

Comparative Evaluation Of Dry Brewer Grain, Palm Kernel Cake, And Wheat Offal With Conventional Additives, Sucrose And Maize, In The Ensiling Process Using Water Hyacinth As Forage

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Abstract: Silage additives are natural or industrial products that are often added to forages to improve or alter fermentation, reduce fermentation losses, promote the growth of lactic acid bacteria and improve the stability of the silage. Concern in added cost as a result of conventional additives in the ensiling process has necessitated a need for alternative cheap sources. Hence, three relatively cheap and readily available agro-industrial additives, wheat offal (WO), brewer dry grain (BDG) and palm kernel cake (PKC) were tested with two conventional additives, sucrose (S) and cracked maize grains (CM), for their ability to properly ferment and impart high nutritional qualities to ensiled water hyacinth (WH). Thus WH, a prolific plant with a high biomass yield was ensiled with each of the named additive in turn. From these, the following treatment silages were prepared: WHS, WHCM, WHWO, WHBDG and WHPKC. After 42 days ensiling period, quality and chemical composition were assessed. Results indicated positive physical attributes in colour, texture and odour in all experimental silages. Crude protein for WHBDG (23.25 %) and WHPKC (20.10 %) were higher ($p < 0.05$) than those of WHS, WHCM and WHWO. For the fibre detergent fractions, the NDF, ADF and ADL followed similar trend. The dry matter (%) of the silages ranged from 11.34 (WHS) to 22.39 (WHBDG). The pH and temperature (°C) were not significantly different ($p > 0.05$) ranging respectively from 2.8 to 3.45 and 27.5 to 28.5. Findings indicated that all tested additives compared favourably with the controls; WO performed best; BDG and PKC performed no less than the conventional S and CM additives. This observation is suggestive that WO, BDG and PKC can replace the conventional additives, sucrose and cracked maize in an ensiling process.

Keywords: Non-conventional agro-industrial additives, possible usage, for silage fermentation.

1. INTRODUCTION

In the tropics and developing countries, a major problem of the livestock industry is the dry season feeding of livestock because of scarce forage resources which are often highly lignified with attendant low

digestibility. It is quite necessary to devise means by which livestock will be adequately fed all year round. Recent efforts have been towards supplementation of available grasses and other forages especially in the dry season with crop residues, agro-industrial by-products, legumes and

multipurpose browse plants (Jamala et al., 2013; Abegunde et al., 2017).

In the wet season within the agro-climatic region, there exists relative abundance in forage resources even to the extent of having a surplus. It comes to reason therefore to adopt a feed conservation method against the off-season period (dry season), one of which is silage making. As rightly stated, silage making is a tool for farmers for the preservation of surplus forage in the wet season to ensure all year-round availability (Ibhaze et al, 2015).

Many types of silage will ferment better and attain better silage stability when certain additions/additives are added to the silage mass. Such additives have been documented to function in the following ways: add dry matter to reduce moisture, alter the rate, amount and kind of acid production, acidify the silage, inhibit bacteria and mould growth, culture silage to stimulate acid production and increase nutrient content of the silage (Wasaya, 2008). Conventional silage additives include, molasses, cracked maize grains, honey, sugar beet, bagasse, etc. of which each is added at 1-10 % inclusion level. However, in recent time, other researchers have experimented with novel additives like wheat offals, brewer dry grain, poultry litters, citrus pulp, cassava peels, and breadfruit among others (Akinwande, 2011; Falola et al., 2013; Abegunde et al., 2017). The first author had noted the suitability of WO, BDG and PKC as replacement additives. However, there is need for further validation by comparing with conventional additives. The choice of

an additive is dependent on availability, cost and suitability.

On this premise, this study was conceived to carry out a comparative evaluation between two conventional additives, sucrose or cracked maize and three unconventional or novel additives, WO, BDG and PKC in the fermentation of water hyacinth (*Eichhornia crassipes*, Mart. Solms-Laubach) itself being a recently much researched plant for its invasiveness, prolificacy and high biomass yield. The proposed additives (WO, BDG, PKC) are agro-industrial additives, they are available throughout the year, relatively cheap and powdery at mixing time, making them suitable for effluent reduction and nutrient losses. Specifically, the study sought to characterized each silage produced from the combination of WH with an additive in its: proximate composition, fibre detergent fractions, dry matter composition, fermentation pH and temperature attained by the silage mass towards assessing the nutritional implications.

