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Effects of Ensiled Apple Pomace on Milk Yield, Milk Composition and DM Intake of Holstein Dairy Cows

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Abstract: Most developing countries are facing difficulties in providing sufficient food for their animals. Apple Pomace (AP) is a by-product obtained when apples are pressed to make juice. Using such by-products for animal feeding is a means of recycling which otherwise, if accumulated, might cause environmental pollution. The purposes of the current study were to determine the effect of Ensiled Apple Pomace (EAP) on milk production, milk composition and DM intake of Holstein dairy cows. Three multiparous lactating Holstein dairy cows were allocated to 3 diet treatments according to a 3-period cycling change over design in a 3×3 (3 periods and 3 diets) with Latin Square arrangement. The treatments were 1, control diet (no EAP), 2 (15% EAP) and 3 (30% EAP) DM basis. There were no significant differences between treatments on milk yield and milk composition. DMI (Dry Matter Intake) was lower ($p<0.01$) for treatment 2 compared to treatment 1 or treatment 3. The effects of treatments were significant on FCR (Feed Conversion Ratio) and FE (Feed Efficiency). Treatment 2 had lower ($p<0.05$) FCR and higher ($p<0.05$) FE than the others. According to results of this study it may conclude that EAP can substitute successfully at diets up to 30% without negative effect on milk yield and milk composition (percentage of fat, protein and SNF).

Key words: Ensiled apple pomace, dairy cows, dry matter intake, milk yield

INTRODUCTION

Most developing countries are facing difficulties in providing sufficient food for their animals. The cost of feedstuffs is very high and in recent years the price of conventional or basic feeding ingredients has increased. The use of agricultural by-products is often a useful way of overcoming this problem. Agricultural by-products are residues obtained after processing of fruits, vegetables and crops. They may include citrus pulp, tomato pomace, grape pomace and Apple Pomace (AP). Using such by-products for animal feeding is a means of recycling which otherwise, if accumulated, might cause environmental pollution (Huber, 1980).

Apple pomace is the by-products obtained when apples are pressed to make juice and is produced in huge (97,000 tons year^{-1}) amounts in Iran (Pirmohammadi *et al*., 2006). Without even considering compositional differences within specific apple varieties (resulting from such conditions as natural variation, husbandry practices, fruit maturity and post harvest management) there are significant differences in apple composition between varieties. The composition of final pomace is linked to the morphology of the original feed stock and the extraction technique used. The storage of this by-product is difficult due to its high moisture content which is above 700 g kg^{-1} (Kennedy *et al*., 1999). Drying is one method of preserving AP (Gasa *et al*., 1992) and it may also be ensiled, since it has a low pH ranging from 3.2-4.1 (Kennedy *et al*., 1999; Rumsey and Lindahl, 1982).

One study has indicated that, milk production and dry matter intake decreased when high level (more than 10% of DM) of dried AP was fed to Holstein dairy cows. They related decreased milk production and dry matter intake to AP high content of fermentable carbohydrates and low content of protein (Toyokawa *et al*., 1979). Another study has indicated increased milk production, milk fat and decreased feeding cost when AP was mixed well with 10% Wheat bran, 10% chopped alfalfa and 10% milled rice bran and were ensiled then fed to Holstein dairy cows (Toyokawa *et al*., 1984).

There are few published data on nutritional value of ensiled apple pomace for dairy cows. The purposes of the current study were to determine the effect of ensiled apple pomace on milk production, milk composition and DM intake of Holstein dairy cows.

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MATERIALS AND METHODS

Apple pomace: Apple pomace was obtained from a main factory in Urmia city and stored in a 30 tons trench silo for ensiling. The silo was sealed for 45 days. Chemical composition of EAP was determined using the methods recommended by AOAC (1990). The apple pomace has high concentrations of water, NDF, ADF and low concentration of CP. Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) were determined using the methods of Van Soest *et al*. (1991). DM, CP, OM, ADF, NDF and ME content of EAP were 267(g kg^{-1} fresh weight), 64, 929, 405, 473 g kg^{-1} DM and 9.7 MJ kg^{-1} DM, respectively.

