SILAGE CHARACTERISTICS OF ENSILED MIXTURE OF CABBAGE WASTE, WHEAT OFFAL, DRIED CASSAVA WASTE AND BREWERS SPENT GRAINS

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Abstract
An investigation was carried out on the physicochemical properties, proximate composition and phytochemical composition of ensiled cabbage waste, wheat offal, dried cassava waste and brewers spent grains. The agro by products were mixed as - T1 (0% cabbage wastes: 30% cassava waste: 20% wheat offal: 50% BSG), T2 (5% cabbage waste: 30% cassava waste: 15% wheat offal: 50% BSG), and T3 (10% cabbage waste: 30% cassava peels: 10% wheat offal: 50% BSG). The quality characteristics (colour, odour, pH, temperature and texture), proximate composition (crude protein, crude fibre, ether extract, ash and nitrogen free extract) and phytochemical composition (tannin, hydrocyanide, lactate, ammonia nitrogen and saponin) were assayed. The resulting silage was characterized by brown to brownish green colour and the odour was generally alcoholic. The pH range was from 6.15 – 6.70 and temperature ranged from 36ºC to 37ºC while texture was moist. The proximate composition of the ensiled mixtures ranged from 50.34 % (T2) - 56.27 % (T3) dry matter; 14.00 % (T1) – 14.70 % (T2) crude protein and 19.75 % (T2) – 33.56 % (T1) crude fibre. The phytochemical analysis revealed that the silages ranged in the contents of tannin (5.23 mg/g – 5.61 mg/g), hydrocyanide (2.35 mg/g – 4.21 mg/g), lactate (1.82 % - 2.36 %), ammonia nitrogen (2.24 % - 2.35 %) and saponin (3.46 mg/g – 4.18 mg/g). The results of the study concluded that cabbage wastes could be included up to 10% in ruminant diet during periods of drought instead of allowing them to constitute a nuisance to the environment and man.

Keywords: Cabbage wastes, phytochemicals, proximate composition, quality characteristics, silage

Description of Problem

Increased livestock productivity is largely determined by the availability of feed in terms of quality, quantity and continuity (Baris, 2023). The availability of feed is very volatile because of its dependence on seasonal changes. Forage production such as grasses and cereals will increase during the rainy season, which has an impact on increasing biomass production (Despal *et al.*, 2011). Conversely, in the dry season, the production capacity decreases prominently which in-turn affects the productivity of livestock negatively. Imperatively, it is necessary to look for alternative solutions or technology in order to make sure that the availability of feed remains guaranteed throughout the year (Jasin, 2014). One simple technology that can be done is the development of silage making, especially complete silage (Nahak *et al.*, 2019). Silage is animal feed preserved through the process of acylation, which is the process of preserving feed or forage by using the mechanism of spontaneous action of lactic acid fermentation under anaerobic conditions. Silage can be made from a single material or a mixture of other materials that is called complete silage (Thalib *et al.*, 2000). Fortunately, Nigeria is endowed with vegetable and fruit by-products (wastes) that are derived from processing food for human consumption, which are discarded because of poor quality, or damaged during harvest (Gertenbach and Dugmore, 2004), that can be used for animal feeding. Cabbage wastes (*Brassica oleracea*), a vegetable by-product that is readily available in Nigerian cities is reputed to be high in moisture content (86% - 91.40%) and includes between 13.70% and 28.00% of crude protein, and 18.60% of crude fiber (Gupta *et al.*, 1993; Mekasha *et al.*, 2002). If not ensiled, due to its high moisture content, this vegetable wastes deteriorates and is discarded. Hence, it would have to be combined with other high dry matter feedstuff for successful feeding (Nkosi and Meeske, 2010). Incorporation of these by-products in the diets of ruminants has

been reported to reduce the risk of acidosis, which is associated with high grain diets (Ferreira *et al.*, 2011). Ensiled cabbage wastes when combined with other ingredients such as wheat offal, dried cassava wastes, and brewers spent grains, could create a balanced and nutritionally-rich silage mixture (Taiwo, and Ogunmodede, 2018). In order to avoid environmental pollution resulting from wastes of cabbage rejects, then it becomes pertinent to harness its potential by ensiling it into stable feed with a high recovery of dry matter and highly digestible nutrients compared to fresh (Kung *et al.*, 2018). The production of silage is favoured because it is less reliant on the weather, ensures that nutrients are preserved, and can be stored for a long time (Adegun and Ososanya, 2023). The purpose of this study, therefore is to evaluate the levels of inclusion of cabbage wastes into mixture of wheat offal, dried cassava wastes and brewers spent grains for silage making and the quality of the resultant product in terms of its physical attributes and chemical constituents.

