Influence of Ensiled Pineapple Waste on Microbial Population and Fermentation in the Rumen of West African Dwarf Rams

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Abstract

Pineapple waste (PW) is a by-product of pineapple processing industries. There has been the problem of disposal of the waste causing environmental pollution and health hazards. This study was conducted to harness PW into animal feed stuff to replace cassava peel in silages containing Panicum maximum and urea. A total of sixteen West African dwarf (WAD) rams weighing 11.50 ± 1.5kg were randomly allotted to four dietary treatments. The replacement rates were 90% PW, 60% PW, 30% PW and 0% PW respectively. Silages have very good physical characteristics of colour and texture with slightly acidic pH. Similarly, chemical analyses revealed increased dietary crude protein and crude fibre with PW replacement while dry matter was reversed. There were significant increase in the rumen pH which increased with PW inclusion . The same trend was obtained in rumen NH_4-N (mg/dL) ranging from 3.69-7.18mg/dL and were significantly different across the treatments. The different volatile fatty acid (VFA) components had values that were statistically different and increased with the level of supplementation of PW. Lactic acid, butyric acid, propionic acid and acetic acid values ranged between 1.68-6.55, 0.74-4.46, 0.56-2.43, and 5.41-10.02 mg/dL, respectively. Fungi and bacteria population obtained for rams fed 4-hours post feeding showed that fungi population was highest at PW60 inclusion rate with an increase of 5.17cfu/ml amounting to 67.84% and lowest at PW0 which increased by 0.75cfu/ml amounting to 19.08%. Bacteria population increased as PW inclusion increased at 8.68, 4.73, 4.65, and 3.57cfu/ml, respectively. Therefore, PW could be ensiled and recycled for use in sheep diet thereby combating environmental pollution caused by the waste.

Keywords: Microbial load, pineapple waste, rumen ecology, silages, volatile fatty acids.

Introduction

All year round feed availability is a major constraint to improved ruminant production in tropical Africa. The competition between man and animals for conventional feed resources requires urgent attention of animal nutritionists in producing alternative feed resources for various classes of livestock including ruminants (Bawala and Akinsoyinu, 2002). Natural pastures cannot be relied on to provide adequate nutrients for optimal livestock production. Hence, supplementary feeding is important to enhance productivity of livestock (Adebowale and Taiwo, 1996).

The greatest unsolved problem in livestock sector is that of escalating cost of conventional feed ingredients for farm animals. Feed cost alone is about 70% of the total production cost in any livestock enterprise (Tewe and Adamu, 1996). The high cost of feeds for livestock production has been further compounded by the internally stiff competition for maize and other ingredients between man and beast

(Tewe, 1997). In view of the escalating prices for grains and high demand in human nutrition, it is therefore advisable to explore other sources of carbohydrate and protein for use in animal nutrition.

The use of inexpensive, non-traditional feedstuffs such as pineapple waste under traditional production systems is therefore imperative to cut down the cost of production and to achieve sustainable development in livestock enterprise. Ruminants fed on crop residues, by-products and arable weeds add value to resources like pineapple waste which are largely wasted in the absence of a ruminant component in the system (Jutzi, 1993). Waste or by-products represent a valuable resource if properly managed or processed (Akangbe and Adeleye, 2002).

Livestock industry in Nigeria had been appraised for its substantial contribution to the national wealth and for supplying the populace with important animal protein required for health and body maintenance. One major group of these animals that can be exploited is the small ruminant - sheep and goats which are socially and economically important sources of meat, skin and manure Small ruminants constitute 60% of the ruminant species in south western Nigeria and are generally more concentrated in semi-arid area of northern Nigeria (Devendra, 2001). Resource-poor people keep sheep and goats essentially for food and security.