Diets: Diets were formulated using NRC (1989) and AFRC (1995) recommendations. The treatments were 1, control diet (no EAP), 2 (15%EAP) and 3 (30%EAP) DM basis. Ingredients and nutrient composition of the experimental diets are shown in Table 1.

Table 1: Ingredients and nutrient composition of experimental diets (DM basis)

	Treatments		
	1	2	3
Ingredients			
Alfalfa	46.00	34.30	0.16
Barley	38.50	33.48	30.00
Cotton seed meal	12.00	15.00	20.70
EAP	...	15.00	30.00
Sodium bicarbonate	1.40	1.72	1.50
Premix	0.5	0.50	0.50
DCP	0.15		...
Caco3			1.01
Salt	1.50		0.29
Nutrient composition			
DM%	91.40	67.12	53.09
ME (MJ/kg DM)	9.81	10.00	10.12
FME (MJ/kg DM)	8.94	9.02	9.04
CP%	15.40	15.12	15.00
ERDP(g/kg DM)	9.12	9.10	9.32
DUP(g/kg DM)	4.18	4.07	3.93
MP(g/kg DM)	10.02	9.90	9.91
CF%	15.05	17.51	19.12
NDF%	41.71	41.71	39.11
ADF%	26.83	28.25	27.67
Calcium %	0.70	0.53	0.70
Phosphorus %	0.43	0.42	0.45
Sodium %	1.03	0.52	0.57
Potassium%	1.50	1.36	1.11
Chlorine%	1.27	0.28	0.34
Sulfur%	0.21	0.20	0.18
DCAD(meq/KgDM)	342.00	370.00	320.00
Concentrate% (DM basis)	54.00	50.70	54.00
Forage% (DM basis)	46.00	49.30	46.00

EAP, Ensiled Apple Pomace; DCP, Dicalcium Phosphate; DM, Dry Matter; ME, Metabolisable Energy; FME, Fermentable Metabolic Energy; CP, Crude Protein; ERDP, Effective Rumen Degradable Protein, DUP, Digestible Undegradable Protein; MP, Metabolizable Protein; CF, Crude Fiber; NDF, Neutral Detergent Fiber; ADF, Acid Detergent Fiber; DCAD, Dietary Cation-Anion Difference; Premix supplied (on a concentrate DM basis): 34,350 IU of vitamin A kg^{-1}, 6870 IU of vitamin D3 kg^{-1}, 46 mg of vitamin E kg^{-1}, 229 mg kg^{-1} of Zn, 126 mg kg^{-1} of Mn, 69 mg kg^{-1} of Fe, 33 mg kg^{-1} of Cu, 2.6 mg kg^{-1} of I, 0.8 mg kg^{-1} of Co and 0.46 mg kg^{-1} of Se

Dairy cows: This experiment was carried out at the dairy barn of Urmia University, Iran. Three multiparous lactating Holstein dairy cows (BW = 565±16 kg; DIM = 75±23) were allocated to 3 diet treatments according to a 3- period cycling change over design in a 3×3(3 periods and 3 diets) with Latin Square arrangement. Experimental periods were 21 day each, with a 14-day adaptation periods followed by a 7-day collection period. Cows were housed in tie-stalls and were fed adlibitum individually, twice daily as a TMR at 0700 and 1900 h, to provide approximately 10% orts each day (as-fed basis). Amounts of fed and orts were recorded daily in collection period. Cows had free access to water 24 h d^{-1}. Body weight were recorded for 2 consecutive d after the morning milking at the start and end of each feeding period. The ending BW for period 1 and 2 were used as the beginning BW for periods 2 and 3, respectively.

Daily milk yields were recorded throughout the experiment. On day 16 and 19 of each experimental period, milk samples were collected at each morning and evening milking. The same amount of each morning and evening milk sample was mixed and analyzed for fat, protein and SNF at Pegah milk industry by Ekomilk Ultrasonic milk analyzer (fast) Bultch 2000 LTD. Actual milk production was also adjusted for milk composition to calculate 3.5% FCM (Fat corrected milk) yield, 4% FCM yield and ECM (Economic Corrected Milk) yield.

