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Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra, Indonesia

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Abstract. *Muhakka, Suwignyo RA, Budianta D, Yakup. 2020. Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra, Indonesia. Biodiversitas 21: xxxx.* This study was aimed at determining the types and quality of vegetations in the swamp area, which could be used as sources of roughage for Pampangan buffaloes in South Sumatera. In this descriptive study. Results showed that the highest crude protein and ether extract contents, 20.56 and 2.92%, respectively, were found in Kemon air *(Neptunia olerancia)*. The highest ash content of 25.19% was found in Kasuran *(Cyperus digitatus)*. The lowest fiber content (11.01%) was found in Cecengkehan *(Ludwigia hyssopifolia),* which also had the lowest content of Neutral Detergent Fiber (NDF) (40.64%). Hemicellulose content was found to be highest (37.14%) in Bento rayap *(Leersia hexandra)*. The lowest ADF (23.66%) and lignin (14,84%) contents were found in Telepuk gajah *(Nymphaea lotus)*. Kemon air *(N. olerancia)* was found to have the lowest content (27.08%) of cellulose. It was concluded that the swamp vegetation found in this study consisted of 17 types of grasses (89.47%) and two types of legumes (10.53%). Kasuran *(C. digitatus)* and Cecengkehan *(L. hyssopifolia)* were found to have the best nutritional values. Dominant and palatable vegetations with good nutritional values, which were potential to be used as sources of roughage for *Pampangan* buffaloes, were Kumpai tembaga *(Hymenachne acutigluma)*, Kumpai padi *(O ryza rupifogon)*, Kumpai minyak *(Hymenachne amplexicaulis*, Are bolong *(Polygonum barbatum)*, and Purun tikus *(Eleocharis dulcis)*.

Key words: Nutritional value, Swamp grass, Feed, Pampangan buffalo.

INTRODUCTION

The availability of roughage as the main feed for ruminant animals depends considerably on seasons. During the rainy season, it is abundant, and during the dry season, the availability of grasses and legumes is lacking. The limited supply of roughage may hamper productivity including the reproductive performance of ruminant animals including buffaloes.

In South Sumatera, Pampangan buffalo is a potential germplasm which needs to be preserved and developed. There were 37,405 heads of Pampangan buffaloes in 2016, and this population increased by 3.97% to 38,952 heads in 2017. In 2017, of this population, 11,150 heads (28.63%) and 2,227 heads (5.72%) were found in Ogan Komering Ilir Regency and Banyuasin Regency, respectively (Statistik Peternakan Sumsel 2017). The population and productivity of *Pampangan* buffaloes need to be improved, and for this purpose, feed is an important factor to consider. Pampangan buffaloes feed mostly on roughage from the swamp, grassland to meet their maintenance and reproductive needs.

In Indonesia, there are 13.27 million hectares of lowland swamp areas. Only 4 million hectares of these areas have been developed and cultivated by the community and private sectors (2.6 million hectares) and the government assistance (1.3 million hectares) (BPS 2010, Mulyani and Sarwani 2013). In Sumatera, the largest lowland swamp area of 2.98 million hectares is found in South Sumatera, but only 298,189 hectares of it have been utilized (BPS Sumatera Selatan 2014). In order to utilize the potential swamp area as a feed source for Pampangan buffaloes, a study on vegetations as sources of roughage in lowland swamp areas that include vegetation identification and nutritional quality determination needs to be conducted.

