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Moringa oleifera: an alternative forage of multiple uses for the Brazilian semiarid

Moringa oleifera: uma alternativa forrageira de múltiplos usos para o semiárido brasileiro

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Abstract

Moringa oleifera is a medium-sized, fast-growing tree species native to India, which adapts to a wide range of soils and is tolerant to drought. Its importance for human and animal food is due to its nutritive characteristics, having high levels of crude protein, vitamins, minerals and insignificant amounts of antinutritional factors in its leaves. Furthermore, this plant has several other uses that are popularly recognized and corroborated by the scientific community, such as medicinal application, treatment of turbid waters, oil production and live fencing. Due to its climate adaptability, forage potential and various uses, moringa has been shown to be a viable alternative to be used in the Brazilian semiarid. Notwithstanding, there is still little research leading to better information on the use of this plant in the semiarid region and that can subsidize breeders and researchers for its propagation. This review was elaborated with the aim of discussing information to improve the use of *Moringa oleifera* as an alternative forage of multiple uses for the Brazilian semiarid.

Additional keywords: drought; forage; nutritive value; tree species; water clarification.

Resumo

A *Moringa oleifera* é uma espécie arbórea de médio porte, nativa da Índia, de crescimento rápido que se adapta a uma ampla faixa de solos além de ser tolerante à seca. Sua importância para alimentação humana e animal é devida as características nutricionais, possuindo em suas folhas elevados teores de proteína bruta, vitaminas, minerais e insignificantes quantidades de fatores antinutricionais. Além disso, esta planta possui diversos outros usos que são reconhecidos por populares e corroborados pela comunidade científica, como exemplo: medicinal, tratamento de águas turvas, produção de óleo e formação de cerca viva. Diante da adaptabilidade as condições do clima, do potencial forrageiro e de seus diversos usos, a moringa tem se mostrado uma alternativa viável para ser utilizada na região do semiárido brasileiro. Entretanto, verifica-se que ainda são escassas as pesquisas que conduzam a melhores informações quanto à utilização desta planta no semiárido e que possam subsidiar criadores e pesquisadores para sua propagação. Esta revisão foi elaborada com objetivo de discorrer sobre informações para aperfeiçoar o uso da *Moringa oleifera* como alternativa forrageira de múltiplos usos para o semiárido brasileiro.

Palavras-chave adicionais: arbórea; clarificação de água; forragem; seca; valor nutritivo.

Introduction

Moringa oleifera Lam (synonym: *Moringa pterygosperma* Gaertner), a plant belonging to the family *Moringaceae*, is native to India and adapts to a wide range of climatic conditions. In Europe and Africa, it is grown for multiple uses, and its leaves, flowers, fruits and seed oil are used in human food, as well as its branches and leaves are used as fodder. It is also used for medicinal applications, live fencing and windbreaks, and the extract from its seeds is used in the treatment of turbid waters (Bakke et al., 2010).

Moringa has nutritive characteristics favorable to ruminant feeding, since it has high levels of crude protein, vitamins, minerals and insignificant quantities of antinutritional factors in its leaves, in addition to high palatability and digestibility, characterizing this species as a high quality forage (Bakke et al., 2010).

This plant has been highlighted by several other reasons: rapid growth, reaching the forage cutting period at six months; flexible stems; easy handling for cutting; no need for agricultural inputs or advanced technology during planting; pest resistance and absence of integumentary and physiological dormancy in the seeds.

For Almeida et al. (1999), moringa is a foraging tree of great importance for the Brazilian semiarid due to its capacity for survival and production in areas

of low soil moisture, in addition to its tolerance to high air temperatures, high evaporation and large variations in precipitation. However, in the Brazilian semiarid, there is little information on the use of this plant.

In view of the above, this review was carried out with the aim of presenting information to improve the use of *Moringa oleifera* as an alternative forage of multiple uses for the Brazilian semiarid.

