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Potential of *Ipomea aquatica* Hay and Its Phytochemical to Improve Performance and Health Status in Ruminants

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ABSTRACT

In the commercial red meat industry, a great diversity of feed management is found to meet the demands of the market, since the consumer has become more acquainted with of the significance of the relationship between food and health, which has motivated scientists and the farming industry to produce healthy meat with high nutrition value. There has been improving progress in various studies subjected to including feasible alternative products, particularly for forage in the ruminant feeds, which have been proved to have some potential bio-actions and improvement in ruminant production. *Ipomea aquatica* is a popular vegetable and medicinal herb in Asia, which shows a wide range of pharmacological properties, such as anticancer, antimicrobial, antioxidant, anti-calcification, anti-poison, anti-apoptotic agent and anti-mutagenic. The use of *Ipomea aquatica* in ruminant production has been reported by many researchers. The aim of this review is to report and describe the most recent research on the beneficial effect of describe and as an alternative of forage for ruminants and so its effect on the production performance and ruminants health.

Key words : *Feed, Ipomea aquatica, Phytochemical, Ruminant*

Introduction

Red meat and milk production is facing a high feed cost of 70-75% of total production cost. Feasible feed resources are necessary to support animal performance sustainability and fulfill global demand of animal protein that always increases. The quality of forage is one of the key factors affecting daily feed intake, nutrient digestibility, and ruminant performance. Agroindustry by product and crop waste product are usually used by farmers as the feed alternatives for the ruminants, but the low nutrition level and digestibility did not result in good performance of the livestock (Hasanah *et al.*, 2020; Emile, 2016). It is important to give more attention to the ruminant diet formulation using local feed ingredients that is affordable but has high nutrient quality. Green leafy vegetables are a mineral – vitamins rich source, cheap and locally valuable for farmers to use as animal feed beside human food (Saroeun, 2010).

Ipomea aquatica (IA) is a semi-aquatic tropical vegetable, belonging to the Convolvulaceae family which also known as water spinach, morning glory, *kangkung*, and *green kankoong* (Maung *et al.*, 2020). It was first cultivated in southeastern Asia, it has been used as medicinal vegetable since A.D.300 – 200 B.C. IA is considered as a native plant in Asia, Africa, and Southwestern Pacific islands. IA distributed around the world by European explorers worldwide(Austin, 2008). Recently, IA is a common

vegetable in Asia, especially Indonesia, it is a familiar dish as a side dish on daily meals. This plant could wildly grow in the river side or the field that contains high levels of water. It also very easy to cultivate by traditional methods in the soil or by organic and aquaponics technology. *Ipomea aquatica* hay has a high value of nutrition such us: calcium 73%, phosphoras 50%, iron 2.5%, Protein 21.6% and energy 2.900 Kkal/kg (Astawan, 2009; Biyatmoko, *et al*., 2009). This plant also has moderate anticancer and antioxidant activities and has therapeutic effect on constipation, eye diseases and liver diseases(Dua *et al.,* 2015; Prasad *et al.,* 2008).

In Indonesia, 47.805 ha fied have planted with *Ipomea aquatica* which produced 5.79/ha or about 276.976 ton I total (BPS, 2017). However the high production also resulted in a high number of waste products due to not all the commodities bought by the customer although the price is relatively very cheap. Therefore it has high potential to process as feed forage to substitute the fresh grass for ruminants (Hasanah *et al.,* 2020).

In Cambodia and Myanmar, IA has been used as poultry feed, it provides protein, vitamin and minerals to enhance growth, performance, and quality of eggs and carcass (Saroeun, 2010; Ngunyen *at al.,* 2005; Offor and Wariboko, 2013). Moreover it could replace mineral supplementation in the poultry feed without revealing any negative effects on the birds productivity (Maung *et al.,* 2020). However the effect of IA on the ruminant performance still has not been widely discussed.

Nutrition Value of *Ipomeaaquatica*

Ipomea aquatica (IA) belongs to the Convoluvulacea plant family, it is a semi- aquatic plant in the tropical area and could grow very invasive, forming dense patches over the water surface such as ponds, canals, and lakes (Igwenyi, 2011). It could easily grow in suitable condition and be harvested 4-6 weeks old and continue could be harvested periodically (Tenriawaru, 2016).