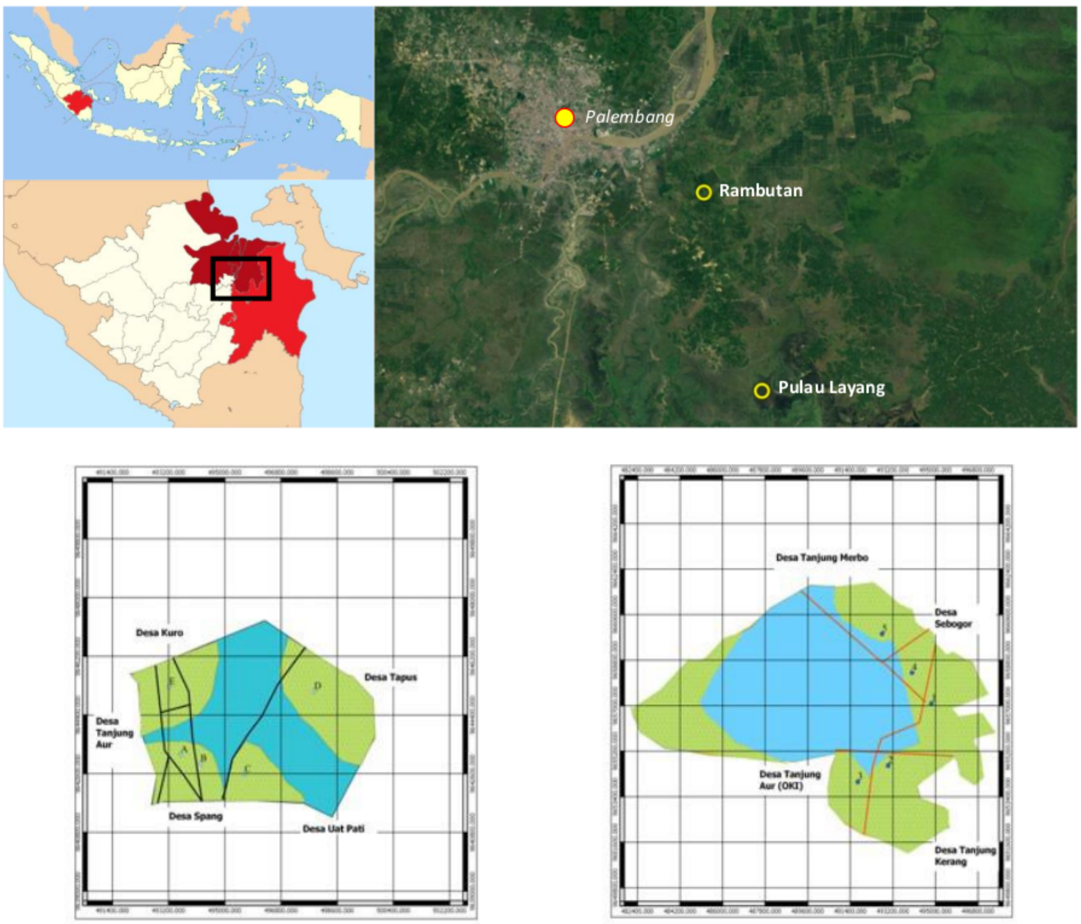
In the previous study, some swamp grasses, including Kumpai minyak grass (*H. amplexicaulis)* (Rostini et al. 2014**;** Muhakka et al. 2015), *I. rugosum* and *L. hexandra* (Ali et al. 2012) were identified. However, many more swamp has not been identified. For example, *P. barbatum,C. digitatus, R. corymbosa* This study was conducted to identify the types and nutritional values of vegetations that could be used as sources of roughage feed for Pampangan buffaloes in South Sumatera. This information was important to support the productivity improvement of Pampangan buffaloes as germplasm in South Sumatera. In this study, some new swamp found where in the previous study it's not found yet.

MATERIALS AND METHODS

Area study

This study was a descriptive study to assess the types and nutritional values of vegetations, which were the dominant and palatable as sources of roughage feed for Pampangan buffaloes. Vegetation samples were taken from grazing areas of Pampangan buffaloes in Rambutan Village and Pulau Layang Village, South Sumatra, Indonesia (Figure 1) from April to Juni 2017. Vegetation samples for nutrient analysis were obtained by following these procedures: (i) vegetation collection was done based on estimated growth age (young age, medium age, and old age based on physical appearance), (ii) collected samples of each vegetation was composited, and (iii) samples were chopped into small sizes, homogenized.

For each vegetation, 1 kg sample was taken randomly and sent to the laboratory for oven drying at 105°C until a constant weight was obtained and dry matter content was determined. Samples were then ground for nutrient content determination by using proximate and Van Soest analyses (Syarifuddin and Wahdi 2010). Sample analyses of Crude protein, fiber, ether extract, and ash contents conducted in Laboratory of Dairy Nutrition, Department of Nutrition and Feed Technology, Institut Pertanian Bogor (IPB), Bogor, Indonesia, while analyses of NDF, ADF, hemicellulose, cellulose, and lignin conducted in Biotechnology Assessment Laboratory, Center for Biotechnology Research, Indonesian Institute of Sciences (LIPI), Cibinong, Bogor; and analysis of soil conducted in Laboratory of Soil Chemistry, Biology, and Fertility, Soil Department, Faculty of Agriculture, Sriwijaya University, Ogan Ilir, Indonesia.



A B

Figure 1. Research location in South Sumatra, Indonesia. A. Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra. B. Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra, Indonesia (Muhakka et al. 2019)

Measured parameters

Soil analysis

Soil sampling is done in a composite manner at a depth of 0-20 cm. Taking the soil sample points is done by making a diagonal line in each zone and determining 5 soil sampling points to analyze chemical fertility (N, P, K) and physical fertility (texture, structure and pH).

