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DETERMINATION OF THE NUTRITIONAL VALUE OF SOME TYPES OF FEED AND THE APPROPRIATE LEVEL OF FEEDING FOR BUFFALO IN THE GROWING STAGE

Major: Animal nutrition and feed

Code: 9 62 01 07

SUMMARY OF THE DOCTOTAL THESIS

Hanoi - 2022

This thesis was completed at: National Institute of Animal Science

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Time: Date … Month ….. Year 2022

The dissertation can be found at:

1. The National Library of Vietnam

2. The Library of the NIAS

LIST OF THE AUTHOR’S PUBLICATIONS

1**. Ta Van Can, Nguyen Van Dai, Nguyen Thi Lan, Chu Manh Thang and Tran Van Thang. 2021**. *The digestibility of nutrients of some common feedstuffs for buffalo rearing by in vivo digestion*. Journal of Livestock Science and Technology, No 127, September 2021, 65 - 76.

2. **Ta Van Can, Nguyen Thi Lan,Nguyen Van Dai and Chu Manh Thang**. **2021**. *Determination of organic matter digestibility and metabolic energy value of some buffalo feeds by in vitro gas production*. Journal of Livestock Science and Technology, No 129, November 2020, 58 - 71.

1. Introduction

According to the General Statistics Office in 2020, the total number of buffalo is about 2.33 million heads, the annual average from 2016 to 2020 decreased by 1.48%. The productivity of live-weight for slaughter increased on average from 2016 to 2020 by 2.34%/year which was the highest in the northern midland and mountainous region (5.01%/year). (Source GSO, April 2021).

Research results of some previous authors show that: The diet of buffaloe and cow is not balanced, or there is a lack or excess of energy and protein (Paul Pozy, 2002. Dinh Van Cai, 2005). We do not have sufficient data on the in vivo digestibility rate (determined in cattle) and therefore the nutritional value of each type has not been accurately calculated of food as well as ration which is the main reason for the unbalanced diet.

To do this, we need to know the chemical composition and then the nutritional value of the feed. In Vietnam, we do not have consistent system to calculate nutritional requirements for buffalo, however, we can use the recommendations from other countries such as the UK's ARC (1980); INRA of France (1989) and Kearl of America (1982). Especially, the nutritional need of Kearl (1982) is suitable for buffaloes in Vietnam, so it can be used before we have a complete nutritional system of Viet Nam.

To creat the data on chemical composition, nutritional value of some common feeds for buffalo in Vietnam instead of borrowing research results from foreign countries, thereby improving buffalo production, we carried out the study *"Determination of the nutritional value of some types of feed and the appropriate level of feeding for buffalo in the growing stage"*.

2. Objectives of the project

2.1. Overall objectives

Determination of chemical composition and digestibility of some basic nutrients of some feeds for buffalo in Vietnam by *in vivo* and *in vitro* gas production method. Determination of the appropriate level of feeding for buffalo at the growing stage of from 7 to18 months of age.

2.2. Detail objective

- To be determined the chemical composition of some popular feeds for buffaloes.
- To be determined the digestibility of nutrients, organic matter and metabolic energy value of some feeds for buffalo by *in vitro* gas production and *in vivo* method. Simultaneously, a linear regression equation was built for organic matter digestibility and exchange energy value between the two *in vivo* and *in vitro* gas production methods.
- To be determined the appropriate level of feeding for growing buffalo from 7 to 18 months of age.

3. Scientific and pratical value of the study

3.1. Scientific value of the study

The results of study have contributed to supplementing the database on chemical composition, digestibility of nutrients (dry matter, protein, fat, crude fiber, NDF, ADF, minerals and organic matter) of some feeds for buffalo.

To be Determined of organic matter digestibility (OMD) and metabolic energy (ME) values by *in vitro* and *in vivo* digestion method of some feeds for buffalo in Vietnam from chemical composition and their digestible nutrient content. A linear regression equation for organic matter digestibility and metabolic energy value was established between the *in vivo* methods and the *in vitro* gas production methods.

To be Determined the appropriate level of feeding for growing buffaloes from 7 to 18 months of age.

3.2. Practical value of the study

The results of the study are valuable references in scientific research and teaching, researchers, lecturers, students, masters and doctoral students of universities and research institute of animal science. At the same time, the results of this study are also applied to businesses, farm owners, and households in building an appropriate level of feeding for growing buffalo at the age of 7-18 months.

4. New contribution of the study

The study was determined the composition of nutritional value and digestibility of organic matter and the metabolic energy value of 11 types of feed ingredients for buffalo (including: 5 types of green forage, 3 types of dry forage and 3 types of starchy feed), based on digestion *in vitro* gas production and *in vivo* method. Simultaneously, 3 linear regression equations for estimating organic matter digestibility and 3 linear regression equations for estimating metabolic energy values of some feeds for buffalo were developed between the two *in vivo* and *in vitro* gas production methods with a strong correlation coefficient.

The study has determined the appropriate level of feeding, using some available materials to raise buffalo growing at 7 -18 months of age in Vietnam.

5. Tucture of the thesis

The thesis consists of 5 parts: Introduction (4 pages); Chapter 1: Literature review (40 pages); Chapter 2: Research content and methods (18 pages); Chapter 3: Results and discussion (66 pages); Conclusions and Recommendations (2 page). There are 38 tables of data, 6 figures, 129 references, and 1 page of list of author's publications.

Chapter 1
LITERATURE REVIEW

1.1. Scientific basis of research problem

The research problem of the thesis is based on the scientific basis of feed and feed classification for ruminant. Digestive characteristics and some methods to determine the nutritional value and digestibility of feed for ruminant. Effect of nutrient levels in the diet on the growth performance of ruminant.

1.2. Research situation in Viet Nam and international

The *in vitro* gas production technique was studied by Menke and Steingass (1986-1988) studied to complete procedure for conducting *in vitro* gas production experiments. Simultaneously, from these studies, equations drawn to diagnose the digestibility rate and energy value of the feeds based on the gas production results when incubating the experimental feed samples in *in vitro* conditions and the nutritional composition of them. In which the result of gas generation at 24 hours after incubation is an important parameter combined with the values of crude protein (CP), crude fiber (CF), crude fat (CL), total mineral (CA) of the analyzed feed samples to estimate the digestibility and energy value of the experimental feed samples.

