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Effects of Dried and Ensiled Apple Pomace from Puree Making on Performance of Finishing Lambs

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Abstract: This experiment was conducted to study the effect of ensiled and dried Apple Pomace (AP) obtained from puree making on finishing performance of lambs. Digestibilities of both ensiled and dried AP were determined using 4 mature sheep. In finishing experiment, 18 Sanjabi male lambs were used (9 per treatment) in a 120 day finishing experiment which was divided into two periods (60 day each). In the first period the ensiled AP and in the second period the dried AP were fed in an iso caloric, iso nitrogenous total mix ration. The Dry Matter (DM), crude protein and neutral detergent fiber of ensiled and dried AP were 247.1, 63.85, 386.4 g kg^{-1} DM and 888.4, 51.2, 385.6 g kg^{-1} DM, respectively. No significant difference was observed in the apparent digestibility of ensiled and dried AP. The apparent DM digestibilities of ensiled and dried AP were 704.3 and 668.2 g kg^{-1} DM, respectively. Feeding ensiled AP significantly increased Dry Matter Intake (0.938 vs. 0.803 kg day^{-1}), Average Daily Gain (ADG) (199.8 vs. 155.56 g) and Feed Conversion Ratio (FCR) (4.69 vs. 5.16). Use of dried AP had no significant effect on DMI (1.030 vs. 0.932 kg day^{-1}) but significantly improved the ADG (192.3 vs. 123.82 g) and FCR (5.36 vs. 7.52). Apple pomace increased carcass dressing percentage but had no effect on the percentage of different cuts. Results of this study suggest that AP, in both ensiled and dried forms, can improve the performance of finishing lambs.

Key words: Apple pomace, finishing lambs, intake, digestibility, carcass characteristics

INTRODUCTION

Shortage of animal feedstuffs is a common problem in many countries. The use of agricultural by-product is often a useful way of over coming this problem. These by-products are residues obtained after processing of fruit, vegetables and crops. They may include citrus pulp, tomato pomace, grape pomace and apple pomace. Feeding these by-products result in a reduction in feed costs. Apple pomace is a very high moisture feed (200-250 g DM kg^{-1}). The chemical-nutritional composition of apple pomace indicates that it has a high nutritive value owing to its high content of readily fermentable carbohydrates. Apple pomace can be used in animal feeding either fresh or after ensiling or dehydration. Because of the problems associated with the fresh form of AP, drying and ensiling are two common methods of preserving this by product. The nutritive value of apple pomace is variable depending on natural variation in the apples themselves, husbandry practice, fruit maturity and the extraction process used to make juice or puree (Kennedy *et al*., 1999). The crude protein content of apple pomace varies from 19 to 65 g kg^{-1} on dry matter basis (Carson *et al*., 1994; ARC, 1976). Use of apple pomace for animal feeding, also reduces the environmental pollution (Huber, 1980). It has been reported that use of apple pomace in finishing lambs ration enhances Average Daily Gain (ADG), Dry Matter Intake (DMI) and improves Feed Conversion Ratio (FCR) (Karami *et al*., 1996). Apple pomace is a good energy source for ruminants and it can be fed with urea as the only supplement to a straw based diet for calves (Singh and Narang, 1992).

There is limited information available on the effect of apple pomace preserved in different forms on performance of finishing lamb. Apple pomaces used in studies available have been obtained after extraction of apple juice. The present study was, therefore carried out to determine the chemical composition, intake and digestibility of dried and ensiled AP, obtained after puree making and its effect on performance and carcass characteristics of finishing lambs.

MATERIALS AND METHODS

Apple pomace: Apple Pomace (AP) was obtained fresh from a puree making factory (Rojin Taak, Agro Industries Co. Kermanshah, Iran). The average dry matter content of the fresh apple pomace was 185 g kg^{-1}. Due to high moisture content and physical property of AP, dried sugar

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beet pulp was added to fresh apple pomace at 20% level (on dry matter) as an absorbent at ensiling. Sun drying was used to prepare the dried apple pomace.

Chemical composition: The chemical composition of ensiled and dried apple pomace was determined using AOAC (1990). Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) were determined using the methods of Van Soest *et al*. (1991).

