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SHORT COMMUNICATION

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Milk yield and composition, dry matter intake and blood parameters of Holstein cows fed ensiled apple pomace co-ensiled with broiler litter

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Abstract

The present study was carried out to evaluate the effects of ensiled mixed apple pomace and broiler litter (EAPBL) on milk yield (MY) and composition, dry matter intake (DMI) and blood parameters at early lactation cow. Four multiparous early-lactating Holstein dairy cows were used in a 4 × 4 Latin square design including 4 periods and 4 experimental diets. The cows were fed diets containing 0 (control), 15, 30 and 45% of EAPBL, respectively. The highest DMI ($p < 0.05$) was observed in cows fed diets containing 15 and 30% of EAPBL. Milk production was lower ($p < 0.05$) in cows fed 0% EAPBL than in the other experimental groups. Diet including 45% of EAPBL increased ($p < 0.05$) blood glucose and blood urea nitrogen concentration. Inclusion of EAPBL on dairy cows rations might efficiently cause an improvement on MY, milk composition and DMI.

Additional key words: apple pomace silage; broiler litter; Holstein dairy cows; performance.

Higher feeding costs and shortage of animal feedstuffs in many parts of the word have increased the number of studies on agricultural by-products used as feeds for ruminants (Lashkari & Taghizadeh, 2013). Some of those by-products derive from industrial extraction and processing of fruits, vegetables and crops (Lashkari *et al*., 2014). The annual amount of produced agricultural by-products in Iran is high, *e.g.* production of apple (*Malus domestica*) pomace exceeds 2.7 million tonnes year^{-1}. Apple pomace is a palatable raw material and has considerable attention as a source of sugar, pectin, and phenolic component (Sato *et al*., 2010). In fact, apple pomace is a suitable source of energy for ruminant, but its crude protein (CP) and neutral detergent fiber (NDF) concentration are low (Pirmohammadi *et al*., 2006). However, high moisture content is the main problem in storage of agricultural by-products because of its susceptibility for spoiling, fungi and mold can expose to risk human and animal health (Lashkari *et al*., 2014). Therefore, usage of apple pomace as feedstuff requires its preservation by dehydration or ensiling (Pirmohammadi *et al*., 2006). Drying of apple pomace is costly; whereas its ensilage is cheaper and more practical for farmers. Apple pomace silage has been successfully used as a feed for ruminants. Rumsey (1979) showed that all of the beef cattle diet forage can be replaced by apple pomace without any adverse effect on the performance. Using of apple pomace in fattening lambs ration improved average daily gain, dry matter intake and feed conversion ratio (Karami *et al*., 1996).

Broiler litter has been also successfully used as a cattle feed around the world for a long time (Kwak *et al*., 2004). Broiler litter is composed of poultry excreta, bedding, feathers, spilled feed, etc. Broiler litter contains 25-30% CP kg of dry matter (Ruffin & McCaskey, 1990) and approximately 50% of that is made up by true protein. The remainder is nonprotein nitrogen, which is primarily composed by uric acid (Bhattacharya & Taylor, 1975). Poultry litter has been

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Abbreviations used: BUN (blood urea nitrogen); CP (crude protein); DMI (dry matter intake); EAPBL (ensiled mixed apple pomace and broiler litter); ECM (energy corrected milk); FCM (fat corrected milk); MY (milk yield); NDF (neutral detergent fiber); NEL (net energy lactation); TMR (total mixed ration).

Table 1. Ingredients and nutrient chemical composition of experimental diets containing different proportion of ensiled mixed apple pomace and broiler litter (EAPBL)

	EAPBL in diet (% of DM[1])			
	0	15	30	45
Ingredients (%)				
Alfalfa	40.64	24	27	21.85
Straw	3.8	8.63	1.75	1.07
EAPBL	0	15	30	45
Corn	38.86	33.99	26	17.58
Soybean meal	16.28	17.78	14.9	14.10
$CaCO_3$	—	0.45	0.35	0.4
Dicalcium phosphate	0.42	0.148	—	—
Nutrient chemical composition				
NE_L[2] (Mcal kg^{-1} DM)	1.65	1.66	1.67	1.66
CP (% DM)	17.63	17.62	17.62	17.63
Ca (% DM)	0.72	0.68	0.7	0.7
P (% DM)	0.4	0.4	0.42	0.46
Neutral detergent fiber (% DM)	25.83	27.48	28.02	29.78
Acid detergent fiber (% DM)	18.15	19.26	20.63	22.59

