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Review Article

Moringa as a Feed Stuff

Muhammad Junaid Akhtar[1]*, Haseeb Ahmad[2] and M Ammar Saleem[3]

[1]Faculty of Veterinary and Animal Sciences, FV&AS, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan

[2]DVM, 3rd Year, FV&AS, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan

[3]DVM, 5th Year, FV&AS, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan

***Corresponding Author:** Muhammad Junaid Akhtar, Faculty of Veterinary and Animal Sciences, FV&AS, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan.

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Abstract

The shrubs and multi-purpose trees i.e. Moringa are the major constituents to overcome the nutritional stress and can boost up the animal's yield. It is cultivated in harsh and dried areas (i.e. upland, semi-arid, arid or hilly) across the world. This has ability to fulfill the major portion of animal's body requirements. Its nutritional profile is mentioned in the tables (1.1, 1.2 and 1.3). It consists of minor quantity of anti-nutritional factors as compared to rest of the green forages. Tannins, saponins, and oxylates are some anti-nutritional factors which are found in it. The effect of these anti-nutritional factors can be diminished by using different techniques i.e. boiling, drying, soaking and biological treatment. Each of the techniques has its own procedure. While feeding the animal, Moringa should be supplied with other energy fodders (i.e. sugarcane and sweet sorghum) in order to avoid over-intake of protein. Its features distinguish it from other forages, so it is more preferable in comparison with other forages.

Keywords: Moringa; Livestock Animals; Cultivation

Introduction

The extended dry period generally from December till May have a direct effect on the farming areas and grasslands and thus results in the shortage of the green fodder for the livestock animals. The utilization of the shrubbery feedstuff and fodder trees in such dry conditions is one of the best plans of owners for continuous supply of the good feedstuff to their animals. Continuous and appropriate amount of fodder supply all over the year is necessary for the growth of livestock and dairy where 50 to 60 percent animals are fed inappropriately [1]. As a result of the nutritional stress, their output or performance is decreased. Thus the shrubs and multi-purpose trees play a vital role in animal nutrition and the idea of feeding to meet the nutritional demands is getting popularity now a days.

Cultivation

Moringa oleifera is a very beneficial tree which is included in the category of the multi-purpose trees and is known as suhanjna at local level. It is inhabited to the sub Himalayan tract of India, Bangladesh, Afghanistan and Pakistan and is grown all over the world [2,3]. Opposite to other kind of forages, Moringa is also cultivated in drier and harsh environment of semi-arid or arid regions as well as in uplands and hills during summer season. This tree is fast growing and evergreen having a good ability to re grow itself after cutting. This is raised as an annual vegetative crop. This tree has the ability to generate huge amount of the new biomass of fodder in a unit area even at the landforms having high densities planting. These trees generally produce the dry matter up to 8.3 ton per

hectare while having the pruning frequency of a duration containing40 days and this can also be cut after the duration of 15 days.

Figure 1

Feedstuff Category	Plant Species	CP	Crude Lipid	CF	Ash
Woody Forages Plants	*Moringa oleifera*	23-30%	7.09%	5.9%	12%
	Morus alba	21.2-29.8%	5.5%	6.9%	11.6%
	Broussonetia papyrifera	21%	3.2%	9.1%	12.1%
	Caragana korshinskii	9.9%	3.2%	34.4%	6.7%
Conventional Crop forages	Alfalfa meal	19.1%	2.3%	22.7%	7.6%
	Soybean meal	25.5%	17.3%	4.3%	4.2%
	Corn meal	9.4%	3.1%	1.2%	1.2%

Table 1

Nutrient Content

Each part of the plant has its own nutritious importance majorly the leaves of Moringa are a good source of proteins which are highly digestible in nature. Moringa leaves are also a rich source of Vitamin C, iron and Calcium which are necessary for the growth in the livestock animals. Its leaves generally constitute the Vitamin A in the amount which is the ten times more as compare to that of carrot, Vitamin C seven times more as compare to orange, calcium seventeen times more as compare to the milk, potassium fifteen times more as compare to bananas, iron twenty five times more as compare to spinach, and proteins nine times more than that of yogurt [4]. These plants are a good source of the copper, manganese, magnesium, chromium, phosphorus, vitamin B-complex and Zinc.