In recent times, pineapple production for fruit manufacture has developed rapidly, from large quantity of pineapple production, 50-80% of the by-product can be used as feed resources for raising livestock (Devendra, 2001). Thus, feeding these by-product to livestock should be considered not only to lessen environmental problems, to diminish dependence of livestock on grains that can support human and to eliminate the cost of waste management problems and to support sustainable development among the agricultural communities in Nigeria (Grasser *et al.,*1995). The rapid deterioration of the pineapple waste and great amount generated within short periods of time requires ensilage to enhance nutritive value, eliminate anti-nutritional or hazardous elements, prolong storage life and improve intake and better digestion of proximate nutrients. A reduction in pH during ensiling process eliminates unwanted microbes in the materials and accelerates the breakdown of any residual agro-chemical in the material. Ensiling pineapple waste with materials such as maize cobs and cassava peels is a sustainable method of conservation of pineapple waste.

Maize cobs and cassava waste provided media for absorbing excess water contained in the pineapple waste (Nguyen, *et al.*, 2009). The objective of this study was to determine the effect of pineapple waste silage on rumen fermentation patterns and microbial population of West African dwarf rams fed pineapple waste silage.

Materials and Methods

Twelve (12) growing West African dwarf rams aged between 5-6 months weighing 11.50 ± 1.5 kg were used for the trial. The animals were treated with Oxtetracycline LA 1mL/10kg live weight and Ivermectin at 1mL/25 kg live weight. The silage was made from wet pineapple waste, wilted *Panicum maximum*, dried cassava peels and urea. *Panicum maximum* were chopped into smaller sizes with forage chopper. As shown in Table 1, the diet comprised varying levels of pineapple waste ensiled with *Panicum maximum* and urea. The animals were fed the experimental diets for 3 weeks, thereafter; rumen fluid samples (80 ml) were collected individually from all the animals using rubber tube suction method as described by Preston (1995). The ruminal fluid was strained through a clean cheese cloth gauge into a thermo flask from different replicates of experimental animals. Rumen fluid pH was determined immediately after sample collection with a pH meter.

Table 1: Gross (g/100gDM) and proximate composition (%/100g DM) of experimental Diets fed to West African dwarf sheep

Parameters (%)	PW90	PW60	PW30	PW0
Pineapple waste (PW)	90.00	60.00	30.00	0.00
Panicum maximum (PM)	8.00	8.00	8.00	8.00
Urea (U)	2.00	2.00	2.00	2.00
Dried cassava Peels (DCO)	0.00	30.00	60.00	90.00
Dry matter	88.70	90.50	95.60	94.90
Crude protein	14.79	13.86	12.70	10.09
Ether Extract	1.72	2.50	0.88	1.44
Ash	7.38	10.53	7.27	6.72
Nitrogen Free Extract	33.22	44.36	63.46	67.03
Acid Detergent Fibre	40.50	30.18	19.83	24.24
Acid Detergent Lignin	4.67	7.70	5.90	8.40
Nitrogen Detergent Fibre	63.63	32.69	17.59	19.51

PW90 = 90% PW+8%PM+2%U+0%DCP; PW60 -60%PW+8%PM+2%U+30%DCP; PW30 - 30%PW+8%PM+2%U+60%DCP; PW0 - 0%PW+8%PM+2%U+90%DCP

Volatile fatty acids (propionic acid, butyric acid and acetic acid) were determined using high-performance liquid chromatography, while ammonia nitrogen was determined using the process described by AOAC (2005).

Data were subjected to analysis of variance (ANOVA) in a completely randomized design according to the procedure of SAS (2000), means were separated using Duncan Multiple Range Test option of same software.

Results

Table 2 shows the ruminal volatile fatty acids, ammonia-nitrogen and pH of West African dwarf rams fed different levels of pineapple waste based diets. Rumen pH ranged from 6.40 to 6.80 with the lowest pH obtained in PW90 and highest in PW0. Ammonium nitrogen values obtained were 3.690-7.177 mg/dl for PW90-PW0 respectively.

Ammonia-nitrogen [NH_3-N] concentration in rams was not affected by supplementation of urea at 2% in all the treatments. Similarly, lactic acid concentration obtained in this study ranged from 1.70 - 6.55mg/dl. Lactic acid concentration was not significantly affected by replacement of cassava peels with pineapple waste. The butyric acid concentration ranged from 0.74mg/dl to 4.45mg/dl for PW90 – PW0, respectively. There were observed significant differences ($p < 0.05$) among the treatments, but the result did not follow any particular trend.