Ipomoea aquatica contains carbohydrates and other nutrients (Table 1), such as protein, lipid, fiber, vitamins, and minerals (Ali and Kaviraj, 2018). The levels of crude protein might be influenced by the stage of leaf harvest and the agro-climatic conditions of the area such as water, air, and soil (Gakuya *et al*., 2014). Also, nutrient contents of vegetable and fruits vary could be resulted by environmental factors such as season, altitude, geographical condition, maturity stages and processing methods (Ismail *et al*., 2013; Wafer and Tarimbuka, 2016). *Ipomea aquatica* contains adequate quantities of most of the essential amino that are comparable to common foodstuffs such as soybean or whole egg, it is an indication of the beneficial effect of *Ipomoea aquatica* as a food supplement (Meira *et al.,* 2012). In the previous study by Silivong and Preston (Silivong and Preston, 2016). IA has been noted to have greater solubility of crude protein and thereby increasing the N utilization by animals with regard to the high

Table 1. Chemical composition of *Ipomea aquatic* hay(%)

Nutrient	Range	References
Dry matter	89.42 - 93.3	(Hasanah *et al*., 2020; Inthapanya and Preston, 2014)
Crude protein	10.65 -28	(Maung *et al.,* 2020; Astawan, 2009; Umar *et al.,* 2007; Kong Manila and Leidin, 2009)
Protein solubility	67.4	(Silivong and Preston, 206)
Organic matter	81.4 - 87.6	(Hasanah *et al*., 2020; Opene *et al*., 2018; Kongmanila and Leidin, 2009; Umar *et al*., 2007)
Crude Fat	1.86	(Hasanah *et al*., 2020)
Crude Fiber	13 – 21.62	(Hasanah *et al*., 2020; Opene *et al.,* 2018; Kongmanila and Leidin, 2009; Umar *et al*., 2007)
NFE	50.47	(Hasanah *et al*., 2020)
NDF	40,27	(Mashudi *et al*., 2014)
ADF	23.5	(Hue and Preston, 2016)
Ash	15.40	(Hasanah *et al.,* 2020)
Total Digestible Nutrient	54.28	(Hasanah *et al.,* 2020)
Cellulose	26.88	(Hasanah *et al.,* 2020)
Lignin	12.22	(Hasanah *et al.,* 2020)
Hemicellulose	27.24	(Hasanah *et al.,* 2020)

crude protein level.

Ipomoea aquatica leaves have high crude fiber, intake of fiber could stimulate weakening hunger, stimulating peristaltic movement, increasing excretion of bile acids, increasing moisture content of excrements, lower the serum cholesterol level, and risk of heart disease (Ramula and Rao, 2003). *Ipomea aquatica* also contains high levels of minerals (Table 3.), such as potassium (K), sodium (Na), calcium (Cl), phosphorus (P), magnesium (Mg), iron (Fe), copper (Cu), manganese (Mn), and zinc (Zn) (Umar *at al*., 2007). These minerals play significant roles in several biological processes. Bone growth and turnover are influenced and regulated by the metabolism of calcium, phosphate and magnesium while iron is important in the formation of hemoglobin (Burtis and Ashwood, 2003).

Several types of vitamins contained in *Ipomoea aquatic* (Table 2) include vitamins A, B1, B2, B6, B12, C,K, and E (Igwenyi, 2011). Vitamin A is known as an anti-inflammation vitamin due to its critical role in enhancing immune function (Huang *et al*., 2018); Vitamin B2 intake appears to have a protective effect on various medical conditions such as sepsis and ischemia. Furthermore, B6 and B12 have been shown to be important for neural function (Suwannasom *at al.,* 2020); Vitamin C plays an important role in a number of metabolic functions including the activation of the vitamin B, folic acid, the conversion of cholesterol to bile acids and the conversion of the amino acid, tryptophan, to the neurotransmitter, serotonin (Chambial *et al*., 2013); Vitamin K is an anticalcification, anticancer, bone-forming and insulin-sensitising molecule (DiNicolantonio *et al*., 2015); Vitamin E is a fat-soluble antioxidant that could protect the polyunsaturated fatty acids (PUFAs) in the membrane from oxidation, regulate the production of reactive oxygen species (ROS) and reactive nitrogen species (RNS), and modulate signal transduction (Lee and Han, 2018).

