorded highest in T2 and minimum in T5 with the corresponding values of 7.65 and 4.37 per cent, respectively. Similar trend was recorded in AIA content of the silage. Fang *et al.* (2016) also reported similar results with 3.9 per cent ash content in apple pomace. Massod *et al.* (2017) reported that the ash content in apple pomace was 2.77 per cent and 3.84 per cent in corn silage which are in agreement with findings of the study.

In the second experiment the silage prepared in treatment T3 (higher CP) was utilized in an animal feeding trial on jersey crossbred cows to evaluate the changes in milk production and composition. It was observed that feeding of silage to the crossbred cows (Fig 1) resulted in significantly higher average peak mean milk yield than that of control group (Fig 1). Feeding of silage to the crossbred cows in the treatment group resulted in 10.21 per cent higher milk yield as compared to the control group. The results in the present study were in agreement with the previous studies of Edwards and Parker (1995) who reported that the supplementation of apple pomace resulted in the increase in the milk yields of dairy cows in late lactation. Bal *et al.* (1997) also reported that the milk production in dairy cows increased by 1 kg day^{-1} which were fed silage from corn harvested at 2/3 milk line stage. Anrique and Dossow (2003) also reported that inclusion of apple pomace in cow's diet resulted in 9 and 5.9 per cent increase in standardized (4% fat) and non-standardized milk production.

Table 2: The nutritive value of different maize silage (% DM basis).

	pH	DM	CP	EE	CF	NDF	ADF	NFE	TA	AIA
T1 (Control maize silage)	4.24^{a}	33.20^{b}	7.35^{d}	4.27^{a}	26.36^{b}	38.65^{d}	21.55^{e}	54.38^{e}	6.55^{b}	1.04^{e}
T2 (15% Wheat Straw + 85% Apple pomace)	4.05^{b}	39.11^{a}	6.52^{e}	3.29^{e}	27.46^{a}	50.59^{a}	27.27^{a}	56.18^{c}	7.65^{a}	2.15^{a}
T3 (80% Maize + 10% AP + 10% mulberry leaf)	3.84^{c}	29.20^{c}	8.73^{a}	4.10^{b}	25.67^{c}	48.38^{b}	25.55^{b}	55.36^{d}	6.15^{c}	1.55^{b}
T4 (70% Maize + 20% AP + 10% mulberry leaf)	3.75^{d}	25.74^{d}	8.37^{b}	3.87^{c}	22.72^{d}	42.55^{c}	23.97^{c}	59.79^{b}	5.27^{d}	1.35^{c}
T5 (60% Maize + 30% AP + 10% mulberry leaf)	3.65^{e}	22.91^{e}	7.83^{c}	3.55^{d}	21.53^{e}	37.15^{e}	23.37^{d}	62.73^{a}	4.37^{e}	1.25^{d}
Overall mean	3.91	30.03	7.76	3.82	24.75	43.46	24.34	57.67	6.00	1.47

*Means bearing different superscripts within a column are statistically different to each other.

