Research Article

Nutritive Value and In-Vitro Digestibility of Blended Ratios of Wheat Offal and Wet Sorghum Brewer Residue as Feed for Livestock

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Received: 6 August 2025; Revised: 22 September 2025; Accepted: 23 September 2025

Abstract

The use of agro-industrial by-products as animal feeds has been a matter of interest for the last few decades. Hence, this study evaluated the chemical composition, volatile fatty acid profile, and in-vitro digestibility of blended ratios of wheat offal and wet sorghum brewer residue. Fresh wet sorghum brewer residue (WSBR) was collected from local gin (Burukutu) producers and blended with wheat offal (WO) on a weight-for-weight basis in the following rations: 1WO:1WSBR, 1WO:1.5WSBR, 1WO:1.2WSBR, 1WO:2.5WSB, 1WO:1.3WSBR, and 1WO:3.5WSBR, arranged in a Completely Randomized Design. The blends were air-dried for 3 days at 39 °C. Samples of blended ratios were analyzed for chemical composition, volatile fatty acids profile, and in-vitro digestibility using standard procedures. The dry matter contents of ratios 1:1, 1:2, 1:2.5, 1:3, and 1:3.5 were significantly higher ($p < 0.05$) than the 1:1.5 ratio. The crude fibre content significantly increased ($p < 0.05$) as the proportion of WSBR increased in the blends. The carbohydrate fractions of ratios 1:2, 1:2.5, and 1:3 were significantly higher ($p < 0.05$) than those of ratios 1:1 and 1:1.5. The neutral detergent fibre was significantly higher ($p < 0.05$) in ratio 1:3.5 than in other blended ratios. Furthermore, the hemicellulose content was significantly higher ($p < 0.05$) in ratios 1:1.5, 1:2.5, and 1:3 than in ratio 1:1, and was lowest in 1:3.5. However, ratios 1:1 and 1:1.5 had significantly higher ($p < 0.05$) acetic, propionic, butyric, valeric, and lactic acid contents than the other ratios. Notably gas production was significantly highest ($p < 0.05$) in ratio 1:1 from 3 to 24 hours of in-vitro digestibility compared to other ratios. It could be concluded that blended ratios of wheat offal and wet sorghum brewer residue improved nutrient availability for livestock animals; however, ratios 1:1 and 1:1.5 produced more in-vitro gases, while ratios 1:1, 1:1.5, and 1:2 showed superior dry matter digestibility.

Keywords: Nutritive value, In-vitro digestibility, Fatty acids, Wheat offal, Wet brewer residue

Introduction

Agricultural by-products are good alternative feed for ruminants and are reported to be economical, viable, and environmental concerns (Rahman et al., 2013). These by-products can have different applications or uses. One valuable possibility in the field of animal nutrition is the recycling of these materials as alternative feedstuffs, in particular for herbivores (Salami et al., 2019). The use of agro-industrial by-products as animal feeds has been a matter of interest for the last few decades according to Vasta et al. (2008). By-products with high energy content could replace grains in the ration (Abo-Zeid et al., 2017), whereas those with high fibre content might replace roughage (Salman et al., 2014). Brewer's grains are a highly variable by-product, whose composition and nutritional value depend on the grain used, the industrial process (e.g., temperature, fermentation), and the method of preservation. Brewer's grains are sold wet or dried, and can be ensiled (Blezinger 2003). Wet brewery waste is a typical example of alternative feed, being used in diets for ruminants due to its high nutritional content, especially energy and protein, and great availability along the year for a low cost, which may minimize the costs of animal feeding (Souza et al., 2012). However, the wet brewery waste presents a low dry matter content (ranging from 9 to 30%), which represents an expressive limiting factor for its effective use, causing problems for transport, storage, and preservation of this by-product (Geron et al., 2007). The high moisture content and storage conditions of the wet brewery waste under aerobic environment, commonly used on farms, provide ideal conditions for the development of microorganisms, mainly filamentous fungi (Souza et al., 2012). These fungi promote the degradation of the waste' nutrients and can produce toxins that affect animal metabolism. Difficulty in the conversion of high-moisture by-products arises from high cost of drying equipment and lack of simple and appropriate alternatives (Makinde and Sonaiya 2010). Makinde and Sonaiya (2007) developed a quick method (maximum of 4-h drying period) to convert such wet sorghum brewer residue using vegetable carriers (wheat offal) as absorbents. The wheat offal prevents nutrient seepage while enhancing drying. Therefore, this study aimed to determine the nutritive value and in-vitro digestibility of blended ratios of wheat offal and wet sorghum brewer's residue.

