**In vitro** evaluation of ruminal digestibility and fermentation characteristics of local feedstuff-based beef cattle ration

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Abstract

**Background:** Optimum productivity of beef cattle is achieved with adequate feed supply, both in quality and quantity. Consumption of local feedstuff *Neptunia plena* L. Benth and *Leersia hexandra* Swartz as a ration by the animal subject is expected to promote cost efficiency and production, as well as provide essential nutrition needs. Therefore, this research aimed to evaluate dry matter digestibility (DMD), organic matter digestibility (OMD), N-NH$_3$ production, and volatile fatty acid (VFA) in beef cattle.

**Methods:** Feed and rumen inoculum samples were prepared and analyzed for their proximate contents. There were five treatment groups based on the diet received by beef cattle. *In vitro* approaches were used to determine the DMD, OMD, N-NH$_3$ production, and VFA in beef cattle. The research was conducted in the Laboratory of Feed Nutrient Science, Faculty of Animal Husbandry and Agriculture, Diponegoro University, Semarang. The data were analyzed using ANOVA at a significance level of 95%, and a Duncan Multiple Range Test.

**Results:** The results showed that the highest DMD ($P<0.05$) was derived from T$_5$ (56.47%), followed by T$_4$ (56.45%) and T$_3$ (55.90%). T$_5$ =62.40% significantly ($P<0.05$) generated the highest OMD followed by T$_4$=61.95% and T$_3$=60.82%. This treatment had the highest N-NH$_3$ value, namely 5.02 mM, compared with T$_3$=4.55 mM, T$_4$=4.50 mM, T$_2$=4.22 mM, and T$_1$=3.99 mM. Furthermore, T$_5$ had the highest VFA ($P<0.05$) compared with T$_4$, T$_3$, T$_2$, and T$_1$ with the value of 150.5, 133.0, 130.5, 130.0, and 123.5 mM, respectively.

**Conclusions:** The local feedstuff-based ration contributed to beef cattle production.

**Keywords**
digestibility, fermentation, ration, beef cattle, in vitro, Functional Food, Nutrition
**Introduction**

Livestock, particularly ruminants, is an integral part of the agricultural sector and represents a significant impact on the national economy (Beigh et al. 2017). Ruminants are produced at a more competitive rate than poultry to enhance business sustainability (Silva et al. 2019). They form nutritious food material (meat) from plant fiber (Krizsan et al. 2012). Global food demand for animal protein has been rising significantly, hence some efforts are needed to ensure adequate supply. One of these efforts is to increase livestock productivity through more efficient use of available resources, which are 98% natural (Andriarimalala et al. 2019). Feed is the main constraint faced by breeders in Indonesia to boost beef cattle productivity. Feed deficiency becomes a dominant threat during the dry season (Al-Arif et al. 2017), specifically for forages (Al-Masri 2010). Wild grass and agriculture biomass are consumed as an alternative during the dry season. However, these feedstuffs contain high fiber and low nutrients such as protein, energy, mineral, and vitamin that affect the ruminal microbe fermentation process (Andriarimalala et al. 2019). The maintenance and production needs of beef cattle cannot be fulfilled from a single feed source such as forages (Al-Arif et al. 2017), therefore a balanced or quality ratio is needed (Ramaiyulis et al. 2018).

The beef cattle population in the East Kalimantan Province has reached 119,675 heads (Indonesian statistics 2020). This needs to be increased through some efforts which include enhancement of the feed sector. The optimum productivity is achieved with adequate feed supply, both in terms of quality and quantity (Daru and Mayulu 2020). Local feedstuffs are accessible for breeders due to being available in abundance (Hasan et al. 2020), hence their exploitation is expected to increase feed production sustainability. The local feedstuffs sources in East Kalimantan Province, such as Supan-Suppen Leguminosae (Neptunia plena L. Benth) and Kolomento grass (Leersia hexandra Swartz) are essential factors in creating a balanced ration for beef cattle (Mayulu et al. 2019).