Origin and Agronomic Characteristics

Moringa oleifera is a medium-sized tree, known in Brazil as "quiabo-de-quina", "lírio-branco" (or white lily), "baqueta" (or "drumstick", because of the shape of its pod) and "rábano" (or radish, in view of the taste of its roots, resembling radish). This plant belongs to the kingdom *Plantae*, division *Magnoliophyta*, class *Magnoliopsida*, order *Brassicales*, being the most popular species and belonging to the monogenic family *Moringaceae* of the genus *Moringa*.

Moringa originates from the Agra and Oudh region of northwestern India, south of the Himalayan mountains, being widely cultivated in Asia, Africa, and other tropical regions of the world, such as Brazil (Okuda et al., 1999). In Central America, it was introduced in 1920 as an ornamental plant, being also used for live fencing (Foidl et al., 1999).

The introduction of moringa in Brazil took place in 1950, probably through the Department of Agriculture of the State of Maranhão, who imported it from the Philippines. Its presentation to the scientific milieu occurred in 1982, through Dr. Warwick Estevam Kerr, resulting in the planting of 25,000 seedlings by university students at workers' homes in the State of Maranhão, aiming at the nutritive properties of its leaves (Kerr & Silva, 1999).

Moringa is a perennial tropical plant of easy production, management and propagation (sexually or asexually), requiring no special treatments or large amounts of nutrients in the soil, not even water after planting (Foidl et al., 1999).

This fast-growing plant reaches up to 15 meters in height (Ferreira et al., 2008) and has a short trunk with 25 cm thickness (Sánchez et al., 2006a). According to Pérez et al. (2010), it is short-lived and can live for up to 20 years, with annual varieties found in India. It reaches 5.0 meters in height in little more than a year and has a straight stem of fragile, low-density light wood (0.19 g/cm^3) (Morton, 1991).

Ramachandran et al. (1980) argued that moringa is very resistant to drought, being grown in arid and semiarid regions of India, Pakistan, Afghanistan, Saudi Arabia and East Africa, with rainfall around 300 mm per year. According to Sánchez et al. (2006a), moringa tolerates an annual precipitation of 500 to 1,500 mm.

This tree provides high amounts of nutrients to the soil, as well as protects it from external factors such as erosion, drying and high temperature (Morton, 1991). The soil pH range for moringa growth is in the range from 5 to 9, but the tree does not adapt to poorly drained and heavy clayey soils, preferring neutral or slightly acidic soils (Sánchez et al., 2006a).

According to Bakke et al. (2010), moringa propagates by means of seeds, seedlings or cuttings, showing good germination rate when freshly harvested under conditions of adequate moisture. As an adult, it reaches an annual production of 3 to 5 tons of seeds per hectare (Morton, 1991).

Flowers, fruits and leaves

The flowers are bisexual, with white petals and yellow stamens (Falasca & Barnabé, 2008). In some regions, moringa blooms only once a year, but its blooming can occur twice a year, as in the case of Caribbean countries such as Cuba (Pérez et al., 2010). The flowers are pollinated by bees, as well as by other insects and some birds (Morton, 1991).

The fruit (pod) is capsule-shaped, containing round seeds of dark brown color with three whitish wings that facilitate wind dispersal under natural conditions (Morton, 1991).

The leaves of 3 to 5 cm in length are composite, alternate and arranged in groups of leaflets with three to five pairs arranged on a main petiole (Sánchez et al., 2006a; Pérez et al., 2010).

According to Kerr & Silva (1999), the leaves are rich in phosphorus, calcium, iron, and vitamins C and A, the latter being present in about 23,000 IU per 100 g of mature leaves, a higher content when compared to traditional plants such as broccoli, carrots, cabbage, spinach and lettuce, which contain, respectively, 5,000, 3,700, 2,200, 1,900 and 1,000 IU vitamin A. Withal, the leaves are an important source of protein, with 27% protein in the dry matter (Becker, 1995).