Finishing experiment: The experiment was carried out at Faculty of Agriculture Research Farm, Razi University Kermanshah, Iran in 2006.

Finishing experiment (120 days) was divided in to two periods (60 days each). In the first period the ensiled AP and in the second period the dried AP were fed in an iso caloric, iso nitrogenous total mix ration. In both periods, the effect of a diet containing AP was compared with a conventional finishing ration. Eighteen Sanjabi male lambs (average body weight 24.85±0.23 kg, 3 months age) were used. Prior to the start of the experiment lambs were treated against internal parasites. In a completely randomized design lambs were divided into two groups and were fed individually throughout the experiment. The composition of diets is shown in Table 1. The diets were offered twice a day. The daily feed offered and the refusals were recorded before each morning meal to measure daily DMI. The lambs were weighed at 2 week intervals prior to morning feeding to determine average daily gain and feed conversion ratio. Representative samples of feeds and refusals were collected at regular intervals and pooled for subsequent analysis.

Carcass characteristics: At the end of the second period, lambs were weighed and slaughtered following 16 h of fasting with access to water. The hot carcass weight was determined immediately after slaughtering the animals. The feet, hands, head, heart, liver, lungs, kidney, spleen, testicle, abdominal fat and total digestive tract were removed and weighed. After refrigeration at 4°C for 24 h, the carcasses were weighed again and chilling loss was calculated. Carcasses dissected into the following cuts: neck, brisket, shank, round and flunk. The weight of each cut was recorded and the ratio of various tissues and cuts to the total weight of carcass were calculated.

Apparent digestibility experiment: Four mature Sanjabi rams were used to determine the apparent nutrient digestibility of ensiled and dried AP. Adequate urea (1-1.5% on DM bases for ensiled and dried AP, respectively) was added to dried and ensiled AP at the time of feeding to bring the CP content of the feed to 9%. The animals were kept individually in metabolic cages with free-access to water. Digestibility experiment consisted of 14 days for adaptation and 1 week for collection of feed refusal and feacal samples. Animals were fed twice a day at *ad libitum* level.

Statistical analysis: All statistical analysis was carried out using SPSS (2002) and MSTATC procedures. The statistical model used was $Yij = \mu + Tij + Eij$. Because of the differences in the weight of the lambs of the control and AP fed group at the end of the first period, live weight at the beginning of the second period was used as a co-variate.

RESULTS AND DISCUSSION

Results of chemical composition of the ensiled and dried AP are shown in Table 2. Table 3 shows the results of apparent digestibility of different nutrients of the ensiled and dried AP. No difference ($p>0.05$) was observed in DM, OM, CP, NDF and ADF digestibility of the two forms of AP used. Digestible organic matter in dry matter was also not different ($p>0.05$) in ensiled or dried AP. The calculated ME values from DOMD according to Givens *et al*. (2000) was not different between the ensiled and dried AP.

Table 1: Ingredients and chemical composition of the diets containing no apple pomace (control), ensiled or dried apple pomace (AP)

	Diets		
Ingredients (%DM)	Ensiled AP	Dried AP	Control
Alfalfa	30.00	30.00	49.5
Barley grain	30.00	30.00	49.5
Dried apple pomace	0.00	20.00	0.0
Ensiled apple pomace	30.00	0.00	0.0
Soybean meal	9.00	9.00	0.0
Dried sugar beet pulp	0.00	10.00	0.0
Mineral + vitamin supplement + salt	1.00	1.00	1.0
Chemical composition			
ME (Mcal kg^{-1} DM)	2.56	2.52	2.5
CP (g kg^{-1} DM)	153.80	153.80	153.9

Table 2: Chemical composition (g kg^{-1}DM) and energy content (MJ ME kg^{-1} DM) of ensiled and dried apple pomace (n = 5)

Items	Ensiled AP	Dried AP
DM	247.10	888.40
OM	962.00	963.00
ASH	38.00	37.00
CP	63.85	51.20
NDF	386.40	385.60
ADF	256.90	309.40
EE	58.25	61.75
NFC[1]	453.50	464.40
ME (MJ kg^{-1} DM)[2]	11.73	11.55