Materials and Methods

Experimental Site

The study was conducted in the sheep unit, Teaching and Research Farms, University of Uyo. It is located at The University of Uyo Annex campus in Uyo Local Government Area of Akwa Ibom State, which lies in South-Southern Nigeria between latitudes 4°58´N and 5°04´N and longitudes 7°51´E and 8°01´E, with an elevation of about 60.96 m above sea level (Meteorological station Uniuyo, 2024). This area falls within the rainforest region and experiences a typical climate characterized by high temperatures and humidity.

Collection and Preparation of Experimental Materials

The Brewers spent grains used for this experiment was purchased from Champions Brewery in Uyo, Akwa Ibom State, Cabbage waste was purchased from Itam Market cabbage traders, the wheat offal was purchased in a shop where animal feeds are sold, while the silo polythene was purchased in a supermarket and the dried cassava peels were gathered from different sources free of charge.

Silage preparation

The preparation was conducted few days after the aforementioned materials were available. The preparation also needed other items, such as 20-litres plastic drums, for the storage of the silage and nylons for the coverage to avoid penetration of air and moisture. The cabbage waste was shredded into smaller pieces of 5 cm length for ease of mixing and the agro by products were mixed as follows, as seen in Table 1, - T1 (0% cabbage wastes: 30% cassava waste: 20% wheat offal: 50% BSG), T2 (5% cabbage waste: 30% cassava waste: 15% wheat offal: 50% BSG), and T3 (10% cabbage waste: 30% cassava peels: 10% wheat offal: 50% BSG). The drums containing the various treatments were stored in a safe place away from rain and heat. The mixtures were allowed to ensiled for 21 days. At the end of the 21 days, the silos were opened and samples taken (top and bottom of silo) out for analysis.

Table 1: Gross Composition (%) of the Experimental Diets

Parameters	T1	T2	T3
Cabbage wastes	0	5	10
Wheat Offal	20	15	10
Dried Cassava Peels	30	30	30
Brewers Spent Grains	50	50	50
Total	100	100	100

Qualitative Assessment of the Silage

Temperature was determined by dipping a laboratory thermometer inside the silo to a depth of 5 cm. The colour assessment was done using visual observation and colour chart. Odour was assessed and characterized by three different people. The pH was determined using a pocket pH metre (Hannah Instruments Hi98107) whereby a silage sample weighing 100g was immersed in 100ml of distilled water. The texture was determined by feeling the sample by three different people.

Phytochemical Determination

The phytochemical composition (Tannin, phytic acid, ammonia nitrogen and saponin) of the silage were determined using the techniques described

by (Raimi and Adeloye, 2022). The tannin was determined using the Folin-Coicalteu method. Phytic acid was determined using High Performance Liquid Chromatography after it was extracted by means of an acid solution. Ammonia nitrogen was determined using the Nesslerization Method while Saponin was determined using the Liquid Chromatography-Mass spectrometer method.

Determination of proximate composition and Silage quality

Fresh silage samples collected and analyzed at the laboratory. The silage samples for proximate analysis were oven dried at 60°C and subsequently ground to pass through a 2mm sieve. The samples of silage were used for proximate analysis to determine crude protein, crude fiber, ether extract and ash using the method outlined by (AOAC, 1990).

Results and Discussions

Silage Qualitative of Ensiled Mixture of Cabbage Waste, Wheat Offal, Dried Cassava Peels and Brewer's Spent Grains

Silage Characteristics of ensiled mixtures is presented in Table 2. The colour obtained from (T1) was brown, while T2 and T3 were brownish green. Good silage usually preserves its original colour and has a pleasant and fruity smell which is characteristics of a good quality silage (Soetan 2008). According to (Pond *et al.,* 2004), a good silage has alcoholic odour and this was found in all the treatments. The pH level of T1 was 6.70, T2 was 6.53 and T3 was 6.15. The pH of the silage for each treatment was slightly acidic and relatively higher than the range classified for a good silage (3.5 - 4.2) (Ma *et al.,* 2008). The high pH observed in this silage could be an indication that there was a limited production of lactic acid during fermentation process.

