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NUTRITIONAL COMPOSITION OF WHEAT STRAW ENSILED WITH ADDITIVES ON DIFFERENT FERMENTATION DAYS

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ABSTRACT

The proximate analysis and fiber fractions of wheat straw ensiled with urea (2.5%), poultry litter, watermelon peels and pineapple peels at 25% inclusion each for 0, 6, 12, 18, 24 and 30 fermentation days were determined. The experiment was laid out in a Factorial arrangement in a Randomized Complete Block Design (RCBD) with five treatments and 3 replications for each treatment. Wheat straw (SWS) was ensilage without additives served as the control. All the treatments were conducted in an open mouthed kilner jar which were opened following the fermentation of 0, 6, 12, 18, 24 and 30 days for sample collection and determination of CP, CF, EE, Ash, DM, NFE, ADF, NDF, Cellulose, Hemicellulose and Lignin. The results obtained shows significant difference (P<0.05) in all the additives across the fermentation days. PLWS shows highest values of CP at 30 FDs (11.07%), CF (35.98%), Ash (5.12%), ADF (35.04g/100g), NDF (55.40g/100g), Cellulose (13.06g/100g), and Lignin (12.00g/100g) while WPWS and PPWS have ranging values CP (5.99-8.50%), CF (24.16-29.87%), EE (1.51-2.03%), Ash (4.45-5.03%), ADF (23.56-29.56g/100g), NDF (35.40-45.42g/100g), Cellulose (8.48-10.59g/100g) and Lignin (7.89-9.88g/100g) across the fermentation days. Ensiling wheat straw with poultry litter (PLWS) for 30 FDs is recommended for ruminant feeding because it yields better proximate composition and fiber fractions.

Keywords; additives, fermentation days, crop residue, wheat straw

INTRODUCTION

Many types of plant residues have the potency of being used as animal feeds (Abdurrahaman *et al*, 2021). However, amongst them, there are wide range of plant residues that are not known publicly and they are underutilized mostly due to the lack of information regarding their feeding value (Salami *et al*., 2019). Crop residues are fibrous by-products that resulted from crop cultivation (Illo *et al.*, 2018). These residues have been a major source of feeds for animals for a very long time and will continue to be so for the predictable future (Avadhanam *et al.*, 2020). Even though most of the crop residues are poor in nutrition values to meet the requirement of ruminants (Bhandari, 2019). Crop residues like wheat straw are among the largest potential feed resource now in Nigeria, but its use and development has not received proper recognition due to their bulkiness, poor nutrient density and high transport cost (Avadhanam *et al.*, 2020).

Wheat straw is one of the most abundant crop residues in Nigeria as reported by Flour Millers Association of Nigeria (FMAN) and Wheat Farmers Association of Nigeria (WFAN). According to Odifa, (2023), wheat production has increased by 42% from 2021 meaning that wheat production is expected to rise from 110,000 metric tons (MT) in 2022-2023 to 156,000 MT in the 2023-24 market year.). The increase is due to the regular production of wheat across the country, for every ton of wheat produced more tons of wheat straw are generated which were usually used as animal bedding, and sometimes it is treated as waste or burned, releasing CO_2 into the atmosphere (Gertenbach and Dugmore, 2004). However, these stalks still have nutritive value. With adequate processing techniques like silage, it will be an alternative for another expensive animal feedstuff.

Silage is the product formed when grass or other green fodder with sufficient moisture contents is stored anaerobically, typically in the silo after wilting, to prevent spoilage by aerobic microorganism (Borreani *et al*., 2018). The fundamental principles of silage process are maintenance of anaerobic conditions throughout the ensiling and rapid decline in pH value by lactic acid bacteria (Oladosu *et al.*, 2016). This involves achieving anaerobic conditions under which natural fermentation can be obtained by enhancing and compacting the materials and adequately sealing the silo to prevent re-entry of air. The entrapped air within the ensiled material will be removed rapidly by respiratory enzymes (Yitbarek and Tamir, 2014). When oxygen is in contact with the material for a period of time, aerobic microbial activity occurs which bring about the development of yeast and mould which results in the decay of the materials to an unwanted product that cannot be utilized by the animal or become toxic. Additionally, absence of oxygen restricts the growth and activities of undesirable microorganisms such as clostridia and enterobacteria. Clostridia multiplies under anaerobic conditions and produce butyric acid which breaks down into amino acids and produce silage with a poor palatability and lower nutritional value but when lactic acid during fermentation is produced, it inhibits the growth of clostridia and enterobacteria (Yitbarek and Tamir, 2014). It is important to say that finer material is ensiled to produce better compaction and fermentation which equally improves the palatability and product intake (Meeske *et al.*, 2005).