Proximate analysis

Crude protein, fiber, ether extract, and ash contents were determined based on the procedures of AOAC (1990). *Crude protein*. Nitrogen (N) content was determined by using a Kjeldahl method. In this analysis, sulphuric acid with a catalyst and a heating process. The organic matter of samples was then oxidized by sulfuric acid, and nitrogen was changed into an ammonium sulfate form. The remaining sulfuric acid was neutralized by NaOH until the solution became basic. Ammonium sulfate was then distilled in an acid medium to obtain the quantitative amount of N. As the average protein contains 16% nitrogen, a factor 100 %: 16% = 6.25 was used to obtain the value of crude protein (crude protein = N% x 6.25). *Fiber*. The filtered fat-free sample was used in fiber content determination. 1.25% sulfuric acid solution was added into the sample, and the mixture was heated for about 30 minutes before the residue was filtered. 1,25% NaOH solution was added into the precipitate, and the mixture was heated for about 30 minutes. The mixture was then filtered, and the precipitate was washed, dried, and weighed. This precipitate was burnt, and the ash was weighed. The difference between the weight of precipitate before it was burnt and the weight of the ass was referred to as fiber content. *Ether extract*. The dry matter sample was extracted with diethyl ether for 5 hours. At the end of the extraction process, ether evaporated and the remaining material was referred to as fat. *Ash*. The third part of the dry matter sample was weighed and burnt in a crucible at 550°C for 8 hours.

Van Soest analysis

Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), hemicellulose, cellulose, and lignin contents were determined by using a Van Soest method (1982).

Neutral Detergent Fiber (NDF). One gram of sample was put in a beaker glass. 50 ml NDS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a filter glass which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. NDF content was calculated by using the following formula:

$$\% \text{ NDF} = \frac{c-b}{a} \times 100\%$$

Acid Detergent Fiber (ADF). One gram of sample was put in a beaker glass. 50 ml ADS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a sintered glass filter which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. Cellulose content was calculated by using the following formula:

$$\% \text{ cellulose} = \frac{c-d}{a} \times 100\%$$

Hemicellulose. Hemicellulose content was calculated as a difference between NDF and ADF contents as follows.

% Hemicellulose = % NDF-% ADF

Lignin. Cellulose residue (d gram) was burnt in a furnace at 500-600°C for 3 hours. After that, it was left to cool and weighed (e gram). Lignin content was calculated by using the following formula:

$$\% \text{ Lignin} = \frac{d-e}{a} \times 100\%$$

Data analysis

The data obtained were used directly to describe the nutritional value of the swamp vegetation that could be used as a roughage source. These data were then combined with those of *in vitro* digestibility as the basis for concluding (Syarifuddin and Wahdi 2010).

RESULTS AND DISCUSSION

Soil analysis

Results of soil analysis showed that soil at the study site had a low fertility level and was highly acidic. It also had very high organic C and total N contents, medium level of exchangeable-K and N contents, very low Ca and Mg contents, medium P content, and very high CEC level (Table 1).

Nutrient contents of lowland swamp

Crude protein, fiber, ether extract, and ash nutrient contents of lowland swamp vegetations found in this study are listed in (Table 2).

The NDF and ADF contents of vegetations found in this study were about 40.65-79.47% and 23.66-60.33%, respectively. Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Lignin contents of lowland swamp vegetation ranged from 14.84 to 43.09% (Table 3).

Discussion

Crude protein content

Results showed that the crude protein contents of swamp green vegetations ranged from 5.26% to 20.56% with the lowest value (5.26%) was found in Berondong grass (*R. corymbosa*) and the highest (20.56%) was found in Kemon air legume (*N. olerancia*). Kasuran grass (*C. digitatus*) had the highest crude protein content (15.31%) (Table 2). This high nutritional value of Kasuran grass was suspected as caused by the fact that most of this grass was found to grow in the area of buffalo pens where the soil was rich in organic matter. However, the growth of this grass was not dominant as it mostly occurred in rainy seasons.

Kumpai minyak (*H. amplexicaulis*), Kumpai padi (*O. rupifogon*), Kumpai tembaga (*H. acutigluma*), and Purun tikus (*E. dulcis*) were found as the dominant palatable grasses containing 12.00, 10.41, 10.96, and 8.22% crude protein, respectively. Results of this study were not too different from those obtained by Rostini et al. (2014), who reported that Kumpai minyak and Pipisangan had protein contents of 10.88 and 15.92%, respectively. Crude protein (CP) contents of these swamp grasses in Pulau Layang and Rambutan Villages were closed to those of prime grasses including 9.11-12.8% CP of *elephant* grass (*P. purpureum*) (Santos et al. 2013; Dahlan and Iskandar 2013; Rahman et al. 2014), 12.4% CP of *elephant* grass hay, 11.1% CP of *elephant* grass silage, 11.4% CP of king grass hay, and 10.2% CP of king grass silage (Santoso and Hariadi 2008). Other vegetations even had higher CP contents including Kumpai tembaga *(H. acutigluma)* with 10.96% CP, Tapak dara (*C. roseus*) 15.20%, Telepuk gajah (*N. lotus*) 13.22%, Cecengkehan (*L. hyssopifolia*) 12.07%, Kasuran *(C. digitatus*) 15.31%, and Kumpai minyak (*H. amplexicaulis)*[R] 12.0% (Table 2). CP contents of vegetations in this study were also higher than those of nature grasses found in coffee plantation areas (6.95%) and pastoral areas (6.65%) in Wulanggitang District, East Flores Regency as reported by Kleden et al. (2015). Meanwhile, CP content of grasses in lowlands was 8.41% (Rochana et al. 2016; Maswada and Elzaawely 2013).