Phytochemical Composition of Ensiled Mixture of Cabbage Waste, Wheat Offal, Dried Cassava Peels and Brewer's Spent Grains

The result of the phytochemical composition of the ensiled mixtures is presented in Table 3. Phytochemicals have been studied extensively for their potential health-promoting effects in animals (Raimi and Adeloye, 2022) and the process of fermentation (ensiling) has also been found to reduce their composition in forages (Sahoo, 2018; Wang *et al.,* 2022).

Table 2: Silage Characteristics of ensiled Mixture

Parameters	T1	T2	T3
Colour	Brown	Brownish greenish	Brownish green
Odour	Alcoholic	Strongly Alcoholic	Alcoholic
pH	6.70	6.53	6.15
Temperature ^{0}C	36	37	36
Texture	Moist	Moist	Moist

Tannin, despite possessing antioxidant and therapeutic qualities, are known to reduce the bioavailability of some essential and non-essential complexes, which lead to increased rumen escape of dietary protein and increase in microbial protein outflow. The Tannin in this study was within the range outlined by (Sahoo 2018) for a good quality silage. The HCN range in this study was above the required level of HCN (200ppm) found in a well-made silage as stated by (Wanga and Abera, 2020) probably due to cassava peels inclusion level. The high level of HCN in the silage tends to posit adverse effects on the livestock. Lactic acid contents in this study were below the required range (3% - 8%) for a well-made silage. Thus, it led to increase in the pH level of the silage. The levels of acetic acid are slightly below the required range of a good silage (2% - 3%) and saponin was above the range (0.5 – 2.0 %) as reported by (McDonald *et al.,* 1991).

Table 3: Phytochemical composition of ensiled mixture

Parameters	T1	T2	T3
Tannin mg/g	5.22±0.03	5.23±0.04	5.61±0.04
HCN mg/g	2.36±0.05	3.54±0.03	4.21±0.03
Lactic acid %	2.21±0.01	2.36±0.01	1.82±0.01
Acetic acid %	1.40±0.02	1.58±0.01	1.22±0.02
Saponin %	3.77±0.00	4.18±0.01	3.40±0.01

Mean ± SD of 3 determinations; SD - Standard Deviation

Proximate Composition of Ensiled Mixture of Cabbage Waste, Wheat Offal, Dried Cassava Peels and Brewer's spent Grains

The result for the proximate composition of the ensiled mixtures is presented in Table 4. In this study the moisture content (T1 = 47.72%, T2 = 49.66, and T3 = 43.7) obtained, were below the normal moisture of 60 - 70% required for good silage. This corroborates the high value of pH obtained in this study. This implied that fermentation was not efficient and thus leading to the unavailability of fermentation byproduct such as Lactic acid (Obua, 2005). Silage with low moisture content is at a higher risk of aerobic spoilage by molds and yeasts, which can lead to a decrease in quality and palatability (He *et al.*, 2016). The crude protein (CP) content ranged from 14.00 %CP (T1) to 14.70 %CP (T2). The normal or required level of CP in good silage should be between 6 – 10 %CP, and this could meet the requirement of ruminants (Babayemi *et al.*, 2010). The ammonia (NH_3H) level in the silage ranged from 2.24 % (T1) to 2.35 % (T2) which was within the normal percentage range of a good silage (1 - 3%).

Table 4: Proximate composition (%) of ensiled Mixture

Parameters	T1	T2	T3
Moisture	47.72±0.001	49.66±0.002	43.70±0.001
Ash	7.39±0.003	5.02±0.002	6.77±0.002
Lipid	5.36±0.001	3.69±0.001	4.86±0.003
CP	14.00±0.05	14.70±0.03	14.35±0.02
CF	33.56±0.02	19.75±0.02	20.85±0.02
CHO	49.69 ± 0.04	56.84 ± 0.04	53.17 ± 0.02
NH_3H	2.24 ± 0.002	2.35 ± 0.03	2.30 ± 0.01
Dry Matter	52.28 ± 0.01	50.34 ± 0.01	56.27 ± 0.01

Mean ± SD of 3 determinations; SD - Standard Deviation CP= crude protein, CF= crude fibre

Conclusion and Applications

Based on the findings of this study, it can be concluded that ensiling the mixture of cabbage waste, wheat offal, dried cassava peels and brewers spent grains yielded promising result and is capable of supporting ruminants during the period of feed scarcity. It can be recommended that its utilization by ruminants would further validate its potentials as an offseason mixed ration.

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