On the basis of dry matter, the 23 to 30% constituents of the Moringa are present in the form of the crude protein that is more than the contents as compare to the *Morus alba* and *Medicago sativa* and almost it have the two times of content as compare to that of *Caragana kroshinskii* and *Lespedeza bicolor*. It is comprised of the 5.9% of the crude fiber which is as low as it can be in any feedstuff [5]. When we compare it with the soybean meal, the crude fiber contents of the both are almost at same level. In common, the lower constituent of crude fiber demonstrate a better palatability for animals [5]. Another important character of the Moringa leaves is that it has a high amount of minerals with 12% ash content which is greater as compare to corn or soybean meal [6]. Moreover, it comprises 7.09% of the fat which is also greater as compare to any woody plant fodder.

Primarily, almost up to 57% of fatty acids present in Moringa are unsaturated in nature and the α-linolenic acid contributes the most whose percentage is probably 45%. Unsaturated fatty acids are the essential part of the diet because they have the ability to esterify and decompose cholesterol, maintain the normal level of cholesterol, and thus minimize the chances of the atherosclerosis and other cerebrovascular abnormalities [7]. Traditionally as compare to other nutrients, amino acids dominates the nutritional index of the forage. The total constituents of amino acids present in the feeds and whether the composition of amino acids fulfills the feeding target can affect the feeding effect directly. *Moringa oleifera*, provided its amino acid constituent, can be utilized as the chief amino acid source for animal feed in addition with other conventional forages. Photochemical examinations demonstrated that Moringa constitutes the up to 19 amino acids, contains the 10 essential amino acids named as the tyrosine, threonine, valine, methionine, isoleucine, phenylalanine, histidine, leucine, tryptophan and lysine. Moringa constitute huge amount of leucine, lysine, glutamic acid, histidine, isoleucine, phenylalanine, arginine, alanine and valine which is important than that in the other kinds of woody plant [7,8]. Animals do not have the ability to synthesize some amino acids or the rate of production and amount of few amino acids in animals do not meet the demands of growth of animal. Thus few amino acids are given to the animals artificially [9]. Amino acids which are not formed in the body of animal are termed as the essential amino acid. For the formation of specific type of proteins, the required non-essential and essential amino acid must be available at the site of production according to the demand of the animal body. On the

other hand, the decrease in any amino acid affects the utilization of other types of amino acids present in the diet. The first ever amino acid which results in the limitation of protein production is known as the 1st limiting amino acid. When the inappropriate constituent of this amino acid is settled then the next amino acid which result in the limitation to the protein production is termed as the 2nd limiting amino acid [10]. Methionine is the first limiting amino acid in the soybean meal while lysine is the first limiting amino acid in the corn meal [11]. Therefore the stability in between the non-essential and essential amino acids present in the feed content must be considered while formulating the feed. The essential amino acid are the modest in the *Moringa oleifera* and are almost the 52% of the net amount of the amino acid. Primarily, Moringa has the high content of the lysine as compare toCaragana korshinskii and Broussonetia papyrifera and has 8 times more lysine content as compare to that of the content present in the corn meal. By comparison, the methionine content of Moringa is more as compare to content of alfalfa and is almost same as that of corn meal but it is 2/3rd of the soybean meal content. Inappropriate quantity of the sulfur amino acid can affect the formation of enzymes in a serious manner. Generally, the shortage of amino acid can be overcome by adding the fish meal or soybean meal as a supplement; this technique not only boosts up the total quantity of the amino acids but also increases the palatability of forage. One more sulfur containing amino acid named as cysteine should be available in Moringa leaf meal in an adequate amount so that the requirement for sulfur containing amino acid is fulfilled according to animal demand.

Amino Acids	Woody Plant Forages				Conventional Plant Forages		
	Moringa oleifera	***Morus alba***	***Broussonetia papyrifera***	***Caragana korshinskii***	**Alfalfa meal**	**Soybean meal**	**Corn meal**
Lysine	1.64	1.80	1.25	1.24	0.82	2.43	0.22
Leucine	1.96	1.35	1.69	1.30	1.20	2.75	-
Isoleucine	1.18	1.43	0.89	0.78	0.68	1.57	0.26
Methionine	0.41	0.52	0.36	0.18	0.21	0.60	0.43
Phenylalanine	1.64	1.94	1.24	0.84	0.82	1.79	0.31
Tryptophan	0.49	0.27	0.32	0.30	0.43	0.64	1.03
Valine	1.41	1.76	1.40	0.99	0.91	1.70	0.26
Histidine	0.72	0.69	0.42	0.47	0.39	1.10	0.23
Threonine	1.36	1.31	0.91	0.75	0.74	1.44	0.40
Cystine	0.01	0.30	0.30	0.11	0.22	0.62	0.34
Tyrosine	2.65	0.82	0.32	0.69	0.58	1.53	0.08
Arginine	1.78	1.80	1.00	1.14	0.78	2.53	0.38
Serine	1.09	1.22	0.90	0.80			
Glutamic acid	2.53	3.33	2.03	1.88			
Aspartic acid	1.43	3.06	1.88	2.03			
Proline	1.20	1.31	1.18	1.12			
Glycine	1.53	1.57	1.06	0.77			
Alanine	3.03	1.54	1.13				