Table 1. Properties of soil at the study site

Parameter	*Pulau Layang*		*Rambutan*	
	Value	Remark	Value	Remark
pH H_2O (1 : 1)	5.10	Low	4.41	Very low
pH KCl (1 : 1)	4.39	Very acidic	3.99	Very acidic
Organic C (g/kg)	57.66	Very high	36.14	Very high
Total N (g/kg)	3.64	Very high	2.19	Very high
Available P/Bray I (mg/kg)	11.70	Medium	2.25	Very low
Exchangeable K (cmol/kg)	0.63	Medium	0.45	Medium
Na (cmol/kg)	0.65	Medium	0.65	Medium
Ca (cmol/kg)	1.95	Very low	0.73	Very low
Mg (cmol/kg)	0.45	Very low	0.32	Very low
CEC (cmol/kg)	65.25	Very high	43.50	Very high
Exchangeable Al (cmol/kg)	1.84		2.37	
Exchangeable H (cmol/kg)	0.74		0.88	
Texture:				
Sand (%)	47.08		46.64	
Ash (%)	31.11		27.18	
Clay (%)	21.81		26.18	

Table 2. Crude protein, fiber, ether extract, and ash contents (%) of lowland swamp vegetations

Latin name	Local name	Crude protein	Fiber	Ether extract	Ash
Catharanthus roseus	Tapak dara	15.20	11.18	1.29	12.53
Cyperus digitatus	Kasuran	15.31	14.76	1.42	25.19
Digitaria fuscescens	Kerak Maling/Pasiran	12.00	15.64	1.24	16.26
Eichhornia crassipes	Eceng gondok	8.61	20.66	0.84	14.22
Eleocharis dulcis [P]	Purun tikus	8.22	25.72	0.48	15.13
Eleocharis dulcis [R]	Purun tikus	6.63	24.52	1.69	10.24
Hymenachne acutigluma) [P]	Kumpai Tembaga	6.86	30.26	2.22	7.88
Hymenachne acutigluma [R]	Kumpai Tembaga	10.96	23.73	1.77	10.30
Hymenachne amplexicaulis [P]	Kumpai Minyak	9.21	21.91	2.82	13.96
Hymenachne amplexicaulis [R]	Kumpai Minyak	12.00	15.64	1.24	16.26
Hymenachne sp	Kumpai Merah	8.52	21.20	1.30	12.88
Ipomoea aquatica	Kangkung merah	8.95	14.34	2.24	10.39
Leersia hexandra	Bento rayap	5.35	27.57	2.06	5.63
Ludwigia hyssopifolia	Cecengkehan	12.07	11.01	1.66	9.09
Neptunia olerancia	Kemon air	20.56	15.03	2.92	7.31
Nymphaea lotus	Telepuk Gajah	13.22	11.45	2.84	10.30
Oryza rupifogon [P]	Kumpai Padi	7.93	23.30	1.60	16.25
Oryza rupifogon [R]	Kumpai Padi	10.41	21.59	2.49	11.92
Polygonum barbatum	Are Bolong	7.53	16.60	1.57	8.40
Rhynchospora corymbosa	Berondong	5.26	22.27	1.48	14.84
Sesbania exasperata	Mutiara	18.27	11.22	1.86	19.47

Notes: [P] : Grass in Pulau Layang Village; [R] : Grass in Rambutan Village.

Table 3. Composition of fiber fractions of green vegetations in lowland swamp: NDF, ADF, hemicellulose, cellulose, and lignin (%).

Latin name	NDF	ADF	Hemi-cellulose	Cellulose	Lignin
Catharanthus roseus	47.79	39.67	8.12	16.96	22.71
Cyperus digitatus	58.90	36.93	21.97	5.24	31.68
Digitaria fuscescens	65.43	33.56	31.87	12.11	21.45
Eichhornia crassipes	62.77	41.83	20.94	10.22	31.60
Eleocharis dulcis P	69.57	49.83	19.74	21.80	28.04
Eleocharis dulcis R	75.73	54.91	20.82	19.71	35.20
Hymenachne acutigluma P	75.89	50.60	25.29	12.25	38.34
Hymenachne acutigluma R	64.72	46.38	18.34	16.01	30.37
Hymenachne amplexicaulis	65.31	38.92	26.39	8.29	30.63
Hymenachne sp	60.14	28.40	31.74	8.64	19.76
Ipomoea aquatica	41.40	26.17	15.23	6.32	19.85
Leersia hexandra	79.47	42.33	37.14	25.88	33.92
Ludwigia hyssopifolia	40.64	32.91	7.73	8.39	24.52
Neptunia olerancia	62.31	45.44	16.87	27.08	18.36
Nymphaea lotus	46.05	23.66	22.39	8.82	14.84
Oryza rupifogon P	71.13	60.33	10.80	17.23	43.09
Oryza rupifogon R	65.49	46.19	19.30	14.96	31.24
Polygonum barbatum	61.27	48.46	12.81	20.28	28.18
Rhynchospora corymbosa	65.29	44.64	20.65	16.08	28.56

Note: P : Grass in Pulau Layang Village; R : Grass in Rambutan Village.