2. MATERIALS AND METHODS

2.1. Experimental site

This experiment was conducted in the sheep and goat house of the Teaching and Research Farm of the Department of Agricultural Science, Tai Solarin University of Education, Ijagun, Ijebu-Ode located at 6°47' N and 3° 58' E, elevation 200-400 m above sea level and 1200 mm annual rainfall (Department of Geography, Ogun State College of Education, 1990).

2.2. Water hyacinth sourcing and silage production

Water hyacinth procurement took place at an inland fresh-water river at Itoikin, along Ijebu-Ode-Ikorodu road, Lagos State, Nigeria. Samples were collected in batches and brought down to Ijebu-Ode into a shady location. Fresh plant shoots were separated from the roots. The shoots were lacerated and chopped into 3-5 cm pieces by kitchen knives and then wilted on polythene sheets under shade for 24 h. Following the procedure of Akinwande (2011), the WH pieces were then weighed on a kitchen scale and mixed in turn with each of the additives at the following inclusion levels (W/W) to obtain the silage types:

WHS = 95 % WH + 5 % S

WHCM = 95 % WH + 5 % CM

WHWO = 80 % WH + 20 % WO

WHBDG = 80 % WH + 20 % BDG

WHPKC = 80 % WH + 20 % PKC.

Each of the silage mixture was now packed into a large polythene bag, thoroughly compacted while filling in so as to displace pockets of air. After filling, each bag was tied with twine before placing inside a 65 litre capacity basin for reinforcement and stabilization. About 25 kg sandbag was placed on top of each container to weigh down the content to promote anaerobic conditions. Each silage type was replicated thrice and fermentation was for 42 days (Babayemi, 2009).

2.3. Physical and chemical evaluation of silage

After 42 days, the fermentation of each of the silages was terminated and silo opened for quality assessment using the procedure of Babayemi (2009). Quality characteristics looked at were colour, texture, odour, temperature and pH. For colour assessment, a rotary colour chart was used for cross-matching; texture was by gripping a small sample in hand between the fingers to determine whether firm or watery. The odour test was as to whether silage was pleasant / fruity or odoriferous /unpleasant. For temperature of silage, a thermometer was dipped into the midst of silage immediately after opening and left in place for about 5 min before taking a reading. The pH of silage was taken using a glass electrode pH meter.

2.4. Chemical Analysis

Samples were taken from different depths in a silo, mixed and dried in an oven, first at 65°C to inactivate the enzymes and later at 80°C to constant weight for dry matter determination. The samples were later milled and stored in sample bottles. Later, crude protein, crude fibre, ether extract and ash were determined in the laboratory by the standard procedure of AOAC (2005). Also, another set of samples were analysed for their fibre detergent fractions according to the methods of Van Soest et al. (1991). Every analysis was done in triplicate.

Other nutritive value parameters were done by calculations following the procedure of Horrocks and Vallentine, 1999, cited by Baba et al. (2018).

$$\text{DDM} = 88.9 - (0.779 \times \text{ADF \% dry matter basis})$$

$$\text{DMI} = (120/\text{NDF \% dry matter basis})$$

$$\text{RFV} = (\text{DDM\%} \times \text{DMI\%} \times 0.775)$$

Where, DDM = digestible dry matter, DMI = dry matter intake and RFV = relative feed value.

2.5. Statistical analysis

All generated data were analysed using analysis of variance procedure of SAS (2003). Significant treatment means were compared and separated by the Duncan multiple range F-test (1955). Experimental model for the analysis was:

$$Y_{ij} = \mu + \alpha_i + \epsilon_{ij}$$

Where, Y_{ij} = the studied parameters or individual observations, μ = general mean of the population, α_i = effect of additive type on silage and ϵ_{ij} = residual error.

3. RESULTS AND DISCUSSIONS

The colour, texture and odour characteristics of water hyacinth silages using different additives are presented in Table 1. The colour varied from brownish or dark green to yellowish green suggesting good fermentation of silage.