AP: Apple Pomace, DM: Dry Matter, OM: Organic Matter, CP: Crude Protein, NDF: Neutral Detergent Fiber, ADF: Acid Detergent Fiber, EE: Ether Extract, NFC: Non Fiber Carbohydrates, ME: Metabolizable Energy. [1]: ME (MJ kg^{-1} DM) = 0.016 DOMD. (Givens *et al.*, 2000); [2]: NFC= 100 (%NDF+ %CP+ %Fat + %Ash) (NRC, 2001)

Table 3: Mean dry matter intake (g day^{-1}) and apparent nutrient digestibility of ensiled and dried apple pomace (g kg^{-1} DM) in sheep (n = 4)

Items	Ensiled AP	Dried AP	SED	Sig.
Intake (g DM day^{-1})	1291.1	902.9	79.05	**
Digestibility (g kg^{-1} DM)				
DM	704.3	668.2	6.57	NS
OM	717.7	698.8	6.33	NS
CP	511.5	396.7	11.32	NS
EE	524.1	444.2	11.94	NS
NDF	537.3	440.7	10.32	NS
ADF	721.7	458.9	10.98	NS
DOMD (g DOM kg^{-1} DM)	733.0	721.7	46.06	NS

AP: Apple Pomace, DM: Dry Matter, OM: Organic Matter, CP: Crude Protein, NDF: Neutral Detergent Fiber, ADF: Acid Detergent Fiber, EE: Ether Extract, DOMD: Digestible Organic Matter in Dry Matter, SED: Standard Error of Difference between means, NS: Non Significant, *: $p<0.05$, **: $p<0.01$

Table 4: Effect of feeding ensiled apple pomace on dry matter and organic matter intake (kg day^{-1}) average daily gain (g day^{-1}) and feed conversion ratio in the first period of the finishing experiment (n = 18)

	Experimental diets			
Traits	Ensiled AP	Control	SED	Sig.
First body weight (kg)	24.640	24.970	0.08	NS
Final body weight (kg)	36.630	34.300	1.44	*
ADG (g day^{-1})	199.800	155.560	14.39	*
DMI (kg day^{-1})	0.938	0.803	0.04	**
OMI (kg day^{-1})	0.856	0.760	0.03	*
FCR	4.690	5.160	0.24	*

ADG: Average Daily Gain, DMI: Dry Matter Intake, OMI: Organic Matter Intake, FCR: Feed Conversion Ratio, SED: Standard Error of Difference between means, NS: Non Significant, *: $p<0.05$, **: $p<0.01$

Results of the first period of finishing experiment, in which ensiled AP was compared with control diet, are shown in Table 4. Use of ensiled AP resulted in a significant increase in DMI (0.938 vs. 0.803 kg), ADG (199.8 vs. 155.56 g) and a decrease in FCR (4.69 vs. 5.16). Results from the second period (feeding dried AP) are shown in Table 5. Use of dried AP, had no significant effect on daily DMI compared to control (1.030 vs. 0.932 kg). However, feeding dried AP resulted in a significantly higher ($p<0.05$) ADG (192.3 vs. 123.82 g) and lower FCR (5.36 vs. 7.52).

Percentages of different cuts of carcasses were not affected ($p>0.05$) by dietary treatments (Table 6). Dressing percentages, carcass weights (both hot and cold) were significantly affected by dietary treatments.

The higher protein content of ensiled apple pomace compared with dried apple pomace was likely due to the addition of dried sugar beet pulp at ensiling. The crude protein of dried apple pomace was in the range of those reported by Carson *et al.* (1994) and Pirmohammadi *et al.* (2006). Singhal *et al.* (1991) in a study feeding dried AP reported lower values for NDF (30%) and ADF (25%) than those observed in the present study (38.6 and 30.9%,

Table 5: Effect of feeding dried apple pomace on dry matter and organic matter intake (kg day^{-1}) average daily gain (g day^{-1}) and feed conversion ratio in the second period of the finishing experiment (n = 18)