Silage fermentation process is a unique procedure that can be affected by different factors including different silage additives which are used to increase nutrient and energy recovery, reduce fermentation losses, promote rapid fermentation, and improve animal performances. Silage additives when used, should improve good quality forage to become excellent. According to Morais *et al.* (2017) and Yitbarek and Tamir (2014), silage additives are divided into 5 broad categories. These include fermentation stimulants (bacteria culture and carbohydrate sources, molasses, pineapple peel, orange peel and watermelon peel), fermentation inhibitors (acids, formaldehyde etc.), aerobic deterioration inhibitors (lactic acid bacteria, propionic acid etc.), nutrients (urea, ammonia and poultry litter) and absorbents (barley, straw and husks). Urea, poultry litter, watermelon peels and pineapple peels were used in this study to evaluate the effects of these additives and different fermentation days on the quality of wheat straw silage.

MATERIAL AND METHODS

Study area

The research was conducted at the Laboratory of the Department of Animal Science, Faculty of Agriculture, Federal University Dutse, Jigawa State. located at latitude 11.69174° N and 9.34525° E longitude, with an average temperature ranging between 20°C and 39.76°C. The dry season lasts for about 7 month and rainy season for about 4 months (NIMET, 2022).

Collection and preparation of experimental materials

Wheat Straw was obtained from a Farm in kiyawa Local Government Area, Jigawa State after mechanical threshing of wheat grains. They were screened for impurities and foreign particles to prevent contamination and then transported to the study area. The screened wheat straw was weighed and mixed with silage additives adequately in the recommended quantities. The additives were added as follows: urea was used as 2.5% and 97.5% wheat straw as reported by (Morais *et al.*, 2017), 25% of poultry litter was used plus 75% of wheat straw ensiled, watermelon peels were used at rate of 25% and 75% of wheat straw and Pineapple peel at the rate of 25% with 75% of wheat straw.

Experimental design

The experiment was laid in a factorial arrangement in a Randomized Completely Block Design (RCBD) (2x5x6) consisting of five different (5) treatments with 3 replications each, as shown in table 1 below;

Table 1: Treatments combinations

Treatments	Combinations
T1 Control (SWS)	Sole wheat straw (100%)
T2 UWS	Wheat straw (97.5%) + urea (2.5%)
T3 PLWS	Wheat straw (75%) + poultry litters (25%)
T4 WPWS	Wheat straw (75%) + watermelon peels (25%)
T5 PPWS	Wheat straw (75%) + pineapple peels (25%)

Ensiling procedure

Wheat straw including additives were thoroughly mixed, homogenized and ensiled in an open mouthed Kilner jars (Cope BS 910-8, 1000 ml) and sealed tightly to prevent air from entering into the jar and was stored in the laboratory. The treatments were varied in 0, 6, 12, 18, 24 and 30 fermentation days in triplicates with a total of 90 bottles.

Analytical methods

Samples were collected according to the days of fermentation for each treatment (day 0, 6, 12, 18, 24 and 30). The jars were opened and the upper layer of the materials were scrubbed off and samples were taken from middle of the jar to prevent possible contamination

Proximate Analysis

Parameters such as dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE), \nitrogen free extract (NFE) and ash of the samples were determined according to method developed by AOAC (1999).

Determination of Fiber Fractions

Fiber fractions such as acid detergent fiber (ADF), nitrogen detergent fiber (NDF), lignin and hemicellulose were determined according to the method developed by Van Soest *et al*., (1991).

Data analysis

All data generated were subjected to analysis of variance (ANOVA) according to the standard the Generalized Linear Model (GLM) procedures of GenStat version 17. the means were separated using Fishers LSD

The yield equation is shown below.