Table 1: Colour, texture and odour characteristics of water hyacinth silages treated with different additives

Treatment	Colour	Texture	Odour
WHS	Brown Green	Firm	Pleasant

WHCM	Dark Green	Firm	Pleasant
WHWO	Yellow Green	Firm	Pleasant
WHBDG	Dark Green	Firm	Pleasant
WHPKC	Dark Green	Firm	Pleasant

(WHS= Water hyacinth sucrose treated silage; WHCM= Water hyacinth cracked maize treated silage; WHWO= Water hyacinth wheat offal treated silage; WHBDG= Water hyacinth brewer dry grain treated silage; WHPKC = Water hyacinth palm kernel cake treated silage).

A well fermented silage is expected to exhibit a colour similarity to the actual forage ensiled (t'Mannetje, 1999, cited by Babayemi 2009). The water hyacinth in its natural state is known to have a very intense green colouration which usually turns yellowish-green following a 24 h wilting exercise. The texture for the silages was firm, also expected of a good silage (Kung and Shaver, 2002, cited by Babayemi 2009). Odour-wise, all the silages came out with pleasant odour buttressing the fact that all additives might have contributed positively to making good silages. This agrees with the findings of Abegunde et al. (2017) who fermented water hyacinth with bread fruit.

Figure 1 depicts the temperature developed in the silage mass. Temperature ranged from 27.5 to 28.0°C. This was consistent with value (26.0-27.5°C) obtained by Babayemi (2009) in a Guinea grass silage study. According to the author, this indicated a well preserved silage as temperature is one of the factors that could affect silage colour. The less the temperature, the less the likelihood of colour change in a silage. It is

posited further that a higher temperature than 30°C could result in caramelisation of sugars in a forage. In overheated silage, the colour change could give a black brown if

the temperature exceeds 55°C, Protein digestibility may be reduced out rightly (McDonald et al., 1981).

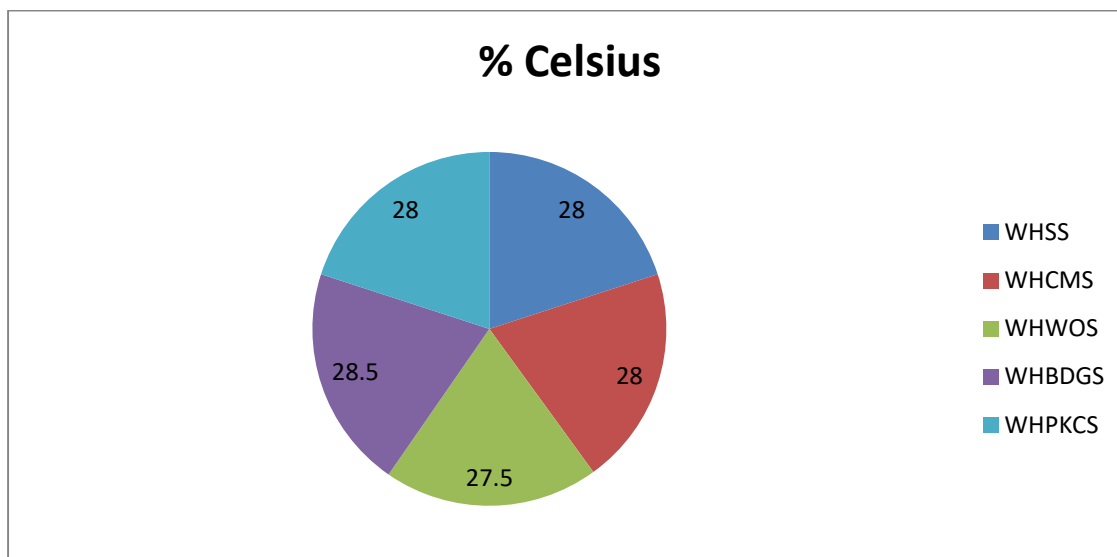


Figure 1: The temperature of ensiled water hyacinth

(WHSS= Water hyacinth sucrose silage; WHCMS= Water hyacinth cracked maize silage; WHWOS= Water hyacinth wheat offal silage; WHBDGS= Water hyacinth brewer dry grain silage; WHPKCS; Water hyacinth palm kernel cake silage).