Propionic acid and acetic acid concentrations increased with decreasing inclusions of PW in the diet. Also, significant differences ($p<0.05$) were observed across the treatments. The highest total volatile fatty acids 14.38 mg/dl was observed in PW30.

Table 2: Rumen pH, ammonia-nitrogen concentration and total volatile fatty acids of rams fed ensiled pineapple waste

Parameters	PW90	PW60	PW30	PWO	SEM
Rumen pH	6.40^{a}	6.50^{a}	6.70^{b}	6.80^{b}	0.13
Rumen NH_3N (mg/dl)	3.69^{a}	5.04^{b}	5.43^{b}	7.18^{c}	0.69
Lactic acid (mg/dl)	1.68^{a}	3.53^{b}	6.30^{c}	6.55^{c}	0.80
Butyric acid (mg/dl)	0.74^{a}	2.99^{ab}	4.10^{b}	4.46^{b}	0.59
Propanoic acid (mg/dl)	0.56^{a}	0.77^{b}	1.48^{c}	2.43^{d}	0.39
Acetic acid (mg/dl)	5.41^{a}	6.49^{b}	7.33^{c}	10.02^{d}	0.25

Means with the same superscripts in a column are not significantly different from one another at P>0.05. PW90 = 90% PW+8%PM+2%U+0%DCP; PW60 = 60%PW+8%PM+ 2%U+30%DCP; PW30 = 30%PW+8%PM+2%U+60%DCP; PW0 – 0%PW+8%PM+ 2%U+90%DCP; PW – Pineapple Waste; PM – *Panicum maximum*; U – Urea; DCP – Dried Cassava Peels. SEM=standard error of means

Results of the microbial population of West African dwarf rams fed varying levels of pineapple waste and dried cassava peels are presented in Table 3. Microbial population obtained before feeding were: total microbial population at 10^{-4} for bacteria were 5.10cfu/ml, 5.33cfu/ml, 4.33cfu/ml and 4.13cfu/ml for PW90, PW60, PW30 and PW0, respectively. The total microbial population at 10^{-4} for fungi were 1.95cfu/ml, 2.45cfu/ml, 2.92cfu/ml and 3.18cfu/ml for PW90 – PW0, respectively. However, with 4 hour post feeding, the total microbial population at 10^{-4} for fungi increased with increase in fibre content of the diet. The values obtained before feeding and 4-hours post feeding decreased across the diets for PW90 to PW0.

Table 3: Microbial population in the rumen of rams fed varying levels of pineapple waste and dried cassava peels before and after feeding

Parameters	PW90	PW60	PW30	PW0	SEM
Before feeding 10^{-4}					
Fungi (cfu/ml)	1.95	2.45	2.92	3.18	0.30
Bacteria (cfu/ml)	5.10	4.93	4.72	4.13	0.25
4-Hour post feeding 10^{-4}					
Fungi (cfu/ml)	7.62	4.45	3.93	2.61	0.74
Bacteria (cfu/ml)	8.68	4.73	4.65	3.57	0.58

PW90 – 90%PW+8%PM+2%U+0%DCP; PW60 – 60%PW+8%PM+2%U+30%DCP; PW30 – 30%PW+8%PM+2%U+60%DCP; PW0 – 0%PW+8%PM+2%U+90%DCP; PW – Pineapple Waste; PM – *Panicum maximum*; U – Urea; DCP – Dried Cassava Peels

Discussion

The values obtained for rumen pH were similar to the findings of Mom serg *et al* . (2001); Nguyen (2001) and Promkot and Wanapat (2003). Vongsamphanh and Wanapat (2004) reported that pH was not significantly different ($p<0.050$) when ruminants were supplemented with different cassava hays. Hungate (1966) reported a range of 6.5 to 7.0 as the optimum pH needed for maximum microbial growth.