$$Yijk = \mathscr{M} = Ai + Bj + Ck + Dl + ABCDijkl + £ijkl$$

Where,

Y = observation on the performance of wheat straw

$\mathscr{M}$ = universal mean

Ai = i^{th} effect of urea in wheat straw silage

Bj = jt^{h} effect of poultry litter on wheat straw silage

Ck= k^{th} effect of pineapple peel on wheat straw silage

Dl = l^{th} effect of watermelon peel on wheat straw silage

ABCDijkl = interaction effect of silage additives in wheat straw silage

£ = random and residual error

Yijkl = observations of silage additives on ensiled what straw

RESULTS AND DISCUSSION

Proximate composition of the resultant silage

The quality of silage accessed by analyzing the proximate composition of that silage. The addition of silage additives in this study had significant effect on the resultant silage ($P<0.05$). As shown in Table 2, the CP of the resultant silage differs according to the silage additives used the highest CP (11.07%) was observed in PLWS at 30 FDs because the poultry litters contain significant quantity of NH_3-N which fermented during silage process and improved the protein content of the resultant silage. The CP content in UWS, PLWS, and PPW treated silage increased with increasing level of inclusion of the test ingredients from 0 fermentation day (FD) to 18 FD but gradually decrease at 24 and 30 FD. This was because most silage fermentation and synthesis process stabilize at 18-24 FDs. Trujillo *et al.* (2014) reported higher ($P<0.05$) CP value with 30% poultry litter and higher fermentation days used but Shahowna *et al.* (2013) and San Pedro *et al.* (2015) reported lower CP values with less than 20% poultry litter used although no specific range of fermentation days recorded. It can be said that the values of CP in poultry litter treated silage increases with increase in the level of inclusion of the additive. UWS shows significantly difference ($P < 0.05$). Urea is known to improve the CP content of silage because of the amount of nitrogen (N) present in it. The CP of UWS (9.44%) was higher ($P<0.05$) than 6.04% and 5.89% reported by Muhammad *et al.* (2023) and Ubwa *et al.* (2014) respectively and lower EE and ASH content. WPWS has the lowest ($P<0.05$) CP value (5.99 at 0 FD and 6.85 at 30 FD) likewise, PPWS lower CF, EE, ASH, DM and NFE were observed compared to the control except for CP, PPWS has higher CP content than WPWS and SWS. The crude protein levels explained above were within the range reported by Muhammad *et al.* (2023), Abdurrahaman *et al.* (2021) and Abdullahi *et al.* (2019) for silages with urea, poultry litter and fruit peels.

Table 2. effect of additives and fermentation days on crude protein of wheat straw silage

Treatments	Fermentation days						P-value
	0	6	12	18	24	30	
SWS	$7.88^{i}±0.08$	$7.96^{i}±0.08$	$7.74^{ij}±0.08$	$7.85^{i}±0.08$	$7.87^{i}±0.08$	$7.63^{j}±0.08$	<0.001
UWS	$8.98^{f}±0.08$	$9.23^{e}±0.08$	$8.87^{f}±0.08$	$9.94^{d}±0.08$	$9.82^{d}±0.08$	$9.82^{d}±0.08$	<0.001
PLWS	$8.29^{h}±0.08$	$10.49^{c}±0.08$	$10.75^{b}±0.08$	$10.99^{a}±0.08$	$10.66^{b}±0.08$	$11.07^{a}±0.08$	<0.001
WPWS	$5.99^{n}±0.08$	$6.17^{m}±0.08$	$6.68^{l}±0.08$	$6.51^{l}±0.08$	$6.57^{l}±0.08$	$6.85^{k}±0.08$	<0.001
PPWS	$5.95^{n}±0.08$	$8.57^{g}±0.08$	$7.56^{j}±0.08$	$8.21^{h}±0.08$	$8.57^{g}±0.08$	$8.50^{g}±0.08$	<0.001

Means within rows and columns with different superscripts (a-d) are significantly different (P<0.05) SWS = sole wheat straw, UWS = urea + wheat straw, PLWS = poultry litter + wheat straw, WPWS = watermelon peels + wheat straw and PPWS = pineapple peel + wheat straw.

Table 3. effect of additives and fermentation days on crude fibre of wheat straw silage

Treatments	Fermentation days						P-value
	0	6	12	18	24	30	
SWS	28.05^{n}±0.2	32.07^{fgh}±0.2	31.17^{ij}±0.2	31.68^{hi}±0.2	31.52^{i}±0.2	30.45^{kl}±0.2	<0.001
UWS	29.94^{lm}±0.2	30.79^{jk}±0.2	29.59^{m}±0.2	32.23^{f}±0.2	32.75^{e}±0.2	32.23^{efg}±0.2	<0.001
PLWS	33.41^{d}±0.2	34.11^{c}±0.2	34.11^{c}±0.2	35.72^{a}±0.2	34.67^{b}±0.2	35.98^{a}±0.2	<0.001
WPWS	24.16^{r}±0.2	24.88^{q}±0.2	26.97^{o}±0.2	26.45^{p}±0.2	26.32^{p}±0.2	27.26^{o}±0.2	<0.001
PPWS	23.85^{r}±0.2	29.99^{m}±0.2	28.13^{n}±0.2	29.94^{lm}±0.2	29.99^{m}±0.2	29.87^{lm}±0.2	<0.001

SWS = sole wheat straw, UWS = urea + wheat straw, PLWS = poultry litter + wheat straw, WPWS = watermelon peels + wheat straw and PPWS = pineapple peel + wheat straw.

Table 3 shows the effect of additives and fermentation days on crude fibre of wheat straw silage. The CF of the resultant silages shows a significant difference (P<0.005) in all the treatments. From the table its shows that WPWS and PPWS have the lowest CF (24.16% in 0 FD to 27.26 in 30 FD and 23.85 in 0 FD to 29.87 in 30 FD respectively) lower than the control (28.05 in 0 FD to 30.45) which explains the effect of watermelon peels and pineapple peels towards improving the %CF in wheat straw silage. The highest CF values were obtained in PLWS (35.98 at 30 FDs), and then in UWS (32.23 at 30 FDs). The increase in %CF of non-protein nitrogen source additives as explained by Zeleke *et al.,* (2017) is because urea and poultry litter contain some significant content of organic compounds such as ammonia that are capable of improving the crude protein and crude fiber level of poor-quality roughages and crop residues.