*Neptunia plena* L. Benth is a semi-aquatic legume from the Fabaceae family, with compound leaves and a stem that forms a fibrous sponge and taproots to support growth on the water surface, known as floating (Mayulu et al. 2020; Mayulu et al. 2021). Also, *Leersia hexandra* Swartz is annual in nature, easily grown (Liu et al. 2011) in inundated wetlands, known as swamps (Lin et al. 2018), tolerant to heavy metal chromium (Cr) (Zhang et al. 2007), and can be cultivated artificially (Ning et al. 2018). This plant possesses the potential for copper phytoextraction on contaminated soil (Lin et al. 2019) and is harvested several times during the growing period. It has dry matter production up to nine tons/ha within 60 days and is used as feed ingredients for the beef cattle ration (Liu et al. 2011).

Knowledge of the potential nutrition contained in local feedstuff ration is expected to increase breeders’ willingness to adopt their respective sources. *Neptunia plena* L. Benth and *Leersia hexandra* Swartz tend to be developed into a sustainable feedstuff ration for beef cattle due to being abundant throughout the year, specifically during feed scarcity. It is important to measure ruminant digestibility and fermentation level with the feedstuffs, as well as compose these to formulate a perfect ration. Various feedstuffs need to be evaluated in ration formulation (Hasan et al. 2020; Peiretti 2020) because the chemical content presents quality-related information (Forejtová et al. 2005; Al-Arif et al. 2017). Determination of feed nutrient quality requires a fast and accurate method such as chemical and biological analysis (Baran et al. 2017). An *in vitro* method is a digestibility and fermentation rate test (Mayulu et al. 2020) that provides animals’ biological attributes in a simpler way (Fondevila and Espés 2008). This can be used in daily feeding evaluation which is performed to achieve feed optimization and usage efficiency as well as to minimize nutrient excretion into the environment (Dijkstra et al. 2005). Ideally, the ruminant feed is evaluated *in vivo* to obtain more accurate results, particularly for nutrient quality, but the method is not practical and cost-effective. Therefore, alternative evaluations need to be performed in laboratory conditions using *in vitro* methods (Dijkstra et al. 2005; Daru and Mayulu 2020).

Advantages of evaluating ruminal feed digestibility using *in vitro* methods include testing several feed samples simultaneously to ensure cheaper cost and less time consumption (Dijkstra et al. 2005; Mayulu et al. 2019; Zewdie 2019; Daru and Mayulu 2020). Hence, this research aimed to evaluate the beef cattle ration biologically on a laboratory scale through quantitative assessment or *in vitro* method.

**Methods**

This research was carried out in the Laboratory of Feed Nutrient Science, Faculty of Animal Husbandry and Agriculture, Diponegoro University, Semarang. Some of the materials used were feed ration which consisted of *Neptunia plena* L. Benth and *Leersia hexandra* Swartz, as well as rice bran, palm cake, and calliandra. The *in vitro* analysis used beef cattle rumen fluid derived from the Boestaman Semarang animal slaughterhouse, pepsin-HCl solution as the protein-degrading enzyme, McDougall solution (artificial saliva), saturated sodium carbonate (Na₂CO₃), 15% sulfuric acid (H₂SO₄), and 0.5N NaOH, boric acid solution, 0.5% HCl, 1% phenolphthalein indicator, 0.005N sulfuric acid, vaseline, methyl red and Bromocresol Green, Whatman filter paper 41, Aquadest, CO₂, and ice for stopping the fermentation process.
Preparation of feed and rumen inoculum sample
Feedstuff sample materials were prepared through physical treatment consisting of cutting, drying, and milling process, until they were mashed (Fondevila and Espés 2008). These were tested through proximate analysis (Acland 1985), to determine their nutritional content. Local feed resources (*Neptunia plena* L. Benth and *Leersia hexandra* Swartz), and other rations, namely rice bran, maize, palm oil cake, and calliandra, were obtained from wild grasslands, agricultural by-products, and plantations in Samarinda, East Kalimantan Province. The rumen fluid was obtained from the Boestaman Slaughterhouse Semarang, which was taken in the morning, then filtered and put in a thermos previously filled with warm water at a temperature of 39°C. This was closed to maintain an anaerobic atmosphere and brought to the laboratory for research observation.

