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Review

Benefits and risk of giving oleifera moringa as ruminant animal feed: brief

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Abstract

Lack of animal feed is a serious problem worldwide and is a challenge for ruminant livestock productivity, especially in many developing countries. In this regard, legumes are a promising feed ingredient to overcome these limitations. Moringa oleifera has been known for centuries as a plant with various benefits, nicknamed The Miracle Tree or magic tree. Currently, Moringa oleifera has increased the attention of researchers because the plant is believed to be rich in nutrients that can provide many benefits to livestock. Researchers believe that Moringa oleifera is an alternative plant with high nutritional value and has been proven to be very beneficial for ruminants.ative plant of high nutritional value and has been proven to be very beneficial for ruminants.

Keywords: animal feed; legume; Moringa oleifera; ruminants

Introduction

Increasing the consumption of ruminant livestock has encouraged efforts to improve livestock feed production from plants that encourage large land clearing to be used as forage land for animal feed. The consequences of massive land clearing will undoubtedly impact the reduction in forest area as the lungs of the world. According to the Food and Agriculture Organization (FAO) (2019), the global demand for protein from meat worldwide has increased rapidly in recent years. Food and Agriculture Organization reported that the consumption of global meat products increased by 1.2% from 2017 and reached 336.4 million tons in 2018. One alternative plant of high nutritional value that can used as animal feed is Moringa Oleifera which has proven to be very beneficial for ruminants in many studies that have carried out. Moringa Oleifera is now a concern for the people of Indonesia because it has been considered one of the magic plants. All parts of the plant can be used as food, feed, medicines, and alternative energy sources of environmentally friendly fuel (Ramachandran et al., 1980; Khalafalla *et al.,* 2010; Daba, 2016; Rahman *et al.,* 2017). Moringa Oleifera is a tree from the tropical region that proliferates and is widely cultivated, especially in Africa and India. It is currently also commonly planted in tropical and subtropical areas worldwide. Moringa Oleifera is a drumstick or horseradish (Paliwal *et al.,* 2011; Manaware, 2020). This plant can grow in a tropical environment with hot, humid, dry, and infertile soil conditions. In the last few years, Moringa Oleifera has increased the attention of researchers because the plant has believed to be rich in nutritional content that can provide many benefits to livestock. The results of various studies that carried out show that almost all parts of the Moringa oleifera plant, especially the leaves, have high-quality nutritional and antioxidant content

and have prevention and healing properties for certain diseases (Su and Chen, 2020; Sivasankari *et al.,* 2014; Saxena *et al.,* 2013). Moringa oleifera plants are also rich in crude protein, vitamins, minerals, and fatty acids (Qwele *et al.,* 2013; Mendieta-Araica *et al.,* 2011). However, Moringa Oleifera also contains a variety of phytochemicals that can harm livestock development if the administration as a feed is incorrect.

Characteristics and Benefits of Moringa Oleifera Plants

Moringa Oleifera is a crop included in the Moringaceae family and is a popular staple food in various parts of the world (Gopalakrishnan *et al.,* 2016). At present, there are around 33 species of the Moringaceae family. Moringa Oleifera is one of the Moringaceae family. Among them, the best known of thirteen species, namely: M. Arborea, M. Borziana, M. Concanensis, M. Douhardi, M. Hildebrandtii, M. Longituba, M. Oleifera, M. Ovalifolia, M. Peregrina, M. Pygmaea, M. Rivae, M. Ruspoliana, M. Stenopetala is known and discovered throughout the world (Yisehak *et al.,* 2011; Arora *et al.,* 2013; Abd Rani *et al.,* 2018; Mallenakuppe *et al.,* 2019). In Indonesia, the Moringa oleifera or moringa plant has various names in several regions, including kelor (Java, Sundanese, Bali, Lampung), maronggih (Madura), moltong (Flores), keloro (Bugis), ongge (Bima), marunggai (Sumatra). West) (Kurniawan, 2019; Suhaemi *et al.,* 2019; Marhaeni, 2021). Moringa oleifera is consumed not only for its nutritional value but also for its medical benefits (Anwae *et al.,* 2015). Moringa oleifera in Indonesia originated from Agra and Oudh, located in Northwest India, the southern Himalayan region (Leone *et al.,* 2015; Mallenakuppe *et al.,* 2019). Apart from Asia, this plant is also widely distributed in the Arabian Peninsula, tropical Africa, Central America, the Caribbean, and tropical South America (Dani *et al.,* 2019).