Figure 2. Dominant and palatable swamp roughages with good nutrient contents included. **A**. *Hymenachne acutigluma*, **B**. *Oryza rupifogon* **C**. *Hymenachne amplexicaulis,* **D**. *Polygonum barbatum*, and **E**. *Eleocharis dulcis*.

This high protein content was suspected to be caused by the fact that soil organic C and total N contents in the study site were also high, namely 36.14-57.66 and 2.19-3.64 g.kg^{-1}, respectively (Table 1). Soil organic C and total N contents affected protein content in plants. Four swamp grasses including Kasuran (*C. digitatus*), Tapak dara (*C. roseus*), Telepuk gajah (*N. lotus*), and Cecengkehan (*L. hyssopifolia*) and a legume, Kemon air (*N. olerancia*) were found to be the lowland swamp vegetations having the highest N contents of 15.31,15.20, 13.22, 12.07, and 20.56%, respectively.

Fiber contents

Fiber contents of lowland swamp green vegetations ranged from 11.01 to 30.26%, with the lowest content found in Cecengkehan (*L. hyssopifolia*) and the highest in Kumpai tembaga *(H. acutigluma* P*)*. Four vegetations including *Cecengkehan* (*L. hyssopifolia*), Tapak dara (*C. roseus*), Mutiara legume (*S. exasperata*), and Telepuk gajah (*N. lotus*) were found to have the lowest fiber contents of 11.01, 11.18, 11.22, and 11.45%, respectively (Table 2). These results were almost similar to those found by Ali et al. (2012) who reported that the fiber contents of roughage in a pasture ranged from 7.20 to 34.98%. These researchers found that the fiber content of Bento rayap (*Leersia hexandra*) was 27.40% which was very close to that (27.57%) of the same vegetation in this study. Meanwhile, Rostini et al. (2014) reported that the fiber contents of swamp vegetation in South Kalimantan ranged from 14.84 to 29.35% with the lowest content found in Hadangan (*Paspalum sp*) and the highest in Dadangsit (*L. adscendens*). These figures were lower than those found by Kleden et al. (2015) who revealed that nature grasses in a coffee plantation area and pasture in Wulanggitang, East Flores contained 34.57 and 35.59% of fiber. They also found that the lowest fiber content was found in *L. peploides* and the highest in *I. rugosum*. Fiber contents reported by Kleden et al. (2015) were higher than the results reported by Ahmed *et al*. (2013) with a fiber content of 29.32% in *D. aegyptium* plants. A previous study showed that fermented *I. rugosum, H. amplexicaulis*, and *O. rifipogon* had fiber contents of 29.27, 29.57, and 33.07%, respectively (Muhakka et al. 2015).

The fiber content of Eceng gondok (*E. crassipes*) in this study (20.66%) was lower than those found by Hossain et al. (2015), Tham and Uder (2015), and Make et al. (2016). In addition, the fiber content of Eceng gondok (*E. crassipes*) in this study was lower than those of *Azolla*, another water plant, ranging from 13.19 to 16.54% (Kathirvelan et al. 2015; Anitha et al. 2016) and 9.25 to 13.25% (Ahmed et al. 2016). These fiber contents of *Azolla* equaled to those of Cecengkehan (*L. hyssopifolia*) (11.01%), Tapak dara (*C. roseus*) (11.18%), Mutiara legume (*S. exasperata*) (11.22%), Telepuk gajah (*N. lotus*) 11.45%, and Kangkung merah (*I. aquatica*) (14.34%) found in this study. Fiber contents of swamp green vegetations found in this study indicated that they were potential to be used as feed for Pampangan buffaloes.

