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PROXIMATE COMPOSITION, FIBRE FRACTION AND MINERAL COMPOSITION OF ENSILED RICE MILLING WASTE ENHANCED WITH UREA AND POULTRY LITTER

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ABSTRACT

The experiment was conducted to examine the physical properties, pH, temperature, proximate composition, fibre fraction, energy content and mineral composition of ensiled rice milling waste (RMW) treated with urea and poultry litter in a completely randomized design. RMW was treated with of Urea and Poultry Litter (PL) and ensiled in *in-vitro* laboratory silos (946ml). The treatment combinations were; A (100%RMW), B (100%RMW+ Urea), C (80%RMW + 20%PL), and D (60%RMW + 40%PL). The treatments were ensiled for 21 days in triplicates. At the expiration of each ensiling period, samples were taken for analyses. The results for physical properties showed that most of the silages were adequately fermented with sweet aroma. The compounded silages were acidic 4.34 – 4.86 except treatments B and D which had pH of 7.96 and 7.91 respectively. The temperatures of the silages were significantly (P<0.05) different. Based on the physical properties, pH and temperature evaluated, most of the silages can be considered to be well prepared. The proximate composition of silages differ significantly (P<0.05), higher percentages in CF and Ash were recorded in Treatment A. Dry matter content was also significantly different (P<0.05) with treatment A having the highest DM (97.19%). The CP in treatment D (6.13%) proved superior. RMW and Urea mixtures resulted in silages with highest %NDF, %HEM and Energy. Lowest NDF, ADF, CEL and ADL values were obtained in treatment D. The nutritive quality of treatment D was proved to be higher and thus it is recommended for dry season ruminant feeding.

Keywords; Additives, ensilage, in-vitro, poultry litter, rice milling waste.

INTRODUCTION

Rice milling waste is one of the commonest agro-industrial wastes generated in large quantity in most parts of Nigeria. Rice processing generates a great volume of by-products that constitute a large proportion of agro-industrial waste in many parts of the world (NAERLS and PCU, 2004). Rice processing by-products are obtained from rice milling industries, and these are abundant in the rice producing regions of Nigeria (Omotola and Ikechukwu, 2006). Rice milling waste is one of the by-products of rice processing making about 60% of the total by-products (Foulkes, 1998; Abdullahi *et al*., 2019). Ensiling is the anaerobic fermentation process used to preserve immature green corn, legumes, grasses, grains and plant by-products with about 70-80% moisture and put in air-tight environment or the preservation of forages (or crop residue or by-products) of high moisture content based on lactic acid fermentation under anaerobic condition (Moran, 2005). The ensiling of plant by-product is the most suitable method of conservation for long periods (Lien *et al*., 1994). Ensiling improves palatability, reduces significantly toxic substances present in fresh leaves or plant by-products to safe level concentrations such as cyanogenic glycosides in fresh cassava leaves. Ensiling also increases digestibility of crude protein by breaking linkages between protein and fibre. It destroys harmful microorganisms possibly present in poultry litters or fish waste to be used as feed (Lee and Kayouli, 1998). It increases dry matter, lactic acid contents and NH_3-N (Hang and Preston, 2007). To take correct step in ensiling any plant by-product like rice milling waste, it is important to know the ensilability characteristics which have resulted from its chemical and microbial composition.

Although one can hardly classify rice milling waste among hazardous wastes, its treatment is very important in view of the great volume of waste materials involved. Waste treatment techniques are normally employed to alter the physical, chemical, or biological characteristics of waste and make it safer for disposal. These include composting, pyrolysis, gasification and combustion. In Nigeria and many other developing countries, where the bulk of rice produced is for consumption, the most common waste treatment technique employed is combustion which has several disadvantages including environmental pollution (Bhattacharya *et al*., 1999; Thipwimon *et al*., 2004). Moreover, some countries under the environmental protection legislation now strongly oppose and even prohibit this practice.

