pH, FERMENTATION PATHWAYS AND PHYSICAL CHARACTERISTICS OF CASSAVA PEELS SUPPLEMENTED AND ENSILED WITH BREWERS' DRIED GRAINS AND POULTRY LITTER

Ekanem[1*], N. J., Olorunnisomo[2], O. A., Ikwenze[3], K. Mbaba[1], E. N. and Ifut[1], O. J.

ABSTRACT

[1]Department of Animal Science, University of Uyo, Uyo, Akwa Ibom State. [2]Department of Animal Science, University of Ibadan, Ibadan, Oyo State. [3]Department of Animal Production and Livestock Management, College of Animal Science and Production, Michael Okpara University of Agriculture, Umudike, Abia State. [*]Corresponding author: ekanem_n@yahoo.co.uk. Tel: 08038701314.

This study evaluated the effect of ensiling duration on the pH, fermentation and physical characteristics of cassava peels, brewers' dried grains and poultry litter ensiled mixtures. The compositions of the silage were; diet 1 (80% Cassava Peels (CSP) + 20% Brewer's Dried Grains (BDG)), diet 2 (80% CSP + 20% Poultry Litter (PL)) and diet 3 (80% CSP + 10% BDG + 10% PL). Plastic silos of 4 liters capacity were used to ensile the mixtures. Each treatment was replicated 15 times. The ensilage lasted for 35 days. The pH, dry matter, and physical characteristics were assessed at days 0, 7, 14, 21, 28, and 35 of ensiling. The final pH values of 3.8, 4.1, and 4.1 for treatments 1, 2, and 3 respectively were within acceptable range of well-made silage. While final pH was attained for diets 1 and 3 at day 7, diet 2 attained its final pH at day 28 of ensiling. There was reduction in dry matter contents with the conversion of fermentable carbohydrate to lactic acid. Percentage dry matter recovered were 97, 91, and 90% for diets 1, 2, and 3 respectively at day 28 of ensiling. The smell was pleasant for diet 1 and slightly pleasant for diets 2 and 3. All the silages maintained same colour as the original ingredients colour while texture was firm. Ensiled CSP with 20% BDG supplementation (diet 1) gave improved silage characteristics for well-made silage.

Keywords: *Cassava peels, brewers' dried grains, poultry litter, silage, fermentation characteristics.*

INTRODUCTION

The basal feed resources for ruminants available in the tropics are crop residues, forages from infertile lands, or agro-industrial by-products, which are low in crude protein, digestibility and feed to gain ratio (Leng 2004; Ifut and Mbaba, 2014; Ekanem *et al.*, 2015). Cassava peel (CSP) is a major by-product of cassava tuberous root processing industry. Cassava peel is a cheap source of readily fermentable carbohydrate which can be added to the feed of ruminants in high proportion without eliciting ill effects on animal production. Due to its high starch content (Olorunnisomo *et al.*, 2012; Jolaosho, *et al.*, 2013), Cassava peel can serve as a source of readily fermentable carbohydrate and also improve energy concentration in silage. Brewers' spent grain is an excellent protein and energy sources due to its high digestibility, fibre content and ruminal escape protein (Ekanem, 2012; Heuez *et al.*, 2014). Poultry litter (PL) includes the beddings and other contamination in the poultry house and the poultry manure. Poultry litter is a good source of nitrogen, protein and ash (Oluyemi and Roberts, 1979; Ekanem, 2012). The ensiling of by-products is a simple and appropriate method of conservation. It is the most effective way to improve animal feed resources through the rational use of locally available agricultural and industrial-by products likely to be available to small-scale farmers at village level. Fermentation analyses have long been used to assess silage quality and to determine whether an excellent, average or poor fermentation has occurred and also the kind of organisms that controlled the ensiling process (Kung and Shaver, 2001; Ifut *et al.*, 2015).The objective of this work therefore was to assess the physical and chemical characteristics of cassava peels, supplemented and ensiled with brewers' dried grains and poultry litter.