[1] DM: dry matter. [2] NE_L: net energy lactation.

fed as unprocessed, air dried, and ensiled (Silva *et al.*, 1975). Broiler litter can be used as a proper source of crude protein for ruminant, increasing the nitrogen content in the diet rich in apple pomace while facilitating the conserving of poultry litter as silage. The objectives of this study were to evaluate the effects of replacement lactating Holstein cow diets with apple pomace co-ensiled with poultry litter (EAPBL) at four levels (0, 15, 30, and 45% of diet DM) on milk yield (MY), milk composition, dry matter intake (DMI) and blood parameters.

Apple pomace was obtained from a major Iranian factory located in Urmia. Broiler poultry litter that contained wood-shaving base was obtained from a local broiler house. The average DM content of apple pomace and poultry litter was 155 and 850 g kg^{-1}, respectively. Silage of apple pomace and poultry broiler litter was prepared by mixing 5 tonnes of apple pomace and 700 kg of poultry litter. The mixture was sealed and ensiled for 60 days.

Four multiparous Holstein cows at early lactation from the same group in the herd with an average body weight of approximately 640 ± 10 kg were housed individually in a tie-stall barn. The cows were assigned to one of the four experimental diets including control diet (0% EAPBL) and diets containing 15, 30 and 45% EAPBL. All rations were formulated based on the NRC (2001) to contain approximately 17.6% CP and 1.65 Mcal net energy lactation (NE_L) kg^{-1} on a DM basis. Ingredients and chemical composition of the experimental diets are listed in Table 1. Four experimental periods of 20 days were carried out, including 10 days of adaptation period followed by 10 days of collection period. Cows were fed *ad libitum* a total mixed ration (TMR), two times per day, and had free access to clean water. Daily DMI and feed refusals were recorded before each feeding.

During the last 7 days of each experimental period, blood samples were collected via jugular venipuncture at approximately 2 h after morning feeding and were placed on ice for transport to the laboratory. The samples were centrifuged, and the plasma was frozen until later analysis. Plasma urea nitrogen, glucose, total protein and cholesterol were determined by auto analyzer (Biochemical Analyzer BT2000/3000 TARGA, Rome, Italy).

Cows were milked twice daily (07:00 and 19:00 h).The amount of milk produced for each cow at each milking was measured using special graduated jars (Agri & SD Co., Frankfurt, Germany). Milk was sampled at both consecutive milkings and stored at –20°C until later analysis. Milk samples were analyzed for lactose, fat, protein and solids not fat by infrared analysis (Milko Scan S50, Hillerød, Denmark). Energy corrected milk

Table 2. Dry matter intake, milk yield and milk composition of lactating cows fed diets with different proportion (0, 15, 30 and 45%) of ensiled mixed apple pomace and broiler litter (EAPBL)

	EAPBL in diet (% DM[1])				SEM[2]
	0	15	30	45	
DM intake (kg d^{-1})	19.80[b]	20.47[a]	20.12[ab]	19.96[b]	0.140
Efficiency of milk production [3] (kg d^{-1})	1.47[c]	1.55[b]	1.59[a]	1.57[a]	0.015
Milk yield (kg d^{-1})	29.29[b]	31.58[a]	31.78[a]	31.47[a]	0.270
3.5% fat corrected milk (kg d^{-1})	27.63[b]	29.49[a]	28.67[b]	28.63[b]	0.405
Energy corrected milk [4] (kg d^{-1})	26.53[b]	29.34[a]	28.86[a]	28.87[a]	0.500
Fat (%)	3.13[a]	3.10[a]	2.91[b]	2.95[b]	0.040
Fat (kg d^{-1})	0.923[b]	0.977[a]	0.919[b]	0.926[b]	0.003
Protein (%)	2.83[ab]	2.80[b]	2.85[ab]	2.90[a]	0.001
Protein (kg d^{-1})	0.831[b]	0.882[a]	0.906[a]	0.910[a]	0.009
Lactose (%)	4.33	4.32	4.33	4.37	0.019
Lactose (kg d^{-1})	1.27	1.36	1.37	1.37	0.025
Solid not fat (%)	7.88	7.88	7.89	7.96	0.056
Solid not fat (kg d^{-1})	2.31[b]	2.48[a]	2.50[a]	2.49[a]	0.020
Milk density (kg L^{-1})	1.039	1.037	1.033	1.036	0.006

