Effect of Replacing Grass Silage with Hydroponic Maize Fodder on Nutrient Intake and Digestibility, Rumen Parameters and Blood Metabolites of Weaned Ongole x Brahman Calves

Benu I[1], Jelantik IGN[1,*], Penu CL[2], Laut MM[3]

[1]*Faculty of Animal Science, Marine and Fisheries, Universitas Nusa Cendana, Kupang, 85148, NTT-Indonesia*
[2]*Kupang State Agricultural Polytechnic, 85148, NTT, Indonesia*
[3]*Faculty of Medicine and Veterinary Medicine, Universitas Nusa Cendana, Kupang, 85148, NTT-Indonesia*
** Corresponding author: igustingurahjelantik@staf.undana.ac.id*

(received 06-06-2023; revised 02-01-2024; accepted 02-01-2024)

ABSTRAK

Benu I, Jelantik IGN, Penu CL, Laut MM. 2024. Pengaruh substitusi silase rumput dengan fodder jagung hidroponik terhadap konsumsi nutrient, kecernaan nutrient, parameter rumen dan metabolit darah pedet sapi Ongole x Brahman lepas sapih. JITV 29(1):36-44, DOI: http://dx.doi.org/10.14334/jitv.v29i13331.

Fodder jagung hidroponik (FJH) dapat menggantikan silase rumput sebagai alternatif hijauan ternak ruminansia selama musim kemarau. Percobaan in vivo dilakukan untuk mengevaluasi pengaruh penggantian silase rumput dengan FJH terhadap konsumsi nutrient, kecernaan nutrient, parameter rumen dan parameter darah pedet sapi lepas sapih. Sebanyak 4 ekor pedet sapi jantan persilangan Ongole x Brahman (BB 127±17,45 kg) lepas sapih diberikan pakan 70% silase rumput + 30% konsentrat (G); 35% silase rumput + 35% FJH + 30% konsentrat (GCF1); 17,5% silase rumput + 52,5% FJH + 30% konsentrat (GCF2); dan 70% FJH + 30% konsentrat dalam percobaan bujur sangkar latin 4x4. Pedet sapi yang diberikan FJH dengan level berbeda memiliki lebih sedikit (P<0,05) total konsumsi bahan kering (BK), total konsumsi bahan organik (BO), dan total konsumsi serat kasar (SK) dibandingkan pedet yang hanya mendapat silase rumput saja. Tidak terdapat perbedaan antar perlakuan (P>0,05) untuk konsumsi protein kasar, kecernaan BK, kecernaan PK, kecernaan SK, konsumsi serat kasar tercerna, konsumsi protein kasar tercerna dan pH rumen. Pedet sapi yang mengkonsumsi FJH memiliki konsentrasi ammonia-nitrogen (NH3-N) dan total volatile fatty acids (TVFA) lebih tinggi (P<0,05) dibandingkan pedet sapi yang hanya mendapat silase rumput saja. Tidak ada perbedaan antar perlakuan (P>0,05) untuk konsentrasi asam asetat, propionate, butirat, iso-butirat, iso valerat, glukosa darah dan urea darah. Dengan demikian, dapat disimpulkan bahwa FJH dapat digunakan sebagai pengganti silase untuk meningkatkan fermentasi rumen pedet sapi jantan Ongole x Brahman lepas sapih, walaupun mungkin dapat menurunkan konsumsi bahan kering.

Kata kunci: Hijauan Jagung Hidroponik, Intek Nutrien, Kecernaan Nutrien, Pedet Sapi Persilangan Ongole Brahman

ABSTRACT

Benu I, Jelantik IGN, Penu CL, Laut MM. 2024. The effect of replacing grass silage with hydroponic maize fodder on nutrient intake, nutrient digestibility, rumen parameters and blood metabolites of weaned Ongole x Brahman calves. JITV 29(1):36-44. DOI: http://dx.doi.org/10.14334/jitv.v29i13331.

Hydroponic maize fodder (HMF) may replace grass silage as an alternative green forage for ruminants during dry seasons. An *in vivo* experiment was conducted to investigate the effect of replacing grass silage with HMF on nutrient intake, nutrient digestibility, rumen parameters and blood metabolites of weaned calves. Four weaned Ongole x Brahman calves (BW= 127±17.45 kg) were fed 70% grass silage + 30% concentrates (G; control), 35% grass silage + 35% HMF + 30% concentrates (GCF1), 17,5% grass silage + 52,5% HMF + 30% concentrates (GCF2), and 70% HMF + 30% concentrates (GCF3) in a 4 x 4 Latin Square Design experiment. Calves fed HMF had lesser total dry matter intake (DMI) (P<0.05), total organic matter intake (OMI), and total crude fibre intake (CFI) compared with calves fed only grass silage. There were no differences (P>0.05) between treatments for total crude protein (CP) intake, dry matter digestibility (DMD), crude protein digestibility (CPD), crude fibre digestibility (CFD), digestible crude fibre intake (DCFI), digestible crude protein intake (DCPI) and ruminal pH. Calves provided HMF in their diet had the greatest (P < 0.05) ammonia-nitrogen (NH3-N) and total volatile fatty acids (TVFA) concentration compared with calves fed only grass silage. There were no differences between treatments (P> 0.05) for the concentration of acetate, propionate, butyrate, iso-butyrate, iso-valerate, blood glucose or blood urea of calves. Hence, hydroponic maize fodder could be used as a replacement for silage to improve the rumen fermentation of weaned Ongole x Brahman calves, although it might decrease the total dry matter intake.