Proximate analysis
The Association of Official Agricultural Chemists (AOAC) procedure (Acland 1985) was applied to determine the observed feedstuffs’ nutritional content, namely dry matter (DM), crude fiber (CF), crude protein (CP), ether extract (EE), ash, and nitrogen-free extract (NFE) (Evan *et al.* 2020). The proximate analysis results were presented in prior research (Mayulu *et al.* 2020, Table 1).

Experimental design
In this research, a completely randomized design with five treatments was used. The main consideration in ration formulation used was 11%-12% crude protein balance, with ration energy calculated based on the total digestible nutrient (TDN) ±60%. The ration CP balance was in the range of 10% minimum and 14% maximum, and the energy needs TDN was ±60%. The treatments consisted of T1 = 100% *Leersia hexandra* Swartz and T2 = 100% *Neptunia plena* L. Benth. Meanwhile, T3, T4, and T5 were formulated from *Leersia hexandra* Swartz, *Neptunia plena* L. Benth, maize, rice bran, and palm oil cake. Their composition was T3 = 12% CP and TDN 60%, T4 = 11.92% CP and TDN 59.80%, and T5 = 11.68% CP and TDN 59.39% based on a prior research (Mayulu *et al.* 2020, Table 2).

In vitro analysis
Tilley and Terry’s (1963) *in vitro* analysis is an alternative method to specifically evaluate ruminants’ feed nutrient usage amount to determine the DMD, OMD, N-NH₃ production, and VFA in a laboratory setting (Gosselink *et al.* 2004; Banakar *et al.* 2017). The *in vitro* analysis employed rumen fluid as microbial inoculum (Tufarelli *et al.* 2010), and two stages were involved: fermentative digestion by using a buffer of rumen fluid for 48 hours and enzymatic digestion by using a pepsin-HCl solution for another 48 hours (Hristov *et al.* 2019; Daru and Mayulu 2020). Fermentation levels of N-NH₃ and VFA were determined with the Conway microdiffusion technique and steam distillation, respectively.

Calculation and statistical analysis
Parameters of DMD, OMD, NH₃ fermentation level, and VFA fermentation level were calculated by using the following equations (Hristov *et al.* 2019; Daru and Mayulu 2020).

**DMD equation:**

$$\text{DMD} = \frac{\text{DM weight of the sample} - (\text{DM contained in residue} - \text{blank})}{\text{DM weight of the sample}} \times 100\% \quad (1)$$

### Table 1. The nutritional content of the feedstuff ration.

<table>
<thead>
<tr>
<th>Feedstuffs</th>
<th>DM (%)</th>
<th>Ash (%)</th>
<th>OM (%)</th>
<th>CF (%)</th>
<th>EE (%)</th>
<th>CP (%)</th>
<th>NFE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Neptunia plena</em> L. Benth</td>
<td>86.89</td>
<td>4.82</td>
<td>95.18</td>
<td>54.76</td>
<td>3.20</td>
<td>15.49</td>
<td>21.73</td>
</tr>
<tr>
<td><em>Leersia hexandra</em> Swartz</td>
<td>85.09</td>
<td>9.57</td>
<td>90.43</td>
<td>49.23</td>
<td>1.99</td>
<td>11.28</td>
<td>27.93</td>
</tr>
<tr>
<td>Calliandra</td>
<td>93.54</td>
<td>11.35</td>
<td>88.65</td>
<td>55.84</td>
<td>2.23</td>
<td>23.86</td>
<td>6.72</td>
</tr>
<tr>
<td>Maize</td>
<td>89.97</td>
<td>0.77</td>
<td>99.23</td>
<td>0.38</td>
<td>1.68</td>
<td>8.14</td>
<td>89.13</td>
</tr>
<tr>
<td>Rice bran</td>
<td>88.91</td>
<td>5.49</td>
<td>94.51</td>
<td>24.75</td>
<td>5.97</td>
<td>9.97</td>
<td>53.82</td>
</tr>
<tr>
<td>Palm oil cake</td>
<td>92.27</td>
<td>1.37</td>
<td>98.63</td>
<td>48.78</td>
<td>9.57</td>
<td>14.03</td>
<td>15.17</td>
</tr>
</tbody>
</table>

Source: Proximate analysis result, Laboratory of Feed Nutrient Science, Faculty of Animal Husbandry and Agriculture, Diponegoro University.