Moringa oleifera species can grow well at temperatures of 19oC - 28oC and grow best in sandy or clay soils with slightly acidic pH (Thurber and Fahey, 2010; Udikala *et al.,* 2017). This tree can reach 5 to 10 m with a straight trunk 10-30 cm thick and can be cultivated in almost all tropical plains. The leaves of the Moringa oleifera plant are imperfectly finned, egg-shaped with an average size of a fingertip with a green to brownish green color, and Moringa oleifera has yellowish-white flowers and green flower midribs (Palupi *et al.,* 2007; Heuzé *et al.,* 2016).

According to Leone et al. (2016), humans and animals can consume all parts of the Moringa oleifera tree through leaves, seeds, roots, and flowers. Various studies have shown that Moringa oleifera has various properties and can be used as a food or feed ingredient because it has a relatively complete nutritional content. Studies the efficacy of Moringa oleifera in treating various diseases widely studied, such as anti-inflammatory (Faizal *et al.,* 2014), cancer (Shin *et al.,* 2007; Budda *et al.,* 2011; Al-Asmari *et al.,* 2015; Christianto and Smarandache, 2019), hypertension (Sailesh *et al.,* 2018), diabetes (Giridhari *et al.,* 2011; Adeeyo *et al.,* 2013), respiratory tract disease (Mcknight *et al.,* 2014), skin (Ali et al. al., 2013), bacterial infections (Eilert *et al.,* 1981; Abraham *et al.,* 2014; Abdalla *et al.,* 2016), fungal infections (Ganie *et al.,* 2015; Jimoh *et al.,* 2020) and fungal infections viruses (Chollom *et al.,* 2012). This ability is believed to be because Moringa oleifera has a variety of phytochemicals, such as phenolic acids, flavonoids, tannins, saponins, and various alkaloids (Vergara-Jimenez *et al.,* 2017).

Studies on the benefits of Moringa oleifera as animal feed such as fish (Afuang *et al.,* 2003), poultry (Alabi *et al.,* 2017), goats (Kholif *et al.,* 2015), sheep (Jelali and Ben-Salem, 2014), pigs (Zhang *et al.,* 2019), beef cattle (Roy *et al.,* 2016) and dairy cattle (Mendieta-Araica *et al.,* 2011) had been carried out to increase the production of this livestock. This paper briefly reviews the benefits of Moringa oleifera as a ruminant feed.

Moringa oleifera Nutritional Value

Moringa oleifera has been known for centuries as a plant with various benefits, nicknamed The Miracle Tree or the magic tree. (Falowo *et al.,* 2018) Because it is naturally proven to have nutritional content that is considered complete compared to other food-source plants (Jongrungruangchok *et al.,* 2010; Bashir *et al.,* 2016). Almost all parts of the Moringa oleifera plant have various properties; one of the parts of the Moringa oleifera plant that have been extensively studied for its

nutritional content. And usefulness for both the health sector, human food and animal feed, and animal health is the leaf part (Anwar *et al.,* 2007; Kasolo *et al.,* 2010; Anjorin *et al.,* 2010; Sultana, 2020). Nonetheless, various studies have shown that roots, stems, bark, fruits, flowers, and seeds also have various therapeutic properties and high nutritional value (Adesina and Omitoyin, 2011; Luqman *et al.,* 2012; Khattak *et al.,* 2020; Gull *et al.,* 2016; Udechukwu *et al.,* 2018; Saa *et al.,* 2019).

Moringa oleifera leaves contain very diverse nutrients such as protein (Mapiye *et al.,* 2010; Islam *et al.,* 2021), carbohydrates (Moyo *et al.,* 2011), fat (González-Burgos *et al.,* 2021), vitamins (Conroy, 2005; Mbikay, 2012), minerals (Rockwood *et al.,* 2013; Gopalakrishnan *et al.,* 2016). The results also showed that the Moringa oleifera plant contains various vitamins, namely beta-carotene, vitamin A, B vitamins such as folic acid, pyridoxine, and nicotinic acid, vitamins C, D, and E are also found in M. oleifera (Ramachandran *et al.,* 1980; Sultana and Anwar, 2008; Ferreira *et al.,* 2008; Mbikay, 2012). The mineral content in the Moringa oleifera plant is also quite complete, so it further improves the quality of the plant when used as ruminant animal feed. The minerals in the Moringa oleifera plant include Ca, Mg, K, Zn, Fe, Na, Mn, and Cl (Aslam *et al.,* 2005; Jongrungrung Ruangchok *et al.,* 2010; Mulyaningsih and Yusuf, 2018). Besides its complete nutritional content, Moringa oleifera also contains various phytochemicals, such as phenolic acids, flavonoids, tannins, saponins, and alkaloids, which benefit the treatment of various diseases (Berkovich *et al.,* 2013; Panda *et al.,* 2013). The nutritional content of the Moringa oleifera plant from various studies was presented in table 1.