Determination of digestibility of feeds directly on cattle (*in vivo*) plays an important role in estimating the nutritional value of ruminant feed. This work has been carried out for a long time in most countries of the world where ruminant farming is developed.

Before 2000, in Vietnam, there were also many studies on the chemical composition and nutritional value of feed for cattle and poultry in Viet Nam. These studies have been published in the "Handbook on nutritional composition of animal feed Viet Nam" (Nguyen Van Thuong et al., 1992) and the book "Composition and nutritional value of cattle and poultry feeds Viet Nam" (National Institute Animal Science, 2001).

In vitro gas production technique is the method to estimate digestibility and energy value of feed. Vu Chi Cuong et al. (2004d) studied to estimate the digestibility and energy value of 20 types of feeds for ruminant including green forage groups (natural grass, 60-day-old elephant grass, guine grass, etc.), dry forage group (dried straw, Alfalfa hay, pangola hay), starchy feed group (Red cornmeal, rice bran, tapioca), compound feed group (C40 bran, BS18 bran), group of foods rich in protein (cotton seed, beer residue, concentrated bran GYO 68) and some other feeds. The author caried out the experiments on sheep and cattle.

Dinh Van Muoi (2012) studied the chemical composition, *in vivo* digestibility, energy values and protein of some green forages, dry forages, crop by-products, silage, feeding energy, protein supplement for ruminants and determining a regression equation to estimate organic matter digestibility (OMD), metabolizable energy (ME) of ruminant feed from data on the amount of gas produced after 24 hours and chemical composition. The author has published the chemical composition, *in vivo* digestibility, energy and protein value of regenerating Elephant grass in summer and autumn; 13 types of green forage, hay, agicultural by-products and 3 types of silage; 7 types of energy-rich foods and 14 types of protein-rich foods. However, the author experimented on cattle and sheep.

Nguyen Cong Dinh et al. (2021) studied the effect of levels of starchy feed on the weight gain of Bao Yen buffalo raised commercially at the age of 13 -18 months showed that dry matter consumption (DM) per 1 kg weight gain is from 11.43 kg - 12.85 kg. Metabolic energy per 1 kg weight gain is from 112.53 - 124.64 MJ. Protein per 1 kg weight gain is from 1.56 - 1.64 kg.

Chapter 2
RESEARCH CONTENTS AND METHODS

2.1. Research subjects, location and time of study

2.1.1. Research subjects

- Feed: 11 types of feed for buffalo divided into 3 groups: green forage group (5 types: Grass VA06, Elephant grass cut at 40-45 days old at regeneration, Panicummaximum Hamill grass (*P. Hamill*); Brachiaria Decumbens grass (*Decumbens*); Brachiaria Ruziziensis grass (*Ruzi*), cut at 35- 40 days of age of regeneration), dry forage group (3 types: dry straw, dry Ruzi grass and dry Decumbens grass) and starchy feed group (3 types: cornmeal, milled rice and rice bran).
- Cattle: 06 domestic buffaloes, 30 months of age, average body weight: 280 kg and 12 growing domestic buffaloes (6 male and 6 female) 7 months of age, body weight: 80 - 90 kg.

2.1.2. Research location

The Mountainous Animal Research and Development Center and Department of Analysis for feed and liverstock product belong to Institute of Animal Science. Institute of Life Sciences belongs to Thai Nguyen University of Agriculture and Forestry.

2.1.3. Study period: 2016 - 2021.

2.2. Reseach contents

2.2.1. Determination of nutritional composition of some feeds for buffalo

2.2.2. Determination of organic matter digestibility and metabolic energy value of some feeds for buffalo by *in vitro* gas production method.

2.2.3. Determination of digestibility of feed nutrients, metabolic energy values of some feeds for bufalo by *in vivo* digestion method

2.2.4. Building a linear regression equation for organic matter digestibility and metabolic energy value determined by *in vitro* gas production method with *in vivo* method

2.3.5. Determination of the appropriate level of feed for growing buffalo at 7 - 18 months of age

2.3. Reseach methods

2.3.1. Determination of nutritional composition of some feeds for buffalo

- Sampling method according to TCVN 4325-2007.

- DM is determined according to TCVN 4326 - 2007.
- CP is determined according to TCVN 4328- 2007.
- Crude fat is determined according to TCVN 4331-2007.
- Raw fiber is determined according to TCVN 4329 - 2007.
- NDF and ADF are determined according to AOAC 973.18.01
- Total minerals are determined according to TCVN 4327- 2007.

2.3.2. Determination of organic matter digestibility and metabolic energy value of some feeds for buffalo by in vitro gas production method

2.3.2.1. In vitro gas production experiment

Table 2.1. Diagram of the experiment for *in vitro* gas production digestion

Feed symbol	Type feed of experiment	Number of repetitions
TA1	VA06 grass	3
TA2	*P. Hamill* grass	3
TA3	*Decumbens* grass	3
TA4	*Ruzi* grass	3
TA5	Elephent grass	3
TA6	Dried Straw	3
TA7	Dried Ruzi grass	3
TA8	Dried Decumbens Grass	3
TA9	Corn bran	3
TA10	Milled rice	3
TA11	Rice bran	3
Blank	Does not contain food samples	3
	Total number of cylinders	**36**

* Reseacrh contents and methods of determination

Total gas production of feed at 0; 3; 6; 12; 24; 48 and 96 h after incubation were recorded for each cylinder. The amount of gas accumulated during *in vitro* fermentation is calculated as following: accumulated gas (ml) = amount of gas produced at time t (ml) - average amount of gas produced at time t (ml) of cylinders without sample feed (blank).