[1] DM: dry matter. [2] SEM: standard error of the mean. [3] Efficiency of converting energy corrected milk to dry matter intake. [4] Energy corrected milk = (0.3246 × kg of milk) + (12.95 × kg of fat) + (7.65 × kg of protein). Means in a row with different superscripts differ significantly ($p < 0.05$).

(ECM, kg d^{-1}) was calculated using equations of Bernard (1997) as: ECM = (0.3246 × kg of milk) + (12.95 × kg of fat) + (7.65 × kg of protein). Fat corrected milk (FCM, kg d^{-1}) was calculated using equations of NRC (2001) as: FCM = 0.4 × MY + 15 × (Milk Fat / 100) × MY. Also, efficiency of milk production (kg d^{-1}) was calculated by converting energy corrected milk to dry matter intake.

Data were analyzed as rotational 4 × 4 (period × animal effect) latin squares design using the MIXED procedure of SAS (SAS Inst. 1996). Level of significance was $\alpha = 0.05$, and the Tukey test was used to test all pair wise comparisons among means. The model used for this analysis was:

$$y_{ijk} = \mu + T_i + C_j + P_k + \varepsilon_{ijk}$$

where y is the dependent variable; μ is the overall mean; T_i is the effect of the experimental diets (i = 1, 2, 3 and 4); C_j is the cow effect (j = 1, 2, 3 and 4); P_k is the period effect (k = 1, 2, 3 and 4) and ε is the random residual error term.

The DMI, MY and milk composition of cows fed different levels of EAPBL are presented in Table 2. Cows fed 15% EAPBL had higher DMI ($p < 0.05$) compared to the control diet; however, there were no significant differences among the other experimental diets. The efficiency of milk production was the highest in cows fed 30 and 45% of EAPBL ($p < 0.05$). Cows fed EAPBL had higher ($p < 0.05$) MY than the control animals; however, differences between diets containing EAPBL were not significant. The FCM was higher ($p < 0.05$) in cows fed 15% of EAPBL in comparison to the other experimental diets. The ECM was affected by different levels of EAPBL and it was the highest ($p < 0.05$) for cows fed 15% of EAPBL (Table 2). Feeding diets with 30 and 45% of EAPBL caused a decrease in fat percentage in comparison to the others ($p < 0.05$). Experimental diets had a significant impact on solids not fat yield. In fact, it was the lowest ($p < 0.05$) in the control experimental diet. Feeding EAPBL did not affect percentage of lactose and milk density.

Plasma concentrations of cholesterol and total protein did not significantly differ between the experimental diets (Table 3). Feeding different level of EAPBL caused a significant ($p < 0.05$) effect on blood urea nitrogen (BUN) and glucose concentration. The highest glucose concentration was observed in cows fed diets containing 45% of EAPBL ($p < 0.05$). The lowest BUN concentration was observed in cows fed control diets ($p < 0.05$).

The DMI of cows fed 15 and 30% EAPBL tended to be greater ($p < 0.05$) than other experimental groups. It could be attributed to palatability of apple

Table 3. Blood metabolites concentration of lactating cows fed diets with different proportion (0, 15, 30 and 45%) of ensiled mixed apple pomace and broiler litter (EAPBL)

	EAPBL in diet (% DM[1])				SEM[2]
	0	15	30	45	
Cholesterol (mg dL^{-1})	157.75	154.78	153.25	146.62	0.59
Glucose (mg dL^{-1})	54.05[b]	53.62[b]	52.37[b]	56.28[a]	1.63
Total protein (mg dL^{-1})	8.57	8.50	8.78	8.54	0.17
Blood urea nitrogen (mg dL^{-1})	16.06[c]	17.32[b]	17.71[ab]	18.47[a]	0.74

[1] DM: dry matter. [2] SEM: standard error of the mean. Means in a row with different superscripts differ significantly ($p < 0.05$).

pomace. Similar to this finding, Toyokawa *et al*. (1977) reported that increasing the amount of apple pomace in diets of dairy cows up to 15 and 30% led to 7 and 21% increase in DMI. However, inclusion of 45% EAPBL in the diet had no significant effect on DMI. In contrast to this finding, Hopkins & Poore (2001) found that DMI tended to be lower for the experimental diet containing the highest level of poultry litter compared with the other experimental diet.

