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In vitro evaluation of nutritional quality of ensiled rice offal enhanced with non-protein nitrogen sources and soybean meal residue

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Abstract

An experiment was conducted to assess the appearance, smell, texture, pH, temperature, chemical composition and energy content of ensiled Rice offal (RO) treated with non-protein nitrogen sources and soybean meal residue in a completely randomized design. Rice offal was treated with different proportions of Urea, Poultry litter (PL) and Soybean meal residue (SBMR) and ensiled. The treatment combinations were; A (100%RO), B (100%RO + Urea), C (75%RO + 25%PL), D (50%RO + 50%PL), E (75%RO + 25%SBMR) and F (50%RO + 50%SBMR). The treatments were ensiled for 21 days in triplicates. The results showed that silages were adequately fermented with sweet aroma. The silages were acidic (4.70 – 5.80) except for treatments C and D which had pH of 7.20 and 7.00, respectively. The temperatures of the silages were significantly (P<0.05) different. The proximate composition of silages differed significantly (P<0.05), being highest for %CP, %EE and ash in treatment B. Dry matter contents were also significantly different (P<0.05) with treatment A having the highest (90.25%). Rice offal and Urea mixtures resulted in silages with highest NDF, HEM and Energy. Lowest NDF was obtained in treatment without additive (Treatment A) compared to all other treatments. Least ADF was obtained in Treatment E (75% RO + 25% SBMR). Enhancement of rice offal with urea, poultry litter and soybean meal residue has shown improvement in the silage physiochemical quality.

Keywords: *In vitro*; Additives; Ensilage; Rice offal; Poultry litter; Fermentation;

Introduction

Rice processing generates abundant bulk of by-products that constitute enormous quantity of agro-industrial waste in many parts of the world (NAERLS and PCU, 2004). Rice processing by-products are obtained from rice milling industries which are abundant in the rice producing regions of Nigeria (Omotola and Ikechukwu, 2006). Rice offal is one of the commonest agro-industrial wastes generated in large quantities in most parts of Nigeria which making up to about 20% of the whole rice (Foulkes, 1998). The quantity of rice milling by-products generated in Nigeria annually was estimated to about 1,032,993.6 metric tons (NAERLS and PCU, 2004). A huge amount of these by-products is dumped as waste thereby posing disposal problems that bring methane emissions (Bhattacharya *et al*., 1999; Thipwimon *et al*., 2004). The disposal problems also led to indiscriminate burning of the waste and subsequent accumulation of ash in rice producing areas resulting in environmental pollution and loss of land. It is also reported that rice offal can cause respiratory problems due to its characteristics (Beagle, 1978; Thipwimon *et al*., 2004). Rice offal is believed to contain various nutrients that would enable it to serve as animal feed. However, the major challenges include its high level of fibre and low protein and energy. Studies have shown that processing/treatment techniques such as mechanical treatment, ensilage, biological treatment and chemical treatment with alkalis and urea can be significantly improved nutritional value of rice offal (MacDonald *et al*., 1987; Belewu and Babalola, 2009). Soybean meal residue (SBMR) is a good material which has re-use value and biotransformation possibilities, and it has been described as a potential source of functional food (Mateos-Aparicio *et al.,* 2010). The soybean meal residue in numerous silage experiments has been proven to be an effective silage additive in terms of promoting lactic fermentation, reducing silage pH, discouraging a clostridial fermentation and proteolysis, and generally decreasing organic matter losses (Yitbarek and Tamir, 2014). It is of particular benefit when applied to forage crops low in fermentable. Finding convenient ways to incorporate SBMR into feed could eliminate a possible source of pollution and add economic value to this currently valueless product. The use of SBMR, as a feed additive, is one of the developing trends, which has an important economic function and social meaning. This research was therefore, designed to study the nutritional quality of ensiled rice offal enhanced with non-protein nitrogen sources (Urea; Poultry litter) and soybean meal residue.

Materials and methods

Description of the study area

This research was conducted in the Animal Science Laboratory of Kano University of Science and Technology, Wudil. The laboratory was situated in the main campus behind Central Research Laboratory of the University. It has a coordinate of 11º48'N 8º51'E / 11.80ºN 8.85ºE. The Local Government Area (Wudil) has an area of 362km² and a population of 185189 as of NPC (2006) census. The mean annual rainfall is 600mm per annum with relative humidity of 75 % during the rainy season with a mean annual temperature of 26º C (KNARDA, 2008).