DM = Dry matter; OM = Organic matter; CF = Crude fiber; EE = Ether extract; CP = Crude protein; NFE = Nitrogen-free extract.
Table 2. Feedstuff ration percentage and nutritional value.

<table>
<thead>
<tr>
<th>Composition</th>
<th>Treatment (% DM)</th>
<th>T1 (%)</th>
<th>T2 (%)</th>
<th>T3 (%)</th>
<th>T4 (%)</th>
<th>T5 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedstuffs:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Leersia hexandra</em> Swartz</td>
<td>100.00</td>
<td>-</td>
<td>15.00</td>
<td>20.00</td>
<td>25.00</td>
<td></td>
</tr>
<tr>
<td><em>Neptunia plena</em> L. Benth</td>
<td>-</td>
<td>100.00</td>
<td>15.00</td>
<td>20.00</td>
<td>25.00</td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td>-</td>
<td>-</td>
<td>34.00</td>
<td>39.00</td>
<td>42.00</td>
<td></td>
</tr>
<tr>
<td>Rice bran</td>
<td>-</td>
<td>-</td>
<td>14.00</td>
<td>9.50</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Palm oil cake</td>
<td>-</td>
<td>-</td>
<td>14.50</td>
<td>3.00</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>Calliandra</td>
<td>-</td>
<td>-</td>
<td>7.50</td>
<td>8.50</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td></td>
</tr>
<tr>
<td>Nutritional value:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM</td>
<td>85.09</td>
<td>86.89</td>
<td>89.92</td>
<td>89.65</td>
<td>88.69</td>
<td></td>
</tr>
<tr>
<td>OM</td>
<td>90.43</td>
<td>95.18</td>
<td>94.30</td>
<td>94.27</td>
<td>94.42</td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>11.28</td>
<td>15.49</td>
<td>12.00</td>
<td>11.92</td>
<td>11.68</td>
<td></td>
</tr>
<tr>
<td>TDN*</td>
<td>40.88</td>
<td>38.38</td>
<td>60.00</td>
<td>59.80</td>
<td>59.39</td>
<td></td>
</tr>
</tbody>
</table>

Source: Proximate analysis result, Feed Nutrient Science, Faculty of Animal Husbandry and Agriculture, Diponegoro University, Semarang (2017).
*Calculation result according to Sutardi (2001).

OMD equation:

\[
\text{OMD} = \frac{\text{OM weight of sample} - \left( \text{OM contained in residue} - \text{blank} \right)}{\text{OM weight of the sample}} \times 100\% 
\]  
(2)

Remarks:

- \( M \) sample = sample weight × % DM
- DM residue = weight after oven-CP-filter paper
- OM sample = weight of DM sample × % OM
- % OM = 100% DM − (% ash contained in DM)
- OM residue = weight after oven-tanur-filter paper
- Blank = weight after oven-CP-filter paper

N-NH₃ production equation:

\[
N - \text{NH}_3 \text{ production (mM)} = (\text{mL titrant} \times \text{NH}_4\text{SO}_4 \times 1000) 
\]  
(3)

Remarks: \( N=\text{H}_2\text{SO}_4 \) solution normality

VFA production equation:

\[
\text{VFA production (mM)} = (a - b) \times \text{NHCl} \times 1000/5 
\]  
(4)

Remarks:

- \( a \) = Titrant volume of the blank (mL)
- \( b \) = Titrant volume of the sample (mL)
The in vitro method-derived results were analyzed using ANOVA at a significance level of 95%, followed by Duncan Multiple Range Test (DMRT) which applied the Costas program approach.