2.3.2.2. Method for determination of organic matter digestibility and metabolic energy value.

Based on the amount of gas generated when incubating 200 mg of dry matter feed after 24 hours of incubation and the chemical composition of the studied feed to estimate the *in vitro* organic matter digestibility and the metabolic energy value of the feed. The formulas using to estimate of Menke and Steingass, (1988) are as following:

** For green forage:*

$$OMD\ (\%) = 33.71 + 0.7464 \times G_{24}$$

$$ME\ (MJ/Kg\ DM) = 2.20 + 0.1357 \times G_{24} + 0.0057 \times CP + 0.0002859 \times EE$$

** For dry forage:*

$$OMD\ (\%) = 17.04 + 1.1086 \times G_{24}$$

$$ME\ (MJ/Kg\ DM) = 2.20 + 0.136 \times G_{24} + 0.057 \times CP;$$

** For* starchy feed *(Cereal and by-products):*

$$OMD\ (\%) = 24.59 + 0.7984 \times G_{24} + 0.0496 \times CP$$

$$ME\ (MJ/Kg\ DM) = 2.2 + 0.136 \times G24 + 0.057 \times CP$$

In which: ME is the metabolic energy (MJ/kg DM)

OMD is organic matter digestibility (%)

CP is crude protein (%)

EE is crude fat (%)

G_{24} is ml of gas produced after incubation of 200 mg DM of the sample after 24 h of incubation

2.3.2.3. Determination of total short-chain fatty acids (SCFA)

Calculated according to the formula of Getachew et al., 2000a:

$$SCFA = 0.0239 \times G_{24} - 0.0601$$

2.3.3. Determination of digestibility of feed nutrients and metabolic energy values of some feeds for buffalo by in vivo digestion method

2.3.3.1. Experimental layout

Table 2.2. Diagram of the experiment for *in vivo* digestion

Items	**Experimental buffalo 1 (T01)**	**Experimental buffalo 2 (T02)**	**Experimental buffalo 3 (T03)**	**Experimental buffalo 4 (T04)**
Preparation time (days)	10	10	10	10
Experimental time (days)	5	5	5	5
Experimental feed*	*VA06 grass*	*VA06 grass*	*VA06 grass*	*VA06 grass*

*Notes: * Types of feed: Decumbens grass; P.Hamill grass; Ruzi grass; King grass, Dry Straw; dry Ruzi grass; Dry Decumbens grass; Cornmeal; Rice bran; The milled rice was arranged in a similar way.*

2.3.3.2. The method of determination of digestibility of feed

+ Analysis of chemical composition of leftovers, urine and manure (Method of analysis of indicators as in experiment 1)

+ Weight of buffalo and amount of feed intake, leftovers, manure and urine.

+ Determine the digestibility of a type of feed calculated from the amount of feed intake, leftovers and dry matter of the feed.

The digestion rate of a nutrient A in the feed is calculated by the formula:

- For green forage group:

Digestion rate of substance A (%) =[(Amount of substance A ingested from food - Amount of substance A in leftovers - Amount of substance A excreted in feces, urine)/Amount of substance A ingested from food] x 100 .

- For the group of dry forage and Starchy feed group.

Determination of *in vivo* digestibility of dry forage in diets arranged with 50% green forage (VA06 grass) and 50% dry forage. which are caculted by DM according to Kearl's standard (1982).

Determination of *in vivo* digestibility of Starchy feed group in diets arranged with the ratio of 70% forage (VA06 grass) and 30% starchy feed which are caculted by DM according to Kearl's standard (1982.

- *In vivo* digestibility of substance A (%) = [Amount of substance A ingested from feed (50% grass VA06 + 50% dry forage) - Amount of substance A leftover (50% VA06 grass + 50% dry forage) - Amount of substance A in manure, urine (50% VA06 grass +50% dry forage)/ [Amount of substance A ingested from feed (50% VA06 grass + 50% dry forage)] x 100%.

- *In vivo* digestibility of substance A (%) = [Amount of substance A ingested from feed (70% VA06 grass + 30% starchy feed) - Amount of substance A of leftovers (70% VA06 grass + 30 % of concentrate) - Amount of substance A in manure and urine (70% VA06 grass +30% starchy feed)/ [Amount of substance A ingested from food (70% VA06 grass + 30% starchy feed)] x 100%.

+ Determination of the amount of methane (CH_4) emitted according to the equation of Yan et al., (2006)

Methane (L/day) = 0,34* BW(kg) + 19,7*DMI (kg/d) +12

In which: DMI is the feed dry matter intake; BW: body weight

+ Determination of the value of metabolic energy (ME, MJ/kg DM) calculated directly based on crude energy (GE) for all 3 feed groups

ME = GE of feed - GE of feces - GE of urine - GE of methane

- Crude energy (GE) of feed, feces and urine is determined by calorimetric method on Bomb calorimeter IKA C2000 made in Germany.

2.3.4. Creating a linear regression equation for organic matter digestibility and metabolic energy value determined by in vitro gas production method with in vivo method.

The dataset of *in vitro* gas production digestion experiments at 24 h of 11 types of feed including: 05 types of green forage group; 03 types of dry forage group and 03 types of concentrate group:.

Using the regression algorithm to creat a first order linear, multi-dimensional regression equation to estimate the digestibility of organic matter and the metabolic energy value of the feed based on the volume of gas produced at 24 h in the *in vitro* gas production experiment and the nutritional composition of the feed compared to the organic matter digestibility and metabolic energy value in the *in vivo* digestion experiment. The first order multidimensional regression equation will have the following form:

$$y = ax + b$$

In which: y is the organic matter digestibility or metabolic energy value of *in vivo* digestion;

x is the organic matter digestibility or metabolic energy value of *in vitro* digestion;

a is the regression coefficient; b is the coefficient of freedom.

2.3.5. Determination of the appropriate level of feed for growing buffalo at 7 - 18 months of age

* Research indicators

The experiment was conducted in 12 months (7-18 months old), the research indicators will be divided into two phases: the first stage is 7-12 months old and the second stage is 13-18 months old.

Table 2.3. Experimental diagram

Items	Experiment		
	Control treatment	**Treatment 1**	**Treatment 2**
Number of buffaloes (head)	4	4	4
Weight (kg)	88.8	87.7	88.5
Age of buffalo starting the experiment (months)	7	7	7
Preparation time (days)	15	15	15
Experiment time (month)	12	12	12
Meal level according to Kearl standard, 1982	100%	105%	110%

+ Effect of different feeding levels in the diet on daily feed intake of buffaloes at 7-12 and 13-18 months of age.