The EE obtained in the control is relatively higher than the treated groups, this may be because the additives treated significantly lower the EE value while increasing other nutritional components. In WPWS the %EE was increasing from 1.57% at 0 FD to 1.78% at 18 FD but drastically decrease to 1.61% at 24 and 1.73% at 30 FD. Similarly, PPWS. The drop in %EE was also explained by Nieman *et al.* (2023) as end at which the highest improvement in crude fat is obtained in the resultant silage.

Table 4. effect of additives and fermentation days on ether extract of wheat straw silage

Treatments	Fermentation days						P-value
	0	6	12	18	24	30	
SWS	1.78^{efghi}±0.08	2.94^{c}±0.08	2.81^{c}±0.08	3.27^{b}±0.08	2.92^{c}±0.08	2.51^{d}±0.08	<0.001
UWS	1.93^{ef}±0.08	1.87^{efgh}±0.08	1.41^{k}±0.08	1.82^{efgh}±0.08	1.76^{efghi}±0.08	1.61^{ghijk}±0.08	<0.001
PLWS	3.53^{a}±0.08	1.68^{fghijk}±0.08	1.74^{fghij}±0.08	1.84^{efgh}±0.08	1.58^{ghijk}±0.08	1.79^{efghi}±0.08	<0.001
WPWS	1.57^{hijk}±0.08	1.64^{fghijk}±0.08	2.03^{e}±0.08	1.78^{efghi}±0.08	1.61^{ghijk}±0.08	1.73^{fghij}±0.08	<0.001
PPWS	1.51^{ijk}±0.08	1.86^{efgh}±0.08	1.78^{efghi}±0.08	1.88^{efg}±0.08	1.51$_{ijk}$±0.08	1.46$_{jk}$±0.08	<0.001

SWS = sole wheat straw, UWS = urea + wheat straw, PLWS = poultry litter + wheat straw, WPWS = watermelon peels + wheat straw and PPWS = pineapple peel + wheat straw.

ASH content in the resultant silage as shown in table 5 was highest (P<0.05) in PLWS (4.45% at 0 FD to 4.97% at 30 FD) compared to other treatments. Nieman *et al.* (2023) reported that poultry litter can improve the quality of other low-quality grasses in silage. Various studies reported similar results when poultry litter is used as a silage additive. The values of ASH generally increase with the increase in fermentation days, mainly because with an increase in the rate of fermentation poultry litter tends to ferment and release it content which in turn improve the quality of the resultant silage Trujillo *et al.* (2014).

Table 5. Effect of silage additives and fermentation days on ash of the resultant silage

Treatments	Fermentation days						P-value
	0	6	12	18	24	30	
SWS	$3.97^{p}\pm0.01$	$5.13^{a}\pm0.01$	$5.02^{c}\pm0.01$	$4.71^{i}\pm0.01$	$4.97^{d}\pm0.01$	$5.07^{b}\pm0.01$	<0.001
UWS	$4.05^{o}\pm0.01$	$4.27^{n}\pm0.01$	$4.49^{l}\pm0.01$	$4.73^{i}\pm0.01$	$4.78^{h}\pm0.01$	$4.83^{g}\pm0.01$	<0.001
PLWS	$4.87^{f}\pm0.01$	$4.87^{f}\pm0.01$	$4.97^{d}\pm0.01$	$5.02^{c}\pm0.01$	$5.02^{c}\pm0.01$	$5.12^{a}\pm0.01$	<0.001
WPWS	$4.51^{l}\pm0.01$	$4.62^{j}\pm0.01$	$4.78^{h}\pm0.01$	$4.93^{e}\pm0.01$	$4.98^{d}\pm0.01$	$5.03^{c}\pm0.01$	<0.001
PPWS	$4.45^{m}\pm0.01$	$4.56^{k}\pm0.01$	$4.72^{i}\pm0.01$	$4.86^{f}\pm0.01$	$4.91^{e}\pm0.01$	$4.97^{d}\pm0.01$	<0.001

SWS = sole wheat straw, UWS = urea + wheat straw, PLWS = poultry litter + wheat straw, WPWS = watermelon peels + wheat straw and PPWS = pineapple peel + wheat straw.

Table 6 below shows the dry matter content of the resultant silage. All treatments were significantly different compared to the control. WPWS and PPWS shows higher DM values 30.48 at 0 FD to 50.47 at 30 FD and 28.11 at 0 FD to 49.94 at 30 FD, which relatively indicates that fruit peels have significant impact on the dry matter of the resultant silage while PLWS shows inverse effect as the DM values were decreasing throughout the fermentation period 48.02 at 0 FD and 41.64 at 30 FD.