The pH values of the silages are shown in figure 2. These ranged from 2.8 to 3.45 which may be regarded as good silages as Meneses (2007) had classified a good silage to be below 5.5 pH and McDonald et al. (1981) had classified silage categories as lactate silages (pH 3.7 to 4.2), acetate silages

(pH 4.2 to 5.0) and butyrate silages (pH 5.0 to 6.0) in a descending order of quality. By this categorisation, all five silages in this study fell within the best (i.e. lactate silages). The silage stability obtained in this study was better than that obtained by Abegunde et al. (2017) who recorded a pH range of 4.45 to 5.40. Difference in the two observations could be explained to be the result of using different additives and to a lesser extent, management procedure.

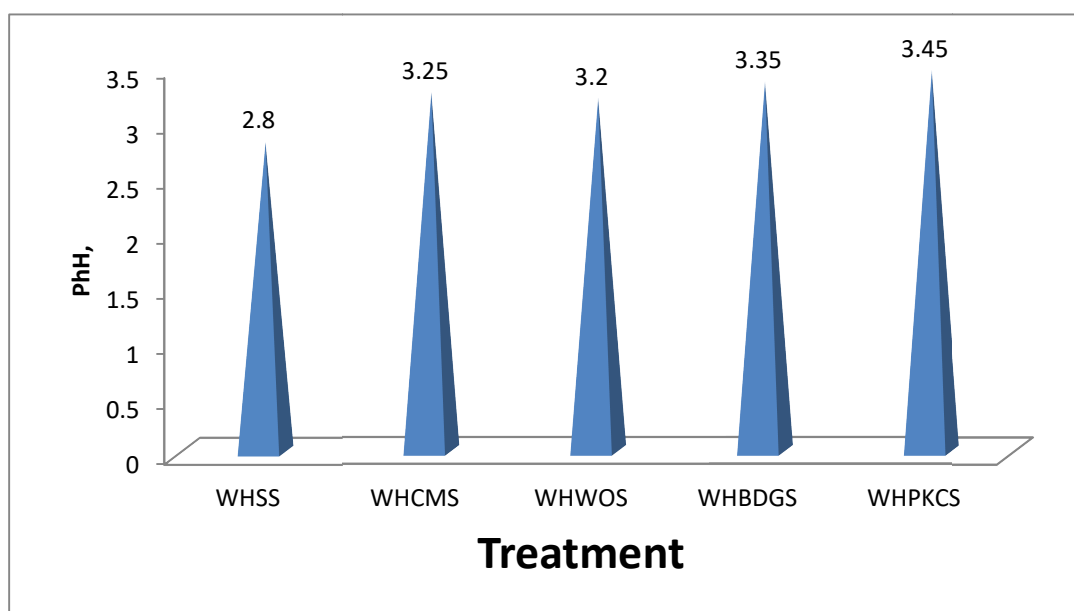


Figure 2: pH of water hyacinth silages treated with different additives

(WHS = Water hyacinth sucrose treated silage; WHCM = Water hyacinth cracked maize treated silage; WHWO= Water hyacinth wheat offal treated silage; WHBDG = Water hyacinth brewer dry grain treated silage; WHPKC = Water hyacinth palm kernel cake treated silage).

The dry matter (DM) levels of the silages are presented in Figure 3. The DM (%) ranged significantly ($p < 0.05$), from 11.34 (WHS, sucrose treated silage) to 22.39 (WHBDGS silage). The observed difference in DM was expected indicating properties of each individual additive. For example, WHS silage having the lowest dry matter, behaved

to type as the additive sucrose could not have made any appreciable contribution to DM. In agreement, Akinwande (2011) had obtained an equivalent DM of 9.84 % for a fresh unfermented sample of water hyacinth. The DM values of WHCM, WHWO, WHBDG and WHPKC silages obtained in the present study were within the range (14.21 to 28.44 %) obtained by Abegunde (2017). In light of the above, the WHS silage would appear inferior to others for nutritional sustenance. Caution should therefore be observed when using sucrose treatment in silage because of low dry matter.