+ Effects of different feeding levels in the diet on changes in body weight of buffaloes at 7-12 and 13-18 months of age: Cumulative growth (kg); Absolute growth (gr/head/day)

+ The efficiency of using feed of buffalo at 7-12 and 13-18 months of age: DM intake per 1 kg weight gain; ME intake per 1 kg weight gain; Cost of CP per 1 kg weight gain.

+ Cost of feed for buffalo at 7-12 and 13-18 months of age.

** Method of research indicators*

+ Nutritional composition of experimental feed

- The nutritional value composition of each ingredient in the diet was determined from the results of previous experiments.

+ Effects of different feeding levels in the diet on feed intake of buffaloes at 7-12 and 13-18 months of age.

- Feed intake and leftovers were weighed daily to determine feed intake. The amount of food obtained was calculated as follows:

- Dry matter intake (%) = (Feed intake × % dry matter) - (Residual feed intake × % dry matter).

- Nutrients intake such as ME and Protein were calculated in the same way as dry matter.

+ Effects of different feeding levels in the diet on body weight changes of buffalo at 7-12 and 13-18 months of age:

- Cumulative growth: buffaloes were periodically weighed once every 30 days using Australia's Rud Weight-1200 electronic scale with an accuracy of 99.5%. Buffaloes were weighed in the morning before feeding and drinking of 3 consecutive days to get the average weight.

- The absolute growth (g/head/day) of experimental buffaloes was calculated according to the routine method in livestock research.

+ The efficiency of using feed of buffalo at 7-12 and 13-18 months of age.

- DM consumption (kg/kg weight gain) = Total weight of DM intake/total weight gain (kg) of buffalo.

- ME consumption (MJ/kg weight gain) = Total weight of ME intake/total weight gain (kg) of buffalo.

- CP consumption (g/kg weight gain) = Total weight of protein intake/total weight gain (kg) of buffalo.

+ Feed cost per 1 kg weight gain was calculated according to the following formula:

$$C = \frac{T}{P}$$

In which: C is feed cost per 1 kg weight gain (VND)

T is the total feed cost for whole experimental period

P is the weight gain in whole experimental period

2.4. Data analysis methods

2.4.1. Data analysis method of the experiments to determine the composition of nutrients, digestibility of organic matter and energy value of some buffalo feeds used by in vitro and in vivo digestion methods

Research data were preliminarily processed by Microsoft Office Excel software, then analysis of variance (ANOVA) by minitab 17 software: Sample size (n), mean (Mean), error of mean (SE). The pairwise mean was compared by Tukey comparison with P = 0.05 level.

Determination of Regression correlation of OMD and estimated ME values from gas production data after 24 hours of incubation of *in vitro* gas production digestion experiments were calculated based on the existing equation of Menke and Steingas (1988). The *in vivo* digestion is used a first-order regression equation as following:

$$y = ax + b$$

In which: y is the OMD or ME value of *in vivo* digestion.
x is the OMD or ME value of *in vitro* digestion.
a is the regression coefficient;
b is the coefficient of freedom.

2.4.2. Data analysis method of the experiment to determine the appropriate level of feeding for growing buffalo from 7-18 months of age

Research data is preliminarily processed by Microsoft Office Excel software, then analysis of variance (ANOVA) by Minitab 17 software. Statistical parameters include: sample size (n), mean (Mean), error of mean (SE). The pairwise mean was compared by Tukey comparison with P = 0.05 level.

Chapter 3
RESULTS AND DISCUSSION

3.1. Results of determining the nutritional composition of some feeds for buffalo

The results of Table 3.1 show that: The DM ratio of green forage group is 15.52 - 22.58%. Crude protein ratio is 7.99 - 12.14%. NDF rate ranges from 58.91 - 67.65%. The percentage of OM ranges from 89.25 to 91.41%. The dry matter ratio of dry forage group is 86.75 - 91.25% and crude protein ratio from 5.15 - 10.77%. The rate of NDF is from 65.15 - 67.25 and the rate of OM is 87.44 - 88.14%. The DM ratio of starchy feed group is 84.62 - 87.85%, CP ratio ranging from 6.70 - 15.41%. The rate of NDF ranged from 23.97 - 28.24%, the rate of ADF ranged from 6.33 - 18.31% and the rate of OM 88.18 - 97.52%.

Table 3.1. Nutritional composition of some buffalo feeds

Type of feed	Dry matter (%)	Nutritional composition (% Dry matter)						
		CP (%)	***F (%)***	***CF (%)***	***NDF (%)***	***ADF (%)***	Total Minerals ***(%)***	***OM (%)***
Green forage group								
VA06 grass	15.52	9.35	1.34	27.76	62.38	26.05	8.72	91.28
Elephent grass	18.32	7.99	1.46	27.50	67.60	31.27	10.75	89.25
P.Hamill grass	21.54	9.72	1.09	26.17	67.65	27.93	8.86	91.14
Decumbens grass	21.63	10.96	1.52	30.83	60.75	31.28	8.59	91.41
Ruzi grass	22.58	12.14	1.95	28.75	58.91	33.93	8.85	91.15

			Dry forage group					
Dried *Ruzi* grass	87.94	10.77	2.55	30.95	66.41	38.20	11.86	88.14
Dried *Decumbens* grass	86.75	9.91	2.45	31.67	67.25	36.71	12.18	87.82
Dried Straw	91.25	5.15	2.22	32.56	65.15	39.29	12.56	87.44
			Starchy feed group					
Cornmeal	86.57	6.70	2.86	2.80	23.97	6.33	2.48	97.52
Milled rice	84.62	9.06	4.68	12.57	28.24	18.31	11.82	88.18
Rice bran	87.85	15.41	7.15	10.82	26.18	10.90	5.47	94.53

3.2. Results of determination of organic matter digestibility and metabolic energy values of some feeds for buffalo by *in vitro* gas production method.

3.2.1. Gas accumulation fermenting in vitro gas production of some feeds for buffalo at different times

In the green forage group, the total accumulated gas up to 96 hours after incubation ranged from 40.17 to 51.25ml, the average gas production ranged from 0.42 to 0.53ml/hour. In the dry forage group, the total accumulated gas up to 96 hours of incubation was 33.89 - 39.90 ml, equivalent to 0.35 - 0.41ml/hour. In the starchy feed group 46.50 -51.50 ml is equivalent to 0.48 - 0.54 ml/hour.