Table 6. effect of additives and fermentation days on dry matter of wheat straw silage

Treatments	Fermentation days						P-value
	0	6	12	18	24	30	
SWS	$39.98^{j}\pm0.6$	$47.94^{cd}\pm0.6$	$49.28^{abc}\pm0.6$	$47.02^{d}\pm0.6$	$44.77^{e}\pm0.6$	$43.59^{efg}\pm0.6$	<0.001
UWS	$40.38^{h}\pm0.6$	$46.86^{d}\pm0.6$	$47.95^{cd}\pm0.6$	$47.59^{cd}\pm0.6$	$42.43^{fg}\pm0.6$	$43.91^{ef}\pm0.6$	<0.001
PLWS	$48.02^{cd}\pm0.6$	$46.86^{d}\pm0.6$	$44.47^{e}\pm0.6$	$42.77e^{fg}\pm0.6$	$42.22^{fg}\pm0.6$	$41.64^{gh}\pm0.6$	<0.001
WPWS	$30.48^{l}\pm0.6$	$36.44^{k}\pm0.6$	$48.49^{bcd}\pm0.6$	$43.37^{efg}\pm0.6$	$47.04^{d}\pm0.6$	$50.47^{a}\pm0.6$	<0.001
PPWS	$28.11^{m}\pm0.6$	$36.27^{k}\pm0.6$	$40.00^{j}\pm0.6$	$40.29^{i}\pm0.6$	$44.63^{e}\pm0.6$	$49.94^{ab}\pm0.6$	<0.001

SWS = sole wheat straw, UWS = urea + wheat straw, PLWS = poultry litter + wheat straw, WPWS = watermelon peels + wheat straw and PPWS = pineapple peel + wheat straw.

Table 7 shows the content of nitrogen free extract obtained in all treatments. PLWS and UWS have the lowest values of NFE, 1.88% at 0 FD to 4.06% at 30 FD in PLWS which was increasing from 0-24 FD and decreases at 30 FD and 14.52% at 0 FD to 7.75% at 30 FD in UWS but it was decreasing across the fermentation days. WPWS (33.28% at 0 FD t0 8.65% at 30 FD) and PPWS (36.12% at 0 FD to 5.25% at 30 FD) has the highest NFE. Muhammad *et al.* (2023) reported that the NFE in some treated crop residue should less than 50%.

Table 7. effect of additives and fermentation days on nitrogen free extract of wheat straw silage

Treatments	Fermentation days						P-value
	0	6	12	18	24	30	
SWS	18.33^{d}±0.7	3.94^{n}±0.7	3.88^{o}±0.7	5.46^{l}±0.7	7.94^{i}±0.7	10.75^{g}±0.7	<0.001
UWS	14.52^{e}±0.7	6.97^{i}±0.7	7.67^{i}±0.7	3.21^{jk}±0.7	8.45^{g}±0.7	7.75^{j}±0.7	<0.001
PLWS	1.88^{r}±0.7	1.96^{r}±0.7	3.13^{q}±0.7	3.66^{p}±0.7	5.70^{k}±0.7	4.06^{n}±0.7	<0.001
WPWS	33.28^{b}±0.7	26.24^{c}±0.7	10.38^{g}±0.7	16.92^{d}±0.7	13.81^{f}±0.7	8.65^{h}±0.7	<0.001
PPWS	36.12^{a}±0.7	18.74^{d}±0.7	17.81^{e}±0.7	14.80^{e}±0.7	10.48^{g}±0.7	5.25^{m}±0.7	<0.001

SWS = sole wheat straw, UWS = urea + wheat straw, PLWS = poultry litter + wheat straw, WPWS = watermelon peels + wheat straw and PPWS = pineapple peel + wheat straw.

Table 8. Participation of silage additives and fermentation days on the proximate analysis of the wheat straw silage.