	Experimental diets			
Traits	Dried AP	Control	SED	Sig.
First body weight (kg)	38.340	34.840	1.25	**
Final body weight (kg)	49.860	42.260	1.04	**
ADG	192.300	123.820	16.75	**
DMI (kg day^{-1})	1.030	0.932	0.01	NS
OMI (kg day^{-1})	0.975	0.880	0.03	*
FCR	5.360	7.520	0.50	**

ADG: Average Daily Gain, DMI: Dry Matter Intake, OMI: Organic Matter Intake, FCR: Feed Conversion Ratio, SED: Standard Error of Difference between means, NS: Non Significant, *: $p<0.05$, **: $p<0.01$

Table 6: Mean physical carcass characteristics and the percentage of different carcass cuts of lambs fed diets with or without apple pomace (n = 18)

	Experimental diets			
Traits	Apple pomace	Control	SED	Sig.
Live body weight (kg)	48.80	42.55	0.78	**
Hot carcass weight (kg)	25.52	20.72	0.69	**
Cold carcass weight (kg)	24.85	20.23	0.58	**
Dressing percentage	52.29	48.70	1.38	*
Back fat (mm)	3.68	3.84	0.34	NS
Fat tail (kg)	5.62	4.37	0.75	NS
Carcass without fat tail	19.27	15.83	0.30	**
Percentage of				
Neck	5.79	6.83	0.56	NS
Brisket	11.96	12.21	0.43	NS
Shank	14.64	14.34	0.50	NS
Round	25.65	27.06	0.97	NS
Flunk	4.14	4.27	0.47	NS

SED: Standard Error of Difference between means, NS: Non Significant, *: $p<0.05$, **: $p<0.01$

respectively). In contrast Pirmohammadi *et al.* (2006) found higher NDF (46.3%) and ADF (40.5%) in dried AP. Such differences in the chemical composition of AP can be expected due to the morphology of the original apple, the extraction technique (Kennedy *et al.*, 1999) and probably drying method used.

Digestible organic matter content of dried (699 g kg^{-1} DM) and ensiled (718 g kg^{-1}) AP were not significantly ($p>0.05$) different. Since the addition of sugar beet pulp at the time of ensiling did not have any effect on the digestibility of organic matter compared to the dried AP, it may be concluded that the digestibility of organic matter of AP was similar to that of sugar beet pulp.

Diet with ensiled AP resulted in 17% more daily DMI than control during the first period of the finishing experiment (Table 4). However addition of AP in dried form did not result in any increase in DMI when compared to the control in the second period of finishing experiment. A direct comparison between intakes of dried and ensiled form which were available from digestibility trial in which sheep were fed at ad libitum level also showed a 43% higher intake of ensiled AP over its dried form (Table 3). This is in contrast with the report of Karami *et al*. (1996) in which DMI decreased when ensiled AP was included in the diet of finishing lambs at 18% of diet DM. Method of silage making could have a great impact on quality and hence the amount that is consumed by animal. Type of absorbent substance, probably the speed and conditions in which AP is transported from where it is produced to the stage that silo is sealed are the major factors affecting the quality of silage.

Average daily gain was significantly ($p<0.05$) improved with inclusion of either dried or ensiled AP. This improvement was 55 and 28 percent more than the control for dried and ensiled AP, respectively. Faster growth rate was responsible for a lower feed: gain ratio in lambs received diet with either ensiled or dried AP compared with lambs fed the control diet.

Mean feed conversion ratio decreased from 5.2 to 4.7 in those received diet containing ensiled AP and from 7.5 to 5.4 when dried AP group were compared to their respective control groups during each stage of finishing. The higher FCR obtained with feeding dried AP, partly or totally could be due to the fact that lambs received dried AP at later stage of growth in which energy requirement for weight gain is higher because of the change in the composition of gain and higher maintenance requirements. These results indicate that depending on the method of preservation of AP and the stage of growth of lambs from 0.47 to 2.16 kg less feed was required for each kilogram of live body weight gain.

CONCLUSION

It may be concluded that apple pomace as a feedstuff is a good energy source for ruminants. It can be substituted, in part, for grasses and roughages of good quality either in dried or ensiled form in finishing ration of lambs. Improvements in FCR and shortening the finishing period in one hand and its availability at low cost on the other hand can decrease the cost of production.

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