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Effect of Apple Pomace and Poultry Manure in Mixed Diets on Productive Performance in Replacement Female Lambs

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Abstract: The study was conducted at the Technologic Institute El Llano, Aguascalientes, Mexico to evaluate Ensiled Apple Pomace (EAP) as energy source combined with poultry manure in a mixed diet and the effects on productive performance and digestibility in replacement female lambs. About 24 lambs were used of an initial live weight of 16±2.5 kg and distributed in a random block design with four treatments and six blocks. The treatments were: T1, 0% EAP and 0% poultry manure; T2, 30% EAP and 0% poultry manure; T3, 0% EAP and 20% poultry manure and T4, 30% EAP and 20% poultry manure. The evaluated variables were: feed intake, average daily gain, feed conversion *in situ* digestibility, ruminal VFA and feed costs. Data were statistically evaluated by analysis of variance and multiple comparisons of means. In Daily Gain (ADG) T1 was higher than the rest of the treatments ($p<0.05$), DMI was lower in T2 than T1 and T3 while Feed Conversion (FC) and DM digestibility in different ruminal incubation times presented no differences among treatments ($p>0.05$). In the cost of 1 km of body weight gain, T4 had a saving of 21% ($p<0.05$) compared to T1 and 29% to T3. The molar production of volatile fatty acids in rumen fluid was higher ($p<0.05$) in T1-T3 but no differences were observed in the percentage of acetic, propionic and butyric acids. Ensiled apple Pomace combined with poultry manure is an alternative in growing lambs feeding in order to reduce the production costs.

Key words: Apple Pomace silage, chicken manure, replacement lambs, *in situ* digestibility, variance and multiple comparisons, production costs

INTRODUCTION

Female lambs to replace unproductive ewes are an important part of sheep production systems and represent approximately 20% of the total flock, however, these lambs are unproductive until parturition. Lambs in this period of growth have become a financial burden for companies engaged in sheep production and it is necessary to find feed alternatives that contribute to reduce the costs of production.

In addition, the high price of grains and other ingredients for the formulation of diets as well as the scarcity of good quality forages available in Mexico, oblige to seek by-products generated by the agro-industries that have a great potential to be employed in ruminant nutrition. Apple Pomace (AP) is a by-product resulting from the extraction of apple juices and nectars which contains apple peels, seeds and fibrous pulp residues and generates from 15-20 100/kg of fruit entering the process. The nutritional composition of the AP is variable, dry matter 14-26%, crude fiber 14-23%, DM basis and crude protein 4-8%, DM basis, variation due in part to apple variety, state of maturity and differences in processing (Hardy, 1992). Apple Pomace is low in protein but energy is the main contribution, derived from an important content of digestible fiber and soluble carbohydrates and is considered a feed of good taste for cattle (Carson *et al*., 1994). Hardy (1992) found that in spite of the low initial pH of the fresh Pomace, AP silage allows additional acidification with formation of lactic acid and alcohols, associated with increments in CP and CF content and may be available up to 1 year. Poultry manure is a by-product from the poultry industry and its use in ruminant diets is based mainly on the nitrogen and protein content, although, it contributes a considerable amount of energy and minerals, mainly calcium, phosphorus and

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copper (Aguero and Iglesia, 2006). The objectives were to determine the chemical composition of Apple Pomace Silage (APS) and evaluate the effect on productive parameters, digestibility and ruminal fermentation products in female lambs fed diets with a combination of APS and poultry manure.

MATERIALS AND METHODS

This study was carried out at the sheep experimental facilities of the Technological Institute of El Llano, Aguascalientes, Mexico, located at 18 km, Aguascalientes-San Luis Potosi highway at an altitude of 2020 m asl. The climate is semi-dry with an average annual temperature of 17.4°C and 526 mm annual rainfall (Garcia, 1987).

About 3 tons of fresh apple Pomace were ensiled without additives using a structure of cement floor and metal side walls of 2 m of width×4 m of length×0.9 m of height. The apple Pomace was compacted lightly with a tamper and covered with a layer of 10 cm of oat straw and a plastic cover. The Apple Pomace Silage (APS) had a fermentation period of 45 days before being used in lamb diets. Fresh and ensiled apple Pomace (Table 1) were analyzed for proximal analysis (AOAC, 2000) NDF and ADF (Van Soest *et al*., 1991) and pH was taken directly from the silage juice.