In addition, *Ipomoea aquatica* also contains bioactive compounds such as flavonoids and phenols (Table 2). The amounts of flavonoids and phenols in IA were s (81.28 ± 5.362 mg / g QE) and (76.96 ± 2.245 mg / g GAE), respectively. These values are higher than those found in the land spinach of (24.56 ± 3.043 mg / g QE) and (31.37 ± 0.849 mg / g GAE), respectively (Mariani *et al*., 2019).

Ipomea aquatica on The Dairy Ruminants Performance

As a feed for ruminant *Ipomea aquatica* (IA) prefers processed into hay form rather than fresh plant. It naturally lives in the water with some water snail species which act as biological hosts of various kinds of helminths that could be infected to the animal by feed (Tenriawaru, 2016). It has a high possibility to transmit cyst of *Fasciola* sp. and other helminth eggs to the ruminant if consumed freshly.

Hasanah *et al.* (2019) in the in vitro study showed that IA has the highest gas production and nutrient

Table 2. Phytochemical and Vitamin (mg/g) in *Ipomeaaquatic*a hay

Phytochemical and Vitamin	Total	References
Tannins	0.09	(Igwenyi *et al*., 2011)
Cyanogenic glycosides	0.17	(Igwenyi *et al*., 2011)
Saponin	0.21	(Igwenyi *et al*., 2011)
â-carotene	0.26	(Igwenyi *et al.,* 2011)
Phenols	1.13	(Igwenyi *et al*., 2011)
Steroids	1.34	(Igwenyi *et al*., 2011)
Glycosides	2.68	(Igwenyi *et al*., 2011)
Flavonoid	9.38	(Igwenyi *et al*., 2011)
Alkaloids	73.98	(Igwenyi *et al.,* 2011)
Vitamin A	0.02 - 0.13	(Igwenyi *et al*., 2011; Tenriawaru, 2016)
Vitamin B1	0.06 – 0.10	(Igwenyi *et al*., 2011; Tenriawaru, 2016)
Vitamin B2	0.1 - 0.13	(Igwenyi *et al.,* 2011; Tenriawaru, 2016)
Vitamin B6	0.08 – 0.6	(Igwenyi *et al.,* 2011; Tenriawaru, 2016)
Vitamin B12	0.008	(Igwenyi *et al*., 2011; Tenriawaru, 2016)
Vitamin C	0.83 – 120	(Igwenyi *et al.,* 2011; Tenriawaru, 2016)
Vitamin E	0.0007	(Igwenyi *et al*., 2011; Tenriawaru, 2016)
Vitamin K	0.26 – 0.81	(Igwenyi *et al.,* 2011; Tenriawaru, 2016)

digestibility compared with regular forage for ruminants such us *Pennisetum purpureum* cv Mott grass, due to IA having lower lignin than grass. Higher cell wall level of the forages decrease digestibility of feed, high lignin in the fiber inhibits rumen microorganism to optimize fermentation rate and limited feed intakes of the cattle (Janèík *et al*., 2009; Chumpawadee and Pimpa, 2008). Therefore, it may need a technology for degrading fiber such as pelleting technology. Bertipaglia *et al.* (2010) and Oyaniran *et al.* (2018) reported that pelleting break downs the cell wall of forage (cellulose, hemicellulose and lignin) so that it will be easier to be degraded by microbes in the rumen.

Table 3. Minerals (mg/g) in *Ipomeaaquatic*a hay

Minerals	Total	References
Calcium (Ca)	135	(Tenriawaru, 2016)
Phosphor (P)	56	(Tenriawaru, 2016)
Kalium (K)	447	(Tenriawaru, 2016)
Natrium (Na)	43	(Tenriawaru, 2016)
Iron (Fe)	1.7	(Tenriawaru, 2016)
Zinc (Zn)	0.4	(Tenriawaru, 2016)
Cuprum (Cu)	0.3	(Tenriawaru, 2016)
Magnesium (Mg)	34	(Tenriawaru, 2016)
Mangan (Mn)	0.8	(Tenriawaru, 2016)
Selenium (Se)	0.09	(Tenriawaru, 2016)

Research by Kongmanila *et al*. (2011) that supplemented IA in the mango foliage base basal diet could accelerate growing goats. It suggested that the high content of soluble protein in IA resulted in more amino acids and peptides, required by rumen bacteria for efficient digestion (Silivong P and Preston, 2016). The availability of amino acid sources is also important for milk production, the efficiency of nutrient utilization of the dairy cow is relatively low compared with monogastric animals, and this is particularly so with absorbed nitrogen (N) in the form of amino acids (AAs). Therefore, efforts have been made to balance AAs in the diet of dairy cows to produce more milk and milk protein (Park *et al.*, 2020).