Results and discussion
Dry matter and organic matter digestibility

Beef cattle convert low-quality feed (high fiber) into products containing high nutritional value and quality, such as meat (Deutschmann et al. 2017; Mayulu et al. 2020; Daru and Mayulu 2020). This ability is promoted by a complex digestive system, particularly the stomach which consists of four compartments, namely the rumen, reticulum, omasum, and abomasum (Mayulu et al. 2021). The rumen, sometimes called reticulum-rumen, accommodates about 80% of the total digested amount and contains microbes that digest fibers effectively. Therefore, it enables ruminants to survive with poor nutritional quality and conditions (Mohamed and Chaudhry 2008). Feed deficiency elevates ruminal microbes’ degradation rate and increases the metabolic capacity to use energy, both of which lead to an OMD increase (Al-Masri 2010).

Digestibility is defined as the number of nutritional feedstuffs absorbed or used by livestock to satisfy their needs such as production, growth, reproduction, and other functions (Abbasi et al. 2018). It is also an important indicator in measuring the nutritional quality of feed (Al-Arif et al. 2017). Low quality of feed or rations is caused by high crude fiber content, including ADF and NDF (Güls¸en et al. 2004). Dry matter consists of all nutrients, while organic matter comprises all nutrients excluding ash. DM digestibility in beef cattle plays an important role in evaluating feed nutrients absorbed by the digestive tract (Al-Arif et al. 2017). A decrease in this parameter is affected by the ratio of stems and forage leaves (Kamal et al. 2020). Table 3 shows the in vitro DMD and OMD of beef cattle rations formulated from local feedstuffs.

ANOVA results showed that T2 = 56.47% was the highest DMD mean, followed by T4 = 56.45%, T3 = 55.90%, T2 = 42.94%, and T1 = 41.30%. According to DMRT results, T5 produced the highest DMD but was not significantly different from T4 and T3. T5 treatment resulted in a significantly higher DMD (p < 0.05) than T1 and T2. Local feedstuff usage in the ration with percentages of 15, 20, and 25 produced T5 = 56.47%, T4 = 56.45%, and T3 = 55.90%. These values were higher compared with single feedstuff T1 (100% Leersia hexandra Swartz) and T2 (100% Neptunia plena L. Benth) which had a DMD of 42.94% and 41.30% respectively, as presented in Table 3. Based on Table 1, the low digestibility of single feedstuff in T1 and T2 is due to high crude fiber content i.e., 49.23% and 54.76% respectively. This is in line with the results of Mayulu et al. (2021) who stated that high CF contained in the feedstuffs causes low digestibility.

Crude fiber is part of the nutritional components of feedstuffs which is difficult to digest but is needed in the digestive tract for promoting peristalsis, specifically to support ruminal performance (Adesogan et al. 2019; Andriarimalala et al. 2019; Mayulu et al. 2019). This is composed of lignin which causes low feedstuff digestibility due to being hard to degrade enzymatically by ruminal microbes. It also increases along with the plant’s age and maturity (Andriarimalala et al. 2019). Different digestibility values are caused by several factors including nutritional content, composition ratio, and duration of feedstuffs inside the rumen (Mayulu et al. 2019). The DMD value produced from all treatments was higher compared with Al-Arif et al. (2017) results, i.e. 23.76% obtained from single feedstuff and 49.96% from the in vitro ration. This indicates that in terms of quantity, the local feedstuff-based ration contributes to beef cattle productivity.

Organic matter (OM) acts as the energy source for building substances to promote the body’s metabolic processes (Mayulu and Sutrisno 2010). OMD is defined as a proportion of OM digested by the digestive tract, which is used to measure available energy, and estimate protein synthesis by ruminal microbes (Al-Arif et al. 2017). This is closely related to DMD since the part of DM consists of OM which contains CF, CP, EE, and NFE (Mayulu et al. 2020).