Table 2

Generally the quantity of ash gives information about total mineral contents. Moringa comprises of the greater quantity of elements belongs to the category of minerals such as phosphorus, iron, calcium, zinc and potassium which play a vital role in the development and growth of animals. The quantity of different mineral contents present in Moringa on dry matter basis are given below [6].

Minerals	Amount (mg/kg)
Calcium	24,700
Phosphorous	4,400
Iron	318.81
Magnesium	190
Zinc	22.05

Table 3

The occurrence of the above mentioned minerals in the leaves of Moringa is usually high in contrast to the leaves of other trees [10]. In the living beings, calcium is an important element for the development of eggshells, bones, and teeth, the conservation of nervous system, the lessening in permeability of capillaries and the maintenance of activation of enzyme and metabolism. The powder of Moringa leaf can be used in place of milk for calves just due to its calcium reservoirs [10]. Interestingly, the shortage of iron is a common feature in many of the plant feeds except the Moringa feed. The quantity of iron that is supplied by the Moringa leaf is twenty-five times higher as contrast to that of spinach [6,10]. As we know the spinach has more content of iron but the rate of absorption of iron in spinach is comparatively slow. The rate of absorption of iron in Moringa is comparatively faster than that of the spinach and other leafy vegetables. Iron is a major part of many proteins and takes part in many metabolism reaction of the organism body. The shortage of iron have an effect on the physiological functioning of the animal. An adequate quantity of iron ions boosts up the growth of animal, majorly in the existence of zinc. Higher contents of zinc is another good feature of Moringa. Zinc, an essential part of enzymes, performs a chief role in the respiration of enzymes and in the metabolism reaction of proteins, sugar, nucleic acids and fats [12]. Moringa also comprises of greater quantity of magnesium which has a good effect on milk outcome [13]. Generally, finding the adequate amount of magnesium in the forage for various cows in accordance with their growth level is not an easy task just because of their various demands. Cows possess a flexible maintenance system to counter the excess of magnesium ions, the supply of excess magnesium salts into the feed is highly emphasized.

Presently, antioxidants obtained from plants are utilized as a feedstuff in husbandry on a large scale. Animals utilizing plant-based feed additives having antioxidants demonstrate a good anti-oxidation ability [14]. The active constituents of anti-oxidants found in nature are majorly polysaccharide, polyphenols, vitamins and alkaloids [15]. Commonly, the woody plants comprises higher amount of secondary metabolites as compare to herbaceous plants [16]. The leaves of Moringa has higher quantity of flavonoids, carotenoids, vitamins and phenols. Moringa leaves and their extracts have been utilized as feed supplement in animal diet to better the quality of meat due to presence of excess of secondary metabolites [17,18]. The concentration of carotenoids in Moringa leaves comprises 40,139 µg per 100 g of fresh weight [19]. The β-carotene constitutes the 47.8% of the total concentration, which is a chief precursor for the Vitamin A, an active material that boost the reproduction and growth and many other physiological functions, such as epithelial tissue, bone, and visual and mucosal epithelial secretion [19]. Almost β-carotene may be transmitted into vitamin A within the body of animal. Moringa has the sufficient amount of the Vitamin A and vitamin E in it and is provided to the animals. Vitamin A is beneficial for the growth and development of the animal while Vitamin E performs its function as an anti-oxidants and thus shields the cells against harmful free radical and aids the body to boost up the cellular immunity. Moringa leaves additives transmits the higher antioxidants capability to the goats and other animals and this feature is usually observed in the shelf life and meat oxidative stability. The above discussion demonstrates that Moringa is a healthier feedstuff than other vegetable feedstuff in the nutritional aspect.

Anti-nutritional factors in *M. oleifera* leaves

The presence of anti-nutritional factors in *M. oleifera* depends upon different factors such as genetic history of the plant and growing environment.