Keywords: Hydroponic Maize Fodder, Nutrient Intake, Nutrient Digestibility, Ongole X Brahman Calves

INTRODUCTION

Sufficient growth of weaned Ongole x Brahman calves is required for higher beef production. Providing adequate nutrients at the early age of calves is necessarily important to prepare for the success of weaning (Fischer et al. 2019) as well as to facilitate the animal to express the genetic potential to maximize the intramuscular fat production or marbling during finishing (Xuan et al. 2018) and thus to achieve a higher beef production (Tian et al. 2019). On the other hand, insufficient nutrition during the early life of calves may impair growth performance and production (Vendramini & Moriel, 2018). Early weaned calves, however, are generally inefficient in utilizing nutrients due to their undeveloped both structure and rumen function as compared to adult ones (McCoard et al. 2019; van Niekerk et al. 2021). In addition, early weaning programs also induced stress to the weaned animal (Ungerfeld et al. 2016; Diao et al. 2019). Therefore, the provision of high protein and energy feeds is necessary for newly weaned calves (Fischer et al. 2019). Good quality fresh forages including young leafy grass and forage legumes are required to ensure a high growth rate of newly weaned calves. In the seasonally dry tropics of west Timor-Indonesia, the availability and quality of fresh forages throughout the year is problematic. During the rainy season, the availability of good quality forages is abundant but becomes scarce during the dry season. The lack of high-quality forages during the dry seasons has been reported to adversely affect the body weight gain of weaned Bali calves (Mullik & Jelantik 2009). Hence, providing grass silage during the dry season is one important option and it has gained a lot of success. However, for newly weaned crossbred calves, grass silage alone may not be sufficient in terms of nutrient availability (McCoard et al. 2019). Indeed, newly weaned calves commonly have low intake due to stress and undeveloped rumen function (Rajkumar et al. 2018). Therefore, it may require a higher quality of forages which has high digestibility but provide a certain amount of fibre. Fibre is also required for both rumen health and rumen development (Diao et al. 2019). In addition, smallholder farmers are unable to maintain grass silage for long time during the dry season due to difficulty in grass conservation. It is therefore crucial for finding an alternative green forage as a replacement for grass silage in tropical areas.

Hydroponic maize fodder offers an alternative feed to grass or green forage particularly during the dry season where high-quality forage is limited. In addition, hydroponic maize fodder also can be used as an alternative feed when there are no other basic feeds for the animal. This is due to its flexibility to produce at any time of the year with minimum investment. Furthermore, hydroponic maize fodder production is efficient in water utilization and small land utilization, especially for those with marginal land and limited resources. Maize fodder is produced from maize grains that are germinated and grown for a short period (Arif et al. 2023). Hydroponic maize fodder can be grown and harvested within a week and fed to cattle (Naik et al. 2016). There is limited information, however, on the effects of the rate of substitution of maize fodder in a grass-based diet for calves in West Timor. Therefore, this study was designed to investigate the effect of increasing concentrations of hydroponic maize fodder in the diet on the dry matter intake and rumen parameters of weaned Ongole x Brahman calves.

MATERIALS AND METHODS

Location of the study

The present study was carried out at the dry land laboratory (-10.1761° S, 123.3793° E) of Nusa Cendana University Kupang, West Timor, Indonesia.

Hydroponic maize fodder production

The maize grain used in this study was purchased from the local market. Five kilograms of maize were washed in tap water to remove debris. The maize was then washed with antifungal solution (Antracol; Bayer Indonesia; Jakarta) at 2 ml/l (v/v) concentration to minimize fungi contamination and then stored in a dark area to allow the grains to steep for 12 hours (overnight). The maize was then soaked in fresh tap water for 24 h before distributing maize evenly into the planting trays. The trays were manually watered two or three times per day depending on the weather. The sprouted maize seeds were grown for 7 days before harvesting and fed to the animals. A sample of the harvested sprouted maize seeds was taken for every tray and then dried in the oven at 60^0C for 48-72 h before the representative samples were taken for further proximate analyses following the method of AOAC (2005).