Collection and preparation of experimental materials

The samples were obtained from three brothers rice processing industry waste dump which is 5km away from Hadejia town along Nguru-road of Hadejia, Jigawa State, Nigeria. Random sampling technique was employed to collect samples of the waste taken at depths of 15cm from different points using a clean plastic container and shovel. All foreign materials (stones, glass, iron, polythene, etc.) were removed. The samples were pooled together, mixed thoroughly and packed into an empty polythene bags which was later conveyed to Animal Science Laboratory. Soybean meal residue (SBMR) was obtained from various soybean cake (Awara) processing centers in and around Hadejia local government area of Jigawa State. Inorganic granulated urea was obtained from market (Certified dealer) while poultry litter (PL) was obtained from a deep litter poultry production system of Binyaminu Usman Polytechnic Hadejia. The collected RB, SBMR and PL were sundried for three days during dry season by thinly spreading on a concrete floor.

Ensiling procedures

The dried rice offal was ensiled with urea, PL and SBMR in proportions as presented in Table 1. Eighteen bottles of (946mL) were used as laboratory silos (Ogunlolu *et al.,* 2010). The procedure of Roy and Rangnekar (2006) was followed in which 1kg urea was dissolved in 15 litres of water and sprinkled on 25kg of rice offal, for samples without urea 15 litres of water was used for every 25kg rice offal. Greese and Masking tape were used to further seal the bottles (see Plate 1) after filling with weighed materials and compressed. The silos were kept at an average room temperature of 26^{o}C for 21 days' incubation period in the laboratory. At the expiration of the ensiling period (21 days), the silos were opened and the top most 5cm materials were scooped off to avoid contamination with partially ensiled materials. The samples were then taken using forceps from each ensiled bottle for physical observations. The contents were scored for aroma and colour by three independent scorers on a subjective score of 1-4 (Table 2). A portion of the rice offal were left untreated and used for the control experiment as in the research of Ashiru *et al*. (2010).

Table 1: Proportion (%) of Rice Offal (RB) for ensiling with urea, Poultry Litter (PL) and Soybean Meal Residue (SBMR)

	Proportions (%)				
Treatments	RB	Urea	PL	SBMR -	Total
A	100	-	-	-	100
B	100	+ Urea*	-	-	100
C	75	-	25	-	100
D	50	-	50	-	100
E	75	-	-	25	100
F	50	-	-	50	100

*Urea treatment (66.67g of urea is dissolved in 1L of water and sprinkled on 1.67 kg Rice Offal)

Table 2. Description of colour and aroma rating used as indices of silage quality

Rating	Colour	Aroma
1	Dark or deep brown	Putrid or rancid
2	Light brown	Pleasant
3	Pale yellow	Sweet
4	Yellowish green	Very sweet

Source: Muhammad *et al.* (2009).

Analytical techniques

The temperature of the ensiled materials was determined through insertion of thermometer into the silage for 2 - 3 minutes and the readings were recorded while a digital pH meter was used to measure the pH of the ensiled materials following a standard procedure (AOAC, 2005). Furthermore, sub-samples were taken from the prepared silages and oven dried at 60^{o}C for 48h for proximate analysis.

Proximate analysis

Samples from each replicate of the treatments were grounded to pass 1mm screen using Tecator Cyclotec 1093 sample mill. Proximate analysis was done to determine nitrogen (N) for crude protein determination (N×6.25), crude fibre (CF), ether extract (EE), nitrogen free extract (NFE) and ash according to AOAC (1999); for organic matter was calculated as the difference between DM and ash. Hemicellulose was calculated as a difference between NDF and ADF; Energy was calculated using Vansoest and Robertson (1985).

Experimental design

A Completely Randomized Design (CRD) was used as outlined by Steel and Torrie (1980). There were six treatments designated as: A to F (Table 1) with three replications each.

Data analysis

The data generated were subjected to

analysis of variance (ANOVA) in completely randomized design (CRD) of GenStat (2011), where significant differences between the means were detected and separated using Least Significant Difference (LSD). Differences between the means were considered at 5% probability level.