Materials and methods

Experimental location

This study was conducted at the Department of Animal Health and Production Technology, The Oke Ogun Polytechnic, Saki Teaching and Research farm, located at longitude 8.6275°N and latitude 3.4058°E in Oyo State, Nigeria.

Processing of wheat offal and sorghum brewer wet waste blended ratios

Wheat offal (WO) was purchased from a reputable feed mill while fresh wet sorghum brewer residue (WSBR) was collected in polyethylene woven sacks from local gin (Burukutu) producers in Ago Are at ATISBO Local Government Area of Oyo State, Nigeria. The blended ratios were mixed weight for weight: 1WO:1WSBR, 1WO:1.5WSBR, 1WO:1.2WSBR, 1WO: 2.5WSBR, 1WO:1.3WSBR, and 1WO:3.5WSBR. The mixtures were air-dried by spreading thinly on black polythene sheets (0.7 mm thickness) in two replicates each on the concrete floor for 3 days at room temperature (39 °C). The dried blends were stored in high-density polythene bags and then kept in a cool dried place.

Chemical analysis

Samples of WSBR and blended ratios were analyzed for chemical composition (dry matter (DM), ash, crude protein, starch, neutral detergent fibre (NDF), and acid detergent fibre (ADF) following previously described methods. Specifically, feedstuff samples were oven-dried at 100 °C for DM (988.05) and for ash content by combustion at 600 °C (942.05) (AOAC 2012). Kjeldahl method (AOAC 2012) was used for N analysis and CP was determined based on N x 6.25. Furthermore, NDF and ADF were determined based on Mertens (2002). Oil

content was determined by the "Wiebul" acid hydrolysis method and ether extract (EE) content was measured by direct solvent extraction (Soxhlet 1879). Metabolizable energy (ME, MJ/kg DM) content was estimated using CP and EE contents (in g/kg DM) and the volume of gas measured after 24 h of incubation (G24 in mL per 200 mg DM incubated) as described by Menke and Steingass (1988):

$$ME = 2.43 + 0.1206 \times G24 + 0.0069 \times CP + 0.0187 \times EE$$

The carbohydrate was determined using the formula (DM basis) = 100 - (CP + EE + Ash + CF) while the Hemicellulose = NDF - ADF and Cellulose = ADF - ADL were estimated.

Determination of in-vitro gas production

Ruminal fermentation of the blended ratio samples was conducted using an in-vitro gas production technique described by Menke and Steingass (1988), as demonstrated previously by Santoso et al. (2019). Briefly, 300 ± 5 mg of the oven-dried samples were put into 100 mL glass syringes (3 replications per sample) (Model Fortune, Häberle Labortechnik, Germany). Syringes were filled with 30 ± 1.0 mL of rumen fluid-buffer mixture and placed in a water bath at 39 °C for 48 hours. Each syringe was then gently shaken by hand every 8 hours. The gas production from each syringe was recorded before incubation (0 h) and after 3, 6, 9, 12, 15, 18, 21, and 24 hours of incubation. The gas production was blank-corrected, adjusted to standard temperature and pressure (STP), and expressed per unit of substrate (e.g., mL/200 mg DM). The sample of about 10 mL of the syringe content was drawn at the end of the incubation period. The pH of the medium was immediately measured using a digital pH meter (Hanna, Hi 8520, Ronchi di Villafranca, Italy). Two milliliters of sub-sample were added to 2 mL of 20 g/L (w/v) NaCl for NH3-N analysis. The in-vitro dry matter digestibility (IVDMD) was done using the formula of Tilley and Terry (1963):

$$IVDMD\ (\%) = \frac{M - (U - B)}{M} \times 100$$

Where: M is the weight of dry matter incubated (g), U is the weight of undigested dry residue after incubation (g), and B is the mean dry matter residue from the blank (g).