Animals, diets, and experimental design

The experiment used four males weaned Ongole x Brahman calves (127±17.45 kg) in a four 21-day periods x four diets in a Latin Square design experiment. Each period consisted of a 14-day dietary adaptation followed by 7 days of sample collection. The four diets offered were 70% grass silage +30% concentrates (G), 35% grass silage +35% hydroponic maize fodder +30% concentrates (GCF1), 17.5% grass silage +52.5% hydroponic maize fodder +30% concentrates (GCF2) and 70% hydroponic maize fodder +30% concentrates

Table 1. Ingredient and chemical composition of experimental diets

	Treatments			
	G[1)]	GFC1	GFC2	GFC3
Ingredients				
Grass silage (% DM)	70	35	17,5	0
Hydroponic maize fodder (% DM)	0	35	52,5	70
Ground Corn (% DM)	16	16	16	16
Rice bran (% DM)	10	10	10	10
Fishmeal (% DM)	3	3	3	3
Mineral (% DM)	1	1	1	1
Total	100	100	100	100
Chemical composition				
DM (% DM)[2)]	93.12	90.67	91.54	92.85
OM (% DM)	81.75	87.64	88.48	88.35
CP (% DM)	5.35	12.67	12.64	12.49
CF (% DM)	35.34	18.17	16.62	14.86
Ash (% DM)	11.38	3.04	3.06	2.89

G= 70% grass silage + 30% concentrates; GFC-1= 35% grass silage + 35% hydroponic maize fodder + 30% concentrates; GFC-2= 17.5% grass silage + 52.5% hydroponic maize fodder + 30% concentrates; GFC-3= 70% hydroponic maize fodder + 30% concentrates; DM= Dry matter; OM= Organic matter; CP= Crude protein; CF= Crude fibre

(GCF3). The animals were familiarized with handling and sampling procedures before the start of the experiment. Throughout the experiment, the animals were assigned to individual pens (2 x 1 m) within a cattle housing facility. The animals were fed their dietary treatments (Table 1) twice per day. Water was offered ad libitum.

Parameters measured

To determine the dry matter intake of the animals, orts were weighed following each meal for concentrates, grass silage, and hydroponic maize fodder. Daily intake was calculated as diet allowance – orts= daily intake. Total dry matter intake (DMI) was calculated as (daily intake x %DM= DMI) for concentrate, grass silage, and maize fodder. Total nutrient intake was also calculated for DMI grass silage as (DMI grass silage x % grass silage nutrient profile= grass silage nutrient intake), for DMI maize fodder as (DMI maize fodder x % maize fodder nutrient profile= maize fodder nutrient intake), and for DMI concentrate as (DMI concentrate x % concentrate nutrient profile= concentrate nutrient intake).

At the end of the digestibility trial, samples of rumen fluid were collected from each calf using a stomach tube. The rumen liquor samples were then filtered using four layers of cheesecloth before measurement of pH using a digital pH meter. Ammonia concentration was measured using micro diffusion plates following the method of Conway (1947). Total volatile fatty acids (VFA) were determined using the steam distillation method while the partial VFA was assessed by gas-liquid chromatography. Blood samples from each calf were collected at the end of each period of the study via jugular venepuncture and using vacutainer tubes containing EDTA 4 hours after the morning meal. The samples were immediately placed on ice and brought to the laboratory for later analysis.

Statistical analysis

Data obtained in this study were statistically analyzed using General Linear Model (GLM) procedure adapted by IBM SPSS Statistic for Windows, version 21 (IBM Corp Armonk, N.Y USA) for user's guide with ANOVA. Duncan's multiple range tests within the SPSS program were conducted to examine the degree of significance among means. The significant difference was set at $P<0.05$ and $0.05<P<0.10$ was assigned as a tendency to be significant.

RESULTS AND DISCUSSION

Intake and digestibility of nutrients

The voluntary feed intake and nutrient digestibility of calves fed grass silage alone or with an increasing substitution rate of maize fodder are presented in Table

2. Calves fed grass silage alone had greater dry matter intakes compared with calves fed various substitution rates of the maize fodder (P= 0.02). As the substitution rate of maize fodder increased, the dry matter intake of calves decreased, with the lowest intake in the GCF3 treatment. Similarly, the increasing substitution rate of maize fodder in the diet of calves caused a decrease in their total OM intake (P= 0.02) and total CF intake (P= 0.02) compared with intake of calves fed grass silage only. There were no differences, however, between treatments for total CP intake (P= 0.53). There were also no differences between treatments for DMD (P= 0.67), CPD (0.56), CFD (P= 0.47). In addition, there were no differences between treatments for DCFI (P= 0.05) and DCPI (P= 0.72).

Total dry matter, as well as organic matter intake, were linearly decreased in the present experiment with an increasing substitution rate of hydroponic maize fodder. This decline was unexpected and not in line with our hypothesis that feeding a diet with an increasing substitution rate of maize fodder would increase DM intake. The dietary CP was increased and CF was reduced with an increasing level of substitution. Increasing dietary CP commonly results in an increasing rate of ruminal digestion which, therefore, stimulates dry matter intake (Tian et al. 2019). Similarly, diets with lower crude fibre content commonly have higher digestibility (Fustini et al. 2017). Moreover, the concentration of TVFA in rumen liquid as an indication of rumen carbohydrate fermentation (Liu et al. 2020) was also significantly increased in the present experiment. Previous studies also demonstrated that hydroponic maize fodder was palatable to ruminant animals and it contains no substance that may reduce intake. Kide et al. (2015) reported that goats consumed all parts of maize fodder (leaf, stems, and roots), showing that it is considered palatable to goats. Moreover, dry matter intake (DMI) has been demonstrated to be increased when maize fodder is included in the diets formulated for cattle. Rajkumar et al. (2018) also showed that the DMI of calves was increased with increasing substitution rates of hydroponic maize fodder in the diet.