MATERIALS AND METHODS

The study was conducted at the Dairy Unit, Teaching and Research Farms of the University of Ibadan, Ibadan, Oyo State, Nigeria (Latitude 7° 27´ and Longitude 3° 45´ E). Annual rainfall averages 1250 mm and occurs from April to November with a marked dry season from December to March. The fresh CSP were collected from a garri processing unit at Mokola, Ibadan. The brewers' dried grains were sourced from a reputable dealer at Bodija, Ibadan. The dried poultry (cockerel) litters were obtained from the poultry unit, Teaching and Research Farms, University of Ibadan. The CSP were chopped using an improvised chopper to reduce the particle size to about 2-3 cm to ease compaction. Accurately weighed quantities of the ingredients (Table 1) were mixed properly, packed into corresponding treatment silos (4 liters plastic buckets) and well compacted manually. The silos were properly sealed with polythene sheets and sand bags were placed on top of the compacted mixtures to further minimize air entry. The silos were covered as fast as possible to disallow air from entering and being trapped in the ensiled mass. The ensilage was done in three treatments as shown in Table 1.

Samples were taken on the day the feed were compounded (Day 0) for physical and chemical analyses. Three replicates silos each of the experimental diets was also opened at days 7, 14. 21, 28, and 35 respectively and representative samples were taken from each mini silo for physical and chemical analyses. pH was determined using a pH meter (model PHS-25). Five grams of the samples were added to 10 ml of distilled water and thoroughly stirred. The standardized pH meter was then inserted into the suspension and the readings obtained. The dry matter (DM) was determined according to the method of AOAC (1990). Samples of the diets were oven-dried at 60 °C for 48 hours and subsequently ground using electric blender. The fermentation pathways were arrived at based on the dry matter range and other parameters postulated by Kung (2001). The theoretical dry matter recovery rate was calculated as the later dry matter contents divided by the initial dry matter contents multiplied by 100. Data obtained on pH and dry matter was subjected to analyses of variance using SAS (2000) software. Significantly different treatment means were separated using Duncan New Multiple Range Test at 5% level of probability.

RESULTS AND DISCUSSIONS

The effect of ensiling duration on the pH of cassava peels, brewers' dried grains and poultry litter silage is shown on Table 2. There were significant differences ($p<0.05$) among the diets at day 0 to 21 of ensiling. At days 28 and 35 of ensiling, there were significant differences between diet 1 (20% BDG) with the other two diets (diet 2 and 3) with 20 and 10% PL inclusion respectively. Diets 2 and 3 with PL inclusion did not differ ($p>0.05$) from each other at days 28 and 35 of ensiling. The final pH reached was 3.8, 4.1, and 4.1 for diets 1, 2 and 3 respectively. The silages pH was within the acceptable range of 3.6 to 4.5 for good quality silage as reported by Kung (2001) and Olorunnisomo *et al.* (2012). There was a rapid decline and stabilization in the pH of diet 1 from 4.3 to 3.8, and that of diet 3 from 5.2 to 4.0 at day 7. This underscores the presence of the homo-fermentative lactic-acid bacteria during ensiling and the oxidization of the water soluble carbohydrates to organic acids such as lactic acid, thus adequately explaining a probable reason for reduced pH (McDonald *et al*., 2002; Olorunnisomo and Fayomi, 2012). Diet 2 on the other hand took a considerably longer period to attain its final pH. The pH declined from 6.1 at day 0 to 4.6 at day 7, then to a final pH of 4.1 at days 28 and 35. This was probably due to the high buffering capacity of the poultry litter. Buffering capacity (the crop's resistance to drops in pH) could be due to the organic acids (e.g., citrate, malate, and quinate), orthophosphates, sulfates, nitrates, chlorides, and non-protein nitrogen in the material (McDonald, 1991). Buffering capacity is measured as the amount of lactic acid (mEq) required to reduce the pH of 1.0 g of dry matter from pH 6.0 to 4.0. Highly buffered forage (e.g., alfalfa [366 mEq per g]) requires more water-soluble carbohydrate than a low-buffered crop (e.g., corn forage [200 mEq per g]) for bacterial fermentation to decrease pH to desired levels (Seglar, 2003). High nitrogen (Oluyemi and Roberts, 1979; Ekanem, 2012) and non-protein nitrogen (ammonia nitrogen and uric acid) content of poultry litter in diet 2 contributed to its resistance to reduction in pH. McCaskey and Anthony (1975) indicated that ensiled materials should reach a pH of less than 5 in order to destroy Salmonella and other pathogens. In the present study, pH values lower than 5 were obtained in all silages. The effect of fermentation period on the dry matter contents of the silages is shown on Table 3, while the fermentation pathways on day 28 of ensiling is as shown in Table 4.