Determination of volatile fatty acids

Volatile fatty acids (VFAs) in the blended ratio samples were determined following the procedures of Erwin et al. (1961) and Playne (1985), with slight modifications. Approximately 2.0 g of fresh or ground feed was weighed into a 50 mL centrifuge tube and mixed with 10 mL of distilled water containing an internal standard (2-ethylbutyric acid). The mixture was homogenized, centrifuged at 4,000 x g for 10 min at 4 °C, and the supernatant was transferred to a clean tube. To stabilize VFAs and precipitate proteins, 25% metaphosphoric acid was added at a ratio of 1:4 (v/v, acid:extract) to achieve a final concentration of 5%. The mixture was incubated on ice for 20 min, centrifuged at 10,000 x g for 10 min, and the clear supernatant was filtered through a 0.45 μm syringe filter into gas chromatography (GC) vials. VFA concentrations were quantified using a gas chromatograph (equipped with a flame ionization detector and a Nukol capillary column, 30 m x 0.25 mm x 0.25 μm). The injector and detector were maintained at 250 °C, and helium was used as the carrier gas at a flow rate of 1 mL/min. The oven program started at 60 °C (2 min), increased by 10 °C/min to 150 °C, and was held for 5 min. One microlitre of each sample was injected, and VFAs were identified by comparing retention times with those of external standards (acetate, propionate, butyrate, iso-butyrate, valerate, iso-valerate, and caproate). Concentrations were calculated using calibration curves constructed from VFA standards, and results were expressed as grams per kilogram of feed dry matter.

CH_4 production estimates

Before sample injection, a five-point (25,000, 50,000, 75,000, and 100,000 ppm) standard curve for CH_4 was created to allow calculation of CH_4 concentrations of samples using peak area. Following the gas pressure readings and for each reading time point, a sample (10 mL) of gas was collected from each flask using a two-way valve on the pressure transducer and was manually injected into a gas chromatograph (Bruker 450 GC) via the port valve to

determine the CH_4 concentration. Full column and GC conditions were previously reported (Munoz et al., 2012). Gas components were separated on a CH_4-packed Poropak N column (1.2 m length, 2 mm i.d. Varian Inc., Walnut Creek, CA), and CH_4 was detected using a flame ionization detector. The CH_4 concentrations were applied to calculated gas volumes to obtain CH_4 volume. For each reading time point, the CH_4 volumes were expressed as cumulative CH_4 yield was measured in mL/g substrate. Similar to the gas dataset, cumulative CH_4 yield curve profiles were fitted based on the model described by France (1993).

Data analysis

The data collected were subjected to a one-way analysis of variance procedure of the General Linear Model of SAS (2002) version 9.0. Significant means ($p < 0.05$) were separated using the Duncan New Multiple Range Test. The following statistical model was applied to the data analysis:

$$Y_{ij} = \mu + F_i + E_{ij}$$

Where: Y_{ij} = all independent variables, μ= overall mean, F_i = effect of blended ratios, and E_{ij} = random error.