The decline of DMI in the present experiment might have resulted from the high-water content in hydroponic maize fodder. Previous results showed that feeding excessively high moisture feeds lessened dry matter intake. The intracellular or inexpressible water might increase the bulk of feedstuffs. In the previous reports that demonstrated negative effects of high feed moisture content on intake, it was commonly argued that water intake contributes to rumen fill (Havekes et al. 2020). This was caused by intracellular or inexpresible water of increased bulk of feedstuffs particularly when forage proportion in the diet increases. The contained water will be released when the cellular structures in feedstuffs are broken through mastication or fermentation and

Table. 2. The intake and digestibility of dietary treatments of weaned Ongole x Brahman male calves

Parameters	Treatments				Standard Error of Mean	P-Values
	G[1)]	GCF1	GCF2	GCF3		
Daily intake						
Dry matter, (g/d)	4132.11[a2)]	3301.66[b]	2859.34[b]	1557.63[b]	275.78	0.02
Organic matter, (g/d)	3015.82[a]	2613.83[b]	2456.42[b]	1497.49[b]	205.25	0.04
Crude protein, (g/d)	201.23	225.58	258.47	212.95	25.82	0.53
Crude fibre, (g/d)	1293.95[a]	886.35[ab]	661.55[bc]	299.88[cd]	104.38	0.02
Nutrient digestibility						
DMD, (%)[3)]	70.16	62.57	62.26	66.15	4.84	0.67
CPD, (%)	48.52	48.39	52.25	69.86	11.08	0.56
CFD, (%)	72.65	60.01	56.94	55.95	7.33	0.47
DDMI, (g/d)	2989.82[a]	2099.17[ab]	1752.98[ab]	1063.27[c]	333.51	0.09
DOMI, (g/d)	2071.73	1634.07	1550.54	1089.52	252.80	0.23
DCPI, (g/d)	108.44	107.85	141.56	150.29	31.64	0.72
DCFI, (g/d)	978.68	555.11	365.77	197.42	116.08	0.05

G= 70% silage grass + 30% concentrates; GFC-1= 35% silage grass + 35% hydroponic maize fodder + 30% concentrates; GFC-2= 17.5% silage grass + 52.5% hydroponic maize fodder + 30% concentrates; GFC-3= 70% hydroponic maize fodder + 30% concentrates. Values in the same row with different superscripts are significantly different (P< 0.05). DMD= Digestibility of dry matter; CPD= Crude Protein Digestibility; CFD= Crude fibre digestibility; DDMI= Digestible Dry matter intake; DOMI= Digestible Organic matter intake; DCPI= Digestible Crude protein Intake; DCFI= Digestible Crude fibre intake

Table 3. Ruminal fermentation of weaned Ongole x Brahman male calves fed with experimental diets

Parameters	Treatments				Standard Error of Mean	P-values
	G[1)]	GCF1	GCF2	GCF3		
pH	7.79	7.36	7.41	7.39	0.26	0.68
NH_3-N, (mg/L)	64.96[a2)]	84.24[a]	202.87[b]	210.47[b]	19.49	0.02
Acetate, (mM)	19.65[a]	22.29[ab]	25.10[ab]	25.55[b]	1.24	0.11
Propionate. (mmol/L)	5.71[a]	7.09[a]	8.83[ab]	11.04[b]	1.03	0.11
Iso-butyrate, (mmol/L)	1.16	1.12	1.69	2.55	0.64	0.49
N-butyrate, (mmol/L)	2.57[a]	4.49[a]	5.25[ab]	6.95[b]	0.60	0.05
Iso-valerate, (mmol/L)	0.76	1.03	1.68	1.49	0.17	0.09
N-valerate, (mmol/L)	0.35	1.05	1.04	1.26	0.22	0.19
TVFA, (mmol/l)[3)]	30.22[a]	37.09[ab]	43.61[bc]	48.86[c]	2.29	0.03
Molar proportion						
Acetate, (%)	64.02[a]	60.52[b]	57.47[ab]	53.68[b]	1.69	0.07
Propionate, (%)	19.04	18.61	20.41	22.58	1.53	0.41
Butyrate, (%)	12.96	15.06	15.96	18.49	1.97	0.41
Valerate, (%)	2.59	2.98	3.79	2.85	0.38	0.33
Iso-valerate, (%)	1.37	2.82	2.35	2.38	0.47	0.34
Iso-Butyrate, (%)	3.73[a]	5.61[a]	6.95[ab]	9.50[b]	1.03	0.10
Ratio	0.24	0.25	0.27	0.31	0.02	0.33