- 12.0 to 20.6 mg g^{-1} tannins is present in the *Moringa* leaves which leads to less uptake of feed and less palatability as well as less digestibility [6,20].
- Saponins, another anti-nutritional factor, present in leaves of *M. oleifera* present in very minute amount, in dry matter they range from 12.0 to 20.6 mg g^{-1} [20].
- Some other anti-nutrients such as oxalates and phytates are present in very small amount. For example the amount of oxalates is about 27.5 mg g^{-1} in dry matter while phytate is present about 22.3 mg g^{-1} in dry matter [21].

Quality Improvement of *M. oleifera* leaves for Animal Feeds

Tree leaves have been found to have a large portion of anti-nutritional factors in them, therefore the leaves of Moringa are processed by different ways.

- **Boiling:** It destroys majority of anti-nutrients in the leaves of moringa and results into decreased amount of cyanides, trypsin inhibitor and oxalate. As a result, palatability and digestibility of plant leaves is improved [22].
- **Drying:** A large portion of cyanides, trypsin inhibitor and oxalate decreases when treated with various drying methods such as oven drying and sun [23].
- **Soaking:** Soaking reduces mimosine content from 4.4% to 0.2% from moringa leaves [24].
- **Biological Treatment Technology:** Different methods such as enzymolysis and fermentation have been used to improve nutritional quality of moringa leaves [10].

Feeding strategies

When the Moringa fodder is given to the animals then it should be supplied with the addition of sugarcane, sweet sorghum plants, young elephant grass, molasses and any-other stuff like this which is available at local level. The higher amount of the protein present in the Moringa leaves must be maintained with any of the energy feed. This feed should be provided to the animal with great care in adequate amount just to avoid from the over intake of the protein feed as the excess of protein in the animal feed can be dangerous. If Moringa is utilized as the fresh feed, it should be provided after the pruning and intermixed with dry feed content till it become the semi-dry mass. This should be crushed with the help of the meat grinder and converted into pallet form.

General Discussion

Moringa has been utilized as a feedstuff from a long time. The utilization of the Moringa seeds as a feedstuff was first time reported in the 1962. Farm animals were later started to feed on the young branches, leaves and seed residues after extraction. In recent times, the leaves of Moringa has been utilized as a replacement for the protein feeds used earlier for the aquatic, ruminants and mono-gastric animals.

Researches on the growth of broiler chicken showed that Moringa meal can chiefly better the bowel health but the maintenance of the intestinal microflora thus boosts up the weight gain. Arabi., *et al*. confirmed that broilers feed with the supplement containing the Moringa causes the body weight to increase, the feed intake is usually low, but FCR is better when compared to control group. Such outcomes can be compared to the occurrence of various bio-active factors, which are responsible to enhance the usage of nutrients of Moringa leaf extracts. Another research reveals that there is no gap in the utilization of feed and body growth weight of broiler chicken when fed with soybean meal with Moringa at the ratio of 0.0, 5.0, 7.5, and 10%, denoting that the Moringa leaf meal can change partial protein source in poultry diet without having any harmful effect on the growth. The supply of Moringa meal can cause the enhancement of the humoral immunity and causes the lipid peroxidation to decrease in liver without demonstrating any bad effect on the carcass attribute and performance. *M. oleifera* leaf inclusion in groundnut cake meal of up to 24% did not cause any adverse effects on average daily gain, total weight gain, mortality, FCR, along with other features. Hematological features supply essential information for the checking of health status of the body. Broiler chickens who are fed on the Moringa leaf meal demonstrate an increase in RBCs count. Majorly, the groups which are supplied with 0.6% *M. oleifera* leaf powder in basal diet; it was found that these chickens have the highest mean value of red blood cell. As we know Moringa is enriched with iron ions, which are major factors for the myoglobin and hemoglobin formation.

Conclusion

There are several characteristics that make it preferable. First of all, its growth rate is high as compared to other feedstuffs, so it can be radially available to animals. This is a soft wood plant that make it more palatable for ruminants. The performance level of ruminants is highly dependent on its health status and the diet that it is obtaining to carry out its daily activities. All the essential nutrients should be available for this purpose in their diet. *Moringa oleifera* can be regarded as the best diet in this regard. It carries high proportion of crude Proteins, essential fatty acids, vitamins and required minerals. Its benefits are not limited to its nutritional value but it also play its role in supporting the Immune system of animal to defend against pathogens. It is also having a proportion of antioxidants, which are very important in destruction of oxygen radicals.

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