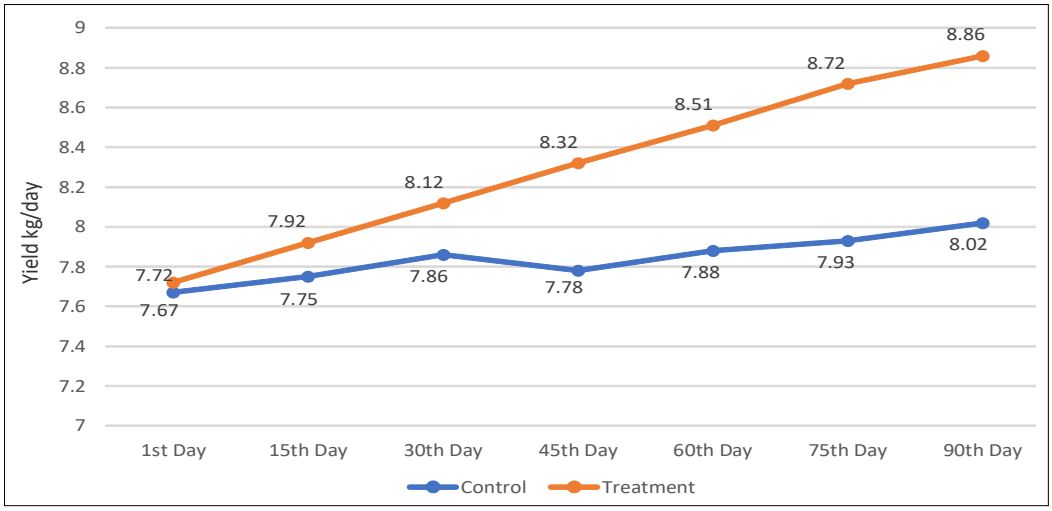

Fig 1: Effect of maize silage incorporated with mulberry and apple pomace on milk yield (animal kg^{-1} day^{-1}) of crossbred cows.

Table 3: Effect of feeding of apple pomace based maize silage on milk composition of crossbred cows

Parameters	Days/groups	I	II	III	IV	V	VI	VII	Mean
		1st day	15th day	30th day	45th day	60th day	75th day	90th day	
Milk fat (%)	Control (C)	3.83	3.92	3.86	3.98	3.85	3.9	3.88	3.89^{a}
	Treatment (T)	3.86	3.91	3.93	4.07	4.19	4.22	4.27	4.06^{b}
Solid not fat (%)	Control (C)	8.96	9.03	8.93	8.83	9.09	9.11	8.94	8.98^{a}
	Treatment (T)	9.01	9.14	9.18	9.24	9.26	9.26	9.27	9.19^{b}
Total milk solids (%)	Control (C)	12.79	12.94	12.79	12.81	12.94	13.01	12.81	12.87^{a}
	Treatment (T)	12.87	13.05	13.11	13.31	13.45	13.48	13.54	13.26^{b}
Milk acidity (%)	Control (C)	0.137	0.135	0.136	0.138	0.14	0.142	0.141	0.138^{a}
	Treatment (T)	0.129	0.138	0.138	0.137	0.138	0.138	0.141	0.137^{a}
Specific gravity	Control (C)	1.029	1.028	1.03	1.028	1.03	1.029	1.028	1.029^{a}
	Treatment (T)	1.029	1.03	1.03	1.029	1.029	1.03	1.029	1.029^{a}
Protein (%)	Control (C)	3.24	3.25	3.31	3.3	3.31	3.36	3.35	3.30^{a}
	Treatment (T)	3.25	3.33	3.36	3.4	3.42	3.45	3.47	3.38^{b}

*Means bearing different superscripts in column for individual parameters differ significantly.

The data pertaining to the milk composition of the treatment and control group of animals are presented in Table 3. The average milk fat, SNF, total solids and milk protein per cent were significantly higher in the treatment group which were fed on silage. The average fat, SNF, total solids and protein content in the treatment group were 4.06, 9.19, 13.26 and 3.38 per cent, respectively. However, no significant difference in milk acidity and specific gravity was observed. The results obtained in the present study are in agreement to the previous study of Dhiman *et al*. (2000), where an increase of 0.35 per cent in milk fat was observed on feeding of corn silage. Anrique and Dossow (2003) also reported that inclusion of apple pulp silage in direct-cut grass silage resulted in higher milk fat and protein content of early lactating dairy cows, which are in conjunction with the findings of the present study. Earlier studies of Edwards and Parker (1995) also reported an increase in milk protein and total solids contents on feeding of apple pomace in lactating animal diets.

Bio-economics of the trial

Data presented in Table 4 revealed that the cost (` cow$^{-1}$ day$^{-1}$) of daily feeding of silage was ` 17.5. In the treatment group, total maintenance cost day^{-1} of ` 294.00 was observed, which was higher as compared to the control group (` 276.50). Average daily milk yield in treatment and control groups was 8.31 and 7.84 kg cow^{-1}, respectively. It was also observed that the gross return (` day$^{-1}$ cow$^{-1}$) was ` 419.50 and ` 443.00 in control and treatment groups, respectively (Table 4). Comparison of net returns between the control and treatment group revealed that the net return was relatively higher in the treatment group (cows fed with silage @ 5 kg day^{-1} + standard ration) as compared to the control group (cows fed with only standard ration). The net return was higher (` 149.00 day$^{-1}$ cow$^{-1}$) in the treatment group as compared to the control group (` 143.00 day^{-1}).