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 large amount of these by-products is dumped as waste thereby posing disposal problems and bringing about methane emissions (Bhattacharya *et al*., 1999; Thipwimon *et al*., 2004). The disposal problems posed by rice milling waste have led to indiscriminate burning of the waste and subsequent accumulation of ash in rice producing areas resulting in environmental pollution and loss of land. Rice milling waste can also cause respiratory problems due to its characteristics (Beagle, 1978; Thipwimon *et al*., 2004). Rice milling waste is believed to contain various nutrients that would enable it to serve as animal feed. The major challenges are however, its high level of fibre and, low protein and energy. Studies have shown that the nutritional value of rice milling waste can be significantly improved by processing/treatment techniques such as mechanical treatment, ensilage, biological treatment and chemical treatment with alkalis and urea (McDonald *et al*., 1988; Belewu and Babalola, 2009).

The problems associated with rice milling waste can be greatly reduced if it can be effectively utilized as animal feed. Effective utilization of rice milling waste as animal feed has not been possible and reports have shown that the major constraints to this utilization includes low crude protein, energy and mineral content (McDonald *et al*., 1988; Maikano, 2007; Yakubu *et al*., 2007; Belewu and Babalola, 2009). However, some research findings indicated that rice milling waste contains moderate level of crude protein, and also have low crude fibre and high metabolizable energy (Crampton and Harris, 1969; Singh *et al*., 1996; Ambasankar and Chandrasekan, 2002). Crude fibre consists of cellulose, hemicelluloses and lignin (Yakubu *et al*., 2007) which are not well utilized by monogastric animals. Lignin, which envelopes some nutrients, is highly resistant to chemical and enzymatic degradation and is poorly degraded by rumen microbes (McDonald *et al*., 1988; Belewu and Babalola, 2009). Strong chemical bonds exist between lignin and many plant polysaccharides, and cell wall proteins, which render these compounds unavailable during digestion. These bonds are however, broken by chemical treatment thereby increasing the digestibility of fibrous feeds (MacDonald *et al*., 1987; Belewu and Babalola, 2009). Among the chemicals that have been utilized, sodium hydroxide has proven to be the most effective in improving digestibility but lacks nitrogen (Omotola and Ikechukwu, 2006). Furthermore, there is increased sodium load in animals fed with diets treated with sodium hydroxide (Adeniji, 2010). Another effective chemical that has been used successfully in achieving this is ammonia, which weakens the hard cell walls, allowing better penetration by rumen microorganisms to produce more effective fermentation and liberation of nutrients (Chenost, 1995). In developing countries like Nigeria, one of the more successful procedures available to improve the digestibility and therefore nutritional value of fibrous feeds is urea treatment since this requires little equipment or expenses, even subsistence farmers can apply urea treatment (Roy and Rangnekar, 2006). Chemical treatment of rice milling waste with urea can lead to significant improvement in nutritional quality and therefore greater utilization (Taiwo *et al*., 1992). The effective utilization of rice milling waste as animal feed will greatly reduce its disposal problems and contributes towards value addition in the rice sector. This research is therefore designed to study the nutritional quality of ensiled rice milling waste enhanced with urea and poultry litter.

MATERIALS AND METHODS

Description of the Study Area

This research was conducted in the Animal Nutrition Laboratory of Binyaminu Usman Polytechnic, Hadejia. The laboratory is situated in the Old (Yamidi) Campus of the Polytechnic, It has a coordinates of 12º28'N /10º01'E. Hadejia Local Government Area has a population of 105,628 (NPC, 2006) and is situated in the Hadejia-Nguru wetland which lies on the southern edge of the Sahel savanna in northern Nigeria. The Hadejia-Nguru wetland is a flood-plain complex, comprised of a mixture of seasonally flooded lands and dry uplands. Prior to the droughts of the 1970s, the wetlands covered an area of about 4,125 km², but are now reduced to 3,500 km². Large parts of the fadama are under rice cultivation during the rainy season and, during the dry season, are usually utilized for growing other crops as water-levels drop. Uncultivated areas are grazed by livestock. Annual rainfall ranges between 200–600 mm, confined to the period late May–September. The average relative humidity is 75 % during the rainy season with a mean annual temperature of 28^0 C (BirdLife International, 2021).

Collection and Preparation of the Experimental Materials

The samples were obtained from Three Brothers Rice Processing Industry waste dump which is 5km away from Hadejia town along Hadejia-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 empty polythene bags which were later conveyed to Animal Nutrition Laboratory, Binyaminu Usman Polytechnic Hadejia. 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 rice milling waste and poultry litter were sundried for 3 days during dry season by thinly spreading on a concrete floor.