Statistical analysis: All statistical analysis was performed using the GLM procedure of SAS and treatment means were compared by the Duncan test.

RESULTS

Body weight: Changes in BW were not significantly affected by substitution of EAP.

Milk production: Mean milk yields, 3.5% FCM yield, 4% FCM yield and ECM yield for the treatments, are shown in Table 2. There were no significant differences among treatments in milk yield but treatment 1(0% EAP) produced more milk yield than others. ECM yield was not affected by treatments. In contrast 3.5% FCM yield and 4% FCM yield were greater ($p<0.05$) for treatment 1 than treatment 2 (15% EAP). There were no significant differences among treatments 1 and 3(30% EAP) or treatments 2 and 3 in 3.5% FCM yield or 4% FCM yield.

DMI, FCR and FE: Mean DMI, FCR and FE for the diets are shown in Table 2. DMI was lower ($p<0.01$) for treatment 2 compared to treatment 1 or treatment 3. The effects of treatments were significant on FCR and FE. Treatment 2 had lower ($p<0.05$) FCR and higher ($p<0.05$) FE than the others.

Table 2: Effects of substitution of EAP on milk production and milk composition

	Treatment				
	1	2	3		
	0% EAP	15% EAP	30% EAP	SEM	Trt[1]
Yield, kg d^{-1}					
Milk	25.00	24.80	24.93	1.504	NS
3.5%FCM[2]	24.55[a]	23.36[b]	24.10[ab]	1.551	*
4%FCM[3]	22.71[a]	21.62[b]	22.30[ab]	1.327	*
ECM[4]	25.89	25.16	25.56	1.746	NS
DMI[5],kg d^{-1}	23.78[a]	22.61[b]	23.65[a]	0.508	**
FCR[6]	0.95[a]	0.91[b]	0.95[a]	0.002	*
FE[7]	1.05[b]	1.10[a]	1.06[b]	0.003	*
Milk composition,%					
Fat	3.40	3.15	3.32	0.133	NS
Protein	3.25	3.26	3.24	0.002	NS
SNF	8.63	8.64	8.59	0.015	NS

[1]Trt: treatment effect, [2]3.5% fat-corrected milk= 0.4255 * amount of milk (kg d^{-1}) + 16.425 * milk fat (kg d^{-1}), [3]4 % fat -corrected milk = 0.4 * amount of milk (kg d^{-1}) + 15 * milk fat (kg d^{-1}), [4]ECM= 9.436* milk fat (kg d^{-1}) + 22.018 * milk protein (kg d^{-1}), [5]DMI= dry matter intake (kg d^{-1}), [6]FCR= dry matter intake (kg d^{-1}) /milk yield (kg d^{-1}), [7]FE = milk yield (kg d^{-1}) /dry matter intake (kg d^{-1}), [a-b] Means within each row with different superscripts are significantly different

Milk composition: There were no significant differences on milk fat among the treatments (Table 2). Treatment 1 had higher percentage of milk fat than others. Percentage of milk protein for all treatments wasn't affected by diets (Table 2). The percentage of milk SNF had the same trend as protein and the effect of treatments was not significant.

DISCUSSION

There were no significant differences between treatments on milk yield. This may be the reflection of identical composition of all experimental diets which balanced according to recommendations of NRC (1989) and AFRC (1995). In contrast, Toyokawa *et al.* (1984) indicated that milk yield was increased when AP was mixed well with 10% Wheat bran, 10% chopped alfalfa and 10% milled rice bran and were ensiled then fed to Holstein dairy cows. This inconstancy may partly be due to difference in composition of the diets, different morphology of the original AP and the extraction technique used (Kennedy *et al.*, 1999).

3.5 % FCM yield and 4% FCM yield were significantly affected by substitution of EAP. Lower 3.5% FCM yield and 4% FCM yield for treatment 2 is likely due to lesser DMI in this treatment. It is clear that milk yield decreases by decreasing DMI in ruminants. There were no significant differences between treatments for ECM yield. This is the consequence of milk protein and fat concentrations in calculating ECM yield which are very similar in all treatments.