Our results regarding to the positive effects of EAPBL on the MY are consistent with those of Abdollahzadeh *et al.* (2010b), who reported an increase on DMI, nutrient digestibility and palatability in cows fed ensiled mixed tomato and apple pomace. The high pectin content of apple pomace (15%) represents a highly fermentable source of carbohydrate for rumen bacteria, which enhance production of acetate (Kennedy *et al*., 1999) and may explain increase of MY in the current study. In contrast to our findings, Hopkins & Poore (2001) compared the feeding value of broiler litter and soybean meal for growing dairy heifers and found a significant decrease in average daily body weight gain when the level of broiler litter increased. The lack of negative effect of broiler litter on MY and DMI in the present experiment may be related to the positive associative effects of the high energy content in apple pomace, which allows to utilize effectively the high nitrogen content in broiler litter.

Improved 3.5% FCM ($p < 0.05$) in cows fed 15% EAPBL may be attributed to higher DMI in this group. The ECM per unit of DMI was the highest when cows were fed EAPBL in contrast to those of the control diet ($p < 0.05$). Inclusion of 30 and 45% of EAPBL in the diet of dairy cows depressed milk fat content ($p < 0.05$). Our results differ from those of Ghoreishi *et al.* (2007) who reported that the lowest value of milk fat content was found in the diet containing 15% of apple pomace silage. Milk lactose content, milk lactose yield and solid not fat content did not differ among experimental diets. However, the addition of EAPBL to the diet increased solids not fat yield relative to the control ($p < 0.05$). Corresponding to the increase on the proportion of EAPBL on the experimental diets, protein yield of cows tended to be greater ($p < 0.05$).

Inclusion of a 45% of EAPBL in the diet increased plasma glucose concentration levels ($p < 0.05$) compared to diets containing 0, 15 and 30% of EMAB. The results of the current study are in agreement with those of Abdollahzadeh *et al*. (2010a) who reported that increasing the presence of soluble carbohydrates and digestible nutrients in ensiled mixed tomato (*Solanum lycopersicum* L.) and apple pomace diets increase concentrations of blood glucose. As the level of corn (*Zea mays* L.) is decreased in the diet and the proportion of EAPBL is increased, ruminally fermentable carbohydrate in the rumen expected to decrease; whereas, available nitrogen in the rumen expected to increase, which may explain the increase in BUN ($p < 0.05$) of cows fed EAPBL. It is well known that BUN levels in plasma reflect ammonia production in the rumen (Torell *et al*., 1974). In the case of feeding, it may also reflect the conversion of high level of non-protein nitrogen of the feedstuff into ammonia nitrogen in the rumen. Silanikove & Tiomkin (1992) showed that when silage containing 3.1 to 6.0 kg of poultry litter was used to fed cattle in a daily ration, ammonia concentration in rumen fluid were 3 to 5 times higher than the optimal level of 10 mg dL^{-1} for maximum fermentation and optimal microbial protein synthesis. It was stated that once the microbial requirements for N in the rumen are met, there should be no further increase in the rate of fermentation. These results are in close agreement with earlier findings of

Cross *et al*. (1978) who studied the effect of graded level of broiler litter silage for beef steers and reported that the level of BUN was simultaneously raised when the level of broiler litter increased.

According to the results obtained from the present study, it is concluded that ensiled mixed apple pomace and broiler litter (EAPBL) might be successfully added at diets up to 45% because it improves milk yield, milk composition and dry matter intake of Holstein dairy cows. However, it is necessary to take into account that cows fed a diet containing 45% EAPBL had the highest level of blood urea nitrogen and it might reduce reproductive performance. Therefore, the diet containing up to 30% is considered the most suitable for dairy cows feeding as a safe level of EAPBL. Also, further research is needed to evaluate the effect of high levels of EAPBL on the ruminal fermentation and performance of dairy cows.

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