Table 3.2. Gas accumulation fermenting in vitro gas production of some feeds for buffalo at different times (ml)

Type of feed		incubation time (hour)					
		3	***6***	***12***	***24***	***48***	***96***
			Green forage group				
VA06 grass	Mean	2.31	5.12	12.90	30.64	36.59	41.40
	SE	0.66	1.07	2.02	1.63	1.58	3.35
King grass	Mean	2.00	5.50	12.33	28.00	35.50	40.17
	SE	0.60	1.17	1.15	0.33	1.45	2.52
P.Hamill grass	Mean	1.83	5.51	12.49	28.85	37.17	47.50
	SE	0.17	0.53	0.97	1.31	0.69	0.76
Decumbens grass	Mean	2.39	6.15	13.80	27.91	41.02	49.33
	SE	0.21	0.85	1.67	0.96	0.95	0.76
Ruzi grass	Mean	2.32	5.64	13.93	28.03	42.95	51.25
	SE	0.16	0.68	0.27	0.91	0.49	1.29
			Dry forage group				
Dry *Ruzi* grass	Mean	1.73	4.01	9.37	26.59	33.95	39.29
	SE	0.15	0.76	0.45	0.43	0.20	0.90
Dry Straw	Mean	1.34	3.33	6.01	22.87	28.55	33.89
	SE	0.33	0.66	0.56	0.62	0.65	0.43
Dry *Decumbens* grass	Mean	1.67	3.84	8.68	27.04	34.06	39.90
	SE	0.33	0.60	0.32	0.69	0.64	1.16

Type of feed		incubation time (hour)					
		3	*6*	*12*	*24*	*48*	*96*
		Starchy feed group					
Cornmeal	Mean	4.67	5.67	21.67	49.17	51.17	51.50
	SE	0.33	1.20	0.34	0.46	0.47	0.47
Milled rice	Mean	4.17	7.00	20.17	40.67	46.50	46.50
	SE	1.20	1.33	2.42	0.33	1.20	1.20
Rice bran	Mean	5.00	7.67	17.67	47.83	49.67	50.33
	SE	0.58	0.88	0.33	1.53	1.48	1.44

3.2.2. Digestibility of organic matter and metabolic energy values of some feeds for buffalo

The result in table 3.3.a shows that averge OMD of 5 types of grass is 54.54 - 56.58%.

ME values is 6.05 - 6.89MJ/kg DM. The diffirence between ME values of king grass and VA06 is significant (P<0,05).

SCFA of green forage group is 0,61-0,67mmol.

Table 3.3a. Digestibility of organic matter, metabolic energy values and SCFA of green forage group

Type of feed	OMD (%)		ME (MJ/kg DM)		SCFA (mmol)	
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*
VA06 grass	56.58	1.22	6.89[a]	0.22	0.67	0.04
King grass	54.61	0.37	6.05[b]	0.05	0.61	0.01
P. Hamill grass	55.24	0.98	6.67[ab]	0.18	0.63	0.03
Decumbens grass	54.54	0.72	6.61[ab]	0.13	0.61	0.02
Ruzi grass	54.63	0.68	6.70[ab]	0.12	0.61	0.02

Note: *In horizontal rows, mean numbers with different letters are statistically significant (P<0.05).*

Table 3.3b. Digestibility of organic matter, metabolic energy values and SCFA of dry forage group

Type of feed	OMD (%)		ME (MJ/kg DM)		SCFA (mmol)	
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*
Dry *Ruzi* grass	46.52[a]	0.48	6.43[a]	0.06	0.58[a]	0.01
Dry *Decumbens* grass	47.02[a]	0.77	6.44[a]	0.09	0.59[a]	0.02
Dry Straw	42.40[b]	0.68	5.60[b]	0.08	0.49[b]	0.01

Note: *In same columns, mean numbers with different letters are statistically significant (P<0.05).*

OMD of dry forage group is 42.40 – 47.02% and ME value is 5,60 - 6,44 MJ/kg DM.

Table 3.3c. Digestibility of OM, ME values and SCFA of starchy feed group

Loại thức ăn	OMD (%)		ME (MJ/kgDM)		SCFA (mmol)	
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*
Cornmeal	64.18[a]	0.37	9.27[a]	0.06	1.12[a]	0.01
Milled rice	57.51[b]	0.27	8.25[b]	0.05	0.91[b]	0.01
Rice bran	63.54[a]	1.22	9.58[a]	0.21	1.08[a]	0.04

Note: *In same columns, mean numbers with different letters are statistically significant (P<0.05).*

The OMD of starchy feed group is 57.51 - 64.18%. ME value is 8.25 - 9.58 MJ/kg DM.

3.3. The results of determination of digestibility of some nutrients, ME of some feeds for buffalo by *In vivo* digestion method

3.3.1. Green forage group

Table 3.4a. The digestibility of DM, CP, NDF and ADF of the green forage group (%,n=4)

Type of feed	DM		CP		NDF		ADF	
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*
VA06 grass	66,19[a]	1.36	66.99[b]	1.30	64.57[a]	1.42	53.89	1.90
King grass	59.03[b]	1.50	50.75[c]	1.84	58.27[b]	1.50	51.22	1.77
P. Hamill grass	63.63[ab]	1.47	74.08[a]	0.89	64.80[a]	1.41	56.57	1.76
Decumbens grass	62.92[ab]	1.40	70.85[ab]	1.06	62.76[ab]	1.65	56.66	1.36
Ruzi grass	61.38[ab]	1.15	74.61[a]	0.74	66.44[a]	0.99	56.71	1.27

Note: *In same columns, mean numbers with different letters are statistically significant (P<0.05).*

Nutrients digestibility *in vivo* of green forage group is 59.03 - 66.19%. DM digestibility is 59.03 - 63.63%. CP digestibility is 50.75 - 74.61%. NDF digestibility is 58.27 - 66.44%, and ADF digestibility is 51.22 - 56.71%.