Four treatments with different levels of inclusion of the two study factors (APS and poultry manure) were evaluated. Diets were formulated to meet nutritional requirements for replacement lambs suggested by Anonymous (1985) and contained: T1 (0% EAP-0% poultry manure); T2 (30 EAP-0% poultry manure); T3 (0, EAP-20% poultry manure) and T4 (30, EAP-20% poultry manure). In the laboratory, diets were processed for the proximal analysis (AOAC, 2000), NDF and ADF (Van Soest *et al*., 1991) (Table 2).

A productive performance trial was carried out with 24 replacement crossbred female lambs (Katahdin and Dorper-Pelibuey) of an initial body weight of 16±2.5 kg, allocated in individual crates provided with feeders and water and were injected a vitamin compound (Vit. ADE, 1 mL) and dewormed with ivermectin (1 mL/20 kg BW). Lambs were randomly distributed in a random block design (Initial body weight) with four replicates. The experiment lasted 75, 15 days of adaptation to the diet and 60 days of experimental period and feed and water were offered for free access and orts recorded daily. The evaluated variables included Average Daily Gain (ADG), Final Live Weight (FLW), feed Intake (DMI) per period and based on their metabolic Weight (g/kgLW$^{0.75}$), Feed Conversion (FC) and the cost of 1 kg of increase of body weight by concept of feeding of each of the treatments. Lambs were weighed every 30 days during the experimental period. The DMI was measured daily by weighing the feed offered and orts and moisture content adjustments were done, the feed intake was also expressed per unit of metabolic Weight (BW$^{0.75}$) and FC was calculated from the feed intake and the live weight gained in the experimental period. Data were

Table 1: Chemical composition (g/kg^{-1} DM) and energy content of the apple Pomace fresh and ensiled

	Apple Pomace	
Items	Fresh	Ensiled
DM	178	212
CP	51	55
EE	29	35
CF	238	273
ASH	16	19
NFE	665	593
NDF	393	409
ADF	368	379
ME (Mcal/kg)*	2.580	2.510
TDN*	676	678
NFC*	511	482
PH**	2.6	2.7

*Calculated, **Taken directly from the AP juice, DM: Dry Matter; CP: Crude Protein, EE: Ether Extract; CF: Crude Fiber; NFE: Nitrogen Free Extract; NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber; ME: Metabolizable Energy, TDN: Total Digestible Nutrients, NFC:None-Fiber Carbohydrates. NFC = 100-(NDF+CP+EE+Ash%) (National Research Council, 2001)

Table 2: Ingredients and chemical composition (g/kg^{-1} DM) of the diets used for female lambs in different treatments

Feed ingredients	T1	T2	T3	T4
Ensiled Apple Pomace (EAP)	0	30	0	30
Poultry manure	0	0	20	20
Barley hay	15	15	15	17
Soy bean meal	7.7	8.7	5.5	6
Canola meal	3.9	3.9	3.9	3.9
Soy plus	6	8	6	8
Rolled sorghum	31.3	8.8	23	0
Soy bean hulls	20	11	16	6
Molasses	12.3	10.5	9.5	8
Salt	0.1	0.1	0.1	0.1
Calcium carbonate	0.7	1	0	0
Sodium bicarbonate	1	1	1	1
Minerals	1	1	0	0
Urea	1	0.95	0	0
Total	100	100	100	100
Chemical composition				
DM	850	450	860	454
Crude Protein*	175	173	175	172
Ether extract*	22	13	24	15
Ash*	112.2	120.7	125	118.3
NFC**	393.8	482.3	400	498.7
NDF*	297	209	276	193
ADF*	188	139	173	126
TDN**	620	624	618	632.3
ME (Mcal/kg)**	2.563	2.519	2.549	2.502
Ca**	6.1	7.0	8.8	8.6
P**	3.5	3.1	6.7	6.3

*Determined in lab; **Taken or calculated from (National Research Council, 2001); Crude protein (%) = N (%)×6.25 NFC = 100-(NDF+CP+EE+Ash%), (National Research Council, 2001) analyzed statistically by analysis of variance and when the treatment effect was significant ($p<0.05$), Tukey's multiple range test was used to compare individual means (SAS, 2003).