The research summary results in table 1 above show the nutritional content of Moringa oleifera leaves with different values. Differences in the value of the nutrient content causing by various factors such as the area of origin of the plant (Rane *et al.,* 2021), the shape of the leaf sample used, and the method of analyzing the nutrient content used. The country of origin of the research shown in table 1 shows the results of the content of Moringa oleifera, which are pretty varied. An example is the research conducted by González-Burgos *et al.,* (2021) conducted in Paraguay showed a different nutritional content from that carried out by other researchers such as Augustyn *et al.,* (2017) in Indonesia, Elkhalifa *et al.,* (2007) in Sudan and Fejer et al. (2019) in the Caribbean Islands. Further research results from Afzal et al. (2020) showed variations in several nutrient contents from one location to another within the same ecological zone, from one ecological zone to another within the same country, and from one country to other countries throughout the world.

Turning the leaves into various forms also influences the nutritional value obtained. Some leaf processing methods used in the research in table 1 show varying nutritional values, such as fresh leaves, dried leaves, leaf meal, and leaf extract. Research methods such as extraction techniques also affect the research results on the nutritional content of Moringa oleifera leaves (Dzięcioł, 2020; Mashau *et al.,* 2021). Furthermore, according to Vongsak et al. (2013), extraction is the best method to obtain maximum antioxidant results. Likewise, the ingredients of the Moringa oleifera plant were used as a food source in the form of twigs, stems, bark, and young stems. Table 1 also shows that almost all parts of the Moringa oleifera plant contain high enough nutritional value so that it can also be used as a feed ingredient even though it has to go through processing so that its nutritional value increases.

Further research is needed to understand the overall optimal composition and nutrient content variability at each growth stage so that it was expected to know the right time to harvest Moringa oleifera leaves. Further research is needed to determine the form of fertilizer and the right fertilization method to obtain maximum results. Moringa oleifera is an ingredient in animal feed and a therapeutic agent for various diseases.

Moringa oleifera for ruminants

Moringa oleifera has a long history as a feed ingredient for ruminants and non-ruminants. As a feed ingredient almost all parts have been used as feed ingredients, such as seeds, fresh leaves, young twigs, and waste of Moringa oleifera seed oil extraction. Currently, Moringa oleifera leaves have attracted the most attention of ruminant nutritionists as a source of protein because of its

Table 1. The nutritional content of Moringa oleifera leaves from various studies.