Bảng 3.4b. *In vivo* organic matter digestibility, metabolic energy values and methane emissions of the 5 forage types (n=4)

Type of feed	OMD (%)		ME (MJ/Kg DM)		CH4 (lít/con/ngày)	
	Mean	***SE***	***Mean***	***SE***	***Mean***	***SE***
VA06 grass	67.08[a]	1.28	8.44	0.26	125.68	8.03
King grass	59.41[b]	1.48	7.76	0.18	126.31	7.79
P. Hamill grass	64.36[ab]	1.44	8.12	0.15	122.37	8.06
Decumbens grass	63.77[ab]	1.36	7.93	0.11	120.44	7.70
Ruzi grass	62.68[ab]	1.11	8.08	0.15	129.49	7.08

Note: *In same columns, mean numbers with different letters are statistically significant (P<0.05).*

OMD is 59.41–67.08% and ME value is 7.76 -8.44 MJ/kg DM.

The amount of CH4 is 120.44 - 129.49 liter/head/day.

3.3.2. Dry forage group

Nutrients digestibility of dry forage group: DM is 44.69 - 57.88. CP is 61.62 - 67.57%. NDF is 54.16 - 60.21% and ADF is 38.16 - 47.54%.

Table 3.5a. Digestibility of DM, CP, NDF and ADF of dry forage group (%, n=4)

Type of feed	DM		CP		NDF		ADF	
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*
Dry *Ruzi* grass	56.70[a]	2.91	67.57[a]	2.08	60.21	2.73	47.54[a]	3.39
Dry *Decumbens* grass	57.88[a]	0.31	66.64[ab]	0.41	60.07	0.31	46.35[ab]	0.20
Dry straw	44.69[b]	1.83	61.62[b]	1.06	54.16	1.29	38.16[b]	1.98

Note: *In same columns, mean numbers with different letters are statistically significant (P<0.05).*

OMD is 52.41 - 61.39%. ME value is 7.28 - 7.87 MJ/kg DM. There is a significant difference in ME value between dry straw and dry *Ruzi* grass and dry *Decumbens* grass (P<0,05)

Amount of CH4 is 132.29 - 137.49 liter/head/day.

Table 3.5b. *In vivo* organic matter digestibility, metabolic energy values and methane emissions of the 3 dry forage types (n=4)

Type of feed	OMD (%)		ME (MJ/kgDM)		CH4 (lít/con/ngày)	
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**
Dry *Ruzi* grass	61.39[a]	2.70	7.85[a]	0.08	137.49	8.04
Dry *Decumbens* grass	60.33[a]	0.64	7.87[a]	0.12	132.29	7.23
Dry straw	52.41[b]	1.37	7.28[b]	0.20	132.92	7.66

Note: *In same columns, mean numbers with different letters are statistically significant (P<0.05).*

3.3.3. Starchy feed group

Digestibility of starchy feed group: DM is 68.65 - 74.99%. CP is 64.18 - 83.46%. NDF is 75.56 - 82.13%. ADF is 45.98 - 61.44%.

OMD is 73.26 - 80.05%, ME is 9.19 – 11.63 MJ/kg DM. CH4 emission is 147.16 - 152.40 liter/head/day.

Table 3.6a. Digestibility of DM, CP, NDF và ADF of starchy feed group (%,n=4)

Type of feed	DM		CP		NDF		ADF	
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*	*Mean*	*SE*
Cornmeal	73.07[a]	0.62	64.18[c]	0.92	82.13	1.18	45.98[b]	2.06
Milled rice	68.65[b]	0.80	68.97[b]	0.74	75.94	1.61	61.44[a]	1.31
Rice bran	74.99[a]	1.22	83.46[a]	0.55	75.56	3.01	56.21[ab]	4.28

Note: *In same columns, mean numbers with different letters are statistically significant (P<0.05).*

Table 3.6b. ***In vivo*** **digestibility of OM, ME and CH4 emission of three types of starchy feed group (n=4)**

	OMD (%)		ME (MJ/kgDM)		CH4 (lít/con/ngày)	
Loại thức ăn	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
Cornmeal	79.94[a]	0.38	11.63[a]	0.10	143.61	7.73
Milled rice	73.26[b]	0.65	9.19[b]	0.26	147.16	7.83
Rice bran	80.05[a]	1.58	11.03[a]	0.21	152.40	7.46

Note: *In same columns, mean numbers with different letters are statistically significant (P<0.05).*

3.4. The result of creating a linear regression equation for OM digestibility and ME value between two digestion methods *in vivo* and *in vitro* gas production of some feeds for buffalo

3.4.1. The result of creating a linear regression equation for OM digestibility between two digestion methods in vivo and in vitro gas production of some feeds for buffalo

3.4.1.1. Green forage group

The linear regression equation for OMD between two digestion methods *in vivo* and *in vitro* gas production as following:

$$Y = 1,2476 X - 4,7351; R^2 = 0,7686; r = 0,88; P = 0,0001$$

The correlation relationship between the *in vivo* and *in vitro* digestion methods in terms of organic matter digestibility of the 5 grees forage types in this study is very close (r = 0.88) and has a high confidence level of 99.99% (P = 0.0001).

3.4.1.2. Dry forage group

The linear regression equation for OMD between two digestion methods *in vivo* and *in vitro* gas production as following:

$$Y = 2,6041X - 57,9940; R^2 = 0,7358; r = 0,86; P = 0,003$$

The correlation relationship between the *in vivo* and *in vitro* digestion methods in terms of organic matter digestibility of the 3 dry forage types in this study is very close (r = 0.86) and has a high confidence level of 99.7% (P = 0.003).

3.4.1.3. Starchy feed group

The linear regression equation for OMD between two digestion methods *in vivo* and *in vitro* gas production as following:

$$Y = 1,2671X - 6,9272; R^2 = 0,9157; r = 0,96; P = 0,0001$$

The correlation relationship between the *in vivo* and *in vitro* digestion methods in terms of organic matter digestibility of the 3 starchy feed types in this study is very close (r = 0.96) and has a high confidence level of 99.99% (P = 0.0001).

3.4.2. The result of creating a linear regression equation for ME digestibility between two digestion methods in vivo and in vitro gas production of some feeds for buffalo

3.4.2.1. Green forage group

The linear regression equation for ME digestibility between two digestion methods *in vivo* and *in vitro* gas production as following:

$$Y = 1{,}3657\ X - 0{,}9857;\ R^2 = 0{,}8436;\ r = 0{,}92;\ P = 0{,}0001$$

The correlation relationship between the *in vivo* and *in vitro* digestion methods in terms of ME digestibility of the green forage feed in this study is very close (r = 0.92) and has a high confidence level of 99.99% (P = 0.0001).