Ammonia-nitrogen [NH_3-N] concentration in rams was not affected by supplementation of urea at 2% in all the treatments. The results were similar to the findings of Wanapat *et al*. (2005)(not cited) that ammonia nitrogen [NH_3-N] concentration was not significantly affected but tended to increase when supplemented with a high level of 4% urea. This result agreed with the reported range of 4.5-12.4 mg/dl obtained when swamp buffaloes were fed untreated rice straw by Chathai *et al*. (1989) and NH_3-N was less than 2mg/dl and increased to 9mg/dl when the straw was treated with urea. This observation agreed with Nguyen *et al*. (2009), who reported the range of 1.6-10.4 mg/dl in sheep fed pineapple waste ensiled with poultry litter. NH_3-N concentration reported in this study did not exceed the concentration of 100mg/dl reported by Church (1993) that could lead to urea toxicity.

Lactic acid concentration was not significantly affected by replacement of cassava peels with pineapple waste. These values were similar to those reported by Nguyen *et al.* (2009) in sheep fed ensiled pineapple waste with maize cobs. The difference might be due to higher content of water soluble carbohydrates in form of fructose and sucrose that are converted to lactic acid by the lactic acid bacteria in the rumen as a result of extraction processing.

The butyric acid concentration were significantly different ($p<0.05$) among PW90 and PW0. However, no particular trend was observed among the treatments.

Propionic acid and acetic acid concentrations increased with decreasing inclusions of PW in the diet. However, significant differences ($p<0.05$) were observed across the treatments. The highest total volatile fatty acids 14.38mg/dl was observed in PW30. PW30 had the highest mean values for the propionate (1.48%) that would be converted into energy and subsequently used for growth and body maintenance by the animals. Inclusion of pineapple waste to replace cassava peels at 30-60% yielded highest volatile fatty acids.

With increase in fibre levels of the diet, proliferation of fungi was enhanced easily. The total microbial population at 10^{-4} for bacteria were 5.10cfu/ml, 5.33cfu/ml, 4.33cfu/ml and 4.13cfu/ml for PW90, PW60, PW30 and PW0, respectively. The total microbial population at 10^{-4} for fungi were 1.95cfu/ml, 2.45cfu/ml, 2.92cfu/ml and 3.18cfu/ml for PW90 – PW0, respectively. These were obtained prior to feeding the experimental animals. However, with 4 hour post feeding, the total microbial population at 10^{-4} for fungi increased with increase in fibre content of the diet. The values obtained before feeding and 4-hours post feeding decreased across the diets for PW90 to PW0. This indicate that with decrease in CF level of the diet, fungi population decreases across the diets. The inclusion of PW in the silage increased the microbial population with increase in CF levels in the diet. However, inclusion of PW at 60% provided favourable condition for the proliferation of rumen microbes.

Pineapple waste at 90% resulted in an increase in fungal and bacterial rumen content 4 hrs after feeding whereas, a reduction of fungal and bacterial content was observed with no pineapple waste included in the feed. This implies that more fermentation took place where there was more pineapple content in the feed.

Conclusion

Replacement of cassava waste with PW silage at 30-60% inclusion rate had the best influence on the rumen fermentation pattern and microbial population of rams. PW could be ensiled and used successfully with other feedstuffs in sheep diets without any adverse effect on the health of the animals. Also, PW can be recycled into the feed of sheep thereby curbing its effect on environmental pollution.

References

Adebowale, E. A. and Taiwo, A. A. (1996). The performance of West African dwarf sheep fed silage and silage plus concentrates. *Nigeria Journal of Animal Production* 23 (1): 153-160.

Akangbe, F. G. and Adeleye, I. O. A. (2002). Effect of supplementation of poultry droppings meal on the live weight changes of West African dwarf sheep. Proceedings of 7th Annual Conference of Animal Science Association of Nigeria (ASAN), pp. 177-179.

Association of Official Analytical Chemist (2005). Official methods of analysis. 18th Edition. Association of Official Analytical Chemists, Washington DC.. pp. 24-54.