The nutritional content of Moringa oleifera leaves						
protein	fat	Carbohydrate/ fiber	vitamin	Mineral	Material origin	References
16,66%	1,70%	3,45%	Not listed	Ca: 0,2 mg/100g Mg: 0,13 mg/100g K : 0,075 mg/100g P: 0,031 mg/100g	Fresh leaves	Elkhalifa *et al.,* (2007)
30,29%	6,50%	8,49%	Vitamin E 77 mg/100 g beta-carotene, 18.5 mg/100 g	Ca: 3,65% P : 0,30% Mg: 0,50 K : 1,50% Fe : 490 mg/kg	Dried leaves	Moyo *et al.* (2011)
6,7%	4,65%	Not listed	Not listed	Tidak tercantum	Fresh leaves	Augustyn *et al.* (2017)
8,1 g	1,7 g	9,1 g/2,1 g	vitamin A 80 µg, thiamine (B1) 0.103 mg, Riboflavin (B2) 0.112 mg, Niacin (B3) 1.5 pantothenic acids (B5) 0.48 mg. vitamin B6 0.129 mg folic acid (B9) 41 µg Vitamin C 8.6 mg	Ca99.1 mg, Fe 1.3 mg, Mg 35.1 mg Mn 0.119 mg, P 70.8 mg, K 471 mg, Na 70 mg, Zn 0.85	Leaf extract	Abbas *et al.,* (2018)
20.54 ± 0.85	12.48 ± 0.62	Not listed	Vitamin E: 178.10 mg/kg vitamin C: 3210.0 mg/kg riboflavin : 4.0 mg/kg vitamin A 10.2 mg/kg nicotinamide 34.0 mg/kg	Mg: 1618,7 mg/kg Cu: 5,9 mg/kg P : 2067,0 mg/kg Zn : 30,6 mg/kg Fe : 57,7 mg/kg Ca: 12,567 mg/kg	Leaf extract	Fejer *et al.* (2019)
25.02 ± 0.37%	10.42 ± 0.63%	28.50 ± 0.45%	Vitamin B1 326.4 ± 1.28 (µg/100 g) Vitamin C: 15.2 ± 0.78(mg/100 g)	Tidak tercantum	Leaf meal	González-Burgos *et al*. (2021)
27,1 g	2,3 g	38,2 gram	Vitamin B1 : 2,64 Vitamin B2: 20,5 Vitamin B3:8,2 Vitamin C:17,3 Vitamin E:113	Ca : 2003 mg Mg : 368 mg P : 204 mg K: 1324 mg Cu :0,57 mg Fe : 28,2 mg	Leaf meal	Islam *et al.* (2021)
2,10 %	0,20 %	8,53%/3,2%	Vitamin A (µg) : 4 Vitamin D (D2 + D3) (µg) : 0 Vitamin D (IU) :0 Thiamin (mg) :0.053 Riboflavin (mg) : 0,074 Niacin (mg) :0,620 Asam pantotenat (mg:): 0,794 Vitamin B-6 (mg): 0,120 Vitamin B-12 (µg): 0 Vitamin E (mg): - Vitamin C, total: Asam askorbat (mg): 141,0 Total folat (µg): 44 Asam folat (µg): 0	Sodium (mg) Potassium (mg): 42 Calcium (mg): 461 Phosphorus (mg) 30 Magnesium (mg) 50 Iron (mg) 45 Zinc (mg) 0,36 Copper (mg) 0,45 Manganese (mg): 0,084 Selenium (µg) : 0,259 Sulfur (mg): 5.20 ± 0.15	pods	Islam et al., 2021
35.97 ± 0.19 gram	38.67 ± 0.03 gram	8.67 ± 0.12 gram/ 2.87 ± 0.03 gram	Vitamin B1 (mg) : 0,05 Vitamin B2 (mg): 0,06 Vitamin B3 (mg): 0,2 Vitamin C (mg) : 4.5 ± 0.17 Vitamin E (mg): 751.67 ± 4.41	Calcium (mg): 45 Phosphorus (mg) 75 Magnesium (mg) 635 ± 8.66 Iron (mg) - Copper (mg); 5.20 ± 0.15 Sulfur (mg): 0,05 Potassium (mg): -	Seed	Fuglie, 2005

optimal balance of amino acid composition and easily digestible protein content (Fahey *et al.,* 2005; Babiker *et al.,* 2017).

Various studies have shown a positive effect of giving Moringa oleifera leaves in various forms when given as non-ruminant feed, such as poultry, fish, and rabbits as well as ruminants (Wu *et al.,* 2013; Selim *et al.,* 2021; Mahfuz and Piao, 2019). However, Moringa oleifera cannot be used as the sole feed for ruminants because it contains various kinds of anti-nutrients, which can negatively affect the development of ruminants.

The results of the research are summarized in table 2. It shows the various benefits of the Moringa oleifera plant as ruminant animal feed. Table 2 also shows that all parts of the Moringa oleifera plant can be used as feed improving livestock performance. However, the results of the above studies also show that the administration volume will affect livestock performance. Inappropriate feeding may harm overall livestock performance or not affect it at all on livestock performance. The results of the research by Babeker and Abdalbagi (2015) showed that giving concentrate containing 20% Moringa oleifera leaf meal was the optimal amount in increasing the performance of Nubian goats when compared to 50%. The research results in table 2 also show that Moringa oleifera in the form of leaves, twigs, and bark that has not been or had been further processed cannot be used as a single feed to improve livestock performance. Moringa oleifera can be mixed or replaced with other feed ingredients with various feed ingredients such as soybean meal (Soltan *et al.,* 2017; Abdel –Raheem and Hassan, 2021). Mixed feeds that were used are corn silage (El-Esawy *et al.,* 2018), alfalfa hay (Dong *et al.,* 2019) and cottonseed flour (Zhang *et al.,* 2018).