Results

Temperature, pH value, colour, aroma and texture of ensiled rice offal enhanced with non-protein nitrogen sources and soybean meal residue.

The temperature, pH, colour and aroma of ensiled rice offal enhanced with non-protein nitrogen sources and soybean meal residue are presented in Table 3. There were significant differences ($P < 0.05$) in the temperature and pH values of the resultant silage produced from the different combinations of rice offal with urea, PL and SBMR. Significant differences ($P<0.05$) were recorded for temperatures in all the treatment means. The highest temperature value (33.4°C) was obtained in treatment D (50% RO + 50% PL); while the lowest temperature value (28.4°C) was recorded in treatment A (100% RO). The pH values obtained in this study vary from 4.70 in treatment F (50% RO + 50% SBMR) to 7.20 in treatment C (75% RO + 25% PL). Treatments A, E and F have colour scores of 2 (Light brown colour) with aroma scores of 3 (Sweet aroma); while treatments B, C and D have scores of 1 (Dark or deep brown colour with putrid or rancid aroma) (Table 3 and Plate 1). All the ensiled materials were firm in texture.

The resultant silages indicated a relationship between pH and aroma, the silage with the lowest pH (4.70) has a sweet aroma while as the pH alkalinity increases the aroma becomes putrid.

Table 3: Temperature, pH and physical properties of the ensiledrice offal enhanced with non-protein itrogen sources and soybean meal residue

Treatments	Temperature	Ph	Colour	Aroma	Texture
A	28.43^{a}	5.38^{c}	2	3	Firm
B	30.17^{b}	5.80^{d}	1	1	Firm
C	32.57^{d}	7.20^{f}	1	1	Firm
D	33.40^{f}	7.00^{e}	1	1	Firm
E	32.87^{e}	4.80^{b}	2	3	Firm
F	31.90^{c}	4.70^{a}	2	3	Firm
LSD	**0.20**	**0.09**			

$^{a-f}$ Means with different superscripts along column s differ significantly at ($P < 0.05$) Colour: 1= Dark brown, 2 = Light brown, 3= Pale yellow, 4 = Yellowish green. Aroma: 1 = Putrid, 2 = Pleasant, 3 = Sweet, 4 = Very sweet.

Plate 1: Rice offal enhanced with non-protein nitrogen sources and soybean meal residue at 21 days ensiled in 946mL glass bottles

Proximate composition of ensiled rice offal enhanced with non-protein nitrogen sources and soybean meal residue

Proximate composition of the resultant silage is presented in Table 4. Significant differences (P<0.05) were recorded for all the proximate components. Dry matter values obtained vary from 87.96% in treatment F (50% RO + 50% SBMR) to 90.25% in treatment A (100% RO). The values of CP ranged from 11.20 in treatment E to 13.72 in treatment B, which had meet the protein requirement for small ruminant production. While %CP, %EE, %ASH %NFE and %OM varied at different levels of additives inclusion.

Table 4: Proximate composition of the ensiled rice offal enhanced with non-protein nitrogen sources and soybean meal residue

	Proximate (%)						
Treatments	MC	DM	CP	CF	EE	ASH	NFE
A	9.75 ᵃ	90.25 ᶠ	12.66 ᵈ	10.00 ᶠ	8.29 ᶠ	9.46 ᵉ	9.84 ᵇ
B	10.14 ᵇ	89.86 ᵉ	13.72 ᶠ	9.84 ᵉ	8.05 ᵉ	10.10 ᶠ	48.15 ᵃ
C	11.33 ᵈ	88.67 ᶜ	11.86 ᵇ	8.80 ᵈ	7.94 ᵈ	8.56 ᵈ	51.51 ᶜ
D	11.64 ᵉ	88.36 ᵇ	12.92 ᵉ	7.13 ᵃ	6.78 ᵇ	7.72 ᶜ	53.81 ᵈ
E	10.87 ᶜ	89.13 ᵈ	11.20 ᵃ	8.19 ᶜ	7.44 ᶜ	6.29 ᵃ	56.01 ᶠ
F	12.04 ᶠ	87.96 ᵃ	12.08 ᶜ	7.22 ᵇ	5.94 ᵃ	6.99 ᵇ	55.73 ᵉ
LSD	**0.08**	**0.08**	**0.03**	**0.06**	**0.06**	**0.08**	**0.12**

[a - f] Means with different superscripts along columns dif fer significantly at (P < 0.05) ; MC = Moisture Content, DM = Dry Matter, CP = Crude Protein, CF = Crude Fibre, EE = Ether Extract, ASH = Ash and NFE= Nitrogen free extract.