To obtain the *in situ* dry matter digestibility, four rumen-fistulated cows were used and fed a forage and concentrate diet. The same treatments used in the in vivo trial were used, in a 4×4 Latin square design. The treatment diets were milled with 1 mm sieve and 4 g were placed in each nylon bag (Ankom F57) and incubated (Orskov and McDonald, 1979). *In situ* digestibility was determined in five incubation times: 0, 24, 36, 48 and 72 h. At the end of each incubation time, feed samples were washed with tap water, put into a drying oven (Feliza) at 65°C for 72 h to obtain dry matter and calculate the disappeared feed.

At the end of the experimental period, ruminal fluid samples (150 mL) were taken from the lambs 6 h after offering the feed, using a vacuum pump and an esophageal probe of 1/2 inches with small holes in one end and ruminal pH was determined and samples were processed for analyses of volatile fatty acids by gas chromatography (Perkin Elmer® Co., Clarus 560 D Gas Chromatograph) (Erwin *et al*., 1961).

RESULTS AND DISCUSSION

Chemical composition of fresh and ensiled apple Pomace: Respect to the chemical composition of fresh and ensiled apple Pomace, ensiled apple Pomace reported an increase in concentration (Table 1) in DM 19.1%, ash 18.7%, EE 20.6%, CF 14.7%, CP 7.8%, NDF 4% and ADF 3% with respect to fresh Pomace while NFE concentration decreased in 12%. During the fermentation, apple Pomace lost some liquid content that carried on soluble fractions composed mainly of easily degradable carbohydrates which was reflected in a higher concentration of DM, ash, fiber components and crude protein. Results like those obtained in this study were reported by Anrique and Viveros (2002), except that they reported an increase of 43.7% in DM of ensiled Pomace with respect to fresh Pomace.

Animal performance in the *in vivo* trial:

Body weight gain in female lambs: Results of the experimental live trial are shown in Table 3. For ADG, T1 lambs (0 EAP and 0% poultry manure) obtained higher ($p<0.001$) values than T2-T4 (30% EAP and 0% poultry manure, 0 EAP and 20% poultry manure and 30% EAP with 20% poultry manure, respectively) and T4 was higher ($p<0.05$) than T2. Lambs of T1 had a higher ADG, since, the energy and protein ingredients of the diet were of higher quality and digestibility than the apple Pomace and poultry manure. In the four treatments the ADG was found to be below the expected levels 250 g/day, this probably due to the genetic quality of the ewe lambs used in the experiment, since, started with a low weight at weaning as they suffered the ravages of a dry year where forages were scarce. The lower ADG obtained by lambs of T2 could be due in part to the conditions of fermentation of the apple Pomace, since, no absorbent ingredient of the excess of moisture was added and the type of fermentation tended to produce a silage with a PH lower than those reported and with a somewhat irritating odor these disadvantages were diluted in T4 with the addition of poultry manure and were not present in T3 because it did not contain apple Pomace and no statistical differences ($p>0.05$) in ADG between these two treatments were observed.

Taasoli and Kafilzadeh (2008) used 20% beet pulp as an absorbent of the excess moisture of the fresh apple Pomace and obtained daily weight gains of 200 g in male lambs weighing 24 kg. By other hand, Rumsey and Lindahl (1982) concluded that protein availability in AP was poor and this by-product may be fed to gestating ewes without adverse effects in feed intake and weight gain up to 50% DM in a diet only if it is supplemented with true protein or poultry manure.

Alvarez *et al.* (2003) reported daily weight gains in pelibuey female lambs of 86, 74 and 111 g, values that are below those obtained this research; using three different diets: the first contained 30% of poultry manure, the second 30% of Parota (*Enterolobium cyclocarpum*) and a third diet was a combination of the two previous ingredients, 15% poultry manure plus 15% Parota, completing the rest of the diet 70% with ground corn and a mineral premix. The low ADG could be due to the low protein content of the diet 11% and to the effect of breed. Bores reported ADG in female lambs F1 Pelibuey x Black belly x Wool lambs of 185 and 165 g when fed a diet with 14% CP and 2.7 Mcal/kg of DM, similar values to those obtained in this study.