Diet 1(No EAP) had higher DMI because of its higher content of dry matter (91.4% Table 1). This is in agreement with Lahr *et al.* (1983) who showed that DMI of dairy cows increased with increasing dry matter content of diets. DMI for treatment 3(30% EAP) was higher than treatment 2(15% EAP). It may have been resulted from palatability of apple pomace. Concerning apple pomace palatability and its effect on increasing DMI, Toyokawa *et al.* (1976) showed that increasing amount of apple pomace containing rice hull in diets of dairy cows up to 15 and 30 kg d^{-1} led to 7 and 21 % increase in DMI. DMI was lower ($p<0.01$) for treatment 2 compared to other treatments. In treatment 2 the ratio of forage: concentrate (49.3: 50.7) is higher than other treatments (46: 54). Our results are in agreement with NRC (2001). According to NRC (2001), amount of DMI is linearly increased by increasing of diets concentrate without considering of forages kind ($p<0.01$). In agreement with the findings of the present study, Johnson and Combs (1992) showed that the increase of concentrate ratio from 26-50% in dairy cows diet resulted in 2.7 kg increase in DMI. Generally, concentrate: Forage ratio, DM content and palatability of diets in our study may describe the differences observed between DMI.

Decreased level of DMI in treatment 2 and failure to observe significant differences among treatments in milk yield, led to significantly decrease in FCR for this treatment. FE was also affected by the same reasons as FCR, so treatment 2 had significantly higher FE among the diets.

The percent of milk fat was not significantly affected by substitution of EAP. However the highest and the lowest values were for diet 1 and 2, respectively. Fundamentally, milk fat can be affected by many factors, but it seems that rumen pH, acetate: Propionate ratio and diet DM contents may have affected milk fat in our study. Low pH (<6) of rumen decreases activities of fiber-digesting ruminal bacteria which digest fiber and produce acetate. Although EAP decreases pH of rumen due to high content of malic acid (Toyokawa *et al.*, 1974; Downing, 1989; Kennedy *et al.*, 1999) but it has high amount of pectin which rumen bacteria can use it to produce acetate by fermentation (Church, 1988). This leads to maintain acetate to propionate ratio and percentage of milk fat. Rumsey (1978) reported that inclusion of 17% apple pomace (DM basis) in diet of fistulated steers led to slight reduction of rumen pH and increase in acetate to propionate ratio, therefore higher milk fat of diet 3 in comparison to diet 2 may be related to higher inclusion of EAP. On the other hand the highest value of milk fat in diet 1(No EAP) may be the action of the highest DM content of this diet. Our results are in agreement with Toyokawa *et al*. (1984) who indicated that milk fat was increased when AP was mixed well with 10% Wheat bran, 10% chopped alfalfa and 10% milled rice bran and were ensiled then fed to Holstein dairy cows.

Percent of milk protein for all treatments was not altered significantly. Commonly, milk protein percentage is more stable than percentage of milk fat. Percent of milk protein can be altered by changing in diet composition but this change is lower compared to percent of milk fat (Philips, 2001; Chamberlain and Wilkinson, 1996). In our study the diets were formulated to balance the same requirements and nutrients, so no difference in milk protein was expectable. In contrast, Toyokawa *et al*. (1973) showed that inclusion of apple pomace in diets of Holstein dairy cows increased milk protein. They related this increase to high available energy of apple pomace. This inconstancy may partly be due to difference in composition and bioavailability of the diets.

There were no significant differences among treatments on percent of milk SNF. Mainly, protein and lactose form major constituents of SNF. On the other hand, milk lactose is one of the stable parts of milk composition and rarely affected by feeding or other factors. In present study, unchanged amount of protein percentage of treatments and stability of milk lactose may have been caused lack of significant differences between treatments on percent of milk SNF.

CONCLUSION

According to results of this study it may conclude that EAP can substitute successfully at diets up to 30% without negative effect on milk yield and milk composition (percentage of fat, protein and SNF). However, substitution of EAP in diets at levels up to 15% and 50:50 ratio of forage to concentrate is recommended because of its low FCR and high FE.

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