Fibre composition and energy content of ensiled rice offal enhanced with non-protein nitrogen sources and soybean meal residue

Fibre fractions of ensiled rice offal enhanced with non-protein nitrogen sources and soybean meal residue are presented in Table 5. The values obtained were significantly different (p<0.05) in the silage mixture. The highest value for NDF was found in treatment B and lowest in treatment A (52.10%; 36.33%), respectively. The values for energy contents ranged 1998.72 and 2268.34 Kcal/kg. All parameters evaluated were within the recommended levels for small ruminant production.

Table 5: Fibre composition and energy content of the ensiled rice offal enhanced with non-protein nitrogen sources and soybean meal residue

	Fibre fractions			
Treatment	NDF	ADF	HEM	Energy(Kcal/kg)
A	36.33 ᵃ	24.31 ᵈ	12.02 ᵃ	1998.72 ᵃ
B	52.10 ᶠ	23.34 ᶜ	28.76 ᶠ	2268.34 ᶠ
C	47.13 ᵈ	24.53 ᵉ	22.60 ᵈ	2048.23 ᵇ
D	51.88 ᵉ	25.04 ᶠ	26.84 ᵉ	2101.18 ᶜ
E	41.48 ᵇ	21.31 ᵃ	20.17 ᵇ	2148.11 ᵈ
F	43.92 ᶜ	22.49 ᵇ	21.43 ᶜ	2204.33 ᵉ
LSD	**0.14**	**0.06**	**0.06**	**14.03**

[a - f] Means with different superscripts along columns differ significantly at (P < 0.05) NDF= Nitrogen Detergent Fibre, ADF= Acid Detergent Fibre and HEM= Hemicellulose.

Discussions

pH value, temperature, colour and aroma of ensiled rice offal enhanced with non-protein nitrogen sources and soybean meal residue

pH is one of the quickest and simplest ways of evaluating silage quality. Kung and Shaver (2002) reported that silage with pH values range between 4.3 - 4.7 has a good quality and aroma. Most of the pH values in the present results showed a linear increase with inclusion of additives (urea, PL, SBMR). Treatments with SBMR have pH values within the recommended rate. This is in line with the report of Leterme *et al.* (1992) who recorded an increase in silage pH when pressed sugar-beet pulp was ensiled with molasses and urea, laying hen excreta or soybean meal. He related such increase to buffering capacity as a result of ash and ammonia from the uric acid hydrolysis. However, our treatments with Poultry Litter have higher pH values of 7.20 in Treatment C (75% RO + 25% PL) and 7.00 in Treatment D (50% RO + 50% PL) even though Akinwande *et al.* (2011) also obtained a pH value of 9.26 when Water Hyacinth was ensiled without additive. These pH values in our results were acidic to moderately acidic (with exception of Treatment C and D), thus indicated proper fermentation and good keeping quality. By using a similar procedure Akinwande *et al.* (2011) obtained a low pH range of 4.30 - 4.66 while Babayemi et al. (2010) obtained a pH range of 3.38 - 4.61 when cassava peel was ensiled together with *Albiza saman* pods. Baba et al. (2010) recorded a range of 5.51 – 7.21 pH values when *Pennisetum pedicellatum* (Kyasuwa) hay was ensiled with varying proportions of poultry litter. **With the** exception of pH values of treatments B, C and D (5.80, 7.20 and 7.00 respectively); most of the results obtained from this study fall within the range of 4.5 - 5.5 which are classified to be pH for good silage (Menenses *et al.,* 2007). The pH levels higher than the normal stipulated range might be an indication of lack of organic acids generation during fermentation.