Table 1: Ingredient composition of experimental diets

Ingredients (%)	Diet 1	Diet 2	Diet 3
Fresh cassava peels (CSP)	80	80	80
Brewers' dried grains (BDG)	20	0	10
Poultry litter (PL)	0	20	10
Total	100	100	100

Table 2: pH of cassava peels ensiled with brewers' dried grains and poultry litter

Days	Diet 1	Diet 2	Diet 3	SEM
0	4.3a	6.1c	5.2b	0.26
7	3.8a	4.6c	4.0b	0.12
14	3.9a	4.5c	4.2b	0.09
21	3.9a	4.4c	4.2b	0.07
28	3.9a	4.1b	4.1b	0.03
35	3.8a	4.1b	4.1b	0.05

Diet 1= 80% Cassava peels (CSP) + 20% Brewers' dried grain (BDG). Diet 2 = 80% CSP + 20% Poultry litter (PL). Diet 3 = 80% CSP + 10% BDG + 10% PL.

There were significant differences ($p<0.05$) in the percentage dry matter (DM) contents of the 3 ensiled diets at the different ensiling duration. Silage 2 with 20% PL had the least DM throughout the ensiling duration except in week 35 in which effluent loss was observed, thus increasing the DM contents The DM contents of the silages reduced from 51.34, 50.17 and 52.99 at day 0 to 50.38, 48.83 and 47.42 on day 35 for diets 1, 2 and 3 respectively. The reduced DM content obtained in this study is in line with previous reports (Akinola, 2008; Jolaosho *et al.,* 2013). This may be due to loss of soluble carbohydrates during fermentation (Olorunnisomo and Fayomi, 2012), which were retained as lactic acid (Ifut *et al.,* 2015). At day 28, the percentage dry matter recovery rate for diets 1, 2 and 3 were 97.27, 91.25 and 90.13 % respectively. Also at day 35, the percentage dry matter recovery rates were 98.13, 97.33 and 89.49% for diets 1, 2 and 3 respectively. The 98% dry matter recovery rate for diet 1 indicated a homolactic (glucose) fermentation (Kung, 2001). Diet 2 whose final pH was attained at day 28 had 91.25% dry matter recovery rate indicating heterolactic (fructose) fermentation with lactic acid, acetate, mannitol, and CO_2 as end products as reported by Kung (2001). The same heterolactic fermentation also applied to diet 3 which recorded a dry matter recovery rate of 90.13% at day 28. The rather higher value of dry matter recovered in diet 2 at day 35 (97.33%) was probably due to the seepage (effluent loss) observed from secondary aerobic spoilage on the surface of the silage in storage. Diet 2 will thus have a short bunk life. The predisposing factor to aerobic instability was likely due to the high epiphytic populations of yeast, mold, or aerobic bacteria present in the manure (poultry litter) used coupled with its high application rate (Seglar, 2003). This is a good pointer to the fact that diet 1 with no poultry litter in the mixture will have a longer bunk life than diet 3 with 10% inclusion rate of poultry litter.