G= 70% silage grass + 30% concentrates; GFC-1= 35% silage grass + 35% hydroponic maize fodder + 30% concentrates; GFC-2= 17.5% silage grass + 52.5% hydroponic maize fodder + 30% concentrates; GFC-3= 70% hydroponic maize fodder + 30% concentrates. Values in the same row with different superscripts are significantly difference, (P<0.05). TVFA= Total Volatile Fatty Acids

potentially increase the satiety of the animals thus decreasing DMI (Hafla et al. 2014). Moreover, increased intake of water could be greater than the ability to transport water from the rumen, therefore limiting intake due to rumen fill (Havekes et al. 2020). Decreased DMI was similarly reported by Farghaly et al. (2019) when calves were fed barley fodder compared to that fed roughage as the control diet. The decrease in DMI found in the present study, as well as in other studies, could be due to the high-water content of hydroponic maize fodders. NRC (2001) indicated that a decrease in DMI does not occur until the moisture content of the diet increases above 50%. Moreover, Khan et al. (2014) observed a decline in DMI of cows when greater amounts of water were added to a high-moisture total mixed ration (TMR). In contrast, a study by Denißen et al. (2021) found a significant effect on DMI when cows were fed a diet with addition of water to total mixed ration (TMR) with a DM content of 42-47%. In addition, cows that were fed a diet with added water were reported to have greater DMI compared with the control group (Havekes et al. 2020). Results of the present study demonstrated that reduced DMI by the animals was caused by the high-water content of hydroponic maize fodders.

Rumen parameters

Ruminal pH did not differ between treatments (P= 0.26; Table.3). Ruminal ammonia-N concentration increases significantly with increasing substitution rates of maize fodder in the complete diet (P= 0.02). Total Volatile Fatty Acids (TVFA) concentration increased significantly with increasing substitution rates of maize fodder in the complete diet (P= 0.03). However, the molar proportion (as a percentage of TVFA) of acetic acid (P= 0.11), propionic acid (P= 0.11), butyrate acid (P= 0.05), iso-butyrate (P= 0.49) and iso-valerate (P= 0.09) did not differ between treatments.

Soaking grains has been reported to increase moisture content and various enzymes activity (Thakur et al. 2021). This leads to the breakdown of storage compounds into more simple and digestible fractions, such as starch to sugars or protein to amino acids (Sharma & Gujral 2020). Moreover, the germination of seeds to sprouts has been reported to increase the hydrolysis of nutrient reserves stored in the seed, allowing for the release of soluble compounds and, increasing the nutrients available for the rumen microflora (Lei et al. 2021). In addition, sprouted maize fodder supplies vitamins and enzymes which function as biocatalysts to support feed metabolism and release of energy from the feed (Farghaly et al. 2019). Providing the animal with a concentrates mixture and sprouted maize fodder caused a significant increase in both ruminal ammonia N and TVFA, presumably due to increased micro-organism activity (De Oliveira Franco et al. 2017). The same results were demonstrated by a previous study performed with goats, where ammonia N concentration increased as a result of sprouted barley feeding (Helal 2015). Based on those results, we hypothesized that feeding a diet with an increasing substitution rate of maize fodder would increase rumen fermentation, as well as DM and nutrient digestibility. The results of the present experiment, however, revealed that there were no differences between treatments for dry matter and nutrient digestibility. Hence, it is not in line with the majority of the previous studies where hydroponic fodder feeding increases nutrient digestibility compared with a control diet. Rather, the result of the present study was similar to those reported by Fazaeli et al. (2021) and Alharthi et al. (2023) that there were no significant effects of sprouted grains feeding on nutrient digestibility for dairy cows and lambs.

The absence of increasing nutrient digestibility with increasing the substation rate of maize fodder for grass silage that we observed in this experiment was somewhat difficult to explain particularly when the ruminal data was considered. The ruminal concentration of TVFA as well as ammonia were increased with the substitution. Since rumen ammonia and VFA concentrations are products of rumen fermentation, their concentrations would indicate the rate and extent of rumen degradation of both carbohydrate and protein (Alharthi et al. 2023). Therefore, rumen fermentation was possibly improved when grass silage was substituted with maize fodder, the DM and nutrient digestibility were expected to increase. According to Allen et al. (2019) DM digestibility is prominently dependent upon the rate and extent of rumen degradation. There was, however, a situation when improved rumen degradation did not follow an improvement in the total tract DM digestibility, i.e., when the improved rate of rumen degradation is, at the same time, followed by an increase of ruminal outflow rate (Jelantik et al. 2011). This perhaps occurred in the present experiment with diet composed of increasing proportion of maize fodder as a replacement of grass silage. With higher water content, the functional specific gravity (FSG) of those diets was increased and diet with a higher FSG had a higher ruminal passage rate (Teimouri Yansari 2017).

Another reason for the absence of treatment deference was that maize fodder contained a large amount of root. Although the total content of crude fibre declined with increasing substitution rate of grass silage with maize fodder, most fibre might be coming from the root which had a lower digestibility than leaf and stem. In addition, Al-zubiadi (2016) reported that the roots of fodder contained husk of the seeds that kept the endosperm at both seed formation and maturity (Dung et al. 2010) and had greater fibre which was made up of the cell wall polysaccharides and thus are more resistant to digestion compared to the young succulent shoots of the fodder (Dung et al. 2010).