Ensiling Procedures

The dried rice milling waste was ensiled with urea and poultry litter in proportions as presented in Table 1. Twelve (12) 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 milling waste, for samples without urea 15 litres of water was used for every 25kg rice milling waste. Grease and masking tape were used to further seal the bottles after filling with weighed materials and compressed. The silos were kept at an average room temperature of 27º C for 21 days incubation period. At the expiration of the ensiling period, 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 milling waste was left untreated and used for the control experiment as in the research of Ashiru *et al*. (2010).

Table 1. Proportion (%) of Rice milling waste (RMW) for ensiling with Urea and Poultry Litter (PL).

Treatment	RMW (%)	Urea	PL (%)	Total (%)
A	100	-	-	100
B	100	+ Urea*	-	100
C	80	-	20	100
D	60	-	40	100

*Urea treatment (1 kg of urea to 25 kg RMW)

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 were 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) and texture was detected by checking the firmness of the materials using hand.. Furthermore, sub-samples were taken from the prepared silages and oven dried at 60ºC for 48hours for proximate, fibre fraction and mineral analyses.

Proximate analysis

Samples from each replicate of the treatment 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 (2005), organic matter was calculated as the difference between DM and ash. Fibre fraction was determined after which hemicellulose was calculated as a difference between NDF and ADF (Van soest *et al.,* 1991). Energy was calculated using the method of Onyeike *et al.,* (2000). Energy contents were estimated using adiabatic bomb-calorimetry in which gross energy was determined by measuring heat of combustion.

Mineral analysis

Sodium (Na) was determined by PEP7 flame photometer, phosphorus (P) by 6505 Ultraviolet visual spectrophotometer and calcium was determined by titration.

Experimental design

A Completely Randomized Design (CRD) was used as outlined by Steel and Torrie (1980). There were four (4) treatments designated as; A, B, C and D (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 (2018), where significant differences between the means were detected and separated using Duncan Multiple Range Test (DMRT), differences between the means were considered at 5% probability level.

RESULTS AND DISCUSSIONS

Results

Temperature, pH value, colour, aroma and texture of ensiled rice milling waste enhanced with urea and poultry litter.

Table 3 shows the temperature, pH, colour, aroma and texture of ensiled Rice milling waste enhanced with urea and poultry litter. There were significant differences ($P < 0.05$) in the temperature; highest temperature was recorded in treatment D while the least was recorded in treatment C which had no significant difference with treatment A. There were also significant differences (P < 0.05) in pH values of the resultant silage among the treatments. The pH values obtained vary from 4.34 in Treatment A to 7.96 in Treatment B which has no significant difference with treatment D. From the results, treatments A and C have pH values within the recommended range. The resultant silage indicated a relationship between pH and aroma, the treatment with the lowest pH was treatment A (4.34), then followed by treatment C (4.86) and all had sweet aroma while as the pH alkalinity increases the aroma becomes putrid as in treatment B (7.96).

Table 3: Temperature, pH and physical properties of the ensiled rice milling waste enhanced with urea and poultry litter.

Treatment	Temperature(^{0}C)	pH	Colour	Aroma	Texture
A	29.00^c	4.34^c	3	3	Firm
B	30.00^b	7.96^a	4	1	Firm
C	28.90^c	4.86^b	4	3	Firm
D	31.00^a	7.91^a	3	2	Firm
LSD	**0.57**	**0.08**			

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

Proximate composition of rice milling waste enhanced with urea and poultry litter.

Table 4 shows proximate composition of the resultant silage. Dry matter values were significantly different (P<0.05). The values obtained varied from 96.30% (Treatment B) to 97.19% (in Treatment A). There were no significant differences (P>0.05) in CP values which ranged from 5.80 (Treatment A) to 6.13 (Treatment D). The CF composition was statistically the same except for treatment B. There were also no significant differences (P>0.05) in percentages of EE and NFE, and higher (P<0.05) ash levels were recorded in control treatment (A) followed by treatment D.