Results

Chemical composition of WO:WSBR blended ratios

The values for the chemical components of wet sorghum brewer residue were far lower than the various blended ratios (Table 1). There were significant differences ($p < 0.05$) among all chemical components across the blended ratios except for crude protein, metabolizable energy, and cellulose contents. The dry matter contents of ratios 1:1, 1:2, 1:2.5, 1:3, and 1:3.5 were significantly ($p < 0.05$) higher than 1:1.5 ratio. The crude fibre content significantly increased ($p < 0.05$) as the blended ratios increased. The carbohydrate fractions of 1:2, 1:2.5, and 1:3 were significantly higher ($p < 0.05$) than that of ratios 1:1 and 1:1.5. The neutral detergent fibre was significantly higher ($p < 0.05$) in ratio 1:3.5 than other blended ratios. However, there were no significant differences ($p > 0.05$) among the gross energy and cellulose contents of the blended ratios. The ratio 1:3.5 had significantly higher ($p < 0.05$) neutral detergent fibre, acid detergent fibre, and acid detergent lignin than the other blended ratios. However, ratios 1:1.5, 1:2.5, and 1:3 had significantly higher ($p < 0.05$) hemicellulose than 1:1 and 1:3.5 the least.

Volatile fatty acids content of WO:WSBR blended ratios

There were no significant ($p > 0.05$) differences in the pH and ammonia contents of the blended ratios (Table 2). However, ratios 1:1 and 1:1.5 had significantly higher ($p < 0.05$) acetic, propionic, butyric, valeric, and lactic acid contents than other ratios. Most volatile fatty acids values decreased with increasing blended ratios. Conspicuously, the total volatile fatty acid content was significantly highest ($p < 0.05$) in ratio 1:1 followed by 1:1.5, 1:2.5, 1:2, 1:3, and lowest in 1:3.5.

In-vitro gas production and digestibility of WO:WSBR blended ratios

There was no significant difference ($p > 0.05$) in gas production at 3 hours across the blended ratios (Table 3). Conspicuously, the gas production was significantly highest ($p < 0.05$) ratio 1:1 from 6 to 24 hours of in-vitro digestibility compared to other ratios. Furthermore, the methane and carbon dioxide gas produced were significantly ($p < 0.05$) higher in ratio 1:1 than other ratios. The in-vitro dry matter digestibility was significantly highest ($p < 0.05$) in ratios 1:2 and 1:1 followed by 1:3, 1:1.5, 1:3.5, and lowest in 1:2.5.

Table 1. Chemical composition of wheat offal and wet sorghum brewers waste blended ratios.

	Blended ratios							
Parameters (%)	**WSBR**	**1:1**	**1:1.5**	**1:2**	**1:2.5**	**1:3**	**1:3.5**	**SEM**
Dry matter	42.76	97.11^{a}	91.66^{b}	96.94^{a}	97.05^{a}	98.26^{a}	98.20^{a}	0.70
Crude protein	0.49	2.72	2.52	2.59	2.88	2.52	3.21	0.11
Crude fibre	17.34	13.84^{d}	14.98^{c}	14.75^{c}	16.21^{b}	15.86^{b}	19.57^{a}	0.49
Ether extract	2.62	8.77^{b}	9.66^{b}	9.77^{b}	9.99^{b}	9.53^{b}	10.19^{a}	0.21
Ash	1.41	16.38^{a}	8.06^{b}	8.11^{b}	7.62^{b}	8.59^{b}	8.61^{b}	0.92
Carbohydrate	20.90	51.72^{c}	51.08^{c}	61.96^{a}	61.12^{a}	61.09^{a}	57.13^{b}	1.36
ME (KJ/kg)	1050.00	2907.50	2886.00	2860.00	2835.50	2821.00	2892.50	18.49
NDF	22.19	36.10^{ab}	34.88^{b}	36.83^{ab}	36.21^{ab}	35.76^{ab}	37.24^{a}	0.78
ADF	14.34	21.28^{c}	17.81^{d}	23.72^{b}	20.84^{c}	18.38^{d}	24.21^{a}	0.67
ADL	9.23	12.65^{b}	11.56^{c}	13.87^{ab}	11.93^{c}	10.22^{d}	15.28^{a}	0.41
Hemicellulose	7.85	13.67^{b}	16.56^{a}	13.09^{b}	15.65^{a}	16.34^{a}	12.71^{c}	0.31
Cellulose	5.11	9.53	7.80	10.47	8.47	7.78	9.12	0.16

Superscript letters ($^{a-d}$) indicate that values with different superscripts are significantly different ($p < 0.05$).