In addition, the high calcium content in *Ipomea aquatica* could help provide sufficient calcium in dairy ruminants. Dairy cows excrete a large amount of Ca during lactation due to the high Ca content in milk, and this Ca flow suddenly and notably increases later during lactation. During the first few months of lactation, the dietary Ca intake is generally lower than the amount of Ca excreted in milk, feces and urine (Gaignon *et al.,* 2016).

Ipomea aquatica on the Meat Ruminants Performance

Ipomea aquatica (IA), could be used as a supplement to the ruminant feed to increase dry matter and crude protein intake, N retention and digestibility (Kongmanila, 2009). Kongmanila *et al*. (2007) reported that the growth performance of goats fed Bauhinia foliage as the basal diet would be improved by supplementing it with water spinach. According to Thu Hong *et al.* (2011), the live weight gain of goats fed Mimosa foliage was increased by supplementing with fresh water spinach at 27% of the total DM intake. Goats fed a sole diet of cassava foliage also responded with increased DM digestibility and N retention when fresh water spinach was provided as a supplement (Pathoummalangsy and Preston, 2006).

Sufficient protein content in feed ingredients will support the growth performance of meat, because ruminants depend on the microbial population in the rumen to produce the amino acids and vitamins needed for the desired production (Soepranianondo, 2005). While, the values of carcass quality parameters are related to growth performance, nutrient digestibility, and nitrogen retention (Purwin *et al*., 2019).

In other hand, Hasanah *et al.* (2020) showed that the increased levels of *Ipomoea aquatica* were correlated to the decreased levels of volatile fatty acid synthesis, it also associated with the increased levels of lignin, cellulose, and hemicellulose in the pelleted water spinach combination feed. Even though volatile fatty acids (VFAs), the end products of rumen fermentation, are the principal energy source for ruminants which potentially affect carcass yield and fat deposition in beef cattle (Bulumulla *et al.,* 2018).

Ipomea aquatica on The Ruminantia Health Status

Ipomea aquatic a contains various beneficial bioactive compounds (Table 4), to support ruminant performance and health condition (Table 5). it has substantial quantities of antioxidants that could protect the hepatocytes from arsenic poisoning, this study has clarified the effectiveness of *Ipomea aquatic* as traditional medicine in India to against Arsenic (As) toxicity (Dua *et al.,* 2015). It contain phenolic compounds (gallic acid and chlorogenic acid), flavonoids (myricetin, apigenindanquercentin), vitamin C, little amount of vitamin E and carotenoids

Table 4. Bioactive compounds in *Ipomea aquatic*a hay

Bioactive compounds	Function	References
Calystegine B1, calystegine B2,	Inhibit lysosomal β-glucosidase.	(Schwarz *et al.*, 2004)
Calystegine C1	Moderate inhibitory activity toward rat α- and β-mannosidases	(Haraguchi *et al*., 2003)
calystegine B3		
N-cis-feruloyl tyramine 21:N-trans-feruloyl tyramine (N-trans-feruloyl tyramine)	inhibit prostaglandin synthesis	(Meira *et al.*, 2021)
3,4-di-O-caffeoyl-quinic acid (3,4-di-O-caffeoyl-quinic acid) (isoclorogenic acid b)	Hypoglycemic, antimutagenic antioxidant and inhibition of HIV replication. Collagenase inhibitory	(Meira *et al.*, 2021)
4,5-di-O-caffeoyl-quinic acid	Hypoglycemic, antimutagenic antioxidant and inhibition of HIV replication. Collagenase inhibitory	(Meira *et al*., 2021)
3α,7β-O-D-diglycopyranosyldihydroquercet	Antioxidant; cytotoxic, in *in vitro*.	(Meira *et al.*, 2021)