Table 3. Means of in vitro DMD and OMD of beef cattle ration formulated from local feedstuffs.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Treatment</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMD</td>
<td></td>
<td>41.30±3.96</td>
<td>42.94±1.51</td>
<td>55.90±0.73</td>
<td>56.45±1.88</td>
<td>56.47±0.31</td>
</tr>
<tr>
<td>OMD</td>
<td></td>
<td>52.89±4.22</td>
<td>49.31±1.17</td>
<td>60.82±1.02</td>
<td>61.95±1.40</td>
<td>62.40±0.28</td>
</tr>
</tbody>
</table>

Remarks: Different superscripts show a significant difference (P < 0.05), where T1 = 100% Leersia hexandra Swartz and T2 = 100% Neptunia plena L. Benth. T3 = Ration of 15% Neptunia plena L. Benth + 15% Leersia hexandra Swartz + 70% other feedstuffs. T4 = Ration 20% Neptunia plena L. Benth + 20% Leersia hexandra Swartz + 60% other feedstuffs. T5 = Ration 25% Neptunia plena L. Benth + 25% Leersia hexandra Swartz + 50% other feedstuffs.
Based on the ANOVA results, in vitro OMD means of beef cattle ration based on local feedstuffs from the highest to smallest value were T₃ = 62.40%, T₄ = 61.95%, T₃ = 60.82%, T₁ = 52.89%, and T₂ = 49.31%. The DMRT results showed that the highest OMD was derived from T₃, but it wasn’t significantly different from T₅ and T₄. T₃ treatment had a significantly higher OMD (P < 0.05) compared to T₁ and T₂. Organic matter digestibility derived from T₁, T₃, T₄, and T₅ had a higher value than the report by Al-Arif et al. (2017) who obtained an in vitro OMD of 24.98% from a single feed forage and 49.70% from the ration. The low T₂ OMD value of 49.31% was probably due to ruminal microbes’ activity or feedstuff nutritional content and extremely small particle, causing a lower rate of feed leaving the rumen and smaller chances of proper degradation (Mayulu et al. 2020).

### Production of N-NH₃ and VFA

In addition to the digestibility value, feed nutritional content was calculated from the fermentation variable, i.e. N-NH₃ and VFA concentration. Protein is an essential nutrient that determines the economic success of the beef cattle industry (Chathurika et al. 2019). The beef cattle rumen degrades low biological protein and low-quality fiber into a microbial protein with high biological value (Liu et al. 2019; Chathurika et al. 2019). Ammonia serves as a primary nitrogen source for most ruminal microbes (Imsya et al. 2013), which is responsible for carrying out higher microbial protein synthesis (Supapong et al. 2019; Mayulu et al. 2021). The measurement of this element is employed to estimate protein degradation and usage by ruminal microbes; hence OMD has a strong correlation with microbial protein synthesis (Imsya et al. 2013). N-NH₃ production reflects the amount of feedstuff protein degraded, and the rate at which this process occurs is an important characteristic for determining protein value (Liu et al. 2019). Ammonia nitrogen is an essential nutrient in promoting microbial growth. High N-NH₃ production is needed to reach maximum fermentation level and increases feed digestibility (Al-Arif et al. 2017). N-NH₃ concentration in the rumen is a balance between the produced and absorbed amount, known to be optimal for microbial needs once ranging from 3.57-7.14 mM (Mayulu et al. 2019).