Treatments	Parameters (%)					
Additives (A)	**CP**	**CF**	**EE**	**ASH**	**DM**	**NFE**
SWS	7.82^{d}±0.03	30.82^{c}±0.08	2.71^{a}±0.03	4.81^{b}±0.05	45.43^{a}±0.02	8.38^{c}±0.03
UWS	9.44^{b}±0.03	31.25^{b}±0.08	1.73^{c}±0.03	4.53^{d}±0.05	44.85^{b}±0.02	8.09^{c}±0.03
PLWS	10.37^{a}±0.03	34.67^{a}±0.08	2.03^{b}±0.03	4.98^{a}±0.05	44.35^{b}±0.02	3.40^{d}±0.03
WPWS	6.46^{e}±0.03	26.01^{e}±0.08	1.73^{c}±0.03	4.81^{b}±0.05	42.71^{c}±0.02	18.21^{a}±0.03
PPWS	7.89^{c}±0.03	28.63^{d}±0.08	1.67^{c}±0.03	4.74^{c}±0.05	39.87^{d}±0.02	17.20^{b}±0.03
P-value	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Fermentation days (FD)						
0	7.42^{e}±0.03	27.88^{d}±0.09	2.06^{ab}±0.03	4.37^{f}±0.05	37.39^{d}±0.03	20.83^{a}±0.03
6	8.48^{c}±0.03	30.37^{b}±0.09	2.00^{bc}±0.03	4.69^{e}±0.05	42.88^{c}±0.03	11.57^{b}±0.03
12	8.32^{d}±0.03	29.99^{c}±0.09	1.95^{c}±0.03	4.80^{d}±0.05	46.04^{a}±0.03	8.57^{c}±0.03
18	8.70^{b}±0.03	31.20^{a}±0.09	2.12^{a}±0.03	4.85^{c}±0.05	44.21^{b}±0.03	8.81^{c}±0.03
24	8.70^{b}±0.03	31.05^{a}±0.09	1.87^{d}±0.03	4.93^{b}±0.05	44.22^{b}±0.03	9.28^{c}±0.03
30	8.77^{a}±0.03	31.16^{a}±0.09	1.82^{d}±0.03	5.01^{a}±0.05	45.91^{a}±0.03	7.29^{d}±0.03
P-value	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Interaction	*	*	*	*	*	*

Note: SWS = sole wheat straw, UWS = urea + wheat straw, PLWS = poultry litter + wheat straw, WPWS = watermelon peels + wheat straw, PPWS = pineapple peel + wheat straw, CP = crude protein, CF = crude fiber, EE = either extract, DM = dry matter and NFE = nitrogen free extract.

Fibre fractions of the resultant silage

The fibre fractions show relatively significant differences (P<0.05) in all the treatments across the fermentation days. ADF plays a crucial role in determining the quality and digestibility of the resultant silage. Higher ADF content was obtained in PLWS and UWS at 30 FDs. Higher ADF content can lead to slower fermentation rates and lower lactic acid production (McDonald *et al.*, 2011) which can result in silages with higher pH levels and lower microbial stability (Kung *et al.*, 2003).Values in PLWS (32.58g/100g at 0 FD to 36.04g/100g at 30 FD) are within the recommended safe range of less than 50 g/100g by McDonald *et al.* (2011). WPWS (23.56 g/100g at 0 FD to 26.51 g/100g at 30 FD) and PPWS (23.50 g/100g at 0 FD to 29.13 g/100g at 30 FD) have ADF values relatively lower than the other treatments throughout the fermentation days. This shows that based on the ADF values of the resultant silage treatments with fruit peels are in digestibility than treatments with urea, poultry litter and sole wheat straw. Studies have shown that the interaction between ADF content and fermentation days can impact silage quality. Nishino *et al.* (2018) reported that high-ADF silages fermented for 30 days had lower lactic acid content and higher pH levels compared to low-ADF silages fermented for the same period.

Table 9. effect of additives and fermentation days on acid detergent fibre of wheat straw silage

Treatments	Fermentation days						P-value
	0	6	12	18	24	30	
SWS	27.68^{j}±0.38	31.27^{ef}±0.38	30.74^{fg}±0.38	31.26^{ef}±0.38	30.70^{fg}±0.38	29.99^{ghi}±0.38	<0.001
UWS	29.59^{hi}±0.38	30.42^{fgh}±0.38	29.17^{i}±0.38	32.02^{de}±0.38	32.26^{de}±0.38	31.45^{ef}±0.38	<0.001
PLWS	32.58^{cd}±0.38	33.23^{c}±0.38	34.61^{b}±0.38	34.85^{b}±0.38	34.85^{b}±0.38	36.04^{a}±0.38	<0.001
WPWS	23.56^{m}±0.38	24.27^{n}±0.38	26.64^{k}±0.38	26.13^{l}±0.38	25.94^{l}±0.38	26.51^{k}±0.38	<0.001
PPWS	23.50^{m}±0.38	29.26^{i}±0.38	27.73^{j}±0.38	29.19^{i}±0.38	29.56^{hi}±0.38	29.13^{i}±0.38	<0.001

SWS = sole wheat straw, UWS = urea + wheat straw, PLWS = poultry litter + wheat straw, WPWS = watermelon peels + wheat straw and PPWS = pineapple peel + wheat straw.