Blood parameters

Increasing the substitution rate of hydroponic maize fodder in the diet did not affect (P= 0.189) plasma glucose concentration. Similarly, there was no difference between treatments (P= 0.065) for blood urea.

Blood urea is associated with the uptake and utilization of nitrogenous substances in the feed (Hristov et al. 2019). Feeding a diet with an increasing substitution rate of hydroponic maize fodder tended to increase (P = 0.06) blood urea of calves. This finding was in line with our hypothesis that increasing the substitution rate of hydroponic maize fodder will increase blood urea nitrogen as a result of increasing protein consumption. This might be due to the ammonia produced from protein degradation in the rumen being efficiently used for microbial protein synthesis..

Blood glucose concentration is an indication of carbohydrate digestion, absorption, and metabolism (Harmon & Swanson 2020). There was no difference between treatments on blood glucose concentration (P= 0.18) observed in this study. Glucose concentration was expected to increase with an increasing substitution rate of maize fodder in the diet of calves. When rumen fermentation was limited by nitrogen availability in the rumen, supplementation of protein-rich feed commonly improved rumen fermentation (Ma et al. 2021). A higher rate of rumen fermentation stimulated higher propionate concentration (Zeidali-Nejad et al. 2018; Castillo-Umaña et al. 2020). In addition, a higher rate of rumen fermentation stimulated higher microbial protein synthesis which resulted in increased amino acids absorption (Ma et al. 2021). Since propionate and amino acids are the important precursors for glucose synthesis

Table. 4. Blood urea nitrogen and blood glucose concentrations of weaned Ongole x Brahman male calves fed with increasing substitution rates of maize fodder and concentrates

Parameters	Treatments				Standard Error of Mean	P-values
	G[1)]	GCF1	GCF2	GCF3		
Blood urea, (mg/dL)	14.53[a2)]	17.58[ab]	23.60[b]	21.37[b]	1.43	0.06
Blood glucose, (mg/dL)	121.77	80.58	120.73	80.54	13.15	0.18

G= 70% silage grass + 30% concentrates; GFC-1= 35% silage grass + 35% hydroponic maize fodder + 30% concentrates; GFC-2= 17.5% silage grass + 52.5% hydroponic maize fodder + 30% concentrates; GFC-3= 70% hydroponic maize fodder + 30% concentrates. Values in the same row with different superscripts are significantly difference, (P<0.05)

in the liver (Castillo-Umaña et al. 2020), increasing the substitution rate of maize fodder in the diet of calves was expected to increase blood glucose concentration. The factor responsible for the failure of the increasing substitution rate of maize fodder in the diet in increasing blood glucose concentration in the present study might be related to the degradable protein from concentrate in the basal diet (about 30%) which provides sufficient amino acids for microbial synthesis and therefore the blood glucose level decreased. Another reason for lower blood glucose concentration was probably due to the role of the liver which is to control the uptake of nutrients from the digestive tract and to detect the rates of metabolites uptake such as glucose and amino acids to keep more stable levels for the general circulation (Castillo-Umaña et al. 2020).

CONCLUSION

Feeding hydroponic maize fodder as a substitute of grass silage to weaned Ongole x Brahman calves resulted in a decrease in the feed intake and nutrient digestibility. However, rumen parameters including TVFA and NH_3-N increased as a result of increasing the substitution rate of maize fodder for grass silage. Hence, hydroponic maize fodder could be used as a replacement for silage to improve the rumen fermentation of weaned Ongole x Brahman calves, although it might decrease total dry matter intake.

ACKNOWLEDGMENT

The authors wish to thank Universitas Nusa Cendana for funding this study. We gratefully thank Dr. Anthony Parker and Kirsten R. Nickles for proofreading and editing the manuscript.

REFERENCES

Allen MS, Sousa DO, VandeHaar MJ. 2019. Equation to predict feed intake response by lactating cows to factors related to the filling effect of rations. J. Dairy Sci. 102: 7961-7969. DOI:10.3168/jds.2018-16166 31326178.

Al-zubiadi IAH. 2016. Effects of substitution barley by 10%, 30% of sprouted barley on rumen characters, digestibility and feed efficiency in diet of Awassi male lambs. Int J Sci Res. 5:2228–2233. DOI:10.21275/v5i4.nov163174.

Alharthi AS, Al-Baadani HH, Abdelrahman MM, Alhidary IA. 2023. Effects of feeding different levels of sprouted barley on fermentation characteristics, bacterial quantification, and rumen morphology of growing lambs. Vet Sci. 10:1–14. DOI:10.3390/vetsci10010015.

AOAC. 2005. Official Methods of Analysis. 18th ed. Washington DC (USA): Association of Officiating Analytical Chemists.

Arif M, Iram A, Fayyaz M, Abd El-Hack ME, Taha AE, Al-Akeel KA, Swelum AA, Alhimaidi AR, Ammari A, Naiel MAE, Alagawany M. 2023. Feeding barley and corn hydroponic based rations improved digestibility and performance in Beetal goats. J King Saud Univ - Sci. 35. DOI:10.1016/j.jksus.2022.102457.