The in vitro N-NH₃ means of beef cattle ration based on local feedstuffs obtained from ANOVA were T₁ = 5.02 mM, T₃ = 4.55 mM, T₄ = 4.50 mM, T₂ = 4.22 mM, and T₅ = 3.99 mM. The DMRT result showed that the highest N-NH₃ was produced from T₅. A high value of N-NH₃ concentration is probably due to the ration’s carbohydrate structure and remnant retention duration inside the rumen (Mayulu et al. 2019). The result of T₃ was significantly higher (P < 0.05) compared with T₁, T₄, T₂, and T₅. The highest N-NH₃ production, i.e. 5.02 mM, was derived from T₁ which contained 11.68% CP and 59.39% TDN. A higher ammonia value was obtained compared to the report by Al-Arif et al. (2017) who produced an in vitro N-NH₃ concentration of 3.95 mM with single forage feedstuff and 2.88 mM with the ration. This result was in the optimum range between 3.57-7.14 mM, hence it was expected to promote ruminal microbial biosynthesis. Higher NH₃ concentration reflects more protein decomposition during in vitro fermentation, and this is associated with higher CP content (Wang et al. 2021). The different N-NH₃ derived in this research tended to be initiated by the amount of feedstuff crude fiber, as well as protein solubility and degradation rate. Low N-NH₃ production causes slow growing rate of ruminal microbes which leads to decreasing population and inhibited carbohydrate degradation (Mayulu et al. 2020; Sarnataro and Spanghero 2020).

VFA is the end product of carbohydrate metabolism by ruminal microbes (Supapong et al. 2019) and acts as an energy source (80%) (Mayulu et al. 2020). VFA is developed through hydrolysis of polysaccharide carbohydrates which are converted into monosaccharides, specifically glucose. These are then converted into acetate (C₂), propionate (C₃), butyrate (C₄), isobutyrate, valerate, isovalerate, methane (CH₄), and CO₂ (Abbasi et al. 2018; Kongphitee et al. 2018). OM in a ration that is easily degraded by ruminal microbes is indicated by a high VFA concentration (Mayulu et al. 2019). VFA concentration depends on nutrient digestibility (particularly that of carbohydrates), VFA absorption rate, the ruminal microbial community activity, and degradation rate (Tilahun et al. 2022).
The in vitro VFA means of beef cattle ration based on local feedstuffs obtained from ANOVA were T5 = 150.5 mM, T4 = 133.0 mM, T3 = 130.5 mM, T2 = 130.0 mM, and T1 = 123.5 mM. The DMRT results showed that T5 had a significantly higher value i.e. 150.5 mM (P < 0.05) compared with T4, T3, T2, and T1. A high VFA concentration indicates an increased ruminal microbes’ activity because more OM is being fermented inside the rumen (Hasan et al. 2020). The result of T4 was not significantly different once compared to T3 and T2 values. The obtained VFA concentration was normal, ranging from 70-150 mM (Tilahun et al. 2022) and 80-160 mM (Mayulu et al. 2019, 2021), with a tendency to promote optimum microbial growth. This is in line with the report by Mayulu et al. (2019, 2021) and Tilahun et al. (2022) who stated that VFA concentration promotes ruminal microbe biosynthesis. Increasing VFA concentration within the optimum range reflects an effective fermentation process, but an extremely high value causes a balance disorder inside the rumen (Mayulu et al. 2019). VFA concentration is influenced by the ration’s carbohydrate content (Supapong et al. 2019), inoculum collecting duration, incubation time, particle size, and inoculum preparation (Patra and Yu 2013), and fiber digestibility.

Conclusions
The digestibility and fermentation level of beef cattle consuming local feedstuff-based ration was obtained using an in vitro method. The ANOVA results showed that the highest DMD (P<0.05) was T5 = 56.47%, followed by T4 = 56.45%, and T3 = 55.90%. The values of OMD (P < 0.05) were T5 = 62.40%, T4 = 61.95%, and T3 = 60.82%, while N-NH3 (P < 0.05) values were T4 = 5.02 mM, T3 = 4.55 Mm, T4 = 4.50 mM, T2 = 4.22 mM, and T1 = 3.99 mM. VFA values (P < 0.05) were T4 = 150.5 mM, T3 = 133.0 mM, T2 = 130.5 mM, T2 = 130.0 mM, and T1 = 123.5 mM. Therefore, it was concluded that, quantitatively, the local feedstuff ration contributed to beef cattle production.

Data availability
Underlying data

This project contains the following underlying data:

- RAW of HAMDI MAYULU in vitro Sapi Potong.xlsx

Data is available under the terms of the Creative Commons Zero “No Rights Reserved” Data waiver (CC0 1.0 Public Domain Dedication).

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