3.4.2.2. Dry forage group

The linear regression equation for ME digestibility between two digestion methods *in vivo* and *in vitro* gas production as following:

$$Y = 0{,}5433\ X + 4{,}4430;\ R^2 = 0{,}8706;\ r = 0{,}93;\ P = 0{,}0001$$

The correlation relationship between the *in vivo* and *in vitro* digestion methods in terms of ME digestibility of the 3 dry forage types in this study is very close (r = 0.93) and has a high confidence level of 99.7% (P = 0.003).

3.4.2.3. Starchy feed group

The linear regression equation for ME digestibility between two digestion methods *in vivo* and *in vitro* gas production as following:

$$Y = 1{,}4942X - 2{,}7643;\ R^2 = 0{,}8046;\ r = 0{,}90;\ P = 0{,}001$$

The correlation relationship between the *in vivo* and *in vitro* digestion methods in terms of ME digestibility of the 3 starchy feed types in this study is very close (r = 0.90) and has a high confidence level of 99.9% (P = 0.001).

3.5. Determination of the appropriate level of feed for growing buffalo at 7 - 18 months of age

3.5.1. Effect of different feeding levels in the diet on daily feed intake of buffalo

Period from 7 - 12 months of age, total DM intake is 3.29 - 3.60 kg/day; total ME intake is 38.1 - 41.7 MJ/kg DM and total CP intake is 408.3 - 446.9 g/head/day. DM intake/100 kg body weight is 2.70 - 2.77 kg/100kg body weight. ME intake and CP intake/100 kg body weight are 31.9 - 33.2 MJ and 339.3 - 352.1 g respectively.

Table 3.7. Daily feed intake of buffalo

Iterms	Unit	Control treatment (100%)		Treatment 1 (105%)		Treatment 2 (110%)	
		Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*
7 -12 months of age							
Total DM	Kg	3.29^{b}	0.28	3.43^{ab}	0.30	3.60^{a}	0.33
Total ME	MJ	38.1^{b}	1.51	39.7^{ab}	1.52	41.7^{a}	1.74
Total CP	g	408.3^{b}	25.8	425.8^{ab}	26.3	446.9^{a}	29.3
DM/100kg body weight	Kg	2.70	0.10	2.74	0.09	2.77	0.12
ME/100kg body weight	MJ	31.9	1.56	32.5	1.92	33.2	2.01
CP/100kg body weight	g	339.3	10.7	344.0	14.1	352.1	15.5
13 -18 months of age							
Tổng DM	Kg	5.21^{b}	0.19	5.41^{ab}	0.18	5.72^{a}	0.19
Total ME	MJ	48.4^{b}	1.78	50.2^{ab}	1.30	53.1^{a}	1.33
Total CP	g	547.3^{b}	16.6	568.7^{ab}	11.3	600.7^{a}	10.9
DM/100kg body weight	Kg	2.52	0.07	2.54	0.05	2.61	0.07
ME/100kg body weight	MJ	23.4	0.15	23.6	0.65	24.3	0.79
CP/100kg body weight	g	265.7	2.71	268.2	9.11	275.1	10.5

In horizontal rows, mean numbers with different letters are statistically significant ($P<0.05$).

Period from 13 - 18 months of age, total DM intake is 5.21 - 5.72 kg/day and total DM intake /100 kg body weight is 2.52 - 2.61 kg/100kg body weight. Total ME intake is 48.4 - 53.1 MJ/kg DM and total ME intake/100 kg body weight is 23.4 - 24.3 MJ. Total CP intake is 547.3 - 600.7 g/head/day and Total CP intake /100 kg body weight is 265.7 - 275.1g.

3.5.2. Effect of different feeding levels in weight gain of buffalo from 7-18 months of age

Bảng 3.7. Weight gain of buffalo from 7-18 months of age

Items	Unit	Treatment					
		Control treatment (100%)		Treatment 1 (105%)		Treatment 2 (110%)	
		Mean	SE	Mean	SE	Mean	SE
7 -12 months of age							
Body weight at start experiment	kg	88.9	2.59	87.7	2.29	88.5	2.65
Body weight at 12 months of age	kg	166.7[b]	3.55	177.4[a]	2.40	182.5[a]	4.61
Total weight gain	kg	77.9[b]	2.03	89.6[a]	1.98	94.0[a]	2.35
Weight gain/head/day	g	432.6[b]	11.3	497.9[a]	11.0	522.2[a]	13.1
13-18 months of age							
Body weight at 13 months of age	kg	166.7[b]	3.55	177.4[ab]	2.40	182.5[a]	4.61
Body weight at 18 months of age	kg	230.3[b]	3.90	255.5[a]	2.87	264.6[a]	5.21
Total weight gain	kg	63.5[b]	0.61	78.1[a]	0.52	82.1[a]	3.24
Weight gain/head/day	g	352.8[b]	3.40	434.0[a]	2.86	456.3[a]	18.0

In horizontal rows, mean numbers with different letters are statistically significant (P<0.05).

The weight of buffalo in the treatments increased gradually with age. At the beginning of the experiment, the average weight was 87.7 - 88.9 kg. At 12 months of age, the average weight ranged from 166.7 - 182.5 kg, at 18 months was 230.3 - 264.6 kg. The average weight gain of buffalo at 7-12 and 13-18 months of age was 432.6 - 522.2 g/head/day and 352.8 - 456.3 g/head/day, respectively.

3.5.3. Feed Consumption of growing buffalo in the period of 7 - 18 months of age

At the stage of 7 -12 months old: Consumption of dry matter for 1 kg of weight increase from 7.03 to 7.68 kg/kg of weight gain. ME ranges from 81.1 to 88.8 MJ/kg weight gain and CP consumption per 1 kg body weight gain ranges from 871.2 to 953.3 g. At the stage of 13 - 18 months of age: The dry matter consumption is 13.5 - 16.0 kg/kg of weight gain. The cost of ME/1kg of weight gain is 125.1 - 148.5 MJ. Cost of CP / 1 kg of weight gain is: 1.41 - 1.67 kg.