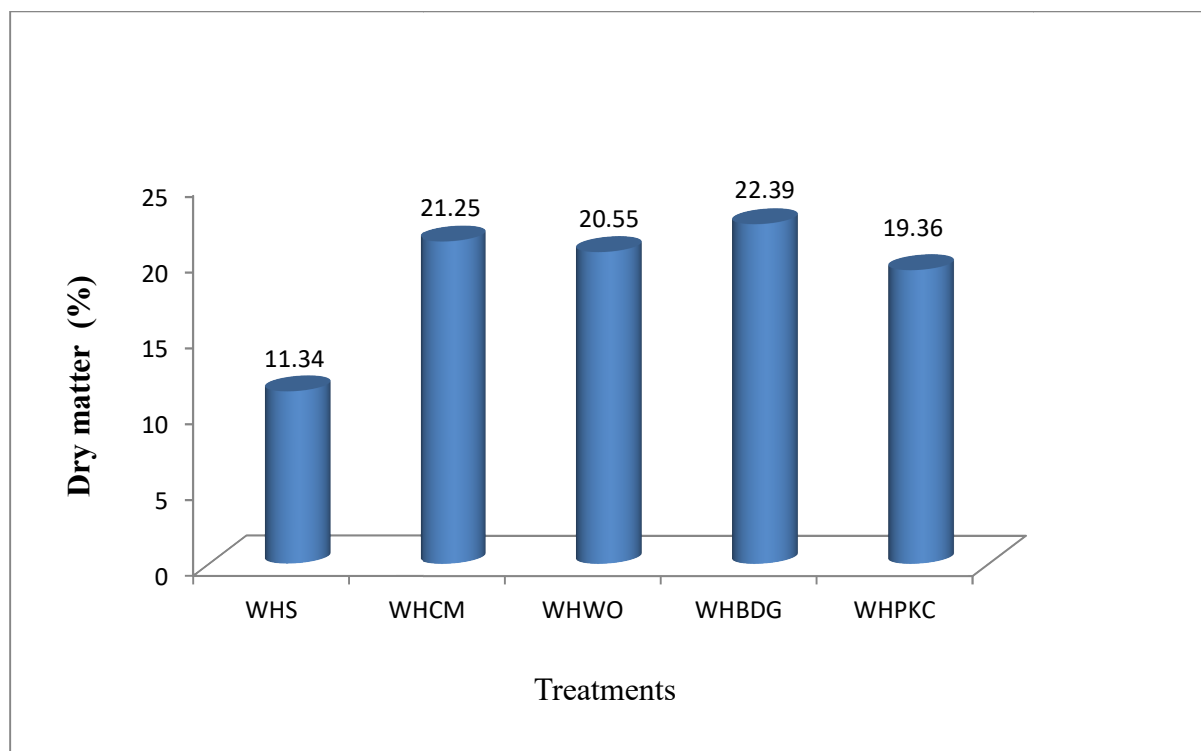


Figure 3: Dry matter (%) of water hyacinth silages treated with different additives

(WHS = Water hyacinth sucrose treated silage; WHCM = Water hyacinth cracked maize treated silage; WHWO = Water hyacinth wheat offal treated silage; WHBDG = Water hyacinth brewer dry grain treated silage; WHPKC = Water hyacinth palm kernel cake treated silage).

The table given in Table 2 depicts the proximate fractions of ensiled water hyacinth treated differently with additives sucrose, cracked maize, wheat offal, brewer dry grain and palm kernel cake.

Table 2: The proximate composition of water hyacinth silages treated with different additives (%)

Treat	CP	CF	EE	Ash
WHS	18.55c	10.52e	6.15a	10.12c
WHCM	13.27e	15.01a	2.11d	10.10c
WHWO	15.01d	13.40d	2.01e	12.27b
WHBDG	23.25a	14.01c	5.01b	14.01a
WHPKC	20.10b	23.34a	2.86c	10.14c
SEM	0.31	0.30	0.05	0.01

(WHS = Water hyacinth sucrose treated silage; WHCM = Water hyacinth cracked maize treated silage; WHWO = Water hyacinth wheat offal treated silage; WHBDG = Water hyacinth brewer dry grain treated silage; WHPKC = Water hyacinth palm kernel cake treated silage).

There were significant differences ($p < 0.05$) in crude protein, crude fibre, ether extract and ash. Crude protein level ranged from 13.27 (WHCM silage) to 23.25% (WHBDG silage) higher than values previously obtained by Akinwande (2011) and Abegunde (2017). The variation could be explained on the basis of additive types used. The range of protein reported in this study was above the 7.7% recommended for small ruminants by NRC (1981) and 10-12% recommended by ARC (1985). It thus appears that the silages were good enough for small ruminants without the problem of protein supplementation. Crude protein ranking would be:

$$\text{WHBDG} > \text{WHPKC} > \text{WHS} > \text{WHWO} > \text{WHCM}$$

The crude fibre range obtained (10.5 to 23.3 %) was also in agreement with both Akinwande (2011), (12.4 to 21.4 %) and Abegunde (2017).