Table 4: Proximate composition of ensiled rice milling waste enhanced with urea and poultry litter

Treatment	%MC	%DM	%CP	%CF	%EE	%ASH	%NFE
A	2.81^c	97.19^a	5.80	24.04^a	2.10	15.03^a	50.22
B	3.70^a	96.30^c	6.04	23.25^b	2.20	14.54^b	50.27
C	3.29^b	96.71^b	6.01	23.99^a	1.96	14.16^c	50.59
D	3.32^b	96.68^b	6.13	23.67^a	2.12	14.75^{ab}	50.01
LSD	**0.33**	**0.33**	**0.38**	**0.38**	**0.38**	**0.38**	**1.27**

$^{a, b, c \text{ and } d}$ Means with different superscripts along columns differ 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 of rice milling waste enhanced with urea and poultry litter.

Table 5 shows fibre composition and energy of ensiled rice milling waste with different additives. The values obtained were statistically significant (P<0.05) in the silage mixture. Highest values of NDF, ADF, ADL, CEL and energy were obtained from treatment B, while lowest values of NDF, ADF and CEL were obtained from treatment D. All parameters evaluated were within the recommended levels for small ruminant production.

Table 5: Fibre composition and energy content of ensiled rice milling waste enhanced with urea and poultry litter

Treatment	NDF (%)	ADF (%)	ADL (%)	CEL (%)	HEM (%)	ENERGY (Kcal/Kg)
A	47.40^b	40.93^b	0.25	40.68^c	6.47^b	1031.02^c
B	48.17^a	42.55^a	0.21	42.34^a	5.62^c	1048.10^a
C	48.10^a	41.30^b	0.23	41.07^b	6.80^{ab}	1027.04^d
D	45.30^c	38.40^c	0.21	38.19^d	6.90^a	1044.73^b
LSD	**0.38**	**0.38**	**0.38**	**0.38**	**0.38**	**0.38**

$^{a, b, c, d}$ Means with different superscripts along columns differ significantly at (P < 0.05), NDF = Nitrogen Detergent Fibre, ADF = Acid Detergent Fibre, ADL = Acid Detergent Lignin, CEL =

Cellulose and HEM= Hemicellulose.

Mineral contents of rice milling waste enhanced with urea and poultry litter.

There was no significant difference (P > 0.05) in the Calcium content except for treatment C (0.0290) which was significantly higher (P<0.05) than others.. Significant differences (P<0.05) were recorded for both phosphorus and sodium contents of the compounded silages. Treatment D had higher (P<0.05) value in Phosphorus content while treatment A has higher value in Calcium content.

Table 6: Mineral composition of ensiled rice milling waste enhanced with urea and poultry litter

Treatment	Calcium (%)	Phosphorus (%)	Sodium (%)
A	0.210^{b}	0.190^{b}	0.089^{a}
B	0.140^{b}	0.210^{b}	0.065^{c}
C	0.290^{a}	0.10^{c}	0.068^{bc}
D	0.180^{b}	0.260^{a}	0.070^{b}
LSD	**0.070**	**0.028**	**0.004**

$^{a, b, c \text{ and } d}$ Means with different superscripts along rows differ significantly at (P > 0.05)

Discussions

Temperature, pH value, colour, aroma and texture of ensiled rice milling waste enhanced with urea and poultry litter.

Temperature is an essential factor that affects silage quality and colour. McDonald *et al.* (1998) stated that temperatures 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 range between 28.9 – 31.0°C obtained were slightly higher than the temperature ranges between 28.3-29.1^{0}C and 25.0-27.5^{0}C reported by Babayemi *et al.* (2010) and Akinwande *et al.*(2013) respectively, and slightly lower than 28.4-33.4^{0}C reported by Abdullahi *et al*. (2019). These would appear to be a good operating temperature for silage fermenting organisms. Although temperature range of 29.40 – 45.00°C was reported as satisfactory silo temperature by Amodu and Abubakar, 2004.

Generally, 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. Treatments A and C had 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 and relates such increase to buffering capacity as a result of ash and ammonia from the uric acid hydrolysis. However treatment with Urea have higher pH values (Treatment B and D) even though Akinwande *et al.* (2013) also obtained a pH value of 9.26 when Water Hyacinth was ensiled without additives. These pH values were acidic to moderately acidic and indicated proper fermentation and good keeping quality. Using a similar procedure Abdullahi *et al*., (2019) obtained a pH range of 4.70 – 7.20 while Babayemi *et al.* (2010) obtained a pH range of 3.38 - 4.61 when cassava peels were ensiled with *Albiza saman* pods. Baba *et al.*, (2010) recorded a range of 5.51 – 7.21 pH values when *Pennisetum pedicellatum* hay was ensiled with varying proportions of poultry litter.