Castillo-Umaña M, Balocchi O, Pulido R, Sepúlveda-Varas P, Pacheco D, Muetzel S, Berthiaume R, Keim JP. 2020. Milk production responses and rumen fermentation of dairy cows supplemented with summer brassicas. Anim. 14:1684–1692. DOI:10.1017/S175173112000021X.

Conway EJ. 1947. Microdiffusion analysis and volumetric error. London (UK): Crosby Lockwood and Son, Ltd. pp.xix + 357 pp.

Denißen J, Beintmann S, Hoppe S, Pries M, Hummel J, Südekum KH. 2021. Influence of the addition of water to total mixed rations on the feeding behaviour, feed intake and milk performance of high-yielding dairy cows. Livest Sci. 254. DOI:10.1016/j.livsci.2021.104743.

Diao Q, Zhang R, Fu T. 2019. Review of strategies to promote rumen development in calves. Animals. 9:1–15. DOI:10.3390/ani9080490.

Dung DD, Godwin IR, Nolan J V. 2010. Nutrient content and in sacco degradation of hydroponic barley sprouts grown using nutrient solution or tap water. J Anim Vet Adv. 9:2432–2436. DOI:0.3923/javaa.2010.2432.2436.

Farghaly MM, Abdullah MAM, Youssef IMI, Abdel-Rahim IR, Abouelezz K. 2019. Effect of feeding hydroponic barley sprouts to sheep on feed intake, nutrient digestibility, nitrogen retention, rumen fermentation and ruminal enzymes activity. Livest Sci. 228:31–37. DOI10.1016/j.livsci.2019.07.022.

Fazaeli H, Golmohammadi HA, Tabatatbaei SN. 2021. Effect of replacing dietary corn silage with hydroponic barley green fodder on Holstein dairy cows performance. Iran J Appl Anim Sci. 11:45–47.

Fischer AJ, Villot C, van Niekerk JK, Yohe TT, Renaud DL, Steele MA. 2019. INVITED REVIEW: Nutritional regulation of gut function in dairy calves: From colostrum to weaning. Appl Anim Sci. 35:498–510. DOI:10.15232/aas.2019-01887.

Fustini M, Palmonari A, Canestrari G, Bonfante E, Mammi L, Pacchioli MT, Sniffen GCJ, Grant RJ, Cotanch KW, Formigoni A. 2017. Effect of undigested neutral detergent fiber content of alfalfa hay on lactating dairy cows: Feeding behavior, fiber digestibility, and lactation performance. J Dairy Sci. 100:4475–4483. DOI:10.3168 /jds.2016-12266.

Hafla AN, Soder KJ, Brito AF, Rubano MD, Dell CJ. 2014. Effect of sprouted barley grain supplementation of an herbage-based or haylage-based diet on ruminal fermentation and methane output in continuous culture1. J Dairy Sci. 97:7856–7869. DOI:10.3168/jds.2014-8518.

Harmon DL, Swanson KC. 2020. Review: Nutritional regulation of intestinal starch and protein assimilation in ruminants. Animal. 14:S17–S28. DOI:10.1017/S17517 31119003136.

Havekes CD, Duffield TF, Carpenter AJ, DeVries TJ. 2020. Moisture content of high-straw dry cow diets affects intake, health, and performance of transition dairy cows. J Dairy Sci. 103:1500–1515. DOI:10.3168/jds.2019-17557.

Helal HG. 2015. Sprouted barley grains on olive cake and barley straw mixture as goat diets in Sinai. Adv Environ Biol. 9:91–102.

Hristov AN, Bannink A, Crompton LA, Huhtanen P, Kreuzer M, McGee M, Nozière P, Reynolds CK, Bayat AR, Yáñez-Ruiz DR, et al. 2019. Invited review: Nitrogen in ruminant nutrition: A review of measurement techniques. J Dairy Sci. 102:5811–5852. DOI:10.3168/jds.2018-15829.

Jelantik IGN, Leo Penu C, Jermias JA, Weisberjg MR. 2011. Effects of fishmeal or urea supplementation on ruminal fibre digestion and passage kinetics in Bali cows. Anim. Prod. 12: 74-81.

Khan MA, Bach A, Castells L, Weary DM, Von Keyserlingk MAG. 2014. Effects of particle size and moisture levels in mixed rations on the feeding behavior of dairy heifers. Animal. 8:1722–1727. DOI:10.1017/S1751731114001 487.

Kide W, Desai B, Kumar S. 2015. Nutritional improvement and economic value of hydroponically sprouted maize fodder. Int J Life Sci Res. 2:76–79.

Lei K, Sun S, Zhong K, Li S, Hu H, Sun C, Zheng Q, Tian Z, Dai T, Sun J. 2021. Seed soaking with melatonin promotes seed germination under chromium stress via enhancing reserve mobilization and antioxidant metabolism in wheat. Ecotoxicol Environ Saf. 220. DOI:10.1016/j.ecoenv.2021.112241.