Table 5. Effect of *Ipomea aquatic*a hay on ruminant performance

Animal	Dose Rate	Major Findings	References
Goat	ad libitum at the level of 130% of the average daily feed intake	increase dry matter and crude protein intake, N retention and digestibility	(Kongmanila and Ledin, 2009)
Goat	Mango foliage + 20 - 25% water spinach	improve digestibility of crude protein and N retention in growing goats	(Kongmanila *et al*., 2011)
Goat	Mimosa foliage + water spinach at the level of 120% of the average daily feed intake	increase the DM digestibility and N retention, improved the biological value of the N and the feed conversion and reduced the ratio of methane to carbon dioxide	(Pathoummalangsy and Preston, 2006)
Goat	Cassava foliage + water spinach at levels of 10-20 g DM per 1 kg	Increase digestibility of DM and crude fibre	()[44]
Goat	Water spinach was fed at 30 g/kg live weight	increase DM intake and tended to increase DM digestibility	(Thu Hong and Lam, 2011)
In vitro Ruminant fermentation	72.0% Ensiled cassava root + 13.0% Cassava leaf meal + 13.0% Water spinach meal + 2.0% Urea	Reduce methane gas production	(Inthapanya, 2015)
Goat	*Tithoniadiversifolia* foliage plus water spinach 1% of LW as DM	Improve appparent DM digestibility in growing goats	(Phonethep *et al*., 2016)
In vitro Ruminant fermentation	The portion of Pennisetum purpureum in the pellet feed was substituted with Ipomoea aquatica at respective levels of 0 – 60%	at a level of 20% in pellet feed, it resulted in highest OMD and VFA production and also lowest ratio of acetate to propionate	(Hasanah, 2020)
In vitro Ruminant fermentation	Urea-treated rice straw with additional urea to provide approximately 15% crude protein + water spinach meal at level of 6 g crude protein per 100 g substrate DM	Reduce methane gas production	(Opene *et al*., 2018)
Dairy goat, local breed of Laos	70% *Bauhinia acuminata* and 30% water spinach + 1% biochar	produce higher values of rumen ammonia, increase weight gain and N retention, decrease FCR	(Silivong and Preston, 2016)
Dairy goat, local breed of Indonesia	15-20% in total feed	Increased performance the goat in the lactation periode	(Mashudi *et al*., 2014)

Table 5. Effect of *Ipomeaaquatic*a hay on ruminant performance

Animal	Dose Rate	Major Findings	References
Cattle	30% in total feed	increased the DM intake, the apparent DM digestibility and N retention	(Inthapanya, 2016)

(Vit A precursors), it has been used in folk medicine in India against different diseases including, diabetes mellitus and arsenics poisoning (Malalavidhane *et al*., 2000; Malalavidhane *et al.,* 2001; Dua *et al.,* 2015), Scorpion poison antidote, as emetic, diuretic, purgative, to treating debility, liver complaints, ringworm, leucoderma, leprosy, fever, against nosebleed and high blood pressure (Uawonggul *et al*., 2006; Mamun *et al.,* 2003; Prasad *et al*., 2005). It could act as a good antioxidant which protects the organs against the destructive effects of free radicals such as singlet oxygen, peroxyl radicals, superoxide and peroxynitrite. The activities of reactive oxygen species (ROS) are highly associated with atherosclerosis, ischemic injury, cancer, inflammation, aging, and neurodegenerative diseases (Igwenyi *et al.,* 2011). These phenolic and flavonoids could be an anti-apoptotic agent to fight oxidants (Choi *et al.,* 2003) through a Bcl-2 independent mechanism (Khanduja *et al*., 2006; Sohi *et al.,* 2003), and to be mediated at the mitochondria (intrinsic) levels (Khanra *et al*., 2015).

Previous studies reported that supplementation of plants extracts rich in secondary compounds such as saponins, tannins, essential oils and also extracts rich in flavonoids, which is could to reduced rumen CH_4 production, showed that the supplementation of the flavonoids naringin and quercetin to ruminate diets could suppress methane production without influencing rumen microbial fermentation (Khanra *et al.,* 2015). Flavonoids are also considered as promoters of the growth and enhancer of the product's quality of animal due to its anti-microbial and antioxidative properties (ahmadipour *et al.,* 2015). Using mixtures of plant flavonoids in a continuous rumen culture system could modify fermentation conditions including pH, propionate proportion and/or protein degradation, although the results were not always homogeneous (Balcells *et al.,* 2012).

Conclusion

The dietary of *Ipomea aquatica* hay, either as a main or additional feed ingredient is could resulted a positive effect on the production performance and health of both, dairy ruminant and meat ruminants through its high nutritional content of protein, metabolizable energy, dry matter (DM), digestibility, palatability, and bioactive compounds.

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Conflict of Interest

There is not conflict of interest in this study

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