Treatments A and C had a pH within the range of 4.5 - 5.5 reported by Menenses *et al.* (2007) which are classified to be pH for good silage. pH values higher than the normal stipulated range might be an indication of lack of organic acids generation during fermentation.

Silage quality can be evaluated physically through smell, colour and 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), Babayemi *et al.*, (2010) and Abdullahi *et al*., (2019) using similar procedure though with different feed materials. Silages without additive (control) 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 (Amodu and Abubakar, 2004).

The aroma was generally sweet for silages except in treatment B that had urea produces putrid or rancid odour. 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 compares with the result of several authors (Menenses *et al.*, 2007; Oduguwa *et al.*, 2007; Muhammad *et al.*, 2009; Baba *et al.*, 2010 and Abdullahi *et al*., (2019), 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 milling waste enhanced with urea and poultry litter

The highest percentage of Dry Matter (DM) was obtained from Treatment A. Treatment D recorded the highest Crude Protein (CP) content while enhancement of the ensiling quality of Rice Milling Waste with Poultry Litter resulted in silages with moderate CP content. Addition of Poultry Litter at 40% level resulted in lower percentage of NFE while decline in %EE contents was observed when Rice Milling Waste was enhanced with urea and poultry litter. The result of this study regarding the proximate composition were within ranges reported by Abdullahi *et al*., (2019) and Abdurrahaman, *et al.*, (2021).

Fibre composition and energy content of ensiled rice milling waste enhanced with urea and poultry litter

Urea ensiled rice milling waste had highest %NDF, %ADF, %CEL and energy while lowest NDF, ADF, ADL and CEL values were obtained in Treatment D. The NDF value was within the range of 36.33 – 52.10 reported by Abdullahi *et al*., (2019). It is also in concord with the findings of Abdurrahaman, *et al.*, (2021) who reported a slightly lower ranges of 46.40 – 51.15, 25.60 – 37.05 and 10.85 – 25.55 for %NDF, %ADF, %HEM respectively. The fibre fractions can also be compared with the value ranges of 68.59 – 71.44, 46.92 – 52.35, 13.96 – 17.15, 33.15 – 36.89 and 17.33 – 21.33 for %NDF, %ADF, %ADL, %CEL and %HEM respectively when *in vitro* gas production technique was used to evaluate some tropical feed sources and by-products (Akinfemi, *et al.*, 2012).

Mineral contents of rice milling waste ensiled with urea and poultry litter

The mineral contents (Calcium, Phosphorus and Sodium) ensiled rice milling waste were lower than the values reported by Abubakar *et al.* (2015) for *Maiwa*-millet mixed with legumes (Lablab, Mucuna and Centro). All the minerals (Ca, P and Na) in the compounded silages were below recommended levels for ruminant animals as reported by McDonald *et al.*, (1998). This could be related to inherent low mineral content of the Rice Milling Waste and also the level of fertilizer applied in the field while growing the crop. Consequently, feeding of these silages may require Calcium, Phosphorus and Sodium supplementation.

CONCLUSION AND RECOMMENDATION

Conclusion

Enhancement of rice milling waste with urea and poultry litter waste has a benefit in improving the silage physiochemical qualities. The result of this research revealed that addition of poultry litter waste to rice milling waste as silage additive resulted in improved quality silage with sweet aroma, light brown colour, high DM, OM, CF and NFE values, with moderate CP, %EE, NDF and ASH contents. Mixture of rice milling waste with urea results in silage with bad (putrid) aroma, dark brown colour, and high % CP, %DM and %ASH.

Recommendations

Further research should be done to evaluate the digestibility and feeding trials to determine preference by the animals. However, the study recommended that farmers should add urea at a very minute quantity (1kg of urea to be dissolved in 16litres of water and sprinkled over 25kg of dry RMW) and should not exceed the range as this will cause poor fermentation during ensiling which will lead to bad and low physiochemical properties.

It is however, recommended that silage of rice milling waste with urea and poultry litter be made because the treatment confer nutritional benefit on the poor quality of Rice Milling Waste. The nutritive quality of treatment D was proved to be higher and thus it is recommended for dry season ruminant feeding. It is also recommended that the research should be conducted to determine the effect of different ensiling period on the nutritional quality of the silage.

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