The fibre detergent fractions of the silages using different additives are presented in Table 3. The neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were significant and different ($p < 0.05$). The NDF and ADF ranged from 58.77 to 68.01 % and 20.31 to 40.82 % respectively. Forages display wide differences in their fibre content which is a good estimate of how digestible the forage is and how much of it an animal will eat.

Table 3: The fibre detergent composition of water hyacinth silages treated with different additives (%)

Treatment	NDF	ADF	ADL
WHS	63.24b	20.31e	9.84b
WHCM	60.36e	21.41c	7.15d
WHWO	58.77d	20.80d	5.00e
WHBDG	69.31a	24.00b	10.81c
WHPKC	68.01a	40.82a	18.20a
SEM	0.61	0.32	0.25

(WHS = Water hyacinth sucrose treated silage; WHCM = Water hyacinth cracked maize treated silage; WHWO = Water hyacinth wheat offal treated silage; WHBDG = Water hyacinth brewer dry grain treated silage; WHPKC = Water hyacinth palm kernel cake treated silage).

While NDF controls voluntary feed intake (VFI) of animals, the ADF controls digestibility. Both NDF and ADF maintain an inverse relationship with VFI and digestibility respectively. Judging by the high levels of NDF and ADF in all the silages in this study, it is obvious that they are best suited for ruminants. From the ADF values, digestibility in PKC and BDG treated silages would be compromised whereas WO treated silage was better than the conventional additive, cracked maize. Similar trend was presented in the case of NDF values with regards to VFI. With regards to intake and digestibility, superiority order could be ranked thus:

$$\text{WHS} > \text{WHWOS} > \text{WHCMS} > \text{WHBDG} > \text{WHPKC}$$

Table 4 presents additive type effect on dry matter intake, digestible dry matter and relative feed value of the silages. All the three parameters were significantly different ($p < 0.05$). The RFV of both wheat offal treated and cracked maize treated silages were greater than others. The DMI followed same trend.

Table 4: DMI, DDM and RFV characteristics of water hyacinth silages treated with different additives

Treat	DMI	DDM	RFV
WHS	1.90c	73.08a	107.61c
WHCM	1.99b	72.22b	111.38b
WHWO	2.04a	72.70b	114.94a
WHBDG	1.73d	70.20c	94.12d
WHPKC	1.76d	57.10d	77.88e
SEM			

(WHS = Water hyacinth sucrose treated silage; WHCM = Water hyacinth cracked maize treated silage; WHWO = Water hyacinth wheat offal treated silage; WHBDG = Water hyacinth brewer dry grain treated silage; WHPKC = Water hyacinth palm kernel cake treated silage; DMI = dry matter intake; DDM = digestible dry matter; RFV = relative feed value.

On the basis of this, ranking of the silages would go thus:

WHWOS > WHCM > WHS > WHBDGS > WHPKCS

Similarly observed by Baba et al, (2018), it should be noted that the wheat offal treated silage had the highest values of DDM, DMI and RFV. This could be explained that the silage had the lowest value of the fibre

components, NDF, ADF and CF which are all involved in digestibility. The DDM did not follow similar trend. The sucrose treated silage gave the highest value while the others were without a trend. This observed effect can plausibly explain to be due to the differential digestibility levels of the various additives used. Sucrose on its own merit is expected to be more digestible than maize, wheat offal, brewer dry grain or palm kernel cake. While sucrose is a disaccharide, the other additives are impregnated with mainly hemicelluloses and polysaccharide starch or cellulose which are not as digestible as sucrose.

4. CONCLUSION

This study indicated highest values in DMI, RFV, second to highest in DDM but lowest in NDF, ADF, ADL and second to lowest in CF (all fibre fractions) for the wheat offal treated silage compared to other silages suggesting the best qualities, better than sucrose and cracked maize treated silages. Although the crude protein (15.0 %) of the wheat offal treated silage ranked second lowest than others, it was far higher than the critical 7-7 % NRC (1981) stipulated for ruminants. Because silage WHWO was found to be superior in quality than WHS and WHCMS, it can therefore be recommended that wheat offal can be used as a replacement additive for either sucrose or maize which is costlier.

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