Table 4: Economics of *Morus* leaf based apple pomace silage in crossbred dairy cows.

Parameters	Control	Treatment
Cost of silage @ 5 kg day^{-1} cow^{-1} (` day^{-1})	0	17.5
Cost of concentrate mixture @ 4 kg day^{-1} cow^{-1} (` kg^{-1} cow^{-1})	94	94
Cost of green fodder @ 20 kg day^{-1} cow^{-1} (` day^{-1} cow^{-1})	80	80
Cost of wheat straw @ 5 kg day^{-1} cow^{-1} (` day^{-1} cow^{-1})	37.50	37.50
Medicine cost (` day^{-1} cow^{-1})	5	5
Labour cost (` day^{-1} cow^{-1})	60	60
Total	276.50	294
Milk production (kg day^{-1})	7.84	8.31
Cost of milk (` kg^{-1})	50	50
Cost of cow dung @ 10 kg day^{-1} cow^{-1} (` day^{-1} cow^{-1})	27.50	27.50
Gross return (` day^{-1} cow^{-1})	419.50	443.0
Net return (` day^{-1} cow^{-1})	143	149

CONCLUSION

From the findings of the present study it is evident that apple pomace can be effectively included in the corn silage without any adverse effect of the silage quality. Inclusion of mulberry leaves and apple pomace in the corn silage resulted in an increase in CP, NDF and ADF contents, however the pH, DM, EE and CF contents were comparatively lower in apple pomace based corn silage as compared to sole corn silage. In the study silage prepared on inclusion of apple pomace and mulberry leaves @ 10 per cent with 80 per cent maize (T3) resulted in production of best quality silage. Feeding of this silage @ 5 kg d^{-1} resulted in 10.21 per cent higher milk yield with better milk composition and bioeconomics in crossbred cows. It is evident from the study that apple pomace can be effectively incorporated to maize during ensiling and can be given to animals for improving productivity. Utilization of apple pomace in this manner will not only reduce the environmental pollution but also help in meeting out the nutrient demands of animals.

ACKNOWLEDGEMENT

The authors are grateful to the Department of Silviculture and Agroforestry, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, HP, India for providing all necessary facilities and funds to conduct the study smoothly.

Conflict of interest: None.

REFERENCES

Abdollahzadeh, F.R., Pirmohammadi, P., Farhoomand, F., Fatehi Pazhoh, F.F. (2010). The effect of ensiled mixed tomato and apple pomace on Holstein dairy cows. Italian Journal of Animal Science. 9: 211-216.

Anonymous (2018). Horticulture Statistics at a Glance. NHB, Government of India.

Anonymous (2019). Area and Production of Apple in Himachal Pradesh. http://www.hpagrisnet.gov.in

Anonymous (2020). Annual Report. Department of Animal Husbandry and Dairying, Government of India.

Anrique, G.R. and Dossow, C.C. (2003). Effects of apple pulp silage inclusion. Archivos de Medicina Veterinaria. 35: 13-22.

AOAC, (1990) AOAC Official Methods of Analysis. 15th Edition, Association of Official Analytical Chemists, Arlington.

Bal, M.A., Coors, J.G., Shaver, R.D. (1997). Impact of the maturity of corn for use as silage in the diets of dairy cows on intake, digestion and milk production. Journal of Dairy Science. 80: 2497-2503.

Ba, N.X., Giang, V.D., Ngoan, L.D. (2005). Ensiling of mulberry foliage (*Morus alba*) and the nutritive value of mulberry foliage silage for goats in central Vietnam. Livestock Research for Rural Development. 17: 35-38.

Brar, N.S., Kumar, B., Kaur, J., Kumar, A., Verma, H.K., Singh, R., Singh, P. (2019). Qualitative study of corn silage of cattle farms in subtropical conditions of Indo-gangetic plains. Range Management and Agroforestry. 40: 306-312.