Liu YR, Du HS, Wu ZZ, Wang C, Liu Q, Guo G, Huo WJ, Zhang YL, Pei CX, Zhang SL. 2020. Branched-chain volatile fatty acids and folic acid accelerated the growth of Holstein dairy calves by stimulating nutrient digestion and rumen metabolism. Anim. 14:1176–1183. DOI:10.1017/S1751731119002969.

Ma J, Wang C, Wang Z, Cao G, Hu R, Wang X, Zou H, Kang K, Peng Q, Xue B, et al. 2021. Active dry yeast supplementation improves the growth performance, rumen fermentation, and immune response of weaned beef calves. Anim Nutr. 7:1352–1359. DOI:10.1016 /j.aninu.2021.06.006.

McCoard S, Heiser A, Lowe K, Molenaar A, MacLean P, Johnstone P, Leath S, Hoskin SO, Khan MA. 2019. Effect of weaning age on growth, mammary gland development, and immune function in Holstein Friesian calves fed conserved alfalfa (FiberStart). J Dairy Sci. 102:6076–6087. DOI:10.3168/jds.2018-15615.

Mullik M, Jelantik IGN. 2009. Strategi peningkatan produktivitas sapi bali pada sistem pemeliharaan ekstensif di daerah lahan kering: pengalaman Nusa Tenggara Timur. Pengemb Sapi Bali Berkelanjutan dalam Sist Peternak Rakyat.:1–15.

Naik PK, Karunakaran M, Chakurkar EB, Swain BK, Singh NP. 2016. Digestibility of nutrients in crossbred heifers supplemented with hydroponically sprouted maize grains. Indian J Anim.Sci. 86:1210–1212.

[NRC] National Research Council. 2001. Nutrient requirements of dairy cattle. 7th Revised. Washington DC [USA]: National Academies Press.

van Niekerk JK, Middeldorp M, Guan LL, Steele MA. 2021. Preweaning to postweaning rumen papillae structural growth, ruminal fermentation characteristics, and acute-phase proteins in calves. J Dairy Sci. 104:3632–3645. DOI:10.3168/jds.2020-19003.

De Oliveira Franco M, Detmann E, De Campos Valadares Filho S, Batista ED, De Almeida Rufino LM, Barbosa MM, Lopes AR. 2017. Intake, digestibility, and rumen and metabolic characteristics of cattle fed low-quality tropical forage and supplemented with nitrogen and different levels of starch. Asian-Australasian J Anim Sci. 30:797–803. DOI:10.5713/ajas.16.0629.

Rajkumar G, Dipu MT, Lalu K, Shyama K, Banakar PS. 2018. Evaluation of hydroponics fodder as a partial feed substitute in the ration of crossbred calves. Indian J. Anim. Res. 52:1809–1813. DOI:10.18805/ijar.B-3421.

Sharma B, Gujral HS. 2020. Modifying the dough mixing behavior, protein & starch digestibility and antinutritional profile of minor millets by sprouting. Int J Biol Macromol. 153:962–970. DOI:10.1016/j.ijbiomac. 2019.10.225.

Teimouri Yansari A. 2017. Effects of specific gravity and particle size of passage marker on particulate rumen turnover in holestine dairy cattle. Iran J Appl Anim Sci. 7:377–385.

Thakur P, Kumar K, Ahmed N, Chauhan D, Ul Q, Hyder E, Jan S, Pal T, Singh H. 2021. Current Research in Food Science Effect of soaking and germination treatments on nutritional , anti-nutritional , and bioactive properties of amaranth (*Amaranthus hypochondriacus* L.), quinoa (*Chenopodium quinoa* L.), and buckwheat (*Fagopyrum esculentu*. Curr Res Food Sci. 4:917–925. DOI:10.1016/j.crfs.2021.11.019.

Tian K, Liu J, Sun Y, Wu Y, Chen J, Zhang R, He T, Dong G. 2019. Effects of dietary supplementation of inulin on rumen fermentation and bacterial microbiota, inflammatory response and growth performance in finishing beef steers fed high or low-concentrate diet. Anim Feed Sci Technol. 258:114299. DOI:10.1016 /j.anifeedsci.2019.114299

Ungerfeld R, Quintans G, Hötzel MJ. 2016. Minimizing cows' stress when calves were early weaned using the two-step method with nose flaps. Anim. 10:1871–1876. DOI:10.1017/S1751731116000793.

Vendramini JMB, Moriel P. 2018. Forage management and concentrate supplementation effects on performance of beef calves. Anim Prod Sci. 58:1399–1403. DOI:10.1071/AN17797.

Xuan NH, Loc HT, Ngu NT. 2018. Blood biochemical profiles of Brahman crossbred cattle supplemented with different protein and energy sources. Vet World. 11:1021–1024. DOI:10.14202/vetworld.2018.1021-1024.

Zeidali-Nejad A, Ghorbani GR, Kargar S, Sadeghi-Sefidmazgi A, Pezeshki A, Ghaffari MH. 2018. Nutrient intake, rumen fermentation and growth performance of dairy calves fed extruded full-fat soybean as a replacement for soybean meal. Anim. 12:733–740. DOI:10.1017/S1 751731117002154.