Ether extract contents

Lowland swamp vegetations in this study were found to have ether extract (EE) contents of about 0.48-2.92%. The lowest EE content was found in Purun tikus (*E. dulcis*) while the highest was found in Kemon air legume *(N. olerancia*). Four vegetations of lowland swamp including Telepuk gajah (*N. lotus*) (2.84% EE), Kumpai minyak (*H. amplexicaulis*) (2.82% EE), Kumpai padi (*O. rupifogon*) (2.49% EE), and Kangkung merah (*I. aquatica* Forsk) (2.24% EE) were revealed to have the highest ether extract contents (Table 2). Results of this study were lower than those found by Rostini et al. (2014), reporting about 0.61-3.67% of EE contents in swamp vegetations in South Kalimantan with the lowest found in Pipisangan (*L. hyssopifolia*) and the highest in Padi hiang (*O. rufigopon spotanea*). EE contents of lowland swamp vegetations were 1.40-1.91% for grasses and 1.36-2.95% for legumes (Asep et al. 2012) and those of grasses in a pasture for buffaloes in Pulau Moa were 1.95-2,41% (Eoh 2014). In other studies, grasses in a natural pasture in North *Lore*, Poso Regency had EE contents of 2.12-2.34% (Damry 2009) and those in Sabana Timur Barat pasture in the rainy season to the end of dry season had an average EE content of 1.91% (Manu 2013). A study by Se'u et al. (2015) revealed an EE content of 1.07% in grasses in a pasture in Timor Tengah Selatan Regency. Another work by Kleden et al. (2015) showed that vegetations in a natural pasture and a coffee plantation area had EE contents of 1.23 and 1.35%, respectively.

Vegetations found in this study had EE contents equaled to those of prime grasses including *elephant* grass (*P. purpuerum*) and *king* grass (*P. purpureophoides*) preserved in the form of hay and silage. *Elephant* grass hay and silage had EE contents of 1.9 and 2.6%, respectively, while those of king grass had EE contents of 1.6 and 2.4%, respectively (Santoso and Hariadi 2008; Ukpabi et al. 2015). EE contents of some species of ruminant roughages were found to be about 1.2-4.1% (Ahmed et al. 2013). Dominant swamp roughages including Kumpai minyak (*H. amplexicaulis* and Kumpai padi *(O. rupifogon)* had EE contents of 2.82 and 2.49%, respectively and they were palatable and potential to be used as feed for Pampangan buffaloes.

Ash contents

Ash contents of green vegetations in lowland swamp ranged from 5.63 to 25.19%. Four types of vegetations with the highest ash contents included Kasuran (*C. digitatus*) (25.19%), Mutiara legume (*S. exasperata*) (19.47%), Kumpai minyak (*H. amplexicaulis*) (16.26%), and Kumpai padi (*O. rupifogon* P) (16.25%). Meanwhile, Bento rayap *(L. hexandra)* was found to have the lowest ash content of 5.63% (Table 2). Ash contents of vegetations found in this study were higher than those of swamp vegetations in South Kalimantan of 2.18-3.28% during the high tidal season and 3.23-9.83% during the low tidal season (Rostini et al. 2014). *Elephant* grass (*P. purpureum*) was indicated to have varied ash contents of 4.4% (Dahlan and Iskandar 2013), 0.95-1.1% (Ukpabi et al. 2015), 9.59% (Nuhuyanan 2010), and 18% (Araica et al. 2009). Meanwhile, the ash content of grasses in lowland areas ranged from 6.32 to 8.91% (Richmond et al. 2015; Mako et al. 2016; Norman et al. 2013; Maswada et al. 2013). Alam *et al*. (2015) found that *B. mutica* had an ash content of 4.20-4.89% and rice straw had 6.63%.

Roughages were found to have average ash contents of 7.28% in a pasture for buffaloes in Pulau Moa (Eoh 2014), 9.82-10.14% in Lore Utara, Poso Regency (Damry 2009), 11.51% in a pasture during the rainy season until the end of dry season in Sabana Timur Barat (Manu 2013), and 8.11 and 8.22% in a natural pasture and a coffee plantation area, respectively (Kleden et al. 2015). Differences in these ash contents were suspected to be caused by differences in plant species (internal factor) and environmental differences, particularly seasonal differences (external factor). In a dry season, pH levels in lowland swamp areas were found to be 3.9-4.8, causing a decreased supply of nutrients, especially total N and K, to the soil. This decreased supply of nutrients led to lowered nutrients contained in plants (Rostini et al. 2014). This was in line with what was stated by Gutteridge and Shelton (1994) that nutrient content in plants was affected by soil nutrient content. In addition, in acidic soil conditions, activities of Fe, Al, and Mn increased which might cause toxicity in plants (Tjondronegoro and Gunawan).

NDF and ADF contents

Neutral Detergent Fiber (NDF) depicts plant cell walls consisting of hemicellulose, cellulose, and lignin. NDF is part of fiber which is not dissolved in neutral detergent representing the component of fiber undissolved in plant cell wall materials. NDF content of a feed affects the ability of ruminant animals to consume the feed. Acid Detergent Fiber (ADF) represents parts of the plant cell wall bond to cellulose and lignin. ADF content is related to energy content and higher ADF content results in lowered digestible energy content (Van Soest 1982).