Table 10. effect of additives and fermentation days on neutal dertergent fibre of wheat straw silage

Treatments	Fermentation days						P-value
	0	6	12	18	24	30	
SWS	42.74^{i}±0.4	47.54^{f}±0.4	46.44^{h}±0.4	47.19^{f}±0.4	46.73^{g}±0.4	45.38^{gh}±0.4	<0.001
UWS	45.68^{gh}±0.4	46.96^{g}±0.4	45.09^{i}±0.4	49.77^{e}±0.4	49.89^{e}±0.4	48.90^{e}±0.4	<0.001
PLWS	49.53^{e}±0.4	51.89^{d}±0.4	53.53^{bc}±0.4	54.38^{b}±0.4	52.74^{cd}±0.4	55.40^{a}±0.4	<0.001
WPWS	35.40^{n}±0.4	36.88^{m}±0.4	40.18^{k}±0.4	39.40^{l}±0.4	39.22^{l}±0.4	40.41^{k}±0.4	<0.001
PPWS	35.53^{n}±0.4	45.22^{h}±0.4	42.28^{j}±0.4	44.89^{h}±0.4	45.42^{gh}±0.4	45.01^{h}±0.4	<0.001

SWS = sole wheat straw, UWS = urea + wheat straw, PLWS = poultry litter + wheat straw, WPWS = watermelon peels + wheat straw and PPWS = pineapple peel + wheat straw.

Table 11. effect of additives and fermentation days on cellulose of wheat straw silage

Treatments	Fermentation days						P-value
	0		12	18	24	30	
SWS	8.98^{j}±0.11	<0.001	11.02^{f}±0.11	11.21^{e}±0.11	11.06^{f}±0.11	10.77^{g}±0.11	<0.001
UWS	10.71^{g}±0.11	<0.001	10.61^{g}±0.11	11.68^{d}±0.11	11.73^{d}±0.11	11.48^{de}±0.11	<0.001
PLWS	11.73^{d}±0.11	<0.001	12.59^{b}±0.11	12.75^{b}±0.11	12.36^{c}±0.11	13.06^{a}±0.11	<0.001
WPWS	8.48^{k}±0.11	<0.001	9.55^{i}±0.11	9.36^{i}±0.11	9.31^{i}±0.11	9.56^{i}±0.11	<0.001
PPWS	8.43^{k}±0.11	<0.001	10.00^{h}±0.11	10.58^{g}±0.11	10.71^{g}±0.11	10.59^{g}±0.11	<0.001

SWS = sole wheat straw, UWS = urea + wheat straw, PLWS = poultry litter + wheat straw, WPWS = watermelon peels + wheat straw and PPWS = pineapple peel + wheat straw.

Table 12. effect of additives and fermentation days on hemicellulose of wheat straw silage

Treatments	Fermentation Days						P-value
	0	6	12	18	24	30	
SWS	9.28^{g}±0.19	10.32^{c}±0.19	10.40^{c}±0.19	10.37^{c}±0.19	10.26^{d}±0.19	9.76^{f}±0.19	<0.001
UWS	10.53^{b}±0.19	10.69^{b}±0.19	10.15^{e}±0.19	10.36^{d}±0.19	10.68^{b}±0.19	10.20^{abc}±0.19	<0.001
PLWS	10.86^{a}±0.19	10.62^{ab}±0.19	10.45^{abc}±0.19	10.57^{bc}±0.19	10.29^{d}±0.19	10.45^{abc}±0.19	<0.001
WPWS	10.02^{d}±0.19	10.43^{c}±0.19	10.68^{b}±0.19	10.28^{d}±0.19	10.28^{abc}±0.19	10.22^{d}±0.19	<0.001
PPWS	9.99^{d}±0.19	10.43^{c}±0.19	10.60^{b}±0.19	10.35^{bc}±0.19	10.26±0.19	10.21^{d}±0.19	<0.001

SWS = sole wheat straw, UWS = urea + wheat straw, PLWS = poultry litter + wheat straw, WPWS = watermelon peels + wheat straw and PPWS = pineapple peel + wheat straw.

Table 13. effect of additives and fermentation days on lignin of wheat straw silage

Treatments	Fermentation days						P-value
	0	6	12	18	24	30	
SWS	9.63^{l}±0.10	10.56^{gh}±0.10	10.32^{hi}±0.10	10.49^{gh}±0.10	10.49^{gh}±0.10	10.07^{jk}±0.10	<0.001
UWS	9.92^{kl}±0.10	10.20^{ij}±0.10	9.79^{kl}±0.10	10.80^{ef}±0.10	10.83^{ef}±0.10	10.61^{fg}±0.10	<0.001
PLWS	11.00^{e}±0.10	11.22^{d}±0.10	11.59^{bc}±0.10	11.76^{b}±0.10	11.41^{cd}±0.10	12.00^{a}±0.10	<0.001
WPWS	7.95^{p}±0.10	8.19^{o}±0.10	8.93^{n}±0.10	8.76^{n}±0.10	8.71^{n}±0.10	8.96^{n}±0.10	<0.001
PPWS	7.89^{p}±0.10	9.88^{kl}±0.10	9.31^{m}±0.10	9.85^{kl}±0.10	9.92^{kl}±0.10	9.83^{kl}±0.10	<0.001

SWS = sole wheat straw, UWS = urea + wheat straw, PLWS = poultry litter + wheat straw, WPWS = watermelon peels + wheat straw and PPWS = pineapple peel + wheat straw.