Its leaves have been shown to be excellent nutritional sources, providing more vitamin A than carrots, more calcium than milk, more iron than spinach, more vitamin C than oranges and more potassium than bananas (Fahey, 2005).

Multiple Uses

Food and medicinal application

In Europe and Africa, moringa is cultivated for multiple uses; its leaves, flowers, fruits and seeds (crude and roasted) are used as feed and its branches and leaves are used as fresh or dehydrated forage (Bakke et al., 2010).

Moreover, since its leaves have high nutritive potential, they are used to combat child malnutrition (Morton, 1991). The seeds can also be used as an excellent substitute food for vegetables that are generally poor in sulfur-containing aminoacids (Ferreira et al., 2008).

The extracts of all parts of this plant have pharmacological properties that are popularly recognized and corroborated by the scientific community, such as production of antibiotic oils and growth hor-

mone. However, the most cited medicinal use of moringa is for skin diseases, digestive system diseases and joint impairments (Ferreira et al., 2008).

Water treatment

Moreover, one of the most reported applications of moringa is the use of its seed extract in the treatment of turbid waters as a clarifying agent and as a natural coagulant, efficiently replacing aluminum salts (Gallão et al., 2006).

The commonly used method consists in placing raw water in contact with 2 to 3 ground seeds for each liter of water in a container; depending on the turbidity, after 2 hours of permanence the supernatant is withdrawn, and then this water is used for consumption (Mendes & Coelho, 2007). Studies have shown that the percentage of turbidity removal is 80 to 99% (Okuda et al., 1999).

Currently, the moringa crop has been spread throughout the Brazilian northeastern semiarid, due to its application in water treatment for domestic use (Gallão et al., 2006). In the state of Ceará, programs were created to distribute kits with moringa seeds with instructions for use to rural populations, aiming to offer a simple and renewable solution to the deleterious effect of drinking water shortages, improving the quality of life, helping to reduce child mortality and collaborating with the region's sustainable development (Ferreira et al., 2008).

Distinct uses

Falasca & Barnabé (2008), belonging to the Colombian Corporation of Ecology, Agriculture and Livestock Ltd., recommend moringa for biodiesel production, since the seeds contain 31 to 47% oil. This light yellow oil is highly resistant to oxidative rancidification, which may explain its various industrial uses (Tsaknis et al., 1999).

For Oliveira et al. (2012), based on the results of the experiment carried out in the northeast of Brazil, the moringa seed produces a good quantity of oil with adequate physicochemical characteristics and within the standards to be used as raw material in the transesterification to obtain biodiesel. The average oil content found in moringa seeds was 40%, with an 83.68% yield in biodiesel.

Moringa is still used in park ornamentation, live fencing, windbreaks, green manure and, furthermore, avoiding soil erosion in areas with intense periods of drought and high winds (Fugliee, 2000).

Foidl et al. (2001) found that the extract of moringa leaves extracted with 80% ethanol can be used to produce an effective hormone for the development of sugarcane roots and in the growth of plants, increasing the yield of onion, pepper, soybean, corn, sorghum, coffee and melon crops from 25 to 30%.

As can be seen, moringa is a multipurpose plant, since it is also used to produce cosmetics, tablets, dragees, syrups, emulsions and creams, glues, paper, paints and others (Pérez et al., 2010).

Moringa in Animal Feeding

Forage production

Sánchez et al. (2006a) carried out an experiment analyzing the effects of different planting densities (250,000, 500,000 and 750,000 plants/ha) and cutting frequencies (45, 60 and 75 days) in the biomass production of *Moringa oleifera* obtained from Nicaragua, and found a higher yield at 75 days for all densities analyzed. The density of 750,000 plants/ha produced the highest yield of fresh matter and dry matter, of 88.0 and 18.9 t ha/year, respectively.