Note: ME is metabolizable energy, NDF is neutral detergent fibre, ADF is acid detergent fibre, and ADL is acid detergent lignin.

Table 2. Volatile fatty acid profile of wheat offal and wet sorghum brewers waste blended ratios.

	Blended ratios							
Parameters (%)	**1:1**	**1:1.5**	**1:2**	**1:2.5**	**1:3**	**1:3.5**	***p*-value**	**SEM**
Acetic acid	30.90^{a}	28.93^{a}	15.12^{bc}	19.20^{b}	15.65^{bc}	12.12^{c}	0.0005	0.22
Propionic acid	31.36^{a}	27.73^{a}	14.69^{bc}	18.54^{b}	14.41^{bc}	12.43^{c}	0.0002	0.21
Butyric acid	2.43^{a}	2.31^{a}	1.49^{b}	1.46^{b}	1.43^{b}	1.19^{b}	0.0025	0.17
Valeric acid	27.07^{a}	23.47^{b}	14.46^{d}	17.35^{c}	13.75^{d}	12.14^{d}	<0.0001	0.18
Lactic acid	32.17^{a}	28.30^{a}	17.78^{b}	22.69^{ab}	18.6^{ab}	16.37^{b}	0.0545	0.21
TVFA	45.22^{a}	36.55^{b}	25.01^{d}	27.89^{c}	21.39^{e}	19.39^{f}	0.0002	2.76
pH	5.60	5.60	5.	5.65	5.45	5.10	0.3012	0.08
NH_3	0.38	0.30	0.35	0.28	0.28	0.28	0.4608	0.02

Superscript letters ($^{a-f}$) indicate that values with different superscripts are significantly different ($p < 0.05$).

Note: TVFA, Total volatile fatty acids.

Table 3. In-vitro gas production and digestibility of wheat offal and wet sorghum brewers waste blended ratios.

	Blended ratios							
Parameters (%)	**1:1**	**1:1.5**	**1:2**	**1:2.5**	**1:3**	**1:3.5**	***p*-value**	**SEM**
3 hours	2.33	1.33	1.00	2.33	1.00	2.33	0.0898	0.21
6 hours	4.33^{a}	3.67^{b}	2.33^{c}	4.00^{ab}	2.67^{bc}	4.00^{ab}	0.1206	0.26
9 hours	6.67^{a}	5.67^{ab}	4.67^{b}	6.33^{a}	4.67^{b}	6.00^{a}	0.1206	0.26
12 hours	9.67^{a}	7.67^{bc}	6.67^{c}	8.33^{b}	6.67^{c}	8.00^{b}	0.0011	0.28
15 hours	13.00^{a}	10.00^{b}	7.67^{d}	10.67^{b}	8.67^{c}	10.00^{b}	0.0006	0.45
18 hours	16.00^{a}	12.33^{b}	8.33^{d}	13.00^{b}	10.33^{c}	12.00^{b}	<0.0001	0.59
21 hours	18.00^{a}	14.67^{b}	9.33^{e}	14.67^{b}	11.33^{d}	13.33^{c}	<0.0001	0.68
24 hours	20.33^{a}	17.33^{b}	9.67^{f}	15.33^{c}	11.67^{e}	13.67^{d}	<0.0001	0.87
Methane	4.33^{a}	4.00^{a}	2.00^{c}	4.00^{a}	3.00^{b}	3.00^{b}	0.0308	0.63
Carbondioxide	9.00^{a}	7.67^{b}	4.67^{d}	6.33^{c}	5.00^{d}	6.00^{c}	0.0344	1.19
DM Digestibility (%)	56.77^{a}	51.12^{b}	58.67^{a}	43.67^{d}	53.70^{b}	51.52^{c}	<0.0001	1.92