NDF in silage production plays a crucial role in determining the feed intake and quality of the resultant silage. All treatments show significant different difference (P<0.05) as shown in table 10**Table** All treatments increase with increase in FDs until day 24 then a slight drop was observed at 30 FDs. PLWS shows the highest values of NDF which also indicates lower fermentation rates and feed intake (Muck *et al.* (2018). WPWS and PPWS shows significantly lower NDF values and research has shown that longer fermentation periods can result in lower NDF content due to the degradation of fiber by microorganisms (Ashbell *et al*. 2017) which explains the reason all NDF values decreases at 30 FDs. However, some studies have shown that NDF can also have a positive effect on fiber digestibility, especially at higher fermentation temperatures (Nishino *et al.* 2018).

Cellulose (13.06 g/100g), Hemicellulose (10.45 g/100g) and Lignin (10.45 g/100g) content recorded in PLWS were within the range recoded by Muhammad *et al.*, (2023) and Abdurrahaman *et al*, (2021). But Abdullahi *et al.* (2019) and Akinfemi, *et al.*, 2012) recorded higher values. However, Higher cellulose content can lead to slower fermentation rates (Muck *et al.*, 2018), lower lactic acid production (Weiss *et al.*, 2016) and. UWS was slightly lower than the recorded the range. WPWS and PPWS were lower in Cellulose and Lignin but higher in hemicellulose content it may be because the inclusion level of the additive is low or fruits additives generally have low effect on fiber fractions. However, Higher hemicellulose content can lead to Faster fermentation rates, Higher lactic acid production, Higher nutrient digestibility (Lee *et al.* 2020).

Table 14. Effect of silage additives and fermentation days on fibre fractions of wheat straw silage

Treatments	Parameters (g/100g)				
Additives (A)	**ADF**	**NDF**	**CELL**	**HEM**	**LIGNIN**
SWS	30.27^{c}±0.15	46.00^{c}±0.18	10.72^{c}±0.04	10.07^{c}±0.07	10.26^{c}±0.04
UWS	30.81^{b}±0.15	47.71^{b}±0.18	11.21^{b}±0.04	10.44^{ab}±0.07	10.36^{b}±0.04
PLWS	34.36^{a}±0.15	52.91^{a}±0.18	12.44^{a}±0.04	10.54^{a}±0.07	11.50^{a}±0.04
WPWS	25.50^{e}±0.15	38.65^{e}±0.18	9.12^{e}±0.04	10.32^{b}±0.07	8.59^{e}±0.04
PPWS	28.06^{d}±0.15	43.06^{d}±0.18	10.16^{d}±0.04	10.31^{b}±0.07	9.45^{d}±0.04
P-value	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Fermentation days (FD)					
0	27.38^{e}±0.17	41.86^{c}±0.19	9.67^{e}±0.05	10.14^{b}±0.08	9.28^{c}±0.04
6	29.69 ^{b}±0.17	45.70^{b}±0.19	10.71^{d}±0.05	10.50^{a}±0.08	10.01^{b}±0.04
12	29.78^{b}±0.17	45.50^{b}±0.19	10.75^{d}±0.05	10.46^{a}±0.08	9.99^{b}±0.04
18	30.69^{a}±0.17	47.13^{a}±0.19	11.12^{b}±0.05	10.39^{a}±0.08	10.33^{a}±0.04
24	30.66^{a}±0.17	46.80^{a}±0.19	11.03^{c}±0.05	10.36^{a}±0.08	10.27^{a}±0.04
30	30.62^{a}±0.17	47.03^{a}±0.19	11.09^{a}±0.05	10.17^{b}±0.08	10.30^{a}±0.04
P-value	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Interaction	*	*	*	*	*

SWS = sole wheat straw, UWS = urea + wheat straw, PLWS = poultry litter + wheat straw, WPWS = watermelon peels + wheat straw and PPWS = pineapple peel + wheat straw, ADF = acid detergent fiber, NDF = nutrient detergent fiber, CELL = cellulose, HEM = hemicellulose

The variations in fermentation days generally increases the levels of ADF, NDF, CELL, HEM and Lignin in the resultant silage. That is basically because the increase in FDs favors further fractions of fiber to degrade.

CONCLUSION AND RECOMMENDATION

In terms of higher protein and crude fiber, PLWS and UWS shows positive results, while in terms of fiber fractions WPWS and PPWS shows better resultant silage. Hence, during wheat straw silage for ruminant production poultry litter should be used at 25% for 24 fermentation days.

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