Chandel, V., Bishist, R., Vaidya, D., Kaushal, M., Sharma, V. (2015). Effect of feeding apple growth performance of crossbred heifers. Indian Journal of Animal Nutrition. 32: 235-236.

Chaudhary, D.P., Kumar, A., Kumar, R., Singode, A., Mukri, G., Sah, R.P., Tiwana, U.S., Kumar, B. (2016). Evaluation of normal and specialty corn for fodder yield and quality traits. Range Management and Agroforestry. 37: 79-83.

Crawshaw, R. (2004) Co-product Feeds: Animal Feeds from the Food and Drinks Industries. Nottingham University Press. 285 pp.

Dhiman, T.R., Bal, M.A., Wu, Z., Moreira, V,R., Shaver, R.D., Satter, L.D., Shinners, K.J., Walgenbach, R.P. (2000). Influence of mechanical processing on utilization of corn silage by lactating dairy cows. Journal of Dairy Science. 83: 2521-2528.

Edwards, N.J. and Parker, W.J. (1995). Apple Pomace as a Supplement to Pasture for Dairy Cows in Late Lactation. In: Proc. New Zealand Society of Animal Production, Department of Agricultural and Horticultural Systems Management, Massey University, Palmerston North, New Zealand, pp 67-69.

Fang, J., Cao, Y., Matsuzaki, M., Suzuki, H., Kimura, H. (2016). Effects of apple pomace-mixed silage on growth performance and meat quality in finishing pigs. Animal Science Journal. 87: 1516-1521.

Food and Agricultural Organization (2019). FAO, Statistical Database. Food and Agriculture Organization, Rome.

Islam.S., Islam, M.N., Matsuzaki, M. (2018). Nutritive value of fermented apple pomace silage and its effect in Suffolk ewes. Journal of Agricultural Science and Food Technology. 4: 80-91.

Juracek, M., Biro, D., Simko, M., Galik, B., Rolinec, M. (2012). The quality of maize silages from west region of Slovakia. Journal of Central European Agriculture. 13: 695-703.

Kara, K., Guclu, B.K., Baytok, E., Aktug, E., Oguz, F.K., Kamalak, A., Atalay, A.I. (2018). Investigation in terms of digestive values, silages quality and nutrient content of the using pomegranate pomace in the ensiling of apple pomace with high moisture contents. Journal of Applied Animal Research. 46: 1233-1241.

Luby, J.J. (2003). Taxonomic Classification and Brief History. In: Apples: Botany, Production and Uses. [D.C. Ferree and I.J. Warrington (Eds.)], CABI Publishing: Cambridge, MA, USA, pp 1-14.

Massod, D., Ganai, A.M., Sheikh, G.G., Farooq, J., Afzal, Y., Ahmad, I. (2017). Effect of feeding graded levels of apple pomace on growth performance, haemato-biochemical parameters and rumen metabolites in crossbred calves. Indian Journal of Animal Reaserch. 72: 1000-1004.

Nazir, S. (2017). Development of feeding technology of Apple Pomace in calves. (M.Sc Thesis), Department of Animal Nutrition, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur.

Pirmohammadi, R., Rouzbehan, Y., Rezayazdi, K., Zahedifar, M. (2006). Chemical composition, digestibility and in situ degradability of dried and ensiled apple pomace and maize silage. Small Ruminant Research. 66: 150-155.

Rodrigues, M.A.M., Guedes, C.M., Rodrigues, A.L., Cone, J.W., Gelder, A.H.V., Ferreira, L.M.M., Santos, A.S., Sequeira, C.A. (2008). Evaluation of the nutritive value of apple pulp mixed with different amounts of wheat straw. Livestock Research for Rural Development. 20: 1-10.

Shalini, R. and Gupta, D.K. (2010). Utilization of pomace from apple processing industries: A review. Journal of Food Science and Technology. 47: 365-371.

Singh, K. and Neelakantan, S. (2007). Experiments in Microbiology of Fodder, Feed and Dairy Farm Waste Utilization. Second edition. National Dairy Research Institute, Karnal, Haryana.