According to Foidl et al. (1999), the use of moringa as fodder occurs at intervals of 35 to 45 days, when its sprouts reach 1.2 to 1.5 m, depending on the crop management conditions. After being ground, the cut material (leaves, fruits and twigs) can be supplied fresh to the animals after an adaptation period, in which the forage should be mixed with other foods to which the animals are already adapted.

In an experiment with moringa for sheep feeding, Sánchez et al. (2006a) used the distance of 5 cm between plants and 40 cm between rows, planted at 1 cm depth, with cutting at 45 days of age at a height of 25 cm from the ground. The authors of this experiment concluded that an intensive production of moringa biomass can be achieved with a density of 50 to 75 plants per square meter and cutting every 75 days.

Nutritive potential

Moringa leaves have all the essential aminoacids, including aminoacids containing sulfur at a higher level than recommended by the Food and Agriculture Organization-FAO, with patterns similar to those of soybean seeds.

When analyzing the seed meal composition, Oliveira et al. (1999) found high contents of essential aminoacids, except for lysine (15.3 g/kg protein), threonine (30.8 g/kg protein) and valine (43.5 g/kg protein).

In turn, when analyzing the centesimal composition of moringa seeds, Oliveira et al. (1999) and Abdulkarim et al. (2005) reported high levels of total proteins (332.5, 383.0 g/kg DM), lipids (412.0, 308.0 g/kg DM), carbohydrates (211.2, 165.0 g/kg DM) and ash (44.3, 45.0 g/kg DM, respectively). In fact, the total protein content found by Abdulkarim et al. (2005) turned out to be larger than that of some important legume seeds with respect to human nutrition.

Melo (2012) analyzed the nutritive value of moringa hays with different cutting ages and found the following values for the chemical composition of hay at 28 and 49 days of cutting, respectively: 91.33 and 92.88% dry matter; 12.01 and 10.49% mineral matter; 25.19 and 21.27% crude protein; 3.63 and 3.91% ethereal extract; 59.16 and 64.32% total carbohydrates; 45.84 and 50.04% neutral detergent fiber; 28.33 and 34.10% acid detergent fiber; 59.95 and 61.01% total digestible nutrients.

Garcia et al. (2006) evaluated the chemical composition of six non-leguminous species (*Azadirachta indica, Cnidoscolus aconitifolius*, *Ficus carica, Moringa oleifera, Morusalba* and *Trichantera gigantea*) in Trujillo, Venezuela, among which *Moringa oleifera* presented higher concentrations of K and Na (2.65 and 0.24%, respectively), as well as higher contents of soluble carbohydrates (24.1%) and ash (25.8%) in relation to the others.

Regarding antinutritional factors, whose consumption may affect animal productivity and health, moringa leaves present insignificant amounts of phenols (2.7%), tannins (1.4%) and saponins (1.2%), similar to those found in soy-based foods (Makkar & Becker, 1996). At these concentrations, they do not produce any adverse effects or toxicity when ingested by ruminants. The leaves also present low amounts of phytates (2.10%) and absence of trypsin, lectins and amylase inhibitors, cyanogenic glycosides and glucosinolates (Makkar & Becker, 1997). The latter interfere in the digestion and absorption of nutrients when found in plants, thus reducing food efficiency.

Phytate levels are higher in the seed samples than in the vegetative parts of the plant. This factor can reduce the bioavailability of minerals (particularly Zn^{2+} and Ca^{2+}) in monogastric animals when present in a range of 1% to 6% phytate (Thompson, 1993). However, in samples extracted with 80% ethanol, tannins were not detected and phenol contents were very low (1.6%), since these are soluble in aqueous organic solvents such as ethanol, methanol, acetone, etc. (Makkar & Singh, 1992).

Foidl et al. (1999) point out that there is a need for an adaptation period of the moringa with other foods at the beginning, however the fodder composed only of moringa leaves can be used both as a protein complement and as a complete feed substitute for animals.

Experiments with animals

According to Foidl et al. (1999), the consumption of green matter of moringa can reach 27 kg/animal/day and maintain a stable production of lactating cows, while its use in feeding can reduce costs by up to 10% when compared to animals supplemented with traditional concentrates.