Feed intake: Dry matter intake per lamb in the experimental period was higher ($p<0.05$). In treatments 1 and 3 (diets without EAP) than that obtained by T2 (diet with EAP) and T4 did not show differences ($p>0.05$) with the rest of the treatments (Table 3). The lowest DM intake in T2 which contained 30% apple Pomace silage may have been due in part to the higher moisture content of the ration in this treatment (Table 2) and the acidic pH of the AP silage which could limit feed intake and decrease palatability of the diet. To estimate voluntary feed intake in dairy cows, the National Research Council

Table 3: Productive performance of replacement female lambs fed diets containing ensiled AP and Poultry Manure (PM) and economic cost

Treatment	AP (%)	PM (%)	ILW (kg)	FLW (kg)	ADG (g)	DMI (kg/period)	DMI (g/kgBW$^{0.75}$)	FC	COST[1]
1	0	0	16.08	29.07[a]	217[a]	68.6[a]	108[ab]	5.33[a]	26.81[ab]
2	30	0	16.02	29.07[a]	148[c]	54.0[b]	91[b]	6.24[a]	26.03[ab]
3	0	20	15.74	26.49[a]	179[bc]	69.3[a]	115[a]	6.55[a]	29.75[a]
4	30	20	16.06	27.06[a]	183[b]	62.3[ab]	101[ab]	5.72[a]	21.04[b]
CV (%)	-	-	-	13.49	10.93	11.2	11.53	18.18	-

[a-c]Means in the same column with different letter are different (p<0.05); ADG = Average Daily Gain; DMI = Dry Matter Intake; FC = Feed Conversion; [1]Mexican pesos to produce 1 kg of body weight increase; CV = Coefficient of Variation

(2001) indicates to reduce 0.02 100/kg live weight for each percentage unit higher than 50% moisture content in diet when fermented feeds are used in the ration.

The feed intake expressed in g/kg BW$^{0.75}$ was also lower ($p<0.05$) in T2 than in T3 (Table 3) in the same way it is attributed to the diets with apple Pomace which contained a high moisture content and the type of fermentation achieved. Rumsey and Lindahl (1982) fed pregnant ewes until parturition a basal diet of fresh apple Pomace supplemented with true protein or none- protein nitrogen sources and observed that in all treatments the energy intake was deficient, mainly in the last third of gestation where the intake of nutrients was limited, possibly by the high content of moisture and low nutrient supply of apple Pomace and to the limitation of forage in diet.

Pedraza and Pacheco (2000) reported average feed intakes between 55 and 61 g DM/kg BW$^{0.75}$ in 24 kg male sheep consuming digitaria decumbens grass, values that are below those found in the present study due to the fact that diets were high in fiber content which limited voluntary feed intake.

Feed conversion: In feed conversion, no statistical differences ($p>0.05$) were observed among treatments (Table 3). The higher ($p<0.05$) feed intake in T3 than T2 was not reflected in an increase in weight gain. The FC values obtained are higher than those reported by Taasoli and Kafilzadeh (2008) in male sheep fed similar diets including ensiled or dried apple Pomace in part because males are more efficient than females and the female lambs used in our study suffered malnutrition at an early age due to drought of that year and the shortage of forage.

By other hand, Vazquez, etc., found feed conversions of 5.36 and 5.53 in female lambs fed a diet containing 30 and 50% of ensiled apple Pomace, values similar to those obtained in the study.

Economic cost: The cost of a kilogram of body weight gain is the most important variable in the application of this study where sheep producers can observe the economic impact of the use of these by-products as

Table 4: Dry matter digestibility (%) of diets containing Ensiled Apple Pomace (EAP) and poultry manure at different times of ruminal incubation

Treatments	EAP (%)	Poultry manure (%)	Incubation time (h) 24	36	48	72
1	0	0	38.61[a]	49.01[a]	52.03[a]	57.01[a]
2	30	0	29.15[a]	47.43[a]	52.24[a]	56.11[a]
3	0	20	37.06[a]	48.25[a]	50.55[a]	56.96[a]
4	30	20	36.02[a]	47.43[a]	48.66[a]	53.43[a]
CV (%)	-	-	13.87	6.41	4.44	3.530