Superscript letters ($^{a-f}$) indicate that values with different superscripts are significantly different ($p < 0.05$).
Note: DM, Dry matter

Discussion

Chemical composition of WSBR and WO:WSBR blended ratios

The proximate components of WSBR in this study were lower than 70% moisture, 3% crude protein, 1% ether extract, and 2% ash, but within the range of 4-40% crude fibre content reported for wet brewers spent grains (Musatto et al., 2006). Furthermore, the fibre fractions of WSBR were far lower than 60% neutral detergent fibre, 30% acid detergent fibre, and 20% hemicellulose, but within the range of 8-20% acid detergent lignin for spent brewer grains revealed by Aliyu and Bala (2011). These differences in nutritional contents might be attributed to the processing methods, the type grains used, and fermentation methods adopted in these studies. Therefore, simple and quick processing to improve the utilization of WSBR is inevitable. The moisture content in this study was less than 12% desirable pertaining to good keeping quality of feedstuffs (Rozis 1997). The crude protein concentrations of the blended ratios were far lower than the recommended value of 7-8% for ruminants to have active and healthy rumen environment (McDonald et al., 2002). Hence these products are not suitable as protein source for poultry, rabbits, and pigs. The crude fibre in this study was higher than 7.61-10.00 reported by Makinde et al. (2011) for blended ration of pineapple wastes and wheat offal but lower than 24.70 reported for rice bran by Ogunbosoye and Salau (2020). The crude fibre content of blended products is in agreement with less than 18% recommended for sheep and goat maintenance diet (NRC 2007), 18-20% required for breeding or adult beef cow (NASEM 2016), and 15-19% for dairy cattle to prevent rumen acidosis and maintain milk fat (NRC 2001). The crude fibre of all the blended rations were higher than 7% recommended for poultry birds by NRC (1994), slightly higher than 8-12% for sow (NRC 2012), but blended ratios 1:1, 1:1.5, 1:2, and 1:3 were suitable for feeding rabbits (12-16%) as reported by Gidenne (2015). It is then evident that these are suitable blended products. The carbohydrate fraction was slightly lower than 59.17-65.66 revealed by Olosunde et al. (2023) for recycled cashew pulp as animal feed. Furthermore, the carbohydrate fraction in this study was higher than 25-40 for brewer spent grain (Mussatto et al., 2006) and 30-38 for rice bran (Saunder 1990), within 60-70 for wheat bran (Mateos et al., 2019), but slightly lower than 66.56 for cassava peel (Amaza 2021) and 70.50 for molasses (Shafiqa-Arikah et al., 2022). Therefore, all WSBP blended ratios were suitable as carbohydrate sources for livestock animals. The NDF values in this study were lower than 72.62-81.86 for maize fodder (Ayandiran et al., 2024)

while the ADF was lower than 46.45 reported for corn bran (Ogunbosoye and Salau 2020). The NDF and ADF in this study were in agreement with recommended ranges for ruminant animals by NRC (2016 for cattle and 2007 for sheep and goats). The hemicellulose content in this study was slightly lower than 17.24-28.59 for agro-industrial by-products, but within 13.96-19.51 for grains reported by Kumar et al. (2015). Moderate fibre fractions in monogastric animal diets improve guts health and motility, microbial fermentation in the hindguts as well as increase satiety and feed intake control, however, excessive fibre in feed reduces feed intake, depresses nutrient digestibility, and energy utilization (NRC 2011; NRC 2012; Gidenne 2015). Furthermore, optimal fibre fraction in ruminant's diets maintains rumen health, provides energy through fermentation, and enhances feed intake and nutrient digestibility while excessive fibre increases methane production and causes nutrient imbalance (Van Soest 1994). Hence these blended products are suitable for feeding ruminant animals especially during the dry season when forages are scarce and even limited in essential nutrients.