In a survey carried out in Nicaragua with Creole cows, the following treatments were used: *Brachiaria brizantha* hay ad libitum not supplemented or supplemented with 2 kg or 3 kg of dry matter of moringa leaves. Moringa supplementation increased ($P<0.05$) dry matter intake to 8.5; 10.2 and 11.0 kg day^{-1} and milk production to 3.1; 4.9 and 5.1 kg day^{-1} for *Brachiaria brizantha* hay alone and supplemented with 2 kg and 3 kg of dry matter of moringa, respectively. Milk fat, total solids and crude protein and organoleptic characteristics (smell, taste and color) were not significantly different between diets. The coefficients of apparent digestibility of dry matter, organic matter, crude protein, neutral detergent fiber and acid detergent fiber increased ($P<0.05$) in the diets supplemented with moringa compared to *B. brizantha* hay alone (Sánchez et al., 2006b).

Studies also found that when the cottonseed cake was replaced with moringa leaf meal at 10, 20 or 30% dry matter, the milk production in cows increased significantly by 0.8; 0.9 and 1.4 kg cow^{-1} day^{-1}, respectively. This substitution had no effect on the chemical composition of the milk (Sarwatt et al., 2004).

The studies of Pérez et al. (2010), in the center of Sinaloa, Mexico, suggest moringa as an alternative forage with high protein content for sheep feeding, due to its adaptability to the climate and low production cost, presenting 70.5% dry matter digestibility and 65.5% apparent protein digestibility. Gebregiorgis et al. (2012), analyzing the consumption of low quality Rhodes grass hay supplemented with increasing levels of dry leaves of moringa (0, 150, 300 and 450 g) in sheep in Ethiopia, obtained increases in dry matter, organic matter and crude protein intake, weight gain (-13.3, 40.2, 79.1 and 110.1 g $head^{-1}$ day^{-1}) and apparent CP digestibility with the inclusion of increasing levels of supplementation with moringa leaves, respectively. Therefore, moringa can serve as a protein supplement during the dry season in sheep production systems. Moyo et al. (2012), in an experiment with crossbred X hosa lop-eared goats, used a basal diet with native pasture grass hay ad libitum and wheat bran (200 g day^{-1}) in three treatments: basal diet alone; basal diet with sunflower cake and basal diet with dry leaves of moringa. The authors obtained results for crude protein of 14.08; 23.2 and 23.75%, mean daily weight gain of 43.3; 101.31 and 103.3 g, feed intake of 404.5; 491.5 and 490.75 g and warm carcass weight of 8.59; 10.48 and 10.34 kg, respectively, for treatments with basal diet alone; basal diet with sunflower cake and basal diet with dry leaves of moringa.

In a study evaluating the nutritive effect of fresh leaves of *Moringa oleifera* as complementary food in the production and quality of eggs of Rhode Island Red chickens in Yucatán, Mexico, Mohammed et al. (2011) obtained satisfactory results with higher egg-laying rates, lower feed intake and a better feed conversion rate, as well as larger yolk size and better yolk color for the treatment with ration supplemented with moringa leaves ad libitum when compared to chickens fed only with control ration ad libitum.

In Brazil, there are still few studies regarding the inclusion of *Moringa oleifera* in animal feeding. Currently, some research on the consumption, digestibility, degradability, ingestive behavior and limitations of moringa use are being developed in order to obtain information to improve the use of moringa as an alternative source of animal feed. However, no scientific data has been published so far regarding these subjects in the Brazilian semiarid.

Conclusions

Based on the reviewed literature, it was possible to emphasize that *Moringa oleifera* is a plant with multiple uses for the human being, since virtually all its parts present numerous possibilities of use. At the same time, the nutritive characteristics of moringa make this plant an excellent option to be used as fodder during the dry season in semiarid regions.

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