[a]Means in the same column with the same letter are not different (p>0.05) CV = Coefficient of Variation

partial substitutes for the conventional feeds that are more expensive. Lambs of T4 which were fed AP silage as a partial substitute for sorghum and soybean hulls showed a reduction in cost ($p<0.05$) of 29.3%, equivalent to 8.45 Mexican Pesos per kg cost of body weight increase with respect to T3 which included a conventional energy source and it should be noted that T4 was numerically slightly higher than T3 in ADG and in FC required 0.830 kg less feed per kg of body weight increase than T3 and although, T1 and T2 were not different in FC ($p>0.05$) to T3 and T4, economically a marked difference between T1 (which did not contain any by-product and served as a control) and T4 (containing AP silage as an energy substitute and poultry manure as the main nitrogen source) of 21.5% reduction in the cost of 1 kg of body weight increase in T4 was observed.

Dry matter digestibility: The DM Digestibility (DMD) of the different treatments in the 5 ruminal incubation times did not show a significant difference ($p>0.05$). The DM digestibility increased linearly as expected as the ruminal incubation time increased (Table 4). The percentage of ruminal degradation of DM per h in the four treatments was greater in the first 24 h, followed by 36 h, reaching from 84-89% of the potential of digestibility. Anrique and Viveros (2002) reported 92% of dry matter digestibility in ensiled apple Pomace for the first 36 h of ruminal fermentation. After these periods of time, DM degradation began to decline as time passed. This behavior is logical, since, in the first hours, the soluble fraction of the diets is consumed, leaving the fraction potentially insoluble. In general, the DMD in the different treatments are lower than those reported

Table 5: Volatile fatty acid concentration and ruminal PH of replacement female lambs fed diets containing ensiled apple Pomace and poultry manure

Treatments	EAP:Poultry M. (%)	VFA (Mmol)	Acetic (%)	Propionic (%)	Butyric (%)	A:P	PH
1	0:0	178.59[a]	61.89[a]	23.74[a]	14.36[a]	2.72[a]	6.5[a]
2	30:0	177.02[a]	63.90[a]	20.32[a]	15.77[a]	3.19[a]	6.8[a]
3	0:20	119.61[b]	61.44[a]	23.55[a]	15.00[a]	2.66[a]	6.6[a]
4	30:20	154.93[ab]	64.12[a]	20.43[a]	15.43[a]	3.15[a]	6.9[a]
CV (%)		16.05	21.11	32.40	27.15	18.53	4.35

[ab]Means in the same column with different letter are different ($p<0.05$); VFA = Volatile Fatty Acids; A:P = Acetic: Propionic rate; CV = Coefficient of Variation

by Azuara (2012) and Anonymous (1985) where poultry manure was included in wether sheep diets. Pirmohammadi *et al*. (2006) reported an organic matter digestibility of ensiled apple Pomace of 57.5% similar values to those found in this study in diets containing apple Pomace.

Ruminal fermentation products: In ruminal fermentation products, the percentage of acetic, propionic and butyric acid showed no significant difference ($p>0.05$) among treatments, however, as shown in Table 5 the total concentration of Volatile Fatty Acids (VFA_t) was higher ($p<0.01$) in T1 and T2 than in T3 while T4 showed no difference ($p>0.05$) with the rest of the treatments. This is related to the higher concentration of easily degradable carbohydrates from grains and apple Pomace in T1 and T2 than T3. Supplementation of forage-based diets with easily fermentable carbohydrates generally results in an increase in a VFA_t concentration (Balcells *et al*., 1996).

The rate of acetic to propionic acid did not present a statistical difference ($p>0.05$) among treatments and remained in the range of 2.66-3.19 acetate units per one of propionate which reflects that the different diets did not contain a high amount of grains rich in starches, including that of T1 that served as a control. In high forage diets, the VFA pattern in rumen fermentation fluctuates between 65:25:10 and 70:20:10 acetate, propionate and butyrate, respectively (Shimada, 1991) values like those obtained in this study.

CONCLUSION

Ensiled apple Pomace presents a chemical composition considered from regular to good to be used in the formulation of rations for lamb sheep included in 30% DM as an energy source along with true protein feeds or poultry manure as a nitrogen source.

Ensiled apple Pomace fed to female lambs in combination with poultry manure may be used to replace 50% of a grain diet keeping adequate productive parameters and reducing costs in growing lambs but more studies are required to improve results, both in the fermentation of apple Pomace and in the productive parameters.

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