Besides being a protein source feed, Moringa oleifera also has a lot of anti-nutritional content, which is useful for treating various diseases in livestock, both non-ruminants and ruminants. Moringa oleifera contains various phytochemicals, which are very beneficial for livestock health. The anti-nutritional content contained in the Moringa oleifera plant can have positive or negative impacts when given as animal feed. The anti-nutritional content found in the Moringa oleifera plant includes tannins, sterols, terpenoids, flavonoids, saponins, anthraquinones, alkaloids, glucosinolates, isothiocyanates, glycoside compounds and glycerol-1-9-octadecanoic (Siddhuraju and Becker, 2003; Berkovich *et al.,* 2013; Al-Taweel *et al.,* 2019). However, we will try to discuss in more detail the benefits of the anti-nutrient content in Moringa oleifera in humans and non-ruminants later in another article.

Table 2. The benefits of giving Moringa oleifera to ruminants in increasing production

Livestock	Administered in a concentrate mixture	Effect on livestock	References
Dairy cows	Leaf silage 263 g/kg feed	Increased milk production	Cohen-Zinder et al., 2017
Bull	Leaves, Twigs and branches form 50% flour	Reducing methane gas emissions and improving cement quality	Sultana et al., 2021
Young Buffalo	Leaf meal 15%	Increased body weight, decreased methane gas production, increased feed conversion efficiency	Abdel –Raheem and Hassan, 2021
Buffalo	Dry leaf 15%	Increased growth of baby buffalo	Elaidy et al., 2017
Young lamb	Root bark	Improves nutrient digestibility by modifying rumen fermentation	Soltan et al., 2018
goat	stems, branches, twigs and leaves 25%	There was no change in final body weight and ADG	Zaher *et al.,* 2020
Ewe	Leaf oil	Increased milk production, fat content and unsaturated fatty acid concentration increased feed efficiency and increased fiber digestion	Selmi *et al.,* 2020
Nubian goat	Leaf meal 20%	Increase in body weight, FCR, feed and drink intake	Babeker and Abdalbagi, 2015

The negative impact of Moringa oleifera on ruminants

As ruminant animal feed, giving in excessive amounts or given as a replacement concentrate material that is not following predetermined needs can negatively impact livestock development. Negative impacts will also arise if the provision of Moringa oleifera leaves as a substitute for concentrate exceeds the specified amount. Moringa oleifera contains various kinds of anti-nutrients, which can harm livestock if given in quantities that are not as needed. The results of the study by Salau et al. (2012) and Auwal et al. (2019) showed that Moringa oleifera contained various kinds of anti-nutrients such as phytate 10.58 ± 0.01 (mg/100g), oxalate 334.33 ± 0.67 (mg/100g), tannins 8.19 ± 0.01 (mg /100g), alkaloids 1.72 ± 0.01% and HCN 3998.30 ± 0.49 (mg/100g). Research on the negative effects of giving negative effects had not revealed much, or they may have shown no negative effects that are quite severe as a result of giving Moringa oleifera. Nonetheless, several studies have shown a negative impact on ruminants due to the influence of the anti-nutrient content contained in Moringa oleifera. Research by Su and Chen (2020) shows that anti-nutritional factors can interact with the chemical composition of feed, disrupting digestive or metabolic processes in the body with various mechanisms and can result in effects contrary to optimal utilization of nutrients. The research results of Zaher et al. (2020) also showed that giving Moringa oleifera leaves 75% and 100% as a substitute for concentrates would reduce the final body weight and ADG. The research results by Olvera-Aguirre *et al.* (2020) showed that dietary supplementation of Moringa oleifera leaf hydroalcoholic extract at a dose of 40 or 60 mL/sheep/day in lactating sheep had no impact on milk production.

Conclusion

Until now, Moringa oleifera is considered the Miracle Tree or magic tree and has been known for centuries as a plant with various benefits. However, in its utilization as a high-quality feed substitute for concentrates, attention must be paid to the presence of secondary metabolites therein to avoid negative impacts.

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