Table 3.8. Feed consumption for 1 kg weight gain of experimental buffalo at 7 - 18 months of age

Items	Unit	Control treatment (100%)		Treatment 1 (105%)		Treatment 2 (110%)	
		Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*
7 -12 months of age							
DMI	kg	591.7	8.27	617.0	8.98	647.8	9.85
MEI	MJ	6860.4	45.4	7154.5	45.7	7503.0	52.2
CPI	kg	73.5	0.77	76.6	0.79	80.4	0.88
Weight gain	kg	77.8[b]	2.03	89.6[a]	1.98	94.0[a]	2.35
DMI/kg weight gain	kg	7.68	0.87	7.03	0.79	7.07	0.90
MEI/kg weight gain	MJ	88.8	4.95	81.1	5.54	81.4	6.63
CPI/kg weight gain	kg	953.3	74.1	871.2	77.8	875.4	90.1
13 -18 months of age							
DMI	Kg	958.7	5.71	995.6	5.55	1052.0	6.12
MEI	MJ	8894.2	52.4	9241.0	39.1	9763.9	43.5
CPI	Kg	100.7	0.48	104.6	0.34	110.5	0.37
Weight gain	kg	63.5[b]	0.61	78.1[a]	0.52	82.3[a]	2.34
DMI/kg weight gain	kg	16.0	2.16	13.5	1.78	13.6	1.58
MEI/kg weight gain	MJ	148.5	18.2	125.1	15.5	125.8	13.6
CPI/kg weight gain	kg	1.67	0.19	1.41	0.16	1.42	0.14

In horizontal rows, mean numbers with different letters are statistically significant ($P<0.05$).

3.5.4. Cost of raising buffalo at 7 - 18 months of age in diets with different feeding levels

Bảng 3.9. Feed cost of raising buffalo at 7 - 18 months of age

Items	Unit	Control treatment (100%)	Treatment 1 (105%)	Treatment 2 (110%)
7 - 12 months of age				
Total starchy feed/head	kg	688	716	767
Starchy feed cost	VND	3,577,997	3,724,364	3,986,494
Total greed forage/head	kg	3,191	3,321	3,555
Green forage feed cost	VND	957,231	996,389	1,066,518
Total cost (Starchy feed + Green forage feed)	VND	4,535,228	4,720,753	5,053,012
Total weight gain/head	kg	77,9	89,6	94,0
Feed cost/1kg weight gain	VND	58,218	52,687	53,755
13 - 18 months of age				
Total starchy feed/head	kg	667	693	749
Starchy feed cost	VND	3,468,400	3,603,600	3,894,800
Total greed forage/head	kg	5007	5205	5625
Green forage feed cost	đ	1,502,145	1,561,461	1,687,478
Total cost (Starchy feed + Green forage feed)	đ	4,970,545	5,165,061	5,582,278
Total weight gain/head	kg	63,5	78,1	82,1
Feed cost/1kg weight gain	đ	78,276	66,133	67,993

The cost of feed for 1 kg weight gain of buffalo at 7-12 and 13-18 months of age was lowest in treatment 1 (52,687 VND and 66,133 VND/kg weight gain), followed by treatment 2 (53,755 VND and 67,993 respectively) and the highest in the control treatment (58,218 and 78,276 VND/kg weight gain). Thus, using a diet with a feed rate of 105% compared to Kearl's (1982) standard for growing buffaloes, the cost of feed for 1kg of weight gain decreased by 5,531 VND/kg of weight gain (equivalent to 9.5%) at 7-12 months old and decreased 12,143 VND/kg weight gain (equivalent to 15.5%) at 13-18 months of age compared to 100% of Kearl's (1982) standard.

CONCLUSION AND RECOMMENDATION

4.1. Conclusion

1. Nutritional composition of 11 popular feeds for buffalo including: 5 types of green forage (VA06 grass; Elephant grass; P. Hamill grass; *Decumbens* grass; Ruzi grass), 3 types of dry forage (dry *Ruzi* grass, dry *Decumbens* grass and dry straw) and 3 types of starch (cornmeal; milled rice and rice bran) to ensure sufficient conditions to combine diets for buffaloes in Vietnam.

2. Using the *in vitro* gas production digestion method was determined the digestibility of organic matter and the metabolic energy value of the forage group which are 54.54 - 56.58% and 6.05 - 6.89 MJ/kg DM respectively; the digestibility of organic matter and the metabolic energy value of the dry forage group are 42.40 - 47.02% and 5.60 - 6.44 MJ/kg DM and that of the starchy feed group is 57.51 - 64.18% and 8.25 - 9.58 MJ/kgDM.

3. Using the *in vivo* digestion method was determined the nutritional digestibility of 11 types of feed for buffalo, in which the digestibility of OM and the ME value of the green forage group are 59.41 - 67.08% and 7.76 - 8.44 MJ/kg DM, respectively. Those of dry forage group are 52.41 - 61.39% and 7.28 - 7.87 MJ/kg DM, respectively and the digestibility of organic matter and the metabolic energy value of starchy feed group are 73.26 - 80.05% and 9.19 - 11.63 MJ/kg DM, respectively.

4. Six linear regression equations were created for organic matter digestibility and exchange energy values between the two methods of digestion *in vivo* and *in vitro*. The all equations have high coefficients of determination and close correlation coefficients, the confidence level (P) reaches from 99.70 to 99.99%.

5. Using a diet with a nutrient level of 105 - 110% compared to the standard of Kearl (1982) to raise buffaloes growing at 7-18 months of age increased body weight (167.7 - 176.1kg) compared

with 141.4 kg (100% rations of Kearl). The average cost is 58,949 - 60,393 VND/kg of weight gain, decreased from 6,833 - 8,277 VND/kg weight gain (67,226 VND/kg weight gain). Reducing feed consumption, increasing economic efficiency compared to level of 100% of Kearl, in which the level of 105% is the most suitable.

4.2. Recomendarion

Using the *in vitro* gas production digestibility method to determine the organic matter digestibility and metabolic energy values.

Applying diets with a feed rate of 105% compared to Kearl's (1982) standards for growing buffalo in production practice to raise buffaloes at 7-18 months of age.

Continue to study digestion *in vivo* on buffalo with a larger sample size to confirm accurate results as a basis for recommendations for practical application.