Bawala, T. O. and Akinsoyinu, A. O. (2002). Nutritional evaluation of browses, *Glyricidia sepium* and *Ficus thoringi* foliage in goat diet: 2: Energy Utilization and requirement. Proceedings of 7th Annual Conference Animal Science Association of Nigeria (ASAN), pp. 174-176.

Chanthai, S.M., Aroeira, L.J.M., Lopes C.F. and Dayrell. M.D. (1989). Derivatives, digestibility and rice straw intake in Swamp Buffaloes – Effects on ruminal ammonia nitrogen and microbial fermentation. *International Journal of Dairy Sci.* 89:2649-2658.

Church, D.C. (1993). Rumen metabolism of carbohydrates and lipids. A workshop on digestive physiology and nutrition of ruminants. Oregon, U.S.A. pp. 245-265.

Devendra, C. (2001). Non-conventional feed resource proceedings of Agric.

Conference on cassava as animal feeds in Asia and the Pacific. Strategies for Expanding Utilization at the Small Farm Level. FAO-APHCA, pp. 73-105.

Food and Agricultural Organisation (2011). FAO Statistical Database. Food and Agriculture Organization of the United Nation, Rome. http//www.aphis.usda.gov/ import-export/plants. World Development Indicators.

Grasser, L. A., Fadel, I. G., Garnett, I. and De Peters, E. J. (1995). Quantity and economic importance of nine selected by-products used in California dairy rations. *Journal of Dairy Science* 78:962-971.

Hungate, R. E. (1966). The rumen and its microbe. Academic Press, New York, NY. Proceedings of Animal Science Technology 16:151-154.

Jutzi, S. (1993). Livestock production Systems in developing countries: status, drivers – *Agricultural Science*, 44 -45.

Nguyen, T.H.N., Nguyen, V.H and Preston, T. R. (2009). Ensiling with or without additives to preserve pineapple residues and reduce pollution of the environment. *Livestock Research for Rural Development* 21(7).

Nguyen, T. H. N., Nguyen, V. H.., Nguyen T. N., Nguyen T. V., Preston, T.R. Leng R. A. (2001). Practical application of defaunation of cattle on farms in Vietnam: Response of young cattle fed rice straw and grass to a single drench of groundnut oil. *Asian Australasian Journal of Animal Science* 14 (4):485-490.

Preston,T.R. (1995). Tropical animal feeding. A manual for research workers. FAO Animal Production and Health Paper 126.Rome,Italy.

Promkot, C. and Wanapat, M. (2003). Ruminal degradation and intestinal digestion of crude protein of tropical protein using nylon bag technique and three-step in vitro procedure in dairy cattle. *Livestock Research of Rural Development* Vol.15, Art. #11. Retrieved December 22, 2015, from http://www.Irrd.org/Irrd15/11/prom 1511.htm

Seng, M., Preston, T. R., Leng, R. A. and Meulen, Uter. (2001). Effect of a single drench of cooking oil on the rumen ecosystem and performance of young local "yellow" cattle fed rice straw and cassava foliage. *Livestock Research for Rural Development.* Volume 13, Article #40. http://www.lrrd.org/lrrd13/4/seng 134.htm

Statistical Analytical System [SAS] (2000). Statistical Analysis System, User's guide, SAS Institute Inc. Cary, North Carolina, USA.

Tewe, O. O. (2004). Cassava for Livestock feed in Sub-Sahara Africa. F A O, Rome, Italy, p. 64.

Tewe, O. O. and Adamu, A. (1996). Feed and feed resources. Paper presented at the first Nutritional Workshop at National Agriculture Research Project Strategy Plan, Abuja, Nigeria-November 1996.

Vongsmphanh, P. and Wanapat, M. (2004). Comparison of cassava hay yield and chemical comparison of local and introduced varieties and effects of level of cassava hay supplementation in native beef cattle fed on rice straw. *Livestock Research for Rural Development* Vol. 16, Art. #55. Retrieved December 22, 2015, from http://www.lrrd.org/lrrd16/8/vong 16055.htm