Volatile fatty acids content of WO:WSBR blended ratios

The volatile fatty acids profile varied significantly among the blended ratio reflecting differences in their chemical composition and fermentation characteristics attributed to varying carbohydrates composition and structures (Marcos et al., 2020). Variables such as volatile fatty acids, pH value, and NH_3 concentration are commonly used as criteria to assess the quality of fermentation (Santos et al., 2020). Acetic acid is produced from fibre fermentation and enhances milk fat content in dairy animals. The acetic acid in this study was far lower than 70.2-75.0 by Christodoulou et al. (2025) for agro-industrial protein-rich products. Danner et al. (2003) reported that lactic acid was more effective in lowering fermentation pH than other volatile fatty acids. The lactic acid in this study was lower than 68.9-90.5% reported by Santos et al. (2020) as well as 80-120% by Chamberlain and Wilkinson (1996). Butyric acid concentrations are important indicator in determining the fermentation quality (Santos et al., 2020). The butyric acid content in this study is slightly higher than 12.2-14.50 reported by (Hassan et al., 2025). Propionic production indicates improved fermentation efficiency as propionate acts as a hydrogen sink, potentially reducing methanogenesis (Van Soest 1994). The propionic acid in this study was in agreement with the 18.4-21.7 reported by Hassan et al. (2025) for agro wastes. It is noteworthy that all blended product in this study produced enough volatile fatty acids for production and maintenance functions of all categories of livestock animals.

In-vitro gas production and digestibility of WO:WSBR blended ratios

The measurement of in-vitro gas production is a good indicator used to predict rumen degradability efficiency and metabolizable energy of animal feed (Contreras-Govea et al., 2011). The increase in in-vitro dry matter digestibility and in-vitro organic matter digestibility with increasing protein levels indicates the potential for improving feed efficiency of low-quality forages (Bargo et al., 2003). The result was consistent with the report of Pereira et al. (2013) where some agro-industrial by-products were evaluated in vitro. The 24 hours gas production was lower than 32.67-40.35 reported by Ayandiran et al. (2024) for ensiled Elephant grass. The reduction in the gas produced when the ratio of WSBR increased could be attributed to high ADF and ADL forming complexes with cellulose and hemicellulose (Getachew et al., 2002). The presence of secondary metabolites such as tannins, saponins, alkaloids, and phenolic compounds, which bind proteins and carbohydrates, inhibits microbial enzymes, or are toxic to rumen microbesm, can lower gas production (Makkar et al., 1995). The volume of methane produced in this study was lower than 5.50 for corn bran (Ogunsosoye and Salau 2020) but similar to the value of Kim et al. (2013) who compared with wheat bran and palm kernel. Methane production is of no use to ruminants but represents a big waste of energy and in fact, it contributes to greenhouse emission (Silivong et al., 2013), for which its

production to the atmosphere should be reduced. The digestibility in this study was comparable with 47.67-61.41 reported by Ayandiran et al. (2024). The higher dry matter digestibility revealed in blended ratios 1:1 and 1:2.0 could be linked to lower ADL fractions as opined by Jung et al. (1995), who stated that lignified feeds ferment slowly, reducing rate of VFA production and energy supply to animals. Furthermore, studies consistently showed a negative correlation between lignin and in-vitro/in-vivo fibre digestibility (Jung et al., 1997).

Conclusion and recommendation

It could be concluded that blended ratios of wheat offal and wet sorghum brewer residue have improved nutrient availability for livestock animals. However, ratios 1:1 and 1:1.5 produced more in-vitro gases, while ratios 1:1, 1:1.5, and 1:2 had superior dry matter digestibility. Based on the findings from this study with respect to fibre contents, none of these blended ratios are suitable for poultry birds. Blended ratios 1:1, 1:1.5, and 1:2 might be suitable for rabbits and pigs. However, all blended ratios could be fed to ruminant animals.

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