The NDF and ADF contents of vegetations found in this study were about 40.65-79.47% and 23.66-60.33%, respectively. Lowest NDF contents were found in Cecengkehan (*L. hyssopifolia*) (40.65%), Kangkung merah (*I. aquatica*) (41.40%), Telepuk gajah (*N. lotus*) (46.05%), and Tapak dara (*C. roseus*) (47.79%). In contrast, highest NDF content of 79.47% was found in Bento rayap (*L. hexandra*). Lowest ADF contents were found in Telepuk gajah (*N. lotus*) (46.05%), Kangkung merah (*I. aquatica)* (26.17%), Kumpai merah (*Hymenachne sp*) (28.40%), Cecengkehan (*L. hyssopifolia*) (32.91%). Meanwhile, the highest ADF content of 60.33% was found in Kumpai padi *(O. rupifogon* P*)* (Table 3). NDF and ADF contents of vegetations found in this study were lower than those of Asep et al. (2012) who reported that the NDF contents of swamp green vegetations in a pasture for buffaloes were about 91.73-93.45% in grasses and 68.11-90.93% in legumes and the ADF content of grasses was 51.6-86.8%. It was shown in other studies that NDF and ADF contents of roughages in a pasture during the rainy season to the end of the dry season in Sabana Timur Barat were on average 65.9 and 43.29%, respectively (Manu 2013). Vegetations in a natural pasture and a coffee plantation area had NDF contents of 74.89 and 72.37% and ADF contents of 57.22 and 55.15%, respectively (Kleden et al. 2015). Meanwhile, swamp vegetations in South Kalimantan had average NDF and ADF contents of 55.97 and 37.87%, respectively, during the high tidal season and 81.44 and 60.86% respectively, during the low tidal season (Rostini et al. 2014).

NDF and ADF contents of roughages in the BPTU-HPT Padang Mengatas area were found to be 75.62 and 45.96%, respectively in the rain season and 69.35 and 38.66%, respectively in the dry season (Muhajirin et al. 2017). NDF and ADF contents of Eceng gondok (*E. crassipes* in this study were 62.77 and 41.83%, respectively. These figures were close to those of *water hyacinth* (*E.crassipes*) plants studied by Tham (2015) with NDF and ADF contents of 63.9 and 34.68% and by Tham and Uden (2015) with NDF and ADF contents of 52.1 and 30.7%, respectively. Other studies conducted by Ahmed et al. (2016), Anitha et al. (2016), and Nampoothiri (2017) showed that *Azolla sp* had NDF and ADF contents of 53.8-54.85% and 36.57-37.0%, respectively. Meanwhile, NDF and ADF contents of *elephant* grass (*P. purpureum*) were found to be 55.8 and 46.5% (Dahlan and Iskandar 2013) and 84.25 and 64.07% (Nuhuyanan 2010), respectively. These figures equaled to the NDF and ADF contents of Kumpai tembaga (64.72 and 46.38%), Kumpai minyak (65.31 and 38.92), and Are bolong (61.27 and 48.46%). This indicated that lowland swamp vegetations had fiber fraction nutritional quality which was not less than that of prime grasses including *elephant* grass and *king* grass.

In this study, NDF and ADF contents of lowland swamp vegetations were 40.65-79.47% and 23.66%-60.33%, respectively. These figures were still within the ranges of NDF and ADF contents of prime grasses such as *elephant* grass (*P. purpureum*), which had NDF and ADF contents of 55.8 and 46.5% (Dahlan and Iskandar 2013) and 84.25 and 64.07% (Nuhuyanan 2010), respectively. In the rumen, NDF degradation is higher than that of ADF as NDF contains hemicellulose fraction which is more soluble (Church and Pond 1986). NDF content has a negative correlation with its degradation rate (Varga et al. 1983) and higher NDF content decreases dry matter digestibility of feed (NRC 1988). Cellulose is an ADF component that is easy to digest while lignin is hard to digest as it contains double bonds. Higher lignin content decreases feed digestibility (Sutardi et al. 1980).