Table 3: Effect of ensiling duration on the dry matter (%) contents of cassava peels ensiled with brewer's dried grains and poultry litter

Days	Diet 1	Diet 2	Diet 3	SEM
0	51.34b	50.17a	52.99c	0.41
7	51.17c	47.24a	50.53b	0.61
14	51.31c	45.11a	47.06b	0.92
21	50.18c	44.89a	48.11b	0.77
28	49.94c	45.78a	47.76b	0.60
35	50.38c	48.83b	47.42a	0.44

a,b,c means with different superscripts on the same row differ significantly ($p<0.05$)
Diet 1= 80% Cassava peels (CSP) + 20% Brewers' dried grain (BDG). Diet 2 = 80% CSP + 20% Poultry litter (PL). Diet 3 = 80% CSP + 10% BDG + 10% PL.

Table 4: Fermentation pathways of cassava peels ensiled with brewer's dried grains and poultry litter at day 28

Parameters	Diet 1	Diet 2	Diet 3
Type of Fermentation	Homolactic (glucose)	Heterolactic (fructose)	Heterolactic (fructose)
End products	Lactic acid	Lactic acid, acetate, mannitol, and CO_2	Lactic acid, acetate, mannitol, and CO_2
Theoretical DM recovery (%)	97.27	91.25	90.13

Diet 1= 80% Cassava peels (CSP) + 20% Brewers' dried grain (BDG). Diet 2 = 80% CSP + 20% Poultry litter (PL). Diet 3 = 80% CSP + 10% BDG + 10% PL

The silages physical characteristics are as shown in Table 5. The colour of the three silages were light brown, dark brown and light brown for diets 1, 2 and 3 respectively throughout the ensiling duration. Good silage usually preserves well the original colour of the pasture or forage from which it is obtained (t'Mannetje, 1999). The colour observed for the silages were the same as the colour of the original ingredients contributing to the mixture (80% cassava peels), which equally remain unchanged throughout the ensilage period. The pleasant and slightly pleasant smell obtained in this study for diets 1 and 3 with BDG supplementation showed that lactic acid was produced more than other acids. The pleasant and acceptable smell however appeared to improve with ensiling days. Pleasant smell is accepted for good or well-made silage (Kung and Shaver, 2001; Olorunnisomo and Fayomi, 2012; Matthew, 2015). Diet 2 (80% cassava peels + 20% poultry litter) had a pungent smell at day 0. The smell is an essential nature of poultry litter. It has a slightly pungent odour which is suspected to be ammonia. The breakdown of nitrogenous materials especially uric acid (non-protein nitrogen) present in the poultry litter into microbial protein and ammonia is probably responsible for the pungent odour (Olorunnisomo and Ososanya, 2015). At day 35, diet 2 had a slightly sweet aroma. All the silages were firm in texture although diet 2 was very firm to the feel, corroborating the work of Kung and Shaver (2001) and Olorunnisomo and Ososanya (2015).

CONCLUSIONS

All the silages recorded better fermentation characteristics due to the readily fermentable carbohydrate in cassava peels, which favored lactic acid fermentation. Silage 1 with 20 % BDG gave better silage characteristics and could be fed out after only 7 days of ensiling. However, silage 2 with up to 20% poultry litter should be ensiled for at least 28 days and should be fed out as soon as possible.

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Table 5: Physical characteristics of cassava peel ensiled with brewers' dried grains and poultry litter

Diet	Days	Colour	Odour	Texture	Other Observations
Diet 1	0	Light brown	Pleasant	Friable	No mould
	7	"	"	Slightly firm	"
	14	"	"	Firm	"
	21	"	"	"	"
	28	"	Slightly pleasant	"	"
	35	"	"	"	"
Diet 2	0	Dark brown	Pungent	Firm	No mould
	7	"	"	"	"
	14	"	"	"	"
	21	"	"	"	"
	28	"	Slightly sweet aroma	"	"
	35	"	"	Very firm	Seepage
Diet 3	0	Light brown	Slightly pleasant	Slightly firm	No mould
	7	"	"	Firm	"
	14	"	"	"	"
	21	"	"	"	"
	28	"	"	"	"
	35	"	"	"	"

Diet 1= 80% Cassava peels (CSP) + 20% Brewers' dried grain (BDG). Diet 2 = 80% CSP + 20% Poultry litter (PL). Diet 3 = 80% CSP + 10% BDG + 10% PL

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