Temperature is another essential factor that affects silage quality and colour. McDonald *et al.* (1998) stated that temperature above 30°C make silages to become dark, due to caramelization of sugars in the forage. A good silage must be cooled at opening or be at room temperature. The temperature ranges of 28.4 – 33.4°C obtained were slightly higher than the temperature ranges of 25.0 - 27.5°C (Akinwande *et al*., 2011) and 28.3 - 29.1°C (Babayemi et al., 2009). This would appear to be a good operating temperature for silage fermenting organisms. Temperature range of 29.40 – 45.00°C was reported as satisfactory silo temperature (Amodu and Abubakar, 2004). Silage quality can be evaluated physically through smell, colour, texture and by chemical analysis (Wattiaux, 2000). The colours obtained in this study were close to the original colour of the materials used for the silages. This observation coincides with the findings of Oduguwa et al. (2007) and Babayemi et al. (2010) whom used similar procedure though with different feed materials. Silages with SBMR were lighter in colour than those silages with Urea and Poultry Litter which were dark or deep brown. Good silage must present a pleasing taste; the colour should be greenish yellow and must be without moulds (AmoduandAbubakar,2004). The aroma was generally sweet for silages with SBMR except in treatment B that had urea which produced putrid or rancid odour. Also, silages with poultry litter (treatments C and D) generally produced putrid or rancid odour which is an indication of poor fermentation.

Oduguwa *et al.* (2007) stated that the most important physical characteristics in terms of acceptability of silages to animals is aroma, but other physical properties helped to determined well preserved silage. The results for aroma obtained in this study compared with the result of several authors (Menenses *et al*., 2007; Oduguwa *et al*., 2007; Muhammad *et al*., 2009; Baba *et al.,* 2010 and Inyang *et al*., 2012), all reported that the end product of good silage had a pleasant or fruity smell. Olorunnisomo and Dada (2011) however, observed a pleasant smell in all their treatments when Elephant grass was ensiled with cassava peels. Amodu and Abubakar (2004) stated that good silage usually has an acceptable aroma (clean and not putrid odour). All the silages were firm in texture and not slimy which is also an indication of good silage; slimy texture indicate spoilage or mould growth (Kung and Shaver, 2002).

Proximate composition of ensiled rice offal enhanced with non-protein nitrogen sources and soybean meal residue

The highest percentage of dry matter (DM) was obtained from treatment A (100% RO). The DM obtained in all other treatments were also considerably high. Treatment with urea (Treatment B) recorded highest CP content while enhancement of the ensiling quality of rice offal with poultry litter and soybean meal residue resulted in silages with moderate CP content. Addition of urea resulted in lower %NFE; while decline in %EE contents was observed when rice offal was enhanced with Non-protein nitrogen sources and soybean meal residue. The result of this study regarding the fibre content were within the ranges as reported by Snyman *et al.* (1990) and Mcitek (2008). While urea mixture with rice offal resulted in silages with highest %CP and % ash compared to all silages mixed.

Fibre composition and energy content of ensiled rice offal enhanced with non-protein nitrogen sources and soybean meal residue

Rice offal and Urea mixtures resulted in silages with highest %NDF, %HEM and Energy. Lowest %NDF was obtained in treatment without additive (Treatment A) compared to all other treatments. Least %ADF was obtained in Treatment E (75% RO + 25% SBMR). Alikhali *et al.* (2005) reported that Soybean Meal Residue has a significant effect on reducing %NDF and %ADF. Guo (2010) also reported that the use of steam treatment in a high pressure vessel at different pressures; for a range of different treatment times increased the degradation *in vitro* in rumen fluid after 24 h and the rate of degradation, but could not enhance the potential degradability of the fibrous fractions (NDF, ADF and hemicellulose). Physical treatments of crop residues have received an appreciable amount of researches. Many of these treatments are not practical for use on small-scale farms, as they require machines or industrial processing. This makes these treatments in many cases economically unprofitable for farmers as the benefits may be too low or even negative (Sarnklong *et al; 2010*).

Conclusion

The study showed that enhancement of rice offal with urea, poultry litter and soybean meal residue improved the silage quality. The addition of soybean meal residue to rice offal as silage additive gave better quality silage with sweet aroma, light brown colour, high dry matter, organic matter, crude fibre and nitrogen free extract, with moderate percentages of crude protein, ether extract, nitrogen detergent fibre and ash.

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