Hemicellulose and cellulose contents

Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Four green vegetations with the highest hemicellulose contents were Bento rayap (*L. hexandra*) (37.14%), Kerak maling (*D. fuscescens*) (31.87%), Kumpai merah (*Hymenachne* sp.) (31.74%), and Kumpai minyak (*H. amplexicaulis*) (26.39%). In contrast, the lowest hemicellulose content was found in Cecengkehan (*L. hyssopifolia*) (7.73%). Highest cellulose contents were found in Kemon air (*N. olerancia*) (27.08%), Bento rayap (*L. hexandra*) (25.88%), Purun tikus (*E. dulcis*) (21.80%), and Are bolong (*P. barbatum*) (20.28%). Meanwhile, Kasuran (*C.digitatus*) had the lowest cellulose content of 5.24% (Table 3). Results of this study were in line with those of a study conducted by Asep et al. (2012) who reported the hemicellulose and cellulose contents of lowland swamp green vegetations ranging from 7.89 to 31.55% and 30.85 to 63.35%, respectively. They also found that Kumpai padi (*O.rupifogon*) had 31.55% hemicellulose content which was higher than those of Kumpai padi (10.80-19.30%) found in this study (Table 4). Swamp vegetations in South Kalimantan had hemicellulose contents of 0.65-25.85% in high tidal season and 5.37-40.09% in low tidal season. Cellulose contents in high and low tidal seasons were about 20.07-34.03% and 7.90-38.31%, respectively (Rostini et al. 2014). Various water plants including Azolla, which was used as animal feed, had hemicellulose and cellulose contents of 10.20 and 12.76% (Nampoothiri 2017), 1.15-10.20% and 12.76% (Nampoothiri 2017), respectively. Roughages in BPTU-HPT Padang Mengatas had hemicellulose and cellulose contents of 29.79 and 33.62% in the rain season and 30.69 and 31.64% in the dry season, respectively (Muhajirin et al. 2017). *Elephant* grass (*P. perpureum*) was found to contain 21.18% hemicellulose and 43.32% cellulose (Nuhuyanan 2010) and 35.3% cellulose (Dahlan and Iskandar 2013). In a study conducted by Archimede et al. (2010), hay was found to have 37.7% hemicellulose and 35.7% cellulose. Based on the above findings, it was suggested that hemicellulose (7.73-37.14%) and cellulose (5.24-27.08%) contents of lowland swamp vegetations in this study were within normal ranges and these vegetations were potential to be used as feed for Pampangan buffaloes.

Lignin contents

Lignin contents of lowland swamp vegetation ranged from 14.84 to 43.09%. Four vegetations including Telepuk gajah (*N. lotus*), Kemon air (*N. olerancia*), Kumpai merah (*Hymenachne* sp.), and Kangkung merah (*I. aquatica*) were found to have the lowest lignin contents of 14.84, 18.36, 19.76, and 19.85%, respectively, while the highest lignin content of 43.09% was found in Kumpai padi (*O. rupifogon* P) (Table 3). Lignin contents in this study were higher than that obtained by Rostini et al. (2014) who reported the lignin contents of swamp vegetations in South Kalimantan were about 2.8-17.59% in high tidal season with that of Kumpai minyak as the lowest and that of *Beberasan* as the highest and 10.06-61.12% in low tidal season with that of *Beberasan* as the lowest and that of Kumpai minyak as the highest.

Lignin contents of Kumpai padi (*O. rupifogon* ^{R}) (31.24%) and Kumpai padi (*O. rupifogon* ^{P}) (43.09%), Bento rayap *(L. hexandra)* (33.92%), and Eceng gondok *(E. crassipes)* (31.60%) (Table 3) found in this study were higher those of Kumpai padi (18.27%) and Bento rayap *(L. hexandra)* (17.96%) found by Asep et al. (2012) and Eceng gondok *(E. crassipes)* (8.17%) found by Tham (2015). In other studies *Azolla* was found to have lignin contents of 5.7% (Ahmed et al. 2016) and 28.24% (Nampoothiri 2017). Meanwhile, lignin contents of *elephant* grass were found to be 15.37% (Nuhuyanan 2010) and 11.2% (Dahlan and Iskandar 2013).

Differences in lignin contents in green vegetation are suspected to be caused by differences in plant species, plant ages, and environmental factors including seasons (rain or dry season), tidal seasons, and fertility levels of the soil where the vegetations grow. In cell walls, cellulose is a bond with hemicellulose and lignin. The animals cannot digest lignin and its molecule structure is different from other carbohydrates as it contains carbon and nitrogen of only 1-5%. Hemicellulose consists of pentose, hexose, uronic acid, and pectin substance. Pectin is a carbohydrate that is composed of uronic acid, galactose, arabinose, xylose, and methanol. Cellulose is degradable by microorganisms and functions as the source of volatile fatty acids. Young grasses (roughages) contain less than 5% lignin and 80% of their cellulose is degradable. On the contrary, in old roughages, lignin content may reach up to 10% causing a decrease in cellulose digestibility by up to 50% (Prawirokusumo 1994).

Based on the results of the study, it was concluded that: (i) The highest protein (20.56%) and crude fat (2.92%) contents were found in Kemon air *(Neptunia olerancia)*. The highest ash content (25.19%) was found in Kasuran *(C. digitatus),* while the lowest (11.01%) was found in Cecengkehan *(L. hyssopifolia)*. The lowest NDF content (40.64%) was found in Cecengkehan *(L. hyssopifolia)* and the highest hemicellulose content (37.14%) was found in Bento rayap. Telepuk gajah had the lowest ADF (23.66%) and lignin (14,84%) contents. Kemon air contained the highest cellulose level of 27.08%. (ii) The best nutritional values were found in Kasuran *(C. digitatus)* and Cecengkehan *(L. hyssopifolia)*. (iii) Dominant and palatable swamp roughages with good nutrient contents included Kumpai tembaga *(H. acutigluma),* Kumpai minyak *(H. amplexicaulis),* Kumpai padi *(O. rupifogon),* Are bolong *(P. barbatum)*, and